13 Mexican and Central American Seasonally Dry Tropical Forests: Chamela-Cuixmala, Jalisco, as a Focal Point for Comparison

Emily J. Lott and Thomas H. Atkinson

CONTENTS

ABSTRACT

In this chapter we discuss the distribution of seasonally dry tropical forests (SDTFs) in Mexico and Central America, emphasize their distinctive characteristics, and provide a summary of floristic and diversity studies of several sites. As a particular case, we analyze floristic affinities and diversity of the Chamela-Cuixmala Biosphere Reserve and adjoining area in Jalisco, Mexico, with respect to different taxonomic levels and life forms. The analysis is based on 1109 species (1064 native), 570 genera (544 native) and 115 families from all the biotic communities in the region from sea level to *c.*500 m. The native flora analyzed consists of 229 species of trees, 227 species of shrubs, 40 epiphytes, 371 herbs and 197 vines (86 herbaceous and 111 woody). At Chamela, about 41.5% of the species are distributed on the Pacific slope from Sonora and Baja California Sur to Central America, and it appears that this coastal flora is a relatively homogeneous and continuous floristic province. There is an (as yet) imprecisely defined zone of endemism which may encompass the area from Jalisco to the Isthmus of Tehuantepec in Oaxaca. Comparisons are made with diversity and floristic affinities of other Mexican and Central America SDTF sites. Based on the combination of species richness, endemism levels and other factors, we suggest that further conservation efforts might best be focused on the Pacific slope states of Michoacán, Guerrero and Oaxaca.

13.1 INTRODUCTION

This chapter has four principal aims. First, we provide an overview of the main areas of seasonally dry tropical forest (SDTF) in Mexico and Central America. Second, we summarize studies of floral diversity in these areas. Third, as an exemplar, we examine in detail the flora of one of the best studied areas of Mexican SDTF in the Chamela-Cuixmala Biosphere Reserve. Finally, we examine the distributions of the species comprising the Chamela flora, which to some extent allows us to make biogeographical generalisations about Mexican SDTF.

13.2 SUBTYPES WITHIN SEASONALLY DRY TROPICAL FOREST

This book uses a broad definition of SDTF which covers a gamut of vegetation types (Pennington et al., this volume). In this chapter we do distinguish at times between tropical deciduous forest (*selva baja caducifolia* of Miranda and Hernández X., 1963; *bosque tropical caducifolio* of Rzedowski, 1978),

tropical semideciduous forest (*selva mediana subcaducifolia* or *subperennifolia*, in part; SM hereafter), and thorn forest (*bosque espinoso*), as have Gordon et al. (2004) and others. The SM typically occurs on deeper soils along drainages with more available moisture than on slopes (Rzedowski, 1978).

13.3 DISTRIBUTION OF SDTF IN MEXICO AND CENTRAL AMERICA

SDTFs on the east coast of Mexico are isolated from each other; they are spottily distributed in Tamaulipas, San Luis Potosí and Veracruz, and are extensive in areas of the Yucatán Peninsula, particularly the north-western part (Figure 13.1). On the Pacific slope they are found in a nearly continuous band from northern Sonora and western Chihuahua to Oaxaca, and also in the southern part of the Baja California Peninsula. In the interior of the country, they are mainly found in the Tehuacán-Cuicatlán and Río Balsas valleys, and the Central Depression of Chiapas (Rzedowski, 1978). In Central America, there are remnant patches of SDTF on the Pacific slope in southern Guatemala, and from El Salvador and Honduras to Costa Rica.
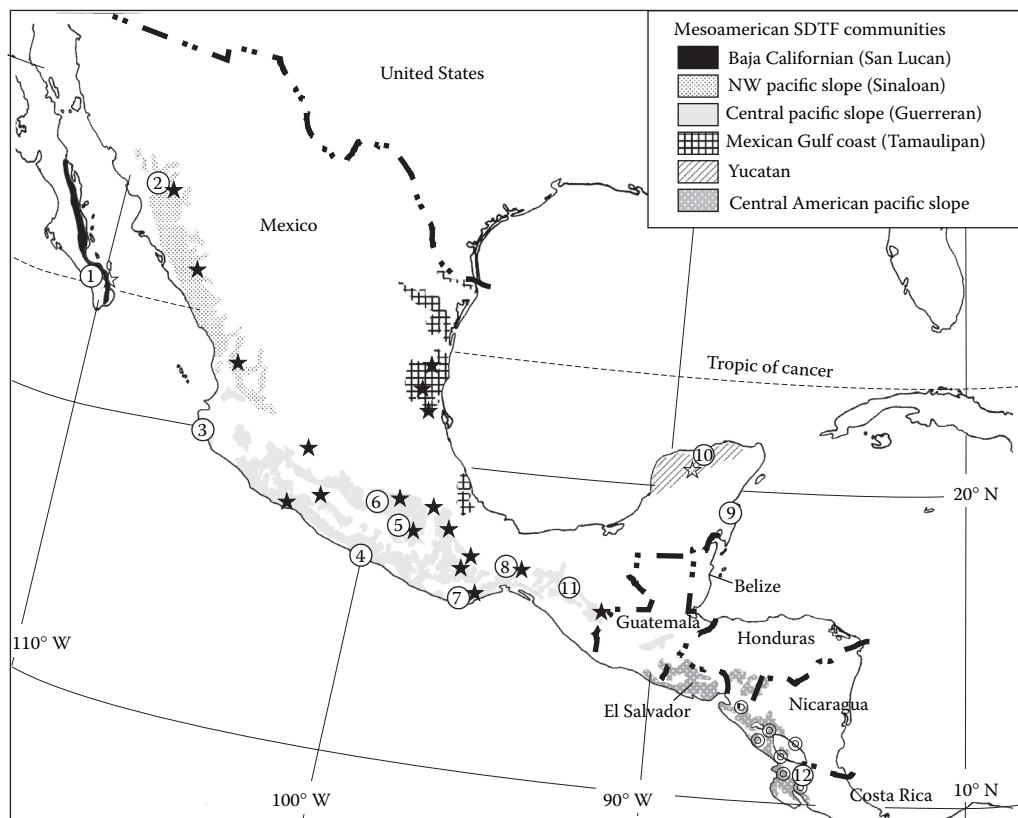
FIGURE 13.1 Distribution of SDTF in Mexico and Central America (modified from Reichenbacher et al., 1998). Numbered locations: 1: Cape Region, Baja California Sur; 2: Rio Cuchujaqui (near Alamos), Sonora; 3: Chamela Bay Region, Jalisco; 4: Costa Grande Region, Guerrero; 5: Canon del Zopilote, Guerrero; 6: Sierra de Nanchititla, Mexico; 7: Zimatan, Oaxaca; 8: Nizanda, Oaxaca; 9: Sian Ka'an, Quintana Roo; 10: area of SDTF, Yucatan; 11: Central Depression, Chiapas; 12: Guanacaste Province, Costa Rica. Stars represent locations from Trejo and Dirzo (2002). Circles represent locations from Gillespie et al. (2000).

There is a profusion of terms referring to these floristic areas in biogeographical and conser-vation literature; in this chapter we refer to Sonoran, Tamaulipan, Baja Californian, Central Pacific coast (Jalisco, Colima, Michoacan, Guerrero and Oaxaca), Balsas, Central Depression of Chiapas, Yucatecan and Central American SDTFs (Figure 13.1).

13.3.1 MEXICO'S EAST COAST

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On the Atlantic slope, we have chosen to discuss only two areas, Tamaulipas and Yucatán.

13.3.1.1 Tamaulipan SDTF

In north-eastern Mexico, at the northernmost limit of SDTF on the Gulf coast where it crosses the Tropic of Cancer, Tamaulipan SDTF is of interest because of its transitional nature and the complex mosaic it forms with Tamaulipan Scrub. There are fewer columnar cacti, no arborescent *Ipomoea* or *Jatropha*, no *Forchhammeria, Fouquieria*, *Alvaradoa, Haematoxylum, Manihot* or *Vallesia.* Some tropical tree genera which occur here but are absent or scarce in Sonoran SDTF are *Amyris*, *Beaucarnea*, *Brosimum* and *Phoebe* (Puig, 1976, cited in Martin and Yetman, 2000). There are regionally endemic taxa of *Caesalpinia* (*C. mexicana* A. Gray and *C. exostemma* DC. subsp. *tampicoana* (Britton & Rose) G. P. Lewis (Lewis, 1998)), along with other tropical elements such as *Bursera simaruba* (L.) Sarg., *Celtis iguanaea* (Jacq.) Sarg., *Zanthoxylum caribaeum* Lam., *Trichilia havanensis* Jacq., *Achatocarpus* sp., *Ficus cotinifolia* H.B.K., *Trophis racemosa* (L.) Urb., *Phyllostylon brasiliensis* Capanema*, Guazuma ulmifolia* Lam., *Coccoloba barbadensis* Jacq., *Maclura tinctoria* (L.) Steud., etc. (González-Medrano,1972).

Tamaulipan SDTF is highly disturbed due to large-scale conversion for cattle ranching, farming of citrus and other crops, petroleum extraction and other economic activities, but a few small patches remain relatively intact and are beginning to be explored in more detail (T. F. Patterson, South Texas Community College, pers. comm., 2005). Although vegetation structure and composition, along with soils, climate, geology and physiography, have been extensively studied at various sites in the Tamaulipan area (Johnston, 1960; González-Medrano,1972; Puig, 1976; Martínez y Ojeda and González-Medrano, 1977; Valiente Banuet, 1984), a comprehensive floristic inventory has not yet been accomplished. A small amount of SDTF is preserved in the Rancho El Cielo Biosphere Reserve.

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13.3.1.2 Yucatán Peninsula

The Yucatán Peninsula is made up of the states of Campeche, Quintana Roo and Yucatán, and adjacent parts of Tabasco and Chiapas, the Peten of Guatemala, and the northern half of Belize; most of the studies we refer to included only the first three Mexican states. The Yucatán has long been recognized as a distinctive geographical, climatic, geomorphological and biogeographical unit (Ibarra M. et al., 2002: 18). SDTF is mostly concentrated in a band in the north-west corner of the peninsula, in Yucatán State (Figure 13.1). This northern end of the Peninsula is the youngest (Pleistocene – Holocene); the substrate is exclusively limestone and the soils are exceptionally thin and stony. Physiographically the Yucatán is distinct because of its large flat areas: elevation varies little from sea level to the highest point (*c.*400 m), although there are small outcroppings and karst areas. There are few surface rivers.

[margin note: This discussion of Yuacaran biogepgrpahy is best at the end of the paper in the final biogeography section]

An important facet of Yucatecan SDTF is its long history of human usage. It has been managed by the Maya for several thousand years in a complex and sophisticated agroforestry system which supported a dense population (Gómez-Pompa et al., 1987; Primack, 1998). Studies on the compar-ison of floristic composition of archeological sites (forest growing on ruins, mounds, pyramids, and in small patches of strikingly different species makeup) with the flora of surrounding areas (Thien et al., 1982; White and Darwin, 1995; White and Hood, 2004), and investigations into how forest management and agricultural traditions of the Maya have affected the forests of today (Gómez-Pompa et al., 1987; Rico-Gray et al., 1985; and others) are numerous and ongoing.

Some projects which have contributed to floristic knowledge of the peninsula are the *Etnoflora Yucatanense* (Sosa et al., 1985), an illustrated flora, and a recent checklist of the Peninsula (Durán et al., 2000) which lists 2477 species in 992 genera of 182 families. This is an area which boasts a wealth of floristic and ethnobiological information, and also some of the largest forest reserves in Mesoamerica.

13.3.2 PACIFIC SLOPE

We will first identify some of the local areas within this SDTF belt while recognizing that the Pacific slope is home to a distinctive, fairly homogeneous and nearly continuous floristic province which stretches from Sonora and Baja California to Costa Rica.

13.3.2.1 Sonoran SDTF

In the north-west of Mexico SDTF occurs in southern Sonora, western Chihuahua and north-western Sinaloa (Figure 13.1). SDTF here was previously referred to by H. S. Gentry as short-tree forest (1942) and later as Sinaloan deciduous forest (1982). The SDTF is bordered on the north by Sonoran Desert, to the east by the Sierra Madre Occidental and to the west by the coastal plain of the Sea of Cortéz.

In addition to numerous studies of the ecology, vegetation and ethnobotany of this zone, there are several excellent local floristic treatments (Gentry, 1942, Martin et al., 1998; Van Devender et al., 2000; Felger et al., 2001) and popular natural history books (e.g., Bowden, 1993). Some tropical genera and species are at the northernmost part of their range here, and characteristic SDTF trees such as *Ceiba*, *Tabebuia*, *Haematoxylum*, *Lysiloma*, *Pseudobombax* and *Guaiacum coulteri* A. Gray are either noticeably smaller in stature or shrubbier than they are in wetter areas further to the south (Martin et al., 1998). Within this zone is the Río Cuchujaqui drainage, a small area in southern Sonora and northern Sinaloa studied by Van Devender et al. (2000) (Table 13.1). Since the early 1970s Sonoran SDTFs have suffered large-scale conversion to Buffelgrass (*Cenchrus ciliaris* L.) pasture (Martin and Yetman, 2000), which in part prompted establishment of the Alamos-Río Cuchujaqui Biosphere Reserve in 1995.

13.3.2.2 Baja California Sur

The Cape region of Baja California is near the northern limits of the SDTF and is isolated from the continent by the Gulf of California (or Sea of Cortéz) to the east and from other areas of similar vegetation by the deserts of the Peninsula and by the coastal plain of Sonora. SDTF is found on the lower to mid-slopes and steep canyon walls of the Sierra de la Laguna and the Sierra Giganta which are topped by oak-pine forest, in a variety of soil types (all igneous) and situations (León de la Luz et al., 1999). This is one the driest Pacific SDTF areas in Mexico (< 500 mm) according to Rzedowski (1978); it is fairly well-preserved and is included in a 112,437 ha biosphere reserve.

13.3.2.3 Central Pacific Slope

The history of botanical exploration on the Pacific slope of Mexico dates from 1790 (McVaugh, 1972). Since the synopsis of Central American botany by Hemsley (1879 – 1888) it has been recognized that the Pacific coast of Mexico boasts a rich and distinctive flora. This is the largest extension of Mexican SDTF, and parts of it are still relatively intact. In recent years there has been a significant advance in the knowledge of the flora owing to the greater access which began with the paving of a coastal highway in 1974, and to the consequent increase in field work. A large-scale floristic work, *Flora Novo-galiciana*, covers Jalisco, Colima, Aguascalientes, and parts of Nayarit, Durango, Zacatecas, Guanajuato and Michoacán (McVaugh, 1983 — present); a flora of Guerrero is in progress, and a number of important local checklists have been published (Table 13.1).

TABLE 13.1
Summary of Floristic Checklists. The Number of Families Reflects Consolidation of Leguminosae (*). SDTF Here includes sm. Numbers in Parentheses for Families, Genera, and Species are for SDTF Only (Not Stated in Most Cases)

Site	Area (km²)	Number of Families	Number of Genera	Number of Species	Elevation (m)	Vegetation Types	Source
Rio Cuchujaqui, Son.	46	115	429	736	220 – 400	SDTF, thorn scrub, oak forest, riparian, aquatic	Van Devender et al., 2000
Sa. de Nanchititla, Mex.	13.2	87*	208	288	600 – 1400	SDTF, gallery forest, 80% secondary	Zepeda and Velazquez, 1999
Dep. Cent., Chis.	9000	103	489	998	200 – 1500	SDTF, thorn scrub	Reyes-Garcia and Sousa, 1997
Dist. Tehuantepec, Oax.	6600	154	776	1720	0 – 1800	SDTF, thorn scrub, conifer forest, gallery forest, oak forest, palm forest, grassland, aquatic, halophytic, coastal	Torres-Colin et al., 1997
Venta Vieja, Canon del Zopilote, Gro.	38	77*	222	307	700 – 1100	SDTF	Gual-Diaz, 1995
Costa Grande, Gro.	2,500	135	527	1047	0 – 300	SDTF, thorn scrub, moist forest, halophytic, aquatic, coastal	Peralta-Gomez et al., 2000
Zimatan, Oax.	713	144	668	1384	0 – 2580	SDTF, thorn scrub, subhumid and humid forest, moist montane forest, oak-pine forest	Salas-Morales et al., 2003
Nizanda, Oax.	85	117*	458	746 (380)	90 – 500	SDTF, gallery forest, savannas, aquatic, agricultural	Perez-Garcia and Meave, 2001
Cabo Baja Calif Sur	8500	130 (92)	522 (312)	943 (454)	0 – 2100	SDTF, oak forest, oak-pine forest	Leon de la Luz et al., 1999
Chamela-Cuixmala, Jal.	350	125	572	1149 (739)	0 – 500	SDTF, thorn scrub, riparian, aquatic, halophytic, coastal	Lott, 2002
Rio Balsas Basin	11,2320	202	1246	4442	0 – 2800	SDTF, thorn scrub, oak, pine, moist montane forest, aquatic, coastal	Fernandez et al., 1998
Sian Ka'an, Q. Roo	5280	112	470	850	0 –	SDTF, seasonally inundated, savannas, swamps, coastal	Duran and Olmsted, 1987
Lowland Guanacaste Prov., Costa Rica		121*	642	1156		SDTF and associated riparian vegetation	Janzen and Liesner, 1980

13.3.2.4   Chamela

A focal point of research in SDTF of Mexico's Pacific slope, the Estación de Biología Chamela (EBCH) was established in 1971 by the Instituto de Biología, Universidad Nacional Autónoma de México (IBUNAM), upon the donation of 1600 ha near the settlement of Chamela, Jalisco, on the Pacific Coast between Puerto Vallarta and Barra de Navidad. The station was established for several purposes: to conserve an area of well-preserved SDTF in the vicinity, to learn about the structure and function of the ecosystems in the protected area, to support research, teaching and extension services, and to understand the social and economic problems of the surrounding region and seek solutions to them (Noguera et al., 2002). In 1993, another parcel of 1700 ha was added on the north-west side of the original rectangle. In this same year, the EBCH and Ecological Foundation of Cuixmala jointly formed the Chamela-Cuixmala Biosphere Reserve, as established by presidential degree; the combined area of the EBCH and the Biosphere Reserve now comprises *c.*13,142 ha (Noguera et al., 2002), including two protected turtle-nesting beaches, and small areas of SM, riparian, dune, mangroves, salt marsh and thorn scrub areas, but vegetation is principally the SDTF sub-type known in Mexico as *selva baja caducifolia* (Miranda and Hernández X., 1963) or *bosque tropical caducifolia* (Rzedowski, 1978). As of 2000, research in the Chamela area had resulted in 359 scientific articles and 124 theses. A list of these is available at the EBCH website, http://www.ibiologia.unam.mx/ebchamela/. Longterm ecological transect studies have been established on the EBCH, one of them since the mid-1970s. The flora (and indeed the overall ecology) of the Chamela-Cuixmala region is probably the best known of the Mexican Pacific Slope (Pérez Jiménez et al., 1981; Lott, 1985, 1993; Martínez-Yrízar et al., 2000: 21; Van Devender et al., 2000; Lott, 2002; Noguera et al., 2002; and others).

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13.3.2.5   Michoacán, Guerrero and Oaxaca

Botanical exploration of this part of the central coast, especially Oaxaca (Pérez-García et al., 2001; García-Mendoza, 2004) and Guerrero, is in an extremely active phase; the large area, highly complex and rugged topography, outstanding diversity and the sheer size of the flora mean that floristic inventory is still in progress. The Isthmus of Tehuantepec in Oaxaca is the southernmost limit of many of the SDTF species.

13.3.3   Río Balsas Basin

The Río Balsas Basin is an east — west-trending, distinct large area of western Mexican SDTF which is joined to the Pacific coast only by the mouth of the Balsas River in Michoacán (border with Colima). The main Pacific slope SDTF and the Balsas Depression are separated by the coastal mountain ranges which run parallel to the coast at this point. There are many species in common with the Pacific SDTF, but there is also an exceptionally high level of endemism, 30 – 45% in some sites (see below).

13.3.4   Central America

The destruction of Central America's SDTFs was called to world attention by Janzen (1988), who estimated that the original Pacific SDTFs have been reduced to only 0.1% of their former range. According to Stevens et al. (2001), SDTF in Nicaragua has undergone several waves of alteration; the latest has occurred in the last 50 years, when the forests were cut again to make way for crops. They estimate that less than 1% of SDTF remains there, and of this little, if any, is in its natural state (Stevens et al., 2001). Gillespie et al. (2000) in Nicaragua and Costa Rica, and Gordon et al. (2004) in Honduras, among others, have also concluded that there is little remaining of mature SDTF in Central America. Thus it is too late to know more of the original extent and composition of these SDTFs, but there is much of vital importance to be learned of their restoration and regeneration.

There are large-scale floristic works, such as a flora of Guatemala, a partial flora of Costa Rica and the *Manual of the Flora of Costa Rica* (Hammel et al., 2003), *Flora de Nicaragua*

(Stevens et al., 2001 — present), and a series of guides to trees of Costa Rica from which information on SDTF could be gleaned with time and effort, but for rapid comparison of floristic composition of Central American and Mexican SDTFs, aside from species lists from vegetation and diversity studies, many studies have used Janzen and Liesner's (1980) widely available, informative and reasonably complete checklist of lowland Guanacaste Province (Figure 13.1).

13.4 LOCAL DIVERSITY: CHECKLISTS AND TRANSECTS

In Table 13.1 we show a summary of floristic checklists with the sites arranged from north to south, beginning with the Río Cuchujaqui in Sonora. The size of the sites ranges from 13.2 to 9000 square kilometers; the elevational range is from sea level to 2800 m; other vegetation types included are coastal, riparian, and aquatic to oak-pine, conifer and cloud forest. Average annual precipitation ranges from 684 mm in the Cañón de Zopilote, Guerrero, to 1100 mm in the Sierra de Nanchititla site, Mexico, but many of the study areas are far from established climatological stations and so precipitation data are of necessity extrapolated from those of the nearest stations, from maps, or else are not reported. Although each site includes a component of SDTF, the disparity in size of area and the variety of other vegetation types surveyed makes it difficult to compare the SDTFs of these areas quantitatively.

For this reason, we turn to a comparison of floristic records, which, though they will not reflect all species present in an area, should give a roughly comparable representation from one site to another when the same sampling protocol is followed. Irrespective of the total number of species in the region, it is possible to examine the floristic diversity of smaller areas and compare them with that of other neotropical forests. Information from these floristic sources was used in our biogeographical analysis of the Chamela flora (see below).
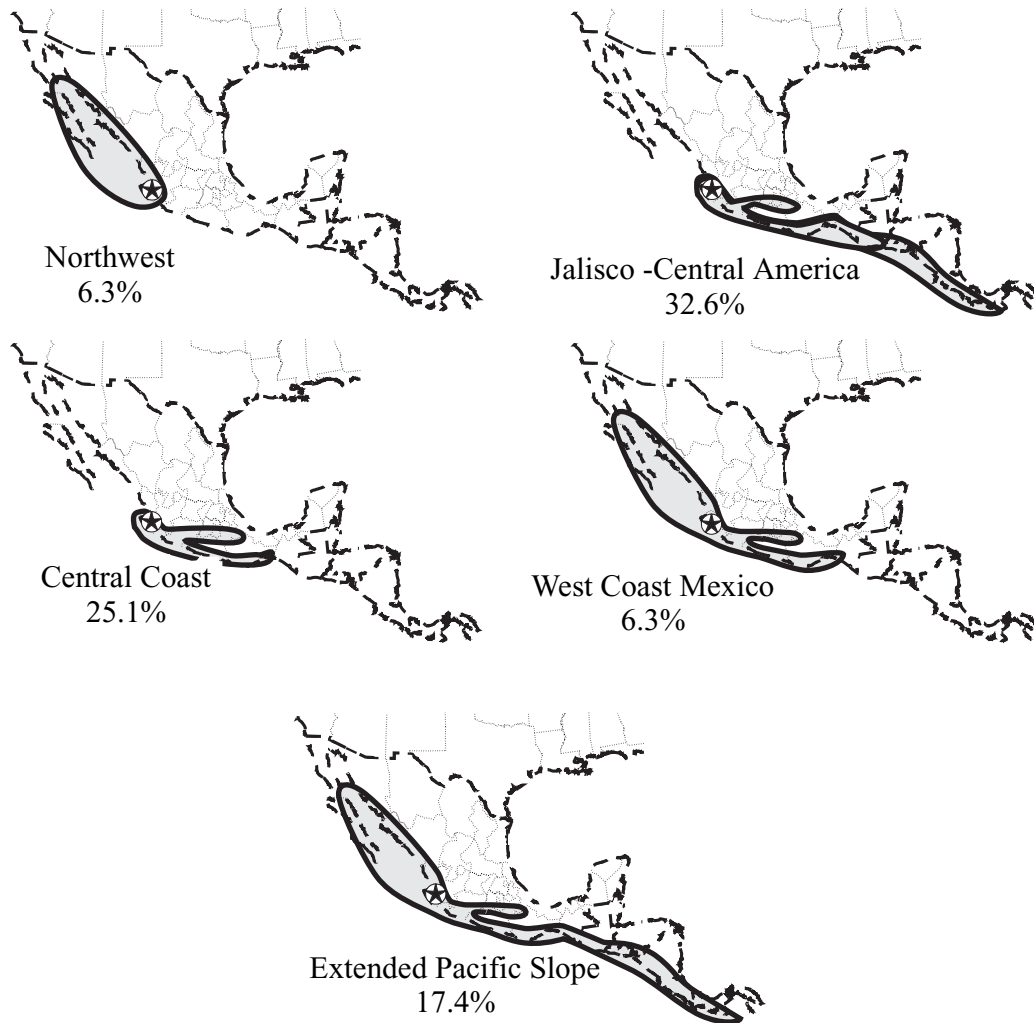
13.4.1 Mexico in a Neotropical Context

A.H. Gentry (1982, 1988, 1995) attempted to explain the patterns of diversity and of floristic composition in neotropical forests based on climatic factors. He used 28 sites of 0.1 ha (with 10 transects of 2×50 m each) to measure the diversity of woody individuals with a dbh of ≥ 2.5 cm. Based on his results, in 1982 and 1988 Gentry postulated that the local species diversity for humid neotropical forests was positively correlated with the quantity of total annual precipitation. Nevertheless, the *alpha*-diversity on the Chamela station (92 and 83 spp./0.1 ha; Lott et al., 1987) was much higher than that predicted by the Gentry model based on total annual rainfall. Gentry later suggested that the unexpected richness of the SDTF is a phenomenon of the subtropics and not 'a biogeographic peculiarity' (Gentry, 1995:155; Trejo and Dirzo, 2002) of Mexico, based on the results of a sample in Quiapaca, Bolivia, whose local diversity (*c.*86 spp./0.1 ha) was comparable to that of Chamela.

13.4.1.1 Mexico-Wide Studies

Trejo (1998) and Trejo and Dirzo (2002), in a landmark study of 20 SDTF sites in Mexico following the basic methodology of Gentry, found that climatic factors alone were not sufficient to explain the differences in diversity between sites. In contrast to Gentry (1982), Trejo and Dirzo's study (2002) included sites from the same biogeographical region, so that climatic factors could be separated from historic and biogeographical ones; they chose sites which included the whole range of environmental variation (precipitation, soils, temperature, rainfall, etc.) in which SDTF is found in Mexico. An important difference in Trejo and Dirzo's sampling protocol was their inclusion of all trees, shrubs and lianas with a dbh ≥ 1 cm, instead of dbh ≥ 2.5 cm. This allowed a more complete picture of the composition and floristic diversity of this forest type, where smaller-stemmed individuals of trees, shrubs and small lianas are an important component (Trejo, 1998; Trejo and Dirzo, 2002), and still yielded a data set that could be compared with Gentry's. For individuals with stems ≥ 2.5 cm dbh,

Northwest
6.3%

Jalisco -Central America
32.6%

Central Coast
25.1%

West Coast Mexico
6.3%

Extended Pacific Slope
17.4%

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FIGURE 13.2 Definition of subregions of distribution patterns restricted to the Pacific slope of Mexico. More precise definitions of the subregions are found in Table 13.2. The percentages are of the Pacific slope flora (Table 13.3, subtotal). Location of Chamela-Cuixmala is indicated by a black star in a white circle.

Trejo and Dirzo (2002) found an average of 58 spp./0.1 ha (a range of 22 to 97) in the 20 sites. The forests of Caleta, Michoacán (97 spp./0.1 ha), and Copalita, Oaxaca (86 spp./0.1 ha), both located on the Pacific Coast (Figure 13.1), had the greatest species diversity and these values were similar to those previously reported from Chamela (Upland 1, 92; Upland 2, 83; Lott et al., 1987). The site at Infiernillo, Michoacán, along the Río Balsas a short distance from the coast, surpassed the number of species expected according to the rainfall model proposed by Gentry by 150%, and this tendency to present more species than those predicted by the model was also found in other sites, where nearly double the predicted number was found.

Two Tamualipan sites, at Las Flores and El Pensil, had only half the number of species predicted by Gentry's model, and they are the two sites with highest annual precipitation, 1370 and 1350 mm respectively. Las Flores (31 families, 55 genera, 61species ≥ 1 cm, 48 species ≥ 2.5 cm), had the third highest total number of species ≥ 30 cm dbh (10), and El Pensil (33 families, 52 genera, 57 species ≥ 1 cm, 41 species ≥ 2.5 cm) was the third highest in number of lianas ≥ 1 cm dbh or greater,

possibly reflecting its history of anthropogenic disturbance. These sites were both richer in families, species and genera than one at Alamos, Sonora (22 families, 40 species ≥ 2.5 cm, 38 genera).

Furthermore, Trejo and Dirzo (2002) found a very high rate of species turnover in their sites: out of 917 species recorded, 72% were present at one site only, and no species was present in all the sites. There was an average similarity of 9% between sites using Sørensen's index.

13.4.2   LOCAL MEXICAN STUDIES

13.4.2.1   Yucatán

The Yucatán has been especially well-studied. Thien et al. (1982) sampled woody vegetation at a Maya archeological site at Dzibilchaltun, Yucatán, on the extreme north — north-western tip of the Yucatán Peninsula. They found plant richness of 50 woody species at ≥ *c.*2.5 cm dbh. Rico-Gray et al. (1988) analyzed composition and structure 'of one of the few patches of late successional — mature deciduous forests left' in the center of Yucatán State, Rancho San Pedro, south of Tixcacaltuyub, Yucatán. A total of 54 species ≥ 1 cm was found, with the largest families found being Leguminosae, Euphorbiaceae and Polygonaceae. For species of ≥ 7.5 cm dbh, Rico-Gray et al. (1988) only found 32% species similarity between their site and that of Thien et al. (1982).

Trejo (1998) also sampled diversity in central Yucatán State, at Sayil: she found 83 species total (that is trees + lianas, at ≥ 1 cm or greater) in 0.1 ha, 65 species at ≥ 2.5 cm or greater and found 53 species of trees ≥ 1 cm. If we accept that the diversity transects of other workers cited above are even roughly comparable, Trejo's number of species at ≥ 1 cm is about the same as Rico-Gray's (1988), and from all these studies there is no indication of high species diversity compared to the Pacific slope SDTF sites in Caleta and Infiernillo, Michoacán; Cañón Zopilote, Guerrero; Copalita, Oaxaca; or Chamela.

Ibarra M. et al. (1995) listed 437 species of trees for the Yucatán Peninsula, from all vegetation types. The largest tree families were Leguminosae, Euphorbiaceae, Rubiaceae and Myrtaceae, while the families with the highest numbers of endemics were Leguminosae, Cactaceae, Polygonaceae and Rubiaceae. Ibarra M. et al. (1995) report 12.3% endemism (54 taxa in 26 families); endemic genera there are *Asemnantha, Goldmanella, Harleya* and *Plagiolophus*.

Studies in the Yuacatan are made difficult by the long human history in these forests. Some studies (refs) have reported small patches of *c.*20 m tall forest surrounded by the lower (8 – 10 m) forest described by Rico-Gray (1988). Although an earlier interpretation was that the tall patches were remnants of primary forest, further study showed them to be dominated by *Brosimum, Manilkara, Sabal* and others known to have been used by the Maya, and still used in their gardens. Some of these patches are ringed by low stone walls (*pet kot*) (Gómez-Pompa et al., 1987).

Phytogeographical relationships of trees from all forest types of Yucatán were studied by Ibarra M. et al. (2002). Of the endemic tree species, about 80% are found in one of the five Mexican Yucatán reserves they analyzed, and 19 species (29.7%) in just one. However, 12 species (18.8%) were not found in any of the five reserves. They noted that more reserves (such as Calakmul, the largest) still needed to be surveyed. Calakmul itself is *c.*1.8 million acres, and a newly acquired reserve to adjoin it is 370,000 acres.

Not sure we need this level of detail of florstics of Rico and Gray's study

13.4.3   CENTRAL AMERICAN STUDIES

Gillespie et al. (2000) sampled seven sites in fragments of SDTF in Costa Rica (Santa Rosa National Park in Guanacaste Province, and Palo Verde) and in Nicaragua (Cosiguina, Masaya, Chacocente and Ometepe), all in conservation areas. They also noted the overall size of the forested area, environmental variables, annual precipitation and degree of human disturbance. Using Gentry's (1982) method, in these seven sites they found a total of 204 species and 1484 individuals ≥ 2.5 cm, with an average of *c.*56 species for the seven sites (ranging from 44 to 75 species), remarkably close to Trejo and Dirzo's (2002) average of 58 species for 20 Mexican sites. Santa Rosa National Park was the richest site,

with 33 families, 60 genera and 75 species. Three other sites, Cosiguina, Masaya, and Ometepe (all in Nicaragua), were significantly less rich than Santa Rosa, and species richness was not significantly different between Santa Rosa and Palo Verde, La Flor, and Chacocente, although there were some significant differences in numbers of tree, shrub or liana species.

Gillespie et al. (2000) then compared their results to 21 other data sets from the West Indies, Mexico (Chamela), northern South America, the Pacific coast of South America, and the 'southern subtropics' of Argentina, Bolivia and Paraguay. They found no significant difference between the diversity of their Central American sites and that of many other neotropical forests, and they stated that the species richness of their sites justifies conservation status. Except for Santa Rosa, Costa Rica, which ranked eighth in total species, tree and shrub species diversity, and Palo Verde, with 65 spp./0.1 ha, the Central American sites were in the bottom half of all the neotropical sites in species richness. No SDTF transect site in Trejo and Dirzo (2002) or Lott et al. (1987) had Bignoniaceae or Sapindaceae in the top two families (although three out of the twenty Trejo and Dirzo sites did have Bignoniaceae in third place). In Gillespie et al.'s (2000) transects, 20% of all stems belonged to Bignoniaceae and Sapindaceae. The level of anthropogenic disturbance may have greatly influenced family composition and vine species (Gillespie et al., 2000; T.W. Gillespie, UCLA, pers. comm., 2005), perhaps because, as Gillespie et al. point out, some families of vines are more resistant to fire than others. The seven Central American sites of Gillespie et al. (2000) were all highly disturbed and had significantly lower density per area than the other neotropical sites they used for comparison. They found a significant correlation between anthropogenic disturbance and species richness (see studies cited in Gillespie et al., 2000).

Gordon et al. (2004) used a plotless rapid species inventory method in mature Oaxacan and highly disturbed, fragmentary Honduran sites. Forest types (hillside, riparian, beach, fallow fields, etc.) were distinguished and surveyed separately. Each site was searched for 4.5 person-hours; woody plants with stem diameters ≥ 2 cm at ground level, including woody stumps but excluding lianas which do not also appear as shrubs, were counted. In 43 sample sites, they found 375 species in 70 families and 210 genera; the Oaxacan sites were more diverse than the Honduran ones at all levels. The findings of Gordon et al. (2004) at the family level were very different from those of Gillespie et al. (2000). At the Honduran sites, the largest families were Leguminosae (37 spp.), Euphorbiaceae and Rubiaceae, with the largest genera *Ficus* (5), *Cordia* (5), *Annona*, *Senna*, *Solanum*, *Trichilia* (4 spp. each). In Oaxaca, the largest families were Leguminosae (64 spp.), Euphorbiaceae (19), Rubiaceae (10); the largest genera were *Bursera* (8), *Caesalpinia* (8), 7 species each in *Acacia*, *Croton* and *Lonchocarpus*, *Ficus* (6), *Cordia* (5), *Capparis* and *Jatropha* (4 each). The difference in the most speciose genera at each of these sites may reveal something of their degrees of disturbance. In our experience it is rare to find *Bursera*, *Lonchocarpus* and *Jatropha* (three of the largest genera in the Oaxacan sites) in highly disturbed sites except as remnants, whereas some species of *Cordia* and *Trichilia*, and many *Senna* and *Solanum* species are commonly associated with disturbed or secondary vegetation.

Please fill in species numbers for Euphorbs and Rubi-aceae

Based on analysis of their results, Gordon et al. (2004) suggested that anthropogenic disturbance and successional status partly explain the latitudinal gradient in species diversity discussed by Gentry (1982, 1988, 1995). The more species rich northern Chamela data sets he used for comparison were taken from relatively more mature undisturbed forest than the highly disturbed southern Guanacaste forests, which were forest remnants on cattle pastures maintained by fire.

13.5 COMPOSITION AND DIVERSITY OF THE CHAMELA FLORA

Direct comparisons between Chamela and other sites are difficult and somewhat tentative partly because while the floristic inventory process at Chamela (at least on the EBCH) and in Sonora is fairly advanced, many other newer reserves and study sites in Mexico are in an accelerating intensive inventory phase, with many additional species being found and new ones being studied and described.

The difficulty with comparisons of diversity studies of Central American sites is the fragmented and highly disturbed condition of what remains there.

13.5.1 LOCAL DIVERSITY

13.5.1.1 Families

To date 125 families of vascular plants have been reported from Chamela-Cuixmala (see floristic checklist, Lott, 2002). The most diverse native families in Chamela are in general those most common in the continental dry forests of the Neotropics (Gentry, 1995) and of Mexico (Trejo and Dirzo, 2002). The family with the greatest number of species (160 species; 14.0% of the flora) is Leguminosae (Caesalpiniodeae: 33 species; Mimosoideae: 47 species; Papilionoideae: 80 species) followed by Euphorbiaceae, with 94 species. These two families make up almost a fourth (22.2%) of the total flora. They are followed in importance by: Compositae (62 spp.), Gramineae (57 spp.), Convolvulaceae (40 spp.), Malvaceae (39 spp.), Solanaceae (29 spp.), Rubiaceae (29 spp.), Acanthaceae (27 spp.), Bromeliaceae (26 spp.), Cucurbitaceae (23 spp.), Verbenaceae (23 spp.) and Boraginaceae (22 spp.). All these, except for Bromeliaceae and Cucurbitaceae, are among the 20 most diverse families in the SDTF sites of Gentry (1995). While Gentry (1995) found that continental dry forests are 'dominated' by Leguminosae and Bignoniaceae and that 'Bignoniaceae are the indisputed number two family of woody plants of neotropical dry forests, averaging …twice as many as third place Rubiaceae' (1995:170-179), the Bignoniaceae and Rubiaceae do not seem to play as large a part in Mexican SDTFs, at least as represented in the transects of Trejo (1998).

In almost all neotropical forests the legume family has been found to be the richest in species (Gentry, 1988; Villaseñor and Ibarra M., 1998) and in all the SDTF sites discussed by Gentry (1995), Euphorbiaceae and Gramineae were among the four most diverse families, and Convolvulaceae and Compositae among the first seven. It is less common that Euphorbiaceae occupies second place (Gentry, 1995), but Chamela shares this characteristic with forests of the Antilles and with other sites on the Pacific slope of México (Trejo and Dirzo, 2002), as well as the Oaxacan and Honduran sites of Gordon et al. (2004).

The family Myrtaceae, of great importance in Antillean SDTF (Gentry, 1995), in our area is represented by only two genera, *Eugenia* and *Psidium*, and four species. Of the three species of *Eugenia* reported in Chamela two are endemic to Jalisco, and *Psidium sartorianum* (Berg) Ndzu. is the only species of the family which Chamela shares with the Antilles. According to J. Ratter (Royal Botanic Garden Edinburgh, pers. comm., 2005), 'In general, Myrtaceae seem to be calcifuges but *P. sartorianum* is a calcicole exception'. Since the Chamela area soils are igneous-derived, not limestone like Yucatán and Cuba, perhaps its presence at Chamela indicates that *P. sartorianum* has wider edaphic tolerances than many other Myrtaceae.

There is not a complete correspondence between species richness in the flora and abundance of individuals in the forest (Lott et al., 1987). There are families which may be considered typical of arid or semiarid conditions such as Burseraceae, Cactaceae, Capparaceae and Zygophyllaceae (Rzedowski, 1978); these are not found among the most important families in number of species, but certain species are very abundant in the SDTF.

Few species belonging to the families Aizoaceae, Basellaceae, Campanulaceae, Cannaceae, Caryophyllaceae, Cruciferae, Hydrophyllaceae, Martyniaceae, Onagraceae (except for *Hauya*), Papaveraceae and Umbelliferae occur in the Chamela region, and these are represented only by species of ephemeral habitats such as riparian (riverbeds or sandbars which are subject to violent changes by seasonal movement of water), and areas with a high level of anthropogenic disturbance. These families are primarily of more boreal affinities (Good, 1974).

The pteridophytes of Chamela have their affinities to the south. All of them (except *Cheilanthes lozanii* (Maxon) R. & A. Tryon), are of wide distribution in Mexico, Central America and South America (Lott, 2002). The richness of this group in other areas of SDTF is also somewhat distinct

[Margin note left:] Theinformation in this para (Trejo, Gillespie, already given in previous section)

[Margin note right:] I don't think the comparisons to rain forests as very relvane to the the. Hope this is OK.

compared to Chamela. In the state of Sonora, near the northernmost limit of SDTF, Van Devender et al. (2000) reported 18 species of pteridophytes for the flora of the Río Cuchujaqui, a region of less precipitation, but with appreciable winter rains from January to March, and Martin et al. (1998) reported 48 species of pteridophytyes in the flora of the Río Mayo (the larger region of which the Cuchijaqui drainage is a part), of which only five are also found in Chamela. These differences from Chamela are possibly due in part to the higher altitude and more sheltered canyon environment of the Sonoran sites. The narrow canyons provide protection from cold northerly winds and from long exposure to the sun (Martin and Yetman, 2000). At the other geographical extreme, Janzen and Liesner (1980) reported 71 species of pteridophytes for the flora of Guanacaste Province, Costa Rica, of which only six species are shared with Chamela. Gentry (1995) considered that this reflects an ecological, not a phytogeographical difference, owing to the fact that in Guanacaste there is a gallery forest which provides a microhabitat similar to more humid forests, and thus more favorable for ferns.

13.5.1.2 Genera

At the generic level the flora of Chamela-Cuixmala is diverse for an area its size, with 555 genera. The most speciose genera are *Ipomoea* (26)*, Tillandsia* (17)*, Croton* (16)*, Mimosa* (13)*, Cyperus* (13)*, Acalypha* (13)*, Solanum* (12)*, Lonchocarpus* (13)*, Phyllanthus* (11)*, Euphorbia (11), Cordia (11), Acacia* (11) and *Senna* (11). A notable characteristic is that four of the largest thirteen genera, *Croton*, *Acalypha*, *Phyllanthus*, and *Euphorbia* (51 species in total), belong to the family Euphorbiaceae. Among the most diverse genera (> 10 spp.), *Lonchocarpus* is the only entirely arborescent one, and almost all its species in Chamela are endemic to the Pacific slope, besides being very abundant (Lott et al., 1987). *Bursera* (9 spp.), *Caesalpinia* (9 spp.) and *Jatropha* (7 spp.), are genera which play an important role due to their abundance and number of species in the SDTF. The other most diverse genera are represented by herbaceous species (*Cyperus,* and *Solanum* in part), epiphytes (*Tillandsia*), shrubs (*Croton*, *Acalypha*, *Mimosa*, and *Acacia* in part), or herbaceous climbers (*Ipomoea* in part).

Some of these genera are associated with specific communities or habitats. *Cyperus*, *Solanum* and *Phyllanthus*, which also are important in humid forests, are typically found here in riparian sites or in the understory of more humid microhabitats. The genera present in Chamela which are important in arid zones are principally of cosmopolitan or pantropical distribution such as *Acacia, Aristida, Caesalpinia, Cassia, Jatropha, Mimosa, Randia, Salvia* and *Solanum* (Rzedowski, 1973). Several genera which are very diverse in other Mexican SDTF sites, such as *Bursera*, *Jatropha*, *Lonchocarpus*, *Croton* and *Ipomoea* (Trejo and Dirzo, 2002), contribute a relatively high proportion of species endemic to our region. However, it should be noted that *Lonchocarpus* is also very diverse in lowland tropical humid forests of Mexico, more so than in similar forests of South America (Wendt, 1993).

In the Chamela-Cuixmala region the diversity of species of *Ipomoea* is especially noteworthy. Of the 26 species of the genus in our area, only two or three are exotic. Also, some of the species of *Ipomoea* are found in disturbed sites, where they play an important role in secondary succession. A group of *c.*14 arborescent, shrubby and stout liana species of *Ipomoea* (Carranza et al., 1998; Carranza and McDonald, 2004; McDonald, 1991), represented in Chamela by *I. wolcottiana* Rose, is practically restricted in distribution to Mexico and Central America in SDTFs and in arid scrub (*matorral xerófilo*). In Mexico there are approximately 146 species of the genus *Ipomoea*, 77 of which are found in the south-west of the country, from Jalisco to Oaxaca. Of these, 25 are endemic, almost all in SDTF.

Maybe a bit too much detail about Ipomoea?

13.5.2 DIVERSITY OF LIFE FORMS

13.5.2.1 Trees (227 Species)

Trees here are classified as woody individuals 4 m or more tall, single stemmed, or branched above 1.3 m breast height. Not surprisingly, the family with the greatest number of trees is Leguminosae

(57 species), with 23.4% of the trees of the total flora. Representative genera include include *Albizia*, *Caesalpinia*, *Lonchocarpus*, *Lysiloma*, *Mimosa*, *Platymiscium* and *Poeppigia*. Euphorbiaceae (26 spp.) is the second largest arborescent family. Families of trees which are common in Chamela but absent in the Sonoran SDTF (Río Cuchujaqui, Van Devender et al., 2000; Felger, 2001) include Anacardiaceae, Annonaceae, Nyctaginaceae, Polygonaceae and Solanaceae. On the other hand, the most important families of trees in the Río Cuchujaqui SDTF are Cactaceae, Convolvulaceae (arborescent species of *Ipomoea*), Moraceae (*Ficus*), Fouquieriaceae and Zygophyllaceae; all these are present in Chamela-Cuixmala except for Fouquieriaceae, a family which is associated with greater aridity. Felger et al. (2001) report 141 species of SDTF trees, (51%) of the total in *Trees of Sonora*, whereas 229 of tree species are reported from Chamela SDTF.

13.5.2.2   Shrubs (227 Species)

The differentiation between shrubs and trees is arbitrary. For purposes of this study we interpreted shrubs as woody individuals (usually up to 4 – 6 m tall), with various branches or trunks from the base or near the base, or shrubs of modest stature and single stems ('*vara*' or treelet type). The families with the greatest number of shrub species are Leguminosae (19%), Euphorbiaceae (13.9%), Malvaceae (6.3%), Rubiaceae (5.5%), Cactaceae (4.6%), Compositae (4.6%), Acanthaceae (4.2%) and Solanaceae (4.2%). Some very conspicuous shrub genera in Chamela-Cuixmala are *Acacia*, *Acalypha, Bauhinia*, *Caesalpinia*, *Capparis, Casearia, Croton, Erythroxylum, Indigofera*, *Mimosa*, *Piper*, *Psychotria* and *Senna*.

13.5.2.3   Lianas and Vines (197 Species)

There are many species of vines and we recognize two types of scandent plants: herbaceous climbers (86 species; stems strictly herbaceous), and woody climbers (111 species; base and some stems woody. The mechanisms by which these species climb are diverse: tendrils, twining, hooks and spines, scrambling, and having rough-textured leaves which prevent slippage (see Burnham and Lott, 1999).

Of the 25 climbing species of *Ipomoea*, two are lianas, *I. bombycina* (Choisy) Benth. & Hook. F. and *I. bracteata* Cav.. The rest are herbaceous, slender-stemmed (< 1 cm) climbers with fleshy roots. These climbing heliophytes take advantage of the insolation of the open canopy and of clearings to grow rapidly at the beginning of the rainy season. Their growth is correlated with the seasonality to which the SDTF is subject.

Other important genera of lianas and woody climbers are *Arrabidaea*, *Clytostoma*, *Cydista* (Bignoniaceae); *Heteropterys, Hiraea*, *Tetrapterys* (Malpighiaceae); *Forsteronia*, *Marsdenia, Prestonia* (Asclepiadaceae); *Paullinia, Serjania* (Sapindaceae); *Combretum* (Combretaceae); *Liabum, Otopappus* (Compositae); *Entada* (Leguminosae); and *Hemiangium, Hippocratea,* and *Pristimera* (Hippocrateaceae). The most speciose families of herbaceous climbers in Chamela-Cuixmala are Cucurbitaceae, Leguminosae, Convolvulaceae and Dioscoreaceae.

As for the distribution patterns of the climbers within the forest, Lott et al. (1987) found that lianas are three times more numerous in the arroyo (a gully or seasonally dry streambed) forest than on the hillsides. This is possibly explained by the greater abundance of clearings in the arroyos and also because there is greater availability of moisture (G. Cabbalé, pers. comm.).

13.5.2.4   Epiphytes (40 Species)

Epiphytes compose 3.9% of the total flora. Here we include parasitic shrubby hemiepiphytes of the families Loranthaceae and Viscaceae as well as more 'conventional' epiphytes. All species of *Ficus* were classified as trees, although some of them begin life as hemiepiphytes.

Among the families which make up the group of epiphytes are Bromeliaceae, Loranthaceae/Viscaceae, Orchidaceae and Cactaceae. Bromeliaceae is the most important family in terms of number

of species present, and probably in number of individuals as well. In this family *Tillandsia* (with 17 species) is the predominant genus, with some species abundant and showy (for example, *T. fasciculata* Sw. var. *venosispica* Mez ex DC., perched high in the canopy with its conspicuous and attractive red and yellow inflorescence, or *T. paucifolia* Baker which appears as dense twisted gray chains of individuals). In this group, slope and insolation noticeably influence local abundance (Medina, 1995; S. Bullock, Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico, pers. comm.).

Again, I'm not sure the comparisons with rain forests are relevant here

There are no reports of epiphytic ferns in Chamela and the same scarcity of epiphytic ferns was found in all the SDTF sites sampled by Gentry (1995).

13.5.2.5   Herbs (366 Species)

Herbs are the predominant life form in the flora, with 371 species (34.9% of the total of native species). The largest families are Gramineae, Compositae, Euphorbiaceae, Leguminosae, Malvaceae, Cyperaceae, Acanthaceae, Solanaceae, Labiatae, Nyctaginaceae, Polypodiaceae and Amaranthaceae. The abundance of herbs is most noted in the rainy season, their period of vegetative growth. There is a tendency to consider the herbaceous plants as annual. Nevertheless, and although we have no exact data, the herbaceous natives apparently are predominantly perennial and survive the annual dry season by means of succulent or woody roots. In contrast to communities where herbaceous plants are principally found in disturbed areas, in the SDTF, many of these species form an important part of the understory.

13.6   PHYTOGEOGRAPHIC ANALYSIS OF DISTRIBUTION PATTERNS AND ENDEMISM

Although knowledge of the flora of Chamela-Cuixmala is sufficiently advanced to permit an analysis of the patterns of geographical distribution, the full neotropical distributions of many of the species are still uncertain and therefore any analysis of the biogeographical patterns must be considered tentative. Nevertheless, we are reasonably confident that the phytogeographical affinities reported here will be sufficiently reliable not to be changed by future discoveries.

The biogeographical patterns we have recognized are presented in Table 13.2. The geographical distributions of the Chamela flora used here were based on critical review of herbarium records and on the recent literature. Only the 1064 species considered native were included in the analysis. We excluded species with unresolved taxonomic problems, species probably new to science but not yet adequately studied, species not determined because of lack of sufficient material for identification (*Daphnopsis* sp., *Schoepfia* sp.), or for lack of other kinds of reliable information. This assured a conservative estimate of the number of endemic species.

The floristic assemblages forming the biogeographical units in Table 13.2 are based on overall distributions with a given species assigned only to the unit where it is regarded as most characteristic. However, this does not mean that species are restricted to a single unit; they may be found in others in which they are less characteristic. In the following pages we discuss these patterns in detail.

13.6.1   PACIFIC SLOPE

A high percentage of the flora of the region is limited, in different degrees, or is endemic to the Pacific Slope of Mexico and Central America (40.7%, Table 13.3; Figure 13.1). The most important subdivisions include the *strictly local* element (Jalisco: 2.6%), Central Coast (Jalisco-Oaxaca: 9.7%), and Pacific slope of Mexico (Baja California to Oaxaca: 8.4 %). *Leucaena lanceolata* S. Wats. is a good example of a wide-ranging Pacific slope species; it ranges from Sonora and Baja California to Chiapas, with small outpost on the coast of Veracruz. It also has a variety, *L. lanceolata* var. *sousae* (S. Zárate) C.E. Hughes, which is restricted to coastal Michoacan, Guerrero and Oaxaca (Hughes, 1998).

TABLE 13.2
Definition of Biogeographic Patterns

Principal Pattern	Secondary Pattern	Definition of Secondary Pattern
Pacific coast[a]	North-west	Jalisco to Sonora and Baja California Sur. Includes the Islas Tres Marías
	Jalisco (only)	Exclusively Jalisco. In many cases these are relatively recently described species known only from the type locality.
	Central coast	Jalisco to Oaxaca (effectively to the Isthmus of Tehuantepec)
	Mexico	Occurs in the northwest and central coast
	Chiapas-Guatemala	Jalisco to Guatemala
	Central America	Jalisco to Panama along the Pacific Coast
	Widespread dist.	Occurs in the northwest and central coast of Mexico, and also from Chiapas to Panama
Mexico[b]	Bicoastal	Occurs on the Pacific and Atlantic coasts
	Interior	Occurs on the Pacific and Atlantic coasts but also found in the interior of Mexico
Widespread neotropical[c]	To Central America	Occurs on the Pacific and Atlantic coasts. May include areas bordering the Gulf of Mexico and the Atlantic coast of the U.S.A.
	To South America	Occurs on the Pacific and Atlantic coasts but extending to South America

[a]The species included here are not found outside the Pacific slope of Mexico and Central America.
[b]Limited to Mexico in the broad sense, including US border states.
[c]Present on both coasta, may also occur in the Caribbean.

In general the endemism is at the level of species, not of genus or family. McVaugh (1961), in a study of some Euphorbiaceae of Nueva Galicia, commented that the western part of the region includes an important endemic element, and that perhaps half of the endemic or nearly endemic species were found in the area of very strong dry periods. McVaugh pointed out that the closest relationships of the SDTF in the coast of Nueva Galicia are with Michoacán and the Sierra Madre del Sur. Many species have distributions ranging up to central Sinaloa, and others also to the extreme southern end of Baja California, but there is little relationship with the flora of the coastal plain of Sonora. Later McVaugh (1983: 1) reiterated this conclusion: 'Relatively few species are strictly confined within the borders of Nueva Galicia, but approximately half of all the known species have their primary areas of distribution on the Pacific side of Mexico, north to central Sinaloa (a few to Sonora, southwestern Chihuahua or southern Arizona), and southeastward to Guerrero or Oaxaca'.

According to Rzedowski (1978) and Gentry (1995), there are numerous genera endemic to the Pacific slope, and Trejo (1998) found 20 genera endemic to Mexican SDTF out of 368 in her transects. Of the four endemic genera of the Pacific slope reported by Lott (1993) for Chamela, *Celaenodendron, Chalema*, *Dieterlea* and *Mexacanthus,* three are still considered valid today because *Celaenodendron* was synonomized with *Piranhea* (Radcliffe-Smith and Ratter, 1996). *Dieterlea* includes two species (McVaugh, 2001), both native to the Pacific slope of Mexico. *Holographis*, *Lasiocarpus*, *Cheileranthemum* (3 species), *Lagascea*, *Conzattia* (2 species) and *Willardia* also have been cited as genera principally endemic to Mexico, though *Willardia* is now accepted as a section (with six species) of the genus *Lonchocarpus* (Sousa S., 1992). None of the three genera endemic to the Río Balsas Basin (*Backebergia* (Cactaceae), *Haplocalymma* (Asteraceae), and *Pseudolopezia* (Onagraceae)), are yet known to occur in Chamela-Cuixmala.

Myrospermum was cited by Gentry (1995: 188) as the only SDTF-restricted genus found in Costa Rican diversity samples which does not also occur in western Mexico (the genus has since been

TABLE 13.3
Tabulation of Life Forms and Geographical Distributions. In Each Cell, the First Number is the Percentage for That Particular Life Form, and the Second (in Parenthesis) is the Number of Species. Both the Geographical Patterns Defined Here and the Life Forms Represent Mutually Exclusive Categories

Principal Pattern	Secondary Pattern	Tree	Shrub	Epiphyte	Herb	Woody Vine	Herbaceous Vine	Total
Pacific slope	Northwest (BCS-Jal)	4.4 (10)	3.5 (8)	0 (0)	1.3 (5)	1.8 (2)	3.5 (3)	2.6 (28)
	Jalisco only	3.5 (8)	11.5 (26)	0 (0)	3 (11)	4.5 (5)	4.7 (4)	5.1 (54)
	Central Coast (Jal-Oax)	16.2 (37)	12.3 (28)	20 (8)	4.9 (18)	10.8 (12)	9.3 (8)	10.4 (111)
	widespread Mexican coast (BCS-Oax)	4.4 (10)	2.2 (5)	0 (0)	2.7 (10)	0.9 (1)	2.3 (2)	2.6 (28)
	Jalisco-Chiapas-Guatemala	9.6 (22)	18.1 (41)	10 (4)	10.5 (39)	9 (10)	7 (6)	11.5 (122)
	Jalisco-Central America	2.6 (6)	0.4 (1)	2.5 (1)	2.2 (8)	1.8 (2)	4.7 (4)	2.1 (22)
	Widespread BCS-Central America	8.7 (20)	5.3 (12)	10 (4)	5.9 (22)	11.7 (13)	7 (6)	7.2 (77)
	Subtotal	49.3 (113)	53.3 (121)	42.5 (17)	30.5 (113)	40.5 (45)	38.4 (33)	41.5 (442)
México	Bicoastal	2.2 (5)	1.3 (3)	2.5 (1)	2.4 (9)	2.7 (3)	1.2 (1)	2.1 (22)
	Interior	2.2 (5)	3.1 (7)	2.5 (1)	2.2 (8)	1.8 (2)	2.3 (2)	2.3 (25)
	Subtotal	4.4 (10)	4.4 (10)	5 (2)	4.6 (17)	4.5 (5)	3.5 (3)	4.4 (47)
Widespread neotropical	To Central America	16.2 (37)	15.4 (35)	17.5 (7)	10 (37)	19.8 (22)	8.1 (7)	13.6 (145)
	To South America	30.1 (69)	26.9 (61)	35 (14)	55 (204)	35.1 (39)	50 (43)	40.4 (430)
	Subtotal	46.3 (106)	42.3 (96)	52.5 (21)	65 (241)	55 (61)	58.1 (50)	54 (575)
Grand total		21.5	21.3	3.8	34.9	10.4	8.1	
		229	227	40	371	111	86	1064

reported from the Río Balsas Basin (Fernández et al., 1998)), and he listed ten 'western Mexican dry-forest-restricted genera which do not reach Guanacaste: *Amphipterygium*, *Apoplanesia*, *Comocladia*, *Elaeodendron*, *Hintonia*, *Lagrezia*, *Pachycereus*, *Peniocereus*, *Recchia* and *Stenocereus*'. Trejo (1998) found 20 genera endemic to Mexico out of 368 found in her transects. So from the generic point of view, Mexico's SDTF appears to be higher in endemism than that of southern Central America.

13.6.1.1 North-West (BCS-Jalisco)

There is a low percentage (Table 13.3: 28 species, 2.6%) of species restricted to the distribution pattern of Jalisco to Sonora (or further north) and Baja California Sur. In fact, when we examine this group of species we find that only species such as *Amaranthus palmeri* S. Wats., *Diospyros* aff. *rosei* Standl., *Gomphrena sonorae* Torr., *Randia mollifolia* Standl. and *Sida alamosana* S. Wats. are distributed from Jalisco to Sinaloa, Sonora or Baja California Sur, and that the greater proportion of the species in this pattern are restricted to Jalisco and Nayarit. This suggests that the principal zone of endemism in reality is the central coast of the Pacific (Jalisco to Oaxaca) and that Chamela is in the extreme north, not in the center.

There is the strong likelihood of a real relationship (not an artifact of collection) between the Islas Tres Marías and the coast of Nayarit and Jalisco. Some examples of species with this distribution pattern are *Astrocasia peltata* Standl., *Cephalocereus purpusii* Britton & Rose, *Esenbeckia nesiotica* Standl., *Jatropha malacophylla* Standl., *Matayba spondioides* Standl., *Peniocereus rosei* Gonzalez-Ortega, *Trixis pterocaulis* B. L. Rob. & Greenm. and *Piranhea* (*Celaenodendron*) *mexicana* (also reported from Colima). This relationship may reflect a common geological history before the separation of the Baja California Peninsula (T.R. Van Devender, Arizona-Sonora Desert Museum, pers. comm.).

Another interpretation that can be drawn from these data is that there are practically no species in Chamela-Cuixmala whose principal distribution is the arid zones of northern Mexico (see also the section on Mexican Distribution, below). Based on the main part of their distributions, apparently the species of the coastal region extend their area of distribution toward the desert and not the reverse. Studies in Sonora by Martin et al. (1998) and by Van Devender et al. (2000) are clarifying the floristic relationship between Chamela-Cuixmala and the northern limit of SDTF in Sonora and Baja California Sur.

Van Devender et al. (2000) reported 734 species in 429 genera and 115 families in the flora of the Río Cuchujaqui in the south of Sonora. These authors found that 22.4% (251 species) of the species of Chamela-Cuixmala (taken from Lott, 1993, not 2002) also occur in that region, although this figure includes all the species of wide distribution (principally herbs). On the other hand, the flora of Río Cuchujaqui shares only 10% of the species of trees and 5.5% of the woody vines, confirming that although physiognomically the two forests are similar, their floristic composition is very different. Some endemic taxa in Sonoran SDTF (including parts of neighboring Chihuahua or Sinaloa) are *Ageratina sandersii* B.L. Turner, *Anisacanthus thurberi* (Torr.) A. Gray, *Bouteloua quiriegoensis* Beetle, *Brongniartia alamosana* Rydb., *Bunchosia sonorensis* Rose, *Caesalpinia palmeri* S. Wats., *C. caladenia* Standl., *Cardiospermum cuchujaquense* M.S. Ferrucci & Acev.-Rodr., *Coccoloba goldmanii* Standl., *Echinocereus stoloniferus* W.T. Marshall var. *stoloniferus*, *Euphorbia alatocaulis* V. W. Steinm. & Felger, *E. dioscoreoides* subsp. *attenuata* V.W. Steinm. (better regarded as a species, V. Steinmann, Rancho Santa Ana Botanical Garden, California, pers. comm., 2005), *Galactia* sp. nov., *Haematoxylum* sp. nov., *Havardia mexicana* (Rose) Britton & Rose, *Holographis pallida* Leonard & Gentry, *Lysiloma watsonii* Rose, *Mammillaria standleyi* (Britton & Rose) Orcutt, *Opuntia thurberi* Engelm. and *Tetramerium yaquianum* T.F. Daniel.

13.6.1.2 Jalisco Only

Due to the low number of species (27 species, 2.6% of the total) present in Chamela which apparently are known only from the state of Jalisco, (even if we consider the 44 species, 6.8% of the total, endemic to Jalisco and one other neighboring state (E.J. Lott, unpublished database, and L. Hernández López,

Centro Universitario de Ciencias Biológicas y Agropecuarias, Jalisco, Mexico, pers. comm.), it is doubtful that Chamela-Cuixmala in itself represents a center of very restricted and isolated endemism, but rather it forms part of a related coastal belt. These data suggest that Chamela and the two sites studied by Trejo and Dirzo (2002) in our 'Pacific slope: Central Coast' region are among the most diverse SDTFs of Mexico, but more in-depth work is needed to determine the similarity of floristic composition between them. Many of these restricted species are recently described (or yet to be described) (Lott, 1993), and at least some are probably actually wider-ranging. In the case of some supposed local endemics, known only from the Chamela region when first described (such as *Chalema synanthera* Dieterle, *Dieterlea fusiformis* E.J. Lott, *Manfreda chamelensis* E.J. Lott & Verhoek*, Croton chamelensis* E.J. Lott, *Jatropha bullockii* E.J. Lott*, J. chamelensis* Perez-Jimenez and *Verbesina lottiana* B.L. Turner & Olsen), within a few years of their publication they were found in sites further away on the Pacific Coast. Some of the endemic species of the region will indeed be found to be of very limited distribution or to be actually rare plants. Hernández López (1995:14) calculated that, in the endemic flora of Jalisco, almost 50% of the endemic species have been reported from only one or two populations, followed by species with an intermediate number of populations, and in third place, those of very wide distribution in Mexico. This proportion is the opposite of that calculated for the flora of Mexico as a whole by Rzedowski (1991a), who proposed that the majority of the total endemic flora would consist of species of relatively wide distribution, followed in number by those of intermediate distribution.

Some species of Chamela-Cuixmala which have not yet been reported from other localities are: *Bourreria rubra* E.J. Lott & J.S. Miller*, Schaefferia lottiae* Lundell*, Bonamia mexicana* McDonald*, Acacia chamelensis* L. Rico*, Acalypha gigantesca* McVaugh*, Lonchocarpus minor* Sousa*, Styphnolobium protantherum* Sousa & Rudd*, Malpighia emiliae* W.R. Anderson*, Mirabilis russellii* Le Duc and *Lantana jaliscana* Moldenke.

De;eted because this issue is dealt with in the para above

Recently, several floristic projects in Colima and Jalisco have sought a better understanding of patterns of local endemism. Based on a census of herbarium collections and a critical revision of the literature, Hernández López (1995) made a preliminary inventory of the endemic flora of the State of Jalisco; for the state she found that 9% of the estimated total flora (*c.*5500 species) was endemic to Jalisco and one neighboring state ('near-endemics'), and another 5.4% of species are strictly limited to the state ('strict endemics'), giving a total of approximately 14.4% endemic to Jalisco and to one or another neighboring state. This same author indicated that Chamela was one of the four important centers of endemism in Jalisco-Colima, but cautioned that possibly this was due to intensive collecting in the general area of the EBCH relative to other parts of the state, and we think that this is most likely the case. A program of collecting in targeted areas of Jalisco which were poorly represented in herbaria has resulted from Hernández López's study.

There is little evidence of a tight relationship between the coast of Jalisco and the Cape region of Baja California Sur. The latter region has a very interesting endemic component: in the SDTF, endemic genera are *Carterella* (Rubiaceae), *Clevelandia* (Scrophulariaceae) and *Faxonia* (Asteraceae; possibly extinct). Aside from its own endemic species (37 (12.3%) out of 454 species reported by León de la Luz et al., 1999, including *Caesalpinia pannosa* Brandegee), the principal component of the SDTF flora of the Cape region consists of a subset the flora which we call endemic to the Pacific slope, some of them shared with Chamela-Cuixmala. Other shared species are of Sonoran distribution or of wide neotropical distribution.

13.6.1.3   Central Coast (Jalisco-Oaxaca)

The group of species whose distribution is limited to the coast from Jalisco to Oaxaca (Table 13.3: 10.4%) is the largest component of the group restricted to the Pacific slope. Lott et al. (1987) estimated that 16% of the species of the SDTF (excluding SM, that is) of the EBCH were endemic to the coast of Sinaloa-Guerrero. In the present work we did not calculate that area separately, but we found that 14.9% (Table 13.4) of the species belonging to the SDTF in Chamela are restricted to Jalisco-Oaxaca, a figure very similar to the former one. If we expand our concept of the coast to

TABLE 13.4
Tabulation of Patterns of Geographical and Plant Communities. In Each Cell, the First Number is the Percentage for That Particular Community, and the Second is the Number of Species (in Parenthesis). The Plant Communities do not Represent Mutually Exclusive Categories (a Species may Exist in More Than One Community)

Principal Pattern	Secondary Pattern	SDTF	Semi-Evergreen Forest (SM)	Halophytes	Beach	Riparian	Aquatic	Disturbed Areas
Pacific slope	Northwest (BCS-Jal)	3.9 (22)	2.1 (4)	0 (0)	0 (0)	1 (1)	0 (0)	1.3 (3)
	Jalisco only	6.4 (36)	4.2 (8)	2.6 (1)	5.7 (2)	2.9 (3)	0 (0)	0.9 (2)
	Central Coast (Jal-Oax)	14.9 (84)	8.4 (16)	0 (0)	8.6 (3)	3.9 (4)	0 (0)	4.5 (10)
	widespread Mexican coast (BCS-Oax)	14.4 (81)	13.2 (25)	10.3 (4)	11.4 (4)	9.7 (10)	7.7 (1)	4.9 (11)
	Jalisco-Chiapas-Guatemala	2.8 (16)	2.1 (4)	0 (0)	2.9 (1)	2.9 (3)	0 (0)	2.7 (6)
	Jalisco-Central America	2.5 (14)	3.2 (6)	0 (0)	2.9 (1)	1 (1)	0 (0)	1.3 (3)
	Widespread BCS-Central America	7.3 (41)	8.4 (16)	2.6 (1)	14.3 (5)	6.8 (7)	0 (0)	3.6 (8)
	Subtotal	52.3 (294)	41.6 (79)	15.4 (6)	45.7 (16)	28.2 (29)	7.7 (1)	19.3 (43)
México	Bicoastal	2.5 (14)	1.6 (3)	0 (0)	2.9 (1)	1 (1)	0 (0)	0.9 (2)
	Interior	2.8 (16)	2.6 (5)	2.6 (1)	2.9 (1)	3.9 (4)	0 (0)	1.3 (3)
	subtotal	5.3 (30)	4.2 (8)	2.6 (1)	5.7 (2)	4.9 (5)	0 (0)	2.2 (5)
Widespread neotropical	To Central America	12.6 (71)	18.4 (35)	5.1 (2)	5.7 (2)	12.6 (13)	7.7 (1)	12.6 (28)
	To South America	29.7 (167)	35.8 (68)	76.9 (30)	42.9 (15)	54.4 (56)	84.6 (11)	65.9 (147)
	subtotal	42.3 (238)	54.2 (103)	82.1 (32)	48.6 (17)	67 (69)	92.3 (12)	78.5 (175)
Grand total		562	190	39	35	103	13	223

include those species restricted to some part of the region from Sonora and the Cape of Baja California Sur to Oaxaca, this number increases to 25.2%, (Table 13.4: total North-west, Jalisco only and Central Coast categories).

13.6.1.4   Río Balsas Basin

There is a very large number of species which are endemic to the Río Balsas Basin (Fernández et al., 1998). Trejo and Dirzo (2002) estimated that about 45% of the species at their site in Cañón del Zopilote, Guerrero, and 30% of the species of the site in Infiernillo, Michoacan, are restricted to the Balsas basin. Several workers (Kohlman and Sánchez C., 1984; Rzedowski, 1991a) consider that the Balsas Basin represents a distinct area of endemism. There are various indications that species-level endemism in Río Balsas Basin SDTF is high: of 45 species of *Bursera* reported in Fernández et al. (1998), around half are endemic. Every zone we have looked at, including Nicaragua, has at least one endemic species of the *Caesalpinia Poincianella-Erythrostemon* group: the Balsas basin has five species (Lewis, 1998); *Brongniartia* and *Desmodium* are also very speciose here.

13.6.1.5   Jalisco-Chiapas-Guatemala

The number of species whose distribution extends along the southern Pacific slope from Jalisco to Chiapas-Guatemala (Table 13.3: 11.5%) or to Central America (Table 13.3: 2.1%) totals 13.6%. This figure is significantly greater than the contribution of species which are found from the Northwest to Jalisco (2.6%), and also supports the idea that the center of the Pacific Coast distribution group is to the south of Chamela.

13.6.1.6   Conclusions on the Endemic Element of the Pacific Slope

We have demonstrated that in the Chamela flora there is an important element of species restricted to different subdivisions of the Pacific slope of Mexico and of Central America, which together form a distinctive flora. Apparently Chamela-Cuixmala and the coast of Jalisco are not an important center of endemism of the region as had been suggested earlier (Gentry, 1995; Hernández López; 1995) but rather the center of endemism extends from the coastal region of Jalisco to Oaxaca. Adding species which are restricted to the coast of Jalisco and the North-west or of Jalisco to Central America has a relatively unimportant effect, which supports the idea that Jalisco-Oaxaca is the center of distribution of this element. Once we have enough information to analyze the SDTFs of Oaxaca in the same manner, it may be that the center will be further to the south. The principle of the mid-range effect (Colwell and Lees, 2000) predicts that highest species diversity should be in geographically central areas. This would imply that the centre of SDTF species diversity on the Pacific slope should be in Guerrero, midway between Sonora in the north and Costa Rica in the south. Our data do not contradict this.

The Central Coast of Mexico (Jalisco-Oaxaca) is delimited to the North-west by arid zones. SDTF in the Sonoran zone is rather restricted to hillsides and canyons at intermediate elevations (200 – 500 m), not to the coastal plain (Martin et al., 1998, Van Devender et al., 2000). Towards the south-east, the Isthmus of Tehuantepec marks a transition to regions of greater annual precipitation distributed over a longer annual period. What is most characteristic of the present-day environment of the endemic element of the Pacific slope is the marked dry season, and to a lesser degree its low elevation.

Although we have not done an analysis of endemism of the Balsas River Basin based on the recent checklist (Fernández et al., 1998) and other floristic studies, every indication is that the endemic element is substantial. Relative to the Coast, it has a greater topographic complexity and in many parts has a more extreme climate as far as precipitation is concerned (Trejo, 1999; Trejo and Dirzo, 2002) which might help to explain its level of endemicity.

13.6.2 DISTRIBUTION IN MEXICO

The species known from the region of Chamela-Cuixmala whose distribution is restricted to Mexico (in the sense of 'Megaméxico III' of Rzedowski, 1991a), but which include the Gulf of Mexico or the Caribbean are relatively few (Table 13.3: 4.4%). Although there are many species in common between the coast of Jalisco and the coast of the Gulf of Mexico, only 2.1% of them are restricted to Mexico. The rest are of broad neotropical distribution.

13.6.3 BROAD NEOTROPICAL DISTRIBUTION

The other large group of species of our region, almost the same size as that of the Pacific slope flora, is that of broad neotropical distribution (54%, Table 13.3). Within this group the greater part are distributed to southern South America (40.4% of the total, 80% of the subcategory). Among those species of continuous distribution from Mexico to South America, some are characteristic of secondary vegetation and disturbed sites, such as *Byttneria aculeata* Jacq., *Celtis iguanaea* (Jacq.) Sarg., *Cochlospermum vitifolium* (Willd.) Spreng*., Cordia alliodora* (Ruiz & Pav.) Oken*, Guazuma ulmifolia* Lam., *Lasiacis ruscifolia* (H.B.K.) Hitchc., *Sapindus saponaria* L., *Tabebuia rosea* (Bertol.) DC., *Trema micrantha* (L.) Blume, and *Trichilia havanensis* Jacq. (Rzedowski,1978).

In their physiognomy the SDTFs of the Pacific slope and those of the Caribbean and Yucatán appear to be similar at first sight (Trejo, 1998; C. Choappy, pers. comm.), but the species shared between the Pacific and the Caribbean are generally species of wider distribution. In the floristic regions delimited by Rzedowski (1978), Chamela is included in the Caribbean region, which comprises the Pacific Coast, the Atlantic Coast to Yucatán, and the Antilles. This classification is based on species which are common to the whole region, and not on species *restricted* to it. That is to say, many of the species which are common to both coasts of Mexico are of even wider distribution, and extend to South America in many cases. In spite of the fact that there are various mentions in the literature (for example, Standley, 1936, cited in Rzedowski, 1978) of possible phytogeographical relationships between the Pacific slope flora and that of the Caribbean or of Yucatán, we find no evidence for those suggestions based on species restricted to those regions. *Enriquebeltrania crenatifolia* (Miranda) Rzedowski (Euphorbiaceae) was one of the few species which was thought to occur only in Yucatán and on the Pacific slope, at Chamela, but the Chamela population is now thought to represent a new species (V. Steinmann, pers. comm., 2005). A related issue concerns the degree of relationship of the Yucatecan to the Antillean flora (Standley 1936; Rzedowski 1978). Miranda (1958) and Estrada-Loera (1991) argued that the closest relationship was with Central America. In a study of 434 tree species from all vegetation types, Ibarra M. et al. (2002) found that the strongest floristic affinities were with Mesoamerica, and affinities with the Antilles weaker.

13.6.3.1 Distribution and Life Forms

The relationship between life form and distribution pattern is shown in Table 13.3. It is interesting that the percentage of trees (49.3%) and shrubs (53.3%) whose ranges are restricted to the Pacific slope is higher than the proportion of the Pacific slope group in total (41.5%) and the proportion of herbaceous plants (herbs 30.5%, herbaceous vines 38.4%) is less. Compared with the species of broad neotropical distribution, those of restricted distribution ('endemics') are disproportionately of the woody element. Many of the widely distributed species of herbaceous plants (65% of the herbs) are ephemeral weeds of disturbed areas or ruderal situations. In a pioneering series of studies, Rzedowski (1991a) made an estimation of the distribution of the endemic elements in the flora of Mexico according to life form: in the categories of herbaceous plants (excluding epiphytes and aquatic and subaquatic plants) and of shrubs, approximately 60% of the species are endemic to Mexico (Rzedowski, 1991a, Table 5). Herbaceous plants have been relatively little studied in Chamela-Cuixmala and in Mexican and Central American SDTF in general, and the significance of this apparent contrast is not clear.

13.6.4 Distribution of Species of Different Communities

We have already mentioned the two principal biotic communities in our area of interest, the SDTF and the SM. There also exists a variety of aquatic, riparian, halophytic and coastal communities, although these are much more limited in their original extent and have suffered more destruction due to human activity. The *Orbignya* forests of the area are almost completely replaced by coconut and banana plantations. The phytogeographical affinities of the species which make up the plant communities of Chamela-Cuixmala are summarized in Table 13.4. It is important to note that our *phytogeographical classifications are mutually exclusive* (each species is only classified in a single group), *but the communities are not* (a species can be found in more than one community).

In general the aquatic plants (*Eichhornia*, *Lemna*, *Marsilea*, *Wolffia*, *Pistia, Thalia*, *Typha*), plants of marshy places (*pantanos*) (Cyperaceae such as *Cyperus articulatus* L., *C. ligularis* L., *C. regiomontanus* Britton), the halophytes (the mangroves *Rhizophora mangle* L., *Avicennia germinans* (L.) L., *Laguncularia racemosa* (L.) Gaertner f., *Conocarpus erecta* L.), the plants of the littoral (*Ipomoea pes-caprae* (L.) Sweet) and those of salt flats (*salinas*) and the surrounding marshes (*Batis maritima* L., *Hippomane mancinella* L., *Phyllanthus elsiae* Urb.), are widely distributed (Good, 1974; Rzedowski, 1978; Castillo and Moreno-Casasola, 1998). That is, these habitats do not include species which are endemic to this area. (An exception to this generalization is *Abronia maritima* Nutt. ex Wats., which is distributed from the central coast of California and Sonora to Baja California, Sinaloa and Jalisco, on coastal dunes.) Those communities associated with water as a group contain few species in comparison with the SDTF (Rzedowski, 1991b).

Those species associated with disturbed areas are disproportionately of wide neotropical distribution, although there is a large number of them (171 out of 224) or of exotic origin (42). In general, there is little penetration of exotic species in natural (primary) communities of any kind in Chamela-Cuixmala.

The SDTF is the community with the greatest number of species in the region (562 natives, Table 13.4). In this community the species which are restricted to the Pacific slope are much more important (52.3%) than the species of wide distribution (29.7%), very different from their proportions in the total flora (42.3% and 54.2%, respectively).

Probably owing to its lesser local extension, the SM has fewer species than the SDTF (190). The respective contributions of the Pacific elements and of the wide neotropical ones are similar to their representations in the total flora (39.2% vs. 40.7% and 52.2% vs. 51.8% respectively; Tables 13.3 and 4). In any event, the importance of the element with restricted distribution (Table 13.4: 39.2%) in this community was surprising to us, probably because of the visual impression made by such conspicuous species of widespread distribution as *Astronium graveolens* Jacq., *Tabebuia impetiginosa* (Mart.) Standley, *Ceiba pentandra* (L.) Gaertn., *Brosimum alicastrum* Sw., and *Ficus insipida* Willd.

13.6.5 Biogeographical Conclusions

In summary, the flora of the Chamela region is basically composed of a group of species restricted to the Pacific slope of Mexico, and of another group of wide neotropical distribution. These two groups account for 92.5% of the total flora. Our tabulations do not support suggestions of close phytogeographical affinities between our region and the Yucatán Peninsula or the Antilles. Their similarities are based solely on shared species of broad neotropical distribution and a certain physiognomic similarity, not on a common history of endemism. On the other hand, neither is there evidence of a strong relationship between the coast of Jalisco and the Cape Region of Baja California Sur. The Cape Region is near the northernmost limits of the SDTF, isolated from the continent by the Sea of Cortéz, and it is in contact with zones of greater aridity, therefore it is not surprising that is has its own, evidently higher, level of endemism. Its flora also is composed of Pacific Coast elements, some of them shared with Chamela-Cuixmala. Other shared species are basically a few of Sonoran distribution.

We have seen that, compared to other sites, Chamela-Cuixmala is not an important center of endemism, but it is a fairly rich center of diversity. In terms of plants narrowly restricted to the coast of Jalisco, the majority are associated with SDTF, the most extensive plant community in the region.

13.7 CONSEQUENCES FOR CONSERVATION

Current rates of deforestation of SDTFs in Mexico are extremely high (Trejo and Dirzo 2000 and others), and only about a quarter of the area covered by SDTF is estimated to retain a fair degree of integrity. In light of the diversity and high turnover of species from one site to another in Pacific slope flora, and given the degree of threat which SDTFs are facing today, the best strategy for conservation is the protection of a variety of reserves spread throughout the range of SDTFs to include all the variations in environmental conditions such as microclimate, soils, and populations of the flora.

Gentry (1995:184) stated that: 'For conservation, areas of endemism are more important than areas of high diversity. Mexico's dry forests have higher endemism than other communities and deserve the attention they are receiving'. However, not all SDTF sites are 'deserving of attention' for the same reasons. As Gillespie et al. (2000) and Gordon et al. (2004) have shown, highly disturbed and secondary SDTFs and fallows can act as refuges of species for later re-colonization of recovering areas.

Dinerstein et al. (1995) assigned Endangered/Regionally Outstanding category ('Level I, highest priority at regional scale for biodiversity conservation') to two Mexican SDTF areas, Jalisco and Balsas, and Endangered/Bioregionally Outstanding to Oaxacan SDTFs. Sinaloan SDTF, also Bioregionally Outstanding, is listed as Vulnerable, and other sites mentioned in this chapter are in the Locally Important category of Biological Distinctiveness. In light of the evident diversity and endemism of Michoacan, Guerreran and Oaxacan SDTFs, it would be well to include them in the first group with the Balsas, perhaps removing Jalisco to a lower level as well. Fortunately, Jalisco has several stable biosphere reserves.

In the Chamela region, riparian, aquatic, coastal communities and palm forest (now almost entirely extirpated in the area, before their associates were well-known) are of very limited extension and contain many plant species limited to them; nevertheless, these species are almost all of wide distribution. In this sense, their conservation is important to insure the survival of the fauna which directly depends upon them and uses them for corridors, and for the hydrology of the region, not for the protection of rare plant species. In addition, from a local viewpoint, it is important to conserve them because of their rarity in the region.

Endemic genera of Cactaceae need to be studied to ensure their conservation. Every zone of Mexican SDTF has endemic genera or at least species of cacti. They are important structural elements (as witnessed by the fact that they are the third most diverse family in the transects of Trejo (1998)) and the need to understand their diversity and distribution is critical.

Continued floristic inventories, fundamental to understanding a site, are to be encouraged and supported in SDTF, as are the resulting checklists which indicate for each species the vegetation types or habitats in which it occurs, as has been done by León de la Luz et al. (1999), Pérez-García et al. (2001) and others.

Mexican protected areas which include some SDTF are too numerous to list here. The degree to which each site is actively protected is not known, but a list which includes National Parks, Areas of Faunistic and Floristic Protection, Biosphere Reserves and Areas of Natural Resources Protection is available at http://www.vivanatura.org/BiodiversityConservationANP.html

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