FROM THE HIGH SIERRA MADRE TO THE COAST : CHANGES IN VEGETATION ALONG HIGHWAY 16, MAYCOBA-HERMOSILLO*.

Alberto Búrquez
Centro de Ecología, Universidad Nacional Autónoma de México
Apdo. Postal 1354, Hermosillo, Sonora 83000, México.
Centro Ecológico de Sonora
Apdo Postal 1497, Hermosillo, Sonora 83000, México.

Angelina Martínez-Yrízar
Centro de Ecología, Universidad Nacional Autónoma de México
Apdo. Postal 1354, Hermosillo, Sonora 83000, México.
Centro Ecológico de Sonora
Apdo Postal 1497, Hermosillo, Sonora 83000, México.

Paul S. Martin
Desert Laboratory, University of Arizona
Tucson, Arizona 85721, USA.

INTRODUCTION

Scenically spectacular, the Sierra Madre Occidental is challenging to researchers in ecology as well as in geology. Like mountain gradients elsewhere in tropical Mexico, it offers a variety of habitats and species. In this section we will introduce some ecological concepts related to the description of gradients, and picture some of the major features of the vegetation that stretches along the east-west transect drawn by the highway 16 from Maycoba to Hermosillo, in the state of Sonora (see accompanying map to this volume).

If not uninhabited the area retains many natural features. One may see military macaws or thick billed parrots flying over forests rich in birdlife. In this area, mining is localized and on a relatively small scale. Logging is widespread, but does not involve clear cuts. Roughness of terrain restricts agriculture and grazing. Some regions in view of Highway 16 could be considered as wilderness; at least, they are isolated and without access roads.

The first lumber mills arrived on the Mesa del Campanero in the mid 1930s. The first motorcar road to Yécora was graded by 1942, and the last wolves, formerly numerous, were killed by the early 1960s. Not until the late 1980s could passenger cars safely make the journey to Chihuahua; and the official opening of the paved road from Hermosillo to Chihuahua was in 1991.

The area is poorly known, and invites exploration by scientists and conservationists. New species are being discovered, and major range extensions of montane tropical species may be expected. The Sonoran stretch of highway 16 crosses biologically very rich communities, from Mexican Madrean and tropical deciduous forests to the hot desert.The Sonoran Desert, specially its southern portion, has many tropical elements and a high biodiversity. The pines and oaks are

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highly diversified in Mexico (35 pine species and nearly 200 oak species). Individual species usually are restricted in their range, and occur in special habitats (Rzedowski 1978). While the pine-oak woodlands of the Sonora-Chihuahua border superficially resemble the mountain ranges in southwestern United States, they are in fact strikingly different, being richer in epiphytes, parasites (mistletoe species) and comprised of many pines and oaks unknown north of Mexico. The surprising levels of endemism typical of Mexico (Rzedowski 1991), are evident in montane riparian habitats.

Highway 16 crosses or pass near by the major rivers coming from the Sierra Madre in Sonora: the Río Sonora at Hermosillo (see Shreve & Wiggins 1964), the Río Yaqui at Tónichi (see White 1948, Marshall 1957), and the northern edge of the Río Mayo region (see Gentry 1942). The paved road allows us to traverse the gradient in a few hours. Contrastingly, Gentry's Río Mayo region, immediately south, is still difficult to access, and requires pack animals (bestias) to explore thoroughly.

PLANT GEOGRAPHY: A BRIEF HISTORICAL INTRODUCTION

The relation between the vegetation and climate has, and continues to intrige plant geographers. Plant geography arose from the need to understand nature, and especially from the need to assess natural resources. Alexander von Humboldt (1769-1859) is perhaps the plant geographer par excellence. In his monumental work: "Voyage aux Régions Equinoxiales", he described the relationship between latitude, elevation and temperature, and its effects on vegetation. Plant ecology rise from this early roots.

The system of climatic classification of Koeppen (1948) matches well the major vegetation types. However, as it depends on two climatic parameters, temperature and precipitation, it is limited in its correspondence to vegetation at local, or even, regional level. At the end of the last century, Merriam (1898) proposed a new method of describing biotic distributions, which he called "life zones". He recognized the broad similitude between dominant plants and animals as affected by latitude and elevation in North America. Although still used, his system has serious drawbacks, in part because of the importance of non-climatic factors as determinants of species distribution.

The obvious effects of temperature and precipitation on vegetation distribution led to a more detailed study of plant-climate relationships. In his pioneering work Johanes E. B. Warming (1909), indicated the relevance of the soil along with the climatic factors. He showed that local changes in the nature of the soil, contributed to more drastic changes in vegetation than regional changes in temperature or humidity. His work at the beginning of the century set the modern concept of plant ecology. Since then, many important contributions have been made, but the essence of his work persist.

In ecology a central role is played by the so called individualistic concept of the natural communities proposed by Gleason (1926). Contrary to the view of the community as an organized assemblage of species, Gleason reasoned that the populations of a given species occur in the environment as their ecological requirements allow. This is the most prevalent view today (see for example Whittaker 1975, Barbour et al. 1980, McIntosh 1985, Diamond and Case 1986).

ECOLOGICAL CHANGE ALONG A GRADIENT

In a broad sense ecological change is determined by two major elements of the geography: latitude and elevation. These two, broadly reflect climate, and lead to major changes in structure and composition in natural communities. Air temperature decreases at higher elevations and latitudes. Precipitation changes in a predictable way from the ecuator to the poles, and generally increases from low to high elevations. Related to precipitation and temperature is the site aspect, that is, the steepness of the slopes, and their orientation. North-facing slopes in the northern hemisphere are cooler and wetter than the south-facing slopes because they receive less solar radiation.

If the physical environment changes regularly, vegetation will also changes. Species along gradients intermingle, either by the preferences of the species, or because they are forced by symbioses with their neighbors to stay at a given segment of the gradient. However, the environment rarely changes in so predictable way. Apart from the change in site aspect, other factors can alter the sequence of plant communities. Other major factors affecting the distribution of vegetation are rock or soil type and fire regime (see Whittaker 1975, and McIntosh 1985).

MAJOR ENVIRONMENTAL CHANGES ALONG THE MAYCOBA-HERMOSILLO ROUTE (HWY. 16)

Along the route from Maycoba to Tecoripa, highway 16 probably undergoes its most dramatic changes in altitude and substrate. In this short distance it traverses the cool Sierra Madre from 1900 m (peaks near the road reaching 2700 m) down into the hot Sonoran Desert at almost sea level.

The soil changes from being absent in the hard conglomerates, agglomerates and tuffs to the deep alluvial yermosols. Andosols are found in the pine forests. However, the prevalent soils in the high sierra are luvisols, cambisols and vertisols (INEGI 1988). Interspersed among them are the very shallow lithosols. From Tecoripa to Hermosillo haplic and calcic yermosols predominate. Perhaps the most remarkable soils found along the way are those altered by hydrothermal activity accompanied by striking vegetational changes that will be described later.

In parts of the stretch from Maycoba to Yécora the soil is hard or even absent preventing the excavation of post holes. Fence posts are often supported by piles of rocks or by weighting them down with stumps or with other posts. In river valleys along this stretch, alluvial bottoms are cultivated for maize. However, apart from these, the soil is indurated and whitish in regions of felsic rock, and brown and stony in regions of andesite or basalt.

In the plains from Tecoripa to Hermosillo, basin-and-range topography is evident. The soils in the plains are of alluvial origin. In some cases they present a surface covered with small angular rocks lying on very fine sediments forming what is known as "desert pavement" (Shreve 1964). In this area, most mountains and hills are of intrusive igneous origin. While north facing slopes on mesas and isolated small sierras support a dense cover of vegetation, most surfaces are poorly covered. This lack of vegetation is usually related to the lack of soil and the low water availability.

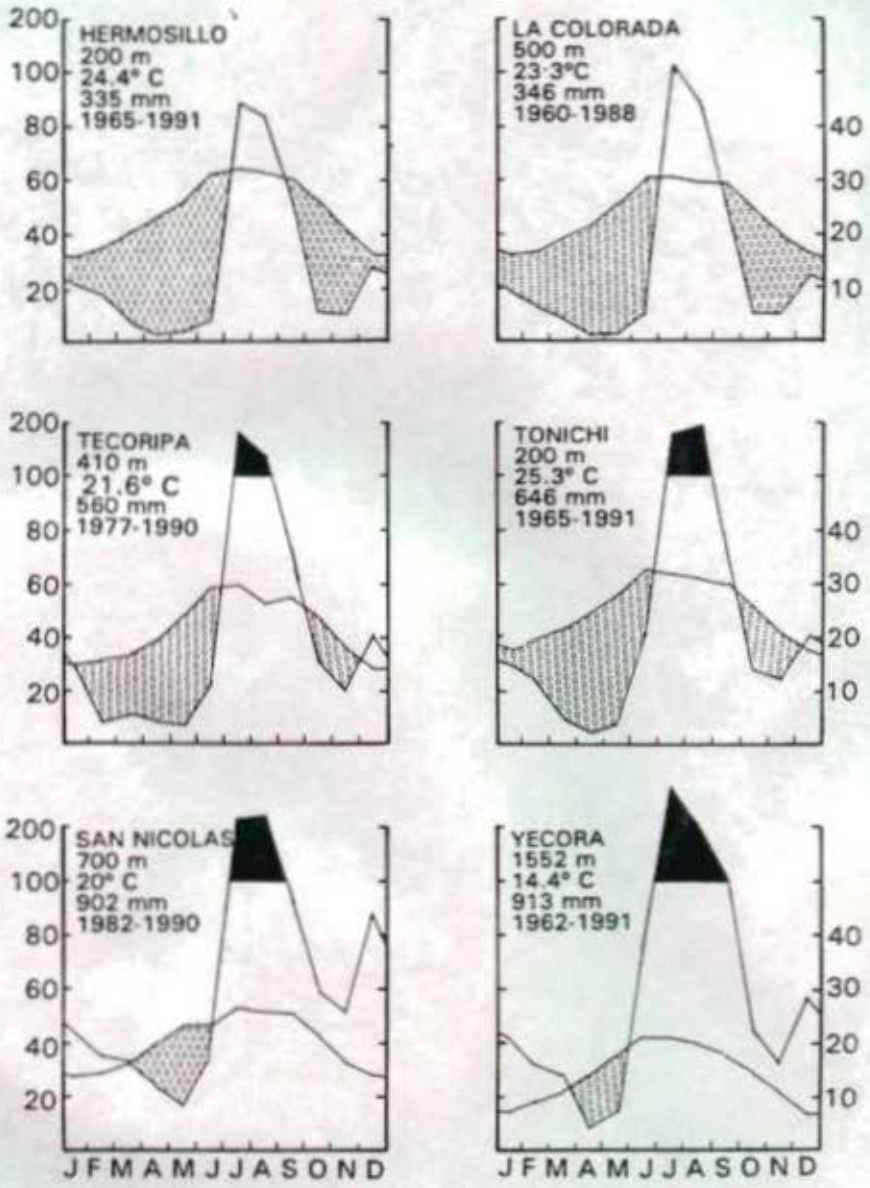

Figure 1

Climatic diagrams for some selected localities along highway 16. The left hand side of the diagram indicates precipitation in mm, and the right side temperature in °C. The open circle shading indicate dry months, and the black wet months. Ombrothermal diagram, using the method of Bagnouls, F. & Gaussen, H. (1957), Les climats biologiques et leur classification. Ann. Geogr., v. 66, p. 193-320.

The onset and amount of annual rainfall differ markedly along the route. In general, the higher sites receive more and earlier precipitation than the lower places. In Yécora, mean annual precipitation is 913 mm, while in Hermosillo it is about three times less (335 mm; Figure 1). In the high Sierra the first summer rains may begin by the end of May, and last up to October, while down in the desert, rains may not start until July, and last no more than two or three months. Temperatures are inversely correlated with precipitation. Yécora has a mean annual temperature of 14.4° C, Hermosillo of 24.4° C. These differences are reflected in the climates that cover a broad range: the Warm Humid (temperate, Cw), in Yécora and Maycoba; the Tropical Rainy Savanna, in Tepoca and San Javier (Aw); and the Dry Steppe and Dry Desert (BS and BW, respectively), in Tónichi, Tecoripa, La Colorada and Hermosillo (see García 1973, INEGI 1988; Table 1). Frost is common in the Sierra, but rare down into the desert. In Hermosillo, short term frost may occur every 20-30 years, while in Yécora there are extended freezing temperatures every winter.

The hydrography along the route is strikingly regular. Most of the water courses are ephemeral and cross the road perpendicularly. This arrangement reflects the general orientation of the mountain ranges, and the slope of the coastal plain. The largest river is the Río Yaqui. In the mountains many small drainages carry water almost permanently. In the desert, Río Tecoripa and Río Mátape have some water most of the year.

MAJOR VEGETATION TYPES ALONG THE MAYCOBA-HERMOSILLO ROUTE (HWY. 16)

Five major types of vegetation can be recognized along this gradient: 1) forests of pines and oaks in the high Sierra Madre, 2) pine-oak and oak woodlands, 3) tropical deciduous forest (tropical short tree forest, and Sinaloan Deciduous Forest as described by Gentry 1942 and 1982, respectively), 4) tropical thorn forest, and 5) Sonoran Desert (plains and foothills of Sonora, according to Shreve, 1964). Brief descriptions of these vegetation are provided, and some of the more common or noteworthy trees and shrubs are cited. Some of the species mentioned are illustrated by Mason and Mason (1987). Because of the scope of this work and space limitations, the herbaceous species are not mentioned. These will be included in a latter publication.

1) Pine and Pine-Oak Forest, 1900 m and above. These forests are characterized by a dense canopy which varies between 12-25 m. Important conifers include Pinus ayacahuite, P. chihuahuana, P. durangensis, P. engelmanii, P. leiophylla, Juniperus sp. and Cupressus sp. Common oaks are: Quercus coccolobifolia, Q. durifolia, Q. rugosa, Q. viminea, and a still undescribed oak with very large leaves (Spellenberg pers. comm.). Other arborescent elements of the flora are: Arbutus arizonica, A. xalapensis, Arctostaphyllos pungens, Fraxinus sp. and Prunus sp.

2) Pine-Oak and Oak Woodland, 1400-1900 m. Characterized by the presence of scattered oaks without continuous canopies, most trees are under 8 m tall. The most common oak in this community is Quercus chihuahuensis associated with Q. albocincta and Q. tuberculata in the lower elevations, and Q. hypoleucoides, Q. toumeyi and Q. oblongifolia in mid-elevations. Some pine trees occur in scattered patches, being the most common Pinus chihuahuana. Piñón, (P. cembroides) is not found west of 108° at this latitude. Other noteworthy woody plants are: Nolina sp. (probably N. matapensis), Agave bovicornuta, A. shrevei, Arbutus arizonica, Tecoma stans, Opuntia (Platyopuntia) spp and Acacia pennatula. For detailed accounts of pine-oak woodland in northwestern Mexico see White (1948) and Marshall (1957).

3) Tropical Deciduous Forest, below 1400 m. This forest is extremely heterogeneous in species composition and in structure. It intergrades sharply with the oak woodland, and imperceptibly with the thorn forest. By virtue of its greater structural complexity tropical deciduous forest can be easily discerned from other types of vegetation (see Rzedowski 1978). In Sonora, this vegetation was studied by Gentry (1942) in the now classic: "Río Mayo Plants". When in leaf, during summertime, the trees form a closed canopy ranging in height from about 4-6 m on open slopes, to more than 15 m in deep canyons. In the better-developed forests three strata are evident: scattered emergent trees, closed canopy trees, and small trees and shrubs. In south eastern Sonora, Ambrosia cordifolia and Jatropha platanifolia are important members of the shrub layer. Almost all of the species are drought deciduous. The dry season appearance of the forest, of many grayish stems in a seemingly lifeless landscape, is hard to reconcile with the closed canopy of intense emerald green to be expected in early August. The most common species are: Pachycereus pecten-aboriginum, Stenocereus thurberi, Acacia cochliacantha, Coursetia glandulosa, Pithecelobium leucospermum, Haematoxylon brasiletto, Guaiacum coulteri, Lysiloma divaricata, L. watsoni, Sabal uresana, Ipomoea arborescens, Ceiba acuminata. Species of Bursera, include B. fagaroides, B. lancifolia and B. laxiflora. Also present are: Jatropha cordata, Bumelia persimilis, Ficus petiolaris, F. radulina, Guazuma ulmifolia, Tabebuia palmeri, Plumeria rubra, Erythrina flabelliformis, Taxodium mucronatum, Vitex mollis, and Helicteres baruensis among others. Buffelgrass pastures are encroaching on the habitat, more so in southern Sonora south of Hwy. 16.

4) Tropical Thorn Forest, below 600 m. The separation of this type of vegetation from the tropical deciduous forest is based more on structural features than in floristics. Tropical thorn forest has fewer arboreal elements, thus a lower height. Typically the thorn forest is composed of trees and shrubs that attain a maximum stature of about 6 m, with a mean height of under 4 m, and a mean canopy coverage near 100%. As Felger and Lowe (1976) indicated, there is a distinct separation between the thornforest, the deciduous forest, and the desert. According to the authors, Shreve's Foothills of Sonora are not desert scrub, but thornscrub or thorn forest. The criterion based on the height of Pachycereus pecten-aboriginum presented by Gentry (1942) to separate both types of vegetation was adopted in the present work. In the cases in which the trees typically exceed the height of this cactus, we refer to those communities as tropical deciduous forest. In the opposite case, we call it thorn forest. The change in vegetation from the extreme desertscrub of the Sonoran Desert to the lush tropical deciduous forests of southern Sonora, Sinaloa, Nayarit, Jalisco and Michoacan involves increasing structural complexity. The major changes from desert to tropical deciduous forest are evident when travelling in southern Sonora either north-south or west-east. Typical tropical thorn forest species are: Pachycereus pecten-aboriginum, Stenocereus alamosensis, S. thurberi, Randia obcordata, Karwinskia humboldtiana, Coursetia glandulosa, Cercidium floridum, C. praecox, Piscidia mollis, Haematoxylon brasiletto, Parkinsonia aculeata, Acacia cochliacantha, Mimosa laxiflora, Prosopis glandulosa var. torreyana, Fouquieria macdougalii, Bursera fagaroides, B. laxiflora, Ipomoea arborescens, Agave angustifolia, A. vilmoriniana, Jatropha cordata, Ceiba acuminata and Guaiacum coulteri.

5) Sonoran Desert, below 600 m. Looking west after the last major mountain range, to the west of San Javier, the tropical thorn forest is rapidly replaced by a more open and less complex vegetation: the foothills subdivision of the Sonoran Desert (see above, also Felger and Lowe 1976). This vegetation was characterized by Shreve (1964) as an arborescent desert with Prosopis glandulosa var. torreyana and Acacia cochliacantha as prevalent elements. Other common species are: Eysenhardtia orthocarpa, Cercidium floridum, C. microphyllum, C. praecox, C. sonorae, Encelia farinosa, Mimosa laxiflora, Coursetia glandulosa, Lysiloma divaricata, Pithecellobium sonorae, Fouquieria macdougalii, Stenocereus alamosensis, S. thurberi, Carnegiea gigantea,

Opuntia (Cylindropuntia) versicolor, Opuntia (Cylindropuntia) fulgida, Opuntia (Platyopuntia) sp., Karwinskia humboldtiana, Guaiacum coulteri, Croton sonorae, Sapium biloculare, Jathropha cordata, Lycium berlandierii, Jacquinia pungens, Ipomoea arborescens and Ceiba acuminata. Here isolated stands of thorn forest appear. These are conspicuous and well differentiated from the desert. Usually, they occur on the top and north side of the hills.

Another ecotone is crossed west of the town of La Colorada. The rolling hills and volcanic mesas give way to extensive alluvial plains with mountains of granitic and sedimentary rocks. Surface geology is mainly Quaternary with loam and clay soils. The vegetation of this region belongs to the Plains of Sonora subdivision of the Sonoran Desert (Shreve 1964). The dominant scattered trees and shrubs include Olneya tesota and Encelia farinosa. Other common species are: Bursera laxiflora, B. microphylla, Forchammeria watsoni, Jacquinia pungens, Guaiacum coulteri, Acacia willardiana, Coursetia glandulosa, Stenocereus alamosensis, S. thurberi, Lophocereus schottii, Opuntia (Cylindropuntia) arbuscula, Opuntia (Cylindropuntia) versicolor, Opuntia (Cylindropuntia) fulgida, Opuntia (Platyopuntia) violacea, Jatropha cardiophylla, J. cordata, Cercidium microphyllum, Mimosa laxiflora, Lycium spp., Acacia constricta, Eysenhardtia orthocarpa. As in the foothills, the desert intergrades with an impoverished tropical thorn forest on the north side of desert peaks. These frequently support Ipomoea arborescens, Agave angustifolia, Jathropha cordata, Acacia willardiana and Caesalpinia pumila.

6) Hydrothermally altered soils. These occur at San Javier, and along Hwy. 16 between the Río Yaqui and San Nicolás. At Agua Amarilla, or Los Pinitos (km 200), there are striking areas of barren yellow and red lithosols supporting pines and oaks as islands in the tropical deciduous forest. Here, Quercus albocincta, Q. chihuahuensis and Q. tuberculata, occur below their normal range. Pinus durangensis grows about 1000 m below its expected lower limit. Similar spots occur elsewhere in the region, such as near the junction of the road to Santa Ana, east San Nicolás. Here Pinus durangensis, P. oocarpa and oaks are well below their typical elevation. Understory is virtually absent in these areas. The name "Agua Amarilla" probably refers to the milky-yellow appearance of the water, presumably by the action of bacteria, in an arroyo draining these acid soils. During the construction of the road, the builders unintentionally set up a natural experiment. At Agua Amarilla they abandoned a pile of gravel from roadside construction. Ten years later the gravel supports a dense low growth of Acacia, Solanum and mallows, not otherwise found in association with the pines and oaks.

In the Sierra de San Javier there is evidence of a large hydrothermal anomaly. Here, growing almost side by side are stands of Tabebuia palmeri and Quercus tuberculata with natural barrens on one side, and a highly diverse tropical vegetation on the other. Some areas in the slopes of the sierra harbor Quercus emoryi; others support broad expanses of grasses (Trachypogon secundus) forming a sharp boundary with tropical deciduous forest growing on unaltered soils (see also soil analyses and experiments of soil effects on establishment of seedlings carried out near Santa Ana by Goldberg 1982, 1985). In the humid tropics of Mexico, Pennington and Sarukhán (1968) and Rzedowski (1966) described several occurrences of oak woodland and forest (Quercus oleoides) in lowland habitats well outside their normal altitudinal range. Apparently, the soils on which most of these woodlands develop are usually red and yellow, or sandy-acidic, soils of igneous origin.

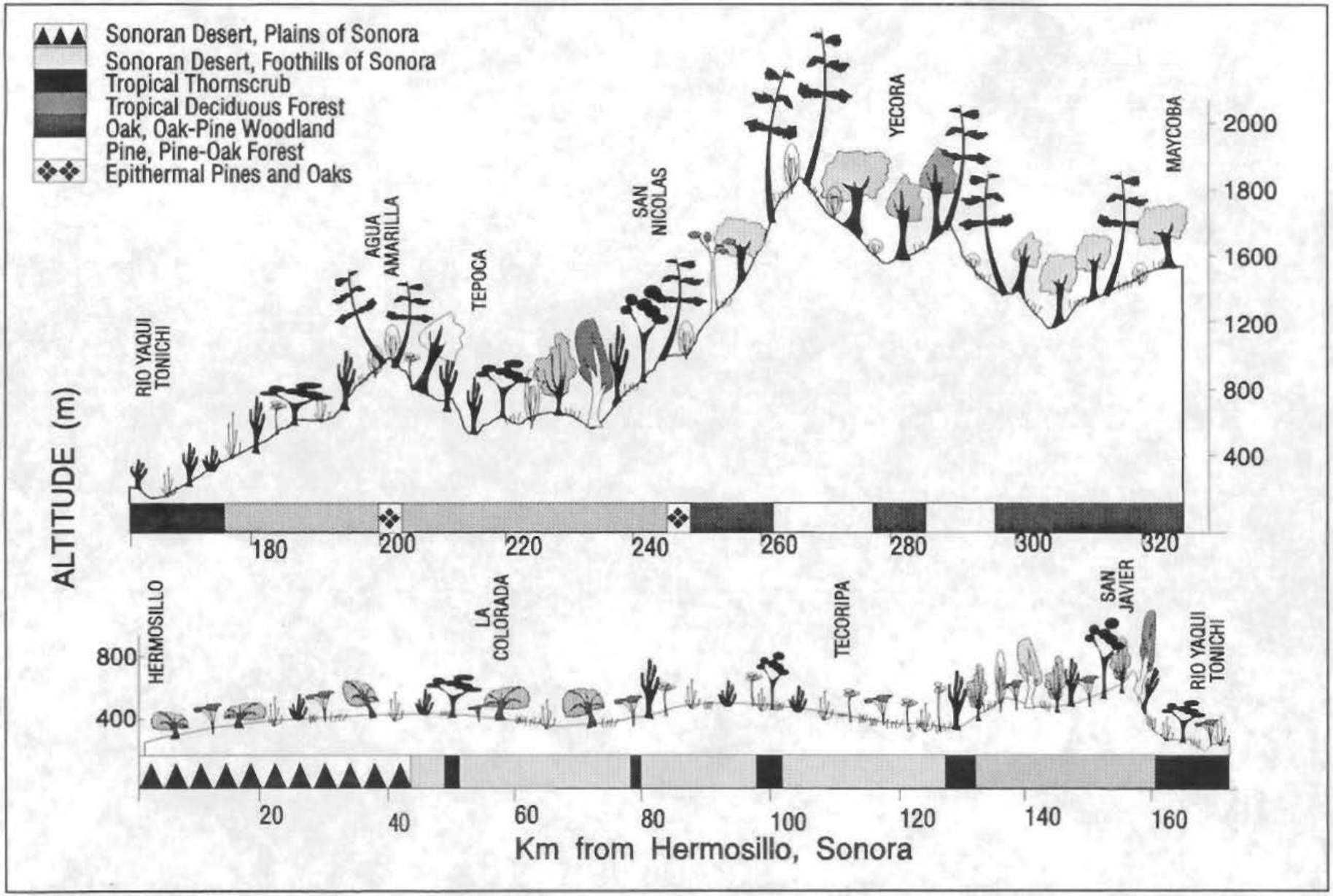

Figure 2. Diagramatic view of changes in vegetation along the road from Maycoba to Hermosillo (Hwy. 16). Distances are as marked on the road signs.

CLOSING REMARKS

Carretera 16 opened a door to a largerly unexplored area. The value of this region in terms of biodiversity and scenery are unrivaled in northwestern Mexico. Undoubtedly, this road will allow scientific discoveries to be made. The same breach will allow a rapid development of the area. This is a rare opportunity as we are still in time to reconcile development and conservation of this extraordinary natural legacy. Is now in hands of foresters, biologists, geologists, developers and tourism promoters to make good use of these resources, and to protect and generate nature preserves and corridors between them for later generations.

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APPENDIX I

Highlights from the Road Log from Maycoba to Hermosillo, Sonora Along Highway 16.

Km 327: Maycoba, elev. 1540 m, pop. 600. Pima Bajo families live here. As in many other places in the Sierra, the soil is so hard that is extremely difficult to dig holes for fence posts. Cultivation for maize of alluvial bottoms was, as recently as 1987, achieved with the aid of oxen. Near the Maycoba airstrip, on the east side of town are quince and peach. Roadside shrub, Senecio salignus, common along with Juniperus arizonica, Quercus toumeyi and Arctostaphylos pungens (small bush with yellowish stems and pointed leaves).

Km 307: (1200 m) marks the lowest point on Hwy. 16 west of the city of Chihuahua and east of San Nicolás. Presumably cold air drainage brings more frost to the valley of Río Maycoba than are experienced at similar elevations west of Yécora which are more tropical and may receive twice as much precipitation. Oak woodland with low, spreading Chihuahua oaks (Q. chihuahuensis), some Opuntia sp. (probably O. (Platyopuntia) wheeleri) and junipers in a short grass pasture cover basaltic soils and rounded boulders. Some Chihuahua pines > 10 m tall, and Chihuahua oaks, Agave spp., Erythrina flabelliformis, Nolina sp. and Dasylirion sp. grow on a volcanic conglomerate, apparently the Baucarit Formation. At km 301-303 is a distant view southward of a valley aptly named "Los Pilares" and resembling the wilderness of rocks in Chiricahua National Monument near Willcox, Arizona.

Km 293: Mountain pass, many rosseted plants hanging from the northern rock wall; Agave spp., Nolina sp. and Dasylirion sp. Pine-oak community ca. 10 m tall. The pines with very long needles may be Pinus engelmanni.

Km. 280 and surroundings. Yécora, elev. 1600 m. pop. 3000. Meadows with a great diversity of forbs and grasses. Orchards of quince, plums, peaches, apricots, apples, etc. 2 km E Yécora, sawmill "La Cieneguita", exploitation of Quercus durifolia, Q. viminea and "pino blanco". Sawmill owner intents to exploit the wood from Q. durifolia for parquet flooring.

Km 265: Upper elevation pine-oak forest, elev. 1900 m. Puerto de la Cruz (roadside restaurant and white house). Quercus arizonica, Q. pennivenia, and a still undescribed oak species, the last two species with very large leaves and the underside light brown, (Spellenberg com. pers.) Q. coccolobifolia (base of leaves heart-shaped), Q. toumeyi (little tree, with small, almost sessile leaves). In ravine nearby, Pinus ayacahuite (locally called piñón), along with other pine species, Prunus sp., Arbutus xalapensis (a remarkable small tree with red and yellowish exfoliating bark), Platanus wrightii and Quercus oblongifolia (oblong leaves and fissured whitish bark).

Km 257- 250: Steep gradient. Oak forest and oak woodland, a few pines and Agave bovicornuta replacing A. shrevei, a larger species, growing at higher altitude. Rocky soils, canopy ca. 3-5 m tall. At **km 257**: Quercus arizonica, Q. hypoleucoides (leaves whitish beneath) and Q. toumeyi. At km **250-252** Lysiloma watsoni trees begin to appear; among them, stands of Q. chihuahuensis, Q. oblongifolia, Q. viminea and Q. albocincta (with a leaf margin distinctively

aristate). El Reparo drainage can be seen to the south. Roadcuts yellowish brown to brick-red. White patch of volcanic ash in the skyline to the north is "Peñasco Blanco" (elev. 1800 m) on the E end of the Mesa Grande. Immediately below this landmark is "Mina La Trinidad".

Km 248-245: Still rapidly descending, pine trees are no longer present. Dominance of low-elevation oak trees, Quercus albocincta, Q. chihuahuensis and Q. tuberculata. In the disturbed roadside, Tecoma stans, a shrub with yellow trumpet-shaped flowers, seen only here.

Km 245-240: First hints of tropical-looking vegetation. Community of Lysiloma watsoni with Acacia pennatula and low elevation oaks. Road junction to the mining towns of Santa Rosa (north) and Santa Ana (south). Frank Dobie's "Lost mines of Toyopa" mentioned in Apache Gold and Yaqui Silver are near here. At **km 242** (ca. 950 m) is an anomalously low-elevation pine community, Pinus oocarpa, and a few P. durangensis. Beneath pine and oak trees is a bare red soil without litter. The pines are displaced roughly 1000 meters below their normal limit on unaltered soils on the slopes of Mesa El Campanero to the east. They are absent along the road west of km 262 with the exception of this place and at Agua Amarilla at km 200. At **km 240** are the first decidedly tropical species, Acacia cochliacantha, with prominent large boat-shaped grey spines; a large columar cactus, Pachycereus pecten-aboriginum, Ipomoea arborescens (with a smooth white trunk), Bursera laxiflora, B. fagaroides, and Ceiba acuminata (a kapok tree with sharp thorns along the main axis of the trunk) growing next to the oaks.

Km 240-230: Hills north of highway across a deep ravine illustrate soil effect on vegetation type. Bare reddish soils, supporting oaks are surrounded by tropical deciduous forest. Ambrosia cordifolia, a shrubby species of ragweed, in the understory. At **km 234** bridge, mountain cottonwoods, Populus monticola, along arroyo San Nicolás. Frank Dobie locates the lost mines Toyopa near güerigo trees. Canopy ca. 5 m tall with Pachycereus and Lysiloma watsoni comparable in size. Paved road to Sahuaripa. Roadcuts with eroding reddish soils.

Km 215: Tepoca (in some maps: El Carrizal, or Las Animas). Tropical vegetation with Pachycereus pecten-aboriginum; Bursera spp., Plumeria rubra, Agave angustifolia, A. vilmoriniana, Stenocereus thurberi, Ceiba acuminata, Ficus petiolaris (tree growing on steep slopes and cliffs, with a distinctive yellow bark, and lustrous green foliage). Among the Quercus albocincta and Q. chihuahuensis oaks growing on red soils, Dodonaea viscosa and Opuntia (Platyopuntia) sp.

km 208: Winding road on the southern side of the canyon and valley of Río Techomoa. Thorn forest of Acacia cochliacantha and Guazuma ulmifolia; on the vertical walls of the roadcut Eucnide hypomalaca (small hanging shrub with bright green foliage and lemon yellow flowers in spring). Andesites dated 17 Ma. These postdate a cemented conglomerate, the Báucarit Formation, which outcrops along the valley of Tepoca.

Km 205-200: Examples of pines and oaks on hydrothermally altered reddish soils. Barren yellow and red lithosols with pines and oaks separated sharply from tropical forest. At **km 200**, Agua Amarilla, the road disects a soil anomaly. Quercus albocincta, Q. chihuahuensis and Q. tuberculata growing together with Pinus durangensis, the latter at an unusually low elevation. Here is the pile of road gravel mentioned in the text.

Km 200-190: Rapid descent, Río Yaqui lies at the southwest. Hills with abundant Lysiloma watsoni, Pachycereus pecten-aboriginum, Sabal uresana, Bumelia persimilis, large fig trees: Ficus petiolaris and F. radulina. Still a few oaks. The canopy of the palms much taller than the rest of vegetation. The trees are generally taller than the Pachycereus. Canopy 6 or more meters tall. Usual assemblage of landscape dominants including: 3 spp. of Bursera, Ceiba, Sabal,

large fig trees, Lysiloma divaricata, Haematoxylon brasiletto, Erythrina flabelliformis, Acacia cochliacantha, Jatropha cordata (with attractive deep yellow peeling papery bark), Croton sp.

Km 166 and environs. Río Yaqui bridge. Tónichi to the north;southward, Onabas. Splendid view of the Baucarit Formation. From km 178 towards Río Yaqui the road continues on a quick descent. The Pachycereus surpass the rest of the plants in height. Vegetation less structured, more a tropical thorn forest than a deciduous forest (sensu Rzedowski 1978). In the poor, indurated soils near the river, vegetation structure as open as to allow passage of a vehicle. Many of the characteristic species of tropical thorn forest are present, including: Haematoxylon brasiletto, Fouquieria macdougalii, Pachycereus pecten-aboriginum, Stenocereus thurberi, Lysiloma divaricata, Acacia cochliacantha, Bursera laxiflora, and on the cliffs: Agave angustifolia, A. vilmoriniana and Plumeria rubra.

After crossing the Río Yaqui and plains to the west, the road enters La Barranca. Mezozoic lutites shown beautifully on roadcuts. Fine examples of tropical deciduous forests growing on steep slopes. In the drier parts, isolated patches of thorn forest. The vine with pink-lavender flowers growing on the roadside is Cryptostegia grandiflora, a naturalized species from India. Many trees of Tabebuia palmeri, with beautiful pink flowers in spring, rarely found east of Río Yaqui, are common up to the western side of San Javier range.

Km 140 and surroundings: Nearby paved road to north, to San Javier. Just before reaching San Javier the road curls along the mountains, to the north scattered oaks can be seen in the side of the mountain, while to the south Pachycereus, Lysiloma watsoni and Tabebuia palmeri. At about **km 141** arroyo San Javier crosses the road, in the north side of the road a tall spreading Ficus. Along the ravine magnificent Montezuma cypresses, Taxodium mucronatum up to 30 m tall; their buttresses supporting Celtis iguanea. On level ground, pockets of thorn forest; on the slopes tropical deciduous forest forming an homogeneous canopy. Dominants include: Tabebuia palmeri, Ceiba acuminata, Vitex mollis, Ipomoea arborescens, Lysiloma watsoni, Bursera spp., Pithecellobium leucospermum, Lysiloma divaricata, Jatropha cordata, Erythrina flabelliformis. Helicteres baruensis found here, not known previously north of Alamos, Sonora. Oaks with a heavy undergrowth of Dodonaea viscosa growing on red, altered soils. The latter species is a good indicator of acid soils associated with a gossan. Antigonon leptopus, a climbing vine with showy pink flowers, Cercidium praecox with a solid, green trunk, are both unmistakable. On the roadside a ragweed, Ambrosia cordifolia, is abundant. This vegetation persists until **km 130**.

Km 130-120: Tropical thorn forest. By **km 125** entering the Foothills of Sonora subdivision of the Sonoran Desert. Tropical thorn forest on top of the rolling hills. Large clearings with artificial grassland of African buffel grass (Cenchrus ciliaris). First individuals of Olneya tesota and Cercidium floridum. Just before reaching Tecoripa from the east, argillic soils, eroded and caving (piping) to the south, suggesting bad lands.

Km 120-50: Tecoripa-La Colorada. Desert arroyo beds with many sizable trees of mesquite, Prosopis velutina, also Piscidia mollis. Olneya tesota in drier, more exposed locations, large pitahayos, Stenocereus thurberi, and Cercidium microphyllum, widespread. Local patches of bare ground between trees and shrubs, the structure of Shreve's Sonoran Desert with great variations in height. Pachycereus pecten-aboriginum, barely present in the desert, although here, along with Ipomoea, Ceiba, and large Fouquieria macdougalii, common on patches of tropical thorn forest that occur in northern slopes such as in **km 103**, and **km 100**. At **km 94-87** large clearings with buffel grass. Here can still be seen remnants of Pachycereus, Prosopis, and Olneya kept to provide a shade for cattle.

Km 80: Last sizable forest of Pachycereus with Acacia cochliacantha. Pachycereus mainly distributed at the base of the hill and toward the plains. A few sahuaros, Carnegiea gigantea, which will be seen again in **km 66**. To the north, view of Sierra de Mazatán, an isolated granitic dome (elev. ca. 1450 m) with oaks on top. At **km 72** crossing of the Río Mátape, large mesquites along the river.

Km 55: Approaching La Colorada small mining town. Last Pachycereus, complex vegetation with Eysenhardtia orthocarpa, Calliandra eriophylla, Mimosa laxiflora, Caesalpinia palmeri, Bursera fagaroides, B. laxiflora, B. microphylla, Cercidium microphyllum, C. sonorae, Stenocereus thurberi, and several cylindropuntias. Granite hills as in Hermosillo (Centro Ecológico de Sonora), granite weathering into a deep sand (gruss).

Km 50-0: La Colorada to Hermosillo. Plains of Sonora subdivision of the Sonoran Desert. Olneya tesota and Encelia farinosa, a small hemispherical bush with gray, pubescent leaves. These species become more abundant until, near Hermosillo, they become dominants. Small pass at km 40 through hills with Acacia willardiana, a handsome slender tree with papery, white, and peeling bark, on the skyline. Lophocereus schottii, a columnar cactus with 5-7 ribs and a beard of spines on the upper part of the stem, becomes common. Jatropha cordata and the shrub Jatropha cardiophylla common on the slopes and the plains, respectively.

APPENDIX II

Scientific and equivalent common names of plants:

Acacia cochliacantha	Chirowi	A. constricta	Vinorama
A. pennatula	Algarrobo	A. willardiana	Palo blanco
Agave spp.	Lechuguilla, Maguey bacanora, Lechuguilla, Amol, Amol	Ambrosia cordifolia	San Miguelito
		Antigonon leptopus	San Miguelito
Arbutus arizonica	Madroño	A. xalapensis	Madroño
Arctostaphylos pungens	Manzanilla -ita	Bursera fagaroides	Torote
B. lancifolia	Torote	B. laxiflora	Torote prieto
B. microphylla	Torote	Bumelia persimilis	Bebelama
Caesalpinia palmeri			
C. pumila			
Calliandra eriophylla	Huajillo	Carnegiea gigantea	Sahuaro
Ceiba acuminata	Pochote	Celtis iguanea	Zacate Bufel
		Cenchrus ciliaris	Zacate Bufel
Cercidim praecox	Palo brea,	C. floridum	Palo verde
C. microphyllum	Palo verde foothill paloverde	C. sonorae	Palo verde
Coursetia glandulosa	Sámota	Croton sonorae	Cuerno
		Cryptostegia grandiflora	Cuerno
Dasylirion sp.	Soto	Dodonaea viscosa	Tarachique
Encelia farinosa	Rama blanca	Erythrina flabelliformis	Chilicote
Eucnide hypomalaca	Palo dulce		
Eysenhardtia orthocarpa	Palo dulce	Ficus petiolaris	Tezcalama
F. radulina	Matapalo	Forchammeria watsoni	Palo jito

Fouquieria macdougalii	Ocotillo macho
Guazuma ulmifolia	Guázima
Helicteres baruensis	Palo Santo
Ipomoea arborescens	Palo Santo
Jatropha cardiophylla	Sangrengado
J. plantanifolia	Táscate
Juniperus spp	Táscate
Lophocereus schottii	Sina, pitayita
Lysiloma divaricata	Mauto
Mimosa laxiflora	Uña de Gato
Opuntia arbuscula	Cibiri
O. versicolor	Cibiri
O. wheelerii	Nopal
P. cembroides	Piñón
P. durangensis	Pino
P. leiophylla	Pino chino, ocote chino
Pachycereus pecten-aboriginum	Hecho
Piscidia mollis	Palofierro
Pithecelobium sonorae	Palofierro
P. leucospermum	Palofierro
Plumeria rubra	Súchil
Prosopis glandulosa var. torreyana	Mezquite
Prunus serotina	Madroño blanco
Q. arizonica	Encino blanco
Q. coccolobifolia	Encino prieto
Q. durifolia	Encino prieto
Q. hypoleucoides	Encino colorado
Q. pennivenia	Encino güeja, Hueja
Q. toumeyi	Encino chaparro, gallinero
Q. viminea	Encino saucillo, Bellota
Sabal uresana	Palma
Senecio salignus	Jarilla
S. thurberi	Pitahayo
Taxodium mucronatum	Sabino
Trachypogon secundus	Uvalama
Guaiacum coulteri	Guayacán
Haematoxylon brasiletto	Brasil
Jacquinia pungens	San Juanico
J. cordata	Torote blanco
Karwinskia humboldtiana	Tullidora
Lycium berlandieri	Barchata
L. watsoni	Tepehuaje
Olneya tesota	Palofierro
O. fulgida	Cholla
O. violacea	Nopal
Pinus ayacahuite	Piñón, pino
P. chihuahuana	Pino, Pino prieto
P. engelmanii	Pino prieto
P. oocarpa	Pino de ocote
Parkinsonia aculeata	Bagote
Platanus wrightii	Aliso
Populus monticola	Güerigo, Huérigo
Prosopis velutina	Mezquite
Quercus albocincta	Encino negro
Q. chihuahuensis	Encino chino
Q. emoryi	Bellota encino
Q. oblongifolia	Encino azul
Q. rugosa	Encino
Q. tuberculata	Encino
Randia obcordata	Papache borracho
Sapium biloculare	Hierba de la flecha
Stenocereus alamosensis	Sinita
Tabebuia palmeri	Amapa prieta
Tecoma stans	Palo de arco
Vitex mollis	Uvalama