

THE VEGETATION OF SONORA, MEXICO

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The New World tropics reaches its northern limit in Sonora, not as often stated at the Tropic of Cancer (23.37°N) just north of Mazatlán, Sinaloa. The northernmost tropical deciduous forest (TDF) is in Sonora (28.6°N), 680 kilometers north-northwest of Mazatlán and 300 km south of the Arizona border.

The Sierra Madre Occidental (SMO) in northeastern Sonora reaches its northern limit in the Sierra de Huachinera (30.25°N; Fig. 1). Between the SMO and the Mogollon Rim in central Arizona, there are 55 isolated Sky Island mountain ranges, or complexes of several ranges, connected by oak woodland corridors in the Madrean Archipelago, 32 of them in northeastern Sonora (Deyo et al. 2013; Van Devender et al. 2013a). These Sky Islands, crowned with oak woodland or pine-oak forest, emerge from lowland ‘seas’ of desert grassland, foothills thornscrub, or tropical deciduous forest.



Figure 1. View to the west from the Sierra Madre Occidental in the Municipio de Yécora, Sonora. Oak woodland in foreground. Photo by Erik F. Enderson.

Sonora, with an area of 184,934 km², is the second largest state in Mexico after Chihuahua. The state of Sonora has a diverse physiography, from the heights of the SMO in eastern Sonora, and the isolated Sky Island mountains in northeastern Sonora, westward to the western lowlands and the Gulf of California. The vegetation of Sonora is equally diverse (Fig. 2). Rzedowski's (1978) *Vegetación de México* provided a general classification for the country of Mexico. Brown & Lowe (1982a, 1982b) presented a more specific classification of the vegetation for the southwestern USA and northwestern Mexico, including Sonora. Martínez-Y et al. (2010) and Van Devender et al. (2010) summarized the vegetation of Sonora. The vegetation from the coast of the Gulf of California to the crest of the Sierra Madre Occidental in southern Sonora is described in *Gentry's Río Mayo Plants: The Tropical Deciduous Forest and Environs of Northwest Mexico* (Martin et al. 1998). Van Devender & Reina-G. (2005) described the same tropical-to-montane vegetation on the western slopes of the SMO in the Municipio de Yécora in eastern Sonora. González-E. et al. (2012) provided an overview of the floristic subprovinces of the Sierra Madre Occidental and defined the Madrean Tropical subprovince in Sonora.

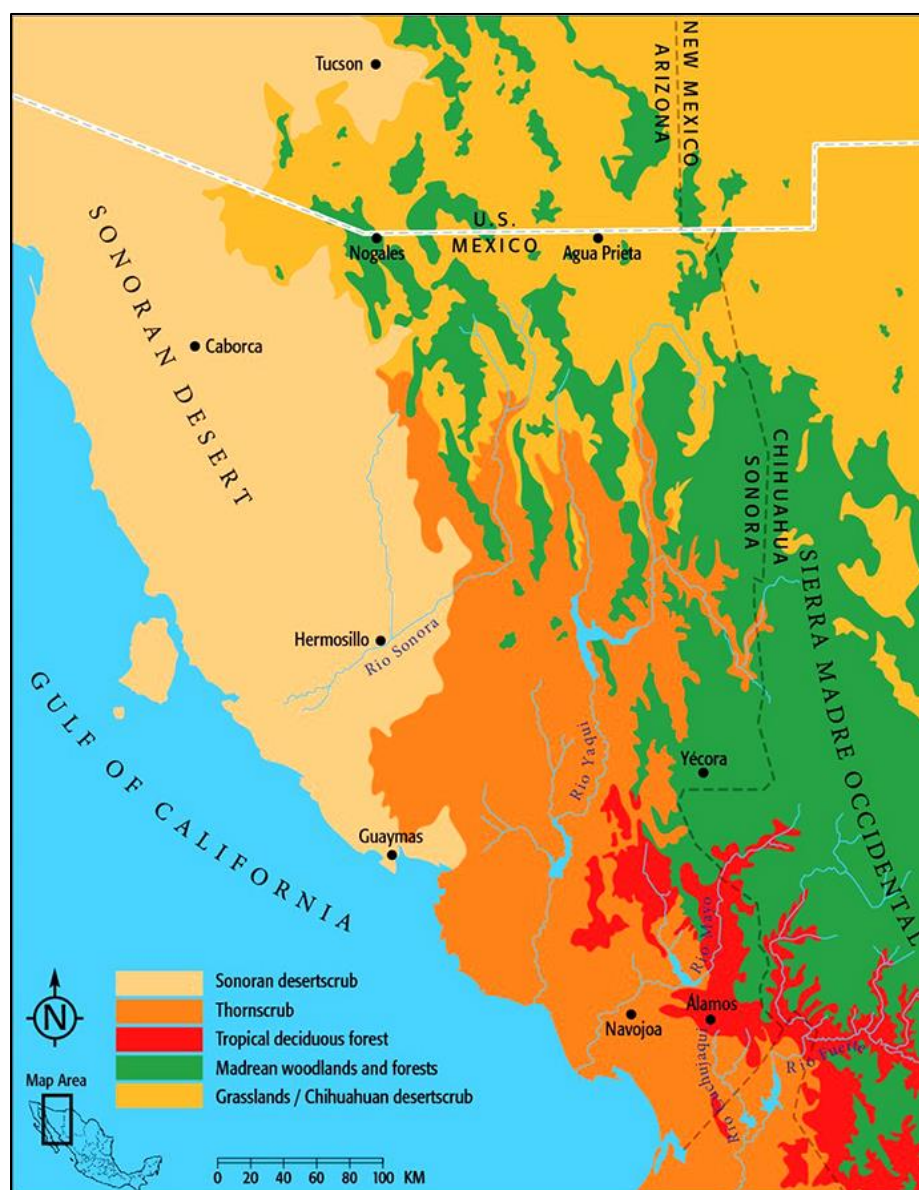


Figure 2. Map of the vegetation of Sonora. Modified from Brown & Lowe (1982b).

TROPICAL DECIDUOUS FOREST. *SELVA BAJA CADUCIFOLIA*

Tropical deciduous forest (TDF) reaches its northern limits in southern Sonora. It extends southward from the Sierra San Javier (28.6°N), through the Álamos area, into Sinaloa, to the highlands of Nayarit. Similar forests are present in Jalisco near Autlán but TDF in other parts of Jalisco such as Chamela-Cuixmala differs in composition and structure (Lott & Atkinson 2006).

TDF in the Río Mayo Region of southern Sonora has a canopy about 12 meters high that is closed in the rainy season from July to October (Martin et al. 1998; Van Devender et al. 2000; Figure 3A). There is also a secondary winter rainy season in December and January when *amapas* (*Handroanthus impetiginosus*) turn the forest magenta, and a spring drought through June when the forest is a grey-red *mojino* color. The forest is in general dominated by *mauto* (*Lysiloma divaricatum*) but is heterogeneous with 30–49 species of trees per 0.4 hectare. *Étcho* (*Pachycereus pecten-aboriginum*) is the dominant columnar cactus (Figure 3C). *Cuajilote* (*Pseudobombax palmeri*) is a notable tree (Figure 3B). There are six species each of elephant trees/*torotes* (*Bursera*) and figs/*higueras* (*Ficus*) in the Municipio de Álamos. The flora is diverse with 740 plant taxa recorded in an area of 46 square kilometers along 42 kilometers of the Río Cuchujaqui southeast of Álamos (Van Devender et al. 2000). A large area of TDF is federally protected in the Área de Protección de Flora y Fauna (APFF) Sierra de Álamos-Río Cuchujaqui and the private Monte Mojino Reserve within the APFF owned by Nature & Culture International.

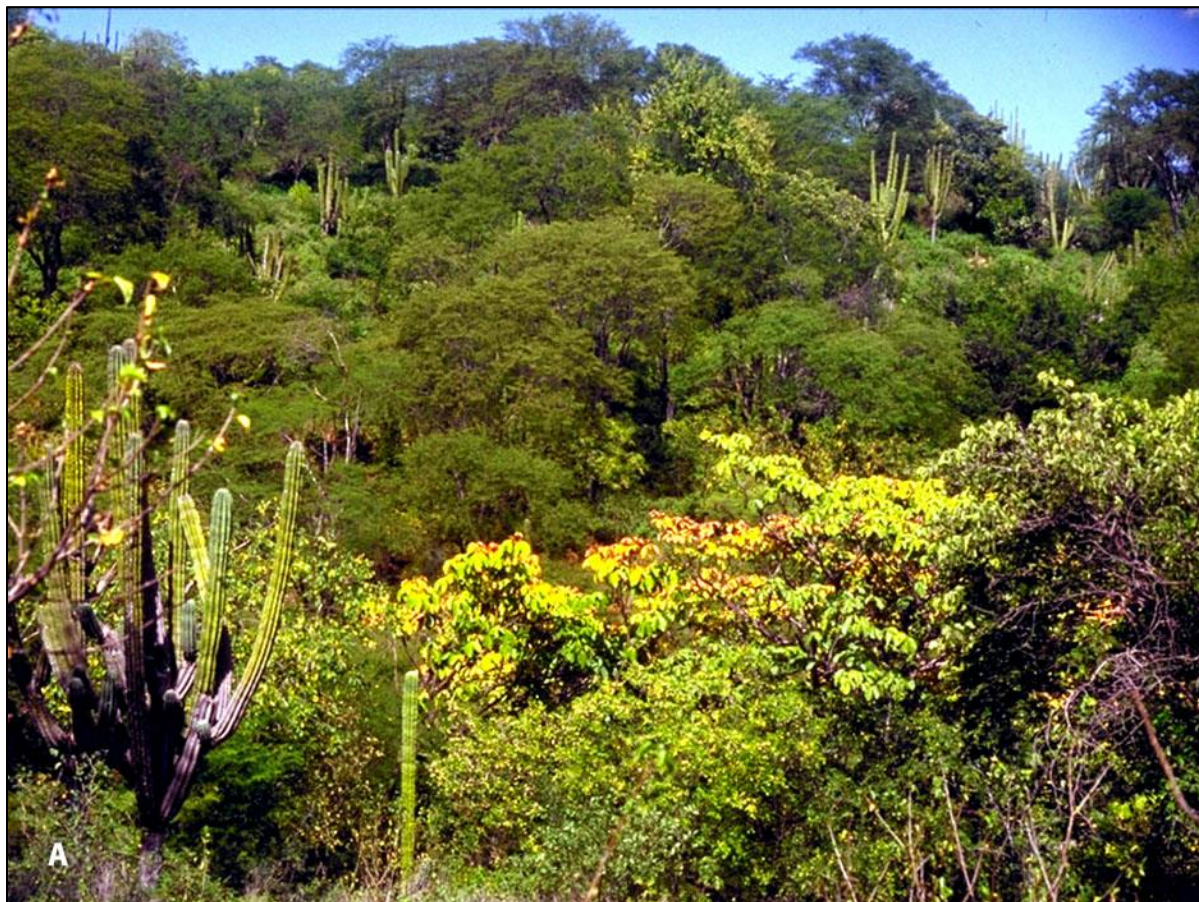




Figure 3. A. Tropical deciduous forest near Álamos Sonora in late summer. Photo by Mark A. Dimmitt. B. *Cuajilote* flower. C. *Étcho* plant and fruits. B & C photos by Van Devender.

Chihuahua oak/*encino peludo* (*Quercus chihuahuensis*) and *encino roble* (*Q. tuberculata*) are in TDF well below the oak zone. *Cusi* (*Q. albocincta*) and eggcone pine/*pino chomonqui* (*Pinus oocarpa*) are found at low elevations in the TDF zone on gossans near Álamos and Yécora (Goldberg 1982; Fig. 4). These are areas of red soils derived from hydrothermally altered rocks. Extremely acidic soils prevent typical TDF plants from growing in the area.

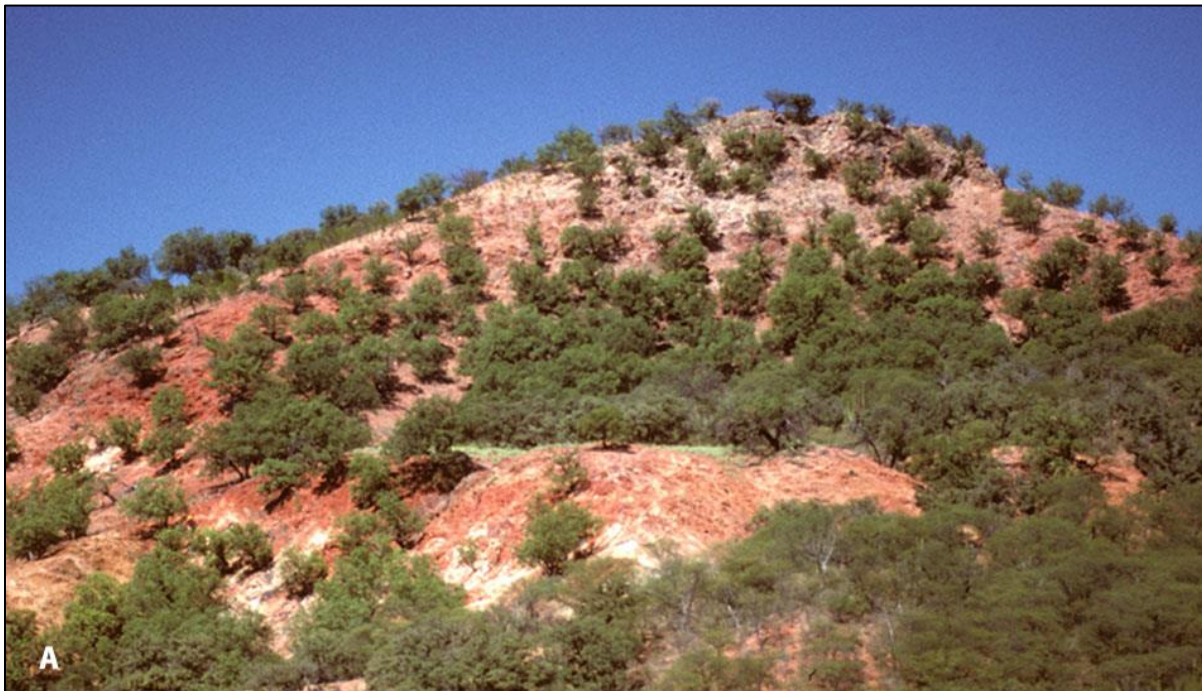




Figure 4. A. Oak woodland on red acidic soils on a gossan at 900 meters elevation near Tepoca. B. Leaves of *cusii* at Cerros Colorados at 220 meters elevation near Álamos. Photos by Van Devender.

THORNSCRUB. *MATORRAL ESPINOSO*

Thornscrub is the tropical vegetation type transitional between TDF and other vegetation types in Sonora (Van Devender et al. 2010). It is shorter in stature and more open than TDF. Coastal thornscrub (*matorral espinoso costero*) is on the coastal plain of the Gulf of California from the Sinaloan border north to Guaymas (Figure 5A). Foothills thornscrub (FTS, *matorral espinoso de piedemonte*) is found inland on rocky slopes (Figure 5B) as far north as 30.4°N (104 km south of the Arizona border; Van Devender et al. 2013b), where it merges into more temperate desert grassland as winter become colder.





Figure 5. A. Coastal thornscrub at Las Guásimas. Trees are *brea* (*Parkinsonia praecox*) and honey mesquite (*Prosopis glandulosa*). Columnar cacti are *pitahaya*, old man cactus/*sinita* (*Lophocereus schotti* var. *tenuis*), and *étcho*. Photo by Reina-G. B. Foothills thornscrub near Tepache. Columnar cactus is *pitahaya*. Photo by Van Devender.

Foothills thornscrub merges into Sonoran desertscrub from the coast in the Guaymas area, in a band northward through central Sonora. In east-central Sonora, FTS merges into oak woodland (OW) in the Sierra Madre Occidental and on the Sky Island mountains (Van Devender et al. 2013b). In the north, as winter become colder, FTS merges into temperate desert grassland.

SONORAN DESERTSCRUB. MATORRAL DESÉRTICO SONORENSE

There are six subdivisions of the Sonoran Desert in Arizona and California in the United States, and Baja California, Baja California Sur, and Sonora in Mexico (Shreve 1964; Turner 1994). The Magdalena Plain and Vizcaíno subdivisions are on the Baja California Peninsula. The Plains of Sonora extends from the Guaymas area northwest through central Sonora. The Plains of Sonora is dominated by legume trees, shrubs, and *pitahaya* (*Stenocereus thurberi*). The Central Gulf Coast subdivision is along the coast of the Gulf of California in central Sonora and eastern Baja California. The vegetation is a diverse desertscrub of succulent plants, including elephant trees/*torotes* (*Bursera hindsiana*, *B. microphylla*), *Euphorbia misera*, *palo adán* (*Fouquieria diguetii*), and *cardón/sahueso* (*Pachycereus pringlei*; Figure 6A). The Vizcaíno subdivision is dominated by boojum tree/*cirio* (*Fouquieria columnaris*). A relictual population of boojum tree is found in Sonora at Punta Cirio south of Puerto Libertad (Figure 6B). The Arizona Upland subdivision is present on the higher edges of the Sonoran Desert in north-central Sonora and southern Arizona (Figure 7). The vegetation on rocky slopes is dominated by *sahuaro* (*Carnegiea gigantea*) and foothill palo verde (*Parkinsonia microphylla*). The Lower Colorado Valley (LCV) subdivision is in the lowlands of northwestern Sonora and adjacent states. It features the lava fields and craters of the Sierra Pinacate and the sand sea of the Gran Desierto (Figure 8). The vegetation is a very open desertscrub dominated by creosote bush/*gobernadora* (*Larrea divaricata*) and white bursage (*Ambrosia dumosa*). A vast area of the LCV desertscrub is protected in the Reserva de la Biósfera El Pinacate y Gran Desierto de Altar.



Figure 6. Central Gulf Coast Sonoran desertscrub at Punta Cirio south of Puerto Libertad, Sonora. A. Visible are ocotillo, cardón, old man cactus, and chainfruit/*choya* (*Cylindropuntia fulgida*). Photo by Reina-G. B. *Cirio* and *cardón*. Photo by Van Devender.



Figure 7. Arizona Upland Sonoran desertscrub near Sonoyta, Sonora. Visible are sahuaro, desert ironwood/palo fierro (*Olneya tesota*), chainfruit cholla, creosote bush, and triangleleaf bursage. Photo by Van Devender.



Figure 8. Lower Colorado River Valley Sonoran desertscrub in the Reserva de la Biósfera El Pinacate y Gran Desierto de Altar. View of the Sierra Blanca from sand dunes. Dark band in the middle are the Ives Lava Flow. Visible plants are big galleta grass (*Hilaria rigida*) and creosote bush. Photo by Reina-G.

CHIHUAHUAN DESERTSCRUB. *MATORRAL DESÉRTICO CHIHUAHUENSE*

The Chihuahuan Desert only occurs in Sonora in a small area near Agua Prieta just south of the Arizona border (Van Devender et al. 2013b). The dominants on limestone hills and soils are ocotillo (*Fouquieria splendens*), creosote bush, sandpaper bush (*Mortonia scabrella*), mariola (*Parthenium incanum*), and Chihuahuan whitethorn acacia (*Vachelia vernicosa*). The scrub oak (*Quercus pungens*) is present on the Sierra Anibácachi (Reina-G. & Van Devender 2013; Figure 9).



Figure 9. Chihuahuan desertscrub on limestone on Sierra Anibácachi near Agua Prieta. Dark shrubs are Arizona rosewood (*Vauquelinia californica*). Desert spoon/sotol (*Dasyliirion wheeleri*) is common. Other common shrubs are ocotillo, Chihuahuan whitethorn acacia, and sandpaper bush. Photo by Van Devender.

COASTAL VEGETATION. *VEGETACIÓN COSTERA*

Mangrove scrub (manglar) is present in coastal estuaries from southern Sonora, north to Guaymas, and scattered along the coast north to Bahía de Kino and Estero Sargento (29.326°N; Felger & Moser 1991; Figure 10). All three mangroves, including black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and red mangrove (*Rhizophora mangle*) are present. A northernmost mangrove stand at Puerto Lobos (30.271°N) has only black mangrove. Mangroves are limited to the north by winter temperatures.

Along the coast there is distinctive saltscrub vegetation (*matorral salitroso*) in saline soils. In areas close to the water in estuaries, iodine bush/*chamizo salado* (*Allenrolfia occidentalis*), saltwort/*hierba salada* (*Batis maritima*), pickleweed (*Salicornia bigelovii*), sea purslane/*verdolaga marina* (*Sesuvium verrucosum*), and sea blite/*romerito marino* (*Suaeda* spp.) are common. *Saladita* (*Frankenia palmeri*; Figure 11) dominates extensive salt flats (Felger & Moser 1991). The shrubs *mangle dulce* (*Maytenus phyllanthoides*) and *Xylothamia diffusa* are locally common.



Figure 10. Mangrove community in the tidal zone at Estero Salado near Guaymas. Photo by Susan D. Carnahan.





Figure 11. A. *Saladita* (*Frankenia palmeri*) saltscrub in Ensenada de los Perros, Isla Tiburón. Photo by Susan D. Carnahan. B. *Saladita* flowers near Puerto Libertad. Photo by Reina-G.

DUNESCRUB. MATORRAL ARENOSO

There is a distinctive dunescrub vegetation on large sand dunes in the Gran Desierto, south of Sierra Blanca in the Reserva de la Biósfera El Pinacate y Gran Desierto de Altar in northwestern Sonora (Figure 12), and on the east side of Playa San Bartolo near Bahía de Kino. Notable shrubs are *Croton wigginsii*, *Encelia frutescens*, *Ephedra trifurca*, *Eriogonum deserticola*, *Koeberlinia spinosa*, and *Psoralea emoryi*. Common perennial herbs are *Abronia villosa*, *Astragalus magdalenae*, *Baileya pleniradiata*, *Dicoria canescens*, *Dithyrea californica*, *Palafoxia arida*, *Stillingia linearifolia*, and *Tiquilia palmeri*.



Figure 12. Sand dunes in the Gran Desierto southeast of El Golfo de Santa Clara. Photo by Reina-G.

GRASSLAND. PASTIZAL

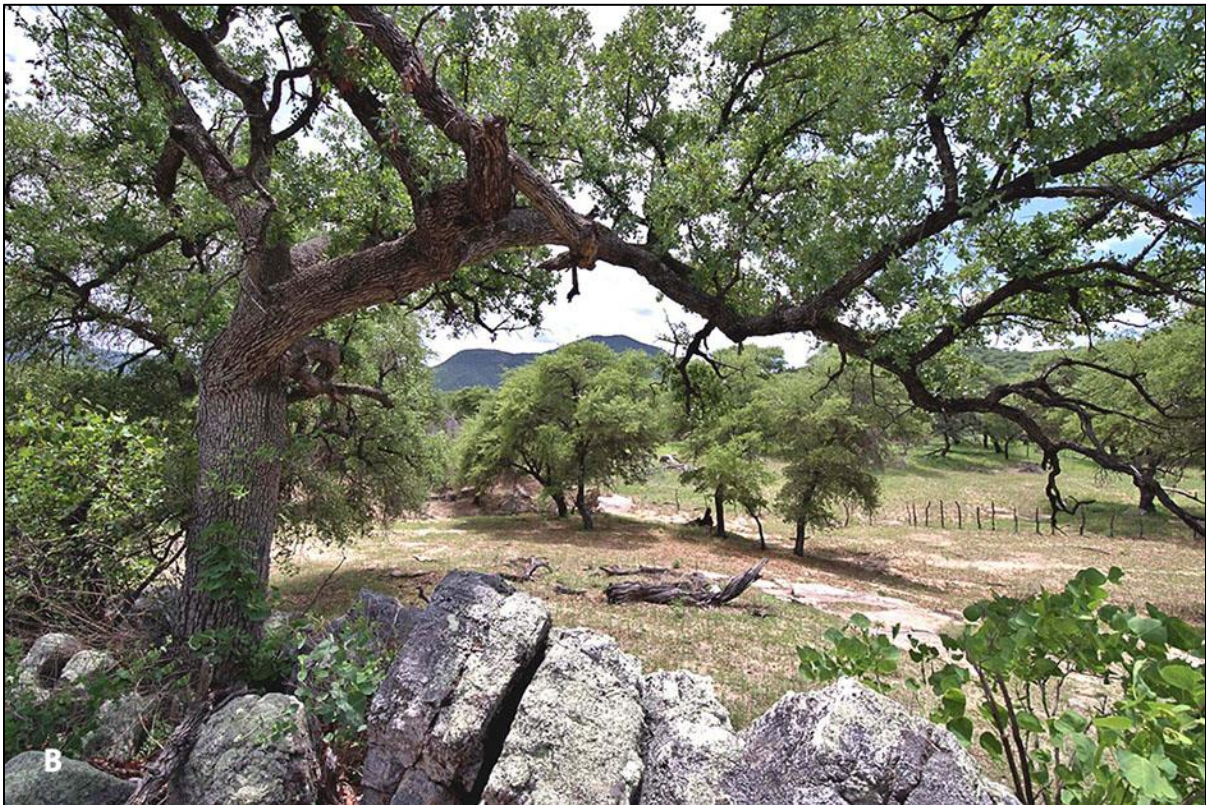
Grasslands are present in the middle of North America, east of the Rocky Mountains, from Canada south to Texas, and the Mexican Plateau east of the Sierra Madre Occidental in Chihuahua and Durango. The drier western part of this mid-continent grassland that extends across New Mexico to Arizona and northeastern Sonora is called desert grassland (*pastizal desértico*; McClaran & Van Devender 1995; Van Devender et al. 2010; Figure 13). This grassland can be dominated by perennial bunch grasses during long periods of heavy summer rainfall, and by velvet mesquite (*Prosopis velutina*) shrubs and Asteraceae (*Ericameria*, *Gutierrezia*, *Isocoma*, etc.) subshrubs during drier periods with reduced summer precipitation, systematic disturbance such as overgrazing, or greater winter precipitation. In Sonora, desert grassland is present in the northeastern borderlands. A cold, windy area in El Valle de las Ánimas in northeastern-most Sonora, east of Agua Prieta, is considered plains grassland (*pastizal de la llanura*).



Figure 13. Desert grassland in the Sierra San Luis, Sonora. Shrubs are Arizona juniper (*Juniperus arizonica*). Succulents are desert spoon and banana yucca/dátil (*Yucca baccata*). Photo by Van Devender.

OAK WOODLAND. BOSQUE DE ENCINO OR ENCINAL

Oak woodland (*encinal*) is present on all 32 Sky Island mountain ranges in northeastern Sonora (Van Devender 2013a; Figures 14A & B) and in an extensive zone at 1050–1700 m elevation in the Sierra Madre Occidental near Yécora (Van Devender & Reina-G. 2016). Dominant oaks on lower Sky Islands include Arizona white oak, Emory oak/bellota (*Q. emoryi*; Figure 14C), *Q. oblongifolia*, and *Q. toumeyi* (Figure 15B). Above Yécora on Rancho el Horquetudo, the tree beargrass/palmilla (*Nolina matapensis*) is co-dominant with the oaks (Van Devender & Reina-G. 2016; Figure 14C).



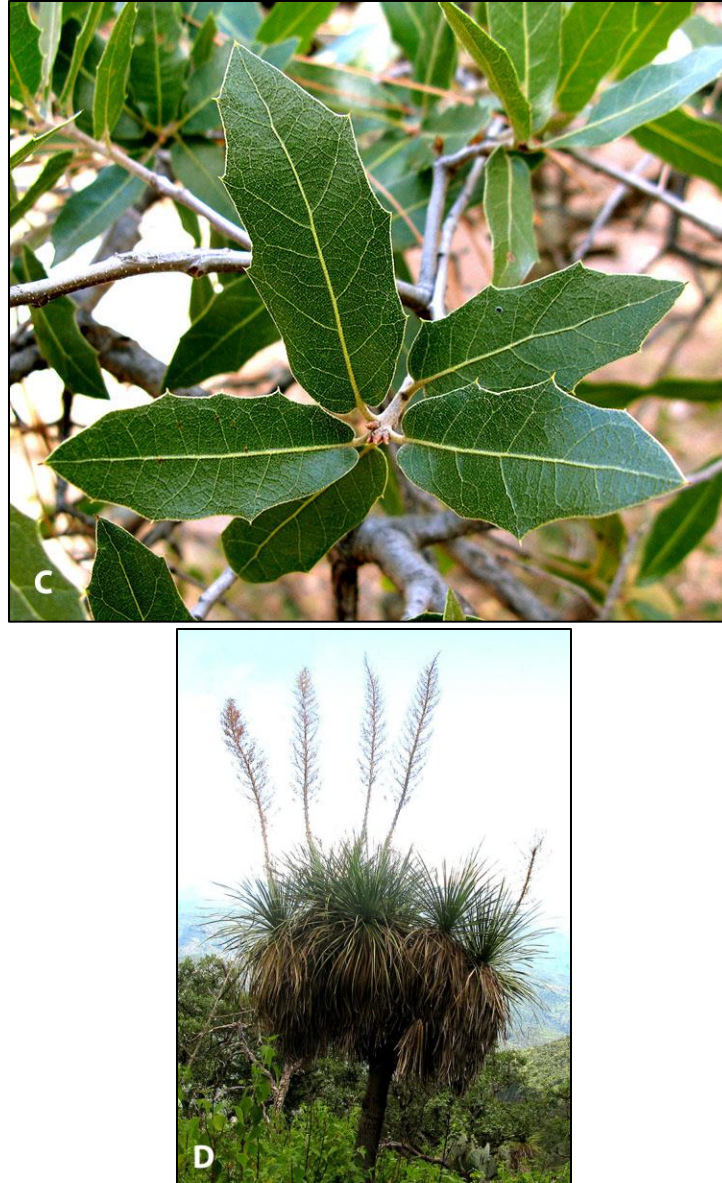


Figure 14. Oak woodland. A. Aerial view in Sierra Chivato, Sonora. Dominants are Emory oak and alligator juniper/táscate (*Juniperus deppeana*). Photo by Luis Gutiérrez, NortePhoto.com. B. Sierra Los Locos. Dominants are Arizona white, Emory, and Mexican blue oaks (*Quercus arizonica*, *Q. emoryi*, *Q. oblongifolia*). Photo by James C. Rorabaugh. C. Leaves of Emory oak. Photo by Van Devender. D. Tree beargrass on Rancho El Horquetudo near Yécora. Photo by Van Devender.

INTERIOR CHAPARRAL. CHAPARRAL

Interior chaparral is a fire climax vegetation dominated by shrub oaks and manzanita (*Arctostaphylos* spp.) in Mediterranean winter rainfall climates in California and northern Baja California. In Arizona, it is found in large areas below the Mogollon Rim. In Sonora, interior chaparral is only found in the westernmost Sky Island mountains near Sásabe on the Arizona border, including the Sierras Cobre, Durazno, and Humo. Scrub oak (*Quercus turbinella*) is a dominant shrub (Figure 15C). In the Sierra San Luis in northeastern Sonora near the Chihuahua border, there is another area of post-fire shrubby chaparral similar to areas in the Chiricahua Mountains in southeastern Arizona. Dominants are Toumey oak/encino finito (*Q. toumeyi*; Figure 15B) and pointleaf manzanita (*Arctostaphylos pungens*).



Figure 15. Interior chaparral. A. Sierra San Luis. Dominant is Toumey oak. Photo by Van Devender. B. Leaves of Toumey oak from the Sierra Azul. Photo by J. Jesús Sánchez-E. C. Leaves and acorns of scrub oak from the Pat Hills, Arizona. Photo by Christopher M. Roll.

PINE-OAK FOREST. *BOSQUE DE PINO-ENCINO*

González-E. et al. (2012) defined the floristic subprovinces of the Sierra Madre Occidental, including the Madrean Tropical subprovince in eastern Sonora. Pine-oak forest (POF) is present in large areas in the Sierra Madre Occidental in Sonora from El Chiribo and Yécora north to Mesa Tres Ríos and the Sierra Huachinera (Martin et al. 1998). At 1220–2240 m elevation in the Municipio de Yécora, POF often occurs in a mosaic with oak woodland (Van Devender & Reina-G. 2016). The Yécora area has the greatest diversity of pines (11 species) and oaks (15 species) in Sonora. Pines include *Pinus arizonica*, *P. cembroides*, *P. chihuahuana*, *P. discolor*, *P. engelmannii*, *P. herrerae*, *P. lumholtzii*, *P. maximinoi*, *P. oocarpa*, *P. strobiformis*, and *P. yecorensis*. Oaks include *Quercus albocincta*, *Q. arizonica*, *Q. barrancana*, *Q. chihuahuensis*, *Q. durifolia*, *Q. hypoleucoides*, *Q. jonesii*, *Q. mcvaughii*, *Q. oblongifolia*, *Q. perpallida*, *Q. rugosa*, Tarahumara oak/guëja (*Q. tarahumara*; Figure 16C), *Q. toumeyi*, *Q. tuberculata*, and *Q. viminea*.

Marshall (1957) provided an overview of the birds and vegetation in the pine-oak forests of southeastern Arizona and northern Sonora. POF is present in Sonora in the higher elevations in the Sky Island mountain ranges in northeastern Sonora. Large areas of POF in the Sierra de los Ajos, Buenos Aires, Elenita, La Madera, and El Tigre are protected in the Área de Protección de Flora y Fauna Bavispe. The most important pines are Arizona pine (*Pinus arizonica*), Chihuahua pine/pino chino (*P. chihuahuana*), Apache pine (*P. engelmannii*; Figure 16B), and Yécora pine (*P. yecorensis*). Important oaks are Arizona white oak/*encino blanco* (*Quercus arizonica*), silverleaf oak/*cusi prieto* (*Q. hypoleucoides*), Mexican blue oak/*encino azul* (*Q. oblongifolia*), netleaf oak/*encino roble* (*Q. rugosa*), and willowleaf oak/*cusi saucillo* (*Q. viminea*). Gambel's oak (*Q. gambelii*) is a temperate species with relictual Sky Island populations in pine-oak forest in the Sierras de los Ajos, Mariquita, Pinito, San José, and Tigre, and near Mesa Tres Ríos in the SMO (Figure 16D). The Huachuca agave/*maguay* (*Agave parryi* var. *huachucana*) is a noteworthy rosette succulent in pine-oak forest in the Huachuca Mountains of Arizona and the Sierras de los Ajos and La Púrica in Sonora (Gentry 1972; Figure 16E).





Figure 16. A. Pine-oak forest in the Sierra Elenita. Photo by Reina-G. B. Apache pine needles and male cones in the Sierra Elenita. Photo by Luis Gutiérrez, NortePhoto.com. C. Leaves of Tarahumara oak from near Maycoba. Photo by Van Devender. D. Leaves of Gambel's oak from the Sierra la Mariquita. Photo by Van Devender. E. Huachuca agave in the Sierra de los Ajos. Photo by Susan D. Carnahan.

MIXED-CONIFER FOREST. *BOSQUE MIXTO DE CONÍFERAS*

The most mesic montane forest at high elevations is mixed-conifer forest (MCF). The only area of MCF in the Sierra Madre Occidental in Sonora is on Mesa del Campanero near Yécora (Van Devender & Reina-G. 2016; Figure 17A). The only Sonoran populations of Durango fir/*pinabete* (*Abies durangensis*) in association with *huejas* (*Quercus jonesii*, *Q. mcvaughii*) and southwestern white pine/*piñón* (*Pinus strobiformis*; Figures 17B, C & D) are in three mesic canyons in this area. In the Sierra de los Ajos, a large Sky Island only 40 kilometers south of the Arizona border, MCF is restricted to north-facing slopes on Cerro Pelón and a few mesic canyons. Douglas fir/*pinabete* (*Pseudotsuga menziesii*) is present (Fishbein et al. 1995; Figure 17E).





Figure 17. A. Mixed-conifer forest. Barranca El Salto, Mesa del Campanero. Dominant tree is Durango fir. Photo by George M. Ferguson. B, C, D Southwestern white pine in the Sierra La Mariquita. Tree with cones. Needles with Convergent Ladybugs (*Hippodamia convergens*). Cone. E. Douglas fir needles in the Sierra de los Ajos. Photos B–E by Van Devender.

RIPARIAN VEGETATION. *VEGETACIÓN RIBEREÑA*

Riparian vegetation is a linear vegetation that transects other vegetation types. In Sonora, riparian habitats vary from permanent waterways along rivers and in canyons, to dry desert arroyos (Van Devender et al. 2010; Figure 18A). All of them harvest water, nutrients, and seeds from large areas in upstream drainages, and, in comparison with adjacent upland habitats, have greater moisture and are more unstable.





Figure 18. Riparian habitats. A. Río Santa Cruz at San Lázaro just south of Arizona border. Large trees are Fremont cottonwood. Photo by Luis Gutiérrez, NortePhoto.com. B. Río Cuchujaqui near Álamos. Large trees are Mexican bald cypress. Photo by Robert A. Behrstock. C. Arroyo Cajón Bonito near Agua Prieta. Large trees are Fremont cottonwoods. Photo by Van Devender.

In tropical southern Sonora, Mexican bald cypress/*sabino* or *ahuehuete* (*Taxodium distichum* var. *mexicanum*) forests are along the Río Cachujaqui east of Álamos (Figure 18B). Riparian forests of *guásima* (*Guasima ulmifolia*) are common in TDF. From east-central Sonora north into Arizona, cottonwood-willow deciduous riparian forests dominated by Fremont cottonwood/*álamo* (*Populus fremontii*) and willows/sauces (*Salix bonplandiana*, *S. gooddingii*) are along waterways (Figure 18C). Other riparian trees include velvet ash/*fresno* (*Fraxinus velutina*), Arizona walnut/*nogal* (*Juglans major*), and Arizona sycamore/*aliso* (*Platanus wrightii*; Figure 19C). Riparian trees in higher elevations in the SMO and higher Sky Island mountain ranges are *alamillo* (*Alnus oblongifolia*), Arizona cypress/*sabino* (*Hesperocyparis arizonica*), *Ilex rubra*, *sabino* (*Juniperus blancoi*), hop hornbeam/*palo prieto* (*Ostrya virginiana*), *Prunus gentryi*, and black cherry/*capulin* (*P. serotina*; Martin et al. 1998; Van Devender & Reina-G. 2016; Van Devender et al. 2003). White fir/*pinabete* (*Abies concolor*), bigtooth maple (*Acer grandidentatum*; Figure 19A), and aspen/*álamo temblón* (*Populus tremuloides*; Fishbein et al. 1995; Figure 19 C & D) are in riparian canyons in mixed-conifer forest in the Sierra Los Ajos.



Figure 19. Riparian trees. A. Bigtooth maple in the Santa Catalina Mountains, Arizona. Photo by Van Devender. B. Arizona sycamore leaves and fruit in the Sierra Azul. Photo by J. Jesús Sánchez-E. C & D. Quaking aspen stand and leaf in the Sierra de los Ajos. Photos by Caroline Treadway and Van Devender.

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