

Flora of the Woodlands of the Sierra de La Laguna, Baja California Sur, México

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Abstract.—The Sierra de la Laguna is the main high mountain range in the arid state of Baja California Sur, Mexico. It is high and narrow, rising boldly from coastal lowlands, with many precipitous and rocky slopes. Its peaks reach up to 2200 m. Above 1500 m this mountains are occupied by the only woodland community in hundreds of kilometers away, and it is believed to have been one island in the geologic past, and in fact now it is in environmental sense. Because the receptive high altitude of the range, plant communities on the tops has been historically less arids than those on the lowlands, such environment has permitted the establishment of woodlands as today.

Origins of the current vegetation seems to amount to middle tertiary period, when some types of montane woodlands in SW United States and NW Mexico were developed under xeric conditions.

The flora of this community is part of a project leading to establishment of an ecological reserve on such area, because the importance as wild recreative area, which was finally decreed in 1993. Number of species of the vascular flora is 272, most of the species (65%) are herbs, both annual and perennial; 43 species are considered endemics (15.8%), including two monospecific genera. This work describes the flora arranged in two communities: the oak-pine and the oak woodland, the first one comprises four plant associations and the later two.

A phytogeographical analysis of this flora shows that the community has high levels of affinity with the tropical element, at both family and genus level (40% and 59% respectively), followed by the cosmopolitan (39% and 20% respectively), this last levels of affinity could suggest a relative recent conformation of the flora.

INTRODUCTION

The woodlands of the Sierra de la Laguna mountains were referred by Axelrod (1950, 1958) in his classification of the Madro-Tertiary Flora as part of the Sierra Madrean Woodland Element, specifically as the Sierra Laguna Component. Table 1 shows the original classification of such Element.

The woodlands of the Cape Region, or Sierra Laguna oak and oak-pine woodlands, differs as much from those of southern California and Arizona, such differences are interpreted as a

reflection of the dry climate prevailing along the Baja California peninsula. These woodlands represent one of the southern limits of the Madrean Element.

The Sierra Madrean Woodland Element find their nearest modern representatives in the woodlands of summer-wet and relatively winter-mild climate, regions now located at the southern mountains in California and Arizona in United States, and mountains of medium altitude in the Mexican states of Baja California Sur, Sinaloa, Durango, and Coahuila (see Table 1).

The Sierra Laguna Component was conceptualized by Axelrod (1950) by the fossil analysis of plants of the Miocene of California, and Pliocene of California and Nevada. Fossils and living representatives are shown in Table 2.

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According with his hypothesis, Axelrod states that the associated species during those epochs included plants whose descendants are now found in the woodland associations elsewhere in southwestern United States and northern Mexico.

The Cape Component, see Table 3, a member of the North Mexican Element, a complex which comprises the arid subtropical scrub, currently occurs immediately below the woodlands of the Sierra de la Laguna, and another localities not well documented today. This same couple of communities are found in the Miocene and Pliocene fossil floras of southern California.

STUDY AREA

The mountains of the Cape Region extend in a south-north from 23° to 23°35'N Lat. It is crossed by the Tropic of Cancer. About 500 km² (200 mi²) of these mountains are estimated to be occur above 1000 m of elevation. The Sierra de La Laguna woodlands are located in the northern part of the Cape Region mountains, it harbors the highest peak at 2200 m. It is conformed by five major canyons (fig. 1); the oak woodland (1000 to 1500 m) has an estimated surface of about 350 km², meanwhile the oak-pine woodland (> 1500 m) around 150 km².

Table 1.—Original classification of Madro-tertiary Geoflora by Axelrod (1950) is based in the assumption of Complexes (biomes), Elements (present climax communities) and Components (fossil groups).

Madró Tertiary Geoflora:	
elements:	current climax communities woodland, chaparral, subtropical scrub, sage & desert.
component:	group of fossil plants, ancestors of the elements

Table 2.—The Sierra Laguna Component was conceptualized by Axelrod (1950) by the fossil analysis of plants of the Miocene of California, and Pliocene of California and Nevada.

Fossils from California	Living Representatives In Sierra de la Laguna Woodlands
<i>Arbutus tehachapiensis</i>	<i>A. peninsularis</i>
<i>Ilex sonomiensis</i>	<i>I. brandegeana</i>
<i>Populus mohavensis</i>	<i>P. brandegeana</i>
<i>Quercus mohavensis</i>	<i>Q. brandegeei</i> <i>Q. albocincta</i>
<i>Garrya</i>	<i>Garrya salicifolia</i>
<i>Rhus</i>	<i>Rhus laurina</i>

Table 3.—Floristic Units in the Madro-Tertiary Geoflora according Axelrod (1950).

WOODLAND COMPLEX
Elements (7):
1 California Woodland
2 Conifer Woodland
3 Sierra Madrean Woodland
Components
a) Arizona
b) Sierra Laguna
c) Edwards Plateau
d) Durango
e) Coahuila
CHAPARRAL COMPLEX
4 California Chaparral
SAGE COMPLEX
5 Coastal Sage
ARID SUBTROPICAL SCRUB COMPLEX
6 North Mexican
Components
a) Sinaloa
b) Cape
c) Tamaulipan
DESERT COMPLEX
7 North American Desert

Methods

Thirty eight visits has been made in all the four seasons to the area between 1984 to 1993. Almost 3000 of voucher specimens has been prepared and are housed at Centro de Investigaciones Biológicas del Noroeste Herbarium (HCIB). Most of the determinations has been checked by comparison with the correspondent stored at CAS and UC Herbariums. Some papers has been published, León de la Luz & Domínguez (1989), Breedlove & León de la Luz (1989) and León de la Luz & Coria (1993). An annotated catalog is provided in such papers. Nomenclature follows mainly that of Wiggins (1980).

The Cape Region, and in particular the montane areas, has an incomplete representation in Wiggins's Flora. About 25 % of the plants listed in our papers were omitted from such Flora, or in the same cases, reported to other areas of the Peninsula but not in the woodlands of the Sierra de la Laguna.

Geology and Soils

The Sierra de la Laguna is composed totally of massive intrusive rocks, granites the most part. It is an extension of a great batholith of upper

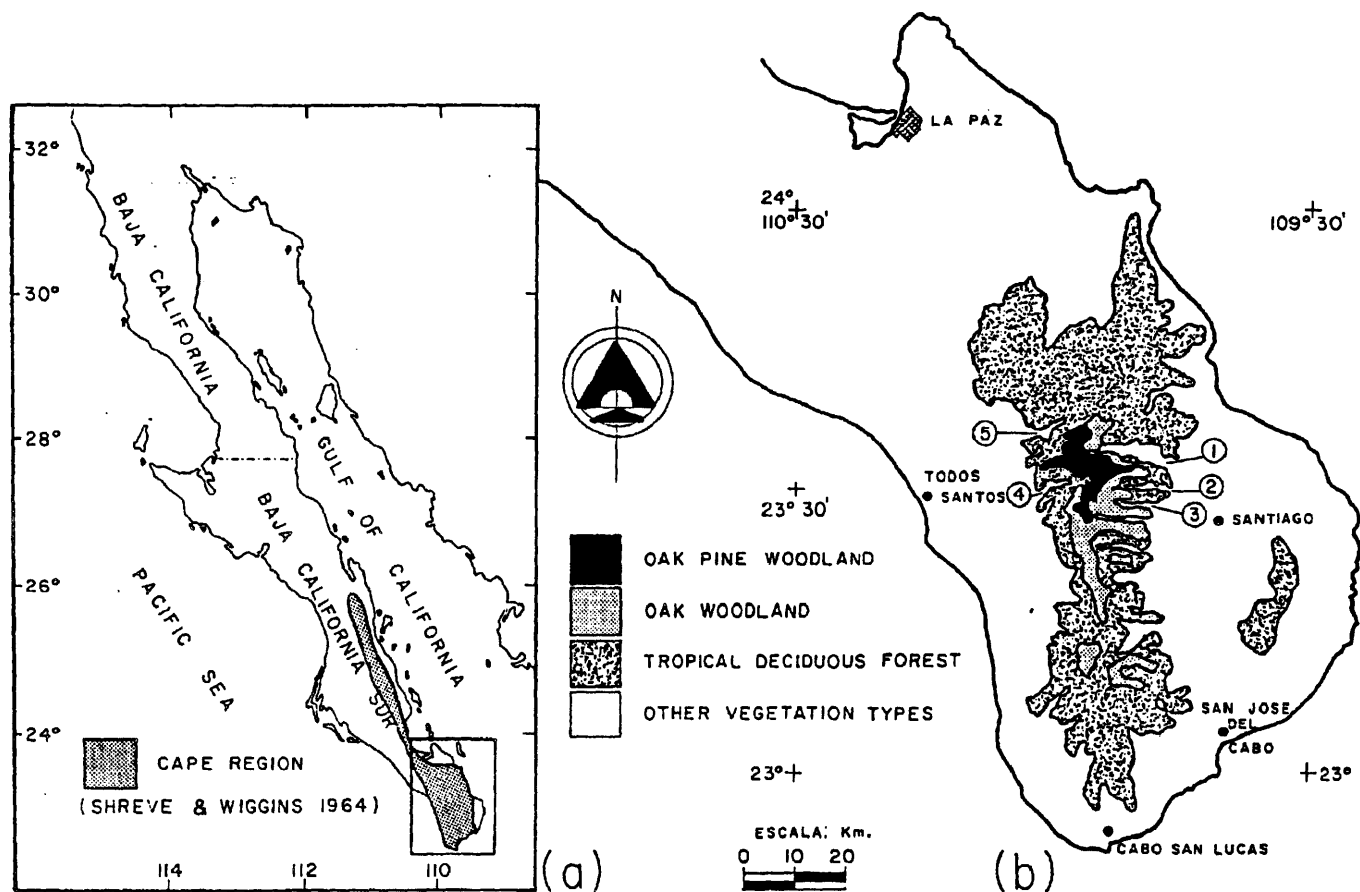


Figure 1.—The Sierra de La Laguna woodlands are located in the northern part of the Cape Region mountains, Baja California Sur, Mexico. It includes five major canyons, having an estimated surface of about 250 km², which approximately 100 correspond to the oak-pine and the rest to the oak forest.

jurassic or lower cretaceous age, which underlies most of the peninsula and presumably also parts of the Gulf of California (Beal 1948; Durham and Allison 1960). Most of these rocks are moderately coarse grained and subject to rapid disintegration. The derived soil is sandy, with a thin layer of litter; the content of loam and clay is relatively low. On slopes, foothills, and alluvial plains there are no differentiated soil layers. These are classified as Regosols (FAO-UNESCO system modified by Mexican government; SPP 1981a). At the bottom of brooks and canyons some permanent pools occur on the hard rock bed.

The courses of the canyons are a direct consequence of active erosion along their escarpments (López Ramos 1973; Hammond 1954). The eastern face of this sierra is more precipitous than the western slopes. Similar patterns are present also in the Sierra de la Giganta and other ranges much further kilometers

to the north, such as San Pedro Mártir, Juárez and several others in California, USA.

Climate

Foothills and adjacent low areas, where the arid subtropical scrub develops, have a warm and dry climate. But the climate of the woodland is relatively cool, and light frosts occur during winter nights. Figure 2 shows both yearly temperature and precipitation obtained from García (1973) at a location at 1620 m and three others at lower elevations (350-368m). Climate in the summits, C(w1), is temperate, subhumid, with main rains in summer, but some also occurring in winter. Precipitation is scarce in some years. At middle and low elevations occurs several BS and BW types respectively; the first one is semiarid climate, with rains mainly in the summer but

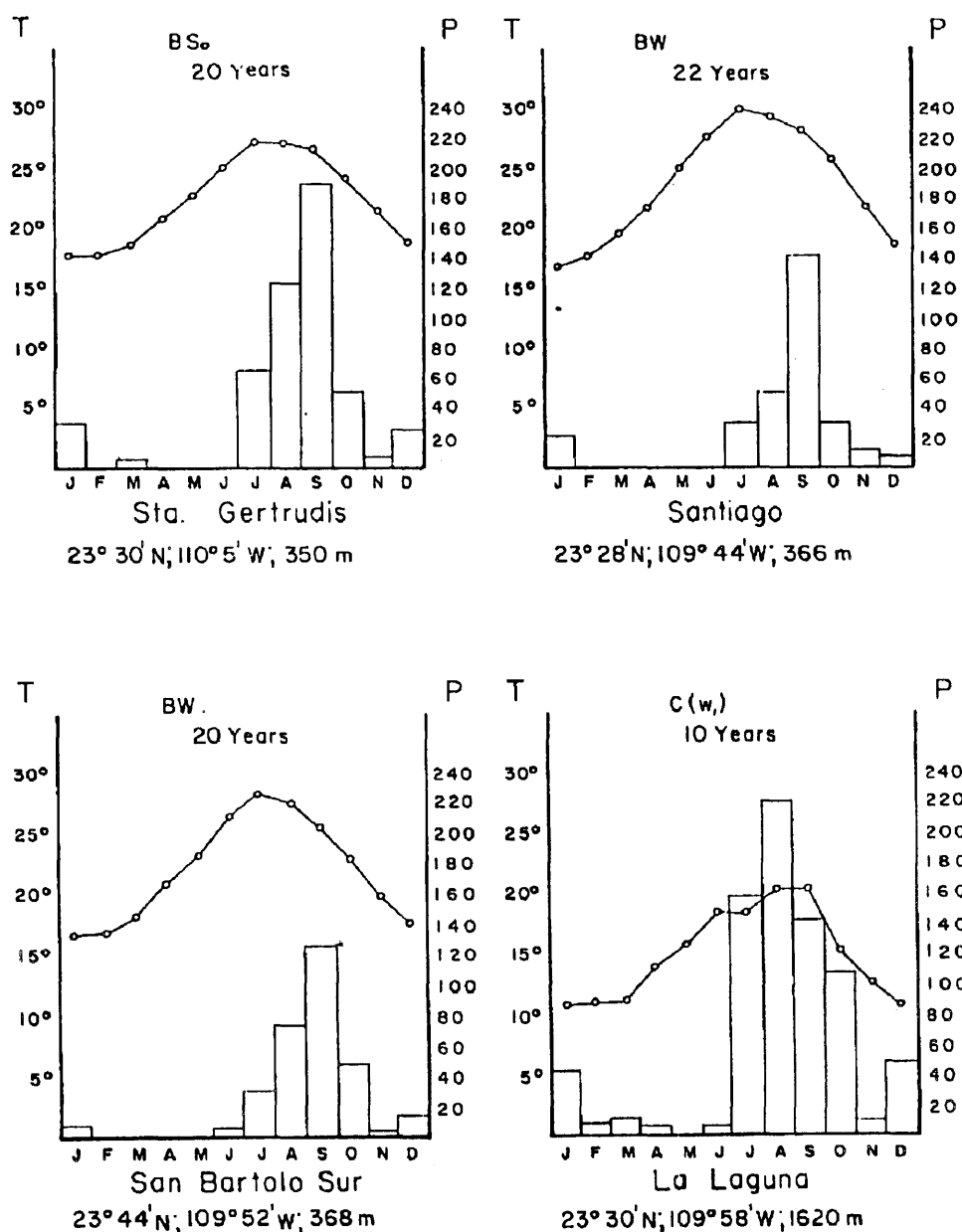


Figure 2.—Annual courses in mean monthly temperature (°C) and total monthly precipitation (mm) in three localities at foothills of the Sierra de la Laguna mountains (Sta. Gertrudis, Santiago and Sn. Bartolo Sur), and one in the woodland (La Laguna).

scattered through the year, the second refers to a very dry and warm climate, with rains occurring mainly also in the summer. Generally precipitation in winter is low, but during the summer months rains occur as thunderstorms caused by cyclone perturbations originating in the Pacific Ocean. Late winter to early summer are usually the driest season.

The high elevations of the mountains receive the highest levels of precipitation in all of the state. Probably, these regions supply the aquifers

that provide for many ranches, urban and suburban populations, and some small agricultural areas in one of the most arid regions of our continent.

Problematic

Within the Cape Region, the Sierra de la Laguna resembles an island. A vegetation of less arid affinities is now restricted to its highest

elevations, above the 1500 m. The oak and oak-pine woodlands communities that occurs in such elevations contains a relative high proportions of both, endemic and disjunct taxa. Increasing human settlement in the vicinities has been resulting in destructive use of this natural resource, and thus the plant communities may be at risk of losing their natural balance.

Rural and urban populations as well as tourism activities around the area of Sierra de la Laguna are increasing rapidly. Recent human population derived from census data, indicate approximately 250,000 inhabitants in the region. This population demands more water to satisfy its primary needs; it is obtained totally from underground aquifers by pumping.

RESULTS

Botanical Collections

In the southern tip of the peninsula botanical explorations have been not so extensive as others xerophitic and mesic areas in the central and northern regions of the same peninsula. This area has been designated as a natural unit by Bryant (1891) as "Cape Region of Baja California". The early reports on its plant composition were published at the end of the last century by Brandegee (1891, 1892a, 1892b, 1894, 1903). Nelson (1921), and Shreve (1937) published vegetational descriptions of this region. Two decades ago, Gilmartin and Neighbours (1978) undertook field work in hopes of preparing a flora of the same, but their project was never completed. Recently, Lenz (1992) compiled a flora for the Cape; our team has also collected on it, and surpassed Lenz's catalogue in almost a 15% because a major field work.

Plant Communities

Vegetation in the Cape Region adjacent areas are here organized into three major plant communities (see fig. 1). The nearly level alluvial lands and valleys with scattered low hills that surround the mountain body contain a "desert scrubland" or "sarcocaulous scrubland" that following modern Mexican systems (SPP 1981b) it designated as a "matorral sarcocaulous". The pediplains with prominent hills and canyons from 400 to 1000 m elevation, support a vegetation called "selva baja caducifolia" (low deciduous

forest, or the arid subtropical scrubland). The middle elevations (1000 to 1500 m) is covered by a oak woodland, and the upper elevations (1500 to 2200 m) by a oak-pine woodland. These woodlands represent the southernmost Sierra Madrean Woodland Elements.

Plant Associations

1) Oak-pine Woodland

This community can be divided into four types of associations or habitats, according to floristic composition and physiognomy. We are termed: "Valleys", "Stream Bottoms", "True Woodland", and "Open Areas".

The dominant species in this community are *Pinus cembroides* var. *lagunae* (pino piñonero), *Quercus devia* (encino negro), *Arbutus peninsularis* (madroño) and *Nolina beltingii* (sotol). Their relative densities vary within different habitats, Table 4 illustrates the composition of the higher stratum of this woodland; the data were taken from "True Woodland" habitat.

- **Valleys:** These are open sunny areas in which both annual and short-lived perennial herbs are the components. These areas are scattered through the Sierra. The largest, known as *La Laguna* (to which this range owes its name), it is located at 1820 m, and is crossed by permanent streams derived from the nearby mountain peaks. It is a flat-bottomed basin of almost 4 square km in surface. It is possible that in the recent past *La Laguna* was a marsh, rather than a lagoon (Nelson, 1921). An association of pinon pine occurs at the valley margins, and it is here that the pines exhibit their maximum vigor. Two habitats can be distinguished in the valleys: a) streams and banks, and b) meadows. Some species typical of this association are listed below.

Streams & Banks

Bacopa monieri
Hydrocotyle umbellata
Mimulus guttatus
Nasturtium officinale
Polygonum punctatum
Potamogeton foliosus
Tinantia modesta

Meadows

Bidens nudata
Centaurea nudicaule
Cosmos parviflorus
Lepechinia hastata
Lychurus phleoides
Oxalis albicans
Tagetes micrantha

- **Stream Bottoms:** These areas are characterized by high soil moisture and low radiation. Trees and shrubs here are generally taller than elsewhere in the range. The environmental condi-

tions of this habitat has favored the presence of some species which are supposed relictuals, such as: *Quercus reticulata* (encino blanco), *Q. arizonica*, *Q. laeta*, *Ilex brandegeana* (manzanita), *I. californica* (palo extraño) and *Prunus serotina* subsp. *virens* (cerezo), all of which also occur in the Sierra Madre Occidental in north Mexico and some ranges in Arizona in not so restricted conditions. In addition there are disjointed species such as *Heteromeles arbutifolia* (toyon), whose main distributional area is in California chaparral and woodlands. Some species of this association includes:

<i>Adiantum capillus-</i>	
<i>veneris</i>	<i>Arethusa rosea</i>
<i>Rhus radicans</i>	<i>Ribes brandegeei</i>
<i>Cyperus pallidicolor</i>	<i>Rubus scolocaulon</i>
<i>Epipactis giganteum</i>	<i>Styrax argenteus</i>
<i>Equisetum hyemale</i> var.	
<i>afine</i>	<i>Thelypteris puberula</i>
<i>Polypodium guttatum</i>	<i>Tripsacum lanceolatum</i>

- **True oak-pine woodland.** This is the most common habitat. It contains many annuals, short-lived herbs, and woody species that vary in relative density from one site to another. This can be attributed to such features as steepness of the slope, exposure to light, elevation, and succesional stage of the area. It is opportune to mention that this plant association is constantly disturbed by fire; there are practically no areas of forest without recent evidence of fire from both natural and human origins. Selected shrubby and woody species include:

<i>Calliandra peninsularis</i>	<i>Lepechinia hastata</i>
<i>Helianthemum</i>	
<i>glomeratum</i>	<i>Mimosa xantii</i>
<i>Helianthus similis</i>	<i>Perezia pinetorum</i>
<i>Heterotoma aurita</i>	<i>Rumfordia connata</i>
<i>Hypericum peninsularis</i>	<i>Verbesina pustulata</i>

Table 4.—Basical dasonomycal characteristics of the woody plants on a slope of 20-30° of steepness, in the Sierra de la Laguna Oak-Pine Woodland in a 3000 m² plot at 1700 m of altitude. Only individuals with ddb 3 cm were considered.

Species	Sampled Individuals	Avg. Cover m ²	Avg. height m
<i>Quercus devia</i>	68	24.1	11.5
<i>Arbutus peninsula</i>	6	21.3	6.8
<i>Pinus cembroides</i> var. <i>legunae</i>	4	7.6	6.9
<i>Nolina beltingii</i>	14	2.5	3.3
<i>Prunus serotina</i> subsp. <i>virens</i>	2	7.4	6.4
<i>Ilex brandegeana</i>	2	5.8	4.3
<i>Heteromeles arbutifolia</i>	1	6.6	3.1

Some short-lived herbs are:

<i>Arracacia brandegeei</i>	<i>Linanthus nuttalli</i>
	subsp. <i>nuttalli</i>
<i>Desmodium prostratum</i>	<i>Oenothera tetraptera</i>
<i>Gibasis heterolhylla</i>	<i>Stachys coccinea</i>
<i>Gnaphalium bicolor</i>	<i>Tagetes lacera</i>
<i>Malaxis unifolia</i>	<i>Verbena carolina</i>

- **Open Areas:** These widely distributed surfaces are of two types; one consists of an early succesional stage induced by fire and contains such species as *Muhlenbergia emersleyi*, *Rhynchelytrum repens*, *Bernardia lagunensis*, *Dodonaea viscosa* and *Tephrosia cana*. Other open areas occur on prominent rocks, with high exposure to sun and thin soil. These areas contain endemics species as *Morangaya pensilis*, *Mamillaria petrophylla*, *Daphnopsis lagunae*, *Myrtillocactus cochal*, *Dudleya nubigena*, *Agave promontorii* and *Russelia retrorsa*.

2) Oak woodland.

The area occupied by this community is very precipitous, with the slopes ranging from 30° to 40° in steepness. The strata consist of trees, low shrubs, and both annual and perennial herbs. Trees are scattered, *Quercus tuberculata* (encino roble) and *Q. albocincta* (encino laurel) characterizes this community. Also, it is common to find some species coming from the Arid Subtropical Scrub and other from the lowlands.

Low shrubs usually are scattered, but grow more densely in some areas. Common species are: *Mimosa xantii*, *Arracacia brandegeei*, *Dodonaea viscosa*, *Bernardia lagunensis* and *Tephrosia cana*. Herbs are typically represented by bunchgrasses as *Muhlenbergia emersleyi*, *Heteropogon contortus* and *Schizachyrium sanguineum* var. *brevipedicellatum*, and small annual herbs such as *Tagetes subulata*, *Crotalaria sagittalis*, *Heterosperma xantii* and *Zornia reticulata*. Vines such as *Phaseolus filiformis* and *Quamoclit coccinea* var. *coccinea* are abundant after the rainy season.

Finally, a local riparian plant association occupies the bottom of the brooks and canyons, descending with the streams until these disappear at elevations of 300 to 500 m. This association is characterized by *Populus brandegeei* var. *glabra* (gueribo), *Salix lasiolepis* (sauce), and the fan palms *Erythea brandegeei* and *Washingtonia robusta* at middle elevations.

The Flora of the Woodlands

A total of 272 taxa of vascular plants have been identified from this region to date. These represent 69 families and 184 genera. Table 5 shows the major taxa of such flora. Excluding large families as Graminae, Compositae, and Leguminosae, the rest of the families have a genus to species ratio of about 1 to 1.5. Forty three species and infraspecific taxa are considered to be endemic (approximately 16%). The area contains two endemic monospecific genera: *Behria* (Amaryllidaceae) and *Morangaya* (Cactaceae). The proportion of endemic species is moderate as compared with the closest biotic provinces: the Californian with around 48% and the Sonoran Desert with about 23%, but these are hundreds of times greater in total surface (Wiggins 1980).

Table 6 shows the frequency of life forms in the woodland. Both, annual and perennial herbs includes plants with herbaceous stem. Hydrophytes are all those plants which grow in or close to streams. Climbing includes herbaceous and woody.

Rare Species

Almost a century ago T. S. Brandegee described *Faxonia pusilla* from a single plant from the locality "Sierra de la Laguna", but it is uncertain if the specimen came from some place in the woodland or the arid tropical scrub, this taxa has not been collected again and may well be extinct. In the same status may be *Pectis uniaristata* var. *uniaristata*, *Muhlenbergia wolfii* and *M. ciliata*, all of them collected only by Brandegee. Specimens of *Ilex californica* are very scarce, only a dozen living trees are known. Others species with very restricted localities, with relatively few individuals, or scarcely collected are:

Table 5.—Distribution of the 272 species of vascular plants which form the recognized flora of the woodland communities of the Sierra de la Laguna.

	Families	Genera	Species & Infra categories
Pteridophytes	4	14	19
Gymnoesperms	1	1	1
Angiosperms	64	169	252
TOTAL	69	184	272

Table 6.—Absolute and relative proportions of life forms in the Sierra de la laguna woodlands.

Life form	No. of species	%
Trees	17	6.25
Shrubs & subshrubs	30	11.02
Annual & perennial herbs	176	64.71
Hydrophytes	34	12.51
Succulents	8	2.94
Climbing vines	5	1.83
Saprophytes & parasites	2	0.74
	272	100.00

<i>Aralia scopulorum</i>	<i>Opuntia lagunae</i>
<i>Arenaria lanuginos</i>	<i>Quercus albocincta</i>
<i>Epipactis gigantea</i>	<i>Quercus arizonica</i>
<i>Heteromeles arbutifolia</i>	<i>Quercus laeta</i>
<i>Hypericum anagalloides</i>	<i>Quercus reticulata</i>
<i>Ilex brandegeana</i>	<i>Rhus schiediana</i>

Some of these rare species are probably relictuals, small populations has remained in places with a relatively less arid environment. Most of the herbaceous endemics are founded in restricted habitats.

DISCUSSION AND CONCLUSIONS

Phytogeography

Table 7 shows the geographical affinity of the floral groups (families and genera) with the elements tropical, temperate, cosmopolite (worldwide and pantropical), disjointed (some of the tropics, subtropics, or both tropical and temperate) and endemic. The geographical affinities were taken from Willis (1985).

Table 7.—Geographical affinity of floral groups of families and genera of the vascular flora of the Sierra de la Laguna woodlands (oak and oak-pine) and their numerical contribution.

	Families No. (%)	Genera No. (%)
Tropical	28 (40.5)	109 (59.2)
Temperate	9 (13.1)	29 (15.7)
Cosmopolite	27 (39.2)	37 (20.1)
Disjointed	5 (7.2)	8 (4.4)
Endemic	0	1 (0.6)
	69 (100)	184 (100)

According with this same table, it is possible to observe that the major affinity at family and genus level is with the tropical element. This result is not surprising because this surface has been influenced by tropical climate since its geological development through tertiary epochs (Moore and Curray 1982). The temperate element only has moderate participation, the presence of these could be considered as remnants of a pleistocene flora.

A paleobotanical study, based on palinological sample, was carried out in the woodland area; preliminary results provide important information on its natural history. Then, 9000 years before present, pollen of *Pinus* and *Quercus* is dominant in the profile, as well those of several grasses, forbs and undetermined Compositae family species.

Conservation

The woodlands and the arid subtropical scrub support several human activities without efficient control including hunting, gathering firewood or harvesting trees, and both intensive and extensive livestock breeding. For 1990, the number of all kind of cattle in the south tip of the peninsula was estimated in no less than 30,000 heads.

For these reasons, it is necessary that simultaneously with the investigations of the flora and vegetation, another studies must be made of its ecological aspects, both basic and applied. Mexican institutions and organizations have realized the importance of ecological preservation of the communities of this range in order to protect the area from the destructive human activities noted above. Late last year an ample area which comprises the woodland was decree as Biosphere Reserve by the Mexican Government.

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