FLORA OF TINAJAS ALTAS, ARIZONA—A CENTURY OF BOTANICAL FORAYS AND FORTY THOUSAND YEARS OF *NEOTOMA* CHRONICLES

Richard Stephen Felger

Herbarium, University of Arizona
Tucson, Arizona 85721, U.S.A. and
Sky Island Alliance, P.O. Box 41165
Tucson, Arizona 85717, U.S.A.
rfelger@ag.arizona.edu

Thomas R. Van Devender

Sky Island Alliance, P.O. Box 41165
Tucson, Arizona 85717, U.S.A. and
Herbarium, University of Arizona
Tucson, Arizona 85721, U.S.A.
VanDevender@skyislandalliance.org

Bill Broyles

Southwest Center
University of Arizona
Tucson, Arizona 85721, U.S.A.

Jim Malusa

School of Natural Resources and the Environment
University of Arizona
Tucson, Arizona 85721, U.S.A.
malusa@email.arizona.edu

ABSTRACT

This flora of the vascular plants of the Tinajas Altas region, within the Lower Colorado Valley subdivision of the Sonoran Desert of southwestern Arizona, includes the present-day species as well as fossils recovered from packrat middens. The vegetation and flora are dynamic, changing even now, and have changed dramatically during the past millennia, along with shifting climate and human presences. This is the first publication for any region of a comprehensive temporal flora and spans more than 43,000 years of plants inadvertently collected and curated by packrats (*Neotoma* spp.) and more recently by botanists. We document a present-day flora of 227 species in 175 genera and 46 families. We also document at least 119 species in 96 genera and 36 families from the fossil record and among these fossils at least 28 species in 17 genera and 6 families are no longer present in the region. The most diverse families, present-day and fossil taxa, are Asteraceae, Poaceae, Boraginaceae, Cactaceae, Brassicaceae, Fabaceae, Solanaceae, Euphorbiaceae, Polygonaceae, and Nyctaginaceae. The most diverse genera are *Cryptantha*, *Ambrosia*, and *Eriogonum*. There are 12 non-native species in the flora, representing only 5.3% of the modern flora, but only Sahara mustard (*Brassica tournefortii*) and Arabian grass (*Schismus arabicus*) are likely to negatively impact the native plants.

The famous waterholes, the Tinajas Altas, were critical for desert travelers and prehistoric people. The Tinajas Altas Mountains, in one of the most arid parts of North America, have one of the richest fossil records for Ice Age plants in the world. The radiocarbon-dated plant assemblages provide a detailed record of dramatic changes in geographic ranges of species and the succession from Ice Age woodlands to modern desertscrub. Prior to 11,000 years ago in the middle and late Wisconsin, Ice Age woodlands with single-leaf pinyon (*Pinus monophylla*), California juniper (*Juniperus californica*), Utah juniper (*Juniperus osteosperma*), Sonoran scrub oak (*Quercus turbinella*), and Joshua tree (*Yucca brevifolia*) were at Tinajas Altas and elsewhere in Sonoran Desert lowlands. The earliest known creosotebush (*Larrea divaricata*) in North America, 18,000 years before present, from a Tinajas Altas midden, was already the modern tetraploid Sonoran Desert race.

The Tinajas Altas region encompasses 80,000 acres (32,375 hectares) adjoining the western margin of the Cabeza Prieta National Wildlife Refuge and is within the Barry M. Goldwater Range. Scientific, cultural, and aesthetic values dictate that the Tinajas Altas should receive increased attention and protection.

RESUMEN

El presente reporte de la flora de las plantas vasculares de la región de las Tinajas Altas en el Desierto Sonorense del suroeste de Arizona incluye tanto las especies actuales como especies fósiles conservadas en depósitos antiguos de ratas de campo (*Neotoma* spp.). Actualmente la flora y la vegetación son dinámicas y siguen modificándose, pero en el último milenio los cambios han sido dramáticamente influenciados por el clima cambiante y la presencia humana. Esta es la primera documentación en cualquier región de una flora integral que abarca más de 43,000 años de plantas inadvertidamente colectadas y preservadas por las ratas de campo y en época reciente por los botánicos. Aquí documentamos la presente flora consistente en 227 especies de 175 géneros y 46 familias. Asimismo documentamos al menos 119 especies de 96 géneros y 36 familias

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como fósiles, de los cuales al menos 28 especies, 17 géneros y 6 familias ya no existen en el área. Las familias más diversas, tanto actuales como fósiles, son Asteraceae, Poaceae, Boraginaceae, Cactaceae, Brassicaceae, Fabaceae, Solanaceae, Euphorbiaceae, Polygonaceae y Nyctaginaceae. Los géneros más diversos son *Cryptantha*, *Ambrosia* y *Eriogonum*. La flora incluye 12 especies exóticas, que representan tan sólo el 5.3% de la flora moderna, pero sólo la mostaza del Sahara (*Brassica tournefortii*) y el zacate árabe (*Schismus arabicus*) probablemente tendrán un impacto negativo en las plantas nativas. Estas famosas tinajas eran una fuente de agua indispensable para los viajeros del desierto y los habitantes prehistóricos. La Sierra de las Tinajas Altas ubicada en una de las regiones más áridas de Norteamérica tiene uno de los registros fósiles de plantas más diversos de la Edad de Hielo del mundo. Las plantas datadas con radiocarbono muestran un registro detallado sobre cambios dramáticos en los rangos geográficos de especies y sucesiones ecológicas desde los bosques de la Edad de Hielo al matorral desértico moderno. Los bosques de la Edad de Hielo con *Pinus monophylla*, *Juniperus californica, J. osteosperma*, *Quercus turbinella* y *Yucca brevifolia* se encontraban en las Tinajas Altas y en otras regiones bajas del Desierto Sonorense hace 11,000 años durante el período Wisconsin Medio y el Wisconsin Tardío. El registro más antiguo de gobernadora (*Larrea divaricata*) en Norteamérica, 18,000 años antes del presente, de un depósito de rata de campo, representa la raza tetraploide moderna del Desierto Sonorense. La región de las Tinajas Altas formó parte del refugio de vida silvestre *Cabeza Prieta National Wildlife Refuge* y actualmente del *Barry M. Goldwater Range*. Los valores científicos, culturales y estéticos sugieren que las Tinajas Altas deben recibir mayor atención y protección.

INTRODUCTION

The Tinajas Altas, or High Tanks, are famous through history and were utilized for millennia by Native Americans (Broyles et al. 2012). If you were traveling across the Camino del Diablo, part of the old Yuma-Caborca trail, you would head for the Tinajas Altas (Fig. 1). Sometimes the lower tanks would be dry and getting to the upper tanks could be daunting, and some travelers did not know about the upper pools or were not able to reach them. Missing the tinajas and their water could spell death to desert travelers. The importance of Tinajas Altas grew during the California gold rush of the mid-nineteenth century and by the end of that century they became a focus for desert research by the likes of WJ McGee and Edgar Mearns. Mearns (1907: 122) wrote, "This important station is at the east base of the [mountains], beside the lowest of a chain of natural rock tanks, in a steep ravine, containing an unfailing and almost inexhaustable supply of good water. The upper tanks are easily overlooked and difficult of access, which facts afford the most plausible explanation of the loss of lives of many persons whose bones and graves were thickly scattered about our camp" (Figs. 2 & 3).

The Tinajas Altas Mountains are a rugged range, rising 500 meters from the desert floor of southwestern Arizona. There are no foothills, only slabs of pale Eocene granite rising abruptly at an unlikely angle of 45 degrees (Fig. 4). Along a skyline fretted with spires and windows there are no trees or saguaros to provide scale, no sense of near or far. If you camp in a comfortable arroyo near the foot of the mountains and look to the peaks on a full-moon evening the Tinajas Altas are as brilliant as snow and as eye-popping as any great mountain (Fig. 5). The extremely arid Tinajas Altas region is situated along the Mexican border at a remote edge of the Barry M. Goldwater Range, about 70 km southeast of Yuma, Arizona (Fig. 6). The Tinajas Altas Mountains are 35 km long, trending southeast-northwest from the international border to the Gila Mountains, where the granite is rather dramatically replaced by dark schist. The Tinajas Altas site (the waterholes) is about 6.5 km north of the Mexican border and is reached by the Camino del Diablo, a graded dirt road running south from Interstate 8 and then eastward across the Lechuguilla Valley and the Cabeza Prieta National Wildlife Refuge. In spite of many visitors, the mountains and much of the adjacent valleys remain in near pristine condition, although the upper bajadas and various other areas continue to be severely impacted by illegal off-road driving and other recreational activities, and more recently by the massive construction activity of the U.S. border fence in 2008 (see Department of Homeland Security 2008).

We selected the flora area because of the rich fossil and modern botanical record and because it embraces a variety of desert habitats, is a convenient biological and cultural zone (delineated by U. S. Fish and Wildlife Service) and is an area of major conservation concern. The core flora area is the 80,000 acres (32,375 hectares) of the Tinajas Altas region encompassing the Tinajas Altas Mountains from the Cipriano Pass to the Mexico border at Frontera Canyon and the south end of the Lechuguilla Valley drained northward by Coyote Wash and southward by La Jolla Wash (Fig. 7). We also include some plant records from the nearby Butler Mountains

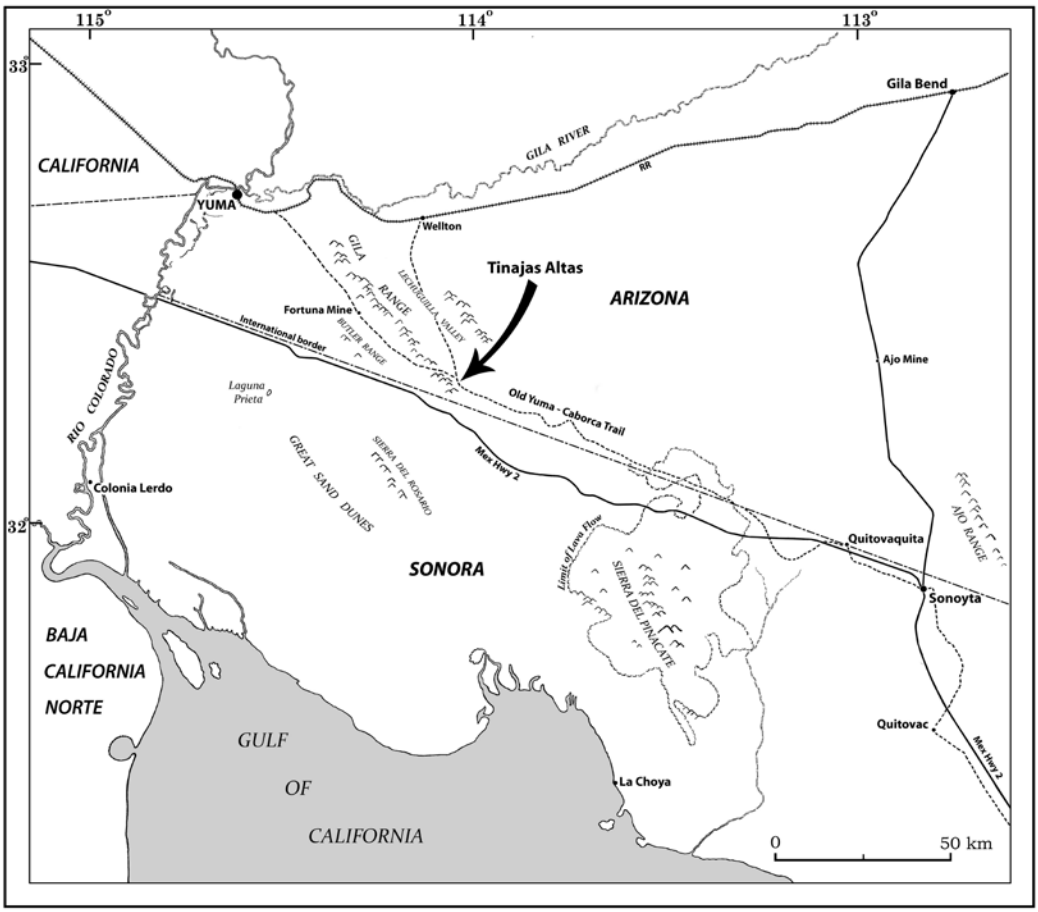

Fig. 1. The Gran Desierto and Camino del Diablo (Quitobaquito–Yuma portion of the Old Yuma–Caborca Trail) and surrounding regions, adapted from map in Lumholtz (1912). Drafted by Cathy Moser Marlett.

to provide perspective for the Ice Age record. A few records from immediately adjacent areas are included when we expect them to occur in the core area. Specific geographic information is given in the regional gazetteer by Broyles et al. (1997, 2007) and abridged in the list of place names below.

The Tinajas Altas region is nested among five major, contiguous protected areas and a sixth de facto area that make up the heart of the Sonoran Desert: Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, and Sonoran Desert National Monument in Arizona, and Reserva de la Biosfera El Pinacate y Gran Desierto de Altar in Sonora and Reserva de la Biosfera Alto Golfo de California y Delta del Río Colorado in Sonora and Baja California. The Barry M. Goldwater Range in Arizona is not a protected area per se but generally is managed as one by the Air Force and the Marines. Spanning 210 miles (338 km) from San Felipe, Baja California, to just southwest of Phoenix, Arizona, these reserves cover 7,515,221 acres (3,041,410 ha), or 11.7 percent of the Sonoran Desert, making them the largest zone of contiguous protected desert anywhere in the Americas (Felger et al. 2007a). Felger et al. (2007b) documented a flora for this bio-network that included 845 vascular plant taxa (species, subspecies, and varieties) in 439 genera and 104 families, including 85 non-native species (Felger et al. 2007b). Some additional records have been discovered since then (e.g., Felger et al. 2012). This is more than one-third of the total flora of the entire Sonoran Desert, a region covering 100,000 mi^2 (310,000 km^2) in five states in Mexico and the United States (Shreve 1951).

Fig. 2. Tinajas Altas, looking westward from the Mesa del Muerto. The tinajas cascade down from the steep rock slope from the notch or low point on the horizon. 29 March 2010. Photo by Joan Scott.

Plants of the Tinajas Altas region have been collected inadvertently by packrats (*Neotoma* spp.) for more than 43,000 years in fossil amberat and purposefully collected by botanists for more than a century. Together these two lines of collecting document a unique record revealing both the deep ecological history of the Sonoran Desert and its vegetation, as explained in a section by Van Devender, and the broad, fascinating range of modern-day plants and their species relationships, as compiled by Felger from his own field studies and those of his colleges and predecessors. In a section on botanizing and a list of collectors, we pay tribute to the role of curious collectors and the process of collecting, reminding readers of the fulfilling joy of discovery. Other sections on geology, climate, human history, land management, and place-names expand our knowledge and appreciation of this special place and provide a baseline as we look from the deep past to the future. Sites like Tinajas Altas will be key stations for studies of global climate change and its effects on particular biological communities. Meanwhile, perseverant neotomas continue to gather floral data.

GEOLOGY

The Tinajas Altas Mountains are linear and narrow with steep slopes, rugged canyons, and higher peaks standing 400–500 meters above the valley floor. Typical of Basin-and-Range tectonics, the range is block-faulted, trends northwest, and is separated from neighboring ranges by broad alluvial valleys or plains. The geology of Tinajas Altas has been strongly influenced by movement of the North American, Pacific, and Farallon continental plates. The Tinajas Altas range batholith is mainly composed of light-colored Gunnery Range granite exposed following the Laramide Orogeny (Figs. 2–4). Basaltic lava dating from the mid-Tertiary Orogeny (16–10 mya) crowns the adjacent Raven Butte (Figs. 8 & 9) as well as Tordillo Butte visible east of Tinajas Altas;

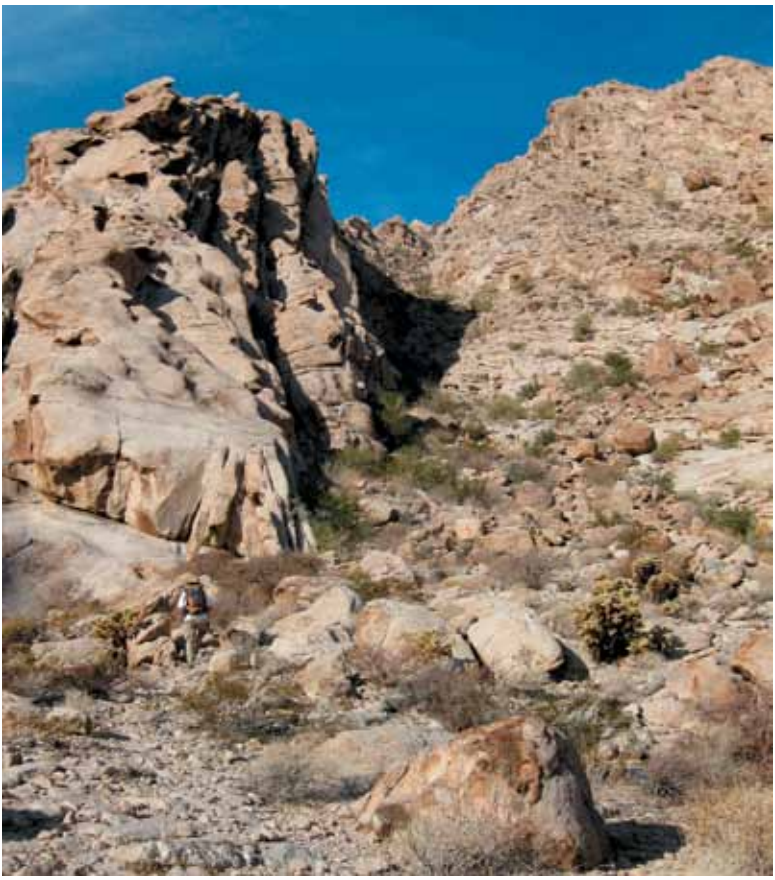

Fig. 3. Tinajas Altas Mountains, looking westward. The steep slope is just north of the tinajas and is the access to the uppermost tinajas and Tinajas Altas Canyon (the upper canyon above the tinajas). *Cylindropuntia bigelovii* in foreground. 21 November 2008. Photo by RSF.

the dark andesite and latite cap of Cabeza Prieta Peak dates to this time, too (Kresan 2007; Shafiqullah et al. 1980). Within the past 5.5 to 4.5 million years rifting and subsidence created the proto-Gulf of California and Salton Basin as well as an inland sea that reached as far as modern Phoenix, Arizona, and Las Vegas, Nevada, and surrounded Tinajas Altas before retreating (Ledesma-Vásquez & Carreño 2010; see Lucchitta et al. 2001, and Spencer & Pearthree 2001). At that time the Colorado River had a much different course than today (Young & Spamer 2001). Over the past 1.6 million years strike-slip faulting opened several off-set passes through the main range (Tucker 1980), but the range shows little recent uplift or lateral movement (Biggs & Demsey 2000). Granite bedrock has been the source for virtually all of the sediment in the Tinajas Altas area. Erosion occurs primarily by infrequent bursts of rainfall runoff. Tributary channels are dendritic and the broad valley floors are characterized by large, ephemeral washes that flow roughly along the central axis of the valleys (Biggs & Demsey 2000). Striking geologic features include tafoni, inselbergs, and embayments.

CLIMATE

Hot and dry! Nothing defines a desert like the Sonoran more than high temperatures and the paired factors of low rainfall and unpredictability—or variability, as shown so elegantly by Shreve (1951) and then by Ezcurra and Rodrígues (1986) and Comrie and Broyles (2002). Climate variability is the norm, as rainfall fluctuates on time scales ranging from seasons and years to millennia. Plant distributions and growth in general are delim-

Fig. 4. Upper elevations along the east side of Tinajas Altas Mountains. 16 March 2011. Photo by JM.

ited in the Tinajas Altas region by drought and heat, especially the seasonal drought and hot weather of late spring and early summer. Wintertime freezing also may play a role for some plants. This brief climate summary incorporates information from Adams and Comrie (1997), Comrie and Broyles (2002), McGee (1906), Sellers et al. (1985), and Sheppard et al. (2002), as well as our own observations. The nearest long-term weather data, from Wellton (40 km to the north) and Yuma (about 70 km to the west), are summarized in Tables 1 and 2.

Summers are long and hot, and winters mild and relatively warm. Rainfall, however, varies wildly—with perhaps 7.6–10.2 cm (3–4 in) average at Tinajas Altas. Rainfall is bimodal, with summer rains and winter-spring rains, although summer rainfall is often nonexistent, rare, or substantially reduced. Summer monsoons, generally occurring July to September, are a northern extension of a tropical phenomenon, and greatly reduced from neighboring regions at somewhat higher elevations to the east, such as most of the Cabeza Prieta Refuge and Organ Pipe Cactus National Monument. Summer rains average about one-third as much as the cool-season rains. Often highly localized and violent, summer thunderstorms can bring heavy rainfall of brief duration, but such rains tend to be sporadic, spotty, and undependable, often drenching one place and leaving adjacent places bone dry. Occasional downpours produce flashfloods in the Tinajas Altas Canyon (Fig. 10), scouring the pools and removing or preventing vegetation in or adjacent to the pools.

Fall can be dry, or the occasional hurricane-fringe or tropical depression storms in late summer and fall ("backdoor monsoons") can dump substantial amounts of rain over great expanses, turning the desert green. These rains can result in spectacular development of the major perennials because the plants are often already in an active state of growth from the summer monsoon—the soil is still relatively moist and the weather still warm. Monsoonal thunderstorms or tropical Gulf of California hurricane-fringes on rare occasions can surpass

Table 1. Yuma Valley climate summary. November 1, 1930 to December 31, 1992, maximum average temperature (F), average minimum temperature (F), and average total rainfall (inches). From www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?azyuva (Verfied 14 July 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Max av. T	68.4	73.3	78.4	85.9	93.3	101.1	105.5	104.4	100.5	90.7	77.8	69.2	87.4
Min av. T	37.7	40.5	44.9	50.7	57.2	64.1	73.9	74.0	66.9	55.1	43.9	38.6	54.0
Av. rainfall	0.35	0.27	0.26	0.12	0.01	0.01	0.17	0.46	0.31	0.27	0.20	0.42	2.86

Table 2. Wellton, Arizona, climate summary. March 18, 1922 to December 31, 1980, maximum average temperature (F), average minimum temperature (F), and average total rainfall (inches). From www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?azwell). (Verified 14 July 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Max av. T	67.8	73.0	78.3	85.5	93.7	102.0	106.5	104.5	100.5	90.1	77.0	68.7	87.3
Min av. T	34.5	38.9	43.7	49.9	57.1	65.2	76.1	75.6	67.5	54.1	41.0	35.0	52.3
Av. rainfall	0.45	0.40	0.34	0.12	0.03	0.02	0.38	0.69	0.57	0.36	0.23	0.58	4.18

12.7 cm (5 in) in a single event. Once in a while these hurricane-fringe or tropical cyclone/depression rains bridge the summer monsoon and winter rains. This happened in the flora area in late September 2003 as a result of Tropical Depression Marty, when summer annuals continued growing and flowering intermixed with early germination and flowering of winter-spring (cool-season) annuals. A similar situation occurred in fall 2004.

Cool-season (winter-spring) rains, frontal storms originating in the Pacific Ocean, may begin as cooler weather approaches in November and can variously occur off and on through March or early April. Typically these rains are gentler than the summer rains and can deliver widespread precipitation. Sporadic El Niño years sometimes bring exceptional amounts of winter-spring rains, which can result in spectacular displays of spring wildflowers. This being an extremely arid region, the cool-season rains are often scanty or insignificant, such as during a La Niña year, e.g., 2011 (CLIMAS 2011).

April and especially May and June become increasingly hot and dry—desiccating is an appropriate word. The hot weather and seasonal drought of late spring and early summer, the fore-summer of Shreve (1951), severely limit the survival and distribution of Sonoran Desert plants. Spring annuals dry up and die and many trees and shrubs lose their leaves and some may even perish during the driest years. High temperatures rival records set elsewhere in North America and frequent winds intensify the aridity. Maximum daily temperatures commonly exceed 38–45°C (100–113°F) from late April to early October. Summer temperatures in the region are known to sometimes exceed 48.9°C (120°F)—on 28 July 1995, Yuma reached its all-time high at 51°C (124°F). Average July maximum temperatures are 40.6°C (105°F).

Average winter daytime temperatures are about 24°C (75°F) and average monthly minimum winter temperatures are about 4.4°C (40°F). Temperatures commonly dip several degrees below freezing on a few nights during each of the colder months. Many species in the region are frost sensitive, e.g., *Bursera microphylla* and *Jatropha cuneata*. Certain places or microhabitats, however, can be nearly or entirely frost-free, permitting a number of species with subtropical affinities to thrive. Such microhabitats include niches among granitic rock shelf and cliff bases, and solid rock slopes and aprons that channel water and often provide shade in summer as well as radiant heat in winter.

It is impressive to find the vegetation and flora so rich and varied in this extremely arid place.

HUMAN HISTORY

Culturally Tinajas Altas is in the Western Papaguería region near the intersection of three major groups: Hohokam, Trincheras, and Patayan (McGuire & Schiffer 1982). Because water is a limiting factor for human activities, the tinajas likely have been a focus of interest since people first arrived in the region during the Paleo-

Fig. 5. Jim Malusa and Pete Sundt camping in the Tinajas Altas Mountains. 1 April 2011. Photo by JM.

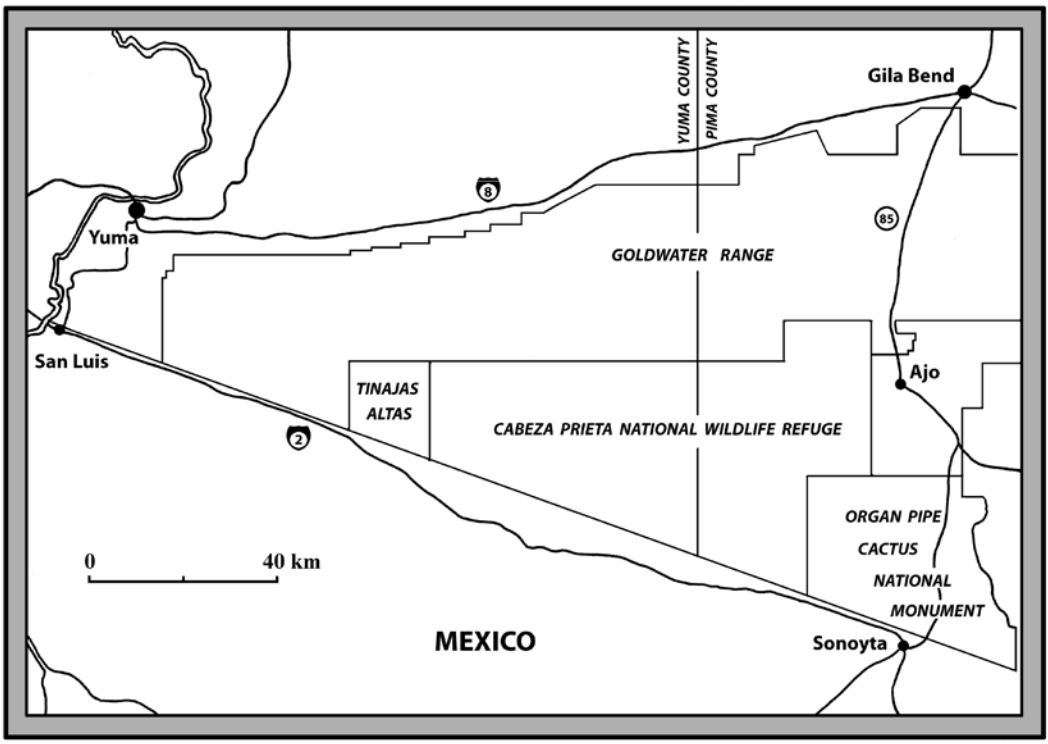

Fig. 6. Tinajas Altas Region, Cabeza Prieta National Wildlife Refuge, and adjacent areas, showing U.S. Interstate Highway 8 and Mexico Highway 2. Drafted by Cathy Moser Marlett.

indian Period (Malpais Period) that extends from 11,000 BCE or earlier to 8000 BCE. An Archaic Period extended from 8000 BCE to 800 CE. A major archaeological survey conducted at Tinajas Altas in 1998 found that "The archeological evidence ranges in age from the Middle Archaic period (5000–2000/1000 BCE) to the 1940s. … There is no evidence from the Paleoindian period" (Hartmann & Thurtle 2000: xxviii). However, archaeological evidence from the surrounding region dates from earlier times, and people likely utilized the site during the Early Archaic and Paleoindian periods (Adrianne G. Rankin, personal communication 2008; Altschul & Rankin 2008; Carpenter et al. 2008). At Tinajas Altas "Prehistoric evidence points to dominant use in the Ceramic period (ca. 800–1850 CE) by the Patayan, those enigmatic gatherers/hunters/farmers who occupied a vast area centered on southwest Arizona and southeast California" (Hartmann & Thurtle 2001: 512). Evidence from the historic period points to use by Hia C'ed O'odham (Hartmann & Thurtle 2001; Hartmann et al. 2007). A Hia C'ed O'odham camp, known as *O'ovak*, was once located on the Mesa del Muerto, the terrace to the east of the tanks (Ahlstrom & Lascaux 2000: 6). A trail used by Cocopahs traveling between the Colorado River delta and the lower Gila River valley intersected Tinajas Altas (Broyles et al. 2012), and an extensive network of foot trails crisscrossed the region allowing trade and travel at least as far as the Pacific Ocean, Colorado Plateau, and interior of Mexico (Becker & Altschul 2008; Broyles et al. 2012). Modern Native American cultural affiliations with Tinajas Altas involve as many as two dozen native nations (Fortier & Schaefer 2010).

Historically, the first Europeans known to have drunk from Tinajas Altas were Jacob Sedelmayr and his party in 1750. Although it has been speculated that Spanish explorer Melchior Díaz went there in 1540, evidence is lacking. Expeditions by Padre Eusebio Kino (1699, 1700, 1701, 1702) utilized other tinajas such as Heart, Cabeza Prieta, and Baker tanks. In 1774 and 1776 Juan Bautista de Anza did camp at Coyote Water, which he called Pozo de En Medio, but not at Tinajas Altas (Broyles et al. 2012). With discovery of gold in California in

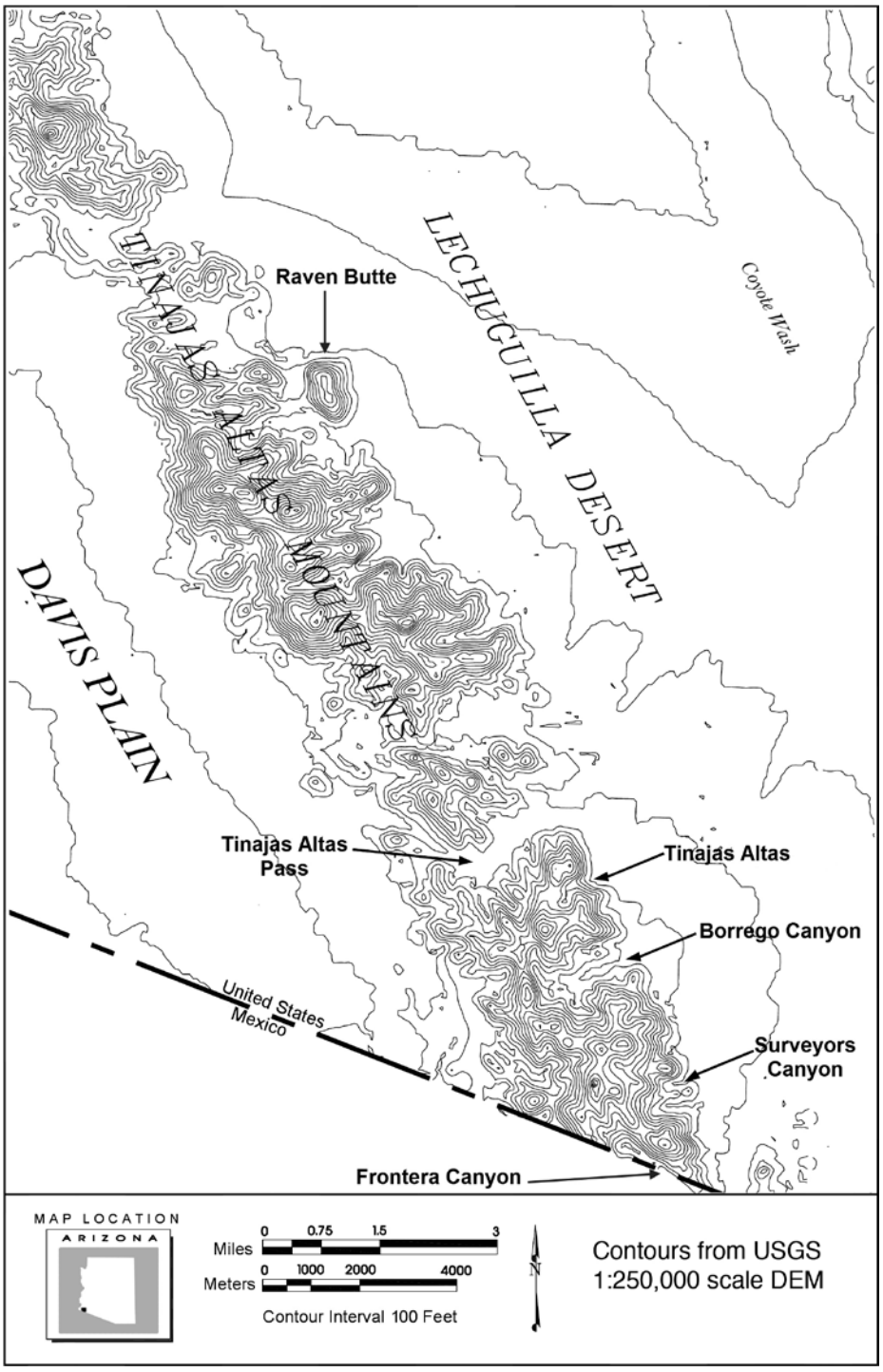

Fig. 7. Tinajas Altas Mountains and adjacent areas, showing major collection sites. Cipriano Pass is the pass north of Tinajas Altas Pass. Drafted by Matt Schultz.

Fig. 8. Raven Butte, east-facing slope. Brittlebush (*Encelia farinosa*), desert lavender (*Hyptis albida*), and saguaro (*Carnegiea gigantea*). 27 April 2010. Photo by JM.

1848, a number of argonauts utilized the El Camino del Diablo route and sought water at Tinajas Altas. Following the Gadsden Purchase, which added Tinajas Altas to the United States in 1854, Tinajas Altas was visited by boundary surveyors (Emory 1987; Gaillard 1896; International Boundary Commission 1898), scientists (McGee 1901, 1905, 1906; Mearns 1907), speculators and geologists (Bailey 1963; Bryan 1925), hunters (Roosevelt 1920; Sheldon 1993), and naturalists and travelers (Lumholtz 1912; Pumpelly 1870, 1918). The area has long been unpopulated and unexploited commercially but popular among campers, tourists, and desert devotees.

MANAGEMENT AND STATUS

The boundaries for the current flora area coincide with those of the Tinajas Altas Addition to Cabeza Prieta National Wildlife Refuge as proposed by U.S. Fish and Wildlife Service (Master Plan Brochure 1970: map; U.S. Fish and Wildlife Service 1970a) and as incorporated within the refuge for a few months in 1975 by the Department of the Interior (Tunnicliff et al. 1986: 3.14). The boundaries extended the northern refuge boundary westward to a point about one mile west of Cipriano Pass and then southward to the US–Mexico border. The Tinajas Altas addition encompassed land sections in townships 12, 13, and 14S in range 17W and townships 12 and 13S in range 18W, totaling approximately 80,000 acres (Master Plan, Backup Volume 1970: 62; U.S. Fish & Wildlife Service 1970b) and including Raven Butte, the Tinajas Altas Mountains, and portions of the Lechuguilla Desert and Davis Plain, but the land was not congressionally included within the refuge. In turn because of its special biological, historical, archaeological, geological, and scenic values, the Bureau of Land Management in coordination with the Department of Defense subsequently designated much of the former addition as an Area of Critical Environmental Concern (ACEC) of irregular configuration comprising about 60,500 acres

Fig. 9. Raven Butte, south-facing slope with brittlebush (*Encelia farinosa*) and ocotillo (*Fouquieria splendens*) in foreground. Granitic mountain in background is part of the Tinajas Altas Range. 27 April 2010. Photo by JM.

(Departments of the Air Force, Navy, and Interior 2006: 4.11), and later as a Special Natural Interest Area of comparable though not congruent boundaries (Range Management Department 2007).

Since 1941 Tinajas Altas has been managed as part of the expansive Barry M. Goldwater Range (BMGR, formerly known by several names including Luke Air Force Range). The U.S Marine Corps manages BMGR-West (which includes Tinajas Altas) and the U.S. Air Force manages BMGR-East. About 90% of the Range, including the Tinajas Altas region, remains largely unscathed by military pilot training and other national defense-related purposes. The Tinajas Altas region was managed by the Yuma Field Office of the Bureau of Land Management (BLM) in collaboration with the military until 2001. The intent of the Tinajas Altas Mountains Area of Critical Environmental Concern (ACEC) continues to be honored by the Marine Corps and the Tinajas Altas region has been designated as a Special Interest/Natural Area (see Departments of the Air Force, Navy, and Interior 2006). Other initiatives have been proposed to give the area special status. "In 1974 the Department of the Interior proposed adding to CPNWR [Cabeza Prieta National Wildlife Refuge] the 79,000 acres immediately adjacent to the Refuge's western boundary. … This area, was actually added to the Refuge in a 1975 public land order…but was revoked several months later due to some technical flaws in the order" (Tunnicliff et al. 1986). Since 1998 citizens have variously proposed incorporating Tinajas Altas within a Sonoran Desert National Park and Preserve or a biosphere reserve, incorporating Tinajas Altas within the CPNWR, or designating it as a Traditional Cultural Property. A major management plan was conducted under the direction of the U.S. Marine Corps (Villarreal et al. 2011). Special designation, stricter regulations, increased staffing, and heightened management attention may be required to surmount expanding tourism, recreation, military exer-

cises, and illegal activities such as smuggling and ensuing law enforcement. Conservation of plants and wildlife and protection of cultural resources at Tinajas Altas are not only merited but necessary under existing stewardship laws.

PLACES

Information for the place names is based in part on the regional gazetteer by Broyles et al. (1997, 2007), which was based on maps and other sources using NAD 27 datum.

Borrego Canyon. A major canyon in the southern part of the Tinajas Altas Mountains. The canyon mouth is at 32°17'58"N, 114°02'25"W, 1240 ft. Borrego Tank is in the canyon at 32°17'07"N, 114°03'03"W, 1590 ft.

Butler Mountains. This small, extremely arid, granitic range is 6 km (4 mi) west of the Tinajas Altas Mountains and adjacent to our core flora area. Its base is partially buried by drifting sands. It is a significant packrat fossil-midden study site (Van Devender 1990) and is named for Gurdon Montague Butler, dean of College of Mines at University of Arizona (1915–1940) and director of Arizona Bureau of Mines (1918–1940). Also known as Las Cuevitas on some older maps in recognition of the many eroded caves (tafoni) in the granitic rock. Summit is at 32°22'34"N, 114°12'23"W, 1169 ft.

El Camino del Diablo. This is the infamous, ancient route from Sonoyta to Yuma. It crosses the northern part of the Pinacate region, runs through Cabeza Prieta National Wildlife Refuge to Tinajas Altas, and ends at the Gila River. Also known as the Old Yuma-Caborca Trail, this was the route taken by some early Spanish explorers, by settlers from Mexico going to the San Diego, Los Angeles, and San Francisco areas, and by many forty-niners to the California goldfields (Fig. 1). The first motorcar trip across the Camino was in 1915 by Raphael Pumpelly (1918) and segments of it remain a primitive road.

> The U.S. Fish & Wildlife Service (2008) provides the following summary:
>
> An historic route linking the northern frontier of Mexico and the Spanish settlements of California, El Camino del Diablo—Highway of the Devil—has witnessed centuries of intrepid travelers. Yet, a journey on El Camino has never been easy.
>
> Starting at Caborca, Sonora, Mexico, the 250-mile trip featured rest stops at Quitovac, Sonoyta, and Quitovaquito, before plunging headlong into the expanse of desolation that lent the trail its name. This stretch between flowing water on the Sonoyta River at Agua Dulce, and the rumor of stagnant water at Tinajas Altas, proved arduous to all, and deadly to many. …
>
> The 130-mile stretch from Sonoyta, Mexico, and what is now Yuma, Arizona, was a long ride through sere desert flats and across leg-wrenching lava malpais and drifting sand. In the cooler months, the trip might be only a slow plod, taking 3 to 10 days. Water might be found at Tule Tank or, if fortune really smiled, rain could deliver pools at Las Playas. In summer, temperatures here soar to 120 degrees F and people require two gallons of water a day just to survive. Waterholes and forage dry up. Yet, many set out anyway with the single-minded thought of reaching Tinajas Altas (High Tanks). Most of the graves line the last 30 miles of that leg; by one count 65 graves near Tinajas Altas proffered mute testimonial.

Cipriano Pass. A pass that separates Tinajas Altas Mountains from Gila Mountains, ca. 2 miles northwest of Raven Butte. Apparently named for Cipriano Ortega, a nineteenth century reformed bandit who may have driven cattle through this gap. It was also used by smugglers and called Smuggler Pass. 32°25'35"N, 114°09'34"W, ca. 1000 ft. Another Cipriano Pass is a gap in the southern Cipriano Hills, 3 mi N of Quitobaquito in Organ Pipe Cactus National Monument (Broyles et al. 2007).

Coyote Wash. The major axial arroyo draining the Lechuguilla Valley northward to the Gila River, though today it is blocked by the Mohawk Canal. It used to meet the Gila River at 32°41'32"N, 114°11'12"W.

Coyote Water. A waterhole on Coyote Wash 6 km northeast from Tinajas Altas, 32°19'59"N, 113°59'23"W, 960 ft. Historically important and known as Pozos en Medio (Broyles et al. 2012). Bryan (1925: 422) writes that Coyote Water

> lies in the axial stream of the valley, which is a channel filled with coarse sand about 100 feet wide and with soft banks about 3 feet high. The sand lies in great waves, which indicates the way in which the sand moves downstream during floods. The water remains in a cavity or scour depression in the hardpan that underlies the sand of the channel and is obtained by digging about 4 ft. A wooden signboard and the marks of coyote or human digging will guide the traveler in

Fig. 10. A flash flood at Tinajas Altas, 13 Sep 2011. Photo by Scott Fischer, Arizona Game and Fish Department.

finding the exact spot. The water is small in amount and not very permanent and has a bad taste. The taste seems to be due to decaying plant roots.

Davis Plain. Sandy plain between the Butler and Tinajas Altas mountains. Named for geologist W. M. Davis (probably William Morris Davis, 1850–1934). The plain slopes gently to the southwest and supports the greatest number of ocotillos (*Fouquieria splendens*) in the study area. Ironwood (*Olneya tesota*) and blue palo verde (*Parkinsonia florida*) are widespread along the washes and runnels, although many of these trees died during the severe drought of 2003–2004. The approximate center of the plain is 32°26'15"N, 114°13'27"W, 900 ft.

Frontera Canyon. A large canyon draining the southern part of the Tinajas Altas Mountains. The canyon wash trends northwest from the vicinity of El Sahuaro (along Highway 2 in Sonora, Mexico) and becomes a canyon entering the mountains as it courses towards the high point in the range. The canyon wash crosses the interna-

tional boundary, hence the name "frontera," coined in March 1998 by a group of hikers including Gayle Hartmann (personal communication, 1998). Some *Nolina bigelovii* in the canyon are unusually tall (see the species accounts). The canyon mouth is at 32°15'02"N, 114°01'31"W, 1100 ft.

High Tanks Gate. A seldom used name for a former border "crossing" along a dirt track in a low, broad pass at the international boundary between the Tinajas Altas Mountains on the west and the Sierra Lechuguilla on the east, 7.2 km (4.5 mi) south-southeast of Tinajas Altas and west of Border Marker 190. The name is a misnomer, since there was neither a gate nor a fence until 2008, when the site was obliterated by the tall, metal border barrier fence (Fig. 11). 32°15'08"N, 114°01'04"W, 1100 ft.

Lamb Tank. Named for young bighorn sheep, it is a subterranean artificial water tank built for wildlife in 1995 at the mouth of Surveyors Canyon, 32°16'26"N, 114°01'36"W, 1200 ft.

Lechuguilla Valley, Lechuguilla Desert. This is the arid valley-plain between the western margin of Cabeza Prieta Mountains and the eastern flank of the Tinajas Altas Mountains. This piedmont has minimal topographic relief as the broad plain slopes gently from the mountains to the axial wash, which drains the valley to the north by Coyote Wash and to the south by La Jolla Wash. The Camino del Diablo logically crosses the approximate divide for the northward and southward drainages since there is no arroyo cutting here. *Lechuguilla* is a common name in Mexico for agave, here *Agave deserti*.

Mesa del Muerto, Mesa of the Dead. This small mesa is named for the graves, once prevalent at the site, of travelers who perished on the trail. The mesa is a few hundred meters east of the Tinajas Altas. Access to the Tinajas and Tinajas Altas Canyon is from the parking area on the mesa. A wide trail leads from the mesa to the areas near the lower tinajas. McGee (1905) called it Mesita de los Muertos. 32°18'45"N, 114°02'53"W, 1160 ft.

Raven Butte. Distinctive basaltic butte abutting the east side of the Tinajas Altas Mountains (Figs. 8 and 9). The butte is possibly named for its raven-black color, but the Board of Geographic Names (U.S. Geological Survey 1987) implausibly states that it was named for the large number of relatively tame ravens found there in the early 1900s. Summit at 32°24'15"N, 114°06'33"W, 1773 ft.

Raven Butte Tank. A tinaja above huge granitic rocks in a canyon south of Raven Butte, at about 1220 ft.

Surveyors Canyon. Canyon in Tinajas Altas Mountains, 1.9 mi NNW of international boundary monument 190. Mouth at 32°16'30"N, 114°01'38"W, 1160 ft. **Surveyors Tank** in Surveyors Canyon is an intermittent natural tinaja used in 1890s by surveyors of the international boundary (International Boundary Commission 1898), 3.5 mi SSE of Tinajas Altas. It may equal Engineers Tank, shown on USGS 7.5 map at 32°16'20"N, 114°02'00"W, 1360 ft. A tank can be found there, but this site does not completely fulfill historic descriptions (see Sheldon 1993: 25, 91).

Tinajas Altas. These are the most significant tinajas or bedrock waterholes in the region. Dependable water made these large tinajas "renowned in the pioneer history of the district," according to Lumholtz (1912: 239, 396), though he was displeased in January 1910 to find "pieces of cast-off clothing, rusty tin cans, and other cheerless marks of human occupancy."

There are nine sets of intermittent and perennial pools that hold at least 77,664 liters (22,000 gallons) when full (Broyles 1996; Broyles et al. 2007). An arroyo from a hanging valley (Tinajas Altas Canyon) in these granitic mountains downcuts steeply through joint fractures to scour and pluck a staircase of pools. Prehistoric people were camping and variously using the area for millennia (Hartmann & Thurtle 2001). Although these waterholes are generally regarded as permanent, at times they have gone dry or nearly so and Broyles (1996: 491) informs us that "even the stalwart Tinajas Altas were virtually dry in the summer of 1905 (McGee 1905, 1906), June 1946 and winter 1957 (CPNWR files)." McGee (1906: 722) wrote, "The supply has been deemed unfailing; though singularly enough the water was practically exhausted in the summer following the exceptionally wet winter and spring of 1905, seemingly for the reason that the unusually prolonged and gentle precipitation served rather to fill the tinajas with sand than to sweep them clean and leave them brimming, as do the ordinary rains of the region." In fact, the lack of wetland plants (except *Typha domingensis*) at these tinajas probably is due to the scouring effect of flash floods and the lack of soil at the margins of the waterholes.

> Many wayfarers arrived to find the lower tinajas dry. … Perilously, they clambered up steep cliffs to retrieve mere bucketfuls for themselves and their struggling animals. Some victims, finding the bottom tanks dry, and unable to feebly

> claw their way up the steep cliffs, perished within a few yards of life-sustaining water. From Tinajas Altas the trail forked, and weary travelers and their exhausted livestock struggled toward the Gila or Colorado Rivers, which promised unlimited water, shade, and forage. Stronger parties swung west through the Yuma Desert directly to Yuma Crossing. More cautious travelers took the northern route from Tinajas Altas, skirting the eastern edge of the Gila Mountains to the Gila River, and then followed it to the Colorado River confluence upstream from Yuma. (U.S. Fish & Wildlife Service 2008.)

Broyles et al. (2007: 671) reported that the O'odham name is "'Ó'ovak or O'o Voopod ('where the arrows were shot'). Lumholtz reports a legend that two O'odham shot arrows from opposite sides of the mountain's spine. One's arrows cleared the mountain; the other's fell short and made holes in the mountains that became the tinajas. Fillman Bell [personal communication to Bill Broyles, 1987] asserts that 'O'ovak means 'a drawing hole', or 'place where moisture is gathered.' Also historically transcribed as Oo'oo'woopa ('where the arrows lie down')." Lowermost tank at 32°18'42"N, 114°03'02"W, 1200 ft.

Tinajas Altas Canyon. This hanging canyon or valley (Fig. 12), also described as the "upper canyon" or "high canyon-valley," leads southwestward above the uppermost tinaja (Fig. 13). This canyon system feeds into the tinajas. There is a surprising rich flora and a scattering, or interrupted small gallery, of xeroriparian large shrub/small tree desert legumes—ironwood (*Olneya tesota*), foothill palo verde (*Parkinsonia microphylla*), and catclaw acacia (*Senegalia greggii*). The canyon bottom just above the uppermost of the waterholes of Tinajas Altas is 32°18'41"N, 114°03'11"W, 1520 ft.

This high canyon is also known as the Upland Valley (Bryan 1925). Hartmann and Thurtle (2001), however, use "Tinajas Altas Canyon" for the large arroyo or entrenchment leading east from the lowermost tinaja into the Lechuguilla Desert.

Tinajas Altas Mountains. The north-south trending granitic range between the Gila Mountains to the north and Cerro Pinto to the south in Sonora. The summit is 32°16'24"N, 114°02'45"W, 2764 ft.

These mountains are described as "Rugged, but not very lofty…although the overall trend of the Tinajas Altas Mountains is straight, the topographic fronts of the mountains are generally very embayed and sinuous….The mountain slopes meet a nearly flat desert floor at a sharp angle, except where major channels exit from the mountain. Very steep, embayed topography with minimal colluvial cover indicates that erosion of the mountain fronts has had a long time to operate in the absence of renewed tectonic activity (Bryan 1925; Bull 1973). Erosion is facilitated by uncommon but intense rainfall and runoff, steep slopes, and sparse vegetation cover" (Biggs & Demsey 2000: 27).

Tinajas Altas Pass. Gap in the Tinajas Altas Mountains, 1.8 km northwest of Tinajas Altas. A primitive road through the pass leads northwest along the west side of the Gila Mountains, passing Fortuna Mine and ending at Yuma. To the east the road joins the main Camino del Diablo. 32°19'19"N, 114°03'48"W, 1130 ft, at the approximate highest point on the road.

BOTANIZING AT TINAJAS ALTAS, RICHARD FELGER

The plant life molded into the spectacular scenery at Tinajas Altas fits easily into Forrest Shreve's (1951) concept of Lower Colorado Valley subdivision of the Sonoran Desert. During the usual drought conditions you won't see much in the way of greenery and even the creosotebushes (*Larrea divaricata*) may be dried up, but go there after a generous rainy time and there is a richness of flowers, greenery, buzzing insects, birds, and other creatures. For example, in late October 2004, following hurricane-fringe rains, there was abundant greenery and a full complement of summer-season annuals (ephemerals) as well as the first winter-spring annuals. At the same time all around the Tinajas Altas little red-spotted toads (*Bufo* (*Anaxyrus*) *punctatus*) had just lost their tails and were stepping out into the dry world.

I had done considerable fieldwork in southwestern Arizona and northwestern Sonora just across the border from the Tinajas Altas, but had only a vague idea of the historically important waterholes before I visited the place. I had been botanizing in Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge for some time, and finally, in February 1990, I camped in the Tinajas Altas Mountains. The intact vegetation nestled among steep sculptured granite was intriguing. An extensive trip across Cabeza Prieta to

Fig. 11. Tinajas Altas Mountains at the U.S.–Mexico border, looking westward. The newly constructed border fence at the site of the former High Tanks Gate. Creosotebush (*Larrea divaricata*) and ocotillo (*Fouquieria splendens*) in foreground. 22 November 2008. Photo by RSF.

the Tinajas Altas Mountains in June 1992 sparked my interest. I was privileged to accompany Bill Broyles for a six-day field trip in Cabeza Prieta and the Tinajas Altas Mountains. It was the second week of June and I expected unbearable temperatures, but it was just wonderfully warm and we had plenty of water and time for good hikes, and of course botanical exploration. We saw no one else the whole time, except the morning of the first day when a van with Cabeza Prieta workers passed us on the road at the east end of the refuge. The rains had been generous that spring. New growth of creosotebushes encroaching narrow roads was full of fuzzy white fruits. I was surprised to see the vegetation so lush and dense, being that the annual rainfall is so scanty and June is the hottest, driest month—a day under 37.8°C (100°F) is rare.

My first really significant botanical reconnaissance of the Tinajas Altas region was in March 1998. In just a few days, Luke Evans and I covered much of the region. Luke was verifying data for a revision of the Dry Borders gazetteer (Broyles et al. 2007). I had heard of giant tree nolinas (*Nolina bigelovii*, see species accounts) growing in the place Gayle Hartmann and friends named Frontera Canyon and Luke knew how to get there.

18 March 1998. We leave Tinajas Altas early in the morning and head for the border on the old Surveyors Tank Road along the east side of the Tinajas Altas Mountains. The road is a rough dirt track to the border at a place sometimes called "High Tanks Gate," although there is not a gate or even a fence. The road continues into Sonora, Mexico, where there has been considerable vehicle traffic that does not continue northward—the vehicle tracks are from drug or people smugglers not driving into the U.S. We lock up the vehicle on the U.S. side (I hope it will be here when we get back) and walk several hundred meters into Sonora, going south and then westward, skirting the southernmost tip of the mountain. We see where a U.S. border patrol helicopter has marked the sand with landing skids on the dirt road on the Mexico side. They come back later to look for foot-

Fig. 12. Tinajas Altas Mountains, looking down at Tinajas Altas Canyon near the uppermost tinaja. Note bighorn trails. 21 November 2008. Photo by RSF.

prints, indicating illegal border crossers. Mexico Highway 2, the only road in Mexico linking mainland Mexico with the Baja California Peninsula, is only a few kilometers to the south. After walking around the southern toe of the mountain we head northward into the large, main canyon draining southward from the Tinajas Altas peaks, soon crossing back into the U.S. There are no border markers or a fence here and we are soon in Frontera Canyon heading northward. This canyon is a "dead end" leading into steep, near impassible steep, rock slopes.

We come across recent trash and "El Yori 1998," the name of a popular Mexican rock band, freshly carved into an overhanging ironwood branch. We hike up the canyon, up and over huge boulders making up the canyon floor, and I record the plant species encountered. We soon find the *Nolina bigelovii* giants—the biggest ones I have ever seen (see the species accounts). We record GPS readings, measure the nolinas, and I collect specimens of the more interesting plants, putting them in plastic bags to prevent them from wilting, to be pressed later. Luke carries out yesterday's trash. Was it left by border crossers or smugglers waiting for nightfall?

Later in the day we are back at Tinajas Altas and climb up above the tanks. From the ridge along an indistinct trail I look down onto ironwood (*Olneya tesota*) and palo verde trees (*Parkinsonia microphylla*) sparsely strung along the bottom of a high hidden canyon, which we are calling Tinajas Altas Canyon (Fig. 12). The place looks eerily pristine, without human influence. The steep slopes across the canyon are marked with switchback animal trails, like the kind you see where there are too many cattle. No cows here, these are from desert bighorns (*Ovis canadensis mexicana*). I remind myself that with all this tinaja water, people have been here since Ice Age times and must have had impacts on the place. Surprisingly, I find no more than several mesquites (*Prosopis glandulosa*) along the canyon bottom. We were lucky that it is a "good" spring and the vegetation is luxurious. By the end of the day my backpack is crammed full of plant specimens in Ziploc plastic bags, each marked with a piece of paper keyed to notes in my pocket notebook. That night and early the next morning I fill the plant presses.

On other occasions it is so dry that even creosotebush leaves are shriveled, such as a November 2002 field trip with Curtis McCasland, then ecologist at Cabeza Prieta National Wildlife Refuge and later manager of the Refuge. Returning with Curt on October 24, 2004, the margins of Coyote Wash, at Coyote Water along the bottom of Lechuguilla Valley, are like a jungle. The hard damp vertical banks, about 1 m high, are shaded in greenery and the soil held together with a carpet-like biological crust of blue-green algae, liverworts, soil lichens, green mosses and the like (*see* Belnap 2007; Rosentreter et al. 2007). I find "semi-wetland" plants such as *Ama-*

Fig. 13. Uppermost tank at Tinajas Altas, looking eastward across the Lechuguilla Valley with Cabeza Prieta Mountains in the background. 28 April 2010. Photo by JM.

ranthus crassipes and *Cyperus squarrosus* that I would not have expected, as well as robust annuals, some bigger than I have ever seen. Recent tropical depression storms soaked the place while it was still warm enough for the summer annuals to keep going or germinate and late enough in the year for the winter-spring annuals to get started. There is a full complement of summer annuals (ephemerals) such as *Amaranthus*, *Pectis*, and *Tidestromia*, as well as the first cool-season annuals such as *Oenothera* and *Plantago.* Green gallery walls on both sides of the wide wash are a tangle of honey mesquite (*Prosopis glandulosa*) to about 8 m tall with heavy trunks, catclaw acacia (*Senegalia greggii*), desert wolfberries (*Lycium fremontii*, *L. macrodon,* and *L. parishii*), brittlebush (*Encelia farinosa*), canyon ragweed (*Ambrosia ambrosioides*), and numerous other species. But ironwood is missing from this lowest part of the valley floor, the nearest ones a few kilometers away on the middle to upper bajada closer to the Tinajas Alas Mountains, and I don't have a good explanation for its absence.

Late afternoon we go to where the Camino del Diablo crosses the divide of the Lechuguilla Valley almost at the Mexican border. There is sheet flow here but no wash has formed, for it is here that the valley drains northward to form Coyote Wash, coursing towards the Gila River, and southward to form La Jolla Wash, coursing into the sands of the Gran Desierto (Broyles et al. 2007). It is humid and warm and an aromatic yellow carpet of desert chinchweed (*Pectis papposa*) and other summer annuals almost completely covers the ground between the creosotebushes, mesquites, lycium shrubs (*Lycium macrodon* and *L. parishii*), desert saltbushes (*Atriplex polycarpa*), white bursages (*Ambrosia dumosa*), canyon ragweeds, brittlebushes, and button encelias (*Encelia frutescens*). Half-grown sphinx-moth caterpillars graze on *Boerhavia* plants and there is a constant buzz of insects. The soil is glistening mud made solid by biological soil crust. Some of the annual desert daturas (*Datura discolor*) are shrub-like about one meter tall.

We turn around to go to Tinajas Altas to camp for the night. It is 5:55 and we have not passed another vehicle since entering the Goldwater Range south of I-8, although a border patrol vehicle is in front of us. They are on a jeep trail roaming around looking for illegal border-crossers on foot and in vehicles. Between the illegals and border patrol the desert floor is being crushed and eroded.

Soon after dark a 4-wheel-drive SUV shows up with four "herpers." They ask Curt if he knows where they might find rosy boas (*Lichanura trivirgata*) and head off with headlamps. They come back after an hour or so and report young red-spotted toads everywhere and one subadult female chuckwalla. I ask if they are collecting and they say, "we hardly do anymore." Later Curt says it's not against the law to collect most herps. They leave and the night is peaceful except for noisy mosquitoes. Bright lights to the northeast are from aerial flares in military maneuvers on the Goldwater Range.

The next morning, October 25, we climb nearly to the top of the Tinajas Altas Mountains, going way up past where Luke and I went in March 1998. Again I find only a very few mesquite trees along the high canyon above the tinajas. Barrel cacti are also scarce—we see only a few large ones on inaccessible cliff faces where bighorn sheep cannot reach them (see species accounts for *Ferocactus cylindraceus*).

During the day I see remains of about half a dozen rusty military ordinances (rocket motors and other remnants of military aerial gunnery training). A golden eagle tops a high ridge. About three-quarters of the way to the top we see a still-standing dead nolina and estimate the trunk to be 6 m tall. On north- and east-facing slopes the vegetation has become denser in places where there is enough soil. There are several more very large, downed and dead nolinas. Apparently the soil eroded away and they fell over. Perhaps they are the same age class as the Frontera Canyon giants. A bighorn sleeping-place in an eroded (tafone) cave is full of fresh, smelly bighorn droppings. Farther up I find a small, localized patch of desert spike-moss (*Selaginella arizonica*). We have not seen it elsewhere on the climb, although I would expect it since this spike-moss is common in similar habitats elsewhere in these mountains. Has it been eliminated by bighorn sheep? I am somewhat surprised to find, apart from subtle increases in vegetation density, only minor elevational differences in the plant life from low- to high-elevation.

Before climbing down steep rough granitic rocks, I stop to look out across a vastness of desert silence. Dark xeroriparian ribbons writhe like double helices across the distant pale brown valley floor scratched only by the Camino del Diablo.

By 2008 the Tinajas Altas portion of the desert had started to make a gradual recovery due to reduced illegal border-crossing traffic, a result of multiple factors, including increased border patrol presence and an economic downturn in the U.S. By mid-year the U.S. Department of Homeland Security began building a 14-foot-high metal fence along the border (Fig. 11).

On 20 November 2008, Ben Wilder and I drive from Tucson to Tinajas Altas, arriving at 1:40 pm. Driving south from I-8 on the wide graded road we pass numerous huge trucks engaged in the border fence construction. They have cleared what appears to be hundreds of acres on the valley floor northeast of Tinajas Altas as a headquarters and staging area. Looks like a moonscape.

The lowermost Tinajas Altas tank has water swarming with mosquito larvae and multitudes of tiny, young red-spotted toads are all about. A sprawling *Boerhavia coccinea* is same plant among rocks in front of the tinaja that I have seen on every visit. Bighorn scats everywhere, plus a small quantity of larger scats that appear to be from a burro (donkey). The vegetation is somewhat dried up—it has not rained for quite a while. Ben climbs to a lower-middle tinaja, tank #4, and finds numerous tadpoles and the elusive cattail (*Typha domingensis*, see species accounts). I investigate the lower slopes and adjacent areas for worthwhile records. The large blue palo verde (*Parkinsonia florida*) in the canyon wash east of tinajas is gone: it was here in 2004. We camp on the Mesa del Muerto east of the tinajas and the roar from border-fence construction trucks goes on all night.

The next morning we climb the steep hanging canyon just north of the tinajas. From the ridge/saddle looking down at Tinajas Altas Canyon we see the numerous bighorn switchback trails on the lower slope across the canyon, leading into the upper tinajas (Fig. 12). In the canyon bottom wash leading to the uppermost tinajas we find the sand pocked with bighorn tracks and their scats are everywhere. Some saguaros (*Carnegiea gigantea*) about 1 to 1.5 m tall have been bashed in by bighorn seeking moisture (Fig. 14).

On the morning of the 22nd we drive south from the Tinajas Altas area along a wide, new graded road approximately along the old Surveyors Tank Road to the new border fence at the High Tanks Gate area (Fig. 11). The desert along the border is scraped bare. The fence stops at the steep granitic mountain, providing a place to walk to and from Mexico.

Returning northward, about half way to Tinajas Altas, the road cross two large washes coursing eastward from mountain canyons. These washes have their margins jammed full of dense green vegetation and a blaze of flowers, apparently the result of a recent flash flood, including yellow of brittlebush (*Encelia farinosa*) and red of hummingbird bush (*Justicia californica*), as well as *Ambrosia dumosa, A. ilicifolia, Bebbia juncea, Brandegea bigelovii, Datura discolor, Funastrum hartwegii, Horsfordia alata, Lycium andersonii, L. brevipes, L. fremontii, L. macrodon, Hyptis albida, Larrea divaricata, Olneya tesota, Parkinsonia florid*a, and *Senegalia greggii* (Fig. 15). The adjacent desert vegetation is dry and drought-stressed.

We turn east on a wide new road past a new mountain of sand being worked by bulldozers for making cement for border fence posts. The border fence construction site is off-limits. We turn back and head for Tucson.

On March 25 to 29, 2010, I accompany Bill Broyles and Joan Scott on a field trip across the Camino del Diablo, from Organ Pipe Cactus National Monument through Cabeza Prieta National Wildlife Refuge to the Tinajas Altas region. At the Refuge offices in Ajo we see Curt McCasland, the Refuge manager. He tells us the area along the Camino del Diablo in the Refuge is not really wilderness anymore: emergency stations (with survival water for border crossers) are every 5 miles and there is a heavy presence of Border Patrol. In camp that night we meet up with the rest of our party. There are six of us: Bill Broyles and his wife Joan Scott, a wildlife expert retired from the Arizona Department of Game and Fish, Luke Evans, an environmental consultant and regional scholar, David Taylor, a Guggenheim fellow from New Mexico State University who is re-photographing all the border monuments from Texas to California, and Richard Laugharn, a fine art photographer from Phoenix who has been tracking specific desert plants year after year. The last two days are spent in the Tinajas Altas region.

On the 28th, Richard Laugharn and I stop at the Camino crossing of the Lechuguilla Valley bottom and explore the mini-jungle of mesquites at the beginning (southern limit) of Coyote Wash. The mesquites, mostly 3–4(–5) m tall, are nearly impenetrable. I am looking for *Teucrium glandulosum*, which I had previously found

Fig. 14. Saguaros (*Carnegiea gigantea*) damaged by bighorn. Tinajas Altas Canyon above the tinajas. 21 November 2008. Photo by RSF.

but only as a dry skeleton, but there was no sign of it. The ground is mostly covered by the invasive Sahara mustard (*Brassica tournefortii*) of incredible size variation. The soil is still damp from last rains and where the ground is not covered by ephemerals I see a continuous blackish surface of microphytic crust with blue greens and bacteria (see Belnap 2007; Rosentreter et al. 2008). Milkweed vines (*Funastrum hartwegii*) interlace the jungle, reaching into the tops of the mesquites. Inside the jungle the air is hot, humid, and still. *Lactuca serriola* and *Sphaeralcea emoryi* are new records for the Tinajas Altas region. Later in the day I am botanizing around Tinajas Altas. Near full moon and using a headlamp I press the day's specimens, all in good shape in Ziploc plastic bags in the frig in the back of Luke's pickup.

On the March 29, after a quick breakfast, I go with Luke Evans in his Toyota pickup. He has a laptop floor-mounted in the cab with topo maps on the ready and other techno conveniences. We drive south and then westward into Surveyors Tank Canyon, to a small parking area near the mouth of canyon at Lamb Tank, an elaborate artificial buried water catchment leading into a small cement water tank for bighorn sheep. Bighorn scats are abundant as well as Sahara mustard. The tank is full and swarming with honeybees, which we had not seen elsewhere on the trip. Surveyors Tank is further up the canyon and is entirely natural. There are bedrock grinding holes near the tinaja. We do not see barrel cacti and agaves are surprisingly few, probably due to bighorn sheep—their scats are numerous.

In the late morning we drive back north to our camp near Tinajas Altas, pack up, and head north. We take a dirt track west from the Camino into a large canyon in the granitic mountains. We park at the end of the road and hike up a canyon with huge granitic rocks. Like most canyon sites in these mountains, there are about two-dozen conspicuous major perennials and more than two-dozen winter-spring annuals. I saw only one small barrel cactus (*Ferocactus cylindraceus*).

Leaving for Tucson in the early afternoon, I am riding with Bill and Joan. Going north on the graded dirt road along the sandy Lechuguilla Valley to Wellton I see large plants of Sahara mustard all along the roadside but no buffelgrass. We pass spectacular ocotillo "forests" along the sandy valley floor, the stems red tipped in full flower. We stop for cold drinks at a convenience store in Wellton. A long line of farm workers bused in daily from San Luis, Sonora, are spending money on junk food and pop. In the back seat I am pressing plants all the way from Wellton to Tucson.

Fig. 15. A major wash from the east side of the Tinajas Altas Mountains. Desert hummingbird-bush (*Justicia californica*), brittlebush (*Encelia farinosa*), sweetbush (*Bebbia juncea*), Anderson wolfberry (*Lycium andersonii*, *Felger 08-196*), and blue palo verde (*Parkinsonia florida*) along the wash. 21 November 2008. Photo by RSF.

DEEP HISTORY AT TINAJAS ALTAS, TOM VAN DEVENDER

Deserts are notoriously bad places for preservation of fossils. In wetter climes plant materials and dead animals fall into water, are quickly buried, and minerals may replace their organic fabric. Yet the Tinajas Altas Mountains, in one of the most arid parts of North America, have one of the richest fossil records for Ice Age plants in the world. The humble packrat has collected and curated hundreds of species in the southwestern United States for more than 43,000 years. In 1962, Phil Wells, a plant ecologist, and Clive Jorgenson, a mammalogist, climbed the isolated, desolate Spotted Range on the Nevada Atomic Test Site. On the way down they entered a rock shelter to eat lunch, where they found a dark, organic mass full of twigs and seeds that Wells recognized as juniper and fecal pellets that Jorgenson knew were from packrats. It was the rich dark reddish-gold color of *amberat*, the caver's name for the shiny crystalline veneers of packrat urine on cave walls. Wells later radiocarbon-dated a piece of the deposit to more than 10,000 years ago. Wells named the deposits 'middens,' a term borrowed from archeologists referring to human garbage piles. The 1980s were a time of discovery—the Amber Rush had begun (Van Devender 2007). These studies are summarized in *Packrat Middens: The Last 40,000 Years of Biotic Change* (Betancourt et al. 1990).

Packrats (also called woodrats) are medium-sized rodents that carry plant and animal materials and other objects back to their houses or dens. In dry rock shelters some of this material on ledges or in crevices away from the main den deposit may become cemented with their urine into hard, dark organic middens (Betancourt et al. 1990). These deposits reflect many years of gradual accumulation of plant material collected within only about 30 m of the rock shelters, and are excellent for reconstructing past vegetation and climate.

In February of 1979, botanists Art Phillips and Barbara Phillips from the Museum of Northern Arizona were exploring the Tinajas Altas Mountains when they found a packrat midden in a canyon on the east side of the range, south-southeast of the famous 'high tanks' area. In March of 1980, I returned to the area in search of more middens and the promise of reconstructing the history of vegetation in a new area in the Sonoran Desert.

On the map, the most direct route was from Interstate 8 east of Yuma down the west side of the Gila Mountains to the old Fortuna Mine and southward through Tinajas Altas Pass. This was a real adventure with stark, beautiful landscapes and wondrous spring wildflowers. But it was a slow trip crossing the myriad of arroyos draining the mountains and a strain on my Volkswagen Beetle and kidneys. Eventually the Tinajas Altas were reached on the east side of the mountains where broad grussy arroyos (from grus, sand-like erosive material from granite) adorned with blooming chuparrosas (*Justicia californica*) drain white granite slopes. As we worked our way above the tanks, we spotted a coiled speckled rattlesnake (*Crotalus mitchelli*), a medium-sized rock dweller. This one was nearly white with black speckling—a perfect match for the pale granite. Looking eastward, the thin ribbon of the Camino del Diablo stretched to the horizon across the broad Lechuguilla Valley. Here the desertscrub is so sparse that the small desert trees are restricted to xeroriparian strips along washes in a sea of widely spaced diminutive creosotebush (*Larrea divaricata*) and white bursage (*Ambrosia dumosa*).

Ancient packrat middens proved to be common, resulting in a remarkable fossil record (Van Devender 1990). A total of 24 middens with 31 different stratigraphic units were found in 12 rock shelters (Table 3). Each discrete unit in a midden was numbered and analyzed separately. A total of 30 radiocarbon dates obtained on materials from 21 of the samples from 11 of the middens ranged in age from 245 to more than 43,000 ybp (radiocarbon years before 1950). An additional 12 dates obtained from nine samples from six middens from the nearby Butler Mountains ranged in age from 740 to 11,250 ybp. The Tinajas Altas and Butler Mountain samples also yielded abundant animal remains, including invertebrates (Hall et al. 1988, 1989, 1990) and small vertebrates (Van Devender & Mead 1978; Van Devender et al. 1983, 1991).

The radiocarbon-dated plant assemblages provide a detailed record of dramatic changes in geographic ranges of species and the succession from Ice Age woodlands to modern desertscrub. Prior to 11,000 years ago, in the middle and late Wisconsin, woodlands with single-leaf pinyon (*Pinus monophylla*), California juniper (*Juniperus californica*), Joshua tree (*Yucca brevifolia*), Mohave sage (*Salvia mohavensis*), and desert tree-beargrass (*Nolina bigelovii*) were present on the slopes near the tanks. The lowest fossil record for single-leaf pinyon was at 460 m in the Tinajas Altas Mountains. The lowest elevation record for California juniper was 240 m in a creosotebush desertscrub assemblage in the Butler Mountains.

The midden fossils mostly record woodland plants at low elevations, reflecting dramatic changes in vegetation with Sonoran Desert dominants mostly displaced to refugia, probably in central Sonora. The trough of the Colorado River Valley likely was desertscrub throughout the Pleistocene, with much simpler vegetation changes than at higher elevations. Middens from Picacho Peak, California (just north of Yuma) recorded continuous desertscrub for the last 12,730 years, where Mohave desertscrub with Joshua tree–blackbrush (*Coleogyne ramosissima*)–creosotebush changed to brittlebush (*Encelia farinosa*)–pygmy cedar (*Peucephyllum schottii*)–creosotebush and was later replaced by a simpler Sonoran desertscrub (Cole 1981). The creosotebush–white bursage desertscrub in the flats below the Tinajas Altas Mountains was probably more stable, with less change or impact from the Ice Age climates than the vegetation on rocky slopes above at higher elevations.

Ice Age climates with greater winter rainfall from the Pacific and reduced summer monsoonal rainfall from the tropical oceans likely favored woody cool-season shrubs with northern affinities (Neilson 1986) rather than the summer-rainfall trees, shrubs, and cacti of dry tropical origin and subtropical deserts. Paleoclimatic reconstructions based on the modern distributions of these cool-season species inferred greater winter rainfall, greatly reduced summer monsoon rains, and cooler summers (Van Devender 1990). The Tinajas Altas middens showed a dramatic shift from predominantly winter annuals in Ice Age woodland assemblages to mixed winter-summer annuals as the summer monsoon developed in the Holocene and Sonoran desertscrub formed.

Creosotebush is one of the most important plants in the warm deserts of North America. Unlike most other Sonoran Desert dominants, it evolved in South America and immigrated to the Chihuahuan Desert. The oldest record for creosotebush in North America is a midden sample from the west base of the Tinajas Altas Mountains. A C-14 date of 18,700 ybp on its twigs documents its presence in the area during the last full glacial,

Table 3. Radiocarbon dates from the Tinajas Altas and Butler Mountains, Arizona. AA = tandem linear accelerator dates.

Sample	Age (ybp)	Lab No.	Material Dated
Butler Mts. #6	16,400±820	AA-617	Pinus microphylla
Butler Mts. #3A	11,250±410	AA-769	Larrea divaricata
Butler Mts. #3B	11,060±360	AA-770	Juniperus californica
Butler Mts. #5	10,360±430	AA-537	Larrea divaricata
Butler Mts. #3B	10,170±610	AA-768	Larrea divaricata
Butler Mts. #6	8590±570	AA-538	Larrea divaricata
Butler Mts. #1	8160±160	A-2652	Neotoma sp.
Butler Mts. #6	7530±90	av. AA-538 & A-3389	
Butler Mts. #6	6490±90	A-3389	Neotoma sp.
Butler Mts. #4	3820±70	A-3517	Neotoma sp.
Butler Mts. #2C	740±50	A-3911	Neotoma sp.
Butler Mts. #2B	220±70	A-3910	Neotoma sp.
Butler Mts. #2A	610±50	A-3790	Neotoma sp.
Tinajas Altas #15B	>43,200	AA-1720	Juniperus californica
Tinajas Altas #15B	>37,000	A-3392	Yucca brevifolia
Tinajas Altas #18B	18,700±1050	AA-536	Larrea divaricata
Tinajas Altas #16A	18,530±1070	AA-780	Juniperus californica
Tinajas Altas #18B	16,150±400	A-3407	Juniperus californica
Tinajas Altas #15A	15,680±720	AA-452	Pinus monophylla
Tinajas Altas #18A	15,050±350	A-3459	Juniperus californica
Tinajas Altas #20A	11,040±270	A-3393	Juniperus californica
Tinajas Altas #2B	10,950±90	USGS-958	Neotoma sp.
Tinajas Altas #3B	10,600±420	AA-781	Ambrosia dumosa
Tinajas Altas #3B	10,300±110	USGS-959	Neotoma sp.
Tinajas Altas #12A	10,070±110	A-3730	Neotoma sp.
Tinajas Altas #14	9900±200	A-3570	Juniperus californica
Tinajas Altas #1B	9790±240	A-2494	Neotoma sp.
Tinajas Altas #3A	9700±100	USGS-957	Neotoma sp.
Tinajas Altas #1A	9230±140	A-2122	Juniperus californica
Tinajas Altas #2A	8970±75	USGS-956	Neotoma sp.
Tinajas Altas #16C	8910±80	A-3520	Neotoma sp.
Tinajas Altas #16B	8700±110	A-3647	Neotoma sp.
Tinajas Altas #16C	8660±140	A-3566	Neotoma sp.
Tinajas Altas #16A	8650±430	AA-779	Parkinsonia florida
Tinajas Altas #16A	7860±100	A-3521	Neotoma sp.
Tinajas Altas #16A	8255	av. AA-779 & A-8255	
Tinajas Altas #13B	5940±70	A-3507	Neotoma sp.
Tinajas Altas #13A	5860±60	A-3506	Neotoma sp.
Tinajas Altas #13B	5820±310	AA-777	Bursera microphylla
Tinajas Altas #20C	5080±80	A-3565	Neotoma sp.
Tinajas Altas #2A	4490±230	AA-535	Carnegiea gigantea
Tinajas Altas #20B	4010±70	A-3535	Neotoma sp.
Tinajas Altas #20A	1770±300	AA-778	Prosopis glandulosa/velutina
Tinajas Altas #11	1230±100	A-3738	Jatropha cuneata
Tinajas Altas #20C	245±250	AA-525	Parkinsonia microphylla

the time of maximum development of continental and montane glaciers at high latitudes and elevations in North America, although it surely emigrated from South America much earlier (Hunter et al. 2001; Lia et al. 2001). These Ice Age creosotebushes were growing in a California juniper-Joshua tree woodland. In North America, evolution in creosotebush resulted in the widespread *Larrea divaricata* subsp. *tridentata* with three chromosome races roughly found in the Chihuahuan (diploid), Sonoran (tetraploid), and Mohave (hexaploid) deserts, and the unusual willowy dune creosotebush (var. *arenaria*) in the Algodones Dunes of California and the Gran Desierto of northwestern Sonora (Felger 2000). In South America there are four species of *Larrea*, all diploids. According to Hunter et al. (2001), the full-glacial creosotebush in the Tinajas Altas was the same Sonoran Desert tetraploid chromosomal race that occurs in the area today. Surprisingly, they also reported all

three chromosomal races in middens from Picacho Peak, California, to the northeast across the Colorado River from Yuma. All of the late Wisconsin creosotebush midden records were diploids or hexaploids from below 310 m in the Lower Colorado River Valley. The first Mohave Desert hexaploids appeared in the Picacho Peak midden record at 8420 ybp (Hunter et al. 2001). This is interesting because Vasek (1980) inferred that the King Clone creosotebush (Sternberg 1976) in the Mohave Desert of California, with an average diameter of about 14 m, was 11,700 years old, even though creosotebush was not found in packrat middens in the nearby Lucerne Valley before 5880 ybp (King 1976). The King Clone may be younger than popular myth would like.

The packrat midden assemblages are rich with 25 to 60 plant species per sample. The fossil records of the majority of the plants, which are not structural dominants, provide different insights. Holly-leaf bursage (*Ambrosia ilicifolia*), as well as desert agave (*Agave deserti*), desert tree-beargrass, many-headed barrel-cactus (*Echinocactus polycephalus*), mountain barrel-cactus (*Ferocactus cylindraceus*), and Spanish bayonet (*Hesperoyucca whipplei*) were present in Ice Age woodlands in Tinajas Altas, unlike Sonoran Desert saguaros and palo verdes, which retreated to Ice Age relictual areas somewhere in Sonora.

Another interesting pattern is that short-lived plants and animals were not affected as much by Pleistocene climates as larger trees, shrubs, and succulents. The midden assemblages have many records of anomalous associations in Ice Age woodland, including holly-leaf bursage with single-leaf pinyon, California juniper, Joshua tree, Mohave sage, and skunk bush (*Rhus aromatica*) in the Tinajas Altas Mountains (Van Devender 1990). The composition of plant communities has changed continuously because each individual species responds differently to climate events, and climate fluctuations range from thousands of years on continental or global scales to months or days for regional or local droughts or freezes. Even in pristine-appearing habitats, some species are increasing, decreasing, absent, or just arrived in response to some drought, rainfall, freeze, or other climate event (see *Amaranthus crassipes* and *Cyperus squarrosus* in the species accounts).

Middens have provided remarkable insight into evolutionary processes. Over 400 species of plants and small animals have been identified from Sonoran Desert packrat middens. These fossils are indistinguishable from their living descendents, no matter what their age. Midden fossils tell us that species are well adapted to fluctuating climates, and simply expand or shrink their ranges.

Considering that there were 15 to 20 glacial/interglacial cycles in the Pleistocene, species distributions and community compositions have been very dynamic in the last 2.4 million years. Similar successional stages from widespread woodlands to expanded deserts likely occurred during each interglacial. Although the late Holocene desertscrub communities likely resembled the original late Miocene Sonoran Desert, relatively modern desertscrub communities were developed for about 5–10% of the 2.4 million years of the Pleistocene. Ice Age climates with woodlands in the desert lowlands typical of about 12,000 ybp persisted for about 80–90% of this period (Porter 1989; Winograd et al. 1997).

Middens in the Tinajas Altas Mountains yielded at least 119 plant taxa, although not all could be identified to species (Van Devender 1990, and this publication, Table 4). Of these, about 28 taxa no longer occur in the flora, including the community dominants single-leaf pinyon, California juniper, and Joshua tree. Other woodland and Mohave plants no longer found in the area are white sage (*Artemisia ludoviciana*), cliff goldenbush (*Ericameria cuneata*), turpentine bush (*E. laricifolia*), green rabbitbrush (*E. teretifolia*), Spanish bayonet, a mint (*Monardella arizonica*), pancake prickly-pear (*Opuntia chlorotica*), skunk bush, Mohave sage, and even a few winter annuals (*Calycoseris parryi, Cryptantha utahensis, Daucus pusillus, Festuca microstachys,* and *Thysanocarpus curvipes*). Among the fossil specimens, 16 species of trees, shrubs, and succulents are shown in a diagram in Van Devender et al. (1990). The rest are published here for the first time.

The inference from the packrat chronicles is that you look at the modern communities, and most of the larger trees and shrubs you see have immigrated into the Tinajas Altas Mountains during the Holocene (9–11 thousand years ago). Other species such as desert agave and holly-leaf bursage, Lower Colorado Valley regional endemics, and many short-lived plants and small animals, probably have been here for most of the Pleistocene. Unlike saguaros and palo verdes, they did not retreat and then return. This scenario shows that although modern and fossil species are virtually identical, the vegetation and community composition of the region has changed dramatically and continuously through time.

TABLE 4. Tinajas Altas plants known from the fossil record. Plants no longer present in the flora area are indicated with two dagger symbols (††). Some fossils identifiable only to genus or a species group might represent species not present today or may be the same as ones now present; these are shown with dagger symbols and a question mark (††?).

GYMNOSPERMS

CUPRESSACEAE
Juniperus californica††
EPHEDRACEAE
Ephedra aspera
PINACEAE
Pinus monophylla††

ANGIOSPERMS

AMARANTHACEAE
Amaranthus fimbriatus
Amaranthus sp./spp.††?
Atriplex polycarpa
ANACARDIACEAE
Rhus cf. aromatica††
APIACEAE
Daucus pusillus††
APOCYNACEAE
Asclepias albicans
ASPARAGACEAE
Agave deserti
Hesperoyucca whipplei††
Nolina bigelovii
Yucca brevifolia††
ASTERACEAE
Ambrosia confertiflora††
Ambrosia dumosa
Ambrosia ilicifolia
Ambrosia salsola
Artemisia ludoviciana††
Bebbia juncea
Brickellia atractyloides
Brickellia coulteri††
Calycoseris parryi††
Chaenactis stevioides
Encelia farinosa
Ericameria cuneata††
Ericameria laricifolia††
Ericameria teretifolius††
Geraea canescens
Gymnosperma glutinosum
Heterotheca sp.††
Peritylе emoryi
Peucephyllum schottii
Pleurocoronis sp./spp.††?
Porophyllum gracile
Rafinesquia neomexicana
Trixis californica
Xanthisma spinulosus
BORAGINACEAE
Amsinckia intermedia
Amsinckia tessellata
Cryptantha barbigera
Cryptantha maritima
Cryptantha pterocarya
Cryptantha racemosa
Cryptantha utahensis††
Pectocarya heterocarpa
Pectocarya platycarpa
Phacelia sp.††?
BRASSICACEAE
Descurainia pinnata
Draba cf. cuneifolia
Lepidium lasiocarpum
Lepidium sp./spp.††?
Thysanocarpus curvipes††
BURSERACEAE
Bursera microphylla
CACTACEAE
Carnegiea gigantea
Cylindropuntia acanthocarpa
Cylindropuntia bigelovii
Cylindropuntia ramosissima
Echinocactus polycephalus
Echinocereus sp./spp.††?
Ferocactus cylindraceus
Mammillaria cf. grahamii
Mammillaria sp./spp.††?
Opuntia basilaris
Opuntia chlorotica††
CROSSOSOMATACEAE
Crossosoma bigelovii
EUPHORBIACEAE
Ditaxis lanceolata
Ditaxis neomexicana
Ditaxis sp./spp.††?
Euphorbia micromera†† &/or E. polycarpa
Euphorbia sp./spp.††?
Jatropha cuneata
FABACEAE
Acmispon rigidus
Dalea mollis
Lupinus sp.††?
Olneya tesota
Parkinsonia florida
Prosopis glandulosa &/or P. velutina††?
Senegalia greggii
FOUQUIERIACEAE
Fouquieria splendens
GERANIACEAE
Erodium texanum
KOEBERLINIACEAE
Koeberlinia spinosa††
KRAMERIACEAE
Krameria erecta
LAMIACEAE
Hyptis albida
Monardella arizonica††
Salvia mohavensis††
LOASACEAE
Mentzelia puberula
Petalonyx linearis
MALVACEAE
Abutilon sp./spp.††
Hibiscus denudatus
Sphaeralcea sp./spp.††?
NYCTAGINACEAE
Boerhavia wrightii
Mirabilis laevis
OROBANCHACEAE
Castilleja sp./spp.††
PLANTAGINACEAE
Penstemon sp.††?
Plantago ovata
POACEAEAE
Aristida adscensionis
Aristida purpurea
Bouteloua aristidoides
Bouteloua barbata var. barbata &/or var. rothrockii††?
Bouteloua repens††
Dasyochloa pulchella
Festuca microstachys††
Festuca octoflora
Heteropogon contortus
Hilaria rigida
Muhlenbergia microsperma
Setaria macrostachya††
Stipa speciosa
POLYGONACEAE
Chorizanthe brevicornu
Chorizanthe rigida
Eriogonum fasciculatum
Eriogonum inflatum
Eriogonum wrightii
RANUNCULACEAE
Anemone tuberosa††
RHAMNACEAE
Condalia cf. globosa††
Ziziphus obtusifolia
RUBIACEAE
Galium stellatum
RUTACEAE
Thamnosma montana
SANATALACEAE
Phoradendron californicum
SOLANACEAE
Lycium macrodon
Lycium sp./spp.††?
Physalis sp./spp.††?
Solanum cf. hindsianum††
VERBENACEAE
Glandularia sp./spp.††
ZYGOPHYLLACEAE
Larrea divaricata

THE COLLECTORS

Botanists have documented the flora of Tinajas Altas for more than a century. The collectors of specimens cited in this flora are listed here. The main repository of their collections is at ARIZ or as indicated. There are, however, more specimens from other collectors that we do not cite to avoid duplication of information (also see Southwest Environmental Information Network 2011).

Marc A. Baker. 24 January 1999, with Ami Pate (ASU).

R.J. Blackwell. 15 April 1932, with A. B. Akens.

Rodney G. Engard.18 April 1976 (ASU), with Russell A. Haughey.

Richard Felger. 3 and 4 February 1990, with Bill Broyles, Stephen Bell, Gayle Hartmann, Paul Huddy, and Carl Wachtmeister. 16 June 1992, with Bill Broyles. 18 and 19 March 1998, with Luke Taylor Evans. 29 November 2002, with Curtis McCasland. 10 January 2002, with Curtis McCasland. 25 and 26 October 2004, with Curtis McCasland. 18 February 2005, with Karen Louise Reichhardt. 21 February 2005, with James L. Heard and Karen Reichhardt. 30 December 2005, with Bill Broyles and Stephen Oertle. 20 to 22 November 2008, with Benjamin Theodore Wilder. 28 and 29 March 2010, with Bill Broyles, Luke Taylor Evans, Richard Burton Laugharn, and Joan Evelyn Scott.

Howard Scott Gentry. 28 October 1937. The 1937 collections, labeled "Tinajas Alas, Camino del Diablo," are probably from or near the actual Tinajas Altas waterholes. There are collections at ARIZ and RSA by Gentry from 1 October 1939 that are labeled "Telegraph Pass, Tinajas Altas Mountains" and some of the same date merely labeled "Tinajas Altas" that are presumably also from Telegraph Pass (as evidenced by the specimens collected) and therefore not part of our flora. In 1939 the Gila and Tinajas Altas Mountains were often considered to be a single range.

Edward Alphonso Goldman. 20 November 1913 (US).

Leslie Newton Goodding. 22 November 1934. 5 and 6 December 1935 with Edward W. Hardies. 17 November 1936, with Edward H. Morris. 1 December 1938. 7 March 1940, with Arthur L. Hinkley. The numbers on his herbarium labels often represent various accession numbers of the U.S. Soil Conservation Service in Tucson, where he worked. These numbers are not consecutive, but are sufficient to identify the Tinajas Altas specimens.

Stephen Ferris Hale. 28 March 1981, with Frank W. Reichenbacher. 5 March 1983, with Thomas R. Van Devender and Timothy Louis Van Devender. 26 Mar 1983, with Thomas R. Van Devender.

Richard Ray Halse. 31 March 1973.

Charles F. Harbison. 6 and 9 March 1937 (ARIZ, SD). The numbers on his herbarium labels represent accession numbers at SD; he did not use collection numbers for his herbarium specimens.

George J. Harrison. 5 March 1927, with G. O. Belden. 28 and 29 March 1930, with Thomas Henry Kearney.

Wendy Caye Hodgson. 18 April 1983 and 8 March 1984 (DES), with Rodney Engard. 11 Feb 1993, (DES), with Lynda P. Kozak, Liz Ecker, and Ted Anderson.

Thomas Henry Kearney. 29 March 1930, and 23 and 25 March 1935. On many labels it is not apparent if the collection number is that of Kearney, George J. Harrison, or Robert H. Peebles.

Edwin Bernard Kurtz. 17 and 18 April 1948, with William Frank McCaughey and Horace S. Haskell.

Cynthia A. Lindquist. 25 and 26 March 1983. See Thomas R. Van Devender.

Steven Paul McLaughlin. 19 and 20 February 1979, with Janice E. Bowers, Martin Karpiscak, Arthur M. Phillips III, Barbara G. Phillips, E. M. Peterson, and J. M. Downs.

Roger E. McManus. 29 February 1976, with Paul Fugate and Steven P. McLaughlin.

Edgar Alexander Mearns. 14 and 21 February 1894 (CAS/DS, US). The first set of his specimens is at US, with duplicates at numerous other herbaria. See Mearns (1907).

Gale W. Monson. 25 September 1955 (herbarium at Cabeza Prieta National Wildlife Refuge headquarters, Ajo).

J.R. Morrison. 16 April 1993 and 10 November 1993, with P.J. Walter (ASU).

Robert Hibbs Peebles. 1935 and 1940. See George J. Harrison and Thomas Kearney.

Timothy Reeves.12 February 1977 with Donald J. Pinkava and J.B. Rodriguez (ASU). "My collection numbers are *5352–5452*, so there were 101 collections that day" (Tim Reeves, personal communication, 31 July 2008). Unfortunately not all 101 seem to be at ASU, but at least 81 were accounted for in Southwest Environmental Information Network (2011). A few Reeves collections at ASU are entered as Pinkava collections, but the numbers are Reeves', e.g., *Dudleya arizonica*, *Pinkava R5370*.

Frank W. Reichenbacher. 9 and 10 March 1980, with Thomas R. Van Devender, Sandra Hunt Stein, etc. (see Thomas Van Devender). Also 28 March 1981.

Forrest Shreve. 26 and 27 March 1932. 21 March 1933. Edward Tattnal "Tad" Nichols IV (2007: 89, Fig. 9.5) shows a photo of himself, Thomas Dwight Mallery, Shreve, and Ira Wiggins at "Tinajas Altas, April 1933" (reproduced in Fig. 16). He provides a fine narrative of the trip and tells us, "The trip was about five or six nights, with two nights at Tinajas Altas" (Nichols 2007: 88). The date, however, must have been in March and not April.

Norman Montgomery Simmons. 21 May 1965. He was assistant refuge manager, Cabeza Prieta National Wildlife Refuge, from 1961 to 1966, during which time he collected plants on the Refuge and adjacent areas (Felger & Broyles 2007; Simmons 1966, 2007).

Peter Christian Sundt, Jr. 2 April 2011, with Mara MacKinnon and Jim Malusa (*Psorothamnus fremontii*; see *Olneya tesota* in the species accounts).

Thomas Roger Van Devender. 9 and 10 March 1980, with Scott Mills, Gary Paul Nabhan, Barry Spicer, Frank W. Reichenbacher, and Sandra Hunt Stein. 5 and 6 March 1983, with Stephen Ferris Hale and Timothy Louis Van Devender. 25–27 March 1983, with Owen K. Davis, Stephen Ferris Hale, Cynthia Lindquist, and Brent E. Martin. 9 March 1986, with Rebecca Kay Van Devender.

Charles T. Vorhies. 16 April 1924, with Walter P. Taylor.

Grady Linder Webster. 17 March 1980. The first set of his collections is at DAV.

Ira Loren Wiggins. 21 March 1933, with Forrest Shreve and others (see entry for Forrest Shreve; Fig. 16).

Benjamin Theodore Wilder. 20 November 2008, with Richard Felger.

Loraine Yeatts. 21 March 1995. In March 1995 she collected in Cabeza Prieta National Wildlife Refuge and the Tinajas Altas region. Her collections are at ARIZ, CAB, CS and KHD and the herbarium at Cabeza Prieta NWR headquarters, Ajo).

THE FLORA

We present a listing of all the vascular plants known to us from the Tinajas Altas region, from the present-day plants as well as fossils recovered from packrat middens. The vegetation and flora are dynamic, changing even now, and have changed dramatically during the past millennia, along with shifting climate and human presences. This is the first publication of a comprehensive temporal flora for any region and spans more than 43,000 years of plants inadvertently collected and curated by humble packrats (*Neotoma* spp.) and more recently by botanists. We document a total of 255 species in 192 genera and 52 families, of which at least 119 species in 96 genera and 36 families are known from the fossil record and among these fossils at least 28 species in 17 genera and 6 families are no longer present (Tables 4 and 5). A summary of the flora and comparison with adjacent and surrounding regions is shown in Table 6.

Felger and Van Devender (2012) provide an abridged checklist of the present-day flora in a comprehensive work on the Tinajas Altas region by Broyles et al. (2012), and an updated listing of the modern flora is included in a regional checklist by Felger et al. (2012). We include some plants from immediately adjacent localities that are expected to occur in the core area.

The most diverse families, present-day and fossil taxa (Table 7), are the Asteraceae (49 species and 2 hybrids); Poaceae (21 species); Boraginaceae (16 species); Cactaceae (14 species); Brassicaceae, Euphorbiaceae, Fabaceae, and Solanaceae (10 species each); Polygonaceae (9 species); and Nyctaginaceae (8 species). This floristic spectrum represents somewhat of a departure from the usual floristic makeup of the present-day Sonoran Desert flora (including that of the Gran Desierto of northwestern Sonora) in which the most diverse families,

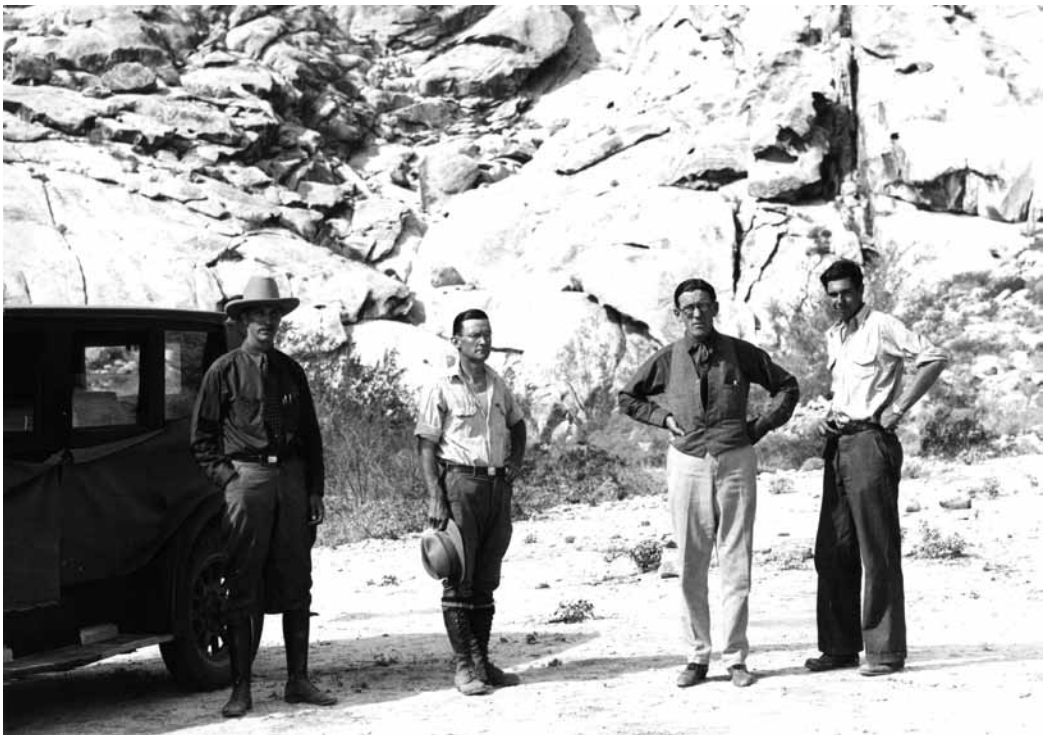

Fig. 16. Botanizing at Tinajas Altas, March 1933. From left to right: Dwight Mallery, Ira L. Wiggins, Forrest Shreve, and Tad Nichols. Photo by Tad Nichols.

in decreasing order, are the Asteraceae, Poaceae, Fabaceae, and Euphorbiaceae (e.g., Felger 2000; Van Devender et al. 2010). The most diverse genera in the Tinajas Altas region are *Cryptantha* (7 species, including one fossil), *Ambrosia* (6 species and 1 hybrid), *Eriogonum* (6 species), *Euphorbia* (5 species), and *Boerhavia*, *Cylindropuntia*, and *Lycium* each with 4 species.

There are 12 non-native species in the flora, which is only 5.3% of the total modern flora. Across the Sonoran Desert region this extremely low percentage of non-natives is matched only in the Gran Desierto dune fields of northwestern Sonora (Felger 2000) and some Gulf of California islands (Felger & Wilder 2012; Felger et al. 2011; Van Devender et al. 2009; Wilder & Felger 2010; Wilder et al. 2007). Sahara mustard (*Brassica tournefortii*) and Arabian grass (*Schismus arabicus*) are the only invasive species that are likely impacting native plants (e.g., Felger 2000; Felger et al. 2003; Felger et al. 2012). Red brome (*Bromus madritensis* subsp. *rubens*) and buffelgrass (*Cenchrus ciliaris*) are serious invasives elsewhere in the Sonoran Desert, but have not become a problem in the Tinajas Altas region, although *Cenchrus ciliaris* poses a potential threat. *Boerhavia coccinea* (native to North America but not to southwestern Arizona) and netleaf goosefoot (*Chenopodium murale*) are localized at the Tinajas Altas visitor area, while the two *Sonchus* species are widely scattered but not common. *Lactuca serriola* is highly localized and *Erodium cicutarium* and *Eragrostis cilianensis* are well established but scarcely seem invasive in the flora area. *Mollugo cerviana*, reported to be non-native in the New World, is an innocuous small annual.

Species Accounts

The plants in this flora are grouped as ferns and lycophytes, gymnosperms, dicotyledons (eudicots), and monocotyledons. Within these categories the plants are listed alphabetically by family, genus, and species. Plant families follow the APG III format (Angiosperm Phylogeny Group; e.g., Stevens 2008). Selected, pertinent

Table 5. Floral diversity of the Tinajas Altas region.

	Families	Genera	Species
Total modern & fossil records	52	192	255
Modern records	46	175	227
Fossil records	36	96	119

Table 6. Present-day floral diversity of the Tinajas Altas and nearby and surrounding areas. Taxa are species, subspecies, varieties, and hybrids. Organ Pipe = Organ Pipe Cactus National Monument, Cabeza Prieta = Cabeza Prieta National Wildlife Refuge, Pinacate Reserve = Reserva de la Biosfera El Pinacate y Gran Desierto de Altar, Dry Borders = the six contiguous protected areas of Organ Pipe, Cabeza Prieta, Sonoran Desert National Monument, Barry M. Goldwater Range, Pinacate Reserve, and the Reserva de la Biosfera Alto Golfo de California y Delta del Río Colorado (Felger & Broyles 2007).

	Tinajas Altas	Organ Pipe	Cabeza Prieta	Pinacate Reserve	Dry Borders
Taxa	227	655	423	479	862
Non-native species	12	72	37	37	91
Genera	175	395	266	--	448
Families	46	93	63	70	107
Acres	80,000	330,689	860,010	1,765,915	7,515,221
Hectares	32,375	133,825	348,034	714,656	3,041,302

Table 7. The ten most diverse plant families of the Tinajas Altas region.

Families	Total genera	Total species	Modern records	Fossil records
Asteraceae	35	49+ 2 hybrids	43+ 2 hybrids	24
Poaceae	17	21	18	13
Boraginaceae	7	16	15	8
Cactaceae	9	14	13	10
Fabaceae	8	10	10	7
Brassicaceae	10	10	9	4
Solanaceae	6	10	9	4
Euphorbiaceae	4	10	10	5
Polygonaceae	3	9	9	5
Nyctaginaceae	4	8	8	2

synonyms are in square brackets following the accepted scientific name. Vernacular (common) names follow the scientific names and when known are given in English, Spanish, and O'odham, respectively. The Spanish-language names are italicized. The O'odham names are from Felger et al. (2007b). Plants not native to the flora region are marked with an asterisk (*). Fossil taxa and/or specimens are indicated with a dagger symbol (†). Ethnobotanical uses are from Felger (2007). Years before present (ybp) are the approximate years before 1950, based on radiocarbon dating—therefore some summarized dates in the species accounts are about one half century older than the ybp-radiocarbon date. Flower color refers to the dominant color and not necessarily to a specific flower part or structure. It may be assumed that the species are common unless otherwise stated. The brief descriptions and identification keys for the various taxa are based on plants from the flora area and are not necessarily applicable to other regions. More extensive descriptions can be found in works by Felger (2000), Felger et al. (2007b), Wiggins (1964), the Vascular Plants of Arizona Project (Vascular Plants of Arizona Editorial Committee 1992), and the Jepson Flora Project (2012). Nomenclature follows the regional checklist by Felger et al. (2012).

This floristic account is a specimen-based except for some records verified by an observation, photo documentation, or published report. Extensive collections from the Tinajas Altas region are at ARIZ, ASU, and DES.

There are often multiple collections of a given species or taxon and in such cases we cite only a few specimens for each species or taxon. Extensive references to herbarium specimens can be found at Southwest Environmental Information Network (2011; also known as SEINet) and other herbarium databases.

Specimens cited are at the University of Arizona Herbarium (ARIZ), unless otherwise indicated by the standardized abbreviations for herbaria (Index Herbariorum 2009), or the herbarium at Cabeza Prieta National Wildlife Refuge headquarters in Ajo, Arizona, identified as CAB. All herbarium specimens cited have been seen by Felger, although some have been seen as images, unless otherwise noted. The name of the collector and collection number is given. In cases where more than one collector is listed on a label, generally only the first collector's name is stated. Locality descriptions and other information on herbarium labels generally are abridged. If no collection number is provided on the herbarium label, then the specimen is identified by the date of collection, for example, *Harbison 6 Mar 1937*. When the date of collection is significant, such as collections of historic interest, especially non-native species, both the collection number and date are given. It should be noted that the labels on many of the early herbarium specimens merely state "Tinajas Altas Mountains" or "Tinajas Altas." Before the mid-twentieth century it was customary to regard the Gila and Tinajas Altas Mountains as a single range and thus some of these specimens might be from the Gila Mountains, which currently are regarded as the range to the north of the Tinajas Altas.

Although we provide extensive documentation of plants from this region, intrepid botanists should be able to discover additional species.

KEY TO THE MAJOR PRESENT-DAY PLANT GROUPS AND FAMILIES

1. Plants spore bearing, without flowers or seeds; leaves like those of typical ferns or scale-like and less than 40 cm long ____ **FERNS AND LYCOPHYTES**
1. Plants seed bearing; leaves various or none.
   2. Shrubs with paired (opposite) scale leaves and small cones, the male and female cones on separate plants, the females cones 1-seeded; not producing flowers ____ **GYMNOSPERM, Ephedraceae** (page 189)
   2. Plants with flowers and seeds; leaves various or none ____ **ANGIOSPERMS—FLOWERING PLANTS**
      3. Agaves, cattails, grasses, sedges, bulb-producing plants, or large non-succulent rosette plants ____ **MONOCOTYLEDONS** (page 244)
      3. All other plants, not as above ---- **DICOTYLEDONS (eudicots)** (page 190)

FERNS AND LYCOPHYTES

1. Leaves more than 10 mm long, deeply divided (pinnatifid) or compound, not scale-like, the petioles conspicuous ____ **Pteridaceae**
1. Leaves less than 4 mm, simple, somewhat scale-like and sessile ____ **Selaginellaceae**

PTERIDACEAE—MAIDENHAIR FERN FAMILY

1. Leaves once pinnate, the blades more than 5 times as long as wide, the petioles about ⅛ as long as the blade ____ **Astrolepis**
1. Leaves 2–3 times pinnate or deeply pinnatifid, the blades less than twice as long as wide, the petioles usually at least half as long as the blade.
   2. Leaflets densely woolly, the hairs obscuring the surfaces and extending beyond the margins ____ **Cheilanthes**
   2. Leaflets not densely woolly, the upper surfaces green and not obscured by hairs, the hairs not extending beyond the margins ____ **Notholaena**

Astrolepis cochisensis (Goodd.) D.M. Benham & Windham subsp. **cochisensis** [*Notholaena cochisensis* Goodding] Scaly cloak-fern, jimmy fern

Small, tufted ferns with slender, pinnate leaves. Among rocks at higher elevations.

Above Tinajas Altas, 1500 ft, *Van Devender 10 Mar 1980*.

Cheilanthes parryi (D.C. Eaton) Domin [*Notholaena parryi* D.C. Eaton] Parry's lip-fern

Small desert ferns with short rhizomes and gray-hairy leaves.

Sheltered among rocks throughout the mountains. This fern extends into drier habitats than any other Sonoran Desert fern.

Tinajas Altas, *Wiggins 21 Mar 1933*. Tinajas Altas, above the tinaja containing *Typha*, shady crevices, in vertical granite faults, 18 Apr 1976, *Engard 920* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Notholaena californica D.C. Eaton subsp. **californica** [*Cheilanthes deserti* Mickel] California cloak-fern

Small tufted desert ferns with bead-like leaf divisions.

Sheltered among rocks in the mountains to the summit.

Tinajas Altas, 6 Mar 1937, *Harbison 16826* (SD). Tinajas Altas Pass, lower slopes, 1200 ft, *Reeves 5353* (ASU). Surveyors Canyon, canyon bottom just below Surveyors Tank, *Felger 10-204*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

SELAGINELLACEAE—SPIKE-MOSS FAMILY

Selaginella eremophila Maxon. DESERT SPIKE-MOSS

Mat-like plants with scale leaves; the plants curl up when dry, and quickly expand with rain to reveal green foliage.

Rocky slopes, mostly north- and northeast-facing exposures and especially at higher elevations. Spike-moss is surprisingly scarce in the vicinity of the Tinajas Altas waterholes, which is likely a result of grazing by desert bighorn. Tim Reeves, an expert on desert ferns, made the following entry in his field notebook for 12 February 1977, at Tinajas Altas: "All ferns [the three species] green and healthy. Suggests fairly recent rain. Area searched for *Selaginella eremophila*, none seen, various good habitat [for it]."

SE side of Tinajas Altas Mts, ca. 2 mi SE of Tinajas Altas, dense, locally extensive mats, not seen elsewhere, *Felger 92-619*. 0.8 mi SE of Tinajas Altas camping area, steep N-facing slope, a patch, 10 × 10 m, *Reichenbacher & Hale 28 Mar 1981*. Tinajas Altas Canyon, among rocks, ca. 0.7 km SW of upper tinaja, 1800 ft, shaded niche at canyon bottom, localized (not seen elsewhere in vicinity), *Felger 98-134*.

GYMNOSPERMS–CONE-BEARING PLANTS

CUPRESSACEAE—REDWOOD OR CYPRESS FAMILY

†Juniperus californica Carrière. CALIFORNIA JUNIPER

Shrubs or small trees. This was the common low-elevation juniper in southwestern Arizona during the late Wisconsin age. It grew in the flora area from about 9000 to more than 43,000 years ago. The early Holocene and late Wisconsin age records from the Butler Mountains at 240 m are the lowest elevation records for any juniper in the Sonoran Desert region. The nearest present-day population occurs at higher elevations in northwestern Arizona where it is disjunct from the primarily distribution along the Pacific side of California and mountains in northern Baja California.

†Butler Mts, twigs, seeds, 10,360–11,250 ybp (3 samples). †Tinajas Altas, twigs, seeds, 8970–18,700 ybp (14 samples), & >43,000 ybp.

EPHEDRACEAE—JOINT-FIR FAMILY

Ephedra aspera Engelm. ex S. Watson [*E. nevadensis* S. Watson var. *aspera* (Engelm. ex S. Watson) L.D. Benson] BOUNDARY EPHEDRA; *CAUTILLO*; KU'UKPALK

Woody shrubs; twigs green with paired, short, brown scale-leaves.

Mostly on rocky slopes. Two-leaved ephedras have been prevalent in the region since at least 43,000 years ago. The fossils were originally identified as *E. nevadensis*, but are more likely to be *E. aspera*. We are unable to distinguish one from the other on the basis of fossil specimens, and they are indeed closely related and often impossible to distinguish. It was an important medicinal plant (Felger 2007).

Ca. ⅓ mi S of Tinajas Altas, *Hodgson 2100* (DES). Tinajas Altas Canyon, *Felger 08-176*. Borrego Canyon, 16 Jun 1992, *Felger* (observation). †Butler Mts, twigs, bracts, seeds, 740–11,250 ybp (7 samples). †Tinajas Altas, twigs, seeds, 1230–18,700 (19 samples), & >43,000 ybp.

PINACEAE—PINE FAMILY

†Pinus monophylla Torr. & Frém. SINGLE-LEAF PINYON; *PIÑÓN*

Small trees. Unlike most pinyon taxa, the fascicles bear only a single leaf. Cones relatively small with wingless, edible seeds.

Pinyons were widespread in the lowland late Wisconsin Ice Age woodlands in sub-Mogollon Arizona. Tinajas Altas is the lowest-elevation regional record for a pine in the Pleistocene. This pinyon presently occurs in northwestern Arizona, mountains in Baja California, California, Idaho, Nevada, New Mexico, and Utah.

The fossils have slender needles, indicating relationship with *P. edulis* Engelm. var. *fallax* Little, which today occurs in woodland and chaparral below the Mogollon Rim in central Arizona and in southern New Mexico. "*Pinus edulis* var. *fallax*…appears to combine features of *P. edulis* and *P. monophylla*. More study is needed" (Kral 1993: 383).

†Tinajas Altas, 460 m, 11,040–15,680 ybp, & >43,000 ybp.

ANGIOSPERMS—FLOWERING PLANTS

DICOTYLEDONS (EUDICOTS)

1. Parasitic plants; without chlorophyll, or if they have chlorophyll (green) then the parasitic attachment is well above the ground (stem parasites).
   2. Broomrape; root parasites, attached to host roots underground _____ **Orobanchaceae**
   2. Mistletoe; stem parasites, attached to shrub or tree branches _____ **Santalaceae**
1. Plants with chlorophyll and not obviously parasitic.
   3. Composites; individual flowers (florets) generally small and borne in a head resembling a single large flower, the head surrounded by a series of somewhat sepal-like bracts (phyllaries) forming an involucre, the heads often sunflower- or daisy-like, with a central group of tubular disk florets often surrounded by a ring of ray florets, or the heads with disk florets only, or all florets ray-like with a strap-shaped corolla; ovary of individual florets inferior, the fruit a cypsela (achene), topped by scales or bristles forming the pappus, or the pappus sometimes none _____ **Asteraceae**
   3. Inflorescence and flowers various but not grouped into heads subtended by a series of bracts forming an involucre, and often with green sepals instead of a pappus.
      4. Plants leafless or essentially so, or with scale leaves or few soon deciduous and reduced leaves (includes trees, shrubs, and some succulents such as cacti but not annuals and generally not plants that are seasonally leafy) _____ **Key 1**
      4. Plants leafy, at least seasonally, or the young growth leafy (when plants are dormant, check for leaf scars or dried leaves).
         5. Vines, the stems twining on other plants or sprawling across the ground _____ **Key 2**
         5. Plants not vining.
            6. Trees and shrubs, conspicuously woody.
               7. Leaves compound _____ **Key 3**
               7. Leaves simple.
                  8. Leaves opposite (and sometimes whorled) _____ **Key 4**
                  8. Leaves alternate _____ **Key 5**
            6. Herbaceous and non-woody plants, or only moderately woody at base; annuals and perennials.
               9. Plants with conspicuously succulent leaves and/or stems (borderline cases key out in both couplets) _____ **Key 6**
               9. Plants not conspicuously succulent.
                  10. Leaves compound _____ **Key 7**
                  10. Leaves simple.
                     11. Larger leaves basal or in a conspicuous basal rosette (basal rosette leaves may be deciduous), the flowering stems leafless or stems with leaves substantially reduced in size and number (borderline cases key out in both leads) _____ **Key 8**
                     11. Midstem leaves well developed; if a basal rosette present, then the stem leaves conspicuous and usually at least ¼ to ⅓ as large as the basal leaves.
                        12. Midstem leaves opposite (a few nodes may bear alternate leaves) or whorled _____ **Key 9**
                        12. Midstem leaves alternate _____ **Key 10**

KEY 1

Plants Leafless or Essentially So, or with Scale Leaves

(note: excluded are most seasonally leafless plants and annuals that have shed their leaves)

1 Stems succulent.
   2 Cactus; sap not milky; with spine-bearing areoles; leaves none or alternate and reduced, succulent, and soon deciduous _____ **Cactaceae**
   2. Sap milky; plants unarmed (spineless), the stems reed-like; leaves opposite, not succulent, and soon deciduous _____ **Apocynaceae** (*Asclepias*, in part)
1. Stems not succulent.
   3. Stem nodes with semi-persistent and opposite scale leaves _____ **Gymnosperms: Ephedraceae**
   3. Leaves few, quickly deciduous, usually not scale-like (plants seasonally leafless or nearly so and thus placed in this key).
      4 Stems yellow-green, conspicuously dotted with lens-shaped glands, the plants noticeably aromatic (citrus-like); leaves sparse and quickly deciduous, the upper leaves reduced and scale-like; flowers 1 cm long, tubular and dark bluish purple _____ **Rutaceae**
      4. Stems not dotted with lens-shaped glands, and not noticeably aromatic; flowers not tubular and dark bluish purple.
         5 Composites (leaves present but these can be leafless or nearly so in dry seasons); flowers sessile in heads surrounded by multiple sepal-like bracts (the involucre), the individual fruits 1-seeded _____ **Asteraceae** (*Baccharis sarothroides, Bebbia, Porophyllum, Stephanomeria*)
         5. Each flower on a separate pedicel, flowers not in heads surrounded by bracts, the fruits usually multiple-seeded (not small achenes).
            6 Palo verdes, the stems remaining green for multiple years; large shrubs or trees; flowers yellow or yellow and white, and bilaterally symmetric; fruits more than 2 cm long _____ **Fabaceae** (*Parkinsonia* when leafless)

6. Stems not remaining green for multiple years; shrubs; flowers orange, red, or purple, or if yellow then radially symmetric; fruits less than 2 cm long.
   7 Plants unarmed, or if twigs sharp-pointed then less than 1 m tall.
      8 Stems brittle, pale bluish-green; flowers red-orange; fruits club-shaped and not spiny ____ **Acanthaceae**
      8. Stems tough, not brittle; flowers purple-magenta; fruits bur-like and spiny ____ **Krameriaceae**
   7. Plants usually more than 1 m tall and armed with spines or thorn-tipped twigs.
      9 Ocotillo; shrubs with wand-like stems mostly unbranched from a common base; nodes regularly spaced and bearing a single stout spine or some stems without spines (leaves quickly drought deciduous); flowers red-orange and tubular; fruits dry at maturity (capsules) ____ **Fouquieriaceae**
      9. Much-branched shrubs often with rigid thorn-tipped twigs; flowers small and yellow-green, not tubular; fruits fleshy ____ **Rhamnaceae**

KEY 2

Vines and Plants with Trailing Stems (stems climbing, twining, or trailing like vines; generally does not include plants that merely have prostrate stems)

1. Plants with tendrils; flowers unisexual, yellow or white ____ **Cucurbitaceae**
1. Plants without tendrils; flowers bisexual, white and purplish or lavender, or purplish.
   2. Leaves pinnately compound with 3 or more leaflet pairs ____ **Zygophyllaceae** (*Kallstroemia*)
   2. Leaves simple.
      3. Sap milky; flowers white and pale lavender; fruits 3 cm or more long ____ **Apocynaceae** (*Funastrum*)
      3. Sap not milky; flowers bright pinkish purple; fruits less than 1 cm long ____ **Nyctaginaceae** (*Allionia*)

KEY 3

Trees and Shrubs with Compound Leaves

1. Leaves opposite; herbage resinous; leaves deeply notched (actually 2 fused leaflets with entire margins that appear to form a simple leaf); fruits of 5-lobed capsules, breaking into 1-seeded segments; widespread ____ **Zygophyllaceae** (*Larrea*)
1. Leaves alternate, not resinous, with several or more leaflets.
   2. Plants unarmed, the herbage strongly aromatic; trunks and limbs often thick, the wood pithy, soft, and semi-succulent; stipules none; leafstalks (petiole and rachis) without glands; fruits globose or nearly so, 1-seeded ____ **Burseraceae**
   2. Plants armed or unarmed, not aromatic; trunks and limbs not unusually thick or semi-succulent; stipules generally present (except *Parkinsonia microphylla*); leafstalks sometimes with a prominent gland; fruits of pods, multiple-seeded (*Olneya* pods sometimes 1-seeded) ____ **Fabaceae** (*Olneya, Parkinsonia*, *Prosopis, Psorothamnus*, *Senegalia*)

KEY 4

Trees and Shrubs with Simple Opposite Leaves (sometimes with some alternate leaves, or whorled)

1. Leaf margins not entire: serrated, toothed, undulate (wavy), or the leaf tip notched.
   2. Creosotebush; herbage resinous/glutinous, glabrous or with small simple hairs; leaves deeply notched (actually 2 fused leaflets with entire margins that appear to form a simple leaf); flowers yellow ____ **Zygophyllaceae** (*Larrea*)
   2. Herbage not resinous; plants with branched (dendritic or tree-like) hairs; leaf tips acute to obtuse or rounded, not notched, the leaf margins wavy to toothed; flowers violet ____ **Lamiaceae** (*Hyptis*)
1. Leaves entire.
   3. Herbage pubescent; leaves 2 or more cm long; flowers red-orange; fruits of capsules not enclosed in a bag-like calyx ____ **Acanthaceae**
   3. Plants glabrous; leaves 1–1.8 cm long; flowers blue and white; fruits enclosed by calyx inflated and hollow like a bag ____ **Lamiaceae** (*Scutellaria*)

KEY 5

Trees and Shrubs with Simple Alternate Leaves

1. Leaves entire
   2. Plants armed with spines or thorns.
      3. Ocotillo; stems long, wand-like, and spiny, the spines regularly spaced and similar in size, or some stems without spines; flowers tubular, red-orange in terminal inflorescences ____ **Fouquieriaceae**
      3. Stems not wand-like, not spiny but the twigs sometimes spinescent at tip; flowers yellowish or purplish, the inflorescences not terminal.
         4. Leaf veins conspicuous, usually 3 major veins from the leaf base; flowers radial, small and yellowish; fruits fleshy and smooth ____ **Rhamnaceae**
         4. Leaf veins not conspicuous; flowers bilateral, showy and purplish; fruits of bristly burs ____ **Krameriaceae**
   2. Plants unarmed.
      5. Plants, or at least the leaves, glabrous or glabrate.
         6. Stems relatively thick and very flexible, often with knobby short shoots; sap copious, watery or blood-like; flowers unisexual ____ **Euphorbiaceae** (*Jatropha*)

6. Stems not unusually thick and not especially flexible; sap not watery, and blood-like; flowers bisexual _____ **Crossomataceae**

5. Plants with hairs or scales.
7. Flowers unisexual; leaves scurfy whitish gray with sac-like hairs; female flowers enclosed in bracts with small finger-like blunt teeth _____ **Amaranthaceae** (*Atriplex*)
7. Flowers bisexual; hairs simple, not sac-like; flowers not enclosed in bracts.
8. Flowers purple, bilateral, not surrounded by bracts, ca. 15 mm wide; fruits of bristly burs _____ **Krameriaceae**
8. Flowers several in dense clusters surrounded by bracts, white to pink, the individual flowers radial, 5 mm or less wide; fruits of inconspicuous nutlets, not bristly _____ **Polygonaceae** (*Eriogonum* in part)

1. Leaves toothed, lobed, or divided.
9. Plants armed with thorn-tipped twigs; widespread but seldom common in the flora area _____ **Rhamnaceae**
9. Plants unarmed.
10. Plants with star-shaped (stellate) hairs; stamens many, the filaments united into a column _____ **Malvaceae**
10. Plants glabrous or glabrate, or with simple hairs; stamens 1 or 5, not united into a column.
11. Leaf blades firm; flowers bisexual; fruits asymmetric drupes, densely glandular _____ **Anacardiaceae**
11. Leaf blades not firm; flowers unisexual, the male and female flowers very different from each other; fruits not asymmetric, not drupes, and not glandular _____ **Euphorbiaceae** (*Jatropha*)

KEY 6

Non-woody Succulents (stems and/or leaves succulent)

1. Annuals; leaves succulent; flowers bright yellow or red-pink, collapsing with daytime heat; fruits of capsules opening around the middle (circumscissile), with several to many seeds _____ **Portulacaceae**
1. Perennials; leaves not succulent; flowers of various colors, but not bright yellow, open all day; fruits not opening around the middle.
2. Stems semi-succulent, slender, erect, reed- or rush-like, and with milky sap; leaves opposite and very slender (thread-like), few and quickly deciduous; flowers bisexual _____ **Apocynaceae** (*Asclepias* in part)
2. Shrubs with thick stems, not reed-like, the sap not milky; leaves alternate, not thread-like; flowers unisexual _____ **Euphorbiaceae** (*Jatropha*)

KEY 7

Herbaceous Plants with Compound Leaves

(includes plants with highly divided leaves that may appear compound)

1. Leaves opposite (sometimes alternate on first or lower nodes); flowers radial _____ **Zygophyllaceae** (*Fagonia, Kallstroemia*)
1. Leaves alternate or in a basal rosette, not obviously opposite; flowers radial or not.
2. Leaflets (5) 7–9 per leaf, palmately (digitately) arranged; flowers lavender-pink with a yellow spot on the banner petal _____ **Fabaceae** (*Lupinus*).
2. Leaflets pinnately arranged.
3. Sepals and petals each 4; stamens 6; leaves deeply parted or divided _____ **Brassicaceae** (*Descurainia, Lyrocarpa*)
3. Sepals or calyx lobes and petals or corolla lobes each 5; stamens 5 or 10.
4. Stipules none; flowers radial, the corollas sympetalous; stamens 5; styles 2 or 2-branched; fruits of globose capsules _____ **Boraginaceae** (*Eucrypta*, *Phacelia*)
4. Stipules usually present; flowers bilateral, some or all petals separate; stamens 10; styles 1, the stigma unbranched; fruits of pods, not globose _____ **Fabaceae** (*Acmipon, Dalea, Lupinus*)

KEY 8

Herbaceous Plants with Simple, Basal Leaves (larger leaves in basal rosettes, the stem leaves smaller, reduced or absent. Many of these plants can also be identified in other keys)

1. Perennials from a hardened, somewhat woody base; perianth parts 6, in 2 separate and similar whorls, surrounded by bracts; fruits 1-seeded _____ **Polygonaceae** (*Eriogonum inflatum*)
1. Annuals, cool-season (except *Mollugo*).
2. Plants glabrous, mat-like or prostrate; leaves opposite but crowded, the stipules and sepals white and papery _____ **Caryophyllaceae** (*Achyronychia*)
2. Plants glabrous or hairy; sepals and stipules (if present) not white and papery.
3. Flowers with perianth parts each 4 (sepals or calyx lobes, and petals or corolla lobes).
4. Perianth brown and papery when dry; fruits of globose capsules opening around the middle _____ **Plantaginaceae** (*Plantago*)
4. Perianth not brown and papery; fruits longer than wide, not opening around the middle.
5. Leaves broadly obovate to 4 cm long, with forked and stellate hair; petals white, less than 5 mm long and soon deciduous; stamens 6; ovary superior _____ **Brassicaceae** (*Draba*)
5. Leaves various but not obovate, often more than 4 cm long, glabrate or with simple hairs; petals 5 or more mm long; stamens 8; ovary inferior _____ **Onagraceae**

3. Flowers 5-merous (sepals, petals, and stamens 5) or the petals and stamens many.
   6. Plants with rough, branched hairs adhering like Velcro; flower parts mostly more than 5 ____ **Loasaceae** (*Mentzelia*)
   6. Plants glabrate, glabrous, or the hairs not sticking like Velcro; flowers 5-merous.
      7. Plants small and glabrous or sparsely pubescent.
         8. Cool-season annuals, glabrous or with few soft hairs at base; flowering stems zigzag; flowers with red-tipped white petals ____ **Campanulaceae**
         8. Warm-weather annuals, glabrous; flowering stems not zigzag; petals none ____ **Molluginaceae**
      7. Plants conspicuously hairy.
         9. Plants with stiff, calcified or silicified hairs, soft hairs, or glandular hairs; flowers blue, lavender, or pink, or if white then less 10 mm long, open in daytime; fruits separating into 4 or fewer 1-seeded nutlets or capsules with few to many seeds ____ **Boraginaceae** (*Cryptantha, Eucrypta*, *Nama, Phacelia*)
         9. Plants sticky with glandular hairs; flowers white, opening at night and closing in daytime or remaining open in cool weather, corollas 12–20 mm long; fruits of capsules with numerous minute seeds ____ **Solanaceae** (*Nicotiana clevelandii*)

KEY 9

Herbaceous Plants, the Midstem Leaves Simple and Opposite or Whorled

(some nodes may have alternate leaves)

1. Sap milky; flowers unisexual, inconspicuous (often with petal-like white or pink appendages); fruits 3-lobed and 3-seeded ____ **Euphorbiaceae** (*Euphorbia subgenus Chamaesyce*)
1. Sap not milky; flowers bisexual, inconspicuous or not; fruits not 3-lobed, 1-seeded, or the seeds more than 3.
   2. Leaves whorled or appearing whorled or densely clustered; flowers small, green and/or white.
      3. Warm-weather annuals, usually 3–14 cm tall; stems thread-like; leaves 3.5–11 mm long; ovary and capsule not open at apex ____ **Molluginaceae**
      3. Non-seasonal annuals 5–40 cm tall; stems slender but not thread-like; leaves 15–40+ mm long; ovary and capsule open and gaping at apex ____ **Resedaceae**
   2. Leaves opposite (sometimes also with some alternate or basal-rosette leaves); flowers of various sizes, not green and/or all white (except *Mirabilis*, Nyctaginaceae).
      4. Plants with branched, tree-like (dendritic) non-glandular hairs, moderately to most often densely white woolly; flowers yellow and minute ____ **Amaranthaceae** (*Tidestromia*)
      4. Herbage glandular pubescent and usually sticky, hairs not branched.
         5. Leaves opposite proximally (below), alternate distally (above), often 6–15 cm long; flowers bilateral, 3–4 cm long; fruits of woody capsules 4–6 cm long with 2 claws 9–14 cm long ____ **Martyniaceae**
         5. Leaves mostly not more than 6 cm long; flowers not more than 2 cm long, radial and white, pink, lavender-pink, or bilateral, purple, and in clusters of 3 resembling a single flower; fruits to 1 cm long, indehiscent, 1-seeded, not woody and not clawed ____ **Nyctaginaceae**

KEY 10

Herbaceous Plants, the Midstem Leaves Simple and Alternate

1. Flowers unisexual, small and relatively inconspicuous.
   2. Sap milky; fruits 3-lobed (sometimes 1 or 2 lobes or carpels not forming due to abortion), each lobe with a single seed; stigma 3-branched (note: flowers in a flower-like cyathium or cluster) ____ **Euphorbiaceae** (*Euphorbia eriantha*)
   2. Sap not milky; fruits 1-seeded, not 3-lobed; petals none.
      3. Stems not noticeably weak and not semi-succulent; flowers all unisexual; sepal 5 ____ **Amaranthaceae**
      3. Delicate annuals, the stems weak and semi-succulent, the leaves thin and soft; flowers in small clusters with both unisexual and bisexual flowers; sepals 4 ____ **Urticaceae**
1. Flowers bisexual, of various sizes.
   4. Plants glabrous; leaves linear-filiform; flowers sessile; petals minute and white; stamens 3; ovary and fruit gaping open at apex ____ **Resedaceae**
   4. Plants glabrous or pubescent; leaves not linear-filiform; flowers sessile or not; stamens various but not 3; ovary and fruit not gaping open at apex.
      5. Plants with star-shaped (stellate) or tree-like (dendritic) branched hairs.
         6. Hairs harsh, dendtritic, and minutely hooked, the leaves and capsules adhering like Velcro ____ **Loasaceae** (*Mentzelia*)
         6. Hairs branched but not harsh and not hooked, not sticking like Velcro.
            7. Sepals and petals each 4 and separate; stamens 6; fruits laterally compressed, longer than wide ____ **Brassicaceae** (*Descurainia, Lyrocarpa*)
            7. Sepals or calyx lobes and petals or corolla lobes each 5; stamens 5 or more, but not 6; fruits rounded or radially symmetrical.
               8. Plants often white woolly (less so in shade and when well watered); hairs branched above the base (dendritic); leaves opposite and alternate on the same plant; flowers small and yellow, each enclosed in a cup-shaped involucre becoming hard as the fruit matures, the fruit indehiscent, inconspicuous, and 1-seeded ____ **Amaranthaceae** (*Tidestromia*)

8. Hairs branched from the base (stellate); leaves alternate; flowers of various colors as well as yellow, not enclosed in a cup-shaped involucre; filaments united below into a column; fruits dehiscent capsules or schizocarps ____ **Malvaceae**

5. Plants glabrous or with simple (unbranched) hairs.
9. Stems yellow-green, dotted with lens-like glands, the plants aromatic, often citrus-like; flowers to 1 cm long, tubular and dark bluish-purple ____ **Rutaceae**
9. Stems not yellow and green and dotted with lens-like glands, not aromatic or if aromatic then not citrus-like; flowers not tubular and dark bluish-purple.
10. Flowers with a calyx but without a corolla; fruits indehiscent and 1-seed.
11. Flowers white, pink or purplish ____ **Nyctaginaceae** (*Allionia, Boerhavia, Mirabilis*)
11. Flowers inconspicuous, green, drying brown ____ **Urticaceae**
10. Flowers with a calyx and corolla; fruits of multiple-seeded capsules.
12. Flowers 4-merous, the ovary inferior: calyx and corolla segments each 4 and attached to the top of the ovary; flowers not purple; stamens 8 ____ **Onagraceae**
12. Flowers 5-merous, the ovary superior; stamens various but not 8.
13. Herbage mucilaginous; flowers ca. 4 cm long and bilaterally symmetric; capsules woody, the body more than 4 cm long, with 2 long, hooked, claws ____ **Martyniaceae**
13. Herbage not mucilaginous; flowers less than 4 cm long or radially symmetric if more than 4 cm long; capsules less than 4 cm long, not woody and not clawed.
14. Capsules with 1–4 seeds ____ **Boraginaceae** (*Phacelia, Tiquilia*)
14. Capsules with more than 4 seeds.
15. Annuals; leaves pinnately lobed or dissected ____ **Boraginaceae** (*Eucrypta, Phacelia*)
15. Annuals or perennials; leaf margins entire or shallowly lobed or wavy.
16. Annuals; flowers purplish, bilaterally symmetrical ____ **Plantaginaceae** (*Pseudorontium*)
16. Annuals or perennials; flowers white or yellowish, radially symmetrical ____ **Solanaceae** (*Datura, Nicotiana obtusifolia, Physalis*)

ACANTHACEAE—ACANTHUS FAMILY

Justicia californica (Benth.) D.N. Gibson [*Beloperone californica* Benth.] DESERT HUMMINGBIRD-BUSH; *CHUPARROSA*. **Fig. 15.**

Shrubs with sparse foliage and tubular, red-orange flowers; massive flowering in spring after favorable rains.

Widespread, mostly along washes and canyons and sometimes on rocky slopes; not seen above 1570 ft. *Chuparrosa* attracts hoards of hummingbirds and it is a favorite food plant of bighorn sheep (Russo 1956).

Tinajas Altas, *Shreve 5940.* Canyon above Tinajas Altas, 26 Oct 2004, *Felger* (observation). Tinajas Altas Pass, *Reeves R-5417* (ASU).

AMARANTHACEAE—AMARANTH FAMILY (INCLUDES CHENOPODIACEAE)

1. Leaves opposite or alternate, with branched hairs, usually densely white woolly; flowers bisexual ____ **Tidestromia**
1. Leaves alternate or sometimes opposite below, glabrous or with short simple hairs or glands, or inflated hairs collapsing on leaf surfaces; flowers unisexual or bisexual.
2. Female flowers and fruits enclosed in sepal-like bracts enlarging as the fruit develops ____ **Atriplex**
2. Female flowers and fruits not enclosed in sepal-like bracts.
3. Flowers unisexual; seeds without a distinct rim, shiny or dull ____ **Amaranthus**
3. Flowers bisexual; seed margins acute with a distinct "rim," the seed surface dull even after removal of pericarp ..... **Chenopodium**

AMARANTHUS

The two species in the flora area have male and female flowers on the same plant. In *A. palmeri*, which occurs in nearby area, the male and female flowers are on separate plants.

1. Stems ascending, sprawling, or prostrate; inflorescence branches and pedicels sinuous, becoming thickened and corky; fruits indehiscent, scaly and warty ____ **A. crassipes**
1. Stems usually erect or ascending; inflorescence branches and pedicels mostly straight, not thickened and corky; fruits dehiscent (circumscissile) and smooth-surfaced ____ **A. fimbriatus**

Amaranthus crassipes Schldl. var. **crassipes.** SPREADING AMARANTH

Summer annuals, glabrous. Leaf blades and petioles about equal in length; blades obovate to broadly elliptic or nearly orbicular. The inflorescence branches, or peduncles, are markedly thickened and corky, forming a unique, compact, hard knotty structure at the base of the plant and smaller clusters in the leaf axils. Sepals inconspicuous, not fringed. Fruits indehiscent.

This unique amaranth was found localized at several sites along Coyote Wash in October 2004 following exceptional rains.

Coyote Water, *Felger 04-24.*

Amaranthus fimbriatus (Torr.) Benth. FRINGED AMARANTH; *BLEDO*, *QUELITILLO*; CUHUKKIA I:VAKI

Summer annuals, glabrous. Leaves sessile or short petioled, the blade narrowly lanceolate. Inflorescences "soft," the bracts not spiny or stiff; female sepals conspicuously fringed; flowers small, green and white. Fruits dehiscent. The seeds are edible.

Common and widespread at low elevations, especially washes, bajadas, and canyon bottoms.

Coyote Water, *Felger 04-25.* Tinajas Altas, 26 Oct 2003, *Felger* (observation). †Butler Mts, calyx, 8160 ybp.

†**Amaranthus** sp./spp.

Unidentified amaranths, likely *A. fimbriatus* and/or *A. palmeri,* are recorded at Tinajas Altas dating to about 10 millennia ago (see Doubtful, enigmatic and potential records).

†Tinajas Altas, seeds, 9900 & 10,600 ybp.

Atriplex polycarpa (Torr.) S. Watson. DESERT SALTBUSH; *CHAMIZO CENIZO*; 'ONK 'I:VAKĬ

Woody shrubs. Fruiting bracts bearing 7 to many small, finger-like blunt teeth. Flowering in various seasons, especially with hot weather following rains.

One of the more common and widespread shrubs in the region. Washes, sandy valley plains, bajadas, pediments, and lower slopes. It has been in the region for more than 10,400 years ago.

Camino del Diablo, E of Raven Butte, *Felger 02-04.* SW side of Tinajas Altas Mts, flats and granitic hills, 10 Jan 2002, *Felger* (observation). †Butler Mts, leaves, 10,360 ybp.

***Chenopodium murale** L. NETLEAF GOOSEFOOT; *CHUAL, CHOAL*; 'ONK 'I:VAKĬ, KAUPDAM

Winter-spring annuals. Herbage smooth, the leaves sometimes semi-succulent.

This species has been collected twice in the flora area, 18 years apart, between the lowermost Tinaja and the parking area—the sites most often frequented by visitors. Our observations indicate that it is rather scarce at Tinajas Altas but apparently well established. It is common in nearby northwestern Sonora at waterholes in the Sierra El Pinacate and as a weed in agricultural fields (Felger 2000). The young herbage and especially the seeds are edible. This species, widespread in the New World, is reported as native to the Old World.

Tinajas Altas, disturbed bank, *Van Devender 10 Mar 1980.* Parking area E of Tinajas Altas [Mesa del Muerto], *Felger 98-149.*

Tidestromia lanuginosa (Nutt.) Standl. subsp. **eliassoniana** Sánchez-del Pino & Flores Olvera [*T. eliassoniana* (Sánchez-del Pino & Flores Olvera) Sánchez-del Pino] WOOLLY HONEYSWEET; *HIERBA CENIZA, HIERBA LANUDA*

Summer annuals, generally low and spreading, the herbage often scurfy-whitish; flowers minute, yellow.

Widespread at lower elevations: washes, bajadas, canyons, and sometimes on lower rocky slopes.

Coyote Water, *Felger 04-64.* Tinajas Altas, 19 Mar 1998, *Felger* (observation; dry plants from previous year).

ANACARDIACEAE—CASHEW FAMILY

†**Rhus aromatica** Aiton cf. var. **trilobata** (Nutt.) S. Watson [*R. trilobata* Nutt.] SKUNK BUSH; *LIMITA*

Shrubs with winter-deciduous leaves. Ice Age *Rhus* seeds seem to be from a skunk bush, likely this one. The nearest present-day population occurs on the north side of Pinacate Peak (Felger 2000).

†*R. aromatica* cf. *trilobata*, Tinajas Altas, seeds, 9230–11,040 ybp (5 samples).

Rhus kearneyi F.A. Barkley subsp. **kearneyi** [*Schmaltzia kearneyi* (F.A. Barkley) F.A. Barkley] DESERT SUMAC; *LIMITA DEL DESIERTO.* **Fig. 17.**

Hardwood shrubs, 2–4 m tall, the leaves tough, green, and generally evergreen, or sometimes partially or fully leafless during extreme fore-summer drought. Flowers white or pink; fruits red, about 1 cm long, November–March. The surfaces of freshly ripe fruits are wet with gooey but not sticky exudate; this liquid has a pleasantly tart (acidic) taste. A refreshing, tart drink is made from the fruits. The growth form and habit of this shrub is unique in the region. The type collection is from Tinajas Altas.

Tinajas Altas Mountains, mostly in steep north-facing canyons and cliff bases, from near the lower tinajas to near peak elevations.

This subspecies occurs in the Gila and Tinajas Altas Mountains and in the nearby north-facing, steep granitic mountains in northwestern Sonora west of the Pinacate region (Felger 2000). Disjunct populations of this subspecies occur in the Sierra del Viejo southwest of Caborca, Sonora, and Sierra San Pedro Mártir in Baja California. Two other

Fig. 17. Desert sumac (*Rhus kearneyi*). North-facing slope at Tinajas Altas. 20 November 2008. Photo by Benjamin T. Wilder.

subspecies occur in mountains of Baja California and Baja California Sur. *Rhus kearneyi* appears to be a relict of a more widespread Pleistocene distribution. This species seems most closely related to *R. integrifolia* (Nutt.) Benth. & Hook. f. ex Rothr. of the Pacific Coast of the Californias; the two species differ in part by leaf shape and pubescence.

Tinajas Altas Mts, [probably at Tinajas Altas], 29 Mar 1930, *Harrison & Kearney 6573* (isotype). Tinajas Altas, *Goldman 2311* (US). NE Tinajas Altas Mts, ca. 500 m SSW of Raven Butte, granitic mountainside, steep NE-facing ravine, shrub to 4 m tall, 488 m, *Morrison 590* (ASU). Borrego Canyon, vicinity of Borrego Tank, *Felger 92-612*.

APIACEAE—CARROT OR PARSLEY FAMILY

†**Daucus pusillus** Michx. Wild carrot; *zanahoria silvestre*

Cool-season annuals.

Recorded for Tinajas Altas more than nine millennia ago. The nearest present-day records are from the nearby Pinta Sands and Las Playas in Cabeza Prieta Refuge.

†Tinajas Altas, fruits, 8970 & 9790 ybp.

APOCYNACEAE—DOGBANE FAMILY (includes Asclepiadaceae)

1. Stems erect, not vining ____ **Asclepias**
1. Stems vining or trailing, not self-supporting ____ **Funastrum**

ASCLEPIAS—Milkweeds

1. Stems stout and conspicuously leafy; leaves ovate, at least 2 cm wide ____ **A. erosa**
1. Stems slender and reed-like; leaves linear, less than 2 mm wide (leaves quickly deciduous and the stems often leafless).
   2. Stems usually relatively few (or sometimes as many as 50), usually 1.5–3 m tall; flowers 8–9 mm long (including the down-turned petals), the hoods 2–2.5 mm long and not longer than the staminal column (anther head) ____ **A. albicans**
   2. Stems many, usually to 1(–1.5) m tall; flowers 15–20 mm long (including the down-turned petals), the hoods 6–10 mm long and obviously longer than the staminal column ____ **A. subulata**

Asclepias albicans S. Watson. White-stem milkweed; *jumate*, *candelilla*

Shrubs to 3 m tall, the stems reed- or wand-like, generally few, white-waxy, semi-succulent, and often leafless or with few, thread-like leaves. Flowers cream-white.

Fairly common on arid, exposed rock slopes, and occasional on the bajada-plain of the Lechuguilla Valley. This highly xerophytic milkweed has been in the region for at least five millennia. The fruits are edible after being roasted in coals.

Tinajas Altas, *Shreve 5941*. Lechuguilla Valley, *Felger 08-216*. †Tinajas Altas, 1230–5080 ybp.

Asclepias erosa Torr. Giant sand-milkweed, desert milkweed; *hierba del cuervo*

Robust perennials, often 1–1.8 m tall, leaves large and rather thick. Flowers greenish white. Plants often green and flowering in late spring and early summer in amazing heat when nothing else seems alive.

Scattered on sandy soils of Lechuguilla Valley.

Lechuguilla Desert, *Simmons 21 May 1965.*

Asclepias subulata Decne. Desert reed-stem milkweed; *jumete, mata candelilla*

Perennials with many, erect, reed-like stems to about 1 (1.5) m tall. Leaves thread-like, few and quickly deciduous. Flowers waxy, cream- and yellow-white.

Occasional in the Lechuguilla Valley, recorded near the northern boundary of the flora area.

Camino del Diablo, NE of Raven Butte, *Felger 04-3.*

Funastrum hartwegii (Vail) Schltr. [*F. cynanchoides* (Decne.) Schltr. var. *hartwegii* (Vail) Krings. *Sarcostemma cynanchoides* Decne. subsp. *hartwegii* (Vail) R.W. Holm] Climbing milkweed; *güirote*

Perennial vines, sometimes climbing up saguaros and enveloping them. Flowers maroon and white.

Mostly along washes and canyon bottoms. The fresh flowers can be eaten as snacks, and chewing gum was made from the milky sap.

Coyote Water, *Felger 04-46.* Camino del Diablo at Coyote Wash, locally common in mesquites, *Felger 10-163.* Tinajas Altas, *Van Devender 9–10 Mar 1980.*

ASTERACEAE—ASTER OR DAISY FAMILY

This is the largest family in the flora, the Sonoran Desert, and globally. The 43 present-day species represent 19% of the flora—comparable to the 15% of adjacent northwestern Sonora (Felger 2000). Additionally, 8 species are known from the flora area only by fossils. Approximately 22 species, or 58% of the composite species in the flora are annuals or ephemerals, comparable to 52% of adjacent northwestern Sonora; in contrast, worldwide about 25% are annuals. Most of the rest of the local composites are herbaceous perennials or small shrubs, and *Baccharis sarothroides* and *Peucephyllum schottii* are woody shrubs reaching more than 1.5 m in height. Two small composite shrubs form important and widespread components of the local desert vegetation: *Ambrosia dumosa* and *Encelia farinosa*. *Lactuca serriola* and the two *Sonchus* species are the only non-native composites in the flora area.

Most composites in the flora are insect-pollinated. More than 16 species have yellows flowers, e.g., *Baileya pleniradiata, Encelia farinosa, Gymnosperma glutinosum*, and *Pectis papposa*. *Stephanomeria pauciflora* has nocturnal or crepuscular white or pinkish flowers; whitish flowers are found on about 10 species. A few species have lavender rays but yellow disk flowers, e.g., *Erigeron lobatus* and *Monoptilon bellioides*. There are no red-flowered composites in the region. The Ambrosiinae, e.g., *Ambrosia*, are wind-pollinated, with corollas absent from female flowers and reduced on male flowers. Others, such as the filaginoids *Logfia* and *Stylocline*, have minute, reduced flowers and are undoubtedly selfing.

1. Plants often with milky sap; all florets conspicuous, bisexual, similar in shape (inner florets often smaller) with strap-like or ray-like (ligulate—the ligules 5-lobed) corollas.
   2. Pappus bristles thread-like (capillary), not plumose.
      3. Florets 3 or 4 per head; phyllaries 4–5 mm long ____ **Prenanthella**
      3. Florets many per head; phyllaries 9–13 mm long.
         4. Upper part of plants including involucres with conspicuous tack-shaped glands, otherwise glabrous or nearly so; leaf margins not spinose-toothed; achenes cylindrical, beaked (narrowed to a slender neck just below the pappus) ____ **Calycoseris**
         4. Plants without tack-shaped glands; leaf margins mostly spinose-toothed; achenes flattened, rounded at apex, not beaked ____ **Sonchus**
   2. Pappus bristles plumose.
      5. Heads medium to large, the larger phyllaries (13–)17–22 mm long; ligules of larger (outer) florets usually 15–30 mm long; achenes tapering into a slender beak; pappus bristles (6–)9.5–14 mm long ____ **Rafinesquia**
      5. Heads small, the phyllaries 6–10.5 mm long; ligules 6–12 mm long; achenes columnar (not tapering), ending abruptly (truncate); pappus bristles 2.2–8 mm long ____ **Stephanomeria**

1. Sap not milky; florets conspicuous or not, and not all strictly ligulate; heads with 1) ray and disk florets, the rays sterile or pistillate, usually 3-toothed or 3-lobed, or 2) disk or disk-like florets only, the corollas showy to reduced or lacking (florets sometimes enclosed in burs), or 3) bilabiate (2-lipped) florets only.

6. Shrubs with vegetative parts (herbage and phyllaries) sticky (conspicuously resinous-glutinous) and aromatic (these plants may also key out elsewhere).
   7. Monoecious, the florets of each flower head of a single sex, the female flowers enclosed in burs _____ **Ambrosia** (in part)
   7. Flower heads unisexual or not, flowers not in burs.
      8. Leaves filiform, terete or nearly so, not lobed, less than 2 mm wide ..... **Peucephyllum**
      8. Leaves not filiform or terete, 2 or more mm wide, or if very narrow then at least some leaves toothed or lobed and the blades flattened or at least not terete.
         9. Plants usually less than 1 m tall; flowers bisexual; pappus none; flowers yellow _____ **Gymnosperma**
         9. Plants often 1–2 m tall; male and female flowers on separate plants; pappus conspicuous; flowers dull whitish _____ **Baccharis**
6. Herbaceous plants or shrubs; vegetative parts resinous or not.
   10. Small shrubs; heads of bilabiate florets only, the flowers yellow; achenes expanded at apex into a disk bearing numerous pappus bristles _____ **Trixis**
   10. Shrubs or herbs; heads with ray and disk florets, or only disk or disk-like florets, the florets not bilabiate, the flowers yellow or not; achenes not as above.
      11. Heads of disk and ray florets, the rays usually obvious (taxa with small, inconspicuous, or early-deciduous rays will key out in either choice; if in doubt, best to go to 21, heads not unisexual).
         12. Pappus none (caution: refers to absence of pappus at top of achene, do not confuse hairs on side of achenes with the pappus).
            13. Leaves essentially glabrous (minutely scabrous), usually resinous; flower heads 1.5 mm wide ____ **Gymnosperma**
            13. Leaves hairy, not resinous; flowers heads more than 10 mm wide.
               14. Annuals; leaves pinnately divided; larger leaves basal or near the base; achenes ribbed, more or less cylindrical, not outlined with hairs _____ **Baileya**
               14. Perennial bushes or shrubs; leaves entire or nearly so, mostly at stem tips; achenes flattened and not ribbed, the margins outlined with white hairs _____ **Encelia farinosa**
         12. Pappus present, at least on disk achenes.
            15. Short-lived perennials and flowering in the first season; plants pubescent with glandular and non-glandular hairs; leaves mostly sessile, entire to deeply divided, the segments mostly spinescent-tipped; flower heads usually 1.5–3.5 cm wide, with ray and disk florets; pappus of slender persistent bristles (or sometimes absent from ray florets) _____ **Xanthisma**
            15. Plants not with all of the above features.
               16. Annuals or perennials; heads medium-sized to large, usually (2) 3–5 cm wide including rays; receptacles with chaffy bracts subtending and partly enclosing each disk floret.
                  17. Winter-spring annuals; phyllaries dark green, fringed (ciliate) with long white hairs _____ **Geraea**
                  17. Small shrubs; phyllaries not fringed with long white hairs _____ **Bahiopsis**
               16. Annuals; heads small to medium-sized, mostly less than 2.5 cm wide; receptacles naked, disk florets without subtending bracts.
                  18. Leaves toothed, lobed, or pinnatifid.
                     19. Plants with soft, spreading hairs; leaves pinnatifid to pinnately lobed or toothed; rays lavender, filiform, numerous, and disk-like _____ **Erigeron**
                     19. Plants with short non-spreading hairs or essentially glabrous; leaves palmately toothed or lobed; rays white, linear but not filiform, one dozen or fewer, and not disk-like _____ **Perityle**
                  18. Leaves entire or entire with bristles at base.
                     20. Plants glabrous, dotted with conspicuous oil glands; leaves with prominent marginal bristles near the leaf base; rays yellow _____ **Pectis**
                     20. Plants pubescent, without oil glands; leaves without bristles; rays whitish or lavender _____ **Monoptilon**
      11. Heads of disk florets only, outer florets without an obvious ligule or ray, or if ray florets present then disk-like (inconspicuous or reduced, or lacking a well-developed ligule—eligulate; if in doubt about presence of rays then take this choice).
         21. Heads unisexual, the female florets enclosed in a bur or woody, winged bur-like involucre _____ **Ambrosia**
         21. Heads not unisexual, the female florets not enclosed in burs.
            22. Plants tomentose or white-woolly; winter-spring annuals (or rarely persisting through the summer in *Trichoptilium*).
               23. Stems thick; leaves obviously petioled, the blades as wide or wider than long _____ **Psathyrotes**
               23. Stems not notably thick; leaves sessile or the petioles inconspicuous or short and winged, the blades longer than wide.
                  24. Leaves coarsely toothed; individual flowers small but readily visible, bright yellow; achenes more than 2 mm long _____ **Trichoptilium**
                  24. Leaves entire; individual flowers minute, inconspicuous and dull-colored; achenes 1 mm or less in length ("fuzzy little composites" including filaginoids).
                     25. Disk florets all bisexual, the disk achenes usually developing and with copious pappus (averaging more than 12 bristles per floret); receptacle often tack-shaped _____ **Logfia**
                     25. Disk florets all staminate, the disk achenes not developing and their pappus none or vestigial (averaging less than 12 bristles); receptacle often conical or cylindrical _____ **Stylocline**

22. Plants glabrous or hairy but not woolly.
    26. Shrubs; florets subtended by chaffy bracts of receptacle, the bracts folded around the achenes and falling with them.
        27. Leaves opposite, or the upper ones alternate; achenes 2.8–4 mm long, the margins not different from the body; pappus present (rays present but often falling early) ____ **Bahiopsis**
        27. Leaves alternate; achenes 7–10 mm long, the margins with long white hairs; pappus none ____ **Encelia frutescens**
    26. Annuals or perennials, herbaceous to shrubby; receptacle naked, without chaffy bracts.
        28. Plants glaucous and pungently aromatic, the leaves and bracts with conspicuous, elongated oil glands; flowers whitish or pinkish ____ **Porophyllum**
        28. Plants not glaucous, without oil glands, not pungently aromatic.
            29. Perennial bushes; pappus of plumose (feathery) bristles ____ **Bebbia**
            29. Annuals and perennials (some bushes); pappus not plumose.
                30. Annuals.
                    31. Spring annuals; leaves 1–3-times pinnatisect (pinnately divided to the midrib) ____ **Chaenactis**
                    31. Leaves entire or margins lobed or parted halfway or less to midrib.
                        32. Leaf surfaces mostly grayish or grayish green with coarse, stiff grayish or white hairs; achenes at least 4 mm long ____ **Palafoxia**
                        32. Leaf surfaces usually green; glabrous or the hairs not coarse and stiff; achenes 3.2 mm or less in length.
                            33. Delicate spring annuals; leaves very thin, almost membranous; flowers yellow; phyllaries 6–7.5 mm long; achenes 2.8–3.2 mm long; pappus bristles capillary (soft and not barbellate) ____ **Senecio mohavensis**
                            33. Annuals, mostly robust and not delicate; leaves not notably thin; flowers whitish; phyllaries 2.5–3.5 mm long; achenes 0.8–1.3 mm long; pappus bristles barbellate ____ **Laennecia**
                30. Shrubby or bushy perennials (or dwarf shrubs or subshrubs), the vegetative parts mostly present all year.
                    34. Leaves petioled, junction of blade and petiole abrupt and well marked, the blades spinose-toothed ____ **Brickellia atractyloides**
                    34. Leaves sessile or the blade gradually narrowed to an indistinct petiole less than ⅛ as long as the blade, the blade entire to toothed but not spinose.
                        35. Leaves conspicuously resinous and densely crowded at stems tips (internodes scarcely discernable); flower heads sessile, mostly solitary at stem tips; phyllaries similar in size in an inner series, plus an outer series of few, narrower and sometimes shorter phyllaries; flowers bright yellow ____ **Peucephyllum**
                        35. Leaves not resinous (or not conspicuously so) and not crowded, the internodes apparent; flower heads stalked; phyllaries conspicuously graduated; flowers whitish to lavender or pale yellow.
                            36. Herbage densely pubescent with stalked glandular hairs; leaves with a long, slender petiole and an arrow-shaped blade sometimes greatly reduced and indistinct; flower heads bisexual ____ **Pleurocoronis pluriseta**
                            36. Herbage yellow-green to glaucous, essentially glabrous or with short, inconspicuous hairs; leaves sessile, linear to lanceolate; flower heads unisexual (male and female flowers on separate plants) ____ **Baccharis**

AMBROSIA—Bur sage, ragweed

Perennial herbs or shrubs; flowers inconspicuous and wind pollinated, the heads unisexual with disk florets, the male flowers producing large quantities of hay fever-causing pollen, the female flowers enclosed in burs.

1. Leaves and leaf segments thread-like (filiform), less than 2 mm wide; burs with flat wings narrowed basally ____ **A. salsola**
1. Leaves and leaf segments not filiform, more than 4 mm wide; burs with straight or hooked spines widest at base.
    2. Leaves pinnately to tri-pinnately deeply dissected ____ **A. dumosa**
    2. Leaf margins toothed or rarely nearly entire, not deeply dissected.
        3. Leaves sessile, firm, with spine-tipped teeth ____ **A. ilicifolia**
        3. Leaves petioled, "soft," and flexible; marginal teeth, if present, not spine-tipped.
            4. Shrubs with erect, few-branched stems to 1 m or tall; leaf blades more than 7 cm long; burs with hooked spines ____ **A. ambrosioides**
            4. Subshrubs usually less than 0.8 m tall with branched stems; leaf blades less than 5 (6.5) cm long; burs with straight spines (rarely a few hooked spines near apex) ____ **A. deltoidea**

Ambrosia ambrosioides (Cav.) W.W. Payne [*Franseria ambrosioides* Cav.] Canyon ragweed; *chicura*; ñuñuvĭ jej

Shrubs with slender stems and large, elongated, triangular and glandular leaves. Male flowers yellow, female flowers and seeds in large burs.

Growing with warm weather, the herbage frost-sensitive. Washes and canyon bottoms. This species is an important medicinal plant (Felger 2007).

Tinajas Altas, *Van Devender 9–10 Mar 1980.* Coyote Wash, 10 Jan 2002, *Felger* (observation).

†**Ambrosia confertiflora** DC. SLIMLEAF BUR-SAGE; *ESTAFIATE*; MO'OSTALK

Herbaceous perennials, winter and spring dormant.

Not known from the Tinajas Altas area today, but it was in the Butler Mountains more than 10,000 years ago. The nearest present-day records are from nearby areas in Cabeza Prieta Refuge in poorly drained, clayish soils of the large playas.

†Butler Mts, bur, 10,360 ybp.

Ambrosia deltoidea (Torr.) W.W. Payne [*Franseria deltoidea* Torr.] TRIANGLE-LEAF BUR-SAGE; *CHAMIZO FORRAJERO;* TADSAD, VA:GITA

Bushy subshrubs; tardily drought-deciduous and summer dormant. Flowers green or yellow, inconspicuous; seeds in small burs.

This species occurs just east of the study area, where it is one of the most widespread and abundant perennials in the region. However, in the more xeric Tinajas Altas region it is replaced by *A. dumosa*. A single Tinajas Altas collection in 1983 is an interesting anomaly, although tellingly, it is noted as being "rare." In nearby regions, such as northwestern Sonora, *A. deltoidea* does not extend into such extremely xeric areas as does *A. dumosa* (Felger 2000).

Tinajas Altas Mountains, Tinajas Altas, 1200 ft, rare on granite, 0.5 m shrub, *Van Devender 26 Mar 1983.*

Ambrosia dumosa (A. Gray) W.W. Payne [*Franseria dumosa* A. Gray] WHITE BUR-SAGE; *CHAMIZO*; TADSAD

Dwarf shrubs, the herbage often whitish. Summer dormant, flowering and fruiting fall to spring; seeds in small burs. In late March, 2010, our shoes and lower pant legs were coated yellow with white bursage pollen.

Valley plains, bajadas, and rocky slopes to higher elevations, and extending into the harshest, driest sites. White bursage is one of the most widespread and common perennials in the flora area as well as across much of the Sonoran and Mojave deserts. It has been in the flora area for more than 15,700 years.

SE of Raven Butte, bajada, *Felger 04-7.* Tinajas Altas, *Felger 10-177.* Tinajas Altas Pass, *Reeves R5398* (ASU). †Tinajas Altas, leaves, burs, 1230–15,680 ybp (11 samples).

Ambrosia dumosa × A. ilicifolia

This putative hybrid appears intermediate between the presumed parents, both of which were present. Only one plant of the presumed hybrid was seen in the flora area.

Tinajas Altas, steep slope N of the tinajas, two branches collected from the one plant seen, *Felger 98-136.*

Ambrosia ilicifolia (A. Gray) W.W. Payne [*Franseria ilicifolia* A. Gray] HOLLY-LEAF BUR-SAGE

Broad, spreading shrubs, often 1–2+ m wide. Leaves firm and holly-like, the dead leaves persistent. Summer dormant; flowering and fruiting winter and spring. Seeds in burs.

Washes, canyon bottoms, and sometimes on rocky slopes. The dry, dead leaves rustling in the wind may sound startlingly like a rattlesnake. Its presence at Tinajas Altas dates from more than 15,700 years ago.

Tinajas Altas, *Vorhies 16 Apr 1924.* 1.7 km WNW of Tinajas Altas Peak, 340 m, *Baker 13308* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, leaves, burs, 1230–15,680 ybp (17 samples).

Ambrosia salsola (Torr. & A. Gray) Strother & B.G. Baldwin var. **pentalepis** (Rydb.) Strother & B.G. Baldwin [*Hymenoclea salsola* Torr. & A. Gray var. *pentalepis* (Rydb.) L.D. Benson] WHITE BURROBUSH, CHEESEBUSH; 'I:WADHOD

Shrubs, usually about as wide as tall, with many spreading and interlacing branches. Flowers straw-colored, the female flowers and seeds in small, winged burs. Flowering March and April; the wet plants smell like a dead animal.

Widespread across much of the Lechuguilla Valley and canyons in the mountains, and present in the region at least 9000 years ago.

Camino del Diablo at Coyote Wash, *Felger 10-166.* Coyote Water, 18 Mar 1998, *Felger* (observation). Tinajas Altas: 1200 ft, *Lindquist 26 Mar 1983*; *Webster 24245.* †Butler Mts, bur, 8570 ybp. †Tinajas Altas, burs, 8970 ybp.

†**Artemisia ludoviciana** Nutt. subsp. **albula** (Wooton) D.D. Keck. WESTERN MUGWEED, WHITE SAGE, SILVER WORMWOOD; *ESTAFIATE*

Herbaceous perennials, flowering in late spring and probably with summer rains.

Western mugweed was at Tinajas Altas from at least 11,000 to more than 18,700 years ago. The nearest present-day records are from mountains in Organ Pipe Monument and higher elevations in the Sierra Pinacate.

†Tinajas Altas, leaf fragments, 11,040–18,700 ybp (4 samples).

BACCHARIS

Shrubs with resinous herbage. Male and female flowers on separate plants; flower heads of disk florets.

1. Shrubs usually low and broader than tall, the stems not broom-like, the herbage not yellow-green and not glutinous, the twigs brown; leaves entire; achenes 5-ribbed _____ **B. brachyphylla**
1. Shrubs usually taller than wide, the stems broom-like, the herbage yellow-green and glutinous-sticky, the twigs green; leaves mostly linear, the larger leaves often minutely toothed (denticulate); achenes 10-ribbed _____ **B. sarothroides**

Baccharis brachyphylla A. Gray. SHORT-LEAF BACCHARIS

Low, spreading shrubs. Flowers inconspicuous; mostly late spring to early fall.

Mostly along canyon bottom and at higher elevations in the Tinajas Altas Mountains; localized and not common.

Tinajas Altas, *Goodding 1186*. Tinajas Altas Canyon, *Felger 04-79*. Frontera Canyon, canyon bottom among rocks, *Felger 98-108*.

Baccharis sarothroides A. Gray. DESERT BROOM; *ESCOBA AMARGA, ROMERILLO*; SUSK KUAGIG

Broom-like shrubs; branches green, mostly leafless or sparsely leaved. Flowers whitish, the fruits become airborne with copious white pappus; flowering and fruiting mostly October and November.

Localized along Coyote Wash; not common.

Coyote Water, *Felger 04-26, 04-27*.

Bahiopsis parishii (Greene) E.E. Schill. & Panero [*Viguiera parishii* Greene. *V. deltoidea* A. Gray var. *parishii* (Greene) Vasey & Rose] PARISH'S GOLDENEYE; *ARIOSA*

Small shrubs; stems slender and brittle, the leaves rough-surfaced (scabrous). Flower heads with bright yellow ray and disk florets.

Canyons and slopes to the summit.

Tinajas Altas, 990 m, *Felger 04-84*. Borrego Canyon, 3 Feb 1990, *Felger* (observation).

Baileya pleniradiata Harv. & A. Gray. WOOLLY DESERT-MARIGOLD

Non-seasonal annuals, but mostly in spring. Flowers yellow and showy.

Sandy soils; washes, bajadas, valley plains, and canyons at lower elevations.

W side of Tinajas Altas Mts, *Felger 05-48*. Frontera Canyon, Mexico border, 18 Mar 1998, *Felger* (observation). Butler Mts, *Van Devender 27 Mar 1983*.

Bebbia juncea (Benth.) Greene var. **aspera** Greene. SWEETBUSH, CHUCKWALLA DELIGHT; HAUK 'U'US

Globose, bushy perennials or shrubs with slender stems and rough (scabrous) herbage; foliate sparse, the leaves quickly drought deciduous. Flowers heads yellow and fragrant, with disk florets only, attracting numerous butterflies and many other insects; flowering response non-seasonal. Karen Reichhardt (personal communication 21 February 2005) has observed chuckwallas (*Sauromalus ater*) at Tinajas Altas eating chuckwalla delight.

Common and widespread; bajadas, washes (Fig. 15), canyons, and rocky slopes. Present in the region for at least 10,800 years.

Camino del Diablo, SE of Raven Butte, *Felger 04-6*. Tinajas Altas Pass, *Reeves R-5411* (ASU). †Butler Mts, achenes, 8160 ybp. †Tinajas Altas, achenes, 4010–10,750 ybp (8 samples).

Brickellia atractyloides A. Gray var. **atractyloides.** SPINY-LEAF BRICKELLBUSH

Subshrubs or small bushy perennials. Leaves firm with spinescent marginal teeth. Flowers pale yellow and purplish; February and March.

Rocky slopes, mostly north facing, and in canyons. It has been in the Tinajas Altas Mountains for more than 15,700 years.

Borrego Canyon, N-facing slope, *Felger 90-7*. Tinajas Altas, *Vorhies 16 Apr 1924*. †Tinajas Altas, leaves, involucres, achenes, 4010–15,680 ybp (13 samples).

†**Brickellia coulteri** A. Gray var. **coulteri.** TRIANGLE-LEAF BRICKELLBUSH; *PACHABA*

Small shrubs. It was at Tinajas Altas more than 4500 years ago. The nearest known present-day records are in the eastern part of Cabeza Prieta Refuge and the Sierra Pinacate.

†Tinajas Altas, twigs, involucres, 4490 & 10,950 ybp.

†**Calycoseris parryi** A. Gray. YELLOW TACK-STEM

Cool-season annuals. Flowers pale yellow.

It was at Tinajas Altas more than 9 millennia ago. The nearest present-day population occurs in the Sierra Pinacate above 550 m.

†Tinajas Altas, achenes, 9230 & 9900 ybp.

Calycoseris wrightii A. Gray. White tack-stem

Cool-season annuals with milky sap, branched at or near the base, and with conspicuous tack-shaped glandular hairs above, otherwise glabrous or glabrate. Rays of flower heads white with pinkish brown streaks (drying purple-brown) on the lower surfaces.

Widely scattered, recorded from Coyote Wash and Surveyors Canyon.

Coyote Water, 21 Feb 2005, *Felger 05-145.* Surveyors Canyon, canyon bottom below Surveyors Tank, 29 Mar 2010, *Felger* (observation).

CHAENACTIS

Spring annuals; flower heads of disk florets, white and often suffused with pink.

1. Stems with short white hairs, not cobwebby; phyllaries with an elongated slender (terete) tip; heads with stout receptacular bristles among the florets; pappus scales 1–3 mm long ____ **C. carphoclinia**
1. Herbage with cobweb-like woolly hairs; phyllary tips blunt; receptacular bristles none; pappus scales 3.5–6.5 mm long ____ **C. stevioides**

Chaenactis carphoclinia A. Gray var. **carphoclinia.** Pebble pincushion

Foliage not cobwebby, the phyllary tips needle-like. Flowers white.

Sandy flats, washes, bajadas, and rocky slopes.

Tinajas Altas, *Van Devender 26 Mar 1983.*

Chaenactis stevioides Hook. & Arn. Desert pincushion

Plants generally slightly more robust than those of *C. carphoclinia*; stem base often with at least some cobwebby hairs; phyllary tips relatively blunt. Flowers white or pinkish white.

Sandy soils of valley bottoms and rocky slopes. It has been in the region for at least 10,000 years.

Coyote Water, 18 Mar 1998, *Felger* (observation). W side of Tinajas Altas Pass, *Lindquist 26 Mar 1983.* †Tinajas Altas, achenes, 9900 ybp.

ENCELIA

Small shrubs, the leaves alternate, and with yellow flowers, and sometimes with brownish disk florets.

1. Leaves and stem tips white-woolly; leaves mostly 3–10 cm long, 1.5–3.5 cm wide; heads usually several or more in broad panicles, the peduncles essentially glabrous; rays well developed ____ **E. farinosa**
1. Leaves and stems rough-haired (scabrous), not woolly; leaves mostly 2–3 cm long, 0.35–0.6 (1.0) cm wide; heads mostly solitary, the peduncles hairy; rays none ____ **E. frutescens**

Encelia farinosa A. Gray ex Torr. var. **farinosa**. Brittlebush; *incienso*, *hierba del bazo, rama blanca*; tohaves. **Figs. 8 and 9.**

Shrubs, not long-lived. Leaves highly variable with soil moisture. Flowering branches usually raised well above the foliage; massive displays of daisy-like flowers with bright yellow rays and yellow or brownish disk florets, mostly in spring but also with summer-fall rains. At maturity the flower heads turn downward, dumping out the seeds.

One of the most common desert perennials in the region; widespread including all slope exposures to summits, dry washes, canyons, and bajadas; generally not in open creosotebush flats. The yellowish resin was used as chewing gum and an all-purpose adhesive and sealant. Brittlebush has been in the region for at least 43,000 years.

Tinajas Altas, 5 Dec 1935, *Goodding 2204.* El Camino del Diablo, E of Raven Butte, *Felger 01-586.* †Tinajas Altas, leaf fragments, achenes, 1230–18,700 (19 samples), & >4300 ybp.

Encelia farinosa var. **farinosa × E. frutescens**

Putative hybrid. Small shrubs. Leaves intermediate in shape from the presumed parent species. Flower heads bear bright yellow rays and disk florets

Scattered, isolated plants in the Lechuguilla Valley.

Camino del Diablo, E of Raven Butte, *Felger 01-585.*

Encelia frutescens A. Gray. Button encelia

Short-lived shrubs, densely branched and often mound-shaped to about 1 m tall. Flowers heads yellow, of disk florets only; reproductive during warmer months.

Locally common on sandy soils of Lechuguilla Valley.

Coyote Water, *Felger 04-65.* Camino del Diablo at W boundary of Cabeza Prieta, *Felger 10-159.*

†**Ericameria cuneata** (A. Gray) McClatchie var. **spathulata** (A. Gray) H.M. Hall [*Haplopappus cuneatus* A. Gray unrnanked *spathulata* (A. Gray) S.F. Blake] WEDGE-LEAF GOLDENBUSH

Perennial herbs or subshrubs.

The nearest present-day population is in the Ajo Mountains, mostly at higher elevations. It was widespread in the region during the Ice Age.

†Tinajas Altas, leaves, 8970–15,680 (4 samples), & >43,000 ybp.

†**Ericameria laricifolia** (A. Gray) Shinners [*Haplopappus laricifolius* A. Gray] TURPENTINE BUSH

Shrubs with bright green, resinous foliage.

The nearest present-day population is in the Ajo Mountains, mostly at higher elevations. It seems to have been very common and ranged across the region during the late Wisconsin Ice Age.

†Butler Mts, twigs, leaves, involucres, 10,360 ybp (common in this sample). †Tinajas Altas, leaves, 8970–18,700 ybp (10 samples).

†**Ericameria teretifolia** (Durand & Hilg.) Jeps. [*Chrysothamnus teretifolius* (Durand & Hilg.) H.M. Hall] GREEN RABBITBUSH

Small shrubs. It was at Tinajas Altas from 15 to at least 43 millennia ago. The nearest present-day populations are in northwestern Arizona; also in the Mojave Desert in southern California at the western edge of the desert into southern Nevada and southwestern Utah at the upper limits of desert and extending into pinyon-juniper vegetation.

†Tinajas Altas, leaves, involucres, 15,050–18,700 & >43,000 ybp (4 samples).

Erigeron lobatus A. Nelson. DESERT FLEABANE

Spring annuals and sometimes also in summer. Disk florets yellow, the rays very slender and pale lavender.

Scattered along Coyote Wash.

Coyote Water, *Felger 98-118.*

Filago, see **Logfia**

Geraea canescens Torr. & A. Gray. DESERT SUNFLOWER, DESERT GOLD

Coarse spring annuals; showy sunflower-like heads with yellow-orange disk florets and large, bright yellow rays.

Surprisingly, it has not been found in the immediate Tinajas Altas area, although it is often abundant nearby on sandy to gravelly and rocky soils. It has been in the region for at least 9 millennia.

Butler Mts, *Van Devender 27 Mar 1983.* †Butler Mts, achenes, 3820 & 8570 ybp.

Gymnosperma glutinosum (Spreng.) Less. [*Selloa glutinosa* Spreng.] GUMHEAD

Small shrubs or subshrub perennials with resinous herbage. Flowers heads small, with bright yellow disk and disk-like ray florets; flowering during the warmer months.

Widely scattered, seldom common, mostly on rocky slopes and mountain arroyos or canyons.

The plants are amazingly drought resistant and often retain bright green foliage and may even produce some flowers during extended drought when nearly all of the surrounding plants are dormant and leafless. It has been in the flora area for more than 15,700 years.

Tinajas Altas, *McLaughlin 1969.* Surveyors Canyon, canyon bottom, *Felger 10-208.* †Tinajas Altas, involucres, achenes, 1230–15,680 ybp (10 samples).

†**Heterotheca** sp. CAMPHORWEED

An unidentified camphorweed grew at Tinajas Altas until about 4000 years ago. This is the only record for this genus in the flora area and no other members of this large genus presently occur in the region. The nearest population of a member of this genus is *H. sessiliflora* (Nutt.) Shinners var. *thiniicola* (Rzed. & C. Ezcurra) G.L. Nesom, a rare dune endemic of northwestern Sonora (Felger 2000). The Tinajas Altas camphorweed probably was a different species.

†Tinajas Altas, achenes, 4010 to >43,000 ybp (13 samples).

Hymenoclea salsola, see **Ambrosia salsola**

*__Lactuca serriola__ L. Prickly lettuce, compass plant

Annuals, often germinating in late winter or spring. Highly variable in size; first leaves in a basal rosette, the stem leaves turned basally to hold the leaf edgewise and upright in a north-south plane, hence the name "compass plant." Flowering late spring and summer; flowers pale yellow.

Locally at the south end of Coyote Wash in the Lechuguilla Valley. Usually a weedy species, native to the Old World.

Camino del Diablo at Coyote Wash, locally abundant in mesquite "forest," some dry dead stalks from last year reach 2+ m in height, *Felger 10-162*.

__Laennecia coulteri__ (A. Gray) G.L. Nesom [*Conyza coulteri* A. Gray] Coulter's horseweed

Warm-weather annuals; flowers inconspicuous. Infrequent along Coyote Wash.

Coyote Wash at Camino del Diablo, *Felger 02-14*.

__LOGFIA.__ Fluffweed

Diminutive or small spring annuals, often white-woolly. Flowers minute. *Logfia* is a genus segregated from *Filago*.

1. Branching pattern usually symmetric (2 equal side-branches at each stem nodes, "pseudo-dichotomous"), the plants generally as broad or broader than tall; flower heads and leaves mostly restricted to the branch nodes (forks); leaves nearly linear, usually much longer than the heads; florets inside innermost chaff bracts 4–12, the minority of them (0–2) pistillate ____ **L. arizonica**
1. Branching pattern usually asymmetric (irregular); well-developed plants often erect and taller than wide, and often branched from a dominant central stem; flower heads and leaves more or less evenly distributed; leaves mostly oblanceolate, acute, usually not much longer than the heads; florets inside innermost chaff bracts 12–40, the minority (3–7) bisexual ____ **L. filaginoides**

__Logfia arizonica__ (A. Gray) Holub [*Filago arizonica* A. Gray] Arizona fluffweed

Small cool-season annuals, often white-woolly; branching pattern usually symmetric (2 equal side-branches at each node, "pseudo-dichotomous").

Sandy, gravelly or clayish-silt soils; washes, canyon bottoms, floodplains, and bajadas and perhaps soil pockets on rocky slopes. Often where rainwater may briefly accumulate. Commonly growing intermixed with *L. filaginoides*.

Camino del Diablo at Coyote Wash, *Felger 02-9*. Coyote Water, *Felger 98-114*. Surveyors Canyon, canyon bottom, *Felger 10-212*.

__Logfia filaginoides__ (Hook. & Arn.) Morefield [*L. californica* (Nutt.) Holub. *Filago californica* Nutt.] California fluffweed

Small, cool-season annuals, often white-woolly; characteristically slender with erect stems. Innermost (disk) achenes mostly sparsely papillate, with a pappus of 17–23 bristles falling away in complete or partial rings; lobes of disk corollas mostly 4, usually red-tipped.

Washes and canyons, bajadas, and among rocks on slopes.

Tinajas Altas, *Felger 98-144*. Surveyors Canyon, canyon bottom, *Felger 10-213*. Canyon below Raven Butte Tank, *Felger 10-234*.

Machaeranthera pinnatifida, see __Xanthisma spinulosus__

__Monoptilon bellioides__ (A. Gray) H.M. Hall. Mojave desert star

Low growing cool-season annuals. Flower heads showy, the rays white or lavender, curling in (inrolling) with age, the disk yellow; pappus bristles of shorter, outer white bristly scales, and more numerous inner straw-colored bristles.

Seasonally common, sometimes producing showy displays on otherwise nearly barren gravelly-rocky flats; sandy to rocky soils, washes, bajadas, desert pavements, canyons, and sometimes on lower slopes.

N of Tinajas Altas Pass, *Halse 31 Mar 1973*. Tinajas Altas Pass, *Reeves 5399* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-215*. Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

__Palafoxia arida__ B.L. Turner & M.I. Morris var. __arida.__ Spanish needles

Spring annuals and sometimes germinating and flowering with summer-fall rains; usually erect, silvery-haired, and the leaves linear. Flower heads of disk florets, dull white or pale pink.

Not recorded from the immediate Tinajas Altas area but common in the western Cabeza Prieta Refuge and near the Butler Mountains.

Butler Mts, sand dune, *Van Devender 27 Mar 1983*.

Pectis papposa Harv. & A. Gray var. **papposa.** Desert chinchweed; *manzanilla del coyote*; ban manzani:ya

One of the most abundant summer-fall annual wildflowers in the region. Plants pungently aromatic with conspicuous oil glands. Flowers showy and bright yellow with ray and disk florets.

Sandy to rocky soils, washes, plains, and less common on slopes.

Coyote Wash at Camino del Diablo, *Felger 04-66.* Coyote Water, *Felger 04-56.*

Perityle emoryi Torr. Desert rock daisy

Cool-weather annuals. Flower heads with white rays and yellow disk florets.

Seasonally common; sandy to rocky soils, washes, plains, and slopes. Documented for the region between 9200 and 11,000 years ago.

Coyote Water, *Felger 04-57.* Canyon below Raven Butte Tank, *Felger 10-237.* Tinajas Altas Mts at Mexico border, 18 Mar 1998, *Felger* (observation). Canyon above the Tinajas, 21 Nov 2008, *Felger* (observation). †Tinajas Altas, achenes, 9230 & 10,950 ybp.

Peucephyllum schottii A. Gray. Pygmy-cedar; *romero del desierto*

Woody shrubs often 1–2+ m tall, resembling a small conifer, with twisted trunks and branches, and shredding bark. Herbage resinous. Flowers fragrant, of yellow disk florets.

Rocky and often exposed mountain slopes and in the region for more than 15,700 years.

S of Tinajas Altas, N-facing slope, 8 ft tall, 7–8 ft wide, *Hodgson 2096* (DES). Tinajas Altas, *Van Devender 5 Mar 1983.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, achenes, 740–11,060 ybp (5 samples). †Tinajas Altas, leaves, involucres, achenes, 1230–15,680 ybp (6 samples).

Pleurocoronis pluriseta (A. Gray) R.M. King & H. Rob. [*Hofmeisteria pluriseta* A. Gray] Arrow-leaf

Small shrubs or subshrubs. Leaf blades very narrowly arrow-shaped, longer than wide, and during drought the blades often scarcely wider than the petiole.

Often growing from crevices on rock faces, canyons, cliffs, and slopes.

Tinajas Altas Mtn, on cliffs and rock slopes, 4 Mar 1927, *Belden 3604.* Tinajas Altas Tanks, on rocky hills above tanks, *McManus 669.*

†**Pleurocoronis** sp./spp.

The younger specimens are probably *P. pluriseta*. The older ones may be *P. laphamioides* (Rose) R.M. King & H. Rob., which nowadays occurs in the Ajo Mountains and farther south in northwestern Mexico.

†Butler Mts, involucres, achenes, 740–11,250 ybp (7 samples). †Tinajas Altas, involucres, achenes, 4010–15,680 ybp (9 samples).

Porophyllum gracile Benth. Slender poreleaf; *odora, hierba del venado*

Herbaceous perennials, pungently aromatic. Stems and leaves bluish green, the foliage sparse and quickly deciduous, the leaves slender. Flower heads with pinkish-white disk florets. Growing and flowering at various seasons.

Widely scattered; rocky slopes, canyons, arroyos, and upper bajadas. It has been in the region since at least 8600 years ago.

Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation). †Butler Mts, achenes, involucres, 740–8570 ybp (4 samples). †Tinajas Altas, involucres, achenes, 1230–8255 ybp (3 samples).

Prenanthella exigua (A. Gray) Rydb. Brightwhite

Diminutive spring annuals. Flower heads 5 mm long, with 3 or 4 ray florets, the rays white with violet tips.

Higher elevations in the mountains.

Tinajas Altas, above the tinajas, *Felger 98-132.*

Psathyrotes ramosissima (Torr.) A. Gray. Desert velvet, turtleback

Spring annuals, compact, woolly, and strongly scented. Leaves velvety gray-green with deeply incised veins. Flower heads of yellow disk florets. Achene hairs and pappus bristles bright, iridescent copper-colored.

Apparently highly localized at the north end of the Tinajas Altas region and the desert plains west of the Tinajas Altas range, observed on a steep granitic slope where it was uncommon and on a cobble-rock bajada.

Camino del Diablo, E edge of Davis Plains, *Halse 31 Mar 1973* (probably slightly north of the flora area). Along the "old" Tinajas Altas Pass road (a bit north of the present Tinajas Altas Pass road), 7 72 843 E, 35 81 704 N, Zone 11, WGS 84, 1050 ft, common, photo, *Malusa 18 April 2011.*

Rafinesquia neomexicana A. Gray. Desert chicory

Cool-season annuals; plants glabrous (as opposed to *Calycoseris wrightii*), the flower heads showy, of ray-like florets, white tinged with pale rose-purple and yellow. Plants often browsed and growing in the protection of small shrubs, the flowering stems overtopping the nurse shrub such as *Ambrosia dumosa* or, especially in drier years, spiny shrubs.

Sandy to rocky soils; washes, plains, and slopes, lowlands to higher elevations. Present at Tinajas Altas more than 10,000 years ago.

Coyote Water, *Felger 05-151*. Tinajas Altas Pass, along wash, *McLaughlin 1974*. †Tinajas Altas, achenes, 10,070 ybp.

Senecio mohavensis A. Gray. Mojave groundsel

Winter-spring annuals, often small and delicate. Stems and lower leaves glabrous and often purple-green; flowers yellow, rather inconspicuous, rays none or sometimes inconspicuous and several mm long.

Often in protected, shaded places, among rocks in mountain canyons and on north-facing slopes.

Tinajas Altas, *Van Devender 26 Mar 1983*. Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

***SONCHUS.** Sow thistle

Winter-spring annuals, the flower heads pale yellow with ray-like (ligulate) florets.

1. Stems sometimes more than 1 m tall; plants usually conspicuously spinescent; achenes smooth between ribs, the margins thin and wing-like, the ribs not knobby ____ **S. asper**
1. Stems seldom reaching 1 m; plants not conspicuously spinescent; mature achenes wrinkled and roughened between the ribs (caution: refers to mature achenes), the ribs themselves are transversally knobby, the margins not thin and wing-like ____ **S. oleraceus**

***Sonchus asper** (L.) Hill subsp. **asper.** Prickly sow thistle; *chinita*; ho'idkam, 'i:vakĭ

Winter-spring annuals; larger plants conspicuously spiny-prickly and sometimes robust.

Localized and seldom common; documented at two localities near the Mexican border—in a wash and a canyon bottom. The nearest known localities are waterholes and canyon bottoms in the vicinity of Quitobaquito at Organ Pipe Monument (Felger 2000).

Coyote Wash at Camino del Diablo, *Felger 02-10*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

***Sonchus oleraceus** L. Common sow thistle; *chinita*; hauvĭ, hehewo

Winter-spring annuals, mostly less than 80 cm tall.

Widely scattered but not common; washes and canyons, sometimes on slopes. This sow thistle is well established in the flora area.

Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Stephanomeria pauciflora (Torr.) A. Nelson. Desert-straw, desert wire-lettuce

Globose or mound-shaped bushy perennials with sparse foliage. Flowers pale pink, closing by mid-day or earlier in hot weather; flowering non-seasonally.

Washes, canyons, and rocky slopes.

Camino del Diablo at Coyote Wash, *Felger 10-168*. 1 mi E of Tinajas Altas, *Van Devender 86-144*.

Stylocline micropoides A. Gray. Desert neststraw

Diminutive, woolly, cool-season annuals; flowers minute and inconspicuous.

Locally common in the Tinajas Altas Mountains on upper bajadas, benches, and washes, and sometimes in soil pockets on rocky slopes and in canyons.

Coyote Water, 18 Mar 1998, *Felger* (observation). Tinajas Altas Canyon, *Felger 98-122*. Vicinity of Tinajas Altas, *Van Devender 05 Mar 1983*.

Trichoptilium incisum (A. Gray) A. Gray. Yellow-head

Annuals with woolly leaves; mostly growing and flowering during cooler seasons, especially in spring, and sometimes flowering into early summer. Flower heads of yellow disk florets.

Widespread in the region, mostly on rocky or gravelly soils; washes, bajadas, and rocky slopes.

Tinajas Altas, *Van Devender 10 Mar 1980*. W end of Tinajas Altas Pass, *Reeves R5425* (ASU).

Trixis californica Kellogg var. **californica.** California threefold

Small shrubs or subshrubs with brittle stems and thin, upright leaves. Flowers yellow and ray-like (bilabiate).

Canyons, bajadas, and rocky slopes including extremely arid hills to higher elevations in the mountains. It has been in the region for more than 11,000 years.

Tinajas Altas, *Vorhies 16 Apr 1924.* Tinajas Altas Pass, 4 mi W of Tinajas Altas, *Webster 24257.* Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger* (observation). †Butler Mts, leaf fragments, 740–8160 ybp (3 samples). †Tinajas Altas, leaf fragments, 4010–10,950 ybp (7 samples).

Viguiera parishii, see **Bahiopsis parishii**

Xanthisma spinulosum (Pursh) D.R. Morgan & R.L. Hartm. var. **gooddingii** (A. Nelson) D.R. Morgan & R.L. Hartm. [*Machaeranthera pinnatifida* (Hook.) Shinners var. *gooddingii* (A. Nelson) B.L. Turner & R.L. Hartm. *Haplopappus spinulosus* (Pursh) DC. subsp. *gooddingii* (A. Nelson) H.M. Hall] SPINY GOLDENWEED

Short-lived herbaceous perennials and also flowering in the first season. Ray and disk florets bright yellow, mostly in spring but also with summer rains.

Mostly in canyons and on slopes to the summit, and sometimes along washes and on the desert floor. This or a closely related *Xanthisma* has been in the flora region for more than 11 millennia.

Borrego Canyon, *Felger 92-617.* 1 mi N of Tinajas Altas, *Kurtz 1169.* †*X.* cf. *spinulosum*: Butler Mts, involucres, achenes, 740–11,250 ybp (7 samples). †Tinajas Altas, achenes, 4010 & 9900 ybp.

BORAGINACEAE—BORAGE FAMILY (INCLUDES HYDROPHYLLACEAE)

There are 17 species in this family recorded for the flora area and all are annuals or semi-herbaceous perennials and all except *Tiquilia* grow only during the cooler seasons (see Felger 2000).

1. Dwarf, suffrutescent perennials; stems with a forked branching pattern (pseudo-dichotomous); leaves with 2 or 3 (4) pairs of shallowly impressed veins, the leaf blades 3–8 mm long; flowers essentially sessile and axillary, the corollas lavender ____ **Tiquilia**
1. Winter-spring annuals or sometimes semi-shrubby and the corollas white; stems not forked; leaf veins not impressed, the blades often more than 8 mm long; corollas various colors.
   2. Plants stinky with glandular, viscid hairs; inflorescences helicoid (coiled like a scorpion tail); flowers lavender ____ **Phacelia**
   2. Herbage not viscid glandular; inflorescences helicoid or not; flowers of various colors.
      3. Plants with stiff, glassy or conspicuously harsh hairs; flowers white or yellow-orange; fruits with 1 or 4 nutlets.
         4. Flowers yellow-orange; nutlets 4, without a ventral groove ____ **Amsinckia**
         4. Flowers white; nutlets 1 or 4, with a ventral groove usually forked near the base, the nutlet attachment forms a triangular slit at the fork ____ **Cryptantha**
      3. Herbage softer or relatively so, the hairs not noticeably harsh; flowers white, pinkish, or lavender; fruits with 4 or more seeds.
         5. Leaves narrowly linear; corollas white; fruits of 4 nutlets spread open like tiny, open jaws with the marginal teeth ____ **Pectocarya**
         5. Leaves narrow or not, but not narrowly linear; corollas pinkish, purplish, or white; fruits not spread open as above, and not toothed, the seeds more than 4 (mostly many).
            6. Leaves sessile or the blade tapering into the petiole, the margins entire (sometimes inrolled); flowers pinkish or purplish ____ **Nama**
            6. At least the lower leaves petioled, the petiole and blade clearly differentiated, the blades pinnately lobed, toothed, or wavy.
               7. Stems slender and delicate; leaves pinnately lobed; flowers pale violet or lavender with a pale yellow throat ____ **Eucrypta**
               7. Stems thick, semi-succulent, short and stubby; leaf blades ovate; flowers whitish ____ **Phacelia neglecta**

AMSINCKIA—FIDDLENECK

Winter-spring annuals, mostly erect, the herbage with conspicuously coarse hairs. Flowers bright yellow-orange.

1. Calyx lobes 5, about equal in size; back of nutlets rough and arched with a high keel and sharp or ragged-edged ornamentations ____ **A. intermedia**
1. Calyx lobes unequal in size, with 5 or mostly 3 lobes with 1 or 2 lobes 2- or 3-toothed at tip due to fusion of lobes; back of the nutlets smooth, enamel-like with smooth-edged bumps (tessellated), not arched, the keel not raised or only slightly so ____ **A. tessellata**

Amsinckia intermedia Fisch. & C.A. Mey. DEVIL'S-LETTUCE, FIDDLENECK; CETKOM

Cool-season annuals. Plants rough-haired, the calyx lobes 5 and about equal in size, and the nutlets rough with ragged-edged ornamentations. Flowers yellow-orange.

Widespread in the region, from lowest to high elevations. Documented for the region from more than 11,250 years ago.

Camino del Diablo at Coyote Wash, *Felger 10-169.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Butler Mts, nutlet, 11,250 ybp. †Tinajas Altas, nutlet, 9230 ybp.

Amsinckia tessellata A. Gray var. **tessellata.** Desert fiddleneck; cetkom

Cool-season annuals resembling *A. intermedia*, but often more robust, and the calyx lobes 3 or 5 and unequal in size (often 2- or 3-toothed at tip due to fusion of lobes), the nutlets with smooth-edged bumps (tessellated). Flowers yellow-orange.

Sandy soils at least in the southern part of the Lechuguilla Valley. Common across the Cabeza Prieta Refuge. It has been in the region for at least 15,000 years.

Camino del Diablo at W boundary of Cabeza Prieta, *Felger 10-161.* †Butler Mts, nutlets, 10,360 ybp. †Tinajas Altas, nutlets, 9230–15,050 ybp (3 samples).

CRYPTANTHA

Winter-spring annuals and one species of long-lived annuals or short-lived perennials; growing and flowering only during the cooler seasons, the plants beset with harsh, glassy hairs. Flowers small and white. Fruits with 1 or 4 nutlets enclosed in a calyx covered with harsh, glassy hairs, the whole structure resembling a miniature bur. Nutlets all similar or dissimilar either in size and/or ornamentation and how readily they fall out of the calyx. Cryptanthas are among the most diverse and widespread plants in the region.

1. Nutlet margins knife-edged or winged.
   2. Calyx broad (lobes ovate to lance-ovate); nutlet wing usually as wide as the nutlet body and fringed with finger-like projections; annuals ____ **C. pterocarya**
   2. Calyx narrow (lobes lanceolate); nutlet wing narrow and bead-like (much narrower than the body) and entire; annuals to short-lived perennials ____ **C. racemosa**
1. Nutlet margins rounded or angled but not knife-edged or winged.
   3. Inflorescences or their branches obviously curled; flowers without bracts between them.
      4. Plants often about as wide as tall, branching from near base; flowers crowded in inflorescence; 1 of the 4 nutlets larger than the others ____ **C. angustifolia**
      4. Plants often taller than wide; flowers often not crowded in inflorescence; all 4 nutlets of the same size (or perhaps 1–3 per fruit) ____ **C. barbigera**
   3. Inflorescences or their branches not prominently curled; bracts present beneath (subtending) at least some flowers.
      5. Stems not especially slender and wire-like; roots and stems without conspicuous dye; bracts relatively few; nutlets 1 per fruit ____ **C. maritima**
      5. Stems slender and wire-like; roots and stems with copious purple dye; each flower subtended by a leaf-like bract; nutlets 4 per fruit ____ **C. micrantha**

Cryptantha angustifolia (Torr.) Greene. Narrow-leaf cryptantha, desert cryptantha

One of the most widespread and abundant cool-season annuals in the region. Flowers white. This is one of those itchy plants that gets in your socks and sleeping bag, revealing a dispersal mechanism.

Valley bottoms and plains, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Pass, *Reeves R5405* (ASU).

Cryptantha barbigera (A. Gray) Greene. Bearded cryptantha

Cool-season annuals; flowers white. The plants are sometimes sterile with abnormal growth due to infestations of mites.

Widespread across the flora area; sandy soils of washes and plains, and on rocky slopes to higher elevations. It was in the region more than 5100 years ago

Tinajas Altas Mts, above the tinajas, *Felger 98-137.* †Tinajas Altas, nutlets, 5080 ybp.

Cryptantha maritima (Greene) Greene [*C. maritima* var. *pilosa* I.M. Johnst.] White-haired cryptantha

Cool-season annuals; flowers minute. As with *C. barbigera*, the plants are sometimes deformed by mites and do not produce flowers. The varieties do not seem worthy of recognition; both occur intermixed (Felger 2000).

Common and widespread; washes and sand flats, and bajadas to rocky slopes at higher elevations. It has been in the region for more than 11,000 years.

Tinajas Altas, *Kearney 10905.* Canyon below Raven Butte Tank, *Felger 10-220.* Tinajas Altas Pass, *Reeves R5401* (ASU; annotated by Jeff Brasher, 2001, "mixed collection, var. *maritima* & var. *pilosa*"). †Butler Mts, calyx, nutlets, 740–10,360 ybp (3 samples). †Tinajas Altas, fruits, nutlets, 4010–11,040 ybp (8 samples).

Cryptantha micrantha (Torr.) I.M. Johnst. subsp. **micrantha.** Dwarf cryptantha

Cool-season annuals; plants diminutive with very slender stems, the roots and stems staining red-purple, the flowers

minute and white. This is the smallest cryptantha in the region. It is common in immediately adjacent regions and expected within the core flora area in sandy soils of valley bottoms and desert plains.

Cabeza Prieta Refuge: Pinta Sands, *Felger 92-17.*

Cryptantha pterocarya (Torr.) Greene var. **cycloptera** (Greene) J.F. Macbr. Wing-nut cryptantha

Cool-season annuals. Readily recognized by the broad sepals, green when fresh and only moderately hairy, relatively large fruits, and relatively large nutlets with broad, ornamented wings.

Widespread throughout the flora area; desert flats, bajadas, washes, canyons, and rocky slopes to highest elevations, and present in the region more than 11,000 years ago.

Tinajas Altas, *Van Devender 10 Mar 1980.* Canyon below Raven Butte Tank, *Felger 10-219.* †Butler Mts, nutlets, 10,360 ybp. †Tinajas Altas, nutlets, 11,040 ybp.

Cryptantha racemosa (S. Watson ex A. Gray) Greene. Bushy cryptantha

Annuals, highly variable in size, or short-lived perennial herbs or subshrubs; growing and flowering only during cooler seasons; flowers white. This species and *C. holoptera*, known from nearby northwestern Sonora, are the only cryptanthas in the region that survive more than one season.

Rocky slopes and sandy gravelly washes in the Tinajas Altas Mountains to higher elevations. It has been in the region for at least 11,000 years.

Vicinity of Tinajas Altas, 1700 to 1900 ft, on cliffs, *Van Devender 5 Mar 1983.* W end Tinajas Altas Pass, *Reeves R5423* (ASU; originally identified as *C. holoptera* (A. Gray) Macbr., the fruits are not mature). †Butler Mts, calyx, nutlets, 10,360 ybp. †Tinajas Altas, calyces, nutlets, 8970–11,040 ybp (3 samples).

†Cryptantha utahensis (A. Gray) Greene. Scented cryptantha

Annuals. This species was at Tinajas Altas 11,000 years ago and is presently in the Mojave Desert and pinyon-juniper regions of Mohave County, Arizona, above about 950 m, and also in east-central California to southwestern Utah.

†Tinajas Altas, calyx, nutlets, 11,040 ybp.

Eucrypta micrantha (Torr.) A. Heller. Desert hideseed

Delicate cool-season annuals, aromatic and viscid-glandular; leaves pinnately divided; flowers small, the corollas pale violet or lavender with a pale yellow throat.

Often in protected niches beneath shrubs or sheltered among rocks. Widespread; washes, bajadas, canyons, and rocky slopes.

Coyote Water, *Felger 05-134.* Tinajas Altas, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-229.*

NAMA—Purple mat

1. Plants semi-prostrate, matted; longer stem hairs 0.4 mm; corollas bright lavender-pink; seeds dark brown, about as wide as long _____ **N. demissum**
1. Plants erect with ascending branches, with age sometimes spreading-prostrate but not matted; longer stem hairs 0.8–1.2 mm; corollas pale lavender to purple; seeds yellowish, about twice as long as wide _____ **N. hispidum**

Nama demissum A. Gray var. **demissum.** Purple mat

Cool-season annuals, mostly semi-prostrate, low and often matted. Flowers bright lavender-pink.

Mostly along washes and gravelly soils of bajadas and plains; often in open, otherwise barren areas such as desert pavement. The plants are more compact, closer to the ground, generally smaller and with brighter and darker-colored flowers than the more common *N. hispidum*.

1 km SE of mouth of Borrego Canyon, *Felger 98-112.*

Nama hispidum A. Gray var. **spathulatum** (Torrey) C.L. Hitchc. [*N. coulteri* A. Gray] Bristly nama

Cool-season annuals, erect with ascending branches, or with age sometimes spreading-prostrate but not matted. Flowers pale lavender to purple.

Widespread and common across the flora area, especially washes, sandy flats, bajadas, and canyons.

Coyote Water, *Felger 04-52.* Tinajas Altas, *Felger 10-191.* Tinajas Altas Pass, *Reeves 5413* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-214.* Frontera Canyon, 18 Mar 1998, *Felger* (observation).

PECTOCARYA—Comb-bur, comb-seed

Small spring annuals. Leaves narrow, lower ones opposite, appearing as a basal rosette, the stem leaves alter-

nate. Inflorescences not helicoid or only moderately so. Flowers minute, at least sometimes cleistogamous; petals white. Nutlets 4, spreading open like tiny jaws, the margins variously toothed.

1. Nutlets not all alike (heteromorphic)—the pairs dissimilar in size and the margins also dissimilar, and each nutlet within a pair slightly different _____ **P. heterocarpa**
1. Nutlets all alike (or essentially so); the margins and marginal teeth lighter-colored (often yellowish) than the nutlet body _____ **P. platycarpa**

Pectocarya heterocarpa (I.M. Johnst.) I.M. Johnst. Mixed-nut comb-bur

Cool-season annuals; flowers minute, white with a yellow throat.

Widespread; sandy soils of washes and valley floor to the mountains. It was in the Butler Mountains more than 10,000 years ago.

Coyote Water, *Felger 05-137.* Tinajas Altas, *Felger 93-204.* †Butler Mts, nutlets, 10,360 ybp.

Pectocarya platycarpa (Munz & I.M. Johnst.) Munz & I.M. Johnst. Broad-wing comb-bur

Cool-season annuals. Similar to *P. heterocarpa* but the nutlets are noticeably larger with broader and usually yellowish wings.

Widespread including washes, desert flats, and bajadas to rocky slopes. It was at Tinajas Altas more than 10,600 years ago.

Coyote Water, *Felger 05-137A.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Tinajas Altas, nutlets, 10,600 ybp.

PHACELIA—Scorpion-weed

The phacelias in the flora area are cool-season annuals, glandular pubescent and can cause unpleasant dermatitis. Inflorescence branches are generally helicoid (curled at the tip like a scorpion tail) except in *P. neglecta*, and the flowers lavender, lavender blue, or white.

1. Plants not especially stinky; stems thick, stubby, and semi-succulent; leaf blades about as wide as long, more or less ovate; inflorescences generally not taller than the leaves; seeds many per capsule, solid, more or less terete in cross--section, similar on all sides _____ **P. neglecta**
1. Plants noticeably stinky; stems not noticeably thick and succulent, or at least not short and stubby; leaf blades more than twice as long as wide, pinnate to pinnatifid; inflorescences taller than the leaves; seeds 4 per capsule, boat-shaped, one side excavated (with a cavity) on either side of a septum (a ridge down the middle), the other side convex.
   2. Fruiting pedicels mostly 1.0–1.5 mm long, shorter than the capsules; fruiting sepals 3–5 mm long, about as long as to ¼ longer than capsules _____ **P. crenulata**
   2. Fruiting pedicels 4–7 mm long, longer than the capsules; fruiting sepals 5–6.5 mm long, about twice as long as the capsules _____ **P. pedicellata**

Phacelia crenulata Torr. ex S. Watson var. **ambigua** (M.E. Jones) J.F. Macbr. [*P. ambigua* M.E. Jones. *P. minutiflora* J.W. Voss ex Munz] Desert heliotrope, desert scorpion-weed

Cool-season annuals, mostly erect, stinky, glandular pubescent, and can cause unpleasant dermatitis. Inflorescence branches curved (helicoid or 'scorpioid'). Flowers lavender-purple. Seeds 4 per capsule.

This is the most abundant and widespread phacelia in the region; in many habitats including washes, canyons, bajadas, plains, and rocky slopes to their summits.

Coyote Water, *Felger 05-128.* Tinajas Altas, *Van Devender 5 Mar 1983.*

Phacelia neglecta M.E. Jones. Alkali phacelia

Short, stubby cool-season annuals, often less than 8 cm tall, semi-succulent with the main stem and root notably thick. Flowers white. Seeds many per capsule. Unlike most phacelias, the plants are not stinky and the inflorescences are short and not coiled (helicoid).

Generally occurring as small, highly localized populations on barren or nearly barren areas of desert pavement and pediments near mountain bases; not common in the flora area.

E margin of Davis Plain, W branch of Camino del Diablo, decomposed granite pediment directly downslope from rocky hill, *Felger 05-62.*

Phacelia pedicellata A. Gray. Pedicellate scorpion-weed

Robust plants, conspicuously glandular-pubescent with an offensive odor, the herbage often pale green. Flowering branches helicoid. Flowers pale lavender-blue. Seeds 4 per capsule.

Canyons bottoms and among rocks, especially on north- and east-facing mountain slopes, from base to higher elevations.

Tinajas Altas, canyon bottom E of tinajas, *Felger 98-145.* Tinajas Altas Canyon, *Felger 98-127.*

†**Phacelia** sp.

This is this only fossil record for a hydrophyll (Hydrophyllaceae, sensu stricto) in the flora area. The seeds are excavated on one side like those of many other phacelias with four seeds per capsule.

†Tinajas Altas, seeds, 1230 ybp.

Tiquilia palmeri (A. Gray) A.T. Richardson. Palmer's crinklemat

Low-growing perennials forming small semi-prostrate mats, the areal portions drying back during drought and re-sprouting from very slender roots issuing from deep, very thick, long, black roots. Stems with a forked branching pattern (pseudo-dichotomous). Leaves with 2 or 3 (4) pairs of shallowly impressed veins; the blades 3–8 mm long. Growing and flowering non-seasonally following spring and summer-fall rains; flowers essentially sessile and axillary, the corollas lavender-pink.

Sand flats and dunes near the Butler Mountains and expected near the Tinajas Altas Mountains and in the Lechuguilla Valley.

Butler Mts, *Van Devender 27 Mar 1983*.

BRASSICACEAE—Mustard Family

The nine species in the flora area are cool-season annuals except *Lyrocarpa*.

1. Fruits of 2 disk-shaped halves (spectacle-shaped) joined along less than 25% of their margins; flowers white and fragrant.
   2. Leaves with slender lobes; petals (fresh) 5–7 mm long; fruiting pedicels 7–20 mm long ____ **Dimorphocarpa**
   2. Leaves with broad, coarse teeth or lobes; petals (fresh) 10–12 mm long; fruiting pedicels 1.5–2.5 mm long ____ **Dithyrea**
1. Fruits not of disk-shaped halves; flowers various colors, fragrant or not
   3. Perennials (sometimes flowering in the first season); petals twisted, 12–20+ mm long; fruits usually widest well above the middle, 8–14 mm wide ____ **Lyrocarpa**
   3. Winter-spring annuals; petals not twisted, not more than 10 mm long; fruits widest at about the middle, less than 7.5 mm wide.
      4. Fruits less than twice as long as wide.
         5. Plants glabrous or with simple hairs; flowers inconspicuous, greenish or whitish; fruits compressed (flattened), 1- or 2-seeded ____ **Lepidium**
         5. Plants (including fruits) with stellate hairs; flowers bright yellow; fruits globose, not at all compressed, several-seeded ____ **Physaria**
      4. Fruits at least 3 times longer than wide.
         6. Fruits turned downward; fruiting pedicels 0.5–1.0 mm long; fruits terete and slender, 2.5–6.5 cm long; stems leafy, the leaves pinnatifid and more or less lanceolate ____ **Caulanthus**
         6. Fruits spreading or erect (not turned downward); fruiting pedicels 4 mm or more in length or if less than 3 mm then leaves all basal and broadly obovate and merely toothed (*Draba*).
            7. Herbage glabrous or with simple hairs; fruits 18–70 mm long ____ **Brassica**
            7. Herbage with forked, branched (dendritic), or stellate hairs; fruits 3.5–12 mm long.
               8. Herbage with branched, candelabra-shaped hairs (stalked and branched above); leaves finely divided, the stem leaves well developed; fruits nearly terete ____ **Descurainia**
               8. Herbage with forked and stellate hairs; leaves merely toothed (not divided), all basal; fruits laterally flattened ____ **Draba**

***Brassica tournefortii** Gouan. Sahara mustard; *mostaza del Sahara*

Cool-season annuals, extremely variable in size, less than 10 cm tall with leaves 1 cm long to sometimes near 1 m tall with leaves to 80 cm long. When dry and dead the larger plants may break off at the root and become tumbleweeds. Flowers pale yellow and apparently selfing (autogamous).

Widespread and seasonally common in lowland disturbed and natural sites across the flora area, especially on sandy soils; washes and valley plains, and sometimes extending onto rocky slopes and in canyons even at higher elevations.

Sahara mustard is the most seriously invasive species in the flora region. The broad, spreading basal-rosette leaves can effectively prevent establishment of other cool-season annuals. Densely crowded or drought-stressed plants may be less than 15 cm tall with leaves as small as 8 cm and be reproductive, whereas plants on sandy soils with sufficient soil moisture may grow to more than 1 meter across and nearly 1 m tall, making this species the largest herbaceous rosette plant in the region (see Felger 2000).

On March 28, 2010, Richard Laugharn and Felger poked around in the miniature mesquite thicket in the Lechuguilla Valley where the Camino del Diablo crosses Coyote Wash and Felger made the following observations: Much of the ground is now 100% covered by *Brassica tournefortii* of incredible size variation, but each local niche or micro-habitat

of *Brassica* generally has same-sized plants—some very crowded stands consist of dwarfed plants, some reproducing with only a single fruit with 3–7 seeds, the larger leaves 1.0 or 1.4 to several cm long, and basal rosette leaves often only 1–3 or sometimes not developing, the stems extremely slender, unbranched and the plants 8.7– 11.4 cm and more in height. Other, less crowded, robust plants have rosette leaves more than 30 cm long. Obviously *B. tournefortii* is changing the cool-season species composition in this habitat.

Native to the Old World, *B. tournefortii* has spread explosively across the Sonoran Desert, especially in sandy-soil habitats. The extreme plasticity in size and presumed selfing are likely components in its success as an invasive species. It was first reported from southeastern California by Jepson (1923–1925) and established in agricultural areas in southeastern California by 1938, recorded from Yuma in 1957, northwestern Sonora in 1966, and widespread across the Sonoran Desert region since at least the 1970s (Dimmitt & Van Devender 2009; Felger 2000; Malusa et al. 2003; Van Devender et al. 1997).

Coyote Water, *Felger 04-33.* Camino del Diablo at Coyote Wash, 28 Mar 2010, *Felger 10-172*. Surveyors Canyon, Lamb Tank, *Felger 10-197.* Canyon below Raven Butte Tank, *Felger 10-242*. Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation). Tinajas Altas Mts, above the tinajas, 19 Mar 1998, *Felger* (observation).

Caulanthus lasiophyllus (Hook. & Arn.) Payson [*Guillenia lasiophylla* (Hook. & Arn.) Greene. *Thelypodium lasiophyllus* (Hook. & Arn.) Greene] California mustard

Spring annuals; flowers minute, white or pink-purple. Fruits slender, straight or nearly so, terete, and turning downward as they mature.

Widespread; washes, valley plains, and mountains. Often in shaded niches beneath spinescent shrubs.

Coyote Water, *Felger 05-131*. Tinajas Altas Pass, *Reeves 5404* (ASU). Tinajas Altas, *Felger 10-181*. Tinajas Altas Mts, above the tinajas, 19 Mar 1998, *Felger* (observation).

Descurainia pinnata (Walter) Britton subsp. **ochroleuca** (Wooton) Detling. Western tansy-mustard; *pamita*; su'uvad

Spring annuals; leaves highly dissected, the flowers minute, pale yellow.

Widespread across the flora area, sandy to rocky soils, washes, plains, bajadas, hills, and mountains. Often in shaded niches, mostly beneath spinescent shrubs. This tansy mustard was an important medicinal plant. It was present in the region more than 10,000 years ago.

Vicinity of Tinajas Altas, *Van Devender 05 Mar 1983.* Coyote Water, *Felger 05-152*. Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, fruit, 10,360 ybp.

Dimorphocarpa pinnatifida Rollins. Dune spectacle-pod

Spring annuals, often becoming large and sprawling. Flowers white and fragrant; fruits of two disc-shaped segments, each 1-seeded.

A single, large and many-stemmed plant was encountered in the Tinajas Altas Mountains. It was probably a waif and apparently not reproducing, presumably due to lack of cross-pollination since they are outcrossers (Andrew Salywon, personal communication 2007). Endemic to dunes in nearby northwestern Sonora and southwestern Arizona.

Tinajas Altas, canyon bottom above uppermost tinaja, one large plant seen, no fruit setting, *Felger 98-138*.

Dithyrea californica Harv. California spectacle-pod

Spring annuals. Flowers cream white and fragrant.

Characteristically on sandy soils. Recorded east of the Butler Mountains and in the Pinta Sands in Cabeza Prieta Refuge.

Butler Mts, *Van Devender 27 Mar 1983*.

Draba cuneifolia Nutt. ex Torr. & A. Gray [*D. cuneifolia* var. *integrifolia* S. Watson. *D. cuneifolia* var. *sonorae* (Greene) Parish] Wedge-leaf draba

Small winter-spring annuals; leaves broad and in a basal rosette. Flowers small and white.

Seasonally common; washes, desert plains, sand flats, canyons, and rocky slopes especially in sheltered niches. This species or a similar one was at Tinajas Altas 11,000 years ago.

Camino del Diablo, SSE of Raven Butte, *Felger 05-36*. Tinajas Altas, 1200 ft, on slopes and in washes, *Reeves R5382* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †*D.* cf. *cuneifolia*, Tinajas Altas, fruits, 10,950 ybp.

Lepidium lasiocarpum Nutt. subsp. **lasiocarpum.** Sand pepper-weed; *lentejilla*

Cool-season annuals. Flowers small and inconspicuous; fruits disc-shaped and notched at apex.

Common and widespread; washes and flats, canyons, and less common on rocky slopes. It has benn in the region for at least 10,400 years.

Coyote Water, *Felger 05-130.* Tinajas Altas, wash floor above tanks, *Van Devender 10 Mar 1980.* Canyon below Raven Butte Tank, *Felger 10-233.* †Butler Mts, fruits with flattened pedicels, seeds, 8160 & 10,360 ybp.

†Lepidium sp./spp. Pepper-weed

Pepper-weed has been in the flora area for more than 18,700 years.

†Tinajas Altas, fruits, seeds, 8700–18,700 ybp (5 samples). Butler Mts, fruits, 11,250 ybp.

Lyrocarpa coulteri Hook. & Harv. Lyre-pod; ban censañig

Weak-stemmed and sprawling herbaceous perennials, sometimes to 1+ m tall, and sometimes flowering in the first season; plants with stellate hairs. Flowers especially fragrant at night, yellow to purple-brown, the petals slender and often twisted, often 1.5–2+ cm long. Growing and flowering any time of year with sufficient soil moisture.

Widespread in the mountains, often growing in the protection of large rocks and beneath shrubs and trees. Washes, canyons, gravelly bajadas, and rocky slopes to higher elevations. This is the only perennial member of the mustard family in the flora area.

Tinajas Altas, 29 Mar 1930, *Harrison 6563.*

Physaria tenella (A. Nelson) O'Kane & Al-Shehbaz [*Lesquerella tenella* A. Nelson] Desert bladderpod

Cool-season annuals; flowers bright yellow; fruits globose, hollow and bladder-like.

Widespread, especially at lower elevations; washes, sand flats, valley plains, and mountains, often growing in the protection of small shrubs.

Coyote Water, *Felger 04-58.* Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

†Thysanocarpus curvipes Hook. Lacepod

Cool-season annuals. Lacepod was well established in the flora region from at least 9000 to 15,000 years ago. The nearest present-day population is in the Agua Dulce Mountains on the east side of Cabeza Prieta Refuge.

†Butler Mts, 10,360 ybp. *Thysanocarpus* cf. *curvipes*, Tinajas Altas, 8970–15,050 ybp (8 samples).

BURSERACEAE—Torchwood Family

Bursera microphylla A. Gray. Elephant tree; *torote*; 'usabkam.

Large shrubs or small trees, with thick, semi-succulent limbs, and pungently aromatic drought-deciduous leaves. Flowers minute, cream-color, produced with the emerging leaves in the first summer rains.

Rocky slopes to peak elevations and sometimes on upper bajadas. The plants often show signs of repeated freeze damage. A large elephant tree in Frontera Canyon measured 4 m tall and 6 m across, with a trunk 110 cm tall and 130 cm in circumference. This species was at Tinajas Altas 6000 years ago, indicating a nearly frost-free habitat.

Tinajas Altas, *Vorhies 16 Apr 1924.* Tinajas Altas Mts, *Van Devender 86-12.* †Tinajas Altas, seeds, 5940 ybp.

CACTACEAE—Cactus Family

Some of the 13 cactus species in the present–day flora are defining aspects of the landscape, while others can be seen only by diligent searching. Two species, the many-headed barrel cactus (*Echinocactus polycephalus*) and beavertail cactus (*Opuntia basilaris*), do not range eastward from the arid, general region of the flora area.

1. Columnar cacti, becoming at least 2 m tall, the stems not constricted into joints or pads _____ **Carnegiea**
1. Not columnar cacti, less than 2 m tall.
   2. Large barrel cacti, usually unbranched (rarely 1- or 2-branched from base); stem more than 20 cm in diameter; larger spines stout and glabrous or with very minute non-overlapping hairs; flowers and fruits glabrous _____ **Ferocactus**
   2. Growth forms various, not large unbranched barrel cacti; individual stems less than 15 cm in diameter; spines generally not very thick and rigid (except in *Echinocactus* and *Grusonia*).
      3. Plants forming dense mounds of multiple stems ("heads") each 9–12 cm thick; spines very stout and rigid, tomentose with overlapping white hairs (use magnification); exterior of flowers and fruits copiously white-woolly _____ **Echinocactus**
      3. Plants not forming dense mounds, the stems mostly less than 7 cm thick and the spines not exceptionally stout and rigid, or plants with jointed stems; spine surfaces not covered with short hairs; flowers and fruits glabrous, scaly, or bearing spine clusters but not woolly.
         4. Chollas or prickly-pears; stems constricted into joints or pads; areoles with glochids (small spines deciduous at a touch).

5. Prickly-pear; stem segments (cladodes) compressed as short, thick pads, not tuberculate, with glochids but lacking larger spines ____ **Opuntia**
5. Chollas; stem segments ("joints") more or less rounded in cross-section (cylindroid), often tuberculate, with glochids and spines.
6. Plants often taller than wide; stems often with more than 6 joints; spines round in cross-section, the largest spines not pointing downward; spine sheaths covering most of each spine; fruits spineless or spiny ____ **Cylindropuntia**
6. Plants usually forming colonies much wider than tall; stems with 1–6 joints; larger spines flattened, sharp-edged and pointing downward; spine sheaths tiny, only at spine tips and soon deciduous; fruits densely spiny ____ **Grusonia**

4. Not chollas or prickly-pears; stems not constricted into joints or pads, without glochids.
7. Stems less than 2 cm diameter, more than 10 times longer than wide; spines rather inconspicuous, 1–8 mm long, not hooked; rare ____ **Peniocereus**
7. Stems 3–9 cm wide (if less than 3 cm then the central spines hooked), less than 5 times as long as wide; spines conspicuous, more than 8 mm long.
8. Most areoles with at least one hooked spine; flowers about 1 cm wide; fruits spineless even when young ____ **Mammillaria**
8. Spines straight or curved but not hooked; flowers more than 4 cm wide; fruits spiny at least when young ____ **Echinocereus**

Carnegiea gigantea (Engelm.) Britton & Rose [*Cereus giganteus* Engelm.] SAGUARO, SAHUARO; HA:SAÑ

This giant columnar cactus is the very symbol of the Sonoran Desert in Arizona and Sonora. The large white flowers open at night and usually remain open much of the following day; flowering late April through much of May. The fruits, with their sweet, juicy red pulp, ripen in June.

Common on upper bajadas and rocky slopes throughout the mountains. Saguaros have grown in the flora area for at least nine millennia—dates more than nine millennia may be due to contaminates.

Saguaro fruits are delicious, the fruits and seeds were major food resources, and the fruit pulp was made into wine. Saguaros are relatively uncommon near the tinajas, undoubtedly due to the desert bighorn that smash the stems with their horns in order to get to the succulent tissue (e.g., Russo 1956; Fig. 14).

†Tinajas Altas, seeds, 1230–8970 ybp (6 samples). †Butler Mts, seeds, 3820–11,250 ybp (4 samples; the oldest dates may be contaminants).

CYLINDROPUNTIA—CHOLLA; *CHOLLA*

Chollas are a conspicuous feature of the landscape and the most diverse cactus genus in the region.

1. Main axis or trunk well developed, straight and erect, often with persistent dead joints bearing blackened spines; joints (3) 4–6+ cm in diameter (excluding spines); tepals pale yellow-green ____ **C. bigelovii**
1. Main axis or trunk not well developed, or if so, then not straight and erect, and without persistent dead joints; joints 3 cm or less in diameter.
2. Joints mostly l cm or less in diameter, their surfaces readily visible through the spines, the lower areoles of each joint likely to bear only glochids; stems remaining green all year; tubercles "flat" and sharply defined with rhomboid (diamond-shaped) outlines; each areole in a groove ____ **C. ramosissima**
2. Joints 1.5 cm or more in diameter, their surfaces partially to fully obscured by spines, usually evenly spiny from tip to base of each joint.
3. Stem tubercles mostly 16–24 mm long; inner (larger) tepals orange-brown to dull golden-yellow, filaments red; basal tubercles of fruits much longer than the upper tubercles ____ **C. acanthocarpa**
3. Stem tubercles 11–16 mm long; inner tepals silvery white, the filaments green or yellowish; basal tubercles of fruits nearly equal to the upper ones ____ **C. echinocarpa**

Cylindropuntia acanthocarpa (Engelm. & J.M. Bigelow) F.M. Knuth var. **coloradensis** (L.D. Benson) Pinkava [*Opuntia acanthocarpa* Engelm. & J.M. Bigelow var. *coloradensis* L.D. Benson] BUCKHORN CHOLLA; *CHOYA*; CIOLIM (also called HANAMĬ, the general term for cholla)

Shrub-sized plants; flowers yellow-orange to dull golden yellow, March and April. Fruits become dry upon ripening in May.

Common and widespread on upper bajadas, canyons, and rocky slopes to higher elevations. The flower buds were prepared as a vegetable. This species has grown in the region for more than 10,000 years.

E end of Tinajas Altas Pass, *Reeves R5395* (ASU). Mesa just E of Tinajas Altas, *Felger 08-190*. SW side of Tinajas Altas range, flats adjacent to granitic hills, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–10,070 ybp (6 samples; variety unknown).

Cylindropuntia bigelovii (Engelm.) F.M. Knuth [*Opuntia bigelovii* Engelm.] TEDDYBEAR CHOLLA; *CHOYA GÜERA*; HADSADKAM (also called HANAMĬ, the general term for cholla). **Fig. 3.**

Often 0.5–1.5 m tall, the trunk erect, stout, straight, and usually beset with dead, persistent branches (joints). Flowers pale yellow-green; March and April. Fruits moderately fleshy, leathery, and yellow.

Abundant on desert pavements, sandy plains and flats, bajadas, pediments, and rocky slopes. It is a clonal species; the upper or younger joints fall at a touch, the spines are painful to pull out of your flesh, and the plants propagate prolifically from readily rooting fallen joints. Packrats have been collecting teddybear cholla for more than 15.7 millennia.

Tinajas Altas, *Mearns 348* (US). 0.5 km N of Tinajas Altas, *Reeves 5393* (ASU). Flats at SW side of Tinajas Altas range, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–15,680 ybp (10 samples). †Butler Mts, spines, seeds, 11,060 ybp.

Cylindropuntia echinocarpa (Engelm. & J.M. Bigelow) F.M. Knuth [*Opuntia echinocarpa* Engelm. & J.M. Bigelow. *O. wigginsii* L.D. Benson] SILVER CHOLLA

Small chollas (the plants generally smaller than those of *C. acanthocarpa*). Flowers silvery white with green filaments; March and April. Fruits dry upon ripening in late May and early June.

Upper bajadas at base of the mountains, onto sandy flats, and generally downslope of the somewhat simillar *C. acanthocarpa*.

SE side of Tinajas Altas Mts, 3 Feb 1990, *Felger* (observation).

Cylindropuntia ramosissima (Engelm.) F.M. Knuth [*Opuntia ramosissima* Engelm.] DIAMOND CHOLLA

Slender-stem chollas to 1 (1.2) m tall but usually much shorter, sometimes forming spreading colonies; the common name derives from the diamond-like pattern formed by the low-relief tubercles. Flowers small, pale yellowish to greenish brown or cream-color with reddish purple outer tepals; opening mid- to late-afternoon, April and May. Fruits dry at maturity.

Especially common on bajadas along the western side of the Lechuguilla Valley in the Goldwater Range and the Tinajas Altas region. This xerophytic cholla is documented from the Butler Mountains more than 10,400 years ago.

E end of Tinajas Altas Pass, *Reeves 5394* (ASU). Camino del Diablo SE of Raven Butte, *Felger 04-08.* SW side of Tinajas Altas range, flats adjacent to granitic hills, 10 Jan 2002, *Felger* (observation). †Butler Mts, stem, 10,360 ybp.

Echinocactus polycephalus Engelm. & J.M. Bigelow var. **polycephalus.** MANY-HEADED BARREL CACTUS, COTTON-TOP CACTUS, CANNONBALL CACTUS; *BIZNAGA*

Multiple-headed, mound-forming barrel cacti with a dense cover of stout spines; young areoles densely white woolly. The spine surfaces are red but covered by felt-like, overlapping, short, white hairs imparting a dull pink-gray color. This covering suddenly becomes translucent when wet, revealing the blood-red spine surfaces—the spines turn red in the rain but soon dry and revert to their usual dull color. Flowers yellow and confined (protected?) by the dense spine cover; flowering late May and June. Fruits densely woolly, drying soon after maturity, tenaciously held among the closely set spines and may remain in place for one year or more, the seeds falling as the fruits disintegrate. Scattered, mostly on upper bajadas and sandy valley flats.

People in Yuma call it the "cannonball cactus" by because of "the small rounded stems piled up." A giant mound-shaped plant on a sandy plain near the eastern boundary of the flora area measured 190 × 201 cm wide, 81 cm tall, and had more than 152 stems ("heads"). We have not seen seedlings or small juvenile plants, and recruitment presumably is a rare event.

This cactus has been in the Tinajas Altas region for more than 43,000 years. Evidence from the fossils indicates it was more common on rocky slopes than today, which is more like the habitat of the northern, or Grand Canyon population, var. *xeranthemoides* J.M. Coult., than that of var. *polycephalus*. In fact, the fossils may be more like the northern variety than the southern one.

0.5 km E of Camino del Diablo on road to Borrego Canyon, *Felger 90-20.* †Butler Mts, seeds, 3820–11,060 ybp (5 samples). †Tinajas Altas, spines, seeds, 9700–15,680 (4 samples), & >43,000 ybp.

Echinocereus engelmannii (Parry ex Engelm.) Lem. var. **chrysocentrus** (Engelm. & J.M. Bigelow) Rümpler. STRAWBERRY HEDGEHOG CACTUS; *PITAYITA*; 'ISVIGÏ

Stems several to many, branching mostly from near the base. Flowers very showy, 7.5–9 cm long, bright purple-magenta; flowering March and early April. Fruits sweet and edible, ripe late May and early June. Upon ripening, the fruit pulp and seeds are quickly consumed by a variety of animals, especially birds that poke a hole in the side of the fruit. Ants quickly finish off what the birds leave and hollowed-out fruits are common.

Widespread in the Tinajas Altas Mountains, upper bajadas and rocky slopes.

Tinajas Altas, *Blackwell SF-709.* Bajada at SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger* (observation). Ridge above Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

†**Echinocereus** sp./spp. (probably *E. engelmannii* and/or other species)

Hedgehog cacti have grown in the Tinajas Altas Mountains for more than 43,000 years. Three species and two varieties of present-day *Echinocereus* are known from Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge (Felger et al. 2007b; 2012).

†Tinajas Altas, seeds, 1030–10,600 (5 samples), & >43,000 ybp.

Ferocactus cylindraceus (Engelm.) Orcutt [*F. acanthodes* (Lem.) Britton & Rose. *F. acanthodes* var. *eastwoodiae* L.D. Benson] Mountain barrel cactus

Stem nearly always solitary, reaching 0.5–1+ m tall, straight (erect), becoming considerably taller than wide. Spines reddish pink; flowers yellow-green.

Widely scattered on upper bajadas and steep rocky slopes and cliffs. Barrel cacti are fairly scarce in the vicinity of the waterholes such as at Tinajas Altas and Surveyors Tank and on up to the peaks. Most of the larger ones grow on inaccessible cliffs and rock faces. Their scarcity near the tinajas is probably due to bighorn sheep, which dislodge the plants with their horns and eat the fleshy stem (Warrick & Krausman 1989).

This barrel cactus was at least reasonably common from about 11,000–3800 years ago, but its absence in younger middens indicates a decline in abundance and it is still locally not common. Is this change due to climate change or perhaps bighorn sheep, which knock over the plants and eagerly eat them? Across much of its geographic range this species characteristically occurs on rock slopes (e.g., Felger 2000).

Borrego Canyon, *Felger 90-5*. Lower slopes adjacent to Tinajas Altas, *Felger 08-182*. Near Camino del Diablo on road to Coyote Water, 24 Oct 2004, *Felger* (observation). †Butler Mts, spines, seeds, 3820–11,250 ybp (5 samples). †Tinajas Altas, seeds, 4010–10,070 ybp (10 samples).

Grusonia kunzei (Rose) Pinkava [*Opuntia kunzei* Rose. *O. stanlyi* Engelm. ex B.D. Jackson var. *kunzei* (Rose) L.D. Benson. *Corynopuntia kunzei* (Rose) M.P. Griff.] Desert club-cholla, devil cholla

Thick-stemmed club chollas, commonly forming sprawling colonies, and well armed with rather large and very sharp spines. Flowers pale yellow or cream-color; May and June, the fruits ripening late August through the following May.

Scattered on the mid-bajada and upper bajada of the Lechuguilla Valley.

Tinajas Altas, *Harbison 9 Mar 1937* (2 specimens, SD 16999 & 17000). Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation).

MAMMILLARIA

1. Seeds 1.6–2.4 mm long, the lower ⅓ covered with a light-colored, corky cup-like base, the seed surfaces reticulate and wrinkled but not pitted (Note: dried fruits can often be found below the spine clusters in the tubercle axils) _____ **M. tetrancistra**
1. Seeds slightly less than 1 mm long, without a corky base, the seed surfaces pitted _____ **M. grahamii**

Mammillaria grahamii Engelm. [Among the many synonyms are: *M. grahamii* var. *arizonica* Quehl. *M. grahamii* var. *oliviae* (Orcutt) L.D. Benson. *M. microcarpa* Engelm. *M. milleri* (Britton & Rose) Bödeker] Arizona fishhook cactus; *cabeza de viejo*; ban 'isvig, ban cekida

Small globose to cylindroid cacti with hooked spines. Flowers pink and rather showy, produced sporadically in pulses, generally following rainfall from April to September. Fruits red and fleshy, smooth, spineless, pleasantly edible; seeds small and black.

Widely scattered across the region; sandy and rocky soils; upper bajadas and rocky slopes at all elevations. A fishhook cactus, probably this species, has been at Tinajas Altas for more than 18,700 years.

Tinajas Altas, *Reeves 5391* (ASU). Granitic mountain at NW side of Raven Butte, *Felger 05-384*. SE side of Tinajas Altas Mts, 3 Feb 1990, *Felger* (observation). †*M.* cf. *grahamii*, Tinajas Altas, spines, seeds, 1230–18,700 ybp (11 samples).

Mammillaria tetrancistra Engelm. Cork-seed fishhook cactus; *cabeza de viejo*

Small globose to cylindroid cacti with hooked spines. Flowers pink, spring and summer; fruits red, fleshy, and spineless. Basal one third of each seed seated in a corky cup. Although the fleshy part of the fruit is edible, the corky seed-cup will make you spit it out—an easy way to identify this species. No other Sonoran Desert cactus has a corky seed-cup.

Rocky soils, hills and mountains, and sandy soils of upper bajadas. This is the most arid-inhabiting of all mammillarias.

Granite hill, SW side of Tinajas Altas Mts, *Felger 02-6*. Camino del Diablo SSE of Raven Butte, 20 Feb 2005, *Felger* (observation).

†**Mammillaria** sp./spp.

†Butler Mts, hooked spines, 740 & 3820 ybp (probably one or both of the present-day species).

Opuntia basilaris Engelm. & J.M. Bigelow var. **basilaris.** Beavertail cactus. **Fig. 18A, B.**

Dwarf prickly-pears with a very thick caudex and very thick, mostly upright and short pads. Areoles bear glochids but no spines. Flowers showy, rose-pink, the stamens with yellow filaments and yellow anthers; flowering early April; fruits ripe in late May.

Southwestern margin of Cabeza Prieta Refuge and the Tinajas Altas Mountains nearly to the summit although generally scarce on the higher slopes. Mostly on nearly barren desert pavements near the base of the mountain and arid, rocky lower slopes. It is especially common in parts of the Tinajas Altas Pass. Beavertail cactus has grown in the Tinajas Altas Mountains for more than 43,000 years.

In drought the pads shrivel and curl inward, and some or even most of the pads drop off in severe drought almost like deciduous leaves. Many pads have a dead, dried area below the old flowers or fruits—the pad tips seem to desiccate. In cultivation, such as in Tucson, these "dwarf" plants can become substantially larger than those in the wild.

Observations: Borrego Canyon, 3 Feb 1990, *Felger*; Tinajas Altas, 29 Nov 2001, *Felger.* †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–11,040 (8 samples), & >43,000 ybp.

†**Opuntia chlorotica** Engelm. & J.M. Bigelow. Pancake prickly-pear; *nopal rastrero*

Shrub-sized prickly-pears. The nearest present-day populations are in mountains in the eastern and central parts of the Cabeza Prieta Refuge and it is more common in the higher mountains of Organ Pipe Monument. This species generally occurs at the upper elevations of the desert and into oak-grassland. It grew at Tinajas Altas more than 11,000 years ago and has been in the Ajo Mountains for at least 32,000 years. Unlike most other cacti in the region, this species seems to have expanded its range during the wetter rainfall climates of the Wisconsin glacial environments, a time of greater winter rainfall and drastically reduced summer rains.

†Tinajas Altas, seed (actually the aril-covered seed), 11,040 ybp.

Peniocereus greggii (Engelm.) Britton & Rose var. **transmontanus** (Engelm.) Backeb. [*Cereus greggii* Engelm. var. *transmontanus* Engelm.] Desert night-blooming cereus; *reina de la noche, sarramatraca*; ho'ok wa'o

Stems slender, to ca. 1.5 m tall, 4-angled, grayish to grayish purple, mostly few-branched, from a single large tuberous root. Flowers large and white with a long tube; spectacularly fragrant, opening shortly after sunset and wilting quickly after sunrise. Fruits bright red throughout, the pulp juicy and sweet. Flowering occurs synchronously on one or a few nights between late May and July, the fruits generally ripening August and September and occasionally persisting until March.

Widely scattered across the Tinajas Altas Mountains, from the base to higher elevations often growing in the shelter of a nurse shrub. The plants are seldom encountered due to the cryptic nature of the stems and throughout its range it characteristically grows at low densities.

The fruits are edible as a fresh snack food. The roots have been utilized medicinally. Packrats are known to chew the stems like a popsicle. An old, forlorn plant at the Borrego Springs Tank was repeatedly eaten back to a stump by bighorn sheep (Broyles et al. 2007: 597).

Tinajas Altas: *Harbison 6 Mar 1937* (SD 16828); *Mearns 2811* (DS, US). E end Tinajas Altas Pass, *Reeves 5396* (ASU).

CAMPANULACEAE—Bellflower Family

Nemacladus orientalis (McVaugh) Morin [*N. glanduliferus* Jeps. var. *orientalis* McVaugh] Redtip thread plant

Small, cool-season annuals with wiry stems. Flowers small, the corollas white with red-tipped lobes.

Known from two localities in the flora area, although probably more widespread.

Coyote Water, *Felger 05-147.* Canyon below Raven Butte Tank, *Felger 10-235.*

CARYOPHYLLACEAE—Pink Family

The two species in the flora area are small, spring annuals.

1. Plants glabrous; stipules conspicuous, papery and white _____ **Achyronychia**
1. Plants densely and conspicuously glandular pubescent; stipules not papery and white _____ **Loeflingia**

Achyronychia cooperi A. Gray & A. Gray. Sand-mat, frost-mat

Cool-season annuals, small and prostrate growing with conspicuous white stipules. Flowers minute and white.

Fig. 18. Beavertail cactus (*Opuntia basilaris*). A) Dry season aspect, Tinajas Altas Canyon above the tinajas. 21 November 2008. Photo by RSF. B) Tinajas Altas Canyon just above the tinajas, 28 April 2010. Photo by JM.

Widespread, mostly on sandy soils in valley bottoms, washes, and bajadas.

Coyote Water, *Felger 04-22.* 1 mi N of Tinajas Altas Pass, W side of mts, *Van Devender 26 Mar 1983.*

Loeflingia squarrosa Nutt. [*L. squarrosa* subsp. *cactorum* Barneby & Twisselm.] Spreading pygmy-leaf

Dwarf, cool-season annuals, quickly forming a slender taproot and small, very compact cushion-like mats about 1 (5) cm wide and less than 2.5 cm tall, and sometimes as small as 3 × 3 mm. Plants glandular pubescent, the stems at least partially obscured by needle-like rigid leaves. Flowers minute and hidden among the leaves.

Locally common on partially barren pediments of decomposed granite on the east side of Tinajas Altas Mountains.

Tinajas Altas, adjacent to parking area, a large but highly localized population among white granitic gravelly soil in open areas without other plants, *Felger 93-202.*

CHENOPODIACEAE, see **AMARANTHACEAE**

CRASSULACEAE—Stonecrop Family

Succulent annual or perennial herbs.

1. Tiny, delicate winter-spring annuals; leaves opposite, less than 0.5 cm long ____ **Crassula**
1. Thick-stemmed perennials; leaves alternate in a rosette, more than 2 cm long ____ **Dudleya**

Crassula connata (Ruiz & Pav.) A. Berger [*C. connata* var. *eremica* (Jeps.) M. Bywater & Wickens. *Tillaea erecta* Hook. & Arn.] Pygmy stonecrop

Diminutive winter-spring annuals, the plants succulent, green, reddish, or yellow-green. Leaves bead-like. Flowers white, minute.

Sandy and gravelly soils of bajada slopes and canyons, widespread following favorable rains.

Camino del Diablo, SSE of Raven Butte, *Felger 05-26.* Tinajas Altas, sandy soil near spinescent shrubs, *Felger 10-184.*

Dudleya arizonica Rose [*D. pulverulenta* (Nutt.) Britton & Rose subsp. *arizonica* (Rose) Moran. *Echeveria arizonica* (Rose) Kearney & Peebles] Arizona liveforever

Perennials with very short, thick stems and rosettes of succulent leaves. Flowers yellow at base, yellow-orange above to red-orange towards tips; April and early May. Growing during cooler seasons and summer dormant. In late spring and early summer the larger leaves dry up and the remaining leaves shrivel and curl in over the center of the rosette, providing a close-fitting canopy over the dormant, central bud.

Mostly on bedrock slopes and cliffs, often north- and east-facing, commonly growing wedged in rock crevices. Common in the Tinajas Altas Mountains to peak elevations.

Tinajas Altas, *Vorhies 16 Apr 1924.* 1 mi N of Tinajas Altas, *Kurtz 1170.*

CROSSOSOMATACEAE—Crossosoma Family

Crossosoma bigelovii S. Watson. Ragged rock-flower

Unarmed shrubs to 1.5 m tall, evergreen or tardily drought deciduous. Flowers white and fragrant, mid-winter and early spring.

Often rooted in crevices in bedrock canyons or cliff faces in the Tinajas Altas Mountains. It has been established in the flora area for more than 43,000 years.

Borrego Canyon, vicinity of Borrego Tank, *Felger 93-194.* Tinajas Altas, *Webster 24254.* †Tinajas Altas, leaves, fruits, 4010–15,680 ybp (9 samples), & >43,000 ybp.

CUCURBITACEAE—Gourd Family

Vining annuals and perennials, the stems with tendrils, the flowers unisexual. The aerial parts of members of this family are frost-sensitive.

1. Mostly growing during cooler times of the year; flowers less than 0.5 cm wide; fruits obovoid-oblique (bilaterally symmetric in cross section), ca. 1 cm long; seeds 1 (2) ____ **Brandegea**
1. Mostly growing with warmer weather; flowers more than 2 cm wide; fruits round, 8–9 cm wide; seeds many ____ **Cucurbita**

Brandegea bigelovii (S. Watson) Cogn. Desert star-vine

Annuals growing with cool-season rains, fall to spring, perishing in late spring; sometimes growing as early as September. Slender, herbaceous vines from a stout, carrot-shaped white root. Leaves thin and highly variable. Flowers small, white, and delicately fragrant.

Sandy-gravelly and loamy soils of washes and their floodplains, often seasonally festooning shrubs and trees in green curtains.

Coyote Water, *Felger 05-139.* Tinajas Altas, 5 Dec 1935, *Goodding 2092.* Tinajas Altas Pass, *Webster 24256.*

Cucurbita digitata A. Gray and **C. palmata** S. Watson

Perennials from a large, tuberous root, the vines sprawling across the desert or climbing through shrubs. Growing and flowering during the warmer months. Flowers large and yellow. Fruit a round gourd 8–9 cm in diameter, mottled green and white, becoming yellow with age.

The leaves of juvenile plants or the first growth of the season of *C. digitata* are essentially indistinguishable from those of both the juvenile and adult leaves of *C. palmata*, although leaves on "adult" *digitata* stems are distinctive (Felger 2000). These taxa are part of a complex of several closely related, arid-region cucurbitas in southwestern United States and northwestern Mexico. The Tinajas Altas region is in the area of contact between the "eastern" (Arizona and Sonora) *C. digitata* and the "western" (Arizona, California, Baja California) *C. palmata* (e.g., Bemis & Whitaker 1965, 1969). The two can be distinguished as follows:

Cucurbita plants in the Tinajas Altas Mountains look like *C. digitata*, while ones on the sandy soils of the Lechuguilla Valley bajada look like *C. palmata*. Even so, these *palmata*-like plants have leaf lobes not as broad and short as in populations farther west in southeastern California and in Baja California.

1. Leaves on reproductive ("adult") stems divided nearly, or sometimes entirely to the base with linear, finger-like segments or lobes with a few large teeth ____ **C. digitata**
1. Leaves with broad, mostly triangular and entire lobes ____ **C. palmata**

Cucurbita digitata A. Gray. Finger-leaf gourd, coyote gourd; *calabacilla, chichi coyota*; 'ADAVI, 'AD

Infrequent along arroyo bottoms in the Tinajas Altas Mountains.

Tinajas Altas, 5 Dec 1935, *Goodding 2090.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). Tinajas Altas Pass, 1100 ft, washes, *Reeves R5408* (ASU).

Cucurbita palmata S. Watson. desert coyote-gourd

Infrequent on upper piedmont/bajada plains of the Lechuguilla Valley.

Camino del Diablo, E of Raven Butte, *Felger 01-584.*

EUPHORBIACEAE—Spurge Family

This large and diverse, mostly tropical and subtropical family is well represented in the Sonoran Desert. The flowers are small, mostly inconspicuous, and unisexual.

1. Shrubs.
   2. Stems slender, not succulent; sap not copious, not watery or blood-like; leaf margins crenulate-toothed ____ **Acalypha**
   2. Stems thick and semi-succulent; sap copious, watery or blood-like; leaf margins entire on short-shoot leaves or with a few broad lobes on long-shoot leaves ____ **Jatropha**
1. Annual or perennial herbs.
   3. Leaves alternate, opposite, or whorled; sap conspicuously milky; flowers in cyathia (small, compact, head-like inflorescences often about as wide as high) ____ **Euphorbia**
   3. Leaves alternate; sap not milky; flowers not in cyathia.
      4. Plants glandular-viscid and sticky, with simple hairs (glandular and non-glandular) ____ **Acalypha**
      4. Plants not glandular-viscid, the hairs 2-armed ____ **Ditaxis**

Acalypha californica Benth. [*A. pringlei* S. Watson] California copperleaf; *hierba del cáncer*

Shrubs or subshrubs with slender stems and glandular-sticky herbage; leaves gradually drought deciduous. Flowers small, generally reddish; flowering during warmer months with sufficient moisture.

Canyons, arroyo bottoms, and protected slopes in the Tinajas Altas Mountains.

Tinajas Altas, *Goodding 5 Dec 1935.*

DITAXIS

1. Subshrub perennials but often flowering in the first season; stems mostly erect and straight ____ **D. lanceolata**
1. Herbaceous, annuals or short-lived perennials; stems mostly ascending to spreading, or sometimes the main axis at first erect but the branches spreading and seldom straight.
   2. Leaves mostly ovate-elliptic, the tips mostly pointed, not truncate; seed surface usually with a reticulate pattern of shallow craters with fine radiating lines, hairs if present not sac-like and papillate; widespread but mostly not on sand flats and dunes ____ **D. neomexicana**

2. Leaves mostly obovate to spatulate, the tips mostly more or less truncate; seed surface smooth to sometimes faintly patterned, the narrower end often with sac-like or minutely papillate white hairs; mostly on sand flats and dunes _____ **D. serrata**

Ditaxis lanceolata (Benth.) Pax & K. Hoffm. [*Argythamnia lanceolata* (Benth.) Müll. Arg.] NARROWLEAF SILVERBUSH

Sparsely to densely branched perennial herbs to subshrubs. Herbage silvery pubescent. Flowers inconspicuous, white and green, flowering during the warmer months.

Common and widespread; washes, canyons, bajadas, and rocky slopes to summit elevations. Often heavily browsed, probably by bighorn. It was in the Butler Mountains about 8200 years ago.

Tinajas Altas, *Felger 04-72*. Borrego Canyon, 16 Jun 1992, *Felger* (observation). †Butler Mts, leaves, fruits, 8160 ybp.

Ditaxis neomexicana (Müll. Arg.) A. Heller [*Argythamnia neomexicana* Müll. Arg.] NEW MEXICO SILVERBUSH

Non-seasonal annuals or small, short-lived perennials. Flowers green and white, small and inconspicuous.

Common and widespread; washes, valley plains, bajadas, and rocky slopes. It has been in the flora area since more than 8600 years ago.

Camino del Diablo, SE of Raven Butte, *Felger 04-10*. †Butler Mts, leaves, fruits, seeds, 3820 & 8570 ybp.

Ditaxis serrata (Torr.) A. Heller var. **serrata** [*Argythamnia serrata* (Torr.) Müll. Arg.] SAND SILVERBUSH

Non-seasonal annuals or perhaps short-lived herbaceous perennials. Leaves gray-green. Flowers green and white, small and inconspicuous. Similar to *D. neomexicana* but the plants more robust and the leaf tips generally truncate rather than pointed. Perhaps they are not distinct species.

Sandy soils, bajadas and washes. In the flora area seen at the south end of the Tinajas Altas Mountains and common in nearby areas.

Mexico border at mouth of Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†**Ditaxis** sp./spp.

†Tinajas Altas, seeds, 5860 to 8255 ybp (3 samples).

EUPHORBIA—SPURGE

Annuals and perennial herbs with milky sap. The individual flowers are generally minute and borne in a cup-like structure, the cyathium, which looks somewhat like a single flower. The petal-like (petaloid) appendages of the cyathia of some species can be attractive and the whole structure is indicated here as the "flower." In Mexico the *Chamaesyce* are generally known as *golondrina*, the term for a swan, apparently in reference to the female flower on a curved, neck-like stalk, and the general Hia C'ed O'odham name is *v'ibam* (see *E. polycarpa*).

1. Plants not prostrate; leaves alternate below and opposite or whorled above, symmetrical, and narrowly linear, less than 3 mm wide _____ Subgenus ***Agaloma*: E. eriantha**
1. Plants prostrate or not; leaves all opposite, asymmetric toward the base, linear or not _____ Subgenus ***Chamaesyce***
   2. Plants glabrous; stems orange; seeds smooth, flattened, more 2 mm long, not mucilaginous when wet _____ **E. platysperma**
   2. Plants glabrous or pubescent; stems not orange; seeds smooth or sculptured, not flattened, not more than 1.2 mm long, mucilaginous when wet.
      3. Petaloid appendages absent (sometimes not developed in young cyathia or drought-stressed plants, these plants key out in both choices).
         4. Leaf margins entire or few toothed mostly near apex; involucral glands rounded, 0.1–0.15 mm wide; seeds 1–1.2 mm long, with transverse ridges _____ **E. abramsiana**
         4. Leaf margins entire; involucral glands oval, 0.3 mm or more in width; seeds 0.8–1 mm long, the surfaces smooth _____ **E. polycarpa**
      3. Petaloid appendages present
         5. Petaloid appendages with triangular, pointed segments, the cyathia thus appearing "star-shaped" _____ **E. setiloba**
         5. Petaloid appendages entire, about as wide or wider than long, blunt-tipped, not pointed.
            6. Leaf margins entire to few toothed mostly near apex; involucral glands rounded, 0.1–0.15 mm wide; seed 1–1.2 mm long, with transverse ridges _____ **E. abramsiana**
            6. Leaf margins entire; involucral glands oval, 0.3 mm or more in width; seeds 0.8–1 mm long, the surfaces smooth _____ **E. polycarpa**

Euphorbia abramsiana L.C. Wheeler [*Chamaesyce abramsiana* (L.C. Wheeler) Koutnik] DESERT SANDMAT; *GOLONDRINA*

Small annuals, mostly prostrate, growing with hot-season rains and probably also with cool-season rain. Herbage often brownish or reddish. The minute cyathia, reduced petaloid appendages, and glabrous capsules are distinctive features.

Sandy and gravelly soils; washes and sandy flats of the Lechuguilla Valley.

Coyote Water, 25 Oct 2004, *Felger 04-44*. Coyote Wash at Camino del Diablo, 25 Oct 2004, *Felger 04-68*.

Euphorbia eriantha Benth. BEETLE SPURGE

Non-seasonal annuals mostly encountered in spring, occasionally short-lived perennials; often with a solitary or few-branched main axis and sparsely branched above, and sparse foliage. Flowers inconspicuous; ovary and capsule covered with short, white hairs.

Sandy, gravelly soils of washes and bajadas of the Lechuguilla Valley and scattered in canyons and slopes in the mountains.

Camino del Diablo, SE of Raven Butte, *Felger 04-12*. Canyon above Tinajas Altas, 18 Mar 1998, *Felger* (observation). Coyote Water, 25 Oct 2004, *Felger* (observation). Vicinity of Coyote Wash along Camino del Diablo, *Yeatts 3242* (CAB).

Euphorbia platysperma Engelm. ex S. Watson [*Chamaesyce platysperma* (Engelm. ex S. Watson) Shinners] DUNE SPURGE

Non-seasonal annuals to herbaceous perennials. Plants glabrous; stems orange, many and sprawling, with sand adhering to the glandular-sticky buried portions of the stems forming a sand jacket. Leaves elliptic to oblong or obovate, relatively thin, the midrib prominent. "Flowers" yellowish. Seeds smooth, flattened, markedly longer than wide (2.4 × 1.4 mm). The seeds are larger than most *Chamaesyce* species and not mucilaginous, unlike those of the other *Chamaesyce* in the flora area that become moderately or conspicuously mucilaginous when wet and adhere tenaciously to a substrate upon drying.

This species is rare in Arizona and California. It is a dune and sand soil endemic, common in the Gran Desierto dunes of northwestern Sonora, and also known from extreme northeastern Baja California, and Arizona on dunes and sand soil at the southwestern margin of the flora area west of Tinajas Altas Mountains near the Mexican border, and occasional waifs are recorded from southeastern California dunes (Felger 2000; Felger et al. 2007b).

NW corner of Yuma Dunes, 7.4 km N of Mexico border, *Douglas 876* (ASU).

Euphorbia polycarpa Benth. [*E. polycarpa* var. *hirtella* Boiss. *Chamaesyce polycarpa* (Benth.) Millsp.] DESERT SPURGE; *GOLONDRINA*; VI'IBAM

Plants highly variable: non-seasonal annuals, sometimes becoming reproductive a few weeks after germination, and also occurring as small perennials. "Flowers" maroon and white, or drought-stressed plants may fail to develop the white, petal-like appendages.

This is the most common and widespread euphorbia in the region. Sandy soils of washes and bajada-plains, and rocky slopes.

Camino del Diablo, SE of Raven Butte, *Felger 04-13*. Wash, ca. 2 mi SE of Tinajas Altas, *Felger 08-205*. Granitic hills, SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger* (observation).

†**Euphorbia** cf. **polycarpa** &/or **E. micromera** Boiss. ex Engelm.

One or both of these species were in the region more than 10,000 years ago. Their seeds appear identical and the two taxa are distinguished by subtle differences in the cyathia.

†Butler Mts, capsules, seeds, 8160 & 10,360 ybp.

Euphorbia setiloba Engelm. ex Torr. [*Chamaesyce setiloba* (Engelm. ex Torr.) Millsp.] FRINGED SPURGE; *GOLONDRINA*

Non-seasonal annuals, especially with summer-fall rains. Plants glandular-pubescent, the herbage yellow-green during hotter months, otherwise reddish. Cyathia with seven tooth-like white or pink appendages (hence the specific name) giving the flower cluster a unique star-like look. The plants are frost-sensitive.

Widely scattered, probably mostly at low elevations; often in broad, sandy-gravelly washes, canyon bottoms, and bajadas.

Camino del Diablo, SE of Raven Butte, *Felger 04-14*. Wash, 2 mi SE of Tinajas Altas, *Felger 08-205*.

†**Euphorbia** sp./spp. (*Chamaesyce*)

One or more unidentified *Chamaesyce* were at Tinajas Altas at least 5,000 to more than 11,000 years ago.

†Tinajas Altas, capsules, 5940–11,040 ybp (4 samples).

Jatropha cuneata Wiggins & Rollins. DESERT LIMBERBUSH; *SANGRENGADO*; VA:S

Shrubs often 1–1.5 m tall, oozing blood-like sap when cut—hence the name *sangrengado* (dragon's blood). Leaves drought deciduous, appearing with rains at various seasons except during the coldest weeks or months. Flowers small and white, with rains from July to October. Stems sometimes freeze-damaged during severe winters.

Common and widespread on rocky slopes and upper bajadas south of Tinajas Altas Pass, uncommon or absent farther north. This was the most common plant for basket-making by the Hia C'ed O'odham. The one prehistoric record in the region is about 1250 years old.

Tinajas Altas, near base, *Harrison 6567*. Borrego Canyon, 3 Feb 1990, *Felger* (observation). †Tinajas Altas, 550 m, leaves, seeds, 1230 ybp.

FABACEAE—Legume Family

Annual or perennial herbs, shrubs, trees, or vines, many with nitrogen-fixing bacteria in root nodules. Leaves alternate and once- or twice-pinnately or palmately compound. The trio of *Olneya*, *Parkinsonia,* and *Prosopis* are the most important desert trees of the region and are significant nurse plants for an array of herbs and larger perennials including saguaros. These trees featured importantly in the economies of the local peoples for food, fuel, shelter, fiber, medicine, and provided some of the rare shade (e.g., Felger 2007; Felger & Moser 1985; Felger et al. 1992; Hodgson 2001; Rea 1997). The Sonoran Desert flora includes 281 legume species, or about 11% of the total flora, while legume species make up only 4% of our flora.

1. Trees and woody shrubs, often more than 1 m tall.
   2. Bark remaining green for multiple years; flowers yellow, caesalpinioid ____ **Parkinsonia**
   2. Bark not green as above; flowers yellow or not, mimosoid or papilionoid.
      3. Leaves once pinnate; flowers papilionoid.
         4. Trees mostly more than 3 m tall with woody trunks; herbage not gland-dotted; leaves with more than 5 leaflets; common ____ **Olneya**
         4. Shrubs not more than 1 m tall, scarcely woody; herbage gland-dotted; leaves with 3 or 5 leaflets; rare ____ **Psorothamnus**
      3. Leaves twice pinnate; flowers mimosoid.
         5. Spines straight; leaflets more at least 4.5 mm long; stamens 10; pods relatively thick, not conspicuously flattened, and with conspicuous mesocarp (pulp) ____ **Prosopis**
         5. Spines (actually prickles) recurved; leaflets 1.5–3 mm long; stamens more than 30; pods flattened (ribbon-like) and dry (without mesocarp, or pulp) ____ **Senegalia**
1. Annuals and herbaceous perennials, less than 1m tall; flowers papilionoid.
   6. Leaves with (3) 5–7 leaflets; flowers solitary or in umbels, yellow or orange and red ____ **Acmispon**
   6. Leaves with 5–23 leaflets; flowers in racemes, purple and white or pale lavender-pink.
      7. Herbage conspicuously gland-dotted; leaves pinnately compound; calyx lobes extending into awn-like plumose bristles; pods indehiscent, less than 3 mm long, 1-seeded ____ **Dalea**
      7. Herbage not gland-dotted; leaves digitately compound; calyx lobes not awned; pods dehiscent, 4 mm or more in length, with 2 or more seeds ____ **Lupinus**

Acacia, see **Senegalia**

ACMISPON

Annuals or herbaceous perennials. Leaves pinnate with 3–7 leaflets. Flowers yellow to red-orange, pea-like. Pods multiple seeded.

1. Perennials; stems firm and upright, the internodes notably longer than the leaves; flower stalks much longer than the leaves; flowers 1.5–2 cm long ____ **A. rigidus**
1. Winter-spring annuals; stems not firm, ascending or prostrate, the internodes usually not longer than the leaves; flowers nearly sessile or on peduncles shorter to slightly longer than the leaves; flowers less than 1 cm long ____ **A. strigosus**

Acmispon rigidus (Benth.) Brouillet [*Lotus rigidus* (Benth.) Greene. *Hosackia rigida* Benth.] Desert rock-pea

Perennial subshrubs with sparse foliage. Flowers 15–20 mm long, the corollas at first bright yellow, a red-orange nectar guide soon develops, and with age the entire corolla becomes red-orange.

Nearly throughout the Tinajas Altas Mountains, arroyos and canyons among boulders and rocky slopes, often east- and north-facing. Documented at Tinajas Altas from about 4000–10,800 years ago.

Tinajas Altas, *Harrison 3610.* Tinajas Altas, crevices in granite, 1400 ft, *Engard 925* (ASU). Surveyors Canyon, canyon bottom just below Surveyors Tank, *Felger 10-203*. Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, fruits, seeds, 4010–10,750 ybp (7 samples).

Acmispon strigosus (Nutt.) Brouillet [*Hosackia strigosa* Nutt. *Lotus strigosus* (Nutt.) Greene var. *tomentellus* (Greene) Isely. *Ottleya strigosa* (Nutt.) D.D. Sokoloff] Hairy lotus

Winter-spring annuals, mostly low growing or prostrate; leaves succulent on well-watered plants. Flowers 7.5–9 mm long, the petals bright yellow with red nectar guidelines on the banner.

Washes and canyon bottoms, and soil pockets on rocky slopes.

Tinajas Altas, *Van Devender 9 Mar 1980.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

Cercidium, see **Parkinsonia**

Dalea mollis Benth. Silky dalea

Non-seasonal annuals; flowers small, purple and white.

Strangely, there are no modern records of this widespread desert annual from the core Tinajas Altas area although it occurs in adjacent areas. It was at Tinajas Altas about 5900–6000 years ago.

E margin of Davis Plain at base of Gila Mountain, W branch of Camino del Diablo, 965 ft, in rock crevices and nearby on sandy soil, *Felger 05-67*. †Tinajas Altas, fruits, 5860 & 5940 ybp.

Lotus, see **Acmispon**

Lupinus arizonicus (S. Watson) S. Watson [*L. arizonicus* subsp. *sonorensis* J.A. Christian & D.B. Dunn] Arizona lupine; *lupino*; tas ha:hag

Winter-spring annuals, the herbage sometimes semi-succulent. Flowers pale lavender-pink.

Widespread in lowland habitats, especially washes, and bajadas; also canyons in the Tinajas Altas Mountains to at least 1530 ft.

Tinajas Altas, *Van Devender 25 Mar 1983*. Tinajas Altas Pass, *Reeves R5400* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-212*.

†**Lupinus** sp./spp.

Lupines are documented for the region for nearly 10,000 years.

†Butler Mts, fruits, calyx, seeds 740 & 3820 ybp. †Tinajas Altas, seeds, 1230–9900 ybp (9 samples).

Olneya tesota A. Gray. Ironwood; *palo fierro*; ho'idkam

Large shrubs or trees, the trunks and limbs often massive, and the wood extremely hard. Leaves gradually deciduous in extreme drought and prior to flowering. Flowers pea-like, pale to dark pink-lavender; mass flowering in late April and May during years of sufficient rainfall; each tree and population might not flower each year.

Widespread along washes, major drainageways, bajada-plains, mountain canyons, and infrequent and usually of smaller stature on rocky slopes. A number of mighty ironwoods are scattered about the arroyo-wash between the Mesa del Muerto and the lower tinajas, and the largest known one in the region, in Coyote Wash, is more than 12 m tall with a massive trunk (Fig. 19). This species is one of the several most common and important trees in the region and one of the favorite foods of desert bighorn and many small mammals. *Olneya* is one of the longest-lived trees in the Sonoran Desert and a prominent nurse plant for numerous other plants (Turner et al. 1995). Desert ironwood has grown in the region for nearly 10,000 years, which is the oldest known record for this species anywhere.

Olneya was an important source of wood and fuel, and the seeds were variously prepared for food (Felger 2007). Many large, old ironwood stumps can be seen throughout the region. For example, numerous large ironwood stumps and limbs in Frontera Canyon appear to be axe- or saw-cut, and many such stumps were noted on the desert flats about 1.5 miles south of the Tinajas Altas site. The ironwood population has largely recovered from the extensive wood-cutting in the nineteenth and first half of the twentieth centuries. Bryan (1925: 422) wrote that at Tinajas Altas, "A few palo verde or ironwood trees are still standing and may furnish horse feed, but the traveler should bring his own firewood."

Tinajas Altas, wash just E of the tinajas, *Felger 08-171*. Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, spines, leaves, fruits, 740–8570 ybp (3 samples). †Tinajas Altas, twigs with spines, leaflets, 1230–9900 ybp (4 samples).

PARKINSONIA—Palo verde

Trees and large, heavy-branched shrubs with green bark and relatively soft wood. Leaflets small, the leaflets and leaves quickly drought deciduous, the leaflets often falling independently; leaves twice pinnate or appearing once pinnate. Flowers yellow, caesalpinioid, produced in prodigious quantities in spring. Pods ripening in early summer, indehiscent to tardily partially dehiscent, 1–several-seeded.

1. Twig tips not spinescent; solitary or paired axillary spines often present; leaves petioled, the leaflets mostly 5–9 mm long ____ **P. florida**
1. Twig tips spinescent; axillary spines none; petiole absent, leaves with two sessile pinnae, the leaflets mostly 1–3.3 mm long ____ **P. microphylla**

Parkinsonia florida (Benth. ex A. Gray) S. Watson [*Cercidium floridum* Benth. ex A. Gray] BLUE PALO VERDE; *PALO VERDE*; KO'OKOMADK, KALISP. **Fig. 15.**

One of the several larger tree species in the region, usually with a well-developed trunk. Flowers bright yellow; mass flowering in spring and sometimes sporadically in fall.

Blue palo verde trees are fairly common in canyon bottoms and the larger washes along the eastern side of the Tinajas Altas Mountains, such as the broad wash leading out of Borrego Canyon, and many of the small washes on the upper bajada. Only two or three blue palo verdes, however, were found between 2000 and 2006 in the wash below Tinajas Altas, the absence of more of the trees perhaps due to earlier woodcutting, but by 2008 even these trees were gone, apparently due to drought and firewood collecting by visitors. Although the soft wood is of poor quality for fuel, it was utilized because little else was available. The seeds served as food for people. The trees were common on the Davis Plain west of the Gila Mountains, although many of them perished during extreme drought of 2004 and 2005. Palo verdes and ironwoods were not seen along Coyote Wash in the vicinity of Coyote Water, yet palo verde is common and ironwood present only eight km south in La Jolla Wash. At the northern end of the study area, blue palo verde replaces foothill palo verde in certain unexpected circumstances, such among the basalt boulders of Raven Butte—hardly typical habitat, but the basalt is a veneer atop course granitic alluvium, and perhaps well drained and not so different from an arroyo. This species has been in the region for at least 8300 years.

Tinajas Altas, wash, *Van Devender 86-11*. Arroyo 2 mi SE of Tinajas Altas, *Felger 08-195*. Borrego Canyon, 16 Jun 1992, Felger (observation). Camino del Diablo, E of Raven Butte, 25 Oct 2004, *Felger* (observation). Canyon wash at NW side of Raven Butte, 30 Dec 2005, *Felger* (observation). †Butler Mts, twigs, spines, fruits, 740 & 3820 ybp. †Tinajas Altas, twigs, spines, 4010 & 8255 ybp.

Parkinsonia microphylla Torr. [*Cercidium microphyllum* (Torr.) Rose & I.M. Johnst.] FOOTHILL PALO VERDE, LITTLE-LEAF PALO VERDE; *PALO VERDE*; KEK CEHEDAGÏ

Small trees or large shrubs. Flowers pale yellow with a white banner petal; mass flowering in April and early May.

Upper bajadas on the east side of Tinajas Altas Mountains; canyons, washes, and rocky slopes from the base to higher elevations on all slope exposures in the mountains but scarce north of Tinajas Altas Pass. The seeds were a significant food resource for people.

Tinajas Altas Canyon, *Felger 08-177*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Prosopis glandulosa Torr. var. **torreyana** (L.D. Benson) M.C. Johnst. [*P. juliflora* (Sw.) DC. var. *torreyana* L.D. Benson. *P. odorata* Torr. & Frém., sensu R. Palacios 2006] WESTERN HONEY MESQUITE; *MEZQUITE*; KUI

Trees and shrubs. Leaves appearing simultaneously in spring after the last freezing weather, the plants gradually become deciduous in winter. Leaves with one pair of pinnae. Flowers dull yellow; mass flowering April and May, and sporadically through early fall; pods mostly ripening in early summer and sporadically through fall.

Mesquites are concentrated along the larger drainageways where the largest trees occur, especially along Coyote Wash where the larger ones are about 8 m tall. Also in the wash below Tinajas Altas, and in the larger canyons and arroyos running out of the mountains. Only a few were found in the canyon above the Tinajas and none were seen at the higher elevations. Many animals consume the pods, which are a primary seasonal food for coyotes.

Mesquite was the single most useful plant in the Sonoran Desert; providing wood for construction, tools, utensils, and weapons, and was the preferred cooking fuel. The mesocarp of the pods was a major food resource. The roots were fashioned into cordage. The whitish gum is edible and was used medicinally, as was the black pitch oozing onto the bark. This black pitch was also used as dye (Felger 2007; Felger & Moser 1985).

Mesquites in the flora area have leaves with one pair of pinnae and the typically elongated and rather widely spaced leaflets characteristic of *P. glandulosa*, but some specimens are conspicuously pubescent like *P. velutina* rather than being glabrate or glabrous as in "typical" *P. glandulosa*. The Tinajas Altas population is within a broad area of mesquites of intermediate appearance (Felger 2000).

Coyote Water, *Felger 04-62*. Base of Tinajas Altas, *Harrison 6581*. 1 mi N of Tinajas Altas, 17 Apr 1948, *Kurtz 1175* [herbage pubescent]. Surveyors Canyon, canyon bottom below Surveyors Tank, *Felger 10-216*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†Prosopis glandulosa &/or **P. velutina** Wooton. MESQUITE

Mesquite has been well established in the region for more than 18,750 years. The fossil specimens do not allow us to determine which of the two species were gathered by Ice Age packrats.

†Butler Mts, leaflets, 740 & 8160 ybp. †Tinajas Altas, spines, leaflets, endocarps, 1230–18,700 ybp (14 samples).

Fig. 19. An exceptionally large ironwood (*Olneya tesota*) in Coyote Wash. Vegetation scientist Peter Sundt is 2 m tall. 5 March 2011. Photo by JM.

Psorothamnus fremontii (Torr. ex A. Gray) Barneby [*Dalea fremontii* Torr. ex A. Gray] Fremont's dalea

Shrubs less than 1 m tall, gland-dotted and generally pubescent (silvery strigose). Leaves odd-pinnate, with 3 or 5 leaflets, and leafless or essentially so in drought. Inflorescence a raceme, the flowers 7–9.5 mm long, pea-like and bright violet-purple. Pods indehiscent, 1-seeded, 7–10 mm long, with small glands forming longitudinal lines. [Description based on plants from farther north in Arizona and the Jepson Manual (Hickman 1993)].

A single shrub of this species was found at the north end of the Sierra de la Lechuguilla at the south end of the Lechuguilla Valley. Fremont's dalea is common farther north with three southern disjunct records: this one, one near the Colorado River in southeastern California collected in 1969, and one in Yuma collected in 1905 (e.g., Southwest Environmental Information Network 2011). This species occurs in the Sonoran and Mohave Deserts in California, Nevada, Utah, and Arizona, Sonora, and Baja California. Additionally, there is a single southern disjunct record of *P. arborescens* (Torr. ex A. Gray) Barneby var. *arborescens* from Puerto Peñasco in northwestern Sonora (*H.L. Cookin 1934* at DS/CAS; Barneby 1977: 33; Felger 2000).

The single specimen from the flora area was collected during a dry season—there were a few buds and no flowers. Two varieties are described: var. *fremontii* generally grows on sedimentary rocks, while var. *attenuatus* Barneby is on granitic and volcanic rocks (Turner et al. 1995). This species, however, may not be distinct from *P. arborescens*, both of which have somewhat similar distributions primarily north of the Sonoran Desert in dry regions of California, Nevada, Arizona, and Colorado (Barneby 1977; Turner et al. 1995).

Rounded hills along La Jolla Wash, between the Sierra de la Lechuguilla and the Tinajas Altas, UTM 2 18 915 E, 35 73 341 N, Zone 12, WGS 84, 1050 ft, shrub about 0.8 m tall, uncommon, with *Larrea*, *Ambrosia dumosa*, *Fagonia californica*, & *Parkinsonia microphylla*, *Sundt, MacKinnon, & Malusa 2 Apr 2011.*

Senegalia greggii (A. Gray) Britton & Rose [*Acacia greggii* A. Gray] Catclaw; *uña de gato, gatuño*; 'u:pad

Large, irregularly branched shrubs or small trees, the twigs bearing sharp, recurved internodal prickles (spines). Leaves gradually winter deciduous. Flowers pale yellow, in spring and occasional at other seasons; pods flattened, ribbon-like, and usually curved or curled, and ripening in early summer.

Lechuguilla Valley in larger washes and less often along smaller drainageways of the bajada, and Tinajas Altas Mountains in washes, canyons, and rocky slopes, especially east- and north-facing, from low to high elevations. Catclaw is one of the favorite foods of desert bighorn (Russo 1956). Packrat collections show it has been in the Tinajas Altas Mountains for more than 43,000 years.

Coyote Water, *Felger 04-21.* Wash just E of Tinajas Altas, *Felger 08-188.* Canyon above Tinajas Altas, 26 Oct 2004, *Felger* (observation). †Butler Mts, stem prickles, leaflets, fruit fragments, 740 to 8160 ybp (3 samples). †Tinajas Altas, twigs (prickles), leaves, 1230 to 11,040, & >43,000 (14 samples).

FOUQUIERIACEAE—Ocotillo Family

Fouquieria splendens Engelm. subsp. **splendens.** Ocotillo; *ocotillo*; melhog. **Figs. 9 and 11.**

Unique, long-lived shrubs with wand-like spiny branches arising from a very reduced trunk. Short-shoot leaves appear at almost any time of year following a ground-soaking rain except during freezing weather, and are quickly shed as the soil dries or with freezing weather. Long-shoots are produced during times of warm or hot weather and high soil moisture. Flowers red-orange, generally in spring.

Widespread; sandy soils of upper bajadas and rocky slopes to summit elevations. Ocotillo served as a framework for the traditional Hia C'ed brush house. The flowers provide sweet nectar for trail snacks. "A 1989 survey…reported the presence of ocotillo sticks, identified as 'spiritual sticks' in a rockshelter near Tinajas Altas" (Rankin 2000: xxxv).

The oldest Sonoran Desert records are from the late Holocene, about 4500 years ago in the Hornaday Mountains in the Pinacate region of nearby northwestern Sonora (Van Devender et al. 1990a). Considering the ecological amplitude (range of habitats) and wide geographic range of this species, its apparent late arrival and rarity in packrat midden assemblages in the flora area is somewhat surprising.

Camino del Diablo, SE of Raven Butte, *Felger 04-15.* Tinajas Altas Canyon, *Felger 08-181.* Tinajas Altas Mts, near the summit, 26 Oct 2004, *Felger* (observation). †Butler Mts, stem fragment with spines, 740 ybp.

GERANIACEAE—Geranium Family

ERODIUM—Storks bill

Winter-spring annuals with small, lavender-pink flowers. The long, corkscrew beak on each fruit segment uncoils when moistened and screws the sharp-pointed and heavier seed-bearing end into the ground.

1. Leaf blades pinnately dissected, much more than twice as long as wide, the petiole shorter than the blade _____ **E. cicutarium**
1. Leaf blades ovate, often 3-lobed or 3-parted, less than twice as long as wide, the petiole longer than the blade_____ **E. texanum**

***Erodium cicutarium** (L.) L'Hér. ex Aiton. Filaree, herons-bill; *alfilerillo*; hoho'ibad

Not widespread in the flora area although common in nearby areas, especially in disturbed sites. Documented in the vicinity of Coyote Water and rare along the canyon above the Tinajas Altas. Native to the Mediterranean region and widely naturalized in the New World.

Coyote Water, *Felger 05-143.* Tinajas Altas Mts, above the tinajas, among rocks, rare, grazed, 19 Mar 1998, *Felger* (observation).

Erodium texanum A. Gray. False filaree, desert stork's bill

Widespread and common; washes, bajadas, plains, and sandy flats. It has been in the flora area for at least ten millennia.

Camino del Diablo, SSE of Raven Butte, *Felger 05-34.* †Butler Mts, fruit, 10,360 ybp. †Tinajas Altas, fruit, 8970 ybp.

HYDROPHYLLACEAE, see **BORAGINACEAE**

KOEBERLINIACEAE—Allthorn Family

†**Koeberlinia spinosa** Zucc. Crucifixion thorn, allthorn; *corona de cristo*

Spinescent woody shrubs, essentially leafless.

The nearest population occurs along the northeastern border of Organ Pipe Monument, except for a single known shrub from the Pinacate Region (Felger 2000). There is one fossil record for it in the Butler Mountains.

†Butler Mts, twig, 10,360 ybp.

KRAMERIACEAE—Ratany Family

KRAMERIA

Small shrubs with small drought-deciduous leaves; reported as root parasites on other shrubs. Flowers bilaterally symmetrical, purple and yellow, and attractive; the 5 sepals are petal-like and the 5 petals modified into a landing-pad lip and two slab-like, thick elaiphores. Female *Centris* bees are the pollinators, gathering saturated fatty acids from the elaiphores (Simpson & Neff 1977).

1. Branches mostly straight and without knotty spur-branches; the 3 upper petals distinct (free), the blades near orbicular; spines of fruit with barbs in a terminal cluster ____ **K. bicolor**
1. Branches tough and knotty with many short spur-branches; claws of the 3 upper petals fused toward base, the blades lanceolate; spines of fruit with barbs alternate along upper part of shaft ____ **K. erecta**

Krameria bicolor S. Watson, 1886 [*K. grayi* Rose & Painter, 1906] White ratany; *cósahui*; edho, he:d

Sprawling shrubs. Flowers magenta-purple (deep rose), at various seasons following sufficient rainfall, especially in spring.

Common and widespread through most of the lowlands of the region, especially in sandy to gravelly soils of washes, plains, and bajadas, and sometimes on rocky slopes.

Camino del Diablo, SE of Raven Butte, *Felger 04-16.* Tinajas Altas, canyon below tanks and on rocky slopes, 19 Mar 1998, *Felger* (observation).

Krameria erecta Willd. ex Schult. [*K. parvifolia* Benth.] Little-leaf ratany, range ratany; *cósahui*

Dwarf woody shrubs with knotty short-shoots. Flowers bright magenta-purple, at various seasons following sufficient rainfall.

Scattered on sparsely vegetated granitic-gravelly dissected bajadas, often with *K. grayi*. It has been in the Butler Mountains for more than 8200 years.

0.3 mi SE of Tinajas Altas, *Felger 08-191.* Butler Mts, 27 Mar 1983, *Van Devender* (observation). †Butler Mts, leaves, fruits and spines from fruits, 740 & 8160 ybp.

LAMIACEAE—Mint Family

Shrubs or perennials. Leaves opposite. Flowers bilaterally symmetrical, violate, blue, or white and lavender.

1. Herbaceous or scarcely suffrutescent perennials ____ **Teucrium**
1. Shrubs, at least the lower branches woody.
   2. Plants densely pubescent with branched white hairs; calyx not bag-like, the calyx lobes toothed ____ **Hyptis**
   2. Plants appearing glabrous or with simple (unbranched) hairs; calyx not toothed, the fruiting calyx inflated and hollow like a bag ____ **Scutellaria**

Hyptis albida Kunth [*H. emoryi* Torr.] Desert lavender; *salvia*

Many-stemmed shrubs, the foliage usually whitish. Flowers small, fragrant, and violet, produced in large quantities through much of the year except during times of freezing weather and extreme drought, and attracting hummingbirds.

Widespread, especially in washes, also in canyon bottoms and on rocky slopes to the mountain summit. The fossil record for the flora area extends to 8700 years.

Hyptis emoryi seems best regarded as a synonym of *H. albida* (see Felger 2007; Martin et al. 1998; Felger & Wilder 2012). The Sonoran Desert populations tend to be more densely white-pubescent than those of *H. albida* from non-desert regions farther south in Mexico, but the variation is continuous. The leaves of well-watered desert plants, even in the Tinajas Altas region, especially following favorable, warm-season rains, can be much larger, greener (sparser pubescence), and thinner than dry-season leaves and can resemble leaves of typical non-desert plants (Felger 2000; Turner et al. 1995). Several varieties of *H. emoryi* have been described and across the large geographic range there is considerable variation in leaf shape that may have some taxonomic value.

1 mi N of Tinajas Altas, *Kurtz 1161.* Tinajas Altas Pass, *Reeves R-5421* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). Camino de Diablo, E of Raven Butte, 26 Nov 2001, *Felger* (observation). Tinajas Altas Canyon, *Felger 08-183.* †Butler Mts, twigs, leaves, fruits, 740–8570 ybp (3 samples). †Tinajas Altas, leaves, calyces, seeds, 1230–8700 ybp (6 samples).

†**Monardella arizonica** Epling. Arizona monardella

Bushy, herbaceous or subshrub perennials.

This mint is documented from the Tinajas Altas Mountains from about 9000 to more than 43,000 years ago. The nearest present-day population occurs in canyons in the Ajo Mountains in Organ Pipe Monument. It occurs elsewhere in southern and western Arizona, but generally above the desert.

†Tinajas Altas, involucres, fruits, 8979–18,700 (9 samples), & >43,000 ybp.

†Salvia mohavensis Greene. MOJAVE SAGE

Broad, spreading shrubs with woody stems.

The fossil record in the flora area extends from about 9300 to more than 43,000 years. It was widespread in the Sonoran Desert region through the late Pleistocene. The nearest present-day occurrences are relictual populations at higher elevations in the Sierra Pinacate in northwestern Sonora, and more extensive populations in the Copper, Maricopa, and Mohawk Mountains in southwestern Arizona. Mojave and Sonoran deserts in southeastern California, southern Nevada, western Arizona, and northwestern Sonora.

†Butler Mts, twigs, leaves, 10,360 & 11,060 ybp. †Tinajas Altas, leaf fragments, calyces, 9230–18,700, & > 43,000 ybp (12 samples).

Scutellaria mexicana (Torr.) A.J. Paton [*Salazaria mexicana* Torr.] BLADDER-SAGE

Shrubs usually with sparse foliage, the stems interlacing and branching at right angles, twigs often rigid and almost spinescent. Flowers white and blue; mass flowering at various seasons following rains. The calyx enlarges as the fruit develops to become hollow like a paper bag.

Tinajas Altas Mountains, on steep rocky slopes, especially north-facing exposures at higher elevations, canyons, and upper bajadas.

Tinajas Altas, Camino del Diablo, canyon bottom, 1000 ft, 28 Oct 1937, *Gentry 3524.* Tinajas Altas Mts, canyon bottom in upper canyon, 0.4 km SW from the uppermost of tinaja, *Felger 04-90.*

Teucrium glandulosum Kellogg. DESERT GERMANDER

Herbaceous, somewhat bushy perennials. Flowers (corollas) relatively large (1.8–2.5 cm long) and attractive, white with lavender markings.

Shaded canyon bottoms in at least several mountains in Cabeza Prieta Refuge, one record in Organ Pipe Monument, and one in Coyote Wash in the Tinajas Altas region, but probably more widespread in the region. The Coyote Wash habitat is unusual for this species—elsewhere it is found in rocky habitats. In the United States known otherwise only from the Castle Dome, Coyote, and Mohawk Mountains in western Arizona and California where it is rare. Also northwestern Sonora and both Baja California states. This is one of the few species in this large genus confined to a desert.

Coyote Wash at Camino del Diablo, clay-like soil in dense mesquite brush, *Felger 02-14.*

LOASACEAE—STICKLEAF FAMILY

Annuals or perennials with silicified or calcified, barbed hairs (the barbs usually in whorls), these hairs resulting in the leaves and fruits sticking like Velcro.

1. Annuals or short-lived herbaceous perennials; leaves not entire, often toothed; flowers orange, yellow, or silvery _____ **Mentzelia**
1. Shrubs or subshrub perennials; leaf margins entire; flowers white _____ **Petalonyx**

MENTZELIA—STICKLEAF; *PEGA PEGA*

Spring or summer annuals, and sometimes herbaceous perennials.

1. Stems markedly slender; petals less than 8 mm long; flowers and capsules sessile; capsules linear but slightly narrowed towards the base, more than 5 times longer than wide _____ **M. albicaulis**
1. Stems not especially slender; petals more than 8 mm long; flowers and capsules pedicelled; capsules to about 2 times longer than wide, not linear.
   2. Caudex often thickened, the stems not woody; larger leaves (5.5) 9–15 cm long, in a basal rosette; petals seemingly 10; seeds 3.3–3.5 mm long _____ **M. longiloba**
   2. Caudex not especially thickened, the lower stems often woody like a dwarf shrub; larger leaves (1.8) 2.5–6.5 cm long, on the stems (cauline; the basal rosette very quickly withering in first season); petals 5 (the larger staminodes petal-like but clearly narrower than the petals); seeds 2.4–3.1 mm long _____ **M. puberula**

Mentzelia albicaulis (Douglas ex Hook.) Douglas ex Torr. & A. Gray [This species complex includes **M. desertorum** (Davidson) H.J. Thomps. & J.E. Roberts] WHITESTEM BLAZING STAR

Cool-season annuals. Flowers bright yellow, sometimes with a dark orange or reddish center.

Sandy and gravelly soils of the bajadas, arroyos, and washes. *M. desertorum* is distinguished on technical features.

Butler Mts, dunes, *Van Devender 27 Mar 1983*. W end of pass just N of Tinajas Altas, *Van Devender 6 Mar 1983*.

Mentzelia longiloba J. Darl. var. **yavapaiensis** J.J. Schenk & L. Hufford [*M. multiflora* (Nutt.) A. Gray subsp. *longiloba* (J. Darl.) Felger. BLAZING STAR; *PEGAPEGA*

Cool-season annuals and perhaps sometimes short-lived perennials. Flowers bright yellow.

Lower canyons and washes in the Tinajas Altas Mountains; apparently not common in the flora area.

Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Mentzelia puberula J. Darl. SILVER BLAZING STAR

Facultative annuals to short-lived perennials, the plants often bushy; leaves often silvery gray-green. Flowers pale yellow, spring and summer with rains.

Canyons and rocky slopes; widely scattered but seldom common. A fossil from the Butler Mountains dates from about 3800 years ago.

Butler Mts, *Van Devender 27 Mar 1983*. Tinajas Altas, cliff face, *Reichenbacher 480*. †Butler Mts, twigs, seeds, 3820 ybp.

Petalonyx linearis Greene. NARROWLEAF SANDPAPER PLANT

Small, densely branched, rounded shrubs, usually less than 0.5 m tall. Flowers white; flowering at least in March and April.

Localized on widely scattered arid, gravelly-sandy washes and rocky slopes. It is documented for the flora area for 9 millennia.

Tinajas Altas, 1 Dec 1938, *Goodding 5335*. Tinajas Altas Mts, 1.7 km WNW of Tinajas Altas Peak, wash of granitic sand and rocks, infrequent, 340 m, *Baker 13307* (ASU). †Tinajas Altas, leaves, 1230 & 9230 ybp.

MALVACEAE—MALLOW FAMILY

1. Fruit a capsule of 5 persistent segments (carpels) spreading open at maturity, the carpels splitting open but remaining attached, the lower and upper portion of each segment essentially similar; perennials ____ **Hibiscus**
1. Fruit a schizocarp, the segments (mericarps) separating at maturity, the upper and lower portion of each segment markedly dissimilar; the lower chamber reticulate, the upper part with flared membranous wings.
   2. Tall skinny shrubs; floral bracts absent; petals bright yellow-orange or pink ____ **Horsfordia**
   2. Annuals and bushy perennials; floral bracts 3 per flower; petals orange or red-orange ____ **Sphaeralcea**

†**Abutilon** sp./spp.

This genus is documented for the flora area from 5900 to about 11,000 years ago. Three species of small shrubs in this genus occur in Cabeza Prieta Refuge: *A. incanum* (Link) Sweet, *A. malacum* S. Watson, and *A. palmeri* S. Watson; and a fourth one, *A. abutiloides* (Jacq.) Garke ex Britton & P. Wilson, occurs in Organ Pipe Monument, but none presently occur in the flora area.

†Tinajas Altas, mericarp fragments, 5860–11,040 ybp (3 samples).

Hibiscus denudatus Benth. var. **denudatus.** ROCK HIBISCUS

Perennial subshrubs. Corollas white to pinkish with maroon spots in the center, flowering at various seasons, especially during warmer months.

Widespread and common in the Tinajas Altas Mountains; pediments, canyons, and slopes to higher elevations. This hibiscus has been in the flora area for at least 15,700 years.

1 mi N of Tinajas Altas, *Kurtz 1157*. Tinajas Altas, ridge above tanks, 1420 ft, *Felger 04-91*. †Butler Mts, stems, leaf fragments, 740 & 8570 ybp. †Tinajas Altas, leaf fragments, seeds, 5860–15,680 ybp (5 samples).

HORSFORDIA—VELVET MALLOW

Tall, slender and sparsely branched shrubs. Flowering at various seasons except during coldest and driest weather.

1. Petals pinkish or sometimes nearly white when fresh, drying bluish to pale lavender; larger leaves mostly broadly ovate and cordate (heart-shaped); mericarps 1-seeded ____ **H. alata**
1. Petals orange when fresh; larger leaves mostly lanceolate and not cordate at base; mericarps 2 (3?)-seeded ____ **H. newberryi**

Horsfordia alata (S. Watson) A. Gray. PINK VELVET-MALLOW

Spindly shrubs (1.7) 2.5–4 m tall. Flowers pale lavender-white to pink, drying bluish to pale lavender.

Small to large washes in upper bajadas, canyons, and rocky slopes to higher elevations.

Large arroyo in front of the Tinajas, *Felger 04-73*. 1 mi N of Tinajas Altas, *Kurtz 1158*. Observations: Camino del Diablo, E of Raven Butte, 10 Jan 2002, *Felger*; Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger*.

Horsfordia newberryi (S. Watson) A. Gray. Orange velvet-mallow

Few-branched shrubs to 2.5+ m tall, often considerably shorter. Flowers bright yellow-orange.

Canyons and rocky slopes in the mountains.

Borrego Canyon, 16 Jun 1992, *Felger* (observation).

SPHAERALCEA—Globemallow; *mal de ojo*

1. Annuals (sometimes may appear perennial), often taller than wide; mericarps (capsule segments) 1-seeded, the dehiscent section short and stubby, less than half as long as the body (indehiscent portion) **S. coulteri**
1. Perennials; mericarps 2- or 3-seeded, the dehiscent section more than half as long as the body.
   2. Mostly globose bushes, often at least as broad as tall; leaf blades usually as wide as long, more or less rounded to ovate; petals orange; mericarps 4–5.5 mm long **S. ambigua**
   2. Plants often as tall to much taller than broad; leaf blades usually conspicuously longer than wide; petals orange to red-orange; mericarps 2.7–4.3 mm long **S. emoryi**

Sphaeralcea ambigua A. Gray subsp. **ambigua.** Desert globemallow; *mal de ojo*

Bushy perennials, slightly woody at the base. Flowers orange; various seasons, especially spring.

Washes, upper bajadas, canyons, and rocky slopes, and also on well-drained soils of valley plains.

Tinajas Altas, *Felger 04-78*. Canyon below Raven Butte Tank, *Felger 10-240*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Sphaeralcea coulteri (S. Watson) A. Gray [*S. orcuttii* Rose] Annual globemallow; *mal de ojo*; hadam tatk, ñiatum

Cool-season annuals and sometimes also growing with summer rains; highly variable in size, from less than 10 cm to 1.8 (2) m tall; sometimes appearing perennial and perhaps surviving one year or more. Flowers orange.

Seasonally common, mostly on valley floors, bajadas, and lower-elevation canyons. Robust, large plants, mostly on sandy soils, have been called *S. orcuttii*; other than the size of the plant, there are no apparent differences (Felger 2000).

Coyote Water, banks of wash, 1.5–1.8 (2) m tall, many, few-branched erect stems, *Felger 05-141*. High Tanks Gate, *Felger 98-111*. Camino del Diablo at Coyote Wash, 10 Jan 2001, *Felge*r (observation).

Sphaeralcea emoryi Torr. ex A. Gray. Emory globemallow; *mal de ojo*

Annuals or short-lived perennials. Flowers orange to red-orange; spring and summer-fall rainy seasons.

Locally in fine-textured soils at the south end of Coyote Wash in the Lechuguilla Valley.

Camino del Diablo at Coyote Wash, localized in the mesquite "forest," *Felger 10-167*.

†**Sphaeralcea** sp./spp. (may be, or includes, *S. ambigua*)

Globemallows have been in the region for at least 11 millennia.

†Butler Mts, twigs, leaf fragments, mericarps, 740–11,250 ybp (4 samples). †Tinajas Altas, leaf fragments, mericarps, seeds, 4010–10,950 ybp (10 samples).

MARTYNIACEAE—Devil's Claw Family

Proboscidea altheifolia (Benth.) Decne. Desert devil's claw; *cuernitos, uña de gato*; ban 'ihugga

Strongly scented, herbaceous perennials from a deeply buried, large, tuberous root. Flowers showy, often 4 cm long, yellow with yellow-orange and bronze markings; growing and flowering with hot weather.

Sandy to silty soils of washes, floodplains, and valley plains.

Camino del Diablo, SE of Raven Butte, *Felger 04-18*.

MOLLUGINACEAE—Carpetweed Family

***Mollugo cerviana** (L.) Ser. Thread-stem carpet-weed, Indian chickweed

Diminutive summer annuals. First leaves in a basal rosette, which is unusual among desert summer annuals. Seeds snail-shaped with dark ridges (striae) on the dorsal side.

Sandy soils along Coyote Wash in the Lechuguilla Valley. Widespread in the Sonoran Desert and elsewhere in southwestern North America and Mexico; reported as native to the Old World and not native in the New World.

Coyote Water, *Felger 04-50*.

NYCTAGINACEAE —Four O'clock Family

Annual or perennial herbs or subshrubs. Sepals petal-like, the petals none. Fruits 1-seeded and achene- or nut-like, enclosed by the calyx tube and technically an anthocarp, the collective structure here called the "fruit."

Abronia flowers are open all day, but among the other seven species the flowers open in the early morning and collapse with daytime heat

1. Perennials; involucral bracts united into a persistent tube with 5 teeth; fruits rounded, nearly smooth ____ **Mirabilis**
1. Annuals or short-lived perennials; involucral bracts separate, 1 to 5, sometimes reduced and/or soon deciduous; fruits not rounded and smooth—variously winged, angled, club-shaped, or grooved.
   2. Spring annuals; flowers very showy, in clusters (3) 4–5 cm wide; fruits 7–9 mm long (including the wings), with 5 conspicuous wings ____ **Abronia**
   2. Annuals or perennials; flowers or flower clusters less than 2.5 cm wide; fruits not 5-winged.
      3. Stems slender, weak, and prostrate-trailing; flowers in clusters of 3, the cluster resembling a single flower; fruits with a single deep cavity formed by a pair of inrolled wings ____ **Allionia**
      3. Stems erect to spreading, sometimes decumbent or prostrate but not trailing; flowers often clustered but each flower conspicuously separate; fruits with 4 or 5 furrows or grooves ____ **Boerhavia**

Abronia villosa S. Watson var. **villosa.** Sand-verbena; *verbena de la arena*

Cool-season annuals; highly variable in size. Flowers diurnal, showy, very fragrant, pinkish purple to pale magenta. Fruits winged and beaked in a globose cluster.

Common and widespread on sandy plains and dunes at the western margin of the flora area near the base of the Butler Mountains. Although not documented elsewhere in the flora area, it is common and widespread on sandy soils in many nearby areas.

Butler Mts, *Van Devender 27 Mar 1983.*

Allionia incarnata L. [*A. incarnata* var. *nuda* (Standl.) Munz. *A. incarnata* var. *villosa* (Standl.) Munz] Windmills, trailing four-o'clock

Short-lived perennials with slender, trailing stems, and also flowering in the first season. Flowers clustered in trios resembling a single flower, violet-rose or magenta; flowering non-seasonally in warmer months with sufficient soil moisture.

Widespread across the flora area in many habitats including gravelly floodplains, washes, canyons, flats, and rocky slopes.

Coyote Water, *Felger 04-23.* Camino del Diablo E of Raven Butte, *Felger 01-583.* Tinajas Altas Pass, *Reeves R5415* (ASU).

BOERHAVIA—Spiderling; *jaunilipin*

Summer annuals and one perennial; the plants at first usually upright, later often spreading and becoming decumbent or even prostrate. Flowers open in the early morning and collapse with daytime heat.

1. Perennials or sometimes annuals; flowers dark red-purple; fruits sticky and densely pubescent with glandular hairs ____ **B. coccinea**
1. Hot weather annuals; flowers white or pale pink; fruits glabrous, not sticky (the stems and flowering branches may be sticky).
   2. Flowers in umbellate or subumbellate clusters ____ **B. erecta**
   2. Flowers on elongated racemose branches.
      3. Fruits 2.1–2.5 (2.7) mm long, slender (narrowly obovate), 5-angled or ridged, the furrows mostly narrow to nearly closed ____ **B. spicata**
      3. Fruits 2–3 mm long, chunky (broadly obovate), all or mostly 4-angled, the furrows broad, open, and roughened inside ____ **B. wrightii**

***Boerhavia coccinea** Mill. [*B. caribaea* Jacq.] Scarlet spiderling

Sprawling, herbaceous perennials and also flowering in the first season, growing and reproductive in warmer months with sufficient soil moisture. Flowers small and bright red-purple, remaining open longer in the day than the other boerhavias in the region. Fruits glandular-pubescent.

Localized and well established at the base of the tinajas; not seen elsewhere in the flora area. Characteristic of disturbed sites regionally. This weedy species, now cosmopolitan in distribution, is probably native in southwestern North America but does not seem to be native in the Tinajas Altas and nearby regions (Felger 2000).

Tinajas Altas, near the lower tinaja: 15 Jun 1992, *Felger 92-609*; 29 Nov 2001, *Felger 01-582*; 28 Mar 2010, *Felger 10-180.*

Boerhavia erecta L. Erect spiderling; *juantilipín*; makkumĭ ha-jeved

Summer annuals; herbage glabrous or with minute hairs, the flowering branches with glandular-sticky bands. Flowers whitish to pale pink, in umbellate or subumbellate clusters. Fruits 5-angled.

Documented along Coyote Wash.

Coyote Water, *Felger 04-28.*

Boerhavia spicata Choisy [*B. coulteri* (Hook. f.) S. Watson. *B. coulteri* var. *palmeri* (S. Watson) Spellenb. *B. spicata* Choisy var. *palmeri* S. Watson] Palmer's spiderling; *juantilipín*

Summer annuals; flowering branches conspicuously glandular-sticky, sticking to shoes, socks, and pant legs. Flowers very small, white to pale pink, on racemose branches. Fruits 5-angled.

Various habitats: sandy to rocky soils; washes, bajadas, flats, and slopes; widespread and often very common.

Coyote Water, *Felger 04-29.*

Boerhavia wrightii A. Gray. Large-bract spiderling

Summer annuals, densely glandular sticky including the flowering branches. Flowers pinkish white to pink, on racemose branches. The plants are often rather robust and the floral bracts, flowers, and fruits are larger than those of the other boerhavias in the region. Fruits 4-angled.

Sandy to rocky soils in many habitats; seasonally common and nearly ubiquitous across the flora area. There is a specimen about 8200 years old from the Butler Mountains.

Camino del Diablo, SE of Raven Butte, *Felger 04-08.* Coyote Water, *Felger 04-30.* Tinajas Altas, 26 Oct 2004, *Felger* (observation). †Butler Mts, fruit, 8160 ybp.

MIRABILIS—Four o'clock

Herbaceous perennials; flowers white or pale pink, collapsing with daytime heat, usually before mid-morning.

1. Involucres 6–9 mm long, the lobes 2–3(–4) mm long ____ **M. laevis**
1. Involucres 10–15 mm long, the lobes 5–9 mm long ____ **M. tenuiloba**

Mirabilis laevis (Benth.) Curran var. **villosa** (Kellogg) Spellenb. [*M. bigelovii* A. Gray] Desert four o'clock

Herbaceous perennials, with glandular-pubescent herbage. Flowers white or pale pink, flowering at various seasons.

Widely scattered on rocky slopes to higher elevations, canyons, washes, valley plains, and bajadas. There is a specimen about 11,100 years old from the Butler Mountains.

Borrego Canyon, canyon slopes, *Felger 92-614.* Surveyors Canyon, *Felger 10-199.* Tinajas Altas, *Goodding 1517.* Tinajas Alas Pass, *Reeves 5397* (ASU). Coyote Water, *Felger 98-119.* Camino del Diablo, SE of Raven Butte, 25 Oct 2004, *Felger* (observation). †Butler Mts, seed/fruit, 11,060 ybp.

Mirabilis tenuiloba S. Watson. Long-lobed four o'clock

Herbaceous perennials; exceptionally sticky with glandular-pubescence. Leaves semi-succulent. Flowers white.

Canyons in Tinajas Altas Mountains. The only other known locality for this species in Arizona is in the Kofa Mountains. The plants differ from *M. laevis* in being more robust, and generally having larger, thicker, and more yellowish leaves, and larger involucres with longer lobes.

Borrego Canyon, common in canyon bottom, *Felger 92-613.* Surveyors Canyon, *Felger 10-200.* Frontera Canyon, *Felger 98-108.* Tinajas Altas Mts, *Goodding 07 Mar 1940* (ASU). Yuma Co: Palm Canyon, ca. ¾ way to the top, 8 Oct 1977, *Harrison 11* (ASU).

ONAGRACEAE—Evening-Primrose Family

All members of this family in the flora area grow and flower during the cool seasons, and the flowers are vespertine (opening near sunset) and collapse after sunrise depending on temperature.

1. Petals (2) 2.5–6 cm long, uniformly (monochromatic) yellow or white without spots or other markings ____ **Oenothera**
1. Petals 0.2–1.7 cm long, color various, often with spots or other markings (*Camissonia* sensu lato).
   2. Flowers and capsules pedicelled ____ **Chylismia**
   2. Flowers and capsules sessile (caution: the slender ovary base may appear like a pedicel).
      3. Flowers minute, petals 2–2.5 mm long, whitish or pink ____ **Eremothera**
      3. Flowers small but not minute, petals 5–7.5 mm long, bright yellow or orange ____ **Eulobus**

CHYLISMIA

1. Largest leaves on stems well above base of plant, leaves not in a basal rosette; leaf blades about wide as long, rounded to ovate or somewhat triangular, toothed or serrated ____ **C. arenaria**
1. Largest leaves in a basal rosette, stem leaves reduced; leaf blades more than 3 times longer than wide, the leaves pinnately lobed to divided ____ **C. claviformis**

Chylismia arenaria A. Nelson [*Camissonia arenaria* (A. Nelson) P.H. Raven] Desert suncup

Annuals to short-lived perennials. Flowers yellow, becoming pink with age.

Rocky slopes and canyons in the Tinajas Altas Mountains.

Tinajas Altas, *Harrison 3608.* Canyon above Tinajas Altas, *Felger 04-83.*

Chylismia claviformis (Torr. & Frém.) A. Heller subsp. **peeblesii** (Munz) W.L. Wagner & Hoch [*Camissonia claviformis* (Torr. & Frém.) P.H. Raven subsp. *peeblesii* (Munz) P.H. Raven] BROWNEYES

Annuals. Flowers white, sometimes with pink tinges, and with a red-brown center, the flowers becoming pink with age and often purplish when dry; the stamens, style, and stigma white.

Widespread, especially on sandy to gravelly soils; washes, valley plains and bajadas, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-222.* Tinajas Altas Pass, *McLaughlin 1973.*

Eremothera chamaenerioides (A. Gray) W.L. Wagner & Hoch [*Camissonia chamaenerioides* (A. Gray) P.H. Raven] WILLOW-HERB EVENING-PRIMROSE

Annuals. Flowers very small, at first white, often becoming pink with age; opening near sunset, usually collapsing soon after sunrise. This is the smallest-flowered evening primrose in the Sonoran Desert; the floral structure and modifications are characteristic of self-pollinated flowers.

Widespread, especially on rocky slopes from low to high elevations.

Tinajas Altas, rocky slope, 1900 ft, *Van Devender 5 Mar 1983.* Tinajas Altas, *Goodding 6 Mar 1940* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-211.* Above the tinajas, 19 Mar 1998, *Felger* (observation).

Eulobus californicus Nutt. ex Torr. & A. Gray [*Camissonia californica* (Nutt. ex Torr. & A. Gray) P.H. Raven. *Oenothera leptocarpa* Greene] CALIFORNIA SUNCUP

Annuals; plants erect and often sparsely branched, the leaves usually shed by the time of flowering. Flowers yellow, becoming orange with age and often drying pink.

Widespread across the flora area; washes, plains, bajadas, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 05 Mar 1983.* Tinajas Altas Canyon, above the tinajas, 19 Mar 1998, *Felger* (observation). Surveyors Canyon, canyon bottom, *Felger 10-206.* Vicinity of Coyote Water, *Felger 04-34.*

Oenothera primiveris A. Gray. YELLOW DESERT EVENING-PRIMROSE

Annuals. Flowers relatively large and lemon-yellow. Capsules woody, persisting on the dried stems long after the plants perishes.

Sandy gravel or silty-clayish soils of washes, sand flats, canyons, and sometimes in soil pockets on rocky slopes. Specimens in the region are generally identifiable as subsp. *bufonis* (M.E. Jones) Munz, distinguished by larger and generally cross-pollinated flowers.

Coyote Water, *Felger 04-54.* Canyon below lowermost Tinajas Altas, 19 Mar 1998, *Felger* (observation).

OROBANCHACEAE—BROOMRAPE FAMILY

†CASTILLEJA sp./spp.

There are records for the genus dated at 11 millennia in the flora area and 20.5 millennia in the Ajo Mountains in Organ Pipe Monument. The nearest present-day members are *C. exserta* (A. Heller) T.I. Chuang & Heckard subsp. *exserta* (owl's clover) at Jose Juan Charco in Cabeza Prieta Refuge and *C. lanata* A. Gray (Indian paintbrush) in the Ajo Mountains.

†Tinajas Altas, seeds, 11,040 ybp. Ajo Mountains, 20,490 ybp.

Orobanche cooperi (A. Gray) A. Heller. DESERT BROOMRAPE; MO'OTADK

Apparently annuals; parasitic on roots of *Ambrosia* shrubs including *A. dumosa* and sometimes *A. ilicifolia* and *A. salsola*, and also reported on *Larrea* (Wiggins 1964). Stems very thick and succulent, appearing in spring, flowering and withering by the end of April or sooner. Flowers purple and white, and the throat marked with yellow.

Often locally common on sandy flats and bajadas, sandy-gravelly washes, and canyon bottoms. Widespread across the flora region. The young plants are edible after thorough roasting.

Near jct of Camino del Diablo and Cipriano Pass Road, Tinajas Altas Mts, *Van Devender 6 Mar 1983.* Frontera Canyon, *Felger 98-104.* Camino del Diablo (West Rte), Davis Plain W of Tinajas Altas Mts, *Reeves R5427* (ASU).

PAPAVERACEAE—POPPY FAMILY

Eschscholzia minutiflora S. Watson. LITTLE GOLD-POPPY

Cool-season annuals. Flowers small and yellow.

Seasonally common during years of favorable rains in the Tinajas Altas Mountains; washes and at least the lower slopes. Like so many other species of ephemerals in the more arid regions of the Sonoran Desert, this poppy is not seen during dry years. In spring 1983 Tom reported it as being rare, and Richard did not record it in the flora area until his spring 2010 field trip, when it was widespread and common.

Vicinity of Tinajas Altas, rare, under *Larrea*, *Van Devender 5 Mar 1983*. Tinajas Altas, canyon-wash just E of the tinajas, *Felger 10-188*. Surveyors Canyon, canyon bottom, *Felger 10-206*.

PLANTAGINACEAE (INCLUDES SCROPHULARIACEAE IN PART)—PLANTAIN FAMILY

1. Vegetative stems short or not developed; flowers 4-merous, the corollas whitish or brown; flowers and fruits sessile; seeds smooth, 2 per capsule _____ **Plantago**
1. Vegetative stems well developed and leafy; flowers 5-merous, the corollas rose-pink or purple; seeds rough-surfaced, many per capsule.
   2. Herbage viscid-sticky; stems usually less than 25 cm long; lowermost leaves paired, others alternate, leaves ovate to broadly lanceolate, prominently petioled; corollas purple _____ **Pseudorontium**
   2. Herbage not viscid sticky; stems usually more than 30 cm long; leaves opposite; corollas rose-pink_____ **Penstemon**

PENSTEMON—BEARD TONGUE

Generally herbaceous perennials, probably short-lived, also flowering in first season.

1. Leaf margins entire, all leaves separate (not connate) _____ **P. parryi**
1. Leaf margins toothed, the upper leaves joined at base (connate)_____ **P. pseudospectabilis**

Penstemon parryi (A. Gray) A. Gray. DESERT PENSTEMON; *JARITOS, VARITA DE SAN JOSÉ*; HEVEL 'E'ES

Usually perennials but at least sometimes functioning as cool-season annuals. Leaves moderately glaucous. Flowers rose-pink, February to April.

Known from the flora area by a single plant and therefore not collected; it was not a perennial.

Tinajas Altas, wash just below the lower tank, rare, 10 Jan 2002, *Felger* (observation).

Penstemon pseudospectabilis M.E. Jones var. **pseudospectabilis.** MOJAVE BEARD-TONGUE

Herbaceous perennials, also flowering in the first year. Flowers bright rose-purple; observed in flower February to May.

Canyons and at higher elevations in the mountains, generally not common.

Tinajas Altas, frequent in wash above tanks, 487 m, *Hodgson 2723* (DES). Canyon above Tinajas Altas, canyon bottom and lower N-facing slopes among rocks, *Felger 04-77*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†**Penstemon** sp.

†Tinajas Altas, fruits, 10,950 & 11,040 ybp.

Plantago ovata Forssk. var. **fastigiata** (E. Morris) S.C. Meyers & Liston [*P. insularis* Eastw. Not *P. insularis* Nyman ex Briq. *P. fastigiata* E. Morris. *P. insularis* var. *fastigiata* (E. Morris) Jeps.] DESERT WOOLLY PLANTAIN, INDIAN WHEAT; *PASTORA*; MUMSA

Cool-season annuals; highly variable in size, flowering stems often 5–20 cm tall. Flowers small, straw-colored and papery. Seeds mucilaginous when wet and clinging tenaciously when dry.

Abundant and widespread, especially on sandy soils; washes, valley plains and bajadas, canyons, and soil pockets on rocky slopes. The seeds were significant food and medicinal resources. It has been in the flora area for more than 11,300 years and in Organ Pipe Monument for more than 20,500 years. Van Devender et al. (1990a) reported 10,000-year-old fossils from the Hornaday Mountains in the Pinacate region.

Drought-stressed plants can be as small 6.4–12 mm tall, with persistent cotyledons to 12 mm long, only 2 leaves, each 7 mm long, and a peduncle bearing a single fruit.

The present-day population is the inland North American variety (Meyers & Liston 2008). The infraspecific status of the fossils is not known.

Coyote Water, *Felger 05-123*. Cipriano Pass, *Reeves R5448* (ASU). Tinajas Altas, *Felger 10-193*. Observations: Canyon above Tinajas Altas, 19 Mar 1998, *Felger*; Frontera Canyon, 18 Nov 1998, *Felger*. †Butler Mts, seeds, 740–11,250 ybp (6 samples). †Organ Pipe Monument: Ajo Mts, Montezuma's Head, seeds, 20,490 ybp.

Pseudorontium cyathiferum (Benth.) Rothm. [*Antirrhinum cyathiferum* Benth.] DESERT SNAPDRAGON

Non-seasonal annuals, viscid glandular-hairy (sticky) and foul smelling. Flowers small and dark purple.

Known in the flora area from a single locality but probably more widespread.

Among rocks in the bottom of Frontera Canyon, 18 Mar 1998, *Felger* (observation).

POLEMONIACEAE—Phlox Family

All members of this family in the flora area are cool-season annuals.

1. Leaves opposite (upper leaves sometimes alternate); flowers nocturnal, pure white ____ **Linanthus**
1. Leaves alternate; flowers diurnal, blue, pink, or white tinged with violet.
   2. Flowers in woolly heads; flowers blue ____ **Eriastrum**
   2. Flowers not in woolly heads; flowers not blue.
      3. Leaves and calyx lobes bristle-tipped; flowers sessile in leaf axils or in dense, compact and leafy-bracted heads.
         4. Leaves broadest near the tip; most leaves with some 2- or 3-forked bristles; corollas radial or nearly so ____ **Langloisia**
         4. Leaves linear, not expanded above; leaf bristles all single; corollas bilateral, 2-lipped ____ **Loeseliastrum**
      3. Leaves and calyx lobes not bristle-tipped; flowers mostly pedicelled, in open inflorescence overtopping the leaves.
         5. Leaves more or less ovate, toothed but not dissected, to about 2 times longer than wide; flowers pink ____ **Aliciella**
         5. Leaves pinnately dissected, more than 3 times longer than wide; flowers white tinged with violet ____ **Gilia**

Aliciella latifolia (S. Watson) J.M. Porter subsp. **latifolia** [*Gilia latifolia* S. Watson] Broad-leaf gilia

Plants highly variable in size; flowers pink.

Known for certain from a single record from near the northern margin of the flora area.

Pass N of Tinajas Altas Pass, 1200 ft, *Halse 31 Mar 1973.*

Eriastrum diffusum (A. Gray) H. Mason. Woolly-star

Flowers small and blue, the corollas tend to fall with daytime heat. The small flowers and small anthers point to a selfing (autogamous) habit.

Washes, bajadas, and low hills.

NE end of Tinajas Altas Pass, *Van Devender 6 Mar 1983.* Coyote Water, 18 Mar 1998, *Felger* (observation).

Gilia stellata A. Heller. Star gilia

Basal rosette leaves well developed, stem leaves greatly reduced. Flowers white tinged with violet.

Common and widespread across the flora area; washes, bajadas, hills, and mountains.

Tinajas Altas Pass, *Van Devender 5 Mar 1983.* Tinajas Altas, *Felger 10-189.* Coyote Water, *Felger 05-146.*

Langloisia setosissima (Torr. & A. Gray) Greene subsp. **setosissima.** Bristly langloisia

Plants bristly and compact, 2–5 cm tall. Corollas bright lavender-pink; anthers and pollen white or blue.

Sandy to rocky soils; washes, valley plains and bajadas, hills, and mountains.

E side Tinajas Altas Pass, *Felger 98-102.*

Linanthus jonesii (A. Gray) Greene. jones' desert-turmpet

Stems wire-like, the plants usually taller than broad. This species charactrized by simple leaves, very coarse glandular hairs (the glands are large, multicellular structures), and relatively small fruit. Flowers white, nocturnal, opening shortly after dusk and powerfully sweet-fragrant, sometimes nauseously sweet, and closing before sunrise.

Washes, valley plains and bajadas, canyons, hills, and mountains at least at lower elevations.

Tinajas Altas, *Van Devender 26 Mar 1983* (det. J. Mark Porter 2012). Frontera Canyon, 18 Mar 1998, Felger (observation, presumably the same species).

Loeseliastrum schottii (Torr.) Timbrook [*Langloisia schottii* (Torr.) Greene] Schott's calico

Plants with a short main axis and compact to spreading branches. Flowers white or pink and showy.

Low dunes near the west side of Tinajas Altas Mountains and perhaps elsewhere in the western part of the flora area.

Butler Mts, *Van Devender 27 Mar 1983.*

POLYGONACEAE—Buckwheat Family

1. Small shrubs ____ **Eriogonum**
1. Annuals or herbaceous perennials.
   2. Small annuals; involucres single-flowered, bearing spine-tipped teeth ____ **Chorizanthe**
   2. Annuals or herbaceous perennials; involucres multiple flowered with blunt-tipped teeth or bracts.
      3. Annuals or herbaceous perennials, with or without woolly hairs; leaf blades about as wide as long ____ **Eriogonum**
      3. Annuals with woolly hairs; leaf blades several times longer than wide ____ **Nemacaulis**

CHORIZANTHE—Spine-flower

Small spring annuals; first leaves in a basal rosette; flowers minute, white or yellow and barely protruding or

hidden in firm, spinescent bracts. The larger leaves in a basal rosette, soon deciduous, usually withering by early March. Flowering mostly February to March, the plants mostly mature in April. By the time they are in full flower with onset of fruiting, the weather is warm and the plants are leafless or nearly so.

1. Stems slender and not spiny, the stems and inflorescences fragile and breaking apart at maturity ____ **C. brevicornu**
1. Stems stout and spiny, not breaking apart at maturity, the died plants ("skeletons") tough and persistent ____ **C. rigida**

Chorizanthe brevicornu Torr. subsp. **brevicornu.** Brittle spineflower, short-horn spineflower

Cool-season annuals. Flowers white and minute. As the plants mature and dry in April and early May, they completely break apart, the inflorescence branches breaking into small seed-bearing segments that have tiny grappling-hook spines at the nodes that aid in dispersal.

Sandy, gravelly, and rocky soils; washes, canyons, upper bajadas, pediments, and lower mountain slopes. It was in the flora area 10,400 years ago.

Tinajas Altas, *Van Devender 5 Mar 1983*. Steep canyon slope N of Tinajas Altas, 19 Mar 1998, *Felger* (observation). †Butler Mts, fruit-bearing segments (with hooks), 10,360 ybp.

Chorizanthe rigida (Torr.) Torr. & A. Gray. Devil's spineflower; *tapacola*

Cool-season annuals. Flowers yellow-green, minute and barely visible. Plants drying as a rigid, spinescent skeleton resembling a miniature ocotillo and often persisting for a number of years.

Widespread; bajadas and valley plains, washes, pediments, and lower rocky slopes. It has been in the flora for at least 8200 years.

Camino del Diablo SE of Raven Butte, *Felger 05-33*. NNE of parking area at Tinajas Altas, *Felger 10-216*. Granitic hills at SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger*, observation. †Butler Mts, 3-parted floral bracts, 740–8160 ybp (3 samples).

ERIOGONUM—Wild buckwheat

Small annuals to woody shrubs ranging across the entire region. This is one of the more diverse genera in the flora area in terms of number of species (6) as well diversity in growth forms.

1. Small shrubs; stems leafy (although leaves drought deciduous and often reduced).
   2. Involucres (flowers) in dense, head-like clusters on top of well-developed peduncles; involucres ca. 2.5 mm long ____ **E. fasciculatum**
   2. Involucres solitary and sessile at nodes (flowering branches may appear racemose); involucres 1–1.7 mm long ____ **E. wrightii**
1. Annuals or herbaceous perennials; stems not leafy, the leaves at the base of the plant and often forming a basal rosette.
   3. Annuals and perennials; leaves green, hairy but not woolly; major flowering stems not unusually slender, not thread-like.
      4. Perennials and forming a hard, knotty base and also flowering in first year; involucres 5-lobed; tepals (1.5–)2–2.7 (–3.5) mm long ____ **E. inflatum**
      4. Annuals; involucres 4-lobed, tepals 1.2–1.8 mm long ____ **E. trichopes**
   3. Annuals; leaves grayish green, woolly at least below; flowering branches very slender, thread-like.
      5. Flowering branches and involucres glabrous; involucres 0.8–2.3 mm long; outer tepals longer than wide, broadest and swollen (inflated) at base ____ **E. thomasii**
      5. Flowering branches and involucres glandular pubescent; involucres 2–3.2 mm long; outer tepals as wide as or wider than long, broadest above (towards the tip), narrowed at base to a claw ____ **E. thurberi**

Eriogonum fasciculatum Benth. var. **polifolium** (Benth.) Torr. & A. Gray. Flat-top buckwheat

Small shrubs; flowers whitish or pink; February to May.

Upper bajadas and washes, canyons, and rocky slopes in the mountains, especially at higher elevations in canyons and east- and north-facing rocky slopes. The history of this variety in the flora area extends to 11,100 years, and this species has been in the area at least 18,700 years.

Tinajas Altas, *Shreve 5942*. Tinajas Altas Mts, NE of upper tanks, *Felger 04-74*. †Butler Mts, leaves, 8160–11,060 ybp (3 samples). †Variety unknown: Tinajas Altas, leaves, 5080–18,700 ybp (7 samples).

Eriogonum inflatum Torr. & Frém. Desert trumpet, bladder stem

Perennial herbs with a hard, knotty base; leaves basal, the flowering stems leafless, the first internode erect or nearly so, the upper part inflated (swollen and hollow) or not without apparent pattern. Flowers small and yellow, mostly in spring and again with the summer rains.

Canyons, rocky hills and mountain slopes. It grew in the Butler Mountains 8200 years ago.

Canyon below Raven Butte Tank, *Felger 10-226*. Cipriano Pass, N end of Tinajas Altas Mts, *Reeves 5441* (ASU). Observations: Canyon above Tinajas Altas, 19 Mar 1998, *Felger*; Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger*. †Butler Mts, fruit with calyx, 8160 ybp.

Eriogonum thomasii Torr. THOMAS' WILD BUCKWHEAT

Small, delicate, cool-season annuals. Flowers pink and yellow; flowering branches and involucres glabrous, the outer tepals longer than wide, and broadest and swollen at base.

Washes, valley plains and bajadas, and canyons.

Coyote Water, *Felger 05-153*. Vicinity of Tinajas Altas, 1900 ft, *Van Devender 5 Mar 1983*. Canyon below Raven Butte Tank, *Felger 10-227*.

Eriogonum thurberi Torr. THURBER'S WILD BUCKWHEAT

Small, delicate, cool-season annuals. Flowers white or pink; flowering branches and involucres glandular pubescent; outer tepals as wide or wider than long, broadest towards the tip, and narrowed to a claw at the base.

Sandy soils on west side of the Tinajas Altas Mountains.

E edge of Davis Plain, west branch of Camino del Diablo, *Felger 05-93*.

Eriogonum trichopes Torr. LITTLE DESERT TRUMPET

Cool-season annuals; highly variable in size. Flowers yellow.

Sandy, gravelly soils; valley plains, bajadas, and washes.

Camino del Diablo, SE of Raven Butte, *Felger 05-28*. Coyote Wash at Camino del Diablo, 10 Jan 2002, *Felger* (observation).

Eriogonum wrightii Torr. ex Benth. var. **nodosum** (Small) Reveal [*E. wrightii* var. *pringlei* (J.M. Coult. & Fisher) Reveal] BASTARD SAGE

Small, scruffy subshrubs with whitish stems and small, quickly drought-deciduous leaves. Flowers white or pink; flowering response apparently non-seasonal, or perhaps not during summer.

Mountains, especially north-facing slopes and canyons. This species has been in the flora area for more than 43,000 years.

Tinajas Altas, 5 Dec 1935, *Goodding 1449*. Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Variety unknown: Tinajas Altas, leaves, 5860–15,680 (14 samples), & >43,000 ybp.

Nemacaulis denudata Nutt. var. **gracilis** Goodman & L.D. Benson. WOOLLY HEADS

Cool-season annuals with very slender, delicate, and spreading stems. Flowers minute, yellow, surrounded by yellow-green or white and pink woolly bracts.

Dunes and sand flats west of the Tinajas Altas Mountains.

Butler Mts, *Van Devender 27 Mar 1983*.

PORTULACACEAE—PURSLANE FAMILY

Portulaca halimoides L. [*P. parvula* A. Gray] SILK-COTTON PURSLANE

Summer annuals, the plants small and succulent. Sepals reddish and relatively persistent; petals, anthers, and stigma golden yellow but these are only evident while the flowers are open—generally from a few hours after sunrise until late morning or mid-day.

Sometimes seasonally common along Coyote Wash.

Coyote Water, *Felger 04-61*.

RANUNCULACEAE—RANUNCULUS FAMILY

†**Anemone tuberosa** Rydb. DESERT WINDFLOWER

Small, herbaceous root perennials; growing and flowering in spring.

It was at Tinajas Altas nearly 10,000 years ago. The nearest present-day population occurs in Arizona Upland in the Ajo Mountains, especially at higher elevations. It is generally not known from the Lower Colorado Desert region, with the exception of a few records from the Whipple Mountains (De Groot 2007).

†Tinajas Altas, seeds, 9900 ybp.

RESEDACEAE—MIGNONETTE FAMILY

Oligomeris linifolia (Vahl) J.F. Macbr. DESERT CAMBESS

Annuals, recorded in the region from October through May. Flowers minute and inconspicuous, white and green.

Usually localized; sandy to rocky soils, valley plains, washes, canyons, and bajadas.

Butler Mts, *Van Devender 27 Mar 1983.* Coyote Water, *Felger 04-53.*

RHAMNACEAE—Buckthorn Family

†**Condalia** cf. **globosa** I.M. Johnst. Crucillo

Hardwood shrubs or small trees with small leaves. Fruits small drupes with a thin blackish pulp.

It is documented from Tinajas Altas between 9000 and 11,000 years ago. The nearest present-day population of *C. globosa* is in the northeastern part of Cabeza Prieta Refuge, where it grows in large arroyos and canyons, and the east side of the Pinacate region.

†Tinajas Altas, seeds, 8970 & 10,950 ybp.

Ziziphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray var. **canescens** (A. Gray) M.C. Johnst. [*Condalia lycioides* (A. Gray) Weberb. var. *canescens* (A. Gray) Trel.] White crucillo, graythorn; *abrojo*; 'u:spad, 'us jevedpad

Sprawling hardwood shrubs 2–3 m tall, with rigid branches, forming dense, thorny tangles. Leaves mostly 8–20 mm long, often grayish green, quickly drought deciduous, with sparse foliage, the shrubs often nearly leafless. Flowers small, yellow-green, appearing at least in early summer. Fruits ca. 1 cm long, edible and slightly sweet but hardly worth the bother.

Uncommon and widely scattered in washes, canyon bottoms, upper bajadas, and lower slopes along the east side of the Tinajas Altas Mountains, and more common at the south end of Coyote Wash. It has been at Tinajas Altas for at least 8700 years.

Tinajas Altas, wash just E of the tinajas, *Felger 08-170.* Camino del Diablo at Coyote Wash, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, twigs, 1230–8700 ybp (3 samples).

Galium stellatum Kellogg [*G. stellatum* var. *eremicum* Hilend & J.T. Howell] Starry bedstraw

Untidy small shrubs or subshrubs. Stems brittle, square in cross-section with stringy, peeling bark. Leaves small and sharp pointed. Flowers minute, whitish or pale yellow, in spring.

Widespread in the Tinajas Altas Mountains, especially on north- and east-facing slopes and in canyons. It has been in these mountains for more than 18,700 years.

Tinajas Altas, *Harrison & Kearney 6574.* 1 mi N of Tinajas Altas, *Kurtz 1153.* Surveyors Canyon, canyon bottom, *Felger 10-209.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, stems, leaves, fruits, 4010–18,700 ybp (13 samples).

RUSCACEAE, see **ASPARAGACEAE**

RUTACEAE—Rue or Citrus Family

Thamnosma montana Torr. & Frém. Turpentine broom

Small, gland-dotted shrubs; stems yellow-green; herbage and flowers highly aromatic, the new growth with a lemon-like fragrance when crushed; stems yellowish green. Foliage sparse, the leaves reduced above to scales and very quickly shed. Flowers ca. 1 cm long, dark indigo-blue. Flowering and fruiting January to April. Flowers stinking at mid-day, visited by large syrphid flies and honeybees (the bees vigorously stick their heads all the way into the corolla, spreading apart the petals to get inside).

Hot, exposed rocky hills, slopes and ridges in the Tinajas Altas Mountains. It has been in these mountains for more than 43,000 years.

Tinajas Altas Mts, *Harrison 3612*. SE base of Tinajas Altas Mts, *Felger 98-103.* Tinajas Altas Canyon, *Felger 08-178*. †Tinajas Altas, twigs, fruits, 5080–15,050 (4 samples), & >43,000 ybp.

SANTALACEAE—Sandalwood Family (includes Viscaceae)

Phoradendron californicum Nutt. Desert mistletoe; *toji*; ha:kvad

Epiphytic parasites; stems photosynthetic and with scale leaves. Male and females flowers on separate plants; flowers small, green or yellow, highly fragrant and attracting great numbers of insects; flowering and fruiting at various seasons, with mass flowering often December to February and fruits ripening in late winter to early spring. The translucent white or whitish and pale orange fruits are a major food of phainopeplas.

Parasitic on the larger woody legumes, *Olneya*, *Parkinsonia*, *Prosopis*, *Senegalia*, and rarely on *Larrea* and *Asclepias albicans*. Distributed with the hosts. Desert mistletoe has been in the flora area for at least 8200 years.

Coyote Water, on *Prosopis glandulosa*, *Felger 04-59.* Observations: Camino del Diablo near Coyote Wash, on *Asclepias albicans*, 29 Dec 2001, *Felger*; Tinajas Altas, on *Olneya*, 19 Mar 1998, *Felger.* †Butler Mts, fruits, 740–8160 ybp (3 samples).

SCROPHULARIACEAE, see **OROBANCHACEAE** and **PLANTAGINACEAE**

SOLANACEAE—Nightshade Or Potato Family

Annuals or perennials including woody shrubs. Flowers 5-merous, radially symmetrical, the corollas sympetalous.

1. Hardwood shrubs with spines or thorn-tipped twigs _____ **Lycium**
1. Unarmed herbaceous annuals or herbaceous perennials sometimes scarcely woody at the base.
   2. Plants stinky; corollas 8–17 cm long; fruits spinescent _____ **Datura**
   2. Plants not stinky; corollas less than 3 cm long; fruits not spinescent.
      3. Corollas white or cream-white; fruiting calyx not enlarging; fruit a capsule (dry) _____ **Nicotiana**
      3. Corollas yellow or yellowish; fruiting calyx enlarging to partially or fully surround fruit; fruit a berry (fleshy).
         4. Fruiting calyx partially growing around and tightly enclosing the berry; corollas tomentose between the stamen bases (resembling a woolly pad in the center) _____ **Chamaesaracha**
         4. Fruiting calyx loosely growing around the berry like a paper bag; corollas not tomentose _____ **Physalis**

Chamaesaracha coronopus (Dunal) A. Gray. False nightshade

Herbaceous perennials from deeply buried roots, the stems often partially buried. Flowers cream-yellow, various seasons including spring and late summer. The above-ground portion is frost-sensitive.

Locally common along Coyote Wash.

Coyote Water, *Felger 04-35.* Coyote Wash at Camino del Diablo, *Felger 04-63.*

Datura discolor Bernh. Desert datura; *toloache*

Non-seasonal annuals but frost sensitive and responding poorly to cooler weather; highly variable in size—ca. 10 cm to occasionally 1 m tall. Herbage stinky. Flowers usually 8–17 cm long, white with a purple flush in the throat, nocturnal and fragrant. Fruits globose, spiny capsules, turning down at maturity.

Widely scattered across the flora area; washes, bajadas and valley plains, and canyon bottoms. The flowers are the largest of any plant in the region, but are comparatively small within the genus.

Camino del Diablo, SE of Raven Butte, *Felger 04-20.* Coyote Wash at Camino del Diablo, *Felger 04-64.* Observations: Tinajas Altas, bajada, 19 Mar 1998, *Felger*; Frontera Canyon, 18 Mar 1998, *Felger.*

LYCIUM—Wolfberry; *salicieso*

The four species in the region are hardwood shrubs often 1–2 m tall and armed with spines or thorn-tipped twigs. Leaves semi-succulent, the margins entire.

Lycium fremontii is morphologically gynodioecious: different plants have (1) smaller flowers that are male-sterile, with well-developed female parts and reduced or sterile stamens and anthers—these plants produce fruit, or (2) larger flowers that appear bisexual with well-developed male and female parts, however, these plants may be largely or functionally male and have substantially reduced or no fruit production (Miller & Venable 2002). The other three species in the flora area produce bisexual flowers. The fruits are edible (except *L. macrodon*), although only *L. fremontii* seems to have been a significant food plant (Felger 2007; Felger & Moser 1985; Hodgson 2001).

1. Stems with spines at nodes; corollas white and green; fruits hard and greenish glaucous, 1- or 2-seeded _____ **L. macrodon**
1. Stems often thorn-tipped, the nodes without spines; corollas white or lavender; fruits fleshy, orange to red-orange when ripe, several- to many-seeded.
   2. Calyx lobes about as long as, or longer than the calyx tube (lobes sometimes shorter on some flowers on a shrub, but some longer-lobed calyces usually present) _____ **L. parishii**
   2. Calyx lobes shorter than the tube.
      3. Plants glabrous; pedicels mostly 1–7 mm long; flowers bisexual, slender, the corolla tube narrow and cylindrical or nearly so _____ **L. andersonii**
      3. Leaves, pedicels, and calyces glandular-pubescent; pedicels 4–16 mm long; male and female flowers on different plants, the female flowers smaller than the male flowers; corolla tubes not narrow and cylindrical _____ **L. fremontii**

Lycium andersonii A. Gray var. **andersonii** [*L. andersonii* var. *deserticola* (C.L. Hitchc.) Jeps.] Anderson's wolfberry

Spinescent shrubs to 2+ m tall. Leaves slender and glabrous. Flowers small, slender, and lavender; non-seasonal. Fruits orange, fleshy, and edible.

Canyons and washes along the east side of the Tinajas Altas Mountains (**Fig. 15**).

Arroyo 2 mi SE of Tinajas Altas, *Felger 08-196*. Borrego Canyon, 3 Feb 1990, *Felger* (observation).

Lycium fremontii A. Gray var. **fremontii.** Frémont wolfberry; *salicieso*; kuavulĭ

Readily recognized by the glandular hairs on the herbage, pedicels, and calyx; long pedicels; dimorphic flowers (male and female flowers on separate plants); and relatively large, soft, red-orange, fleshy, and edible fruits. Flowers lavender. The wet foliage smells like a wet dog.

Widely scattered and often locally common along washes.

Coyote Water, *Felger 04-48*. Arroyo 2 mi SE of Tinajas Altas, *Felger 08-197*. Below Tinajas Altas, wash, *McLaughlin 1967*. Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation).

Lycium macrodon A. Gray. Desert wolfberry; s-cuk kuavulĭ

Long-shoot nodes often bearing stout spines; leaves often moderately glaucous and sometimes unusually large on long shoots. Flowers white and green, February to April. Fruits hard, glaucous, and constricted (appearing pinched) below the middle.

Washes, sand flats, alluvial flats, and sometimes on north-facing slopes at lower elevations. It grew in the Butler Mountains 8200 years ago but is not found there today. The fossil fruits are hard and bony.

Base of Tinajas Altas Mts, *Harrison & Kearney 6571*. Tinajas Altas, Gila Mountains, 6 Mar 1937, *Harbison 16816*. Camino del Diablo at Coyote Wash, *Felger 10-164*. †Butler Mts, twigs, leaves, fruits, 8160 ybp.

Lycium parishii A. Gray. Parish wolfberry; *salicieso*

Readily recognized by the markedly glandular-pubescent herbage, pedicels, and sepals, pale gray-green foliage, and pale lavender flowers with highly variable calyx lobes often much longer than the calyx tube. Corollas lavender; flowering response non-seasonal after rains. Fruits orange, fleshy, and marginally edible.

This is the most common and widespread lycium in the flora area. Washes, flats, canyons, and rocky slopes.

Coyote Water, abundant, *Felger 04-49*. Tinajas Altas, *Van Devender 9 Mar 1980*. Tinajas Altas Pass, *Reeves R5369* (ASU). Observations: Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger*; Frontera Canyon, 18 Mar 1998, *Felger*.

†**Lycium** sp./spp.

These fossil samples may represent more than one species. These seeds are the flattish, oval, and orange-brown typical of various lycium species, but not *L. macrodon*.

†Tinajas Altas, seeds, 4010–10,950 ybp (4 samples).

NICOTIANA—Tobacco

Glandular-pubescent annual or perennial herbs; fruits of capsules with numerous minute seeds.

1. Spring annuals; leaves sessile to short-petioled, the stem leaves not clasping; flowers pure white, nocturnal _____ **N. clevelandii**
1. Perennials, sometimes flowering in the first season; leaves all sessile, the stem leaves clasping (the leaf base wraps around the stem); flowers cream-white, diurnal _____ **N. obtusifolia**

Nicotiana clevelandii A. Gray. Desert tobacco; *tabaquillo del coyote*; ban vivga

Cool-season annuals. The largest leaves in a well-developed basal rosette. Flowers white, nocturnal, closing in the morning or later depending on temperature.

Often along washes and beneath large shrubs or trees; mostly sandy to gravelly soils of washes, bajadas, and desert plains.

Tinajas Altas, *Kearney & Peebles 10913*. Coyote Water, *Felger 05-127*. Tinajas Altas Pass, *Reeves R5407* (ASU).

Nicotiana obtusifolia M. Martens & Galeotti [*N. trigonophylla* Dunal] Coyote tobacco, desert tobacco; *tobaco de coyote*; O'odham ha-vivga

Perennial herbs. Flowers cream-white, diurnal; growing and reproductive almost any time of year depending on soil moisture.

Widespread across the flora area; washes, bajadas, canyons, and rocky slopes. The leaves were smoked as tobacco.

Base of Tinajas Altas, *Harrison 6568*. Steep slope just N of uppermost Tinajas Altas, 19 Mar 1998, *Felger* (observation).

Physalis versicolor Rydb. [*P. crassifolia* Benth. var. *versicolor* (Rydb.) Waterf.] Desert ground-cherry; *tomatillo del desierto*

Perennial herbs or subshrubs, and sometimes flowering in the first season. Flowers dull yellow, at various seasons.

East side of Tinajas Altas Mountains in washes and canyons, and slopes to at least 2100 ft.

Tinajas Altas, *Goodding 4902*. Vicinity of Tinajas Altas, *Van Devender 5 March 1983*. Wash, 2 mi SE of Tinajas Altas, *Felger 08-206*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†**Physalis** sp./spp.

Physalis has been a member of the local flora for more than 43,000 years. The seeds are diagnostic only to genus.

†Butler Mts, seeds, 740–11,250 ybp (5 samples). †Tinajas Altas, seeds, 1230 to > 43,000 ybp (20 samples).

†**Solanum hindsianum** Benth. [or possibly *S. elaeagnifolium* Cav.] HINDS NIGHTSHADE; *MALA MUJER*

Sparsely branched shrubs, variously spiny or not. Flowers showy and lavender.

The nearest present-day populations are in mountains in nearby northwestern Sonora and Organ Pipe Monument. The plants are frost sensitive and its northern limit seems to be determined by freezing weather (Felger 2000; Felger et al. 2007b).

The fossil seeds also match those of *S. elaeagnifolium*, which is not known from the present-day flora area but it is a common urban and agricultural weed in nearby regions. Both nightshade species have rather flat, lens-shaped seeds with a smooth and gray enamel-like surface, and their distinctive seeds compare well with the fossil seeds. The fossil nightshade was in Tinajas Altas 11,000 years ago and in the Ajo Mountains 20,500 years ago.

†Tinajas Altas, seeds, 10,950 ybp. †Organ Pipe Monument: Ajo Mountains, Montezuma's Head, seeds, 20,490 ybp.

URTICACEAE—NETTLE FAMILY

Parietaria hespera B.D. Hinton var. **hespera.** DESERT PELLITORY

Delicate cool-season annuals. Flowers minute and green.

Seasonally common along Coyote Wash and in the mountains, especially in protected niches among rocks and beneath spinescent shrubs.

Coyote Water, *Felger 04-55*. Tinajas Altas, *Felger 10-192*. Canyon below Raven Butte Tank, *Felger 10-236*.

VERBENACEAE—VERBENA FAMILY

†**GLANDULARIA** sp./spp.

Non-seasonal annuals or herbaceous perennials, present at Tinajas Altas 8700 years ago. The nearest present-day occurrences of the genus are *G. bipinnatifida* (Nutt.) Nutt. and *G. gooddingii* (Briq.) Solbrig in Organ Pipe Monument, and the latter is also in the eastern margin of Cabeza Prieta Refuge.

†Tinajas Altas, nutlets, 8660 ybp.

VISCACEAE, SEE **SANTALACEAE**

ZYGOPHYLLACEAE—CALTROP FAMILY

1. Shrubs with hardwood stems, usually 1 or more m tall; herbage strongly resinous; leaves with two fused leaflets appearing as one _____ **Larrea**
1. Annuals or herbaceous or scarcely woody perennials, plants less than 1 m tall; herbage not strongly resinous; leaves with 3 or more leaflets.
   2. Perennials and also flowering in first season; stipules spiny; leaflets 3 (or fewer when some or all leaflets are shed in drought); flowers lavender-pink _____ **Fagonia**
   2. Summer-fall annuals; plants unarmed; leaves with 6 or more leaflets; flowers yellow or yellow-orange _____ **Kallstroemia**

FAGONIA

Low-growing, spinescent perennials and also flowering in the first season. Leaves 3-foliolate. Flowers lavender-pink; flowering with warm weather at various seasons except during extended drought. No other genus is so wide ranging yet so closely restricted to the hot, arid deserts of the world. The seeds, which become mucilaginous when wet and adhere tenaciously upon drying, are probably a major factor in the unique and widely disjunct distributions (Bray 1898).

1. Stipules mostly slightly curved (at least some on each plant), 1.5–3 mm long _____ **F. laevis**
1. Stipules straight, the longer ones 5–12+ mm long _____ **F. pachyacantha**

Fagonia laevis Standl. [*F. californica* subsp. *laevis* (Standl.) Wiggins] **Fig. 20.**

Herbage glabrous or essentially so; spines short and moderately curved.

Rocky, arid slopes, canyons, and upper bajadas; not seen on open desert flats.

Fig. 20. *Fagonia laevis*. Tinajas Altas Canyon just above the tinajas. 28 April 2010. Photo by JM.

Borrego Canyon, *Felger 93-195.* Surveyors Canyon, *Felger 10-202.* Canyon below Raven Butte Tank, *Felger 10-230.*

Fagonia pachyacantha Rydb. [*F. californica* var. *glutinosa* Vail]

Plants glandular-pubescent; spines sharp, straight, and sometimes relatively long.

Arid, rocky slopes and canyons of hills and mountains, and upper bajadas.

Tinajas Altas Mts, 1200 ft, *Lindquist 25 Mar 1983.*

Kallstroemia californica (S. Watson) Vail. *Baiburín, mal de ojo*

Summer annuals. Stems generally trailing; leaves pinnate. Flowers small, yellow to yellow-orange.

Documented from washes and sand flats along Coyote Wash and expected elsewhere.

Coyote Water, *Felger 04-47.*

Larrea divaricata Cav. subsp. **tridentata** (Sessé & Moc. ex DC.) Felger & C.H. Lowe [*L. tridentata* (Sessé & Moc. ex DC.) Coville] Creosotebush; *hediondilla*, *gobernadora*; segai, segoi

Long-lived shrubs to 2+ m tall with very hard wood and gummy, resinous herbage. Flowers yellow, produced at various seasons except during extended drought.

Along with the common bursage *Ambrosia dumosa*, this is the most abundant and widespread shrub in the region, extending across the desert floor and on hills and mountains to at least 1570 ft. Creosotebush has been a major medicinal plant in the Sonoran Desert.

In the Sonoran Desert, *Larrea* was restricted to elevations below 1000 ft in the last glacial period (the Wisconsin) and probably many earlier glacial periods in the Pleistocene. The 18,700 ybp sample from Tinajas Altas is the oldest radiocarbon date for *Larrea* in North America. This is a tandem accelerator radiocarbon date taken directly on fossil twigs and leaves (Van Devender 1990). Kim Hunter related stomatal cell size to ploidy level, enabling her to deter-

mine that the Ice Age creosotebush from Tinajas Altas was tetraploid, demonstrating that the modern race was already here at that early date (Hunter et al. 2001). The Mojave Desert hexaploids were only found in Holocene samples—possibly formed as they migrated out of the Lower Colorado River Valley. Considering that 18,700 ybp was the Wisconsin full glacial, it is likely that creosotebush desertscrub was in the Lower Colorado Valley for much of the Pleistocene—after creosotebush immigrated from South America to the Chihuahuan Desert at some unknown previous interglacial time.

Camino del Diablo, SE of Raven Butte, *Felger 04-17.* Mesa E of Tinajas Altas, *Felger 08-187.* Canyon above Tinajas Altas, rocky bench just above arroyo bottom, 1570 ft (not seen at higher elevations), 26 Oct 2004, *Felger* (observation). †Butler Mts, twigs, leaves, fruits, 740–11,250 ybp (7 samples). †Tinajas Altas, twigs, leaves, fruits, 4010–18,700 ybp.

MONOCOTYLEDONS

1. Leaves in rosettes: thick, tough, and succulent with a stout terminal spine, or linear relatively flat and not succulent ____ **Asparagaceae** (*Agave*, *Nolina*)
1. Leaves not in rosettes and not as above.
   2. Herbaceous perennials from underground corms or bulbs; flowers whitish or blue and showy ____ **Asparagaceae** (*Hesperocallis*, *Triteleiopsis*)
   2. Annuals or perennials but not from underground bulbs; individual flowers often small, the perianth membranous or scale-like, or reduced or absent, and not petal-like.
      3. Cattails; leaves linear, erect, often to 1 m or more in length, thickened and pithy; tinaja wetland habitat ____ **Typhaceae**
      3. Grasses and sedges; leaves less than 1 m long, not thickened and pithy; widespread in many habitats.
         4. Annual sedge, stems solid (pithy); mostly 3–10 cm, each flower subtended by a single scale with a recurved awn tips; in temporarily wet soils ____ **Cyperaceae** (*Cyperus squarrosus*)
         4. Grasses; annuals or perennials; stems hollow or solid; each flower subtended by at least 2 bracts (the lemma and palea) ____ **Poaceae**

ASPARAGACEAE—Asparagus Family (includes Agavaceae, Hesperocallidaceae, Nolinaceae, Ruscaceae, Themidaceae)

1. Century plants (agaves) and beargrasses; leaves in rosettes, firm and variously armed with spines or flexible and with razor-like finely-serrated edges.
   2. Plants stemless or the stems very short, leaves mostly less than 60 cm long, thick and succulent, not flexible, with marginal spines and a stout terminal spine ____ **Agave**
   2. Plants developing a woody trunk; leaves often about 1 m or more long, flat, not succulent, flexible, and ending in a frayed, fibrous tip (not spine-tipped) ____ **Nolina**
1. Herbaceous perennials from underground corms or bulblets (bulbs) during cooler seasons; flowers whitish or blue.
   3. Flowers on racemes; flowers white or nearly so, more than 5 cm wide or long ____ **Hesperocallis**
   3. Flowers in an umbel; flowers blue, less than 2 cm long or wide ____ **Triteleiopsis**

Agave deserti Engelm. subsp. **simplex** Gentry. Desert agave; *lechuguilla*, *mezcal*; 'a'ud

Medium-sized agaves, solitary or forming small colonies from offsets. Leaves thick, dull colored, and with marginal spines. Flowers yellow, mostly April to June; fruits ripening June and July.

Widely scattered in the mountains, and occasional on upper bajadas on the eastern sides of the mountains. These agaves served as major food resources and the leaves yielded fiber.

The distribution expanded during the wetter rainfall climates of glacial times, and its range became fragmented in the Holocene. It is well represented in the fossil record from Tinajas Altas for than more than 18,700 years. Most of the fossil agave specimens were identified by Tony Burgess. His identifications were based in part on examination and comparisons of epidermal cell structure and stomatal patterns including their positions (e.g., sunken or not).

Between Camino del Diablo and Borrego Canyon, *Felger 90-19.* Tinajas Altas, *Goldman 2310* (US, image seen); *Van Devender 86-142*. †Tinajas Altas, leaf fragments (epidermis), prickles, seeds, 1230–18,700 ybp (17 samples).

Hesperocallis undulata A. Gray. Ajo lily, desert lily; *ajo silvestre*; a:sos

Growing and flowering during cool seasons from a single and rather large corm ("bulb"). Flowers white, 6–8 cm wide after opening in the late afternoon or early evening, and partially closing with daytime heat of the next morning. Flowering stalks highly variable sizes, in drier years the flower stalks may scarcely be visible but in wet years they may be more than 1.5 m tall, and in the driest years the plants remain as dormant bulbs.

Mostly on deep, sandy soils of the Lechuguilla Valley, plains and bajadas, and sometimes on rocky pediments. The relatively large corms were baked or boiled and also eaten fresh, probably in spring (Castetter & Bell 1951; Felger 2007; Hodgson 2001), but are rather slimy when fresh (also see Rea 1997).

Coyote Water, *Felger 05-119.*

†**Hesperoyucca whipplei** (Torr.) Baker ex. Trel. [*Yucca whipplei* Torr. *Y. newberryi* McKelvey] SPANISH BAYONET

Agave-like rosettes more than 1 m wide, the plants dying after flowering.

This species was widespread across the Sonoran Desert in early Ice Age times (Van Devender 1990) and is documented for Tinajas Altas from 11,000 to more than 43,000 years ago. It is missing from most Sonoran Desert middle and late Holocene midden samples, indicating that the main range reduction was due to drying climatic conditions, but locally people may have had an effect (Felger 2007). In other regions this species is known to have been a significant food resource: The hearts and the young emerging flower stalks were pit-baked like those of agaves, and the flowers and seeds were also eaten (Felger 2007). The harvesting methods preclude reproduction of the plants. A small relictual population occurs in the Sierra del Viejo (immediately south of Mexico Highway 2 in adjacent Sonora south of the Tinajas Altas Mountains, a place where there is no freshwater source (Felger 2000). It is otherwise absent across most of its former range in the Sonoran Desert. Could overharvesting in early prehistoric times have contributed to the final demise of this plant across most of the Sonoran Desert?

†Tinajas Altas, leaf fragments, 11,040, 18,700, & >43,000 ybp.

Nolina bigelovii (Torr.) S. Watson. DESERT TREE-BEARGRASS, BIGELOW BEARGRASS. **Fig. 21A, B.**

Yucca-like plants developing a woody trunk and large, tall flowering stalks. Flowers small, white and green, in June, and visited by numerous insects; fruits ripening during the same season.

Canyons and slopes including crevices in cliffs and rock faces, from lowest to high elevations in the Tinajas Altas Mountains.

The young flower stalks were pit-baked by the Cahuillas (Bean & Saubel 1972). The fibrous leaves of other *Nolina* species were used for basketry and other practical uses, and the seeds prepared for food, but evidence is lacking for such use for *N. bigelovii* (Felger 2007). *Nolina bigelovii* has been in the Tinajas Altas Mountains for more than 43,000 years.

Spectacularly tall nolinas occur along the bottom of Frontera Canyon (Fig. 21A). Some of these giants have trunks 4–5 m tall, and one fallen, dead nolina had a trunk slightly more than 6 m long (measured 18 Mar 1998). Most of these giants appeared to be declining and had leaves substantially shorter than smaller, "normal-sized" plants. Scattered, few nolinas, mostly in the canyon and higher slopes above the Tinajas Altas tanks, have trunks 3–4+ m tall and may be of the same age class as the Frontera Canyon giants. Bighorn sheep eat nolina leaves (Simmons 1966).

Tinajas Altas, *Shreve 6233.* Tinajas Mts, major tinajas, 390 m, Hodgson 6975 (DES).

†Tinajas Altas, leaf fragments, 4010–18,700 (16 samples), & >43,000 ybp.

Triteleiopsis palmeri (S. Watson) Hoover [*Brodiaea palmeri* S. Watson] BLUE SAND-LILY

Growing and flowering during cooler seasons from a cluster of small cormlets (bulblets). Flowers attractive, deep blue, on tall flowering stalks.

Sand flats and dunes west of the Tinajas Altas Mountains and widespread westward to Yuma and in the nearby western part of Cabeza Prieta Refuge and the Gran Desierto in adjacent Sonora.

The cormlets are tasty, eaten fresh or cooked (Felger 2007; Felger & Moser 1985).

Butler Mts, *Van Devender 27 Mar 1983.* Near Border Monument 198, *Morrison 73* (ASU).

†**Yucca brevifolia** Engelm. var. **brevifolia** and/or var. **jaegeriana** McKelvey [*Y. jaegeriana* (McKelvey) L.W. Lenz] JOSHUA TREE

This unique tree, emblematic of the Mohave Desert, was common in Organ Pipe Monument and the flora area from at least 43,000 to about 11,000 years ago. The nearest present-day occurrences of this species are in west-central and northwestern Arizona.

†Tinajas Altas, leaf fragments, 11,040, 18,700, & >43,000 ybp (abundant in these samples).

CYPERACEAE—SEDGE FAMILY

Cyperus squarrosus L. [*C. aristatus* Rottb. *Mariscus squarrosus* (L.) C.B. Clarke] DWARF SEDGE

Diminutive non-seasonal annuals, tufted and grass-like.

Found along Coyote Wash following rains that resulted in exceptional flow through the wash. The nearest known populations are documented from Las Playas and Cabeza Prieta Tanks, and the nearby Gran Desierto in Sonora (Felger 2000). Bird-dispersal is implied since the nearest populations are not connected to Coyote Wash by surface flow.

Coyote Water, *Felger 04-41.* Cabeza Prieta Refuge: Las Playas, *Monson 9.* Cabeza Prieta Tanks, *Monson 25 Sep 1955* (CAB).

Fig. 21. Desert tree-beargrass (*Nolina bigelovii*). A) An exceptionally tall plant with Luke Evans, Frontera Canyon, 18 March 1998. B) Upper elevation in the Tinajas Altas Mountains above the tinajas, 25 October 2009. Photos by RSF.

NOLINACEAE, see **ASPARAGACEAE**

POACEAE—Grass Family

Grasses are the second largest family in the flora. The 18 species in the present-day flora represent 8% of the total flora, as compared to the 14% of the flora of adjacent northwestern Sonora (Felger 2000). Three additional species are known from the flora area only by fossils. Eight present-day grass species in the flora are annuals (ephemerals) and 7 are tufted perennials, although some of the perennials may become reproductive in the first season. Four species are native to the Old World.

Thirteen grass species have been found in the fossil packrat middens. Three of them, *Bouteloua repens, Festuca microstachys*, and *Setaria macrostachya*, are no longer present in the flora area and today are found in less harsh areas to east of the flora area. Identifiable fragments of the fossils include fragments of inflorescences and reproductive structures that may include spikelets or even spikes or spikelet clusters, florets, caryopses ("grain"), or combinations or pieces of these parts.

1. Plants with stolons and/or rhizomes; perennials.
   2. Stems often more 40 cm tall; rhizomes stout and firm; inflorescence elongated and spike-like, overtopping the leaves, more than 4 cm long, less than 1.5 cm wide; spikelets in clusters of 3s _____ **Hilaria**
   2. Plants less than 15 cm tall, with slender, flexible stolons; flowering stems less than twice as tall as the leaves, the inflorescence branches densely crowded (fascicled); spikelets not in clusters of 3 _____ **Dasyochloa**
1. Plants without conspicuous stolons or rhizomes; annuals or perennials.
   3. Spikelets enclosed in bristly fascicles falling as a unit, the bristles flexible and feathery (plumose) _____ **Cenchrus**
   3. Spikelets not enclosed in bristly fascicles.
      4. At least some spikelets with awns.
         5. Annuals; awns not more than 2.5 cm long.
            6. Spikelets multiple flowered.
               7. Summer annuals (occasionally weakly responding to rains at other seasons or surviving after summer-fall rains); stems with 1-sided spikes (spicate branches), the spikes 2 or more and racemose, the spikes comb-like (the spikelets in a pectinate pattern) or the spikes needle-arrow shaped; individual spikelets 2 or more-flowered including awned rudiments, the fertile florets and rudiments very different from each other _____ **Bouteloua**

7. Cool-season annuals; spikes symmetrical or laterally compressed, but not 1-sided; sterile florets if present not appreciably different from the fertile florets except in size.
   8. Spikelets 12–40 mm long (not including awns); lemmas 8–13 mm long; awns 12–25 mm long ____ **Bromus**
   8. Spikelets 8–13 mm long (not including awns); lemmas 4–8 mm long; awns 1–8 mm long ____ **Festuca**
6. Spikelets 1-flowered.
   9. Spikelets usually 3-awned; without cleistogamous spikelets ____ **Aristida**
   9. Spikelets 1-awned and also producing unawned cleistogamous spikelets near the base of the plant ____ **Muhlenbergia**
5. Tufted perennials; awns 2 or more cm long.
   10. Old leaves semi-persistent and reddish brown or rust colored; inflorescences solitary and spike-like; awns 4.5–7 cm long ____ **Heteropogon**
   10. Old leaves drying straw color; inflorescences of panicles or clusters of spike-like branches; awns 2–4.5 cm long.
      11. Inflorescence cottony, of short branches clustered near top of stem; awns ca. 2 cm long, the basal portion twisted and not feathery ____ **Bothriochloa**
      11. Inflorescence an elongated spike-like panicle, not cottony; awns 3.3–4.5 cm long, bent, the basal portion feathery (plumose) and not twisted ____ **Stipa**
4. Spikelets not awned
   12. Annuals.
      13. Summer annuals; glumes shorter than the spikelet; lemmas not notched ____ **Eragrostis cilianensis**
      13. Cool-season annuals; glumes about as long as the rest of the spikelet; lemmas notched (bifid) ____ **Schismus**
   12. Tufted perennials.
      14. Inflorescences and spikelets cottony with silky, white to purplish hairs ____ **Digitaria californica**
      14. Inflorescences and spikelets not cottony; spikelets glabrous or pubescent but the hairs not silky.
         15. Panicle partially enclosed by an inflated leaf-sheath (often with a reduced blade), the upper part of the panicle often becoming free and the branches spreading; spikelets 1-flowered ____ **Sporobolous**
         15. Panicles narrow and contracted; spikelets several-flowered ____ **Tridens**

ARISTIDA—Threeawn; *zacate tres barbas*

Annuals and perennials. Spikelets 1-flowered, readily breaking off above the glumes (often lodging in socks—people might be supplanting animals as dispersal agents). Lemma hard at maturity, slender and terete, narrowing into an awn column bearing 3 awns, but sometimes the awns reduced or absent.

1. Annuals; awns flattened with minutely serrated margins (seen with at least 10× magnification), the awns reaching 1.5 (1.7) cm long (or awns occasionally very reduced, especially the lateral ones) ____ **A. adscensionis**
1. Perennials (sometimes flowering in first season); awns terete, (1.6) 2 cm long or more ____ **A. purpurea**

Aristida adscensionis L. Six-weeks threeawn; *zacate tres barbas*

Non-seasonal annuals, the roots often weakly developed. Spikelets with 3 awns or sometimes the 2 lateral ones, or all awns, reduced or absent on drought-stressed plants.

Seasonally common across the flora area, from lowest to highest elevations. This is the only annual *Aristida* in the Sonoran Desert. It has been in the region for more than 10,650 years.

Tinajas Altas, *Felger 04-69.* Tinajas Altas Pass, *Reeves R5416* 9 (ASU). Camino del Diablo at Coyote Wash, *Felger 10-165.* †Butler Mts, 8160–10,615 ybp. †Tinajas Altas Mts, 5080–10,070 ybp (3 samples; Van Devender et al. 1990b: 341).

Aristida purpurea Nutt. var. **nealleyi** (Vasey) Allred [*A. glauca* (Nees) Walp.] Purple threeawn; *tres barbas*

Tufted perennials; flowering response non-seasonal.

Tinajas Altas and Butler Mountains. The history of this variety extends to 9700 years in the Tinajas Altas Mountains and this or a similar species was in the Butler Mountains 11,300 years ago.

Butler Mts, *Van Devender 27 Mar 1983.* Tinajas Altas, *Vorhies 16 Apr 1924.* †Butler Mts, 6490 ybp (Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010 & 9700 ybp (Van Devender et al. 1990b: 341). †*A.* cf. *purpurea*, Butler Mts, 6490 to 11,250 ybp (3 samples, Van Devender et al. 1990b: 342).

Bothriochloa barbinodis (Lag.) Herter [*Andropogon barbinodis* Lag.] Cane bluestem; *zacate popotillo*

Robust tufted perennials; growing and reproductive during warm weather.

One small population was seen in Frontera Canyon and other small populations are known from a few scattered waterholes in Cabeza Prieta Refuge and the Gila Mountains.

Tinajas Altas, canyon bottom just above uppermost tinaja, 19 Mar 1998, *Felger* (observation).

BOUTELOUA—Grama grass; *grama*

The present-day grama grasses in the core area (most arid portion) of the Sonoran Desert are summer annuals,

often short-lived and with weakly developed root systems, and the basal leaves sparse and the internodes between them readily visible.

1. Inflorescence branches (spicate branches) needle-arrow shaped, with 1–4 slender spikelets closely appressed to the spike axis (spikelets scarcely spreading) ____ **B. aristidoides**
1. Spicate branches pectinate (comb shaped), often with 20–50 spikelets, these crowded in a double row, the spikelets perpendicular to the spike axis ____ **B. barbata** var. **barbata**

Bouteloua aristidoides (Kunth) Griseb. [*B. aristidoides* var. *arizonica* M.E. Jones] Six-weeks needle grama; *aceitilla*, *navajita aguja*

Summer annuals, the roots often weakly developed.

Seasonally common and widespread from the Lechuguilla Valley to at least 1700 ft in mountain canyons. It has been in the region for at least 11,300 years.

Bouteloua aristidoides is generally more numerous and extends onto drier sites than does *B. barbata*. Both sometimes weakly occur with cool-season rains or survive beyond the summer-fall season. These two species are among the most common hot-weather annuals in the Sonoran Desert.

Coyote Water, *Felger 04-31*. Tinajas Altas, above the tinajas, 19 Mar 1998, *Felger* (observation). 150 m N of Raven Peak (700 m SSW of Raven Butte), steep draw, *Walter & Morrison 584* (ASU). †Butler Mts, 610–11,250 ybp (6 samples; Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010 & 8700 ybp (Van Devender et al. 1990b: 341).

Bouteloua barbata Lag. var. **barbata.** Six-weeks grama; *navajita, zacate liebrero*; s-cuk mudadt-kam

Summer annuals, the roots often weakly developed. Anthers either orange or white.

Widespread from the Lechuguilla Valley and to at least 1700 ft in mountain canyons.

Coyote Water, *Felger 04-32*. Tinajas Altas, *Felger 04-70*.

†**Bouteloua barbata** var. **barbata** &/or var. **rothrockii** (Vasey) Gould [*B. rothrockii* Vasey]

One or perhaps both varieties of this grama grass are represented in the fossil record from about 5000 and 8700 years ago in the Tinajas Altas Mountains (in Organ Pipe Monument for at least 21,900 years). The two taxa are distinguished by growth form (annual for var. *barbata*, perennial for var. *rothrockii*), not by reproductive structures, and cannot be distinguished by the fossils, which are reproductive fragments.

†Tinajas Altas Mts, 5080 & 8700 ybp (Van Devender et al. 1990b: 341).

†**Bouteloua repens** (Kunth) Scribn. & Merr. [*B. filiformis* (E. Fourn.) Griffiths] Slender grama; *navajita delgada*

Tufted perennials, generally growing with warm weather.

Documented for 8200 years ago in the Butler Mountains. The nearest present-day populations are in the Puerto Blanco and Ajo Mountains and locally elsewhere in Arizona Upland portions of Organ Pipe Monument.

†Butler Mts, 8160 ybp (Van Devender et al. 1990b: 342).

***Bromus madritensis** L. subsp. **rubens** (L.) Husn. [*B. rubens* L.] Red brome; *bromo rojo*

Cool-season annuals; inflorescences brush-like at maturity. Lemmas with slender, bifid terminal lobes, and an awn 12–26 mm long, stiff, stout, straight or slightly curved

This invasive grass, native to the Old World, has become abundant in southern Arizona and across the northern part of Sonora, and is thoroughly established in Organ Pipe Monument, Cabeza Prieta Refuge, and the Sierra El Pinacate, but as of 2010 it was not common in the Tinajas Altas region. Unlike at least most native annuals, red brome does not produce dormant seeds and does not maintain a seed bank in the soil (Salo 2004).

Camino del Diablo at Coyote Wash, *Felger 02-8*. Tinajas Altas, *Felger 05-483*.

***Cenchrus ciliaris** L. [*Pennisetum ciliare* (L.) Link] Buffelgrass; *zacate buffel*

Robust perennials and often flowering in the first season; growing and flowering during the warmer months.

Buffelgrass is well established along Mexico Highway 2 across northwestern Sonora and has spread northward into the larger washes and canyons at the southern tip of the Tinajas Altas Mountains. As of 2010 this usually invasive species had been seen in the Tinajas Altas region only along the international border.

Frontera Canyon, international border, not common, 18 Mar 1998, Felger (observation).

Dasyochloa pulchella (Kunth) Willd. ex Rydb. [*Erioneuron pulchellum* (Kunth) Tateoka. *Tridens pulchellus* (Kunth) Hitchc.] Fluff grass; *zacate borreguero*

Low, tufted perennials with slender, arching stolons. Flowering with warm weather and sufficient soil moisture; recruitment apparently occurs with summer rains. Seedlings may grow from the base of old, dry or dead plants, which serve as nurse plants.

Widespread in dry, open sites on mountains, hills, and upper bajadas. This is one of the most arid-inhabiting perennial grasses in the Sonoran Desert. It has been in the region for more than 10,300 years.

Camino del Diablo, SE of Raven Butte, *Felger 04-11.* Tinajas Altas, above upper tinajas, *Felger 04-92.* †Butler Mts, 220–11,250 ybp (9 samples; Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010–10,300 ybp (5 samples; Van Devender et al. 1990b: 340).

Digitaria californica (Benth.) Henrard var. **californica** [*Trichachne californica* (Benth.) Chase] ARIZONA COTTONTOP; *ZACATE PUNTA BLANCA*

Tufted perennials; panicles narrow and densely flowered, the spikelets silky-cottony.

Only two plants of this grass were seen in the flora area, but perhaps it occurs at higher elevations in the mountains.

Tinajas Altas, one plant seen among rocks at base of tinaja slopes, *29 Dec 2005*, *Felger* (observation); 28 Mar 2010, *Felger 10-185* (one panicle collected).

***Eragrostis cilianensis** (Allioni) Vignolo ex Janch. STINK GRASS; *ZACATE APESTOSO*

Summer annuals. The spikelets bear small, wart-like glands that are turgid and glistening when fresh.

Seasonally common along Coyote Wash. Native to the Old World and well established in the Sonoran Desert. The Sonoran Desert plants are considerably smaller than those in more humid regions.

Coyote Water, *Felger 04-21.*

†**Festuca microstachys** Nutt. [*Vulpia microstachys* (Nutt.) Munro] SMALL FESCUE

Cool-season annuals. Documented in the flora area from 11,000 years ago. The nearest present-day populations are in the Ajo Mountains in Organ Pipe Monument. Four varieties are sometimes recognized, but they are not geographically well marked and do not seem worthy of recognition (Felger 2007b; var. *ciliata* A. Gray ex Beal is recorded for the Ajo Mountains).

†Tinajas Altas Mts, 10,950 ybp (Van Devender et al. 1990b: 340).

Festuca octoflora Walter [*F. octoflora* var. *hirtella* Piper. *Vulpia octoflora* (Walter) Rydb.] SIX-WEEKS FESCUE, EIGHT-FLOWERED FESCUE

Small, cool-season annuals; highly variable in size, 2.5–15+ cm tall.

Washes, upper bajadas, canyons, and mountains to at least mid-elevations. It has been in the flora area for at least 11,300 years.

Three varieties are sometimes recognized but are of doubtful significance (Felger 2000; Felger et al. 2007b). Present-day specimens are var. *hirtella*, characterized in part by pubescent spikelets (lemmas).

Tinajas Altas, 1450 ft, *Van Devender 10 Mar 1980.* Tinajas Altas, near lowermost tinaja, *Felger 10-186.* Coyote Water, *Felger 05-136.* †Butler Mts, 11,250 ybp (Van Devender et al. 1990b: 342). *F.* cf. *octoflora*: †Tinajas Altas Mts, 8970–10,950 ybp (4 samples; Van Devender et al. 1990b: 340).

Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult. [*Andropogon contortus* L.] TANGLEHEAD; *ZACATE COLORADO*

Robust tufted perennials; dry leaves rust-colored and persistent. Spikelets bearing stout, brown, and twisted awns 4.5–7+ cm long. Reproductive during warmer months.

Canyon bottoms in the Tinajas Altas Mountains. Although some authors have claimed it is not native in the New World, it has been here at Tinajas Altas for at least 7900 years (Van Devender et al. 1990b).

Tinajas Altas Mts, 1200 ft, *Van Devender 25 Mar 1983.* †Tinajas Altas Mts, 5860–7860 ybp.

Hilaria rigida (Thurb.) Benth. ex Scribn. [*Pleuraphis rigida* Thurb.] BIG GALLETA; *TOBOSA*

Large, tufted perennials, forming dense clumps, the bases tough and knotty, with short, almost woody rhizomes. Growing and flowering primarily during the warmer months. Large, inflated galls often form in place of inflorescences.

Widespread on sandy soils across valley plains and bajadas, and sometimes locally in soil pockets on rocky slopes. It has been in the region for more than 10,400 years.

Coyote Water, *Felger 04-46.* Surveyors Canyon, *Felger 10-201.* Canyon above Tinajas Altas, 19 Mar 1998, *Felger* (observation). †Butler Mts, 3820–10,400 ybp (3 samples; Van Devender et al. 1990b: 342).

Muhlenbergia microsperma (DC.) Kunth. LITTLE-SEED MUHLY; *LIENDRILLA CHICA*

Non-seasonal annuals but best developed during cooler seasons. Spikelets 1-flowered. Lower leaf axils bear cleistogamous spikelets (self-fertilizing and not opening); terminal panicles branched and feathery, with chasmogamous spikelets (stamens and stigmas exposed) with awns 14–28 mm long.

Widespread at all elevations; most abundant in protected sites, especially among rocks and under spinescent shrubs (often eaten by animals in open sites); rocky slopes, canyons, bajadas, and washes. Its history in the region extends to 15,700 years.

Coyote Water, *Felger 04-51.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Butler Mts, 750 ybp (Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 8700–15,680 ybp (3 samples; Van Devender et al. 1990b: 341).

Pennisetum ciliare*, see **Cenchrus ciliaris

***Schismus arabicus** Nees [*S. barbatus* subsp. *arabicus* (Nees) Marie & Weiller] ARABIAN GRASS; *ZACATE ÁRABE*

Small, cool-season annuals. Widespread and well established in the flora area—most abundant on sandy soils of washes and valley plains, and also on rocky soils on slopes. Native to the Old World.

It was seen in the Tinajas Altas Canyon and on adjacent slopes near the uppermost waterhole, but not at higher elevations. The young stems and leaves of this invasive species often spread close to the ground, excluding or preventing other plants from sprouting (Felger 2000). This small grass and Sahara mustard (*Brassica tournefortii*) are the only two invasive species that appear to be impacting native plants in the flora area.

Coyote Water, *Felger 05-154.* Tinajas Altas, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-243.* Tinajas Altas Canyon, ca. 1800 ft, canyon bottom near the uppermost tinaja, 19 Mar 1998, *Felger* (observation).

†Setaria macrostachya Kunth [complex, including *S. leucopila* (Scribn. & Merr.) K. Schumann] PLAINS BRISTLEGRASS; *ZACATE TEMPRANERO*

Perennial clumping grasses; growing and reproductive at various seasons, especially with summer-fall rains.

Documented for the Tinajas Altas Mountains with specimens 11,000 years old. The nearest known present-day population occurs in the Cabeza Prieta Mountains, mostly at higher elevations. It has been in the Ajo Mountains for at least 32,000 years (Van Devender et al. 1990b).

†Tinajas Altas Mts, florets, 10,950 ybp (Van Devender et al. 1990b: 341).

Sporobolus cryptandrus (Torr.) A. Gray. SAND DROPSEED; *ZACATE ARENERO*

Tufted perennials. Panicles enclosed by an inflated leaf-sheath (often with a reduced blade), the upper part of the panicle often but not always becoming free at maturity and the branchlets ultimately spreading. Known in flora area from a single record.

Tinajas Altas, 6 Dec 1935, *Goodding 599.*

Stipa speciosa Trin. & Rupr. var. **speciosa** [*Achnatherum speciosum* (Trin. & Rupr.) Barkworth. *Jarava speciosa* (Trin. & Rupr.) Peñailillo] DESERT NEEDLE GRASS

Perennials forming a dense basal clump of leaves, the leaf blades slender, tough, and rolled inward. Dormant during the coldest and also the hottest months. Growing and reproductive March to May and in fall.

Canyons and mostly north-facing slopes in the Tinajas Altas Mountains to at least 2200 ft. It has been in the flora area for at least 11,000 years. Maximum distribution seems to have been in the early Holocene and this grass is now widespread in the Mohave Desert. Like the Joshua tree, it seems to have expanded northward into Nevada during the last Ice Age/glacial period when it was still persistent in deserts in southwestern Arizona.

Borrego Canyon, *Felger 92-616.* Tinajas Altas, *Van Devender 26 Mar 1983.* 1 mi N of Tinajas Altas, *Kurtz 1164.* †Butler Mts, 3820 & 10,615 ybp (Van Devender et al. 1990b: 341–342). †Tinajas Altas Mts, 5860–10,950 ybp (7 samples; Van Devender et al. 1990b: 341).

Tridens muticus (Torr.) Nash var. **muticus.** SLIM TRIDENS

Tightly clumping small perennials with firm, slender stems, the stems and leaves often bluish glaucous. Apparently non-seasonal in growth and flowering response.

Common on rocky slopes and shallow soils in canyons, hills, and mountain slopes probably to the peaks.

Canyon above Tinajas Altas, *Felger 04-75.* N-facing slope near lowermost tank, 20 Nov 2008, *Felger* (observation). Borrego Canyon, 16 Jun 1992, *Felger* (observation).

THEMIDACEAE, see **ASPARAGACEAE**

TYPHACEAE—Cattail Family

Typha domingensis Pers. Southern cattail; *tule*; 'uduvhag

Robust perennial herbs; winter dormant. Leaves upright, to 1.8 m long. The tiny, lightweight fruits (0.02–0.03 mg) with their associated hairs are produced in prodigious quantities and may be airborne over great distances, and probably are also bird-disseminated.

Cattails were seen at tinajas #4 (*see* Bryan 1925: 133) during the 1970s and 1980s, and a specimen was obtained in 2008 (**Fig. 22**). This is the only wetland plant species known from the Tinajas Altas Mountains. It occurs at scattered waterholes in nearby regions, including the Cabeza Prieta Refuge and northwestern Sonora, and is abundant along the lower Colorado River (Felger 2000; Felger et al. 2007b). Small local colonies or individual plants in nearby areas sometimes come and go with fluctuations in standing water.

Tinaja or pool #4 is a "shelf" Tinaja (about 25 ft perpendicular to flow), narrow (5 ft parallel to flow), nearly inaccessible pool midway up the plunge-pool series and above, not beside, the large wedged boulder. It is filled with sediment and Broyles has only once seen standing water in it, up to 60 cm deep, but the sediment undoubtedly holds moisture for a long time. *Typha* has not been seen at any other pool, for they may be too frequently scoured to support wetland plants.

Tinajas Altas tank, 10 Mar 1980, *Barry Spicer*, observation, in Van Devender field notes. A label for *Cheilanthes parryi* (*Engard 920*, 18 Apr 1976, ASU) states, "above the tinaja containing *Typha*." Tinajas Altas, "cattails at tanks," 12 Feb 1977, *Reeves* (observation recorded in his field notebook). Tinaja #4, sheltered trench in damp soil at the edge of the tinaja, 20 Nov 2008, *Wilder 08-383*.

DOUBTFUL, ENIGMATIC, AND POTENTIAL RECORDS

AMARANTHACEAE—Amaranth Family

Amaranthus palmeri S. Watson. Careless weed, pigweed; *quelite de las aguas*; cuhugia

Summer annuals; leaf blades mostly ovate. Male and female flowers on different plants; pistillate inflorescence bracts firm and often sharp; sepals not fringed; stamens 5.

Strangely, there are no records for it in the flora area, but we would expect it at least along Coyote Wash. It is common in nearby localities.

CONVOLVULACEAE—Morning Glory Family

Jacquemontia pringlei A. Gray

Scandent or sprawling subshrubs, the upper stems often twining. Corollas white, becoming pale lavender as the flower ages during the day.

With one exception, the Ajo Mountains in Organ Pipe Monument is the most arid and westernmost record for the genus. The exception is an enigmatic specimen collected by Andrew Alexander "Nic" Nichol on 25 April 1938 at the "South end of Gila Mountains." Before the mid-twentieth century it was customary to include the Tinajas Altas Mountains in the concept of the Gila Mountains. On that same day Nichol collected *Muhlenbergia dumosa* in the "Mohawk Mountains" and *Aristida purpurea* in the "Gila Mountains." The muhly grass is likewise an enigmatic and tantalizing "extralimital" collection. In addition to canyons in the Tinajas Altas Mountains, other places such as a little side canyon in Spook Canyon in the Gila Mountains seem like a plausible place to support such plants, or perhaps Nichol's locality data is in error.

POACEAE—Grass Family

Aristida californica Thurb. var. **californica.** California threeawn; *tres barbas de California*

Non-seasonal perennials also flowering in the first season. This grass, characteristic of sandy soils, should be sought in portions of the Lechuguilla Mountains and sand soils on the west side of the Tinajas Altas Mountains. It is common on sand flats and dunes at the west side of Cabeza Prieta Refuge and in the Gran Desierto of Sonora just south of the flora area (Felger 2000; Felger et al. 2007b).

Cenchrus palmeri Vasey. Giant sandbur; *huizapori*, *guachapori*

This unique grass has relatively large burs bearing sharp spines. Not known for the United States, but widespread on sandy soils in the nearby Gran Desierto almost to the Arizona border near Frontera Canyon. It should be sought on the Arizona side.

Fig. 22. Cattail (*Typha domingensis*, *Wilder 08-383*) at Tinajas Altas, tinaja #4. 20 November 2008. Photo by Benjamin T. Wilder.

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