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TOWARD THE IDENTIFICATION OF A CORE ZONE IN THE TEHUACÁN-CUICATLÁN BIOSPHERE RESERVE, MEXICO, BASED ON PARSIMONY ANALYSIS OF ENDEMICITY OF FLOWERING PLANT SPECIES

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In Mexico, endemism is most important. Approximately 57% of its flowering plant species are restricted to its territory (Villaseñor, 2003). Higher percentages of endemism have only been found on certain islands, like Hawaii, Madagascar or New Guinea, or on the southern part of the African continent (Gentry, 1986; Akeroyd and Synge, 1992). In particular, many Angiosperm families in Mexico possess a high degree of endemism. For this country, the known families of which more than half of their species are endemic are Asteraceae (Turner and Nesom, 1993; Villaseñor, 1993, 2003), Bromeliaceae (Espejo and López-Ferrari, 1998), Cactaceae (Guzmán *et al.*, 2003), Euphorbiaceae (Steinmann, 2002), Fabaceae (Sousa and Delgado, 1993), Lamiaceae (Ramamoorthy and Elliott, 1993) and Scrophulariaceae (Méndez-Larios and Villaseñor, 2001). More examples can be found in Ramamoorthy *et al.* (1993) and Villaseñor (2003).

Sites with an attention-drawing concentration of endemic taxa, described by Rzedowski (1991) as "ecological islands", have been found throughout Mexico; for example, the Rio Balsas Valley or the Sierra Madre Occidental and Oriental, among others. The Tehuacán-Cuicatlán Valley, located on the southeast and northeast state limits of Puebla and Oaxaca, respectively, and recognized by Rzedowski (1978) as a Floristic Province, can be considered as an ecological island, given the high number of endemic species registered in its territory (Villaseñor *et al.*, 1990; Villaseñor, 1992; Dávila *et al.*, 1995; Méndez-Larios *et al.*, 2004). Moreover, the Tehuacán-Cuicatlán Valley is a region with a vast biological diversity (Dávila *et al.*, 2002a).

Pressey *et al.* (1994) introduced into conservation biology the concept of irreplaceability of regions. When a region consists only of common species with broad distributions, it has a low irreplaceability value. In contrast, areas containing species that are not found anywhere else have an irreplaceability value of 100%. As such, irreplaceable regions represent priority regions for conservation (Vane-Wright, 1996). This is the case of areas of endemism, which are defined by more or less congruent distribution patterns of two or more species (Platnick, 1991; Harold and Mooi, 1994; Morrone, 1994). As these areas contain exclusive species, they are irreplaceable and therefore highly important for conservation.

Morrone (1994) proposed the use of Parsimony Analysis of Endemicity (PAE) as a tool for the detection of areas of endemism.

KEYWORDS / Core Zone / Parsimony Analysis of Endemicity / Tehuacán-Cuicatlán Biosphere Reserve / Tehuacan /

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Its methodology is analogous to the cladistic methods used in phylogenetics and cladistic biogeography. It allows the classification of areas or localities (analogous to taxa) according to the taxa they share (analogous to characters), searching for the most parsimonious solution (Morrone and Crisci, 1995). Input data for PAE are matrices of areas *vs* taxa. The resulting cladograms represent hierarchic areas and the terminal dichotomies are assumed to represent areas with similar biota (Morrone and Crisci, 1995). PAE was originally developed in the field of paleobiogeography (Rosen, 1988). Morrone (1994) modified the technique to be used for the identification of endemism areas. He also proposed that the study area used for the identification of endemism zones might be divided into Operative Geographic Units (OGUs), not necessarily having the same dimensions or shape. This method permits the identification of areas of endemism based on the congruence of distribution patterns of at least two species taxonomically related with each other or not, depending on whether the viewpoint is phylogenetic or ecologic. PAE has been used in different studies around the world and with diverse biological groups (Myers, 1991; Morrone, 1994; Fernandes *et al.*, 1995; Cardoso and Oren, 1996; Posadas, 1996; Sfenthourakis and Giokas, 1998; Watanabe, 1998; Glasby and Álvarez, 1999; Luna *et al.*, 1999; Morrone *et al.*, 1999; Ron, 2000; Bisconti *et al.*, 2001; Ippi and Flores, 2001; Morrone and Márquez, 2001; Cavieres *et al.*, 2002; Dávila *et al.*, 2002b).

In 1996, UNESCO declared that all Biosphere Reserves should include three well defined zones: a core zone, where the ecosystem is strictly protected, surrounded by a buffer zone, where non-destructive human activities are permitted and monitored in order to prevent negative impacts on the core zone, and around both zones, a transition zone with supervised activities forming part of sustainable management plans (IUCN, 1987). The core zone is the most important part of the Biosphere Reserve for biological conservation. As such, when areas of endemism are identified inside the Reserve, they might be proposed as core zones, because of their content of unique species.

The Tehuacán-Cuicatlán Biosphere Reserve (TCBR) is situated in the southeastern Puebla state and the northeastern Oaxaca state, Mexico. The area was declared a Biosphere Reserve in 1998 (Diario Oficial, 1998) and belongs to a region with high biological diversity (Dávila *et al.*, 2002a). Approximately 1910 vascular plant species, typical of the southern xerophytic region of Mexico, have been found in the TCBR. Approximately 9.1% of these species are endemic to the Reserve (Méndez-Larios *et al.*, 2004).

This paper aims to identify the areas of endemism inside the limits of the TCBR. At the same time, due to their irreplaceable value, their potential as priority zones for biological conservation as well as their selection as core zone(s) will be evaluated.

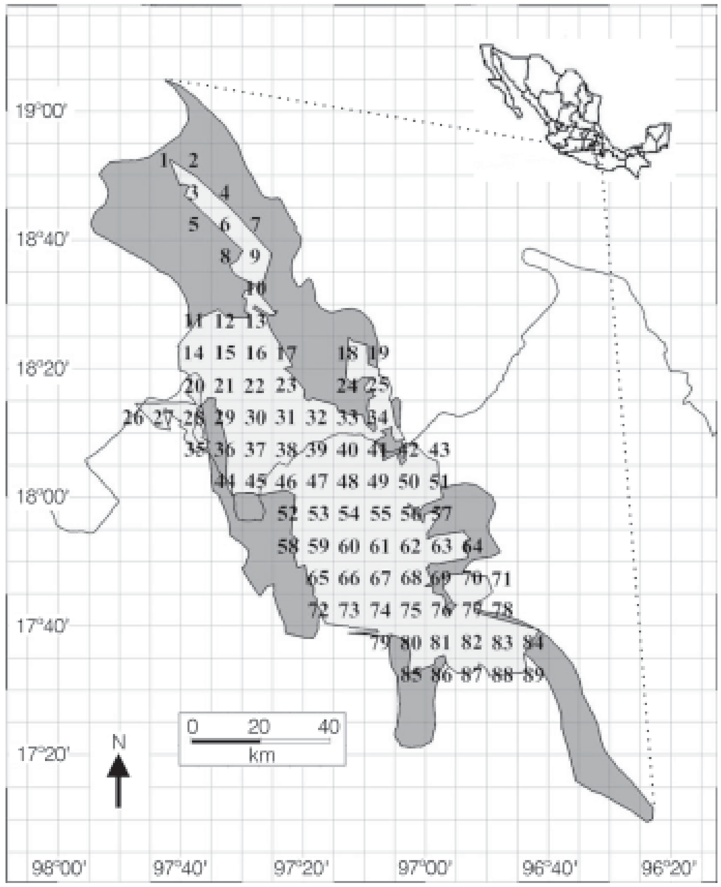

Figure 1. Geographic location of the Floristic Province of the Tehuacán-Cuicatlán Valley (dark zone) and the Tehuacán-Cuicatlán Biosphere Reserve (clear zone), divided into 89 OGUs.

Materials and Methods

The TCBR is situated between 17º30' and 18º55'N and between 96º42' and 97º47'W (Figure 1). It has an area of 481050ha and 78.4% of its surface is covered with xerophilous vegetation, as it comprises a large part of the Floristic Province of the Tehuacán-Cuicatlán Valley (Rzedowski, 1978; Figure 1). The topography of the TCBR is diverse. Altitudes range between 600 and 3000m. In the west, the border is formed by the Sierra de Zongolica, which forms part of the Sierra Madre Oriental, with altitudes of >3000m. In the southeast, the Sierra Mazateca with altitudes up to 2500 and 3000m and other mountain ranges belonging to the Mixteca Alta or Sierra Mixteca border the Mesa del Sur (Catalán, 2001). The climate is represented by three arid subgroups (B) according to the climate classification system of Köppen modified by García (1988): semi arid (BS1), arid (BS0) and dry arid (BW). It presents a typical summer rain season, with a temporal diminution of precipitation also known as phenomenon of intrasummer drought or dog days (Catalán, 2001). At present, the reserve beholds 279 human settlements with a population between 1 and 2407 inhabitants; 7 villages have more than 1000 inhabitants (INEGI, 2000). The main activities of the local people are agriculture, pasturing, salt extraction and mining.

The studied taxa consisted of 174 species (Appendix) of

TABLE I.
ENDEMIC SPECIES RICHNESS
FOR EACH OF THE 89 OGUs
IN THE TEHUACÁN-CUICATLÁN
BIOSPHERE RESERVE

	OGU	Number of species		OGU	Number of species
1	OGU-30	46	46	OGU-6	3
2	OGU-16	35	47	OGU-58	3
3	OGU-22	30	48	OGU-59	3
4	OGU-44	21	49	OGU-4	2
5	OGU-39	20	50	OGU-49	2
6	OGU-68	20	51	OGU-52	2
7	OGU-37	19	52	OGU-53	2
8	OGU-13	18	53	OGU-64	2
9	OGU-21	16	54	OGU-1	1
10	OGU-29	16	55	OGU-5	1
11	OGU-42	16	56	OGU-7	1
12	OGU-56	15	57	OGU-8	1
13	OGU-31	14	58	OGU-10	1
14	OGU-47	14	59	OGU-17	1
15	OGU-81	14	60	OGU-18	1
16	OGU-34	13	61	OGU-19	1
17	OGU-76	12	62	OGU-24	1
18	OGU-28	11	63	OGU-35	1
19	OGU-36	10	64	OGU-51	1
20	OGU-50	10	65	OGU-54	1
21	OGU-62	10	66	OGU-65	1
22	OGU-33	9	67	OGU-66	1
23	OGU-14	8	68	OGU-73	1
24	OGU-41	8	69	OGU-74	1
25	OGU-69	8	70	OGU-83	1
26	OGU-11	7	71	OGU-84	1
27	OGU-23	7	72	OGU-88	1
28	OGU-38	7	73	OGU-2	0
29	OGU-67	7	74	OGU-3	0
30	OGU-75	7	75	OGU-26	0
31	OGU-82	7	76	OGU-43	0
32	OGU-15	6	77	OGU-48	0
33	OGU-40	6	78	OGU-55	0
34	OGU-60	6	79	OGU-57	0
35	OGU-61	6	80	OGU-70	0
36	OGU-63	6	81	OGU-71	0
37	OGU-9	5	82	OGU-72	0
38	OGU-20	5	83	OGU-77	0
39	OGU-25	5	84	OGU-78	0
40	OGU-27	5	85	OGU-79	0
41	OGU-32	5	86	OGU-85	0
42	OGU-45	5	87	OGU-86	0
43	OGU-46	5	88	OGU-87	0
44	OGU-80	5	89	OGU-89	0
45	OGU-12	4			

flowering plants (Magnoliophyta), all endemic to the Floristic Province of the Tehuacán-Cuicatlán Valley (FPTCV; Figure 1) and recorded inside the TCBR (Méndez-Larios *et al.*, 2004).

The reserve was divided in 89 Operative Geographic Units (OGUs) with dimensions of 5×5' latitude and longitude (Figure 1). For each OGU, the number of endemic species of the FPTCV within the reserve was determined. Only 53 OGUs were evaluated because 36 of the 89 lacked information or had just one species recorded (Table I). Using the 53 OGUs and the 174 species, a data matrix was constructed, codifying the presence of a species in a specific OGU with "1" and its absence with "0" (Appendix). To define the cladogram's root, an additional OGU containing zeros for all taxa was added. Data were analyzed with Nona (Goloboff, 1997), implemented in WinClada (Nixon, 2002), using the heuristic search option. Per random calculation sequence, 1000 repetitions were calculated, applying branch swapping. Based on the most parsimonious trees, a strict consensus tree was obtained, and its consistency index (CI) and retention index (RI) were calculated.

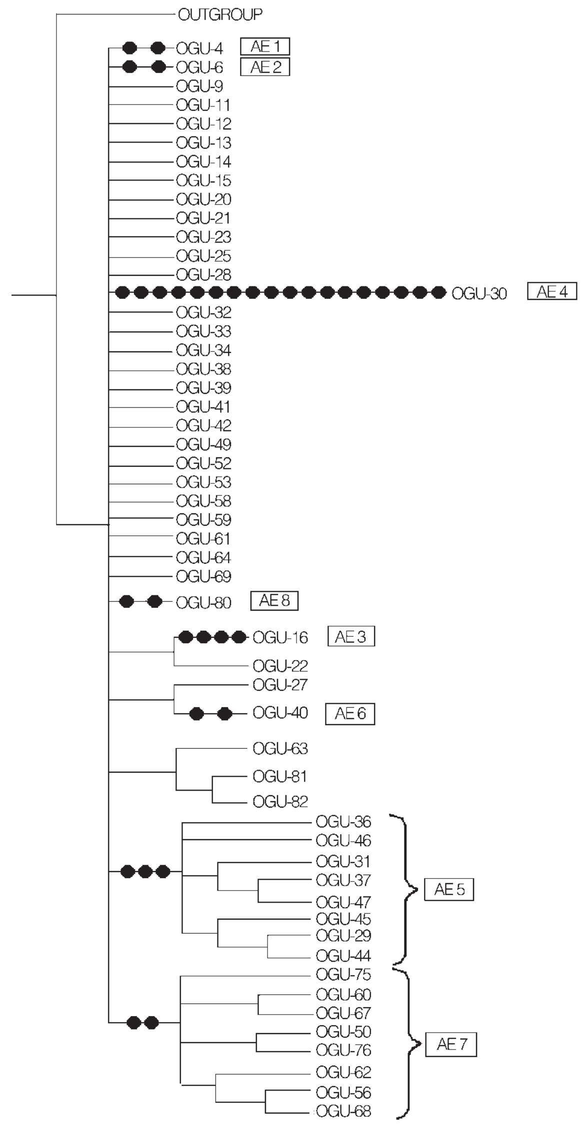

Figure 2. Strict consensus area-cladogram, illustrating the eight areas of endemism (AE) identified in the analysis. Black dots indicate the number of taxa sustaining each clade (see taxa in Table II).

Results

The analysis resulted in 5810 equally parsimonious cladograms, with 403 steps, CI of 0.42 and RI of 0.35. Based on these cladograms, the strict consensus cladogram was 450 steps long, with CI of 0.38 and a RI of 0.21 (Figure 2). Two main areas of endemism may be defined, each consisting of eight OGUs. The first area of endemism includes OGUs 29, 31, 36, 37, 44, 45, 46 and 47, and is supported by three species: *Matelea inconspicua* (Brandegee) Woodson, *Salvia umbraticola* Epling, and *Yucca mixtecana* García-Mend. (black dots in Figure 2). The second area of endemism includes OGUs 50, 56, 60, 62, 67, 68, 75 and 76, and is supported by two species: *Bidens brandegeei* Sherff and *Senna andrieuxii* (Benth.) Irwin & Barneby (black dots in Figure 2). Figure 2 also shows that, in addition to the former clades representing the two areas of endemism, six OGUs not related with any other one also contain two or more endemic species: OGUs 4, 6, 16, 30, 40 and 80. These isolated OGUs are considered important because within their areas (~81km^2) grow irreplaceable species with limited distributions. For example, OGU 30 has 18 species with distributions restricted only to it, whereas OGU 16 has four such species, and OGUs 4, 6, 40 and 80 each have two species.

Considering the former six OGUs as independent endemism areas, 22 of the 53 analyzed OGUs (41.5%) of the TCBR would constitute eight areas of endemism (AE). They

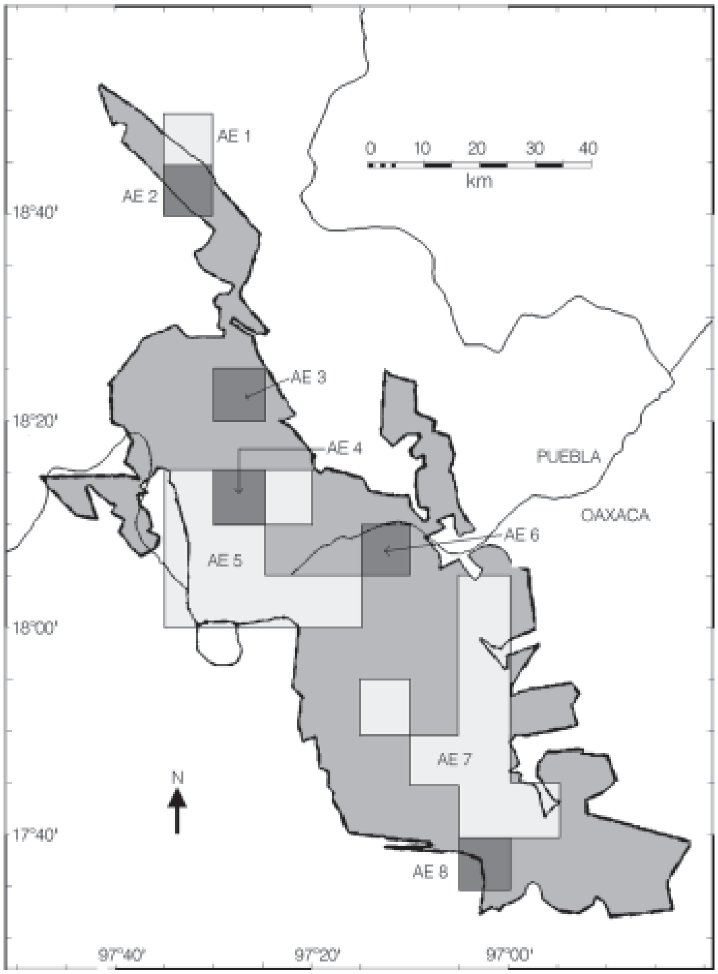

Figure 3. Geographic location of the eight areas of endemism (AE) identified by PAE in the Tehuacán-Cuicatlán Biosphere Reserve.

TABLE II
SPECIES THAT SUPPORT EACH OF THE EIGHT AREAS OF ENDEMISM IN THE TEHUACÁN-CUICATLÁN BIOSPHERE RESERVE*

Area of endemism	Species
AE 1 (4)	*Coreopsis oaxacensis* B.L. Turner *Viguiera purpusii* Brandegee
AE 2 (6)	*Mammillaria viperina* J.A. Purpus *Salvia pannosa* Fernald
AE 3 (16)	*Acourtia lobulata* (Bacig.) Reveal & R.M. King *Bursera arida* (Rose) Standl. *Neobuxbaumia macrocephala* (F.A.C. Weber) E.Y. Dawson *Polygala cuspidulata* S.F. Blake
AE 4 (30)	*Astragalus pueblae* M.E. Jones *Bakeridesia subcordata* (Hochr.) Bates *Beaucarnea gracilis* Lem. *Beaucarnea purpusii* Rose *Caesalpinia melanadenia* (Rose) Standl. *Cnidoscolus tehuacanensis* Breckon *Deutzia occidentalis* Standl. *Euphorbia tricolor* Greenm. *Florestina simplicifolia* B.L. Turner *Fouquieria purpusii* Brandegee *Hesperothamnus grandis* Standl. *Lonchocarpus oaxacensis* Pittier *Nama spathulata* Brandegee *Psacalium calvum* (Brandegee) Pippen *Salvia aspera* M. Martens & Galeotti *Salvia ramosa* Brandegee *Salvia tenoriana* Ramamoorthy *Zapoteca formosa* (Kunth) H.M.Hern. subsp. *mollicula* (M. Martens & Galeotti) H.M. Hern.
AE 5 (29, 31, 36, 37, 44, 45, 46, 47)	*Matelea inconspicua* (Brandegee) Woodson *Salvia umbraticola* Epling *Yucca mixtecana* García-Mend.
AE 6 (40)	*Mammillaria dixanthocentron* Backeb. subsp. *dixanthocentron* *Echeveria purpusorum* Berger
AE 7 (50, 56, 60, 62, 67, 68, 75, 76)	*Bidens brandegeei* Sherff *Senna andrieuxii* (Benth.) Irwin & Barneby
AE 8 (80)	*Anthurium nelsonii* Croat *Asclepias conzattii* Woodson

The eight areas are indicated AE 1 to 8 in Figure 2. The number of OGUs are indicated in brackets and correspond to those in Figure 1.

are indicated in Figure 2 as AE1 to AE8, and the species that characterize each of them are listed in Table II.

The families Asteraceae, Cactaceae, Lamiaceae, Euphorbiaceae and Fabaceae record the largest number of endemic species in the Reserve (Table III). The eight areas of endemism identified in this study, in addition to endemic species that characterize them (Table II), also include a large percentage of endemic taxa of these families. OGU 75 is outstanding because it has the only known populations of *Microdactylon cordatum* Brandegee, a monotypic genus endemic to the floristic province. Out of 20 OGUs that record ten or more endemic species (Table IV), 12 are included in the areas of endemism (Table II).

Discussion

Several authors agree that biogeographic areas should be defined in terms of endemic taxa. For example, based on endemic floristic components, Takhtajan (1986) and Rzedowski (1978) defined regions and floristic provinces in the world and in Mexico, respectively. It has been suggested that an endemism zone should be a region comprising the congruent distribution of two or more monophyletic taxa (Humphries and Parenti, 1986; Harold and Mooi, 1994). Based on this idea, the area of endemism is the result of a historical process, not an ecological one; however, Morrone and Crisci (1995) claim that the origin of any biogeographic pattern is never exclusively historical or ecological, but rather a combination of both. The PAE analysis is not able to reconstruct the history of the studied areas or to recognize their ecological associations, but it is a useful tool to detect congruent distribution patterns of the studied taxa and to mark the boundaries of the endemism areas.

Areas of endemism represent important sites for conservation where the presence of species with restricted distribution makes them unique and therefore irreplaceable, an important criterion in the definition of priority zones for conservation. The obtained PAE results for the TCBR indicate at least eight areas of endemism, supported by the congruent distribution of two or more taxa (black dots in Figure 2; Table II). Their irreplaceability calls for their protection. In a Biosphere Reserve like Tehuacán-Cuicatlán, the best way to obtain strictly protected zones is the declaration of core zones.

Moreover, areas of endemism represent variations of abiotic factors. For example, the reserve's dominant climate is arid (B) which is found in the areas of endemism 3, 4, 5, 6 and 7. However, in the areas 1, 2 and 8 the climate is moist subtropical (C). Variations in annual precipitation are found as well. The areas of endemism 7 and 6 present an annual precipitation of 300-500mm, the areas 5 and 4 between 400 and 600mm, area 3 between 600 and 800mm, and areas 1, 2 and 8 from 600 up to 1000mm. Another important abiotic factor varying between areas of endemism is topography. Areas 7 and 6 are found mainly on altitudes between 600 and 800m, areas 8 and 3 between 800 and 1200m, areas 5 and 4 between 1600 and 2000m and, finally, the areas 1 and 2 are situated at heights over 2600m. These observations confirm the importance of the areas of endemism as they represent the reserves' endemic species richness as well as most of the variations of the abiotic factors.

In the TCBR, still no core zone has been defined and its implementation would secure the survival of endemic species, endangered by possible negative impacts caused by human activities (IUCN, 1987). The eight areas of endemism identified can be joined to form three main zones that could act as core zones in the Reserve (Figures 3 and 4). Core zone I would be formed by the inclusion of AE 1 and AE 2. Core zone II would include AE 3, AE 4, AE 5 and AE 6; although AE 3 is separated from the other areas, it may be joined to the others by including OGU 22 which, in addition to constitute a corridor, is the third top OGU by the number of endemic species scored in its territory (Table IV). Finally, joining AE 7 and AE 8 would constitute core zone III. In total, these three core zones represent 25.8% of the Reserve, and would be able to protect 148 endemic species (85.0% of the total). In addition, they would include 1300 species, which represents about 68.0% of the total floristic richness of the TCBR.

It is important to note that these results depend on the amount of collection and registration of herbarium specimens. Even though the reserves' surface area of approximately 5000ha has been studied floristically for more than 100 years and presently counts with a data base of more than 18000 registers, there are still certain regions which have not been explored into such detail.

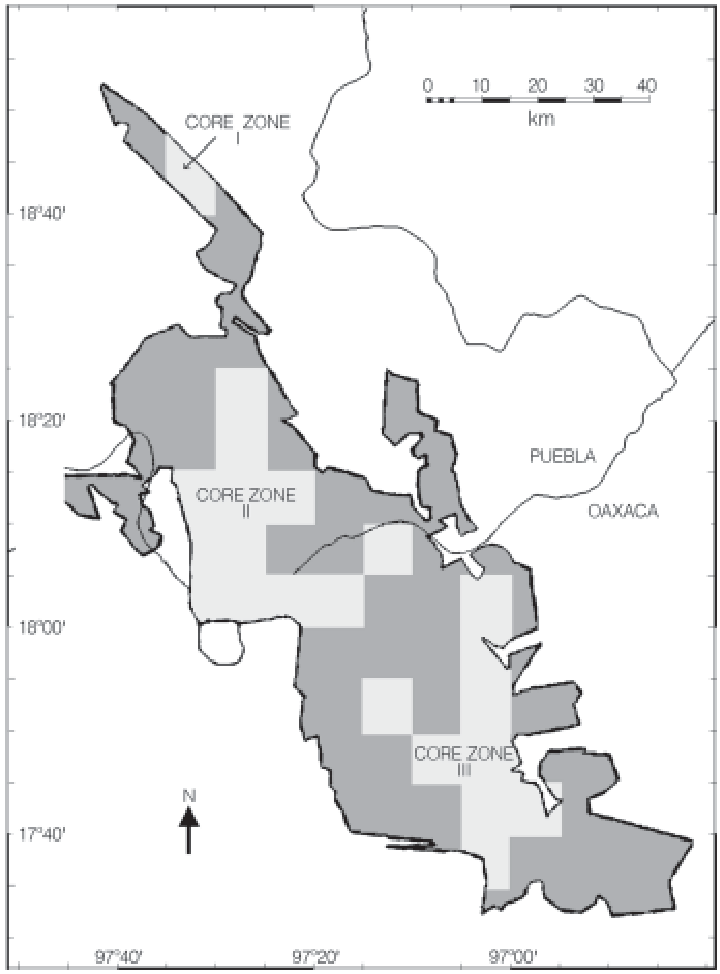

Figure 4. Geographic location of the three core zones proposed for the Tehuacán-Cuicatlán Biosphere Reserve.

TABLE III
THE FIVE FAMILIES WITH HIGHER NUMBER OF ENDEMIC SPECIES IN THE TEHUACÁN-CUICATLÁN BIOSPHERE RESERVE AND NUMBER OF SPECIES RECORDED IN THE AREAS OF ENDEMISM IDENTIFIED IN THIS STUDY

Family	Species in the Reserve	Species in the areas of endemism
Asteraceae	28	27 (96.4%)
Cactaceae	18	16 (88.8%)
Lamiaceae	14	14 (100%)
Euphorbiaceae	14	11 (78.6%)
Fabaceae	12	9 (75.0%)

TABLE IV
GRID SQUARES (OGUs) WITH THE LARGEST NUMBER OF ENDEMIC SPECIES IN THE TEHUACÁN-CUICATLÁN BIOSPHERE RESERVE*

	OGU	Species
1	**OGU 30**	**46**
2	**OGU 16**	**33**
3	OGU 22	29
4	**OGU 68**	**20**
5	**OGU 44**	**19**
6	OGU 39	18
7	**OGU 37**	**17**
8	OGU 13	16
9	OGU 21	16
10	**OGU 29**	**15**
11	OGU 42	15
12	**OGU 56**	**15**
13	OGU 81	14
14	**OGU 31**	**13**
15	**OGU 47**	**13**
16	OGU 34	12
17	**OGU 76**	**12**
18	OGU 28	11
19	**OGU 36**	**10**
20	**OGU 62**	**10**

OGUs in black are those included in the identified areas of endemism.

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Appendix. Data matrix used in the PAE analysis to identify the areas of endemism in the Tehuacán-Cuicatlán Biosphere Reserve. Columns: OGUs, rows: taxa. List of taxa at the bottom; numbers of OGUs correspond with those in Figure 1.

	00011111122222222333333333444444445555556666666677888
	46912345601235789012346789012456790236890123478956012
1	00000000100000000000000000000000000000000111000010
2	00000000101000000010000010000000000000000000000000
3	00000000000000000001000001000000000001000110001000000
4	00000000000100000100000000000000000000000000000000
5	00000000000100000000010001001000000100000000000001000000
6	00000100110000000010000000000000000000000000000000
7	00000000000000000010000000100000000000000000010000000000
8	00000000100000001000000000000000000000000000000000
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173	00000011100000001111000010000000010010000000000000000000
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Taxa:

Acanthaceae: 1.*Dyschoriste purpusii* Kobuski, 2. *Holographis pueblensis* T.F. Daniel, 3. *H. velutifolia* (House) T.F. Daniel, 4. *Justicia paucifolia* T.F. Daniel
Agavaceae: 5. *Agave macroacantha* Zucc., 6. *A. stricta* Salm-Dyck, 7. *A. titanota* Gentry, 8. *A. triangularis* Jacobi, 9. *Yucca mixtecana* García-Mend.
Amaranthaceae: 10. *Iresine discolor* Greenm., 11. *I. nitens* Standl.
Anthericaceae: 12. *Echeandia platyphylla* (Greenm.) Cruden
Araceae: 13. *Anthurium nelsonii* Croat
Asclepiadaceae: 14. *Asclepias conzattii* Woodson, 15. *Marsdenia parvifolia* Brandegee, 16. *Matelea atrocoronata* (Brandegee) Woodson, 17. *M. inconspicua* (Brandegee) Woodson, 18. *M. pueblensis* (Brandegee) Woodson, 19. *Microdactylon cordatum* Brandegee, 20. *Pherotrichis mixtecana* Brandegee
Asteraceae: 21. *Acourtia caltepecana* B.L. Turner, 22. *A. fragrans* Rzed., 23. *A. lobulata* (B *Acta Bot. Mex. 15*acig.) Reveal & R.M. King, 24. *A. umbratilis* (B.L. Rob. & Greenm.) B.L. Turner, 25. *Bidens brandegeei* Sherff, 26. *Brickellia problematica* B.L. Turner, 27. *Coreopsis davilae* Panero & Villaseñor, 28. *C. oaxacensis* B.L. Turner, 29. *Dahlia apiculata* (Sherff) Sorensen, 30. *Flaveria cronquistii* A.M. Powell, 31. *F. ramosissima* Klatt, 32. *Florestina purpurea* (Brandegee) Rydb., 33. *F. simplicifolia* B.L. Turner, 34. *Gochnatia purpusii* Brandegee, 35. *Hofmeisteria malvifolia* (B.L. Rob. & Greenm.) B.L. Turner, 36. *Melampodium pringlei* B.L. Rob., 37. *Perymenium glandulosum* Brandegee, 38. *P. ovatum* Brandegee, 39. *Psacalium calvum* (Brandegee) Pippen, 40. *P. purpusii* (Greenm.) H. Rob. & Brettell, 41. *Sanvitalia fruticosa* Hemsl., 42. *Stevia revoluta* B.L. Rob., 43. *Tetrachyron brandegei* (Greenm.) Wussow & Urbatsch, 44. *Tridax luisana* Brandegee, 45. *Verbesina mixtecana* Brandegee, 46. *V. petrophila* Brandegee, 47. *Viguiera davilae* Panero & Villaseñor, 48. *V. purpusii* Brandegee
Boraginaceae: 49. *Antiphytum paniculatum* (Brand) I.M. Johnst.
Bromeliaceae: 50. *Hechtia conzattiana* L.B. Sm., 51. *H. fragilis* K.B. Utley & J.F. Utley, 52. *H. galeottii* Mez, 53. *H. lyman-smithii* K.B. Utley & J.F. Utley, 54. *Tillandsia califanii* Rauh
Burseraceae: 55. *Bursera arida* (Rose) Standl.
Buxaceae: 56. *Buxus mexicana* Brandegee
Cactaceae: 57. *Cephalocereus columna-trajani* (Karw.) K. Schum., 58. *Ferocactus flavovirens* (Scheidw.) Britton & Rose, 59. *F. latispinus* (Haw.) Britton & Rose var. *spiralis* (Karw. ex Pfeiff.) N.P. Taylor, 60. *F. robustus* (Pfeiff.) Britton & Rose, 61. *Mammillaria crucigera* Mart. subsp. c*rucigera*, 62. *M. dixanthocentron* Backeb. subsp. *dixanthocentron*, 63. *M. huitzilopochtli* D.R. Hunt, 64. *M. pectinifera* (Stein) F.A.C. Weber, 65. *M. sphacelata* Mart., 66. M. *supertexta* C. Mart. ex Pfeiff., 67. *M. tepexicensis* J. Meyrán, 68. *M. viperina* J.A. Purpus, 69. *Neobuxbaumia macrocephala* (F.A.C. Weber) E.Y. Dawson, 70. *Opuntia parviclada* S. Arias & S. Gama, 71. *O. tehuacana* S. Arias & L.U. Guzmán, 72. *Pachycereus hollianus* (F.A.C. Weber) Buxb., 73. *Peniocereus viperinus* (F.A.C. Weber) Buxb., 74. *Polaskia chende* (Rol.-Goss.) A.C. Gibson & K.E. Horak
Caesalpiniaceae: 75. *Caesalpinia melanadenia* (Rose) Standl., 76. *Senna andrieuxii* (Benth.) Irwin & Barneby, 77. *S. apiculata* (M. Martens & Galeotti) Irwin & Barneby var. *apiculata*, 78. *S. galeottiana* (Martens) Irwin & Barneby
Caprifoliaceae: 79. *Viburnum macdougallii* Matuda
Commelinaceae: 80. *Tradescantia monosperma* Brandegee, 81. *T. parvula* Brandegee
Convolvulaceae: 82. *Ipomoea nana* Collete & Hemsl., 83. *I. teotitlanica* McPherson, 84. *Jacquemontia smithii* B.L. Rob. & Greenm.
Crassulaceae: 85. *Echeveria derenbergii* J.A. Purpus, 86. *E. laui* Moran & J. Meyrán, 87. *E. leucotricha* J.A. Purpus, 88. *E. longissima* E. Walther var. *aztatlensis* J. Meyrán, 89. *E. pilosa* J.A. Purpus, 90. *E. pulvinata* Rose, 91. *E. purpusorum* Berger, 92. *Thompsonella spathulata* Kimnach
Euphorbiaceae: 93. *Adelia rotundifolia* Brandegee, 94. *Cnidoscolus egregius* Breckon, 95. *C. tehuacanensis* Breckon, 96. *Croton pulcher* Müll. Arg., 97. *Euphorbia gradyi* V.W. Steimm. & Ramírez-Roa, 98, *E ixtlana* M.J. Huft,, 99.*E. pueblensis* Brandegee, 100. *E. tricolor* Greenm., 101. *Jatropha neopauciflora* Pax, 102. *J. rufescens* Brandegee, 103. *J. rzedowskii* Jiménez-Ramírez, 104. *Manihotoides pauciflora* (Brandegee) Rogers & Appan, 105. *Pedilanthus olsson-sefferi* Millsp., 106. *P. tehuacanus* Brandegee
Fabaceae: 107. *Astragalus pueblae* M.E. Jones, 108. *Ateleia macvaughii* Rudd, 109. *Brongniartia luisana* Brandegee, 110. *B. mollicula* Brandegee, 111. *B. vicioides* M. Martens & Galeotti, 112. *Dalea botterii* (Rydb.) Barneby var. *atrocyanea* (Rydb.) Barneby, 113. *D. rubrolutea* Barneby, 114. *D. tuberculina* (Rydb.) F.J. Herm., 115. *Hesperothamnus grandis* Standl., 116. *Indigofera conzattii* Rose, 117. *Lonchocarpus oaxacensis* Pittier, 118. *Trifolium nelsonii* House
Fouquieriaceae: 119. *Fouquieria purpusii* Brandegee
Hydrangeaceae: 120. *Deutzia occidentalis* Standl.
Hydrophyllaceae: 121 *Nama spathulata* Brandegee
Lamiaceae: 122. *Salvia aspera* M. Martens & Galeotti, 123. *S. boegei* Ramamoorthy, 124. *S. divinorum* Epling & Jativa, 125. *S. incana* M. Martens & Galeotti, 126. *S. inornata* Epling, 127, *S. pannosa* Fernald, 128. *S. ramosa* Brandegee, 129. *S. sousae* Ramamoorthy, 130. *S. tenoriana* Ramamoorthy, 131. *S. umbraticola* Epling, 132. *S. variana* Epling, 133. *Scutellaria saxicola* Brandegee, 134. *Stachys collina* Brandeege, 135. *Stachys inclusa* Epling
Lentibulariaceae: 136. *Pinguicula mirandae* Zamudio & A. Salinas
Loranthaceae: 137. *Struthanthus inornus* Standl.
Lythraceae: 138. *Nesaea pringlei* Rose
Malvaceae: 139. *Abutilon straminicarpum* Fryxell, 140. *Bakeridesia subcordata* (Hochr.) Bates, 141. *Hibiscus longifilus* Fryxell, 142. *Phymosia crenulata* (Brandegee) Fryxell, 143. *Robinsonella chiangii* Fryxell, 144. *Sida pueblensis* Fryxell, 145. *Sidastrum tehuacanum* (Brandegee) Fryxell
Mimosaceae: 146. *Acacia angustissima* (Mill.) Kuntze var. *oaxacana* B.L. Turner, 147. *A. purpusii* Brandegee, 148. *Leucaena confertiflora* Zárate var. *confertiflora*, 149. *Mimosa brevispicata* Britton, 150. *M. hystricosa* Brandegee, 151. *M. luisana* Brandegee, 152. *M. mixtecana* Brandegee, 153. *M. pueblensis* R. Grether, 154. *Zapoteca formosa* (Kunth) H.M.Hern. subsp. *mollicula* (M. Martens & Galeotti) H.M. Hern.
Nolinaceae: 155. *Beaucarnea gracilis* Lem., 156. *B. purpusii* Rose
Orchidaceae: 157. *Schiedeella diaphana* (Lindl.) Burns-Balogh & Greenwood
Passifloraceae: 158. *Passiflora liebmannii* Mart.
Piperaceae: 159. *Peperomia amatlensis* DC.
Poaceae: 160. *Bouteloua distans* Swallen, 161. *Festuca callosa* (Piper) St. Yves
Polygalaceae: 162. *Polygala annectans* S.F. Blake, 163. *P. cuspidulata* S.F. Blake
Rutaceae: 164. *Casimiroa calderoniae* F. Chiang & Medrano, 165. *Helietta lucida* Brandegee, 166. *Megastigma galeottii* Baill.
Sapindaceae: 167. *Thouinidium insigne* (Brandegee) Radlk.
Scrophulariaceae: 168. *Lamourouxia smithii* B.L. Rob. & Greenm., 169. *Leucophyllum pringlei* (Greenm.) Standl.
Theaceae: 170. *Ternstroemia hemsleyi* Hochr.
Thymelaeaceae: 171. *Daphnopsis purpusii* Brandegee
Urticaceae: 172. *Pouzolzia pringlei* Greenm.
Verbenaceae: 173. *Stachytarpheta luisana* Standl., 174. *Stachytarpheta nelsonii* B.L. Rob. & Greenm.

REFERENCES

Akeroyd J, Synge H (1992) Higher plant diversity. In Groombridge B (Ed.) *Global Biodiversity. Status of the Earth's living resources*. Chapman Hall. London, UK. pp. 64-87.

Bisconti M, Landini W, Bianucci G, Cantalamessa G, Carnevale G, Regaini L, Valleri G (2001) Biogeographic relationships of the Galapagos terrestrial biota: parsimony analyses of endemicity based on reptiles, land birds and *Scalesia* land plants. *J. Biogeogr. 28*: 495-510.

Cardoso JM, Oren DC (1996) Application of parsimony analysis of endemicity in Amazonian biogeography. An example with primates. *Biol. J. Linn. Soc. 59*: 427-437.

Catalán F (2001) *Distribución espacio-temporal de la sequía en el Valle de Tehuacán-Cuicatlán, Pue.-Oax., México*. Tesis. Universidad Nacional Autónoma de México. 63 pp.

Cavieres LA, Arroyo MTK, Posadas P, Marticorena C, Matthei O, Rodríguez R, Squeo FA, Arancio G (2002) Identification of priority areas for conservation in an arid zone: application of parsimony analysis of endemicity in the vascular flora of the Antofagasta region, northern Chile. *Biodiv. Conserv. 11*: 1301-1311.

Dávila AP, Medina LR, Ramírez RA, Salinas TA, Tenorio P (1995) Análisis de la flora del Valle de Tehuacán-Cuicatlán: endemismo y diversidad. In Linares E, Dávila AP, Chiang F, Bye R, Elias T (Eds.) *Conservación de plantas en peligro de extinción: diferentes enfoques*. Instituto de Biología. Universidad Nacional Autónoma de México. pp. 33-41.

Dávila AP, Arizmendi MC, Valiente-Banuet A, Villaseñor JL, Casas A, Lira R (2002a) Biological diversity in the Tehuacán-Cuicatlán Valley, Mexico. *Biodiv. Conserv 11*: 421-442.

Dávila AP, Arias S, Lira R, Villaseñor JL, Valiente-Banuet A (2002b) Phytogeography of the columnar cacti (tribe Pachycereeae) in México: A cladistic approach. In Fleming TH, Valiente-Banuet A (Eds) *Columnar cacti and their mutualists: Evolution, and Conservation*. The University of Arizona Press. Tucson, AZ, USA. pp. 25-41.

Diario Oficial (1998) *Decreto por el que se declara área natural protegida con el carácter de reserva de la biosfera, la región denominada Tehuacán-Cuicatlán, ubicada en los estados de Oaxaca y Puebla*. Diario Oficial de la Federación, 18/09/1998. Presidencia de la República. México. pp. 8-20.

Espejo SA, López-Ferrari FAR (1998) Current floristic and phytogeographic knowledge of Mexican Bromeliaceae. *Rev. Biol. Trop. 46*: 493-513.

Fernandes MFB, Cardoso JM, Silva JS (1995) The monkeys of the islands of the Amazon estuary, Brasil: a biogeographic analysis. *Mammalia 59*: 213-221.

García E (1988) *Modificaciones al sistema de clasificación climática de Kóppen (para adaptarlo a las condiciones de la República Mexicana)*. Larios. México, DF. 218 pp.

Gentry AH (1986) Endemism in tropical versus temperate plant communities. In Soulé ME (Ed.). *Conservation biology. The science of scarcity and diversity*. Sinauer. Sunderland, MA, USA. pp. 153-181.

Glasby CJ, Alvarez B (1999) Distribution patterns and biogeographic analysis of Austral Polychaeta (Annelida). *J. Biogeogr. 26*: 507-533.

Goloboff P (1997) *Nona* (Parsiminy program for Windows 95/Windows NT). Published by the author. Tucumán, Argentina. www.cladistics.com/aboutNona.htm

Guzmán U, Arias S, Dávila P (2003) *Catálogo de Cactáceas Mexicanas*. Universidad Nacional Autónoma de México y Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México. 315 pp.

Harold AS, Mooi RD (1994) Areas of endemism: definition and recognition criteria. *Systemat. Biol. 43*: 261-266.

Humphries C, Parenti L (1986) *Cladistic biogeography*. Clarendon. Oxford, UK. 98 pp.

INEGI (2000) *Estados Unidos Mexicanos. XII Censo General de Población y Vivienda 2000*. Instituto Nacional de Estadística Geografía e Informática. Aguscalientes, México. www.e-mexico.gob.mx/wb2/eMex

Ippi S, Flores VO (2001) Las tortugas neotropicales y sus áreas de endemismo. *Acta Zool. Mex. 84*: 49-63.

IUCN (1987) *The IUCN position statement on translocation of living organisms: introductions, reintroductions and restocking*. International Union for the Conservation of Nature. Gland, Switzerland. www.iucn.org/themes/ssc/pubs/policy/trance.htm

Luna I, Alcántara O, Espinosa D, Morrone JJ (1999) Historical relationships of the Mexican cloud forests: a preliminary vicariance model applying parsimony analysis of endemicity to vascular plant taxa. *J. Biogeogr. 26*: 1299-1305.

Méndez-Larios I, Villaseñor JL (2001) La familia Scrophulariaceae en México: diversidad y distribución. *Bol. Soc. Bot. Mex. 69*: 101-121.

Méndez-Larios I, Ortiz E, Villaseñor JL (2004) Las Magnoliophyta endémicas de la provincia florística del Valle de Tehuacán-Cuicatlán, México. *Anales Inst. Biol. Univ. Nac. Auton. Mex., Ser. Botánica. 75*: 1-22.

Morrone JJ (1994) On the identification of areas of endemism. *Systemat. Biol. 43*: 438-441.

Morrone JJ, Crisci JV (1995) Historical biogeography: introduction to methods. *Annu. Rev. Ecol. Systemat. 26*: 373-401.

Morrone JJ, Márquez J (2001) Halffter's Mexican transition zone, beetle generalized tracks, and geographical homology. *J. Biogeogr. 28*: 635-650.

Morrone JJ, Espinosa D, Aguilar C, Llorente J (1999) Preliminary classification of the Mexican biogeographic provinces: a parsimony analysis of endemicity based on plant, insect, and bird taxa. *Southwest. Naturalist 44*: 507-514.

Myers AA (1991) How did Hawaii accumulate its biota? A test from the Amphipoda. *Global Ecol. Biogeogr. Lett. 1*: 24-29.

Nixon KC (2002) *WinClada* ver. 1.00.08. Published by the author. Ithaca, New York, USA. www.cladistics.com/about_winc.htm

Platnick N (1991) On areas of endemism. *Aust. Systemat. Bot. 4*: Preface.

Posadas P (1996) Distributional patterns of vascular plants in Tierra del Fuego: a study applying parsimony analysis of endemicity (PAE). *Biogeographica 72*: 161-177.

Pressey RL, Johnson IR, Wilson PD (1994) Shades of irreplaceability: towards a measure of the contribution of sites to a reservation goal. *Biodiv. Conserv. 3*: 242-262.

Ramamoorthy TP, Elliott M (1993) Mexican Lamiaceae: diversity, distribution, endemism and evolution. In Ramamoorthy TP, Bye R, Lot A, Fa J (Eds.) *Biological Diversity of Mexico: origins and distribution*. Oxford University Press. New York, USA. pp. 513-539.

Ramamoorthy TP, Bye R, Lot A, Fa J (1993) *Biological diversity of Mexico: origins and distribution*. Oxford University Press. New York, USA. 812 pp.

Ron SR (2000) Biogeographic area relationships of lowland Neotropical rainforest based on raw distributions of vertebrate groups. *Biol. J. Linn. Soc. 71*: 379-402.

Rosen BR (1988) From fossils to earth history: applied historical biogeography. In Myers A, Giller P (Eds.) *Analytical biogeography: an integrated approach to the study of animal and plant distributions*. Chapman Hall. London, UK. pp. 437-481.

Rzedowski J (1978) *Vegetación de México*. Limusa. México. 432 pp.

Rzedowski J (1991) El endemismo en la flora fanerogámica mexicana: Una apreciación analítica preliminar. *Acta Bot. Mex. 15*: 47-64.

Sfenthourakis S, Giokas S (1998) A biogeographical analysis of greek Oniscidean endemism. *Isr. J. Zool. 44*: 273-282.

Sousa M, Delgado A (1993) Mexican Leguminosae: phytogeography, endemism, and origins. In Ramamoorthy TP, Bye R, Lot A, Fa J (Eds.) *Biological Diversity of Mexico: origins and distribution*. Oxford University Press. New York, USA. pp. 459-511.

Steinmann VW (2002) Diversidad y endemismo de la familia Euphorbiaceae en México. *Acta Bot. Mex. 61*: 61-93.

Takhtajan A (1986) *Floristic regions of the world*. University of California Press. Berkeley, CA, USA. 522 pp.

Turner BL, Nesom GL (1993) Biogeography, diversity, and endangered or threatened status of Mexican Asteraceae. In Ramamoorthy TP, Bye R, Lot A, Fa J (Eds.) *Biological Diversity of Mexico: origins and distribution*. Oxford University Press. New York, USA. pp. 559-575.

UNESCO (1996) *Reservas de la Biosfera: La Estrategia de Sevilla y el Marco Estatutario de la Red Mundia*l. UNESCO. Paris, France. 20 pp.

Vane-Wright RI (1996) Identifying priorities for the conservation of biodiversity: systematic biological criteria within a socio-political framework. In Gaston KJ (Ed.) *Biodiversity: A biology of numbers and difference*. Blackwell. Oxford, UK. pp. 309-344.

Villaseñor JL (1992) Los parques nacionales y otras áreas protegidas y su papel en la conservación de la riqueza florística. *Bol. Inst. Bot. Univ. Guadalajara 1*: 119-130.

Villaseñor JL (1993) La familia Asteraceae en México. *Rev. Soc. Mex. Hist. Nat., Vol. Esp. 44*: 117-124.

Villaseñor JL (2003) Diversidad y distribución de las Magnoliophyta de México. *Interciencia 28*: 160-167.

Villaseñor JL, Dávila P, Chiang F (1990) Fitogeografía del Valle de Tehuacán Cuicatlán. *Bol. Soc. Bot. Mex. 50*: 135-149.

Watanabe K (1998) Parsimony analysis of the distribution pattern of Japanese primary freshwater fishes, and its application to the distribution of the bagrid catfishes. *Ichthyol. Res. 45*: 259-270.