

Flora of the Sierra Bacha, Municipality of Pitiquito, Sonora, Mexico

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Abstract

The Sierra Bacha is in the Central Gulf Coast Subdivision of the Sonoran Desert along the coast of the Gulf of California, south of Puerto Libertad, Municipality of Pitiquito, Sonora. The flora of the Sierra Bacha has 269 species, one additional subspecies, and one hybrid in 57 families and 183 genera. The most species-rich families are Asteraceae (44 species); Fabaceae (23 species); Euphorbiaceae (17 species); Boraginaceae, Cactaceae, Poaceae, and Solanaceae (15 taxa each). Nineteen species (7.0%) are relictual populations of Baja California species, including the only mainland population of *Fouquieria columnaris* (boojum) at Punta Cirio. Sixteen species (5.9%) are non-native. Eleven packrat (*Neotoma* sp.) middens were radiocarbon dated from 9,970 to 320 yr B.P. (years before 1950). Plant fossils in the samples were identified to 82 species in 30 families and 69 genera. Ten species no longer occur in the Sierra Bacha. In the Early Holocene (9,970 to 9,270 yr B.P.), *F. columnaris* was living farther inland on rhyolitic slopes. Vegetation and climate with greater winter rainfall and cooler summers similar to Baja California today were more widespread in western Sonora during the

Early Holocene and likely the 15-20 glacial periods in the last two million years of the Pleistocene.

Resumen

La Sierra Bacha se localiza en la Subdivisión de la Costa Central del Golfo del Desierto Sonorense en la costa del Golfo de California, al sur de Puerto Libertad, municipio de Pitiquito, Sonora. La flora de la Sierra Bacha tiene 269 especies, en 57 familias y 183 géneros más una subespecie adicional y un híbrido. Las familias más numerosas son Asteraceae (44 especies); Fabaceae (23); Euphorbiaceae (17); Boraginaceae, Cactaceae, Poaceae y Solanaceae (15 taxones cada una). Diecinueve especies (7.0%) son poblaciones relictas de especies de Baja California, incluida la única población continental de cirio (*Fouquieria columnaris*) en Punta Cirio. Dieciséis especies (5.9%) no son nativas. Once depósitos de *Neotoma* tienen fechas de radiocarbono de 9,970 a 320 años A.P. (años anteriores a 1950). En las muestras se identificaron 82 especies de plantas fósiles pertenecientes a 30 familias y 69 géneros. Diez especies ya no se encuentran en la Sierra Bacha. En el Holoceno Temprano (de 9,970 a 9,270 años A.P.), el cirio tenía una distribución más amplia al interior, en las laderas riolíticas. La vegetación y el clima, con mayor precipitación invernal y veranos más fríos, similares a los de Baja California en la actualidad, estaban más extendidos en el oeste de Sonora durante el Holoceno Temprano y probablemente durante los 15-20 períodos glaciares de los últimos dos millones de años del Pleistoceno.

Introduction

There are four major Deserts in North America (Figure 1). The cold temperate Great Basin Desert extends from Oregon, Idaho, and Wyoming south to Nevada, Utah, and Arizona. Broad valleys are dominated by *Artemisia tridentata* (big sagebrush) and other shrubs.

The Mohave Desert from southern Nevada south to eastern California and western Arizona has cold winters and hot summers in a winter rainfall climate. *Larrea divaricata* (creosotebush, *governadora*) is a widespread dominant. In many areas, the arborescent *Yucca brevifolia* (Joshua tree) forms scenic landscapes.

The Chihuahuan Desert in the mid-continent extends from Durango, Nuevo León, San Luis Potosí, and Zacatecas north across the Mexican Plateau through Chihuahua and Coahuila to Texas and New Mexico, reaching its northwestern limit in southeastern Arizona and adjacent Sonora. In the north, the vegetation is an edaphic mosaic with Chihuahuan desertscrub on limestone slopes and desert grassland on deep soils in the adjacent valleys. The climate has hot summers dominated by summer moisture from the Gulf of Mexico. Periodic blue northers (southern incursions of Arctic air) bring hard freezes throughout the Mexican Plateau as far south as Guadalajara and Mexico City. Most of the vegetation is dominated by mixed shrubs. Small cacti are very common and diverse. In the central and southern Chihuahuan Desert, *izotales* of tree yuccas, including *Yucca faxoniana*, *Y. filifera*, *Y. rigida*, *Y. thompsoniana*, and *Y. treculeana* dominate limestone landscapes.

The Sonoran Desert extends from southeastern California and southwestern Arizona south to most of the Baja California Peninsula and central and western Sonora (Shreve 1964, Turner 1994, Van Devender & Reina-G. 2021; Figure 2). The climate has mild winters and bi-seasonal rainfall dominated by summer moisture from the Pacific Ocean and the Gulf of California. The vegetation in most areas has several layers with columnar cacti taller than leguminous trees and understory shrubs. The Vizcaíno and Magdalena Plain subdivisions are on the Baja California Peninsula. The Lower Colorado River Valley subdivision is in the lowlands around the head of the Gulf of California in southeastern California, southwestern Arizona, northeastern Baja California, and northwestern Sonora. *Larrea divaricata* and *Ambrosia dumosa*



Figure 1. Map of the major deserts of North America.



Figure 2. Map of the subdivisions of the Sonoran Desert. Modified from Shreve (1964).



Figure 3. Central Gulf Coast Sonoran desertscrub in the Sierra Bacha dominated by *Pachycereus pringlei*, *Bursaria microphylla*, and *Fouquieria splendens*. Photo by Reina-G.

(white bursage) dominate lowland desertscrub. The Arizona Upland subdivision is present in higher areas in north-central Sonora and southern Arizona. Dominants include *Carnegiea gigantea* (sahuaro) and *Parkinsonia microphylla* (foothills paloverde, *palo verde*). The Plains of Sonora subdivision is in central Sonora as far south as Guaymas. *Neltuma velutina* (= *Prosopis velutina*, velvet mesquite) and *Stenocereus thurberi* (organ pipe cactus, *pitahaya*) are dominants. The Central Gulf Coast subdivision is in eastern Baja California and in central Sonora along the coast of the Gulf of California.

The Sierra Madre Occidental formed in the late Oligocene-middle Miocene (30-15 mya [million years ago], Van Devender 2002). During a drying trend in the middle Miocene (10-8 mya), tropical deciduous forest west of the new cordillera changed first to thornscrub and later to desertscrub as the Sonoran Desert formed. The land separated from the mainland near Mazatlán, Sinaloa, by the formation of the proto-Gulf of California about 12 mya began moving to

the northwest, eventually forming the Baja California Peninsula. The modern Gulf of California was established by the end of the Miocene (5 mya). The modern Sonoran Desert flora has strong evolutionary roots in the tropical vegetation that preceded it along with the evolution of new species, especially in the splendid isolation of Baja California.

Unlike many desert plants that evolved *in situ* as the Sonoran Desert developed, the genus *Larrea* with four species evolved in South America. The weakly differentiated *L. divaricata* subsp. *tridentata* (widely used as the species *L. tridentata*) evolved in Perú before it immigrated north sometime in the Pleistocene and conquered the North American deserts. The most unique creosotebush in North America is the willow-like *L. d.* var. *arenaria* endemic to the Algodones Dunes in southeastern California just west of Yuma, Arizona.

Here we summarize the flora of the Sierra Bacha in the Central Gulf Coast subdivision of the Sonoran Desert along the coast of the Gulf of California in Sonora (Figure 3).

Study Area

The Sierra Bacha is located between Puerto Libertad (29.906°N 112.680°W) and Desemboque del Río San Ignacio (29.506°N 112.396°W, Figure 4) along the Sonoran coast of the Gulf of California in the Municipality of Pitiquito. Desemboque is a Seri Indian village (Felger & Moser 1991) that is often confused with Mexican village of the same name near the mouth of the Río Asunción in the Municipality of Caborca (132 km NNW, 30.569°N 113.056°W). Punta Cirio is in the northern end of the Sierra Bacha (29.855°N 112.647°W). Elevations range from sea level to 455 m elevation. Most of the Sierra Bacha is formed of Late Cretaceous granitic rocks with small areas of Mesozoic metamorphic sedimentary rocks (Darin & Dorsey 2014). Miocene volcanic tuffs and conglomerates are on the inland, southeastern part of the range. Packrat (*Neotoma* sp.) middens were collected in Coloradito Canyon south of Punta Cirio in the northern Sierra Bacha (29.769°N 112.566°W, 240 m elevation) in 1991.

Methods

Records of plant collections in the Sierra Bacha were harvested from the Madrean Discovery Expeditions (madreandiscovery.org) and linked databases in the SEINet-SYMBIOTA network. We note that there are likely many additional specimens in herbaria not in the SEINet network. Older Mexican collections in SEINet herbaria may not have been digitized. Specimens collected during the early Desert Laboratory trips to Puerto Libertad could be at the American Museum of Natural History (AMNH). Additional voucher specimens may have been collected for Punta Cirio vegetation studies (Humphrey 1975, Stromberg & Krischan 1983, Leitner 1987).

Ira L. Wiggins collected at Punta Cirio in 1932 as part of the **Vegetation and Flora of the Sonoran Desert** (Shreve & Wiggins 1964). Records were extracted from his catalog in the California Academy of Science Herbarium (CAS). Major collections in the study area were made by Arthur M. and Barbara G. Phillips, J. Jesús Sánchez-E., Grady L. Webster, as well as Van Devender and Reina-G. Botanists from the University of Arizona Desert Laboratory on Tumamoc Hill, including Janice E. Bowers, Tony L. Burgess,

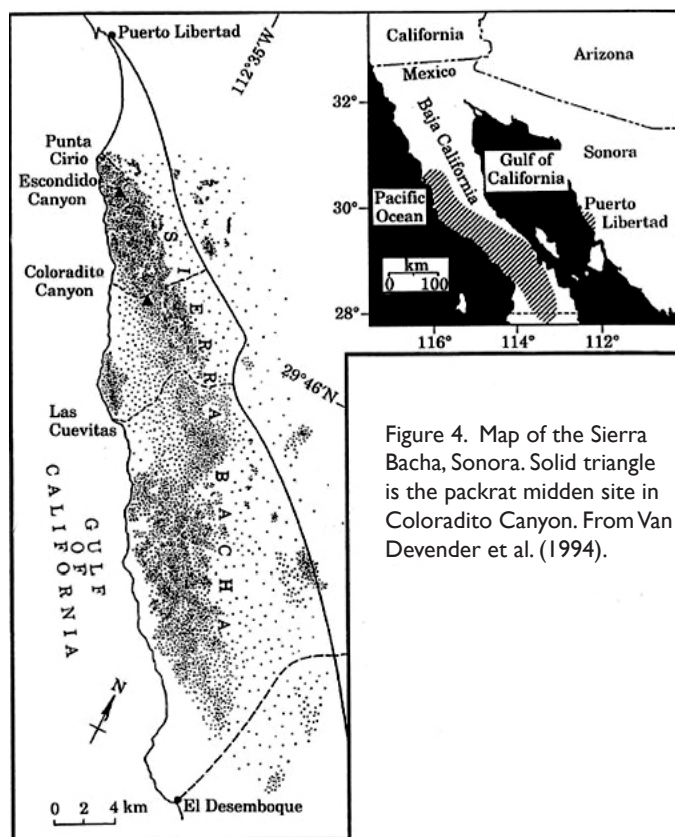


Figure 4. Map of the Sierra Bacha, Sonora. Solid triangle is the packrat midden site in Coloradito Canyon. From Van Devender et al. (1994).

J. Rodney Hastings, Paul S. Martin (Figure 15D), Arthur and Barbara Phillips, Raymond M. Turner, Rebecca K. and Thomas R. Van Devender, and Fred M. Wiseman collected plants at Punta Cirio in April 1960, January 1975, February and November 1977, February 1978, April and November 1979, March 1981, December 1988, and February 1991. Other collectors in the Sierra Bacha study area were Edward Abbey, C. David Bertelsen, Robert L. Bezy, Tracy L. Bunting, Alejandro E. Castellanos-V., S. Danziger, George M. Ferguson, Samuel L. Friedman, Robert R. Humphrey, Kristen J. Johnson, Stephen P. McLaughlin, Charles H. Lowe, Francisco Molina-F., Mary Beck Moser, Jesse C. Piper, Chris Roll, Carlos Saravia-T., A. Saucedo-A., Forrest Shreve, Sally and Tim Walker, Richard S. White, and Benjamin T. Wilder. Specimens are in the herbaria at the University of Arizona (ARIZ), Arizona State University (ASU), California Botanic Garden Herbarium (CalBG-RSA), University of California at Davis (DAV), Desert Botanical Garden (DES), Museum of Northern Arizona (MNA), New York Botanical Garden (NY), San Diego State University (SD), University of Texas (TEX), University of California at Riverside (UCR), Universidad de

Sonora (USON), and University of Texas at El Paso (UTEP). Although Felger only collected in the Las Cuevitas area in the southern Sierra Bacha, he made many collections on at least ten trips to the Desemboque area between February 1961 and December 1973 as part of the **People of the Desert and Sea. Ethnobotany of the Seri Indians** book project (Felger & Moser 1991).

Plants were collected or observed in the Sierra Bacha in November 1923, March 1926, April 1928, September 1961, December 1962, January 1963, May and October 1966, February and December 1967, February and April 1968, February 1969, January 1972, November and December 1973, January 1975, February and November 1977, February and March 1978, February, April, March, and November 1979, March 1981, January and March 1984, December 1988, February and March 1991, April 1992, November 1993, March 1995, October 2002, March 2007, March 2011, January, February, and March 2016, and March 2017.

Plant taxonomy follows Felger & Moser (1991), Felger & Wilder (2012), and more recent revisions. Plant distributions were reviewed in Turner et al. (1995), Felger (2000), and the SEINet databases.

Packrat middens. Packrats or woodrats are a group of about 20 species of North American rodents in the genus *Neotoma* (Figure 5). They collect plant materials from within their home ranges for food and shelter. Their living structures are called houses in open areas and dens in rockshelters. The garbage areas outside the houses are called middens, a term borrowed from archeological site middens. In rockshelters, they often have urination perches where leaves, twigs, seeds, airborne pollen, and animal remains from ringtail (*Bassaricus astutus*) scat and owl pellets are cemented together. Consolidated midden deposits can be preserved in dry rockshelters for thousands of years. Plant remains in these deposits are fossils preserved in urine and not mineralized, and perfect for radiocarbon dating. Packrat midden materials have been dated to more than 40,000 years B.P. (before 1950, Van Devender 1990).

Results

The flora of the Sierra Bacha has 269 species, one additional subspecies, and one hybrid in 57 families



Figure 5. Packrats accumulate plant parts and other materials in their houses.

and 183 genera (Table 1). The most diverse families are Asteraceae (44 species); Fabaceae (23 species); Euphorbiaceae (17 species); Boraginaceae, Cactaceae, Poaceae, and Solanaceae (15 taxa each); Amaranthaceae (11 species); Brassicaceae and Malvaceae (9 species each); Onagraceae and Polygonaceae (7 taxa each); and Plantaginaceae (6 species). The most species-rich genera are *Ambrosia* (10 species); *Lycium* (8 taxa); *Euphorbia* (7 species); *Atriplex*, *Cylindropuntia*, and *Eriogonum* (5 species each); *Phacelia* and *Sphaeralcea* (4 species each); and *Argythamnia*, *Chylismia*, *Fagonia*, *Ferocactus*, *Krameria*, *Lupinus*, *Mentzelia*, and *Nicotiana* (3 species each).

With only 15 non-native species (5.6%), the Sierra Bacha flora is relatively undisturbed. Although *Brassica tournefortii* (Sahara mustard), *Cenchrus ciliaris* (buffelgrass), *Mesembryanthemum crystallinum* (iceplant), and *Nicotiana glauca* (tree tobacco, *juan loco*) are serious invasive plants in other areas, they were only locally common in the Sierra Bacha when collected. *Brassica tournefortii* was first collected in the Sierra Bacha in 1991, although Raymond Turner collected it in 1988 at Rancho El Picú (33.5 km ENE of Puerto Libertad). *Cenchrus ciliaris* was first seen in the Sierra Bacha in 2016 but observed by Turner in the Sierra del Viejo (54 km NE of Puerto Libertad) in 1987. *Mesembryanthemum crystallinum* is scattered along the coast from north of Puerto Peñasco south to Desemboque del Río San Ignacio.

Eleven packrat middens in the Sierra Bacha were radiocarbon dated to 9,970 to 320 yr B.P. (Table 2) plus two undated modern loose debris piles in the midden rock shelter (Van Devender et al. 1994). A total of 82 species of plants in 69 genera and 30 families were

Table 1.

Plants recorded from the Sierra Bacha area, Sonora, Mexico.

* = non-native species.

Acanthaceae
<i>Carlowrightia arizonica</i> A. Gray
<i>Holographis virgata</i> (Harvey ex Benth. & Hook. f.) Daniel
<i>Justicia californica</i> (Benth.) D. Gibson
Aizoaceae
* <i>Mesembryanthemum crystallinum</i> L.
Amaranthaceae
<i>Allenrolfea occidentalis</i> (S. Watson) Kuntze
<i>Amaranthus fimbriatus</i> (Torr.) Benth. ex S. Watson
<i>Amaranthus watsonii</i> Standl.
<i>Aphanisma blitoides</i> Nutt. ex Moq.
<i>Atriplex barclayana</i> D. Dietr.
<i>Atriplex canescens</i> (Pursh) Nutt.
<i>Atriplex linearis</i> S. Watson
<i>Atriplex pacifica</i> A. Nels.
<i>Atriplex polycarpa</i> (Torr.) S. Watson
* <i>Chenopodiastrium murale</i> (L.) S. Fuentes-B., Uotila & Borsch
<i>Suaeda nigra</i> (Raf.) J.F. McBride
Amaryllidaceae
<i>Allium haematociton</i> S. Watson
Apiaceae
<i>Bowlesia incana</i> Ruiz & Pav.
<i>Spermolepis lateriflora</i> G.L. Nesom
Apocynaceae
<i>Asclepias subulata</i> Decne.
<i>Funastrum heterophyllum</i> (Engelm. ex Torr.) Standl.
<i>Matelea pringlei</i> (A. Gray) Woodson
<i>Vallesia glabra</i> Link
Asparagaceae
<i>Agave angustifolia</i> Haw.
<i>Agave subsimplex</i> Trel.
<i>Dichelostemma capitatum</i> (Benth.) Alph. Wood subsp. <i>pauciflorum</i> (Torr.) Keator
<i>Triteleopsis palmeri</i> (S. Watson) Hoover
Asteraceae
<i>Ambrosia ambrosioides</i> (Cav.) W.W. Payne
<i>Ambrosia camphorata</i> (Greene) W.W. Payne
<i>Ambrosia chenopodiifolia</i> (Benth.) W.W. Payne
<i>Ambrosia confertiflora</i> DC.
<i>Ambrosia deltoidea</i> (Torr.) W.W. Payne
<i>Ambrosia dumosa</i> (A. Gray) W.W. Payne

<i>Ambrosia ilicifolia</i> (A. Gray) W.W. Payne
<i>Ambrosia magdalenae</i> (Brandege) W.W. Payne
<i>Ambrosia monogyra</i> (Torr. & A. Gray) Strother & B.G. Baldwin
<i>Ambrosia salsola</i> (Torr. & A. Gray) Strother & B.G. Baldwin var. <i>pentalepis</i> (Rydb.) Strother & B.G. Baldwin
<i>Baccharis salicifolia</i> (Ruiz & Pav.) Pers.
<i>Baccharis sarothroides</i> A. Gray
<i>Bahiopsis laciniata</i> (A. Gray) E.E. Schill. & Panero
<i>Bajacalia crassifolia</i> (S. Watson) Loockerman, B.L. Turner & R.K. Jansen
<i>Bebbia juncea</i> (Benth.) Greene
<i>Chaenactis carphoclinia</i> A. Gray
<i>Chaenactis stevioides</i> Hook. & Arn.
<i>Encelia californica</i> Nutt.
<i>Encelia farinosa</i> A. Gray ex Torr.
<i>Gnaphalium palustre</i> Nutt.
<i>Heliopsis anomala</i> (M.E. Jones) B.L. Turner
<i>Hofmeisteria fasciculata</i> (Benth.) Walp. var. <i>fasciculata</i>
<i>Isocoma felgeri</i> G.L. Nesom
<i>Leucosyris arida</i> (R.C. Jacks. & R.R. Johnson) Pruski & R.L. Hartm.
<i>Logfia arizonica</i> (A. Gray) Holub
<i>Logfia depressa</i> (A. Gray) Holub
<i>Logfia filaginoides</i> (Hook. & Arn.) Morefield
<i>Malperia tenuis</i> S. Watson
<i>Monoptilon bellioides</i> (A. Gray) Hall
<i>Palafoxia arida</i> B.L. Turner & M.I. Morris var. <i>arida</i>
<i>Palafoxia linearis</i> (Cav.) Lag.
<i>Pectis papposa</i> Harv. & A. Gray var. <i>papposa</i>
<i>Perityle californica</i> Benth.
<i>Perityle emoryi</i> Torr.
<i>Perityle microglossa</i> Benth. var. <i>microglossa</i>
<i>Pleurocoronis laphamioides</i> (Rose) R. M. King and H. Rob.
<i>Porophyllum gracile</i> Benth.
<i>Senecio flaccidus</i> Less. var. <i>monoensis</i> (Greene) B.L. Turner & T.M. Barkl.
<i>Senecio mohavensis</i> A. Gray
* <i>Sonchus oleraceus</i> L.
<i>Stephanomeria pauciflora</i> (Torr.) A. Nels.
<i>Thymophylla pentachaeta</i> (DC.) Small
<i>Trixis californica</i> Kellogg
<i>Xanthisma spinulosum</i> (Pursh) D.R. Morgan & R.L. Hartm. var. <i>scabrellum</i> (Greene) D.R. Morgan & R.L. Hartm.

Boraginaceae
<i>Cryptantha barbiger</i> (A. Gray) Greene
<i>Cryptantha maritima</i> (Greene) Greene var. <i>maritima</i>
<i>Cryptantha racemosa</i> (A. Gray) Greene
<i>Eremocarya micrantha</i> (Torr.) Greene var. <i>micrantha</i>
<i>Eucrypta chrysanthemifolia</i> (Benth.) Greene
<i>Johnstonella angustifolia</i> (Torr.) Hasenstab & M.G. Simpson
<i>Johnstonella fastigiata</i> (I.M. Johnst.) Hasenstab & M.G. Simpson
<i>Pectocarya heterocarpa</i> (I.M. Johnst.) I.M. Johnst.
<i>Pectocarya peninsularis</i> (Munz & I. M. Johnst.) Munz & I. M. Johnst.
<i>Pectocarya platycarpa</i> (Munz & I. M. Johnst.) Munz & I.M. Johnst.
<i>Phacelia ambigua</i> M.E. Jones
<i>Phacelia cryptantha</i> Greene
<i>Phacelia coerulea</i> Greene
<i>Phacelia distans</i> Benth.
<i>Tiquilia palmeri</i> (A. Gray) A. Richards
Brassicaceae
* <i>Brassica tournefortii</i> Gouan
<i>Caulanthus lasiophyllus</i> (Hook. & Arn.) Payson
<i>Descurainia pinnata</i> (Walter) Britton
<i>Dithyrea californica</i> Harv.
<i>Lepidium lasiocarpum</i> Nutt.
<i>Lyrocarpa coulteri</i> Hook. & Harv.
<i>Sibara laxa</i> Greene
* <i>Sisymbrium irio</i> L.
<i>Tomostima cuneifolia</i> (Nutt. ex Torr. & A. Gray) Al-Shehbaz, M. Koch & Jordan-Thaden
Burseraceae
<i>Bursera hindsiana</i> Engl.
<i>Bursera microphylla</i> A. Gray
Cactaceae
<i>Carnegiea gigantea</i> (Engelm.) Britton & Rose
<i>Cylindropuntia arbuscula</i> (Engelm.) Knuth
<i>Cylindropuntia bigelovii</i> (Engelm.) Knuth
<i>Cylindropuntia fulgida</i> (Engelm.) Knuth
<i>Cylindropuntia leptocaulis</i> (DC.) Knuth
<i>Cylindropuntia thurberi</i> (Engelm.) F.M. Knuth subsp. <i>versicolor</i> (Engelm. ex J.M. Coulter) M.A. Baker
<i>Echinocereus engelmannii</i> (Parry ex Engelm.) Lem. subsp. <i>fasciculatus</i> (Engelm. ex S. Watson) W. Blum & Mich. Lange
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt
<i>Ferocactus emoryi</i> (Engelm.) Orcutt
<i>Ferocactus tiburonensis</i> (G.E. Linds.) Backeb.

<i>Lophocereus schottii</i> (Engelm.) Britton & Rose var. <i>schottii</i>
<i>Mammillaria grahamii</i> Engelm. subsp. <i>sheldonii</i> (Britton & Rose) D.R. Hunt
<i>Pachycereus pringlei</i> Britton & Rose
<i>Peniocereus striatus</i> (Brandege) Buxbaum
<i>Stenocereus thurberi</i> (Engelm.) Buxbaum
Campanulaceae
<i>Nemacladus orientalis</i> (McVaugh) Morin
Capparidaceae
<i>Capparis atamisquea</i> Kuntze
Caryophyllaceae
<i>Achyronychia cooperi</i> Torr. & A. Gray
Cleomaceae
<i>Wislizenia refracta</i> Engelm. var. <i>palmeri</i> (A. Gray) I.M. Johnst.
Convolvulaceae
<i>Cuscuta desmouliniana</i> Yunc.
Crassulaceae
<i>Crassula connata</i> (Ruiz & Pav.) Berger
<i>Dudleya arizonica</i> Rose
Cucurbitaceae
<i>Brandegee bigelovii</i> (S. Watson) Cogn.
<i>Cucurbita digitata</i> A. Gray
Euphorbiaceae
<i>Acalypha californica</i> Benth.
<i>Argythamnia adenophora</i> A. Gray
<i>Argythamnia lanceolata</i> (Benth.) Müll.-Arg
<i>Argythamnia serrata</i> (Torr.) Müll.-Arg
<i>Croton californicus</i> Müll.-Arg
<i>Euphorbia albomarginata</i> A. Gray
<i>Euphorbia eriantha</i> Benth.
<i>Euphorbia misera</i> Benth.
<i>Euphorbia pediculifera</i> Engelm.
<i>Euphorbia petrina</i> S. Watson
<i>Euphorbia polycarpa</i> Benth.
<i>Euphorbia setiloba</i> Engelm. ex Torr.
<i>Jatropha cinerea</i> (Ortega) Müll.-Arg
<i>Jatropha cuneata</i> Wiggins & Rollins
<i>Pleradenophora bilocularis</i> (S. Watson) Esser & A.L. Melo
* <i>Ricinus communis</i> L.
<i>Stillingia linearifolia</i> S. Watson
Fabaceae
<i>Acmispon maritimus</i> (Nutt. ex Torr. & A. Gray) D.D. Sokoloff var. <i>brevivexillus</i> (Ottley) Brouillet

<i>Acmispon strigosus</i> (Nutt.) Brouillet
<i>Astragalus magdalenae</i> Greene var. <i>peirsonii</i> (Munz & McBurney) Barneby
<i>Astragalus nuttallianus</i> DC. var. <i>cedrosensis</i> M.E. Jones
<i>Dalea mollis</i> Benth.
<i>Desmanthus fruticosus</i> Rose
<i>Ebenopsis confinis</i> Britton & Rose
<i>Errazurizia megacarpa</i> I.M. Johnst.
<i>Hoffmannseggia intricata</i> Brandegee
<i>Hoffmannseggia microphylla</i> Torr.
<i>Lupinus arizonicus</i> (S.Watson) S.Watson
<i>Lupinus concinnus</i> J.G. Agardh
<i>Lupinus sparsiflorus</i> Benth.
<i>Marina parryi</i> (Torr. & A. Gray) Barneby
* <i>Melilotus indica</i> (L.) All.
<i>Neltuma odorata</i> (Torr. & Frém.) C.E. Hughes & G.P. Lewis
<i>Neltuma velutina</i> (Wooton) Britton & Rose
<i>Olneya tesota</i> A. Gray
<i>Parkinsonia florida</i> (Benth. ex A. Gray) S.Watson
<i>Parkinsonia microphylla</i> Torr.
<i>Phaseolus filiformis</i> Benth.
<i>Senegalia greggii</i> (A. Gray) Britton & Rose
Fouquieriaceae
<i>Fouquieria columnaris</i> Kellogg ex Curran
<i>Fouquieria splendens</i> Engelm.
Frankeniaceae
<i>Frankenia palmeri</i> S.Watson
Geraniaceae
<i>Erodium texanum</i> A. Gray
Koeberliniaceae
<i>Koeberlinia spinosa</i> Zucc.
Krameriaceae
<i>Krameria bicolor</i> S.Watson
<i>Krameria erecta</i> Willd. ex J.A. Schultes
<i>Krameria sonora</i> Britton
Lamiaceae
<i>Condea albida</i> (Kunth) Harley & J.F.B. Pastore
<i>Salvia columbariae</i> Benth.
<i>Teucrium cubense</i> Jacq. subsp. <i>depressum</i> (Small) McClintock & Epling
Loasaceae
<i>Eucnide rupestris</i> (Baill.) H.J. Thompson & Ernst
<i>Mentzelia adhaerens</i> Benth.
<i>Mentzelia asperula</i> Wooton & Standl.
<i>Mentzelia involucrata</i> S.Watson

Malpighiaceae
<i>Callaeum macropterum</i> (DC.) D.M. Johnson
<i>Cottisia gracilis</i> (A. Gray) W.R. Anderson
Malvaceae
<i>Abutilon palmeri</i> A. Gray
<i>Hibiscus denudatus</i> Benth.
<i>Horsfordia alata</i> (S.Watson) A. Gray
<i>Horsfordia newberryi</i> (S.Watson) A. Gray
* <i>Malva parviflora</i> L.
<i>Sphaeralcea ambigua</i> A. Gray var. <i>versicolor</i> (Kearney) Kearney
<i>Sphaeralcea axillaris</i> S.Watson var. <i>violacea</i> (Rose) Wiggins
<i>Sphaeralcea coulteri</i> (S.Watson) A. Gray
<i>Sphaeralcea orcuttii</i> Rose
Montiaceae
<i>Calandrinia ciliata</i> (Ruiz & Pavon) DC.
<i>Cistanthe maritima</i> (Nutt.) Carolin ex Hershk.
Namaceae
<i>Nama demissa</i> A. Gray
<i>Nama hispida</i> A. Gray
Nyctaginaceae
<i>Abronia maritima</i> Nutt. ex S.Watson subsp. <i>maritima</i>
<i>Abronia villosa</i> S.Watson var. <i>villosa</i>
<i>Allionia incarnata</i> L.
<i>Mirabilis laevis</i> (Benth.) Curran var. <i>villosa</i> (Kellogg) Spellenb.
Onagraceae
<i>Chylismia cardiophylla</i> (Torr.) Small subsp. <i>cardiophylla</i>
<i>Chylismia cardiophylla</i> (Torr.) subsp. <i>cedrosensis</i> (Greene) W.L. Wagner & Hoch
<i>Chylismia claviformis</i> (Torr. & Frém.) A. Heller subsp. <i>yumae</i> (P.H. Raven) W.L. Wagner & Hoch
<i>Eremothera chamaenerioides</i> (A. Gray) W.L. Wagner & Hoch
<i>Eulobus californicus</i> Nutt. ex Torr. & A. Gray
<i>Oenothera arizonica</i> Munz
<i>Oenothera deltoides</i> Torr. & Frém.
Orobanchaceae
<i>Orobanche cooperi</i> (A. Gray) A. Heller
Papaveraceae
<i>Argemone gracilentia</i> Greene
<i>Eschscholzia minutiflora</i> S.Watson
<i>Eschscholzia parishii</i> Greene
Passifloraceae
<i>Passiflora arida</i> (Mast. & Rose) Killip
Picrodendraceae
<i>Tetracoccus fasciculus</i> (S.Watson) Croizat var. <i>hallii</i> (Brandegee) Dressler

Plantaginaceae
<i>Gambelia juncea</i> (Benth.) D.A. Sutton
<i>Maurandya antirrhiniflora</i> Humb. & Bonpl. ex Willd.
<i>Mohavea confertiflora</i> (A. DC.) Heller
<i>Plantago ovata</i> Forssk. var. <i>fastigiata</i> (E. Morris) S.C. Meyers & Liston
<i>Pseudorontium cyathiferum</i> (Benth.) Rothm.
<i>Sairocarpus watsonii</i> (Vasey & Rose) D.A. Sutton
Poaceae
<i>Aristida adscensionis</i> L.
<i>Aristida californica</i> Thurb. var. <i>californica</i>
<i>Bouteloua aristidoides</i> (Kunth) Griseb.
* <i>Cenchrus ciliaris</i> L.
<i>Cenchrus palmeri</i> Vasey
<i>Chloris barbata</i> Sw.
<i>Diplachne fusca</i> (L.) P. Beauv. ex Roem. & Schult. subsp. <i>uninervia</i> (J. Presl) P.M. Peterson & N. Snow
* <i>Echinochloa colona</i> (L.) Link
* <i>Eragrostis cilianensis</i> (All.) Vignolo ex Janch.
<i>Hilaria rigida</i> (Thurb.) Benth. & Scribn.
<i>Festuca octoflora</i> Walt.
<i>Muhlenbergia microsperma</i> (DC.) Trin.
* <i>Polypogon monspeliensis</i> (L.) Desf.
* <i>Schismus barbatus</i> (L.) Thell.
<i>Urochloa arizonica</i> (Scribn. & Merr.) Morrone & Zuloaga
Polemoniaceae
<i>Linanthus bigelovii</i> (A. Gray) Greene
<i>Linanthus jonesii</i> (A. Gray) Greene
Polygonaceae
<i>Chorizanthe brevicornu</i> Torr.
<i>Eriogonum deflexum</i> Torr.
<i>Eriogonum inflatum</i> Torr. & Frém.
<i>Eriogonum thomasii</i> Torr.
<i>Eriogonum trichopes</i> Torr.
<i>Eriogonum wrightii</i> Torr.
<i>Nemacaulis denudata</i> Nutt. var. <i>gracilis</i> Goodman & L. Benson
Pteridaceae
<i>Notholaena californica</i> D.C. Eaton subsp. <i>leucophylla</i> Windham
Resedaceae
<i>Oligomeris linifolia</i> (Vahl) J.F. Macbr.
Rhamnaceae
<i>Colubrina viridis</i> (M.E. Jones) M.C. Johnst.
<i>Condaliopsis divaricata</i> (A. Nelson) G.L. Nesom

Rubiaceae
<i>Galium stellatum</i> Kellogg
Salicaceae
<i>Salix gooddingii</i> C.R. Ball
Santalaceae
<i>Phoradendron californicum</i> Nutt.
Saururaceae
<i>Anemopsis californica</i> (Nutt.) Hook. & Arn.
Simaroubaceae
<i>Castela emoryi</i> (A. Gray) Moran & Felger
Simmondsiaceae
<i>Simmondsia chinensis</i> (Link) Schneid.
Solanaceae
<i>Datura discolor</i> Bernh.
<i>Lycium andersonii</i> A. Gray
<i>Lycium andersonii</i> A. Gray x <i>L. brevipes</i> Benth.
<i>Lycium brevipes</i> Benth.
<i>Lycium californicum</i> Nutt. ex A. Gray
<i>Lycium exsertum</i> A. Gray
<i>Lycium fremontii</i> A. Gray
<i>Lycium macrodon</i> A. Gray var. <i>macrodon</i>
<i>Lycium parishii</i> A. Gray
<i>Nicotiana clevelandii</i> A. Gray
* <i>Nicotiana glauca</i> Graham
<i>Nicotiana obtusifolia</i> Mertens & Galeotti
<i>Physalis angulata</i> L. var. <i>lanceifolia</i> (Nees) Waterf.
<i>Physalis crassifolia</i> Benth. var. <i>versicolor</i> (Rydb.) Waterf.
<i>Solanum hindsianum</i> Benth.
Stegnospermataceae
<i>Stegnosperma halimifolium</i> Benth.
Urticaceae
<i>Parietaria pensylvanica</i> Muhl. ex Willd. var. <i>hespera</i> (B.D. Hinton) S.L. Welsh
Verbenaceae
<i>Aloysia gratissima</i> (Gillies & Hook.) Troncoso
<i>Lippia palmeri</i> S. Watson
Zosteraceae
<i>Zostera marina</i> L. var. <i>atam</i> T.W.H. Backman
Zygophyllaceae
<i>Fagonia californica</i> Benth. subsp. <i>longipes</i> (Standl.) Felger
<i>Fagonia pachyacantha</i> Rydb.
<i>Fagonia villosa</i> D.M. Porter
<i>Larrea divaricata</i> Cav. subsp. <i>tridentata</i> (Sessé & Moc. ex DC.) Felger & C.H. Lowe

Table 2.

Radiocarbon dates of packrat (*Neotoma* sp.) middens from the Sierra Bacha, Sonora (Van Devender et al. 1994).

C-14 Date	Laboratory Date	Material Dated
9,970 ± 150	A-5097	Midden debris
9,670 ± 170	A-5096	Midden debris
9,270 ± 160	A-5095	Midden debris
5,340 ± 220	A-5441	<i>Neotoma</i> sp. fecal pellets
3,830 ± 100	A-5442	<i>Neotoma</i> sp. fecal pellets
2,765 ± 70	A-5443	<i>Neotoma</i> sp. fecal pellets
2,585 ± 85	A-5444	<i>Neotoma</i> sp. fecal pellets
2,330 ± 70	A-5445	<i>Neotoma</i> sp. fecal pellets
320 ± 65	A-1674	<i>Jatropha</i> sp. seeds

identified in the samples (Van Devender et al. 1994, Table 3). Insect remains and pollen in the samples were published by Van Devender & Hall (1994) and Anderson & Van Devender (1995).

Sierra Bacha Phylogeography

In Sonora, the Central Gulf Coast subdivision is located from Puerto Lobos south to Bahía Kino along the Gulf of California (Figure 2). The vegetation in the Sierra Bacha is a succulent-rich Sonoran desertscrub in the Central Gulf Coast subdivision of the Sonoran Desert (Humphrey 1975, Stromberg & Krischan 1983, Leitner 1987). Dominant shrubs and trees in different habitats, including rocky slopes, bajadas, sandy flats, and sand dunes, are *Ambrosia dumosa*, *Bursera microphylla* (elephant tree, *torote*, Figures 6 A & B), *Encelia farinosa* (brittlebush, *rama blanca*), *Euphorbia misera* (coast spurge), *Fouquieria columnaris* (boojum, *cirio*, Figure 14), *F. splendens* (*ocotillo*), *Jatropha cuneata* (leatherplant, *sangrengado*, Figures 6 C & D), *Larrea divaricata*, *Olneya tesota* (ironwood, *palo fierro*), *Parkinsonia microphylla*, *Simmondsia chinensis* (*jojoba*), *Solanum hindsianum* (desert night-shade, Figure 7A), and *Stenosperma halimifolium* (*tinta*, Figure 7B). Succulents include *Agave subsimplex* (*maguey*, Figure 8A), *Carnegiea gigantea*, *Cylindropuntia bigelovii* (teddybear cholla, *choya*, Figure 8B), *Ferocactus cylindraceus* (California barrel cactus, *biznaga*, Figures 8 C & D), *Lophocereus schottii* (*senita*), and *Pachycereus pringlei* (*cardón* or *sabueso*) (Figures 10 A & B).

Annuals in the flora include *Abronia villosa* (sand

verbena, Figure 9A), *Achyronychia cooperi* (frost-mat, Figure 9B), and *Pseudorontium cyathiferum* (desert snapdragon, Figures 9 C & D).

Notes on the flora. *Isocoma felgeri*, known only from Desemboque and near Bahía Kino, is endemic to Central Gulf Coast subdivision in Sonora. *Citharexylum* (fiddlewood) in the Verbenaceae is a tropical genus of trees and shrubs with about 80 species from Florida and Texas south to Argentina. *Citharexylum shrevei* was described in 1940 by Harold N. Moldenke based on a specimen collected by Daniel T. MacDougal and Forrest Shreve (Figures 15 A & C) from the Desert Laboratory at Rancho El Picú in 1923 – the only known specimen of this distinctive shrub. The northern limits of *C. flabelliformis* and *C. scabrum* are in southern Sonora, respectively 205 km and 395 km southeast of El Desemboque.

Baja California plants that occur in the Sierra Bacha flora include *Amaranthus watsonii*, *Ambrosia camphorata*, *A. chenopodiifolia* (Figure 10A), *A. magdalenae*, *Astragalus nuttallianus* var. *cedrosensis*, *Bajacalia crassifolia*, *Bursera hindsiana*, *Chylismia cardiophylla* subsp. *cedrosensis*, *Encelia californica*, *Euphorbia misera*, *Fouquieria columnaris* (Figure 14), *Pachycereus pringlei* (Figure 10B), *Pectocarya peninsularis*, *Perityle aurea*, *Pleurocoronis laphamiioides*, *Sibara laxa*, *Solanum hindsianum* (Figure 7A), *Sphaeralcea laxa*, and *Triteleopsis palmeri* (19 taxa, 7.0%). Other relictual Baja California species are *Ambrosia divaricata* both north and south of the study area. *Stenosperma gummosus* (*pitahaya agria*) north of Bahía Kino, and *Fouquieria diguetii*

Table 3. Plants identified in packrat middens in the Sierra Bacha (Van Devender et al. 1995). Radiocarbon dates in Table 2.

*Not recorded in modern flora.

Radiocarbon Dates

Family	Species	10	9.7	9.3	5.4	3.8	2.8	2.6	2.3	0.3	0
Acanthaceae	<i>Justicia californica</i> (Benth.) D. Gibson									x	
Amaranthaceae	<i>Amaranthus fimbriatus</i> (Torr.) Benth. ex S. Watson					x	x	x		x	
Apiaceae	* <i>Daucus pusillus</i> Michx.	x	x	x							
Asparagaceae	<i>Agave subsimplex</i> Trel.									x	
Asteraceae	<i>Ambrosia</i> cf. <i>chenopodiifolia</i> (Benth.) W.W. Payne			x							
	<i>Ambrosia dumosa</i> (A. Gray) W.W. Payne	x	x	x		x	x	x	x	x	x
	<i>Bahiopsis laciniata</i> (A. Gray) E.E. Schill. & Panero	x	x	x						x	
	<i>Encelia farinosa</i> A. Gray ex Torr.	x	x	x	x	x	x	x	x	x	x
	<i>Heliopsis anomala</i> (M.E. Jones) B.L. Turner									x	
	<i>Hofmeisteria fasciculata</i> (Benth.) Walp.		x			x	x	x	x	x	x
	* <i>Perityle aurea</i> Rose	x		x							
	<i>Perityle emoryi</i> Torr.	x	x		x	x	x	x	x	x	x
	<i>Pleurocoronis laphamioides</i> (Rose) R.M. King & H. Rob.	x	x	x	x	x	x	x	x	x	x
	<i>Porophyllum gracile</i> Benth.									x	
	<i>Rafinesquia neomexicana</i> A. Gray		x								
	<i>Trixis californica</i> Kellogg				x	x	x	x	x	x	x
	<i>Xanthisma spinulosum</i> (Pursh) D.R. Morgan & R.L. Hartman										
Boraginaceae	<i>Cryptantha barbiger</i> (A. Gray) Greene		x	x							
	<i>Cryptantha maritima</i> (Greene) Greene var. <i>maritima</i>	x	x	x	x	x	x	x	x	x	x
	<i>Eucrypta chrysanthemifolia</i> (Benth.) Greene	x	x								
	<i>Pectocarya recurvata</i> I.M. Johnst.			x							
	<i>Phacelia</i> cf. <i>ambigua</i> M.E. Jones										x
Brassicaceae	<i>Phacelia distans</i> Benth					x					
	<i>Lepidium</i> cf. <i>lasiocarpum</i> Nutt.		x								
	<i>Lyrocarpa coulteri</i> Hook. & Harv.	x	x	x	x						
	* <i>Thysanocarpus curvipes</i> Hook.	x									
Burseraceae	<i>Tomostima cuneifolia</i> (Nutt. ex Torr. & A. Gray) Al-Shehbaz, M. Koch & Jordan-Thaden	x	x	x							
	<i>Bursera microphylla</i> A. Gray				x	x	x	x	x	x	x
Cactaceae	<i>Cylindropuntia arbuscula</i> (Engelm.) Knuth				x		x				
	<i>Cylindropuntia bigelovii</i> (Engelm.) Knuth	x	x	x	x	x		x	x	x	x
	<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt	x	x	x	x	x	x	x	x	x	x
	<i>Lophocereus schottii</i> (Engelm.) Britton & Rose									x	x
	<i>Mammillaria grahamii</i> Engelm.	x	x	x	x	x	x	x	x	x	x
	<i>Pachycereus pringlei</i> Britton & Rose									x	
Ephedraceae	* <i>Ephedra aspera</i> Engelm. ex S. Watson	x	x	x	x		x	x	x		
Euphorbiaceae	<i>Argythamnia lanceolata</i> (Benth.) Müll. Arg.									x	
	<i>Argythamnia serrata</i> (Torr.) Müell.-Arg.					x	x				
	<i>Euphorbia misera</i> Benth.	x	x	x				x		x	x

	<i>Euphorbia</i> cf. <i>polycarpa</i> Benth.	x	x		x	x	x	x	x	x	x
	<i>Jatropha cuneata</i> Wiggins & Rollins				x	x	x	x	x	x	x
Fabaceae	<i>Acmispon maritimus</i> (Nutt. ex Torr. & A. Gray) D.D. Sokoloff										
	<i>Acmispon strigosus</i> (Nutt.) Brouillet		x			x	x	x	x		x
	* <i>Astragalus nuttallianus</i> DC.			x	x						
	<i>Dalea mollis</i> Benth.										x
	<i>Olneya tesota</i> A. Gray					x	x	x	x	x	
	<i>Parkinsonia florida</i> (Benth. ex A. Gray) S. Watson	x									
	<i>Parkinsonia microphylla</i> Torr.	x			x	x	x	x	x	x	x
Fouquieriaceae	<i>Fouquieria columnaris</i> Kellogg ex Curran	x	x	x						x	
	<i>Fouquieria splendens</i> Engelm.				x	x	x	x	x		x
Krameriaceae	<i>Krameria bicolor</i> S. Watson				x						
Lamiaceae	<i>Condea albida</i> (Kunth) Harley & J.F.B. Pastore				x	x	x	x		x	x
Loasaceae	<i>Mentzelia involucrata</i> S. Watson										x
Malvaceae	<i>Horsfordia newberryi</i> (S. Watson) A. Gray										x
Nyctaginaceae	<i>Allionia incarnata</i> L.	x			x	x	x	x	x		x
	* <i>Boerhavia triquetra</i> S. Watson					x	x				
	* <i>Boerhavia wrightii</i> A. Gray				x						
	<i>Mirabilis laevis</i> (Benth.) Curran			x		x				x	
Orobanchaceae	<i>Orobanche cooperi</i> (A. Gray) Heller									x	
Passifloraceae	<i>Passiflora arida</i> (Mast. & Rose) Killip				x						
Plantaginaceae	<i>Gambelia juncea</i> (Benth.) D.A. Sutton									x	
	<i>Mohavea confertiflora</i> (A. DC.) Heller		Aphyllom				x	x	x		x
	<i>Plantago ovata</i> Forssk.	x	x	x		x		x	x		x
	<i>Pseudorontium cyathiferum</i> (Benth.) Rothm.					x	x				
Poaceae	<i>Aristida adscensionis</i> L.				x	x					
	* <i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.				x	x					
	<i>Festuca</i> cf. <i>octoflora</i> Walter	x	x	x							
	<i>Muhlenbergia mocrasperma</i> (DC.) Kunth		x	x							
Polygonaceae	* <i>Eriogonum fasciculatum</i> Benth.	x	x	x							
	* <i>Eriogonum wrightii</i> Torr.			x							x
	<i>Eriogonum inflatum</i> Torr. & Frém.										x
Pteridaceae	<i>Notholaena</i> cf. <i>californica</i> D.C. Eaton			x							
Ranunculaceae	* <i>Anemone tuberosa</i> Rydb.		x								
Rubiaceae	<i>Galium stellatum</i> Kellogg		x	x					x	x	
Simmondsiaceae	<i>Simmondsia chinensis</i> (Link) Schneid.						x			x	
Solanaceae	<i>Datura discolor</i> Bernh.				x	x	x	x			
	<i>Physalis</i> cf. <i>crassifolia</i> Benth.	x			x	x	x	x	x	x	x
	<i>Solanum hindsianum</i> Benth.				x	x	x	x	x	x	x
Stegnospermaceae	<i>Stegnosperma halimifolium</i> Benth.									x	
Urticaceae	<i>Parietaria pensylvanica</i> Muhl. ex Willd.			x						x	x
Zygophyllaceae	<i>Fagonia pachyacantha</i> Rydb.										
	<i>Larrea divaricata</i> Cav. subsp. <i>tridentata</i> (Sessé & Moc. ex DC.) Felger & C.H. Lowe	x			x	x	x	x	x	x	x

Figure 6A



Figure 6B



Figure 6C



Figure 6D



Figure 6. *Bursera microphylla*. A. Plant at Punta Cirio. B. Leaves and fruit from southeast of Puerto Lobos. *Jatropha cuneata*. C. Plant at Sykes Crater in the Sierra Pinacate. D. Stem with leaves and flowers from La Proveedora near Caborca. Photos by Doug Danforth, Reina-G., and Susan D. Carnahan.

Figure 7A



Figure 7B



Figure 7. A. *Solanum hindsianum* at Pápago Tanks, Sierra Pinacate. B. *Stegnosperma halimifolium* at Playa San Lorenzo near Puerto Lobos. Photos by Susan D. Carnahan and David Bygott.

Figure 8A



Figure 8B



Figure 8. A. *Agave subsimplex* at Punta Cirio. B. *Cylindropuntia bigelovii* in Senita Basin, Organ Pipe Cactus National Monument, Arizona. C & D. *Ferocactus cylindraceus* plant and flowers in the Sierra Bacha. Photos by David Bygott, Diane Drobka, Reina-G. and Vonn Watkins.

Figure 8C



Figure 8D



Figure 9A



Figure 9B



(*palo adán*) and *Lysiloma candida* (*palo blanco*) in the Guaymas area.

A forest of immense *Pachycereus pringlei* covers a large sand dune just north of Punta Cirio (Figure 10 A & B). This is the tallest cactus, although others are more massive. *Pandion haliaetus* (osprey or sea hawk, *águila pescadora*) are common and build massive stick nests on top of *cardones* (Figures 10 C & D).

Anemopsis californica (*hierba mansa*) and *Salix gooddingii* (Goodding willow, *sauz*) were collected in a wet area in Arroyo San Ignacio on Rancho Pozo

Figure 9C



Figure 9D



Figure 9. A. *Abronia villosa* at Cerro Lava, Sierra Pinacate. B. *Achyronychia cooperi* at La Proveedora near Caborca. C & D. *Pseudorontium cyathiferum* at Pápago Tanks, Sierra Pinacate. Photos by Van Devender and Susan D. Carnahan.

Figure 10A



Figure 10B



Figure 10. Sand dune north of Punta Cirio. A. Desertscrub with *Ambrosia chenopodiifolia*, *Fouquieria splendens*, *Lophocereus schottii*, and *Pachycereus pringlei*. B. *P. pringlei*. C. *Pandion haliaetus* on nest. D. *P. haliaetus* with fish. Photos by Reina-G.

Figure 10C



Figure 10D



Figure 11A



Figure 11B



Figure 11C



Figure 11. A. *Brandegea bigelovii* at Pápago Tanks, Sierra Pinacate. B. *Cenchrus palmeri* on the Ives Lava dunes, Sierra Pinacate. C. *Astragalus magdalenae* on dune southeast of Puerto Libertad. Photos by Susan D. Carnahan, Van Devender, and David Bygott.

Coyote north of Desemboque. *Allenrolfea occidentalis*, *Aphanisma blitoides*, and *Suaeda nigra* are halophytic plants in the limited area of salt flat habitat in the study area. *Zostera marina* (eelgrass, *zacate del mar*) collected at Desemboque is a widespread seagrass along the Pacific coast of North America and the Atlantic coast in the eastern United States.

Brandegea bigelovii (desert starvine) occurs from southwestern Arizona and southeastern California south onto the Baja California Peninsula but is not common on the Sonora coast (Figure 11A). *Cenchrus palmeri* (giant sandbur, *guachapori*) is an annual with a large bur that is a regional endemic in sandy coastal habits from Sonora northward around the head of the Gulf of California to most of the Baja California Peninsula (Figure 11B). *Astragalus magdalenae* var.

peirsonii (Peirson's milkvetch, Figure 11C), *Eucnide rupestris* (rock nettle, *pega pega*, Figure 12 A & B), and *Fagonia pachyacantha* (Figure 12C) are widespread on the Baja California Peninsula northward around the head of the Gulf of California and southward along the coast in northwestern Sonora.

The genus *Tetracoccus* with three species is in the family Picrodendraceae (formerly in the Euphorbiaceae). *T. dioicus* is in Baja California and California and *T. capensis* is in the Cape Region of Baja California Sur. *T. fasciculatus* has widely disjunct populations in the Chihuahuan and the Sonoran Deserts. *T. f.* var. *fasciculatus* occurs from central Chihuahua southeast to Coahuila, Durango, and Nuevo León. *T. f.* var. *hallii* (Hall's shrubby-spurge) occurs in southwestern Arizona and southeastern California south into the San

Figure 12A



Figure 12B



Figure 12C



Figure 12. A & B. *Eucnide rupestris* at Sykes Crater, Sierra Pinacate. C. *Fagonia pachyacantha* at Playa San Lorenzo near Puerto Lobos. Photos by Susan D. Carnahan, Van Devender, and David Bygott.

Figure 13A



Figure 13B



Figure 13. A. *Gambelia juncea* at Cataviña, Baja California. Photo by Robert A. Villa. B. *Gambelia wislizenii* southeast of Puerto Libertad. Photo by David Bygott.

Felipe area of Baja California. The collection of *T. f.* var. *halli* at Punta Cirio by Arthur M. Phillips in 1978 is the only record for Sonora. The locality is 166 km southeast of the nearest record in Baja California and 660 km west-northwest of the northernmost *T. f.* var. *fasciculatus* record near Ciudad Chihuahua.

Curiously, *Gambelia juncea* (Baja California snapdragon bush, Figure 13A) and *Gambelia wislizenii* (long-nosed leopard lizard, Figure 13B) both occur in the Sierra Bacha.

Mangrove communities do not occur in the Sierra Bacha although *Laguncularia racemosa* (white man-

grove) occurs as far north as Punta Sargento (29.0°N) north of Bahía Kino (28.8°N) and black mangrove (*Avicennia germinans*) reaches Puerto Lobos (30.3°N).

Saga of the boojum. The first specimen of the boojum (Figure 14) collected in the 1850s by John Allen Veatch in Baja California was described by Albert Kellogg in 1860 as *Idria columnaris*. The holotype was lost in the San Francisco earthquake and fire in 1906. Later it was placed in the genus *Fouquieria* and family Fouquieriaceae.

While on a hunting and fishing trip to Puerto Liber-

Figure 14A



Figure 14B



Figure 14C



Figure 14d



Figure 14. *Fouquieria columnaris* at Punta Cirio, Sierra Bacha. A & B. Mature plants. C. Young plant in full leaf. D. Note short lateral branches, terminal inflorescence, and wind swept growth form. Photos by Van Devender, David Bygott, and Reina-G.

Figure 15A



Figure 15. Desert Laboratory allstar botanists. A. First Director Daniel T. MacDougal. B. Godfrey Sykes named *Fouquieria columnaris* 'boojum'. C. Director Forrest Shreve defined the subdivisions of the Sonoran Desert in *Flora and Vegetation of the Sonoran Desert*. D. Director Paul S. Martin was lead author of *Gentry's Rio Mayo Plants* and mentored many Sierra Bacha botanists. Photos Courtesy of the Desert Laboratory and K. Moore.

Figure 15B



Figure 15C



Figure 15d



tad on the Sonoran coast of the Gulf of California in 1922, Gilbert Sykes saw and photographed the 'funny tree' that his Yaqui-Pápagu (as the Tohono O'odham are still called in Sonora) guide said was in the Sierra Bacha to the south (Sykes 1982). It resembled an upside carrot about 20 ft tall with short branches and green leaves. This led to a prompt return trip from Tucson by Gilbert, his father Godfrey, and several Desert Laboratory members to "expose the

apparition." Godfrey Sykes was an extremely versatile Englishman turned American who helped build and maintain the Desert Laboratory and became an accomplished botanist (Figure 15B). On arrival at Puerto Libertad, he looked through his brass telescope and exclaimed "Ho, ho! A Boojum. Definitely a Boojum." This referred to the whimsical character

in the English writer Lewis Carroll's 1876 nonsense poem **The Hunting of the Snark** (Figure 16).

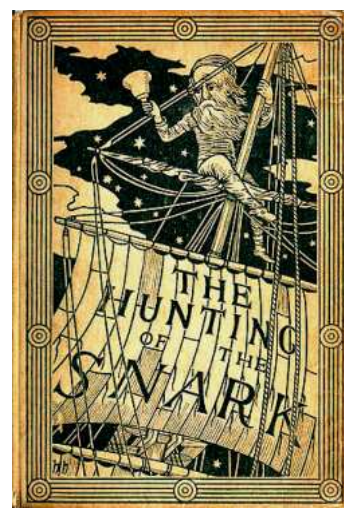


Figure 16. Cover of Lewis Carroll's 1876 *The Hunting of the Snark* by Henry Holiday.

*They hunted till darkness came on, but they found
Not a button, or feather, or mark
By which they could tell that they stood on the ground
Where the Baker had met the Snark.*

*In the midst of the word he was trying to say,
In the midst of the laughter and glee,
He had softly and suddenly vanished away –
For the Snark was a Boojum, you see.*

The Baja California Peninsula was first visited by Europeans in 1533-1535 by Spanish ships sent by Hernán Cortés to the Cabo Pulmo area and established the short-lived colony at Santa Cruz (= La Paz; Moriarty 1965). Both areas are south of the range of boojum. In 1538, ships under the command of Francisco Ulloa sailed from northern Sinaloa along the coast of Sonora past modern Bahía Agiabampo, Guaymas, and Isla Tiburón to El Golfo de Santa Clara at the mouth of the Río Colorado and returned south along the east coast of Baja California. He passed the Sierra Bacha, Sonora, and Isla Ángel de la Guarda, Baja California, both of which have relict boojum populations. Although they stopped near Bahía Los Angeles in central Baja California, they apparently did not explore inland into the core boojum range in the Vizcaino Subdivision of the Sonoran Desert (Shreve 1964, Turner et al. 1995, Webb & Ceseña 2014). He saw a few of the now-extinct Cochimi indigenous inhabitants.

Figure 17A



Figure 17B



Figure 17C



Figure 17. A. *Anemone tuberosa* in the Waterman Mountains, Arizona. B. *Dasyochloa pulchella* at La Proveedora near Caborca. C. *Daucus pusillus* at Trincheras. Photos by Reina-G. and Susan D. Carnahan.

Jesuit missionary Francisco Eusebio Kino established the *Visita Natividad del Señor de Pitiquín* for visiting priests from the *Misión de la Purísima Concepción de Nuestra Señora de Caborca* in 1694 (Pfefferkorn 1989). This became the town of Pitiquito, Sonora. Kino was an astute explorer, cartographer, and scientist who likely learned of the Seri Indians and boojum from the local people. The first reported citing of boojum by a European was in Baja California in 1751 by the Jesuit missionary Fernando Consag, cited in Miguel del Barco's **Historía Natural y Crónica de la Antigua California** published between 1770 and 1780 (Portillo 1980). The Cochimí who formerly lived throughout the boojums range in central Baja California called it *milapá* (Clavijero 1937). The first report of the common name *cirio* (candle in Spanish) for *Fouquieria columnaris* was in Baja California by the Jesuit missionary Wenceslaus Linck in 1762 (Burrus 1977, Humphrey 1975).

On the mainland, Felger & Moser (1991) recounted the Seri Indian oral tradition that a group of giants fled northward from Desemboque to escape a great flood. When the water overtook them in the Sierra Bacha they were changed into boojums. These plants were believed to have great power from the spirit *Icor* to cause strong winds and rain if touched or harmed. The Sykes' sighting was apparently the first by Anglo-Americans on the mainland side of the Gulf of California (Sykes 1982).

Paleoecology. Plant remains in series of packrat middens have documented the sequence of changes in flora, vegetation, and climate from the Late Wis-

consin glacial period to transitional Early Holocene and modern Middle and Late Holocene flora in the Sonoran Desert (Van Devender 1990). In southwestern Arizona, ice age pinyon-juniper-oak woodland expanded widely into desert lowlands in the Late Wisconsin glacial period (40,000 to 11,000 yr B.P.). Ice age climates had more winter and reduced summer rainfall and warmer winters and cooler summers than today. Transitional juniper woodlands with some Sonoran Desert species remained at low elevations in the Early Holocene (11,000 to 8,000 yr B.P.). Sonoran desert scrub developed in the Middle Holocene (8,000 to 4,000 yr B.P.). The late Holocene (after 4,000 yr B.P.) supported modern vegetation and climate. These assemblages are remarkable and fortuitous fossil records of plants on rocky slopes near the rockshelters where they are preserved but packrats did not collect plants in lowland bajada, dune, salt flat, and beach habitats in the Sierra Bacha.

Only ten of the 82 plant species identified in the Sierra Bacha packrat middens no longer occur in the Sierra Bacha (Tables 1 & 3). *Anemone tuberosa* (windflower, Figure 17A), *Boerhavia triquetra*, *B. wrightii*, *Dasyochloa pulchella* (fluffgrass, Figure 17B), *Daucus pusillus* (wild carrot, *zanahoria cimarrona*, Figure 17C), *Eriogonum fasciculatum*, *E. wrightii*, *Perityle aurea*, and *Thysanocarpus curvipes* were only in Early Holocene assemblages dated between 9,970 to 9,270 yr B.P. *Ephedra aspera* (Mormon tea, *canutillo*) was in seven middens and apparently only disappeared from the Sierra Bacha in the last 2,300 years. Today,

Figure 18A



Figure 18B



Figure 18C



Figure 18D



Figure 18. A & B. *Orobanche cooperi* at La Proveedora near Caborca. C. *Lyrocarpa coulteri* at La Proveedora near Caborca. D. *Mirabilis laevis* var. *villosa* at Pápago Tanks, Sierra Pinacate. Photos by Susan D. Carnahan.

most of these plants are widespread in the western and southwestern United States south to Baja California and to north-central and northeastern Sonora. Exceptions are *Anemone tuberosa* which is not in western California and *E. aspera* which extends farther east in the Chihuahuan Desert to western Texas and south onto the Mexican Plateau. They are all either absent or rare in the arid Sonoran Desert in northwestern Sonora, but present in the Central Gulf Coast subdivision along the eastern coast of Baja California. The nearest populations of *Anemone tuberosa*, *Daucus pusillus*, *Ephedra aspera*, and *Eriogonum fasciculatum* (California buckwheat) are in the limestone Sierra del Viejo 55-60 km north-northeast of Puerto Libertad. The only Sonoran locality for *Ephedra aspera* is in this area. Species identified in the middens that still occur in the Sierra Bacha include *Orobancha cooperi* (broomrape, Figures 18 A & B), *Lyrocrpa coulteri* (Figure 18C), and *Mirabilis laevis* (Figure 18D).

The packrat midden series in the Sierra Bacha only covers the Holocene, documenting Sonoran desertscrub vegetation for the last 9,970 years without an Early Holocene transitional juniper woodland. Most of the 24 species of dicot annuals in the middens grow in response to winter-spring rainfall. The midden series in the Sierra Hornaday in the Pinacate region in northwestern Sonora (31.983°N 113.699°W) 255 km to the north-northeast was similar with *Encelia farinosa*, *Ephedra nevadensis*, and *Larrea divaricata* dominants in Early Holocene Sonoran desertscrub

assemblages except that *Carnegiea gigantea* was common and *Juniperus* cf. *californica* (California juniper, *táscale*) was rare (Van Devender et al. 1990). Paleoclimate reconstructions based on the Early Holocene Sierra Bacha midden assemblages reflect vegetation and climate more like central Baja California with greater winter rainfall and cooler summers. Boojum was farther inland than today on rhyolitic slopes not directly influenced by cold water upwelling in the Gulf of California. Very likely the Central Gulf Coast vegetation belt on mainland Sonora was much wider in the glacial periods in the last two million years of the Pleistocene.

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References

1. **Anderson, R.S., and T.R. Van Devender. 1995.** Vegetation history and paleoclimates of the coastal lowlands of Sonora, Mexico - pollen records from packrat middens. *Journal of Arid Environments* 30: 295-306.
2. **Burrus, E.J. 1967.** Wenceslaus Linck's reports and letters, 1762-1778. Translated into English, edited, and annotated by E.J. Burrus. S.J. Dawson's Book Shop, Los Angeles.
3. **Clavijero, F.X. 1937.** The history of (Lower) California. Translated from Italian and edited by S.E. Lake & A.A. Gray. Stanford University Press, Stanford.
4. **Darin, M.H., and R.J. Dorsey. 2014.** Geologic map of the Sierra Bacha, coastal Sonora, Mexico. National Institute of Statistics and Geography of Mexico (INEGI)
5. **Felger, R.S. 2000.** Flora of the Gran Desierto and Río Colorado of Northwestern Mexico. University of Arizona Press, Tucson.
6. **Felger, R.S., and M.B. Moser. 1991.** People of the Desert and Sea. Ethnobotany of the Seri Indians. University of Arizona Press, Tucson.
7. **Felger, R.S., and B.T. Wilder. 2012.** Plant Life of a Desert Archipelago. Flora of the Sonoran Islands in the Gulf of California. University of Arizona Press, Tucson.
8. **Humphrey, R.R. 1975.** Phenology of selected Sonoran Desert plants at Punta Cirio, Sonora, Mexico. *Journal of the Arizona Academy of Science* 10: 50-57.
9. **Leitner, L.A. 1987.** Plant communities of a large arroyo at Punta Cirio, Sonora. *The Southwestern Naturalist* 32: 21-28.
10. **Martin, P.S., D. Yetman, M. Fishbein, P. Jenkins, T.R. Van Devender, and R.K. Wilson. 1998.** Gentry's Río Mayo Plants. University of Arizona Press, Tucson.
11. **Moriarty, J.R. 1965.** The discovery & earliest explorations of Baja California. *Journal of San Diego History* 11.

12. **Pfefferkorn, I. 1989.** Sonora. A Description of the Province. Translated and annotated by T.E. Treutlein. University of Arizona Press, Tucson.
13. **Portillo, L. 1980.** Miguel del Barco's Historia Natural y Crónica de la Antigua California. Dawson's Bookshop, Los Angeles.
14. **Shreve, F. 1964.** Vegetation of the Sonoran Desert. *In* F. Shreve and I.L. Wiggins. Vegetation and Flora of the Sonoran Desert. Vol. 1, Stanford University Press, Stanford, California.
15. **Shreve, F., and I.L. Wiggins. 1964.** Flora of the Sonoran Desert. *In* F. Shreve and I.L. Wiggins. Vegetation and Flora of the Sonoran Desert. Vol. 2, Stanford University Press, Stanford, California.
16. **Stromberg, J.C., and T.M. Krischan. 1983.** Vegetation structure at Punta Cirio, Sonora, Mexico. *Southwestern Naturalist* 28: 211-214.
17. **Sykes, G.G. 1982.** The naming of the boojum. *Journal of Arizona History* 23: 351-356.
18. **Turner, R.M. 1994.** 154.1 Sonoran desertscrub. Pp. 181-221 *in* D.E. Brown (ed.). Biotic Communities of the Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City.
19. **Turner, R.M. J.E. Bowers, and T.L. Burgess. 1995.** Sonoran Desert Plants. An Ecological Atlas. University of Arizona Press, Tucson.
20. **Van Devender, T.R. 1990.** Late Quaternary vegetation and climate of the Sonoran Desert, United States and Mexico. Pp. 134-165 *in* J.L. Betancourt, T.R. Van Devender, and P.S. Martin (eds.), *Packrat Middens. The Last 40,000 Years of Biotic Change*, University of Arizona Press, Tucson.
21. **Van Devender, T.R. 2002.** Deep history of immigration in the Sonoran Desert Region. Pp. 5-24 *in* B.J. Tellman (ed.), *Invasive Exotic Species in the Sonoran Region*, University of Arizona Press, Tucson.
22. **Van Devender, T.R., T.L. Burgess, R.S. Felger, and R.M. Turner. 1990.** Holocene vegetation of the Hornaday Mountains of northwestern Sonora, Mexico. *Proceedings of the San Diego Natural History Museum* 2: 1-19.
23. **Van Devender, T.R., T.L. Burgess, J.C. Piper, and R.M. Turner. 1994.** Paleoclimatic implications of Holocene plant remains from the Sierra Bacha, Sonora, Mexico. *Quaternary Research* 41: 99-108.
24. **Van Devender, T.R., and W.E. Hall. 1994.** Holocene arthropods from the Sierra Bacha, Sonora, Mexico, with emphasis on beetles. *The Coleopterists Bulletin* 48: 30-50.
25. **Van Devender, T.R., and A.L. Reina-Guerrero. 2021.** The vegetation of Sonora, Mexico. *Phytoneuron* 2021: 67: 1-22.
26. **Webb, R.H., and M.S. Ceseña. 2014.** The distribution of cirio (*Fouquieria columnaris*) in Baja California. *Haseltonia* 19: 26-37.