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AJO PEAK TO TINAJAS ALTAS: A FLORA OF SOUTHWESTERN ARIZONA:
PART 3: FERNS, LYCOPODS, AND GYMNOSPERMS

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ABSTRACT

A floristic account is provided for the ferns, lycopods, and gymnosperms as part of the vascular plant flora of the contiguous protected areas of Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, and the Tinajas Altas Region in southwestern Arizona—the heart of the Sonoran Desert. This floristic treatment includes identification keys, common names when available in English, Spanish, and the local O'odham language, brief descriptions, local and global distributions, fossil records from packrat middens, ethnobotanical information, natural history observations, and specimen citations. This is the third contribution for our flora and follows Felger et al. (2013a, 2013b). We also include a brief explanation of the format for the species accounts in this and forthcoming contributions. These contributions are also posted open-access on the website of the University of Arizona Herbarium (ARIZ).

This publication is a floristic account of the ferns, lycopods, and gymnosperms as part of the vascular plant flora of the contiguous protected areas of Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, and the Tinajas Altas Region in southwestern Arizona—the heart of the Sonoran Desert (Figure 1). The floristic treatment includes identification keys, brief descriptions, common names when available in English, Spanish, and the local O'odham language, local and global distributions, fossil records from packrat middens, ethnobotanical information, natural history notes, and specimen citations. This is the third contribution for this flora and follows Felger et al. (2013a, 2013b) and includes a brief explanation of format and contents for the species accounts for the present and forthcoming treatments. These contributions are also posted open access on the website of the University of Arizona Herbarium (ARIZ).

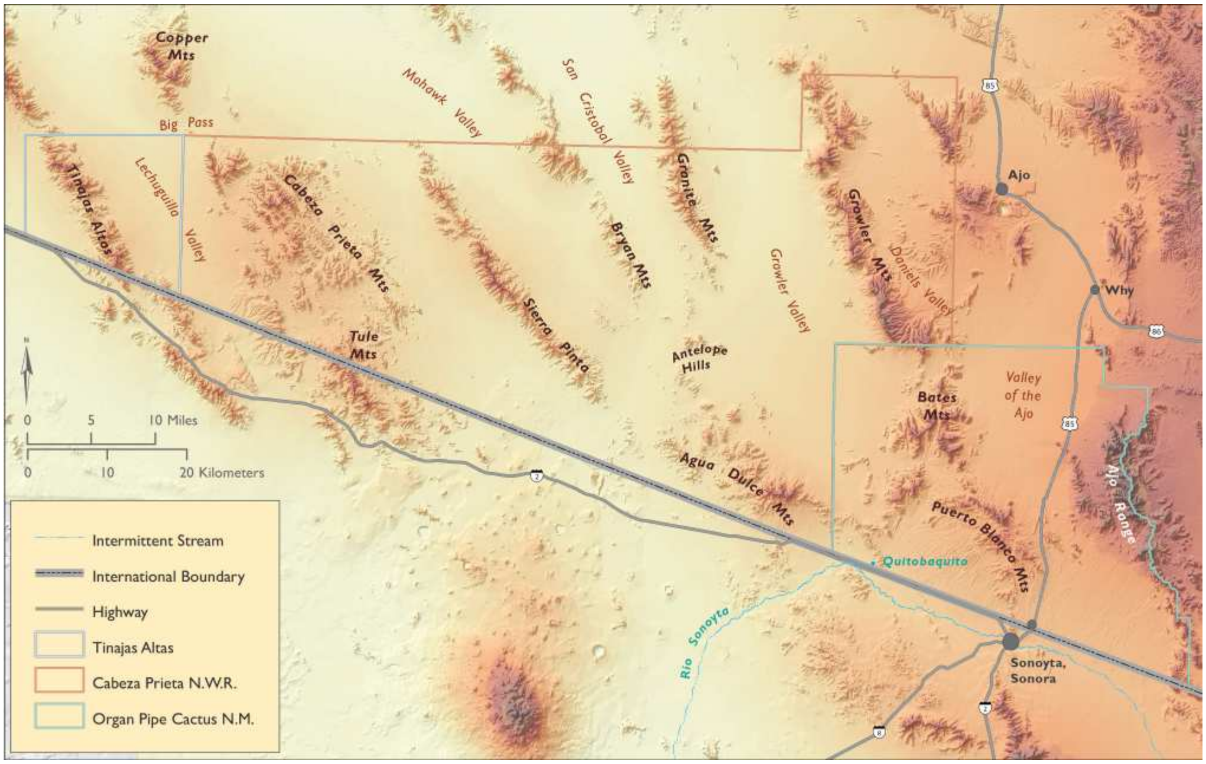

Figure 1. Flora area in southwestern Arizona. Map prepared by Ami Pate of Organ Pipe Cactus NM, 2013.

SPECIES ACCOUNTS – THE FLORA

Plants in this flora are grouped as pteridophytes (ferns and lycopods or "ferns and fern relatives"), gymnosperms (cone-bearing plants), magnoliids (early angiosperms, or early dicots), eudicots (eudicotyledons, dicotyledons in general), and monocots (monocotyledons). Within these categories the plants are listed alphabetically by family, genus, species, and infraspecific taxa (subspecies or varieties). The accepted scientific names are in bold. The authors of scientific names are not in bold. Selected synonyms of scientific names are italicized within brackets [--]. Vernacular, or common names, follow the scientific names or synonyms and when known or deemed worthwhile are given in English, Spanish, and the Hia C-ed O'odham dialect, respectively. The Spanish-language names are italicized. The O'odham orthography generally follows that of Alvarez and Hale (1970), with the exception that *v* is substituted for *w*. In Hia C-ed O'odham speech, *v* and *w* are both used, depending on context (Gary Nabhan in Felger et al. 1992; Felger et al. 2007b). Plant family designations follow the APG III system (Angiosperm Phylogeny Group; Stevens 2011).

All specimens cited are at the University of Arizona Herbarium (ARIZ) unless otherwise indicated by the abbreviations for herbaria at Cabeza Prieta National Wildlife Refuge (CAB), Organ Pipe Cactus National Monument (ORPI), and the standardized abbreviations for herbaria (Index Herbariorum, Thiers 2013). This is a specimen-based flora and all specimens cited have been seen or verified by Felger or co-authors unless otherwise noted. Some records are verified by a scanned image of a herbarium specimen; others records are noted as documented by an observation, photo, or a published report. The date of collection, name of the collector and collection number are provided, or 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*. Additional specimen records can often be found in the Southwest Environmental Information Network (SEINet 2013), and/or the regional herbaria including ARIZ, ASU, DES, SD, and the herbaria at Organ Pipe Cactus National Monument (ORPI) and Cabeza Prieta National Wildlife Refuge (CAB). In cases where more than one collector is listed on a label, generally only the first collector's name is given. In a few cases the herbarium accession or identification number follows the herbarium abbreviation in order to avoid confusion and provide additional accuracy.

Area designations are as follows: **OP** = Organ Pipe Cactus National Monument, **CP** = Cabeza Prieta National Wildlife Refuge, **TI** = Tinajas Altas region. Non-native plants established as reproducing populations in the flora area are indicated with an asterisk (*), and non-native species or taxa not established as reproducing populations are marked with two asterisks (**). (All ferns, lycopods, and gymnosperms in the flora area are native.) The identification keys are for the modern flora, although some extirpated on not-established non-natives not included in the keys. The deep history plant records (fossils) of ones not found in the modern flora are not included in the keys. Fossil specimens and taxa known only from the fossil record are indicated with a dagger symbol (†). The two states of the Baja California Peninsula are listed by their formal names, Baja California for the northern state and Baja California Sur for the southern state, and Baja California Peninsula refers to both states or in cases where the specific state is not known.

An effort has been made to use key features (key characters) that can be readily seen and are as non-technical as possible. The drawback to such user-friendly keys can be loss of precision, since more technical features such as detailed floral or other reproductive structures can be more reliable than many vegetative features. But the flora area is a desert and flowers and fruits, or reproductive structures are often not available, and even leaves may not be available in times of drought. Borderline cases will often key out in more than one choice and in order to make the keys user friendly there may be redundancies. The keys, however, cannot be totally user-friendly and 100 percent accurate—for some difficult specimens you sometimes will have to go to more than one choice in the keys and then look at the descriptions and illustrations, or even other, more detailed regional floras (e.g., Felger 2000) or more general floras such as the Vascular Plants of Arizona (Vascular Plants of Arizona Editorial Committee 1992), The Jepson Manual (Baldwin et al. 2012), the Flora of North America volumes, etc.

FERNS (PTERIDOPHYTES) AND LYCOPODS (LYCOPHYTES)

Sixteen species of non-seed-bearing vascular plants, the ferns and lycopods, are known from the flora area. These plants make up 2 percent of the local flora as compared to 4 percent of the world flora of vascular plant species. These plants require moist conditions for active growth and with the exception of *Marsilea*, in the Sonoran Desert they are restricted to rocky places, especially at higher elevations and north-facing exposures—places where there often is shade and extra soil moisture. These plants often occur in microhabitats in and among rock, rock crevices, and ledges that protect the gametophytes (the small plants of the sexual phase) or young plants and rhizomes of adult plants (sporophytes). *Marsilea*, in a low-lying desert habitat with seasonal flooding, has taken on a desert annual (ephemeral) way of life, which is unusual among pteridophytes.

Pteridophyte species richness correlates with rainfall—diversity is highest in the Ajo Mountains and drops off sharply westward in the more arid regions. All except *Marsilea* occur in Organ Pipe. The Ajo Mountains and other higher ranges in Organ Pipe support 13 species and 5 of them do not occur elsewhere in the flora area. Cabeza Prieta has only 6 species and *Astrolepis cochisensis* and *Cheilanthes parryi* are the only ones found in the hyper-arid Tinajas Altas Mountains. The two lycophytes (*Selaginella*) occur in Organ Pipe and Cabeza Prieta, and only *S. eremophila* is in the Tinajas Altas region.

Desert pteridophytes generally desiccate with dry conditions and rehydrate with return of moisture, and therefore are often called “resurrection” plants or “resurrection ferns,” especially the arid-inhabiting spike–mosses (*Selaginella*) and cheilanthoid ferns (the Pteridaceae genera in the flora area). The leaflets, leaves, and also the stems in the case of the spike-mosses, curl up and desiccate during dry times, which is the majority of the time. During dry conditions you won’t see much or any green surface in these plants, but they quickly unfold with return of rain. The spike-mosses become green again and photosynthetic. However, “with the ferns, there is a limit to how long a leaf can remain desiccated before dying. Most of the time when you see dried up ferns before the summer rains start, their leaves don’t revive, but rather new leaves are produced. It is true that in many cases one can soak a specimen in water overnight and because of the mechanical response get a decent pressing [for a herbarium specimen] the following morning [or sometimes in a few hours]. However, those leaves generally are dead and also create a wind-free zone around the emergent rhizome tip” (George Yatskievych, pers. comm. 2013).

“Much of the research on ferns has focused on the ability of gametophyte tissues to survive desiccation (or grow back from just a few cells) and the high concentrations of solutes that accumulate in cells during this phenomenon. A wide variety of fern gametophytes are physiologically adapted to drought tolerance, not just those in deserts” (George Yatskievych, pers. comm. 2013). Many of the xerophytic adaptions are derived from tropical taxa (e.g., Watkins et al. 2007). Other adaptations to xeric conditions include apogamic reproduction, reduced leaf surface area (e.g., smaller leaves and leaflets), dense induments of scales, hairs, and farina (waxy coverings), especially on surfaces remaining exposed during dry times, and inhabiting locally favorable microhabitats such as north-facing exposures among rocks (e.g., Hevly 1963; Nobel 1978; Quirk & Chambers 1981; Rothfels et al. 2008; Sigel et al. 2011).

1. Leaves less than 4 mm long, scale-like and sessile .... **Selaginellaceae**
1. Leaves more than 10 mm long, with prominent petioles.

    2. Leaves resembling a “4-leaf clover,” with 4 leaflets at apex of petiole .... **Marsileaceae**
    2. Leaves deeply divided (pinnatifid) or with more than 4 leaflets, not resembling a clover leaf .... **Pteridaceae**

MARSILEACEAE – Water-clover Family

MARSILEA VESTITA Hooker & Greville
[*M. mucronata* A. Braun]
Hairy water-clover. Figure 2.

Annuals (ephemerals), apparently non-seasonal in the flora area. Highly variable in size depending on quantity and duration of water, those in the flora area known as small, stunted land forms producing dense tufts of nodes, leaves, and sporocarps. Leaves densely hairy, less so with age and size, resembling a “4-leaf clover” with four closely set, fan-shaped leaflets at the apex of the petiole. (Submerged aquatic forms, characteristic of younger plants, have not been observed in the flora area, but presumably would be present; these can form long rhizomes, floating leaves, and are glabrous). Land forms have functional pulvini that orient the leaflets during the day and cause them to fold together at night. The sporangia are enclosed in nutlike, drought-resistant bony sporocarps on short stalks.

In the flora area known only from Las Playas and also found in similar large playas in adjacent northwestern Sonora, where it likewise is an ephemeral or desert annual (Felger 2000). In these places *Marsilea* can be seasonally abundant at the margins of temporarily pools or rivulets in

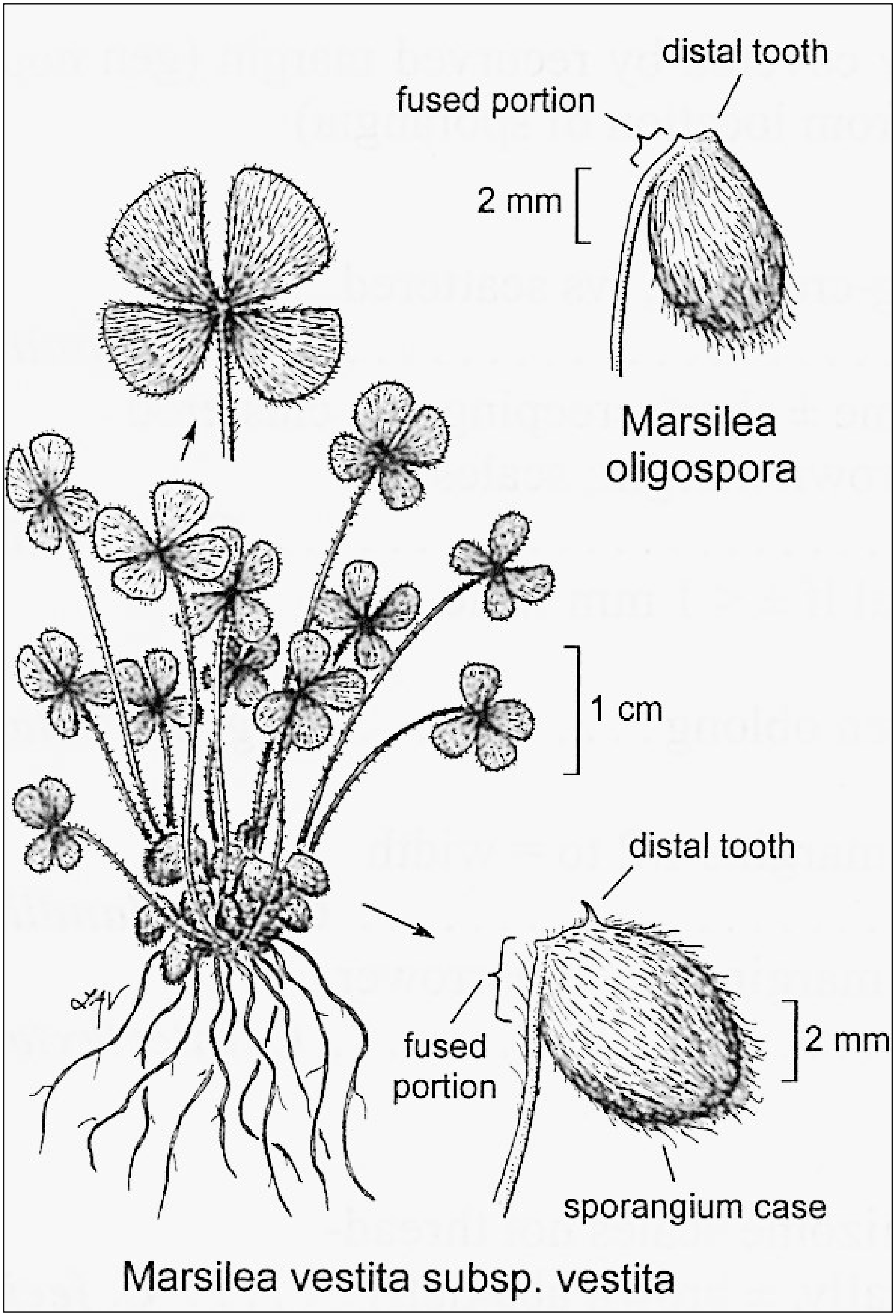

Figure 2. *Marsilea vestita* var. *vestita* and sporocarp of *M. oligospora*. Illustration by Linda Ann Vorobik (Hickman 1993).

water-logged, muddy, clayish soils. These *Marsilea* plants have been observed as emergent from very shallow water and persisting in the drying mud and were visible for about 6–8 weeks after the water dried up. No signs of the plants were found during dry seasons. *Marsilea* at Las Playas is often found beneath or close to mesquite shrubs bordering the playas and in close proximity or with *Eryngium nasturtiifolium*, *Euphorbia spathulata*, and *Teucrium cubense*.

Western two-thirds of North America from Canada to central Mexico.

Marsilea vestita is the only Sonoran Desert terrestrial pteridophyte to be functionally ephemeral and the only one found away from rocky habitats. The annual habit is also known among *M. vestita* from south of the Sonoran Desert (e.g., *Sanders 9247*) and among other *Marsilea* species such as *M. ancylopoda* A. Braun and *M. deflexa* A. Braun, which "does not persist as sporophytes with viable rhizomes through the dry season, but new plants are produced each wet season by dehiscence of sporocarps" (Mickel & Smith 2004: 184).

"*Marsilea* requires an aquatic environment to reproduce via spores. The sporocarps open when water penetrates their innards to extrude a large gelatinous ring of hydrophilous material, to which the sori are attached. These eventually release micro- and megaspores and the sperm have to swim to the egg for fertilization. What's different about *Marsilea* is that the whole process, from dehiscence of the sporocarp to the emergence of the next generation of sporophytes, takes only about a week. So, there doesn't need to be water present for very long" (George Yatskievych, pers. comm. 2013).

Spores in sporocarps taken from 77-year-old herbarium specimens of *Marsilea vestita* originally collected in California produced viable plants, and century-old spores from a herbarium specimen of the closely related *M. oligospora* Goodding also produced plants (Johnson 1985). Birds are likely agents of dispersal because the sporocarps survive undamaged after passing through the digestive tract of certain waterfowl that feed on the plants as well as sticking to their muddy feet (Malone & Proctor 1965). *Marsilea* shares "many characteristics with those of weedy seed plants, such as long propagule dormancies, self-compatibility, rapid growth, and occurrence in early successional habitats" and "further differs from most ferns . . . in its use of biotic rather than abiotic dispersal agents" (Johnson 1986: 27).

CP: Las Playas: Under a *Prosopis* on the bank of a channel, with *Euphorbia spathulata*, *Teucrium cubense*, 14 Mar 1993, *Harlan 366-CB*; 28 Nov 2001, *Felger 01-571*; Clayish soil with mesquite shrubs, 11 Jan 2002, *Felger 02-36*.

Sonora, Mexico: [Municipio] Huatabampo, Rio Mayo region, S of Huatabampo on road to Huatabampito, 26°44' N, 109º35'W, 49 ft elev., dried pool near roadside in arid coastal scrub, uncommon annual on bed of dried pool, fertile, 4 Sep 1989, *Sanders 9247* (UCR, det. A.R. Smith, Nov 1989).

PTERIDACEAE – Maidenhair Fern Family

Throughout the Sonoran Desert the ferns in this family are restricted to rocky substrates, such as among rocks and in crevices on cliffs and canyon walls, and are often referred to as cheilanthoid ferns. Among the 13 species in the flora area, only *Cheilanthes parryi* and *Notholaena californica* are not known from the Ajo Mountains. These two fern species are characteristic of the driest parts of the Sonoran Desert, where fern species are indeed few.

Some cheilanthoid ferns are apogamous and of hybrid origin (often triploid or tetraploid), e.g., *Argyrochosma limitanea*, members of the *Cheilanthes lindheimeri* complex, and *Notholaena californica*. These ferns are well adapted to relatively dry conditions since they do not have gametophytes that require water for fertilization and can develop new sporophyte plants with viable spores under conditions difficult for sexual species. The terms "lower surface" or "below" refer to the abaxial surface of the leaf or leaflet, and the "upper surface" is the adaxial surface.

Native Americans in the Southwest used various cheilanthoid ferns as medicinal herbs and for medicinal and non-medicinal tea. Moreman (2003) cited 21 uses for *Pellaea* in the Southwest and only few uses for other genera.

1. Leaves once pinnate, the blades more than 5 times as long as wide, the petioles about 1/8 as long as (or shorter) than the blade .... **Astrolepis**
1. Leaves 2- or 3-times pinnate or deeply pinnatifid, the blades less than 4 times as long as wide, the petioles mostly at least half as long as the blade.

2. Leaf blades less than twice as long as wide.

3. Leaf blades conspicuously hairy on both surfaces; not farinose .... **Bommeria**
3. Leaf blades not obviously hairy; conspicuously white-, yellow-, or golden-farinose on the lower surface (sometimes sparsely so on the upper surface as well).

4. Rhizome (stem) scales with toothed margins; leaf blades divided into separate small, bead-like segments .... **Notholaena californica**
4. Rhizome scales with entire margins; leaf blades divided into deeply dissected segments but these not bead-like.

5. Leaf blades with (3) 5 major segments, these more or less palmately arranged; lower leaf surfaces with golden farina (in the flora area); widespread including Ajo Mts. .... **Notholaena standleyi**
5. Leaf blades usually with 5–10+ major segments, these pinnately arranged and progressively smaller towards the leaf tip; lower leaf surfaces with whitish farina; Ajo Mts. .... **Pentagramma**

2. Leaf blades twice to mostly more than twice as long as wide.

6. Leaves conspicuously scaly and/or hairy .... **Cheilanthes** (except *C. wrightii*)
6. Leaves not scaly or hairy on the blades or segments (leaf stalks sometimes with few hairs or scales).

7. Lower (abaxial) surfaces of leaf segments conspicuously white-farinose . **Argyrochosma**
7. Leaf segments green on both surfaces (although often paler below).

8. Rhizome scales uniformly light brown; leaves less than 10 (15) cm long; ultimate (distal) leaf segments pinnately lobed and not wholly separate ...... **Cheilanthes wrightii**
8. Rhizome scales bicolored—with a narrow, blackish center-stripe and narrow, pale brown margins; leaves often more than 15 cm long; ultimate (distal) leaf segments completely separate, oval or ovate .... **Pellaea**

ARGYROCHOSMA LIMITANEA (Maxon) Windham subsp. **LIMITANEA**
[*Notholaena limitanea* Maxon var. *limitanea*]
Powdery cloak fern. Figure 3.

Small compact, tufted ferns. Leaf blades broadly triangular-ovate with 4 or 5 pairs of pinnately arranged major pinnae, bearing numerous small segments, pale green above and conspicuously white-farinose below, the leaves otherwise glabrous. Sporangia near margins of the leaf segments. The white farina is remarkable and unique among the ferns of the flora area—it is easily rubbed off and under magnification it looks like powdery snow.

Known from the flora by a single record from the Ajo Mountains. The nearest known population is in the Sand Tank Mountains of the Sonoran Desert National Monument (Arrowhead Mtn, 29 Nov 2003, *Rutman 20031129-21*).

Subspecies *limitanea* occurs in southeastern California to Utah and New Mexico and in Chihuahua and Sonora. Another subspecies occurs in southeastern Arizona and the Chihuahuan Desert region to Hidalgo. Both subspecies are asexual triploids, producing spores asexually.

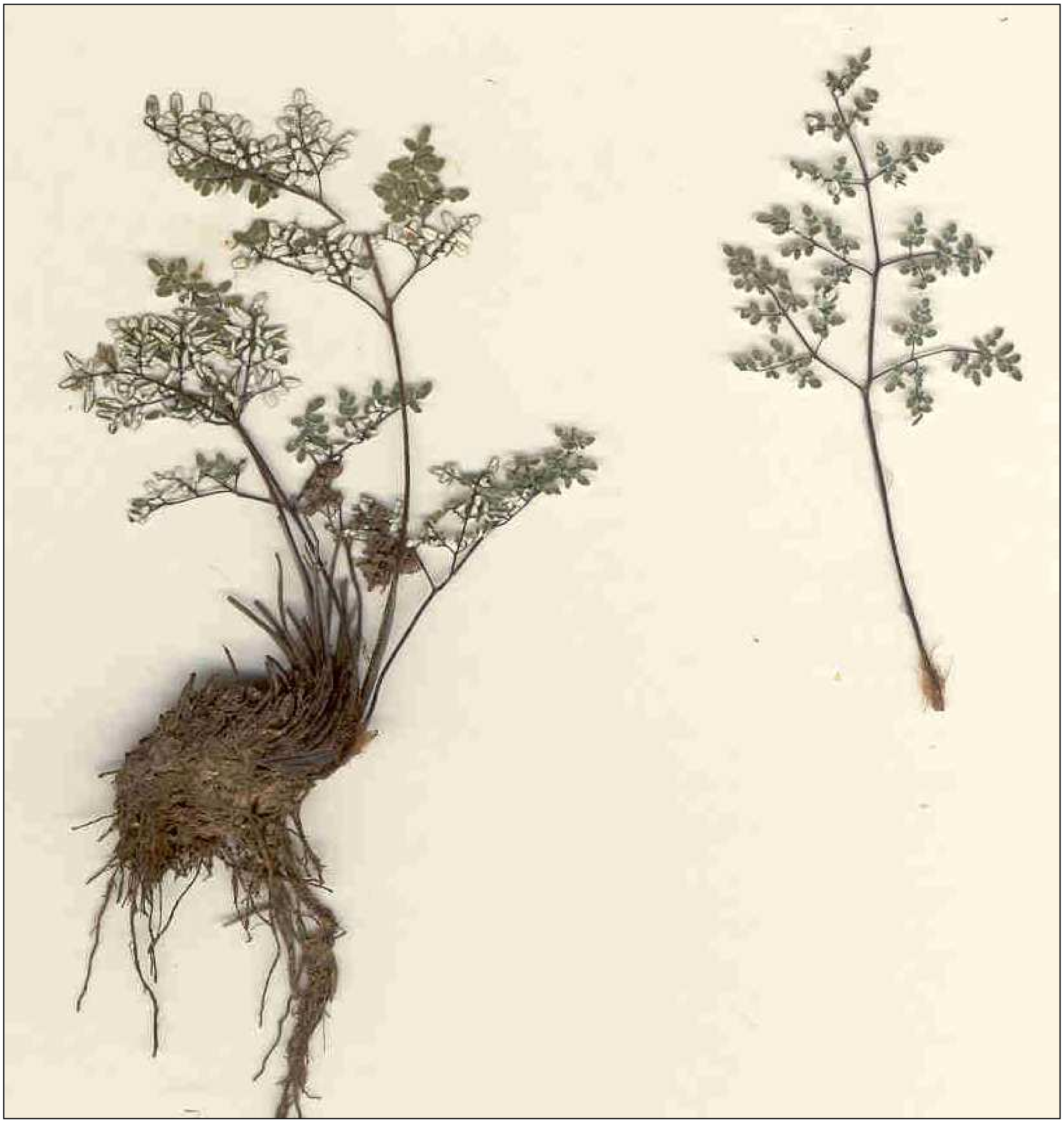

Figure 3A. *Argyrochosma limitanea* subsp. *limitanea*. A. Sand Tank Mountains, Sonoran Desert National Monument, Maricopa Co., Arizona, 29 Nov 2003, *Rutman 20031129-21*; photo by Sue Rutman.

Figure 3B. *Argyrochosma limitanea* subsp. *limitanea*. Lower leaf surface with mature sporangia. Percha Box, eastern foothills of Black Range, Sierra Co., New Mexico, 5 Oct 2008; photo by Patrick Alexander.

A congener that ranges from New Mexico to Wyoming, *Argyrochosma fendleri* (Kunze) Windham, is reported as a remedy for cold sores after it is pulverized and applied to the lips (Robbins et al. 1916).

OP: Pitahaya Canyon, 3400 ft, *Nichol 23 Feb 1939* (ORPI 1376).

ASTROLEPIS – Star-scaled Cloak-fern

Small to medium-sized densely tufted ferns with short-creeping, scaly stems. Leaves linear, once pinnate, the leaf-axis scaly; leaflets somewhat thickened, the upper surfaces with deciduous stellate to coarsely ciliate or dendritic scales (star-shaped or variously coarsely fringed or tree-like), the lower surfaces densely covered with overlapping ciliate (fringed) scales and an underlying layer of stellate scales. Sporangia arranged along veins near leaflet margins and partially hidden by scales.

Southwestern USA to South America and West Indies; 8 species.

1. Leaves usually 10–20 (28) cm long, 1–1.5 cm wide; leaflets usually 4–8 mm long; scales on lower leaf surface 0.5–0.8 mm long. .... **Astrolepis cochisensis**
1. Leaves often 20–37 cm long, 3–3.5 cm wide; leaflets usually more than 15 mm long; scales on lower leaf surface 1.6–2.1 mm long. .... **Astrolepis sinuata**

Astrolepis cochisensis (Goodding) D.M. Benham & Windham
[*Notholaena cochisensis* Goodding. *Cheilanthes cochisensis* (Goodding) Mickel]
Small star-scaled fern. Figure 4.

Rhizome (stem) scales 6–7.5 mm long. Leaves (6) 10–20 (28) × 1–1.5 cm; petioles (1.5) 2–4.5+ cm long. Larger leaflets 4.5–8 mm long, shallowly lobed; upper surfaces dark green with few to many scales; lower surfaces obscured by dense, overlapping scales 0.5–0.8 mm long (to 1.0 mm including cilia at the tip and base), these scales ovate to narrowly lance-attenuate, brown at middle with irregularly ciliate-fringed membranous margins.

Widely scattered across the flora region to mountain summits; among rocks, especially on north-facing and/or shaded exposures, and often common on limey (calcic) substrates such as caliche and limestone.

Southwestern USA and the northern two-thirds of Mexico.

Figure 4A. *Astrolepis cochisensis*. South Fork, Alamo Canyon, Ajo Mountains, Organ Pipe Cactus NM, 26 Mar 2009; photo by Sue Rutman.

Figure 4B. *Astrolepis cochisensis*. Upper leaf surface. Boynton Canyon, near Sedona in Red Rock Secret Mountain Wilderness Area, Yavapai Co., Arizona, 8 Dec 2001; photo by Max Licher (from SEINet).

This fern extends into more arid habitats than does *Astrolepis sinuata* and is distinguished by having smaller plants, leaves, and leaflets, and only shallowly lobed leaflets. The rhizome scales of both species are similar, but the scales on the lower leaflet surfaces are larger in *A. sinuata.*

In the Flora of North America, Benham and Windham (1993) recognized three subspecies of *Astrolepis cochisensis*, two of which are apogamous and occur in southwestern Arizona including the flora area: subsp. *cochisensis* and subsp. *arizonica* D.M. Benham. The taxa in this polyploid complex are relatively cryptic morphologically and have been separated primarily based on genetic rather than morphological differences. In their *Pteridophytes of Mexico*, Mickel and Smith (2004) treated the subspecies of Benham and Windham as cytotypes. “As it turns out, there is more going on with the complex in terms of past hybridization than even the three subspecies in FNA can account for. That said, the three basic units within what has been called *A. cochisensis* do not interbreed (in part because the two polyploids are apomictic), which is why biosystematists would want to separate them at some taxonomic level" (George Yatskievych, pers. comm., 19 November 2012).

Subspecies *arizonica* is reported as "favoring limestone and other calcareous substrates" and subsp. *cochisensis* as "favoring granite, quartzite, and other non-calcareous substrates, occasionally on limestone" (Benham & Windham 1993: 141).

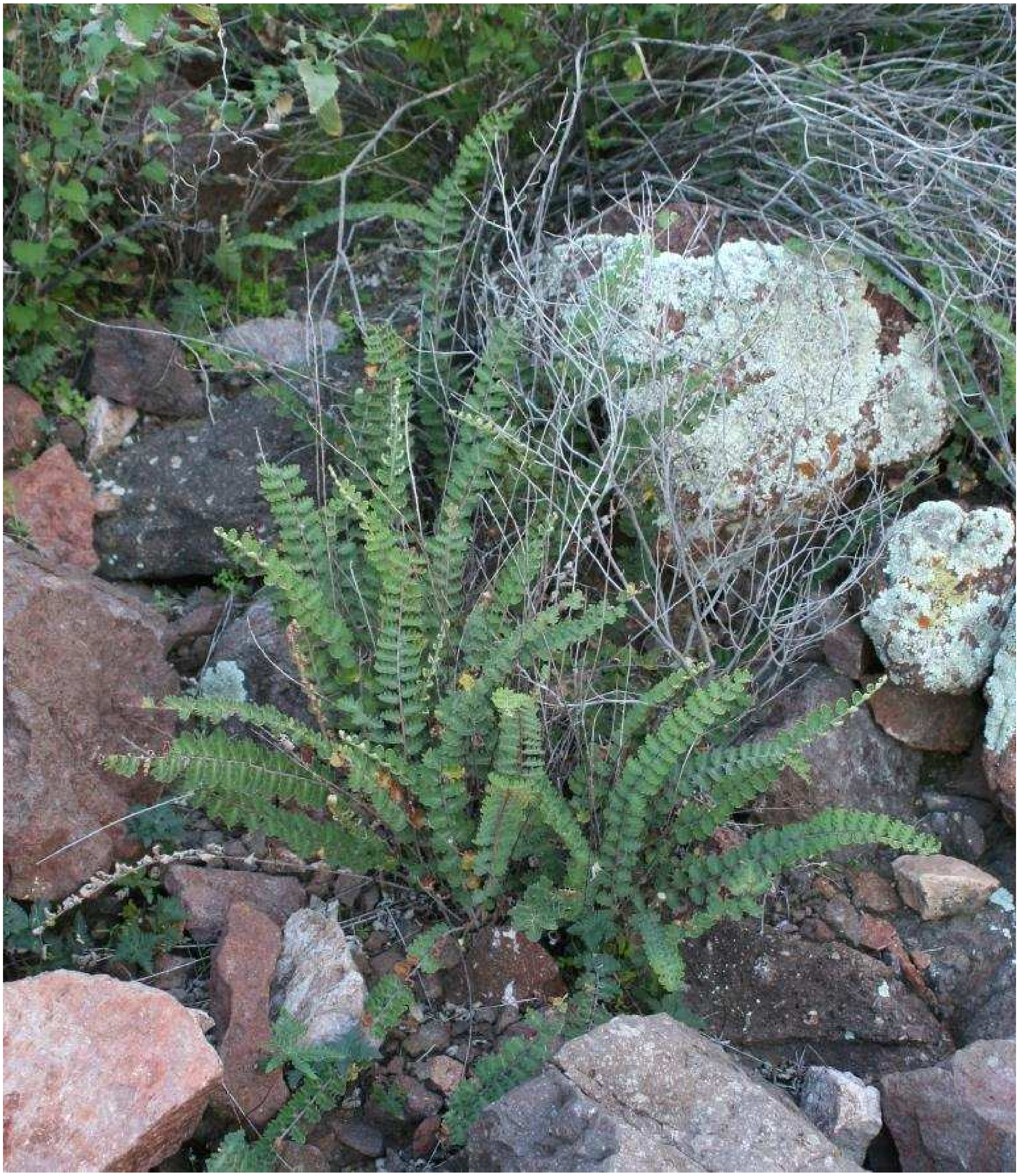

Figure 5A. *Astrolepis sinuata* subsp. *sinuata*. South Fork of Alamo Canyon, Ajo Mountains, 28 Feb 2009. Photo by Sue Rutman.

Figure 5B. *Astrolepis sinuata* subsp. *sinuata*. Upper leaf surface. South Fork of Alamo Canyon, 10 Apr 2005; photo by Sue Rutman.

OP: Alamo Canyon, 21 Nov 1941, *Goodding 455-41*. Quitobaquito Hills, rocky NE slope of granitic hills, 1200 ft, 18 Mar 1945, *Darrow 2418* (annotated as subsp. *cochisensis* by D.M. Benham 1989). Senita Basin, *Beale & Beale 13 Nov 1987* (ORPI 6380). Lost Cabin Mine, *Wirt 24 Nov 1990* (ORPI 14171). 1 mi E of Senita Basin, *Wirt 26 Feb 1991*. W of Bates Well Road, N boundary, upper bedrock portion of limestone hill, 8 Mar 2003, *Rutman 2003-265*. Middle fork of Alamo Canyon near crestline of Ajo Mts, 15 Mar 2003, *Rutman 2003-348* (ORPI 15182). Bates Mts near Growler Pass, 7 Mar 2003, *Rutman 2003-225* (ORPI 15181). Puerto Blanco Mts, 31 Oct 2003, *Rutman 200331031* (ORPI 15178).

CP: Scarface Mt, E-facing rocky, limestone slope, *Mathes 20 Mar 1992* (ASC, annotated: 32 spores per sporangium (apomictic), mean spore diameter 78.1 micra, James E. Beck, Duke University, 2010; therefore this would be subsp. *arizonica*). Childs Mt, 2240 ft, rocky, N-facing slope, basalt with much calcium carbonate caliche, 2240 ft, 25 Feb 1993, *Felger 93-29*.

Astrolepis sinuata (Lagasca ex Swartz) D.M. Benham & Windham subsp. **sinuata**
[*Cheilanthes sinuata* (Lagasca ex Swartz) Domin. *Notholaena sinuata* (Lagasca ex Swartz) Kaulfuss]
Wavy star-scaled cloak fern. Figure 5.

Rhizome scales narrowly linear-attenuate, mostly 5–7.5 mm long, chestnut brown with narrow, membranous (whitish), and minutely toothed margins (darkening with age). Leaves often 20–37 × 3–3.5+ cm; petioles 2–9+ cm long. Larger leaflets (15) 18–30 mm long, with 3 or 4 conspicuous lobes on each side; upper surfaces olive-green with few to many scales; lower surfaces obscured by dense, overlapping scales, each 1.6–2.1 mm long, narrowly lance-attenuate, brown at mid-base with white ciliate-fringed broad membranous margins.

Larger mountains in Organ Pipe, at least in the Ajo and Bates Mountains, especially at higher elevations; abundant above 3200 feet in the Ajo Mountains. Often on shaded and north-facing slopes. This species and the cliff brake (*Pellaea truncata*) are the largest of the 13 ferns in the flora area.

Subspecies *sinuata* is an apogamous triploid; Arizona to Texas and South America, the Baja California Peninsula, Georgia, and the West Indies. Subspecies *mexicana* D.M. Benham is a sexually reproducing diploid occurring in Texas and New Mexico to Central America.

OP: Pitahaya Canyon, 3400 ft, *Nichol 23 Feb 1939* (2 sheets, ORPI 1375 & 1416). Alamo Canyon, 21 Nov 1941, *Goodding 462-41*. Kino Mt, *Hoy Feb 1971* (ORPI 4443). Arch Canyon, 900 m, 2 Dec 1990, *Felger 90*-568 (ORPI 14172). Arch Canyon, *Rutman 14 Aug 1996* (ORPI 14428). Middle fork Alamo Canyon near crestline, 15 Mar 2003, *Rutman 2003-327* (ORPI).

BOMMERIA HISPIDA (Mettenius ex Kuhn) Underwood
Copper fern. Figure 6.

Small ferns with creeping stems. Young leaves dark, dull green, often becoming coppery with age. Leaf blades conspicuously hairy on both surfaces, pentagonal in outline, reaching ca. 7 cm wide, about as long as wide, and divided into 3 major segments, each again deeply dissected almost to their midribs. Upper (adaxial) surfaces with short, straight hairs; lower surfaces densely covered with scales and crowded straight as well as coiled, curly hairs resembling wood shavings. Sporangia along distal leaf veins, especially near the leaf margins.

Higher elevations in the Ajo and Santa Rosa Mountains, mostly in shaded, mesic microhabitats.

Figure 6A. *Bommeria hispida*. Peloncillo Mountains, Hidalgo Co., New Mexico, 28 Jul 2010; photo by Elizabeth Makings.

Figure 6B. *Bommeria hispida*. Upper leaf surface. Pima Canyon, ca. 3800 ft, Santa Catalina Mountains, Pima Co., Arizona, Jan 2013; photo by Jim Verrier.

Eastward in southern Arizona, southern New Mexico, and western Texas, and southward to Michoacán and Estado México, and in Baja California Sur.

OP: Alamo Canyon, 17 Dec 1939, *Harbison 26317* (SD). Notch near Santa Rosa Peak, *Steenbergh 1 Mar 1962* (ORPI 4390). Bull Pasture, *Hoy Feb 1971* (ORPI 4447). Upper part of south fork of Alamo Canyon, *Rutman 7 Mar 1998* (ORPI 14427). Middle fork of Alamo Canyon, near crestline of Ajo Mts, 3400 ft, 15 Mar 2003, *Rutman 2003-342* (ORPI 15184).

CHEILANTHES — Lip Fern

Small ferns; rhizomes (buried stems) relatively thick and short or long, with scales that darken with age. Leaves mostly 2- or 3-pinnate, hairy, scaly, waxy, or glandular especially on lower (abaxial) surfaces, or glabrous. Costae (stalks supporting the pinnae or clusters of leaf segments) with or without scales or hairs. Sporangia in sori near margins of leaf segments or leaflets, the margins sometimes folded over the sori.

Cheilanthes is the most diverse fern genus in the Sonoran Desert region (*see* Windham & Rabe 1993). A complex of several similar-appearing species in southwestern North America, including *C. lindheimeri*, *C. wootonii*, and *C. yavapensis*, are of hybrid origin. These ferns have bead-like leaf segments and can be challenging to distinguish. *Cheilanthes lindheimeri* and *C. yavapensis* occur in the Ajo Mountains and nearby ranges north and east of the flora area, and can form rather extensive local colonies or populations. Another Ajo Mountain species with bead-like segments, *C. villosa*, apparently is not closely related to the *C. lindheimeri* complex. *Cheilanthes*, with about 150 species worldwide, is the largest genus of arid-adapted ferns.

1\. Leaves glabrous (or essentially glabrous) .... **Cheilanthes wrightii**
1\. Leaves conspicuously scaly or hairy.

  2\. Lower leaf surfaces densely hairy, without scales; ultimate leaf segments not bead-like, the larger ones 3–5 mm long .... **Cheilanthes parryi**
  2\. Lower leaf surfaces densely scaly, hairs absent or inconspicuous; ultimate leaf segments bead-like, the larger ones not more than 3 mm long.

    3\. Rhizomes (stems) short, plants growing in discrete tufts; scales on the lower leaf surfaces erose (minutely and shallowly toothed) but not ciliate (without marginal hairs) .... **Cheilanthes villosa**
    3\. Rhizomes (stems) forming long runners (long creeping), plants forming mats (unless confined by rocks); scales on the lower leaf surfaces ciliate (with marginal hairs), the cilia poking through to the upper leaf surfaces.

      4\. Rhizome scales uniformly brown (concolored); upper leaf surface grayish or silvery, appearing densely hairy from a tangled mat of the long, delicate, curly cilia of the scales of the lower leaf surface .... **Cheilanthes lindheimeri**
      4\. Rhizome scales with a dark central stripe or central area and paler margins (bicolored); upper leaf surface green, appearing sparsely hairy from the coarse cilia of the scales of the lower leaf surface, which do not form a tangled mat .... **Cheilanthes yavapensis**

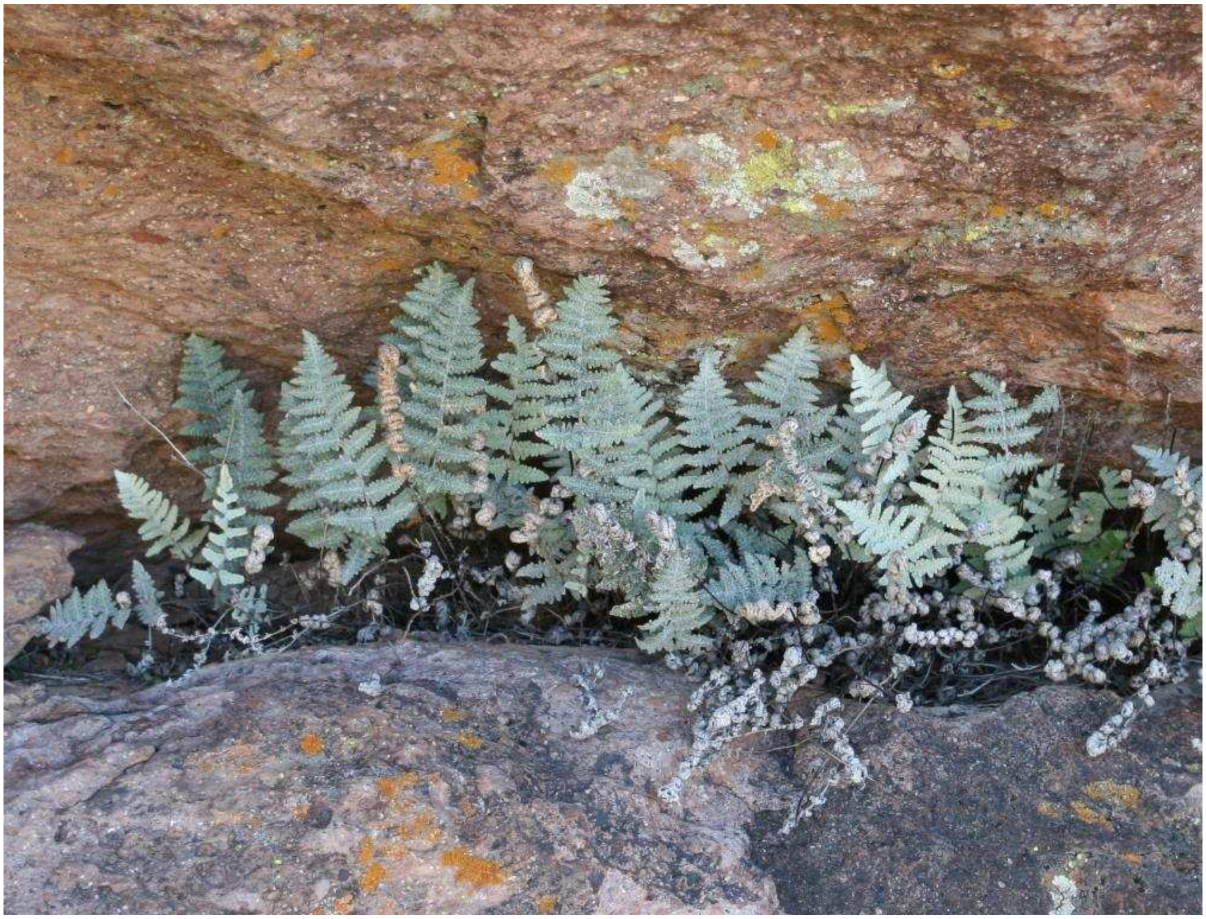

Figure 7A. *Cheilanthes lindheimeri*. Arch Canyon, Ajo Mountains, 16 Sep 2006; photo by Sue Rutman.

Cheilanthes lindheimeri Hooker
Fairy swords. Figure 7.

Plants usually with long, creeping rhizomes, often forming dense colonies. Rhizome scales concolored (uniformly brown). Leaf blades mostly lanceolate, 4-times divided, grayish above, densely tomentose and rusty brown below; costal scales conspicuously ciliate, leaf segments bead-like, covered below (abaxially) with ciliate scales, the cilia reaching over and enveloping the upper (adaxial) surfaces, the adaxial surfaces actually glabrous beneath the enveloping cilia from the lower surfaces. This species is an apogamous triploid of unknown parentage.

Ajo Mountains especially at higher elevations and locally in the Puerto Blanco and Santa Rosa Mountains.

Eastward in southern and central Arizona, southern New Mexico, and western Texas, southward to Michoacán and Hidalgo, and in Baja California Sur.

OP: Alamo Canyon, 12 Dec 1939, *Harbison 26234* (SD). Top of notch, NW of Santa Rosa Peak, *Steenbergh 1 Mar 1962* (ORPI 4389). Bull Pasture, 5 Nov 1977, *Bowers 941* (ORPI 1600). Alamo Canyon, W slope of south fork, *Ellarson 8 Mar 1981* (ORPI 4491). Arch Canyon, 900 m, 2 Dec 1990, *Felger 90-559*. Middle fork of Alamo Canyon, near crestline, 15 Mar 2003, *Rutman 2003-351*.

Figure 7B-C. *Cheilanthes lindheimeri*. Estes Canyon, Ajo Mountains, 28 Feb 2009; photos by Sue Rutman.

Cheilanthes parryi (D.C. Eaton) Domin
[*Notholaena parryi* D.C. Eaton]
Parry's lip-fern. Figure 8.

Small tufted ferns with short-creeping rhizomes. Leaves (5) 8–15 × 1.8–3.6 cm (fully expanded); leaf blades oblong-lanceolate, twice pinnate, densely woolly; leaflets with tangled hairs obscuring the surfaces and extending beyond the margins, whitish on the upper (adaxial) surfaces, and white to brown and denser on the lower surfaces.

Figure 8. *Cheilanthes parryi*. Black Canyon, just N of Black Canyon City, Yavapai Co., Arizona, 3 Mar 2001; photo by Max Licher (SEINet).

Mountains westward from the west-central and southwestern part of Organ Pipe, with specimens and observations documented for the Bates Mountains. This fuzzy little fern is the most arid-inhabiting fern in the Sonoran Desert.

Arid and semi-arid regions in western Arizona, southern Nevada, southwestern Utah, southern California, Baja California, and northwestern Sonora.

OP: Kino Mt, *Hoy Jan 1971* (ORPI 4445). Kino Peak, *Wirt 5 Dec 1990* (ORPI 14177). NW of Kino Peak, 2000 ft, 20 Mar 2005, *Rutman 20050320-36* (ORPI).

CP: First canyon N of Heart Tank ravine, *Simmons 21 Nov 1964*. Sheep Mt, NE part of Agua Dulce Mts, steep N-facing granitic slope, 31 Jan 1992, *Felger 92-7*. Tule Mts, 1160 ft, 2 Feb 1992, *Felger 92-47*. Tuseral Tank, 1350 ft, N-facing rocky slopes, 14 Jun 1992, *Felger 92-597*. Childs Mt, basalt with much calcium carbonate caliche, 25 Feb 1993, *Felger 93-41*. 0.5 mi S of Sunday Pass, 2600–2700 ft, *Cain 15 Nov 2003*.

TA: Tinajas Altas, 29 Mar 1930, *Kearney & Harrison 6575*. Tinajas Altas, crevices of rock, 18 Apr 1976, *Engard 920* (DES). Tinajas Altas, above tinaja containing *Typha*, 1500 ft, shady crevices where only reflected light penetrates, vertical granite faults, 8 Mar 1984, *Hodgson 2725* (DES). Borrego Canyon, 3 Feb 1990, *Felger*, observation. Vicinity of Raven Tank, Tinajas Altas Mts, 29 Mar 2010, *Felger*, observation.

Cheilanthes villosa Davenport ex Maxon
Hairy lip-fern. Figure 9.

Tufted ferns, not forming long rhizomes; rhizome scales bicolored. Leaves clustered, the larger leaves often 20–30 cm long; leaf blades mostly lanceolate, 3- or 4-times divided, green to grayish; costal scales not ciliate or rarely with 1 or few cilia, the ultimate leaf segments bead-like with the lower (abaxial) surfaces densely pubescent with whitish hairs—these hairs often tangled and enveloping the upper (adaxial) surfaces (like those of *C. lindheimeri*) and the upper (adaxial) surfaces also bearing hairs. An apogamous triploid of unknown parentage.

Figure 9A. *Cheilanthes villosa.* Upper leaf surface. Bear Den Canyon, San Andres Mountains, Sierra Co., New Mexico, 24 Apr 2010; photo by Patrick Alexander.

Figure 9B. *Cheilanthes villosa.* Lower leaf surface. Bear Den Canyon, San Andres Mountains, 24 Apr 2010; photo by Patrick Alexander.

Higher elevation in the Ajo Mountains. At least some specimens (from the flora area) have grayish and densely hairy leaves like those of *C. lindheimeri*, but the bicolored rhizome scales, costal scales not markedly ciliate, and hairs actually attached to the upper (adaxial) leaf segments serve to distinguish *C. villosa*. At least sometimes growing together with *C. yavapensis*. *Cheilanthes villosa* is characteristically found on limestone in much of its range (Patrick Alexander, pers. comm. 2013). Although the Ajo Mountains do not have limestone, there are substantial areas of calcic or caliche soils (see *Astrolepis cochisensis*).

Arizona to western Texas and adjacent northern Mexico to Zacatecas.

OP: Steep N-facing slope below cliff E of Saddle between Arch and Boulder Canyons, 2947 ft, 26 Oct 2003, *Rutman 2003-1026-1*. Trail from The Cones to Mount Ajo, 4025 ft, 10 Apr 2005, *Felger 05-267* (ARIZ, MO, ORPI).

Cheilanthes wrightii Hooker
Wright's lip-fern. Figure 10.

Small rhizomatous ferns. Leaves glabrous (or essentially so) and mostly lanceolate to ovate, mostly 5–15+ cm long, delicate and bright to dark green, 1 or 2 (3) times longer than wide, 2 (3) times divided. Leaf segments oblong to linear, mostly flat, and not bead-like.

Ajo Mountains and locally in the Bates Mountains; among rocks and grasses, often on north-facing slopes and commonly in thick mats of *Selaginella*.

Figure 10. *Cheilanthes wrightii*. Pima Canyon, Santa Catalina Mts, Pima Co., ca. 3200 ft, Jan 2013; photo by Jim Verrier.

Eastward in southern and central Arizona to west Texas, and Sonora to Coahuila and Durango, and Baja California Sur.

OP: Ajo Mts, *Goodding 21 Nov 1941* (ASU). Bates Mts, 31 Oct 1943, *Clark 11153* (ORPI 1378). Ajo Mts, E side, *Hoy Feb 1971* (ORPI 4448). Above Pitahaya Canyon, 2500 ft, 16 Jan 1976, *Phillips 76-8*. Bull Pasture Trail, 5 Nov 1977, *Bowers 950* (ORPI 1602). Alamo Canyon, 2800 ft, 28 Jan 1978, *Bowers 1003*. Arch Canyon, 900 m, 2 Dec 1990, *Felger 90-567*. Middle fork of Alamo Canyon, near crestline of Ajo Mts, 15 Mar 2003, *Rutman 2003-355*. Bull Pasture, 10 Apr 2005, *Felger 05-203*.

Cheilanthes yavapensis T. Reeves ex Windham
Yavapai lip-fern. Figure 11.

Small ferns with slender creeping rhizomes; rhizome scales bicolored. Leaves often close together but not conspicuously clustered. Leaf blades mostly oblong-lanceolate, 4-times divided into many bead-like segments; upper (adaxial) leaf surfaces green and sparsely pubescent; lower (abaxial) leaf blades whitish when young, becoming brownish with age, and densely covered with ciliate scales. This species is an apogamous tetraploid.

Ajo Mountains mostly at higher elevations to the crestline, often growing with *Cheilanthes lindheimeri*.

East and northeast in Arizona to western Texas, both states of Baja California, and presumably in northern Sonora. This fern is an apogamous tetraploid of hybrid origin.

Figure 11A-C. *Cheilanthes yavapensis*. Above Bull Pasture, 10 Apr 2005; photos by Sue Rutman. A. Habit. B. Lower leaf surface. C. Upper leaf surface.

OP: Alamo Canyon: 3000–3800 ft, 31 Mar 1948, *Gould & Darrow 3863*; 2800 ft, 29 Jan 1978, *Bowers 1004* (ORPI 1601). Above Pitahaya Canyon, 3200 ft, 16 Jan 1976, *Phillips 76-6*. Arch Canyon, 900 m, desertscrub with lowermost *Vauquelinia*, 2 Dec 1990, *Felger 90-559a* (ARIZ, MO). Middle fork of Alamo Canyon near crestline of Ajo Mts, 15 Mar 2003, *Rutman 2003-349* (ORPI 15191). Steep N-facing slope below cliff E of Saddle between Arch and Boulder Canyons, 2947 ft, 26 Oct 2003, *Rutman 2003-1026-32*. Trail from Bull Pasture to crestline, base and N side of The Cones, 3565 ft, 10 Apr 2005, *Felger 05-243* (ARIZ, ASU, MO, ORPI, UC, SD). Trail from Bull Pasture to crestline, above The Cones, 3940 ft, 10 Apr 2005, *Felger 05-256* (ARIZ, ASU, MO, ORPI).

NOTHOLAENA – Cloak Fern

Plants often similar to *Cheilanthes.* Lower leaf surfaces with white or yellow farina (glandular exudate). Sporangia in more or less continuous bands on leaflet margins, the unmodified leaflet margins recurved and partially covering the sporangia.

1. Rhizome scales with toothed margins; leaves divided into separate small segments ....**Notholaena californica**
1. Rhizomes scales with the margins entire to slightly ragged but not toothed; leaves deeply dissected but not divided into separate segments. .... **Notholaena standleyi**

Notholaena californica D.C. Eaton subsp. **californica**

[*Cheilanthes deserti* Mickel]

California cloak-fern. Figure 12.

Small tufted ferns or with very short rhizomes. Rhizome scales dark red-brown, with membranous (translucent) to orange-brown and toothed margins, the center becoming blackish with age. Petioles (2.5) 4–12.5 cm long, dark brown. Leaf blades triangular-ovate to pentagonal, 2–5.5 × 1.5–4.8 cm, 3- or 4-times divided, with small separate bead-like segments; upper surfaces bright green to olive-green, dotted with small yellowish glands, the lower surfaces often obscured by pale to bright golden yellow glandular exudate (farina). Apogamous.

Widespread and common across Cabeza Prieta, in the Tinajas Altas Mountains, and the southwestern part of Organ Pipe. Among rocks in mountains and hills, mostly on north-facing slopes.

This species occurs in southern California to the Cape Region of Baja California Sur, southwestern Arizona, and northwestern Sonora. A second variety, characterized by white farina, does not occur in Arizona. This species and *Cheilanthes parryi* are the most arid-inhabiting ferns in the Sonoran Desert.

OP: Quitobaquito, N-facing rocky slope, 29 Mar 1988, *Felger 88-135*.

CP: Tule Tank, *Wiggins 26 Mar* 1932. 7 mi E of Papago Wells, 15 Mar 1937, *Harbison 16858* (SD). Bassarisc Tank, 1400 ft, under rocks, *Simmons 11 Jan 1963.* Agua Dulce Pass, 1600 ft, *Simmons 4 Mar 1964* (CAB). Christmas Pass, Cabeza Prieta Mts, 1100 ft, *Van Devender 9 Mar 1980*. Buckhorn Tank, Cabeza Prieta Mts, 14 Jun 1992, *Felger 92-600.* Childs Mt, rare, 5 Mar 1994, *Felger 94-14*.

TA: Tinajas Altas, 6 Mar 1937, *Harbison 16826* (SD). Tinajas Atlas Mts, N side below peak, 26 Oct 2004, *Felger* (observation). Tinajas Altas Mts, Surveyors Canyon, 380 m, rock crevice on N-facing steep slopes, 29 March 2010, *Felger 10-204.*

Figure 12. *Notholaena californica* subsp. *californica*. Quitobaquito Hills, Organ Pipe Cactus NM, 4 Feb 2005; photo by Sue Rutman.

Notholaena standleyi Maxon
[*Cheilanthes standleyi* (Maxon) Mickel]
Star cloak-fern. Figure 13.

Small tufted ferns. Rhizome scales with a dark red-brown center, the margins membranous to orange-brown and entire to slightly ragged, the center becoming blackish with age. Petioles (3) 5–13 cm long, dark brown. Leaf blades pentagonal in outline, 3–7 cm wide, about as long or slightly longer than wide, divided into (3) 5 major, deeply cleft pinnate pinnae or segments; upper surfaces olive-green, the lower surfaces often obscured by golden yellow farina.

Figure 13A. *Notholaena standleyi*. Child's latite in Chuckwalla Hills, Organ Pipe Cactus NM, 23 Feb 2009; photo by Sue Rutman.

Figure 13B. *Notholaena standleyi*. Estes Canyon, Ajo Mountains, 16 Mar 2008; photo by Sue Rutman.

Southern and central Arizona to Texas, Oklahoma, and Colorado, both states of Baja California, and northern Mexico to Sinaloa and Tamaulipas to Oaxaca. The Sonoran Desert plants are usually smaller than those in more mesic regions. Probably sexual diploids.

Seigler and Wollenweber (1983) found three geographic chemical races of this species. Those in the flora area belong to the western "golden race," so called because of the golden-colored exudate or farina on the lower surface of the leaf blades.

Widespread in hills and mountains to their summits across Organ Pipe and Cabeza Prieta except the western portion. This is the most common and widely distributed fern in the flora area.

OP: Pitahaya Canyon, *Nichol 23 Feb 1939*. Quitobaquito Hills, 17 Mar 1945, *Darrow 2421*. Dripping Springs, Puerto Blanco Mts, 18 Mar 1945, *Darrow 2441*. Kino Mt, *Hoy Jan 1971* (ORPI 4446). East Loop, 3.3 mi from Rte 87 [Hwy 85], rock crevices of butte, 24 Nov 1972, *Pinkava 9966* (DES). Montezuma's Head, 2500 ft, 16 Jan 1976, *Phillips 76-11*. Senita Basin, 6 Dec 1978, *Hodgson H-204*. Alamo Canyon, 14 Mar 1981, *Yatskievych 81-92*. Arch Canyon, 900 m, 2 Dec 1990, *Felger 90-544* (ORPI 14176). E end Growler Mts, 7 Mar 2003, *Rutman 2003-247* (ORPI 15194). W side and base of Sierra Santa Rosa, 12 Mar 2003, *Felger 03-326*. Puerto Blanco Mts, 1733 ft, 14 Mar 2003, *Rutman 2003-309* (ORPI 15192.). Middle fork of Alamo Canyon, near crestline, 15 Mar 2003, *Rutman 2003-347*. Bull Pasture, 10 Apr 2005, *Felger 05-205* (ORPI 15895).

CP: Vicinity Agua Dulce Pass and Agua Dulce Tank, 2080 ft, 13 Jun 1992, *Felger 92-575*. Sheep Mt, 31 Jan 1992, *Felger 92-6*. Childs Mt, 2240 ft, 9 Apr 1993, *Felger 93-272*.

PELLAEA TRUNCATA Goodding

Spiny cliff-brake. Figure 14.

Tufted ferns with short, thick rhizomes. Leaves glabrous, to ca. 40 cm long but usually much shorter in Organ Pipe, the blades triangular in outline, 2-times divided; leafstalks dark brown or black and shiny; leaflets (leaf segments) small, firm, numerous, separate, short-stalked, bright green when young, becoming bluish gray with age, and minutely acuminate. Leaf segment becoming folded or grooved when dry; margins inrolled, forming false indusia.

Figure 14A. *Pellaea truncata*. Habit. Middle Fork, Alamo Canyon, Ajo Mountains, 26 Mar 2005; photo by Sue Rutman.

Figure 14B. *Pellaea truncata*. Lower surface. Estes Canyon, Ajo Mountains, 28 Feb 2009; photo by Sue Rutman.

Common among rocks and in crevices; Ajo Mountains, especially on north-facing slopes and at higher elevations, and locally in the Bates and Puerto Blanco Mountains. This species and the star-scaled cloak-fern (*Astrolepis sinuata*) are the largest ferns in the flora area.

Southeastern California and western and southern Arizona to Utah, Colorado, and western Texas, both states of Baja California, Sonora, and Chihuahua.

OP: Ajo Mts, Sierra del Alamos, *Nichol 16 May 1937*. Dripping Springs, Puerto Blanco Mts, N slope of volcanic hill, 18 Mar 1945, *Darrow 2439*, *Gould, & Haskell*. Arch Canyon, *Jackson? 14 Jan 1965* (ORPI 4539). Kino Mt, *Hoy Jan 1971* (ORPI 4444). W slopes of Montezuma's Head, 3150 ft, 16 Jan 1976, *Phillips 76-7*. Bull Pasture, 5 Nov 1977, *Bowers 940* (ORPI 1598). Bull Pasture Trail, 2800 ft, 9 May 1979, *Bowers 1701*. Alamo Canyon, S-slope of South Fork, *Ellarson 8 Mar 1981* (ORPI 4489). Dripping Springs, near springs, 6 Mar 1988, *Pinkava 14363* (ASU, ORPI 9777). Arch Canyon, 900 m, Dec 2 1990, *Felger 90-516* (ORPI 14180). Middle fork of Alamo Canyon, near crestline, 15 Mar 2003, *Rutman 2003-324* (ORPI 15199). Saddle between Arch and Boulder Canyons, 2335 ft, 26 Oct 2003, *Rutman 20031026-28* (ORPI 15196). N of Pinkley Peak, 2335 ft, 31 Oct 2003, *Rutman 20031031-31* (ORPI 15195).

PENTAGRAMMA TRIANGULARIS (Kaulfuss) Yatskievych, Windham & E. Wollenweber subsp. **MAXONII** (Weatherby) Yatskievych, Windham & E. Wollenweber
[*Pityrogramma triangularis* (Kaulfuss) Maxon var. *maxonii* Weatherby]
Goldback fern. Figure 15.

Small tufted ferns with short-creeping rhizomes. Petioles glabrous, 8–26 cm long. Leaf blades 5–12 cm long, somewhat triangular or pentagonal in outline, about as wide as long, soft and thin (especially compared to other ferns in the flora area), and pinnatifid; pinnae (leaf segments) lobed, pale green above with golden, bead-like glands, and whitish farinose below.

Common in shaded canyons, cliff bases, and north-facing slopes in the Ajo Mountains.

This subspecies occurs eastward and northward in southern and central Arizona, and in southeastern California, southwestern New Mexico, Baja California, and northern Sonora. Three other subspecies range from British Columbia to Baja California.

OP: Pitahaya Canyon, *Nichol 23 Feb 1939*. Bull Pasture Trail, 5 Nov 1977, *Bowers 930*. Arch Canyon, 900 m, 2 Dec 1990, *Felger 90-514*. Crestline of Ajo Mts, middle fork of Alamo Canyon, 15 Mar 2003, *Rutman 2003-355*.

Figure 15A. *Pentagramma triangularis* var. *maxonii*. Estes Canyon, Ajo Mountains, 28 Feb 2005; photo by Sue Rutman.

Figure 15B. *Pentagramma triangularis* var. *maxonii*. Bull Pasture Trail, Ajo Mountains, 6 Apr 2010; photo by Sue Rutman.

SELAGINELLACEAE – Spike–moss Family

SELAGINELLA – Spike-moss; *flor de piedra*

The two spike-moss species in the flora area are the only ones that truly extend into the core of the Sonoran Desert. These species are low, creeping plants forming dense mats, often 1–3 cm tall, sometimes to 5+ cm in shaded areas, firm and wiry when dry, and visibly green only during the brief wet periods. The stem tips and leaves curl inward during dry weather and rapidly unfold when wet; even dry, dead plants open when wet. Leaves dimorphic or not, appearing densely and spirally arranged, the base abruptly adnate to the stem, the midvein prominent on the abaxial (lower or outer) side and extended into a deciduous awn-like or hair-like appendage (seta), the margins ciliate, the tip sharply pointed; and with a minute ligule at the base of the adaxial (upper) side of the leaf blade; leaf surfaces minutely striated. Leaves of the adaxial (upper) stem side lanceolate, green to yellowish green when hydrated, the base abruptly adnate to the stem and differing in color from the stem. Leaves of the abaxial (lower) stem side at first green on the upturned stems tips, becoming gray to brown as the stems become prostrate; leaf base abruptly adnate to the stem and with age similar in color to the stem. Strobili (when present) solitary at branch tips, 4-sided, the sporophylls different from the vegetative leaves and without a terminal seta. (*Selaginella* descriptions based largely on Yatskievych & Windham 2009 and the specimens cited here.)

Anthony Ernest-Fiorentino Baniaga of the University of Arizona (abaniaga@email.arizona.edu) is currently studying the genus in southwestern Arizona and provided the following summary:

> This genus is composed of more than 700 species with a cosmopolitan distribution and concentration of species diversity in the tropics. Traditionally, the genus has been organized into subgenera based on shared morphological characters. However, recent molecular evidence indicates that several of these phenetic groupings are artificial and do not accurately portray evolutionary relationships (Korrall & Kenrick 2002, 2004), indicating an interesting history of convergent phenotypic evolution.
>
> The two spike-moss species in the flora area (*S. arizonica* and *S. eremophila*) belong to subgenus *Tetragonostachys*. This subgenus represents a clade of about 50 species with a center of diversity in the southwestern deserts and semi-arid regions of North America (Tryon 1955; Valdespino 1993). These taxa are characterized by spirally arranged monomorphic and dimorphic microphylls, four-ranked sporophylls, and the presence of dorsal rhizophores (Korrall & Kenrick 2002). Additionally, a spectrum of morphological adaptations to xeric habitats is found in these species. These range from microphyll orientation to reduce exposure to direct sunlight, to “resurrection” phenotypes where stems curl inward when dry, remain dormant for an extended period, and unfurl upon the arrival of rains. Both *S. arizonica* and *S. eremophila* possess the resurrection phenotype.
>
> *Selaginella arizonica* and *S. eremophila* are also closely related but they inhabit different ecological niches that correspond with temperature and precipitation gradients (Arrigo et al. 2013). *Selaginella arizonica* (600–2000 m) is found from central Arizona to northern Mexico with disjunct populations found in west Texas and adjacent New Mexico. *Selaginella eremophila* (130–1000 m) has a narrower range, endemic to the Sonoran Desert; southern California, southern Arizona, and northwest Mexico including Baja California. These plants are generally locally abundant on north to east facing slopes, and occupy rocky outcrops to gravelly areas on igneous, volcanic, and at times sedimentary substrates.
>
> In the flora area in southwestern Arizona, hybrids between the two species are found in the desert mountains in the transition zone from the Lower Colorado Valley to Arizona Upland (Shreve 1951) roughly corresponding to Highway 85 through Organ Pipe

National Monument and the vicinity of Ajo. Hybrids generally possess intermediate morphological characters to both parents including microphyll and setae shape (Yatskievych & Windham 2009). Interestingly, several different hybrid populations have been observed. These include hybrids with one or both parents as well as hybrids with neither of the parents. Correspondingly, considerable variation has been observed in hybrid fertility. Hybrids are found with abortive megaspores as well as populations with apparently fertile spores that are larger than both of the parents, indicative of cryptic species via diploid hybrid or allopolyploid speciation (Therrien 1996). Further field and molecular work is warranted to characterize the hybrid zone and to investigate patterns of chromosomal evolution, as well as to understand the content, function, and network connectivity of genes experiencing introgression. Current investigations regarding the relative contributions of parental taxa to the hybrid transcriptome are ongoing for homoploid hybrid and allotetraploid populations found in the hybrid zone.

1. Bristle at leaf tip straight, firm, thickish, and persistent or breaking off above a persistent base .... **Selaginella arizonica**
1. Bristle at leaf tip squiggly, slender, and quickly deciduous from the base (look for bristles among newest growth) .... **Selaginella eremophila**

Selaginella arizonica Maxon
Arizona spike-moss. Figures 16 & 18.

Plants rooting along prostrate to semi-prostrate stems, the mats close to the ground, mostly 1–3 cm tall, sometimes to 5+ cm in shaded areas. Leaves dimorphic, the upper stem leaves somewhat smaller than the lower stems leaves. Leaf margins minutely serrate; leaf tips with a straight stiff and deciduous bristle (seta), this bristle often bent (at its base) downward from the leaf blade; ligule minute but larger than on *Selaginella eremophila*. Upper (adaxial) stem leaves 0.6–2.2 mm long (not including the bristle tip), lanceolate with a truncate base. Lower (abaxial) stem leaves lanceolate.

Figure 16. *Selaginella arizonica*. Ajo Mountains, 28 Feb 2009; photo by Sue Rutman.

Widespread in the Ajo Mountains and rocky slopes and mountains elsewhere in the Monument. In Cabeza Prieta known only from granitic slopes in the Agua Dulce Mountains where it is locally abundant from near the base to peak elevation on the north side of the mountain. It was in the Ajo Mountains 1200 years ago.

Southern and central Arizona to Texas, Sonora, Baja California, and Chihuahua.

OP: Alamo Canyon, N side of cliff, 17 Apr 1952, *Cottam 12891* (mixed collection with *S. eremophila*). Bull Pasture Trail, about 3000 ft, *Bezy 25 Oct 1964*. Alamo Canyon, 16 Feb 1979, *Bowers 1561* (ORPI 1599). Bird's Eye Point, Ajo Mtn Drive, *Beal & Beale 6 Mar 1988* (ORPI 6368). Arch Canyon, 900 m, 2 Dec 1990, *Felger 90-566* (ORPI 14204). Puerto Blanco Mts, *Rutman 8 Mar 2002* (ORPI 15205). Alamo Canyon, 29 Mar 2003, *Felger 03-410*. Bull Pasture Trail, 3500 ft, 10 Apr 2005, *Felger 05-198*. †Alamo Canyon, stems, leaves, 1150 ybp.

CP: Sheep Peak, NE part of Agua Dulce Mts, 31 Jan 1992, see *S. eremophila*, *Felger 92*-8 (mixed collection with *S. eremophila*). Agua Dulce Mts, near base of mountain, canyon below Agua Dulce Pass, N-facing granitic slope, locally abundant among rocks, 1420 ft, 13 Jun 1992, *Felger 92-578* (2 sheets: ARIZ 301788; ARIZ 302117, possible hybrid with *S. eremophila*).

Selaginella eremophila Maxon

Desert spike-moss. Figures 17 & 18.

Plants resembling *Selaginella arizonica* but with a different leaf-tip bristle (seta) and the leaves tend to be smaller, and the minute ligule is even smaller. Leaves lanceolate, dimorphic or not. "The tortuous, delicate, and early deciduous setae set this species off from all others. The setae are attached only on the young leaves in the apical bud and are so inconspicuous that they had been overlooked until C. Weatherby noted them in 1943" (Tryon 1955: 80). The setae tend to break off even more readily when the plants have been dried and rehydrated.

Figure 17. *Selaginella eremophila*. Hill near Sheep Mountain along Camino del Diablo, 1700 ft, Cabeza Prieta NWR, 21 Mar 1979, *Mason 3371 & Yatskievych* (MO); photo by Ann Larson, Missouri Botanical Garden (also shown in Yatskievych & Windham 2009).

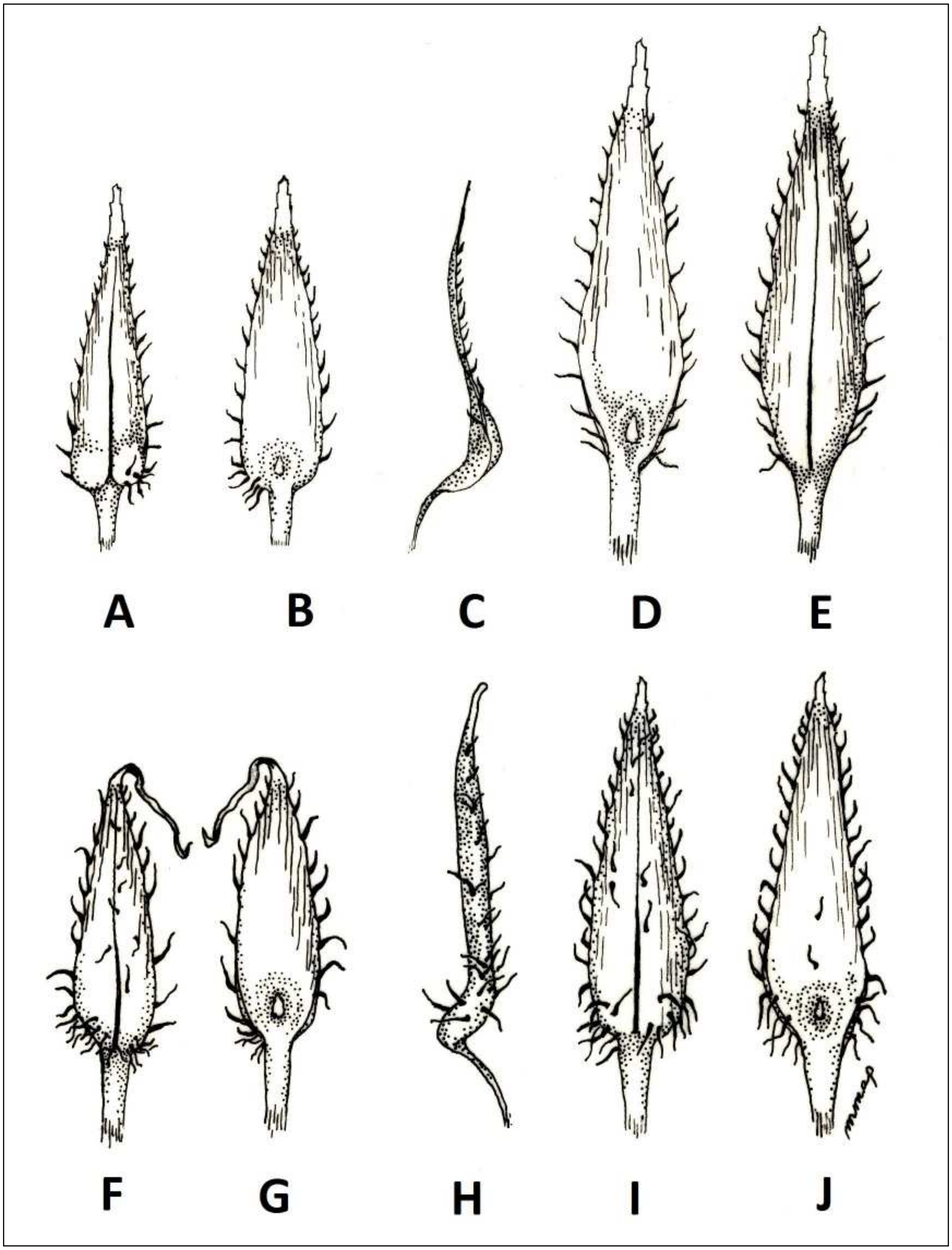

Figure 18. *Selaginella arizonica* and *S. eremophila*. Top row: *S. arizonica*. N side of Hat Mountain, Barry M. Goldwater Range, Maricopa Co., 10 Mar 2003, *Felger 03-207*. A. Young leaf from upper (adaxial) side of the stem; lower (abaxial) suface. B. Upper (adaxial) surface; note ligule at base of blade and decurrent leaf base. C. Lateral view shows the somewhat fleshy leaf. D. Young leaf from lower (abaxial) side of the stem; upper (adaxial) surface; note ligule at base of blade and decurrent leaf base. E. Lower (abaxial) suface. Bottom row: *S. eremophila*. Tinajas Altas Moutains, *Felger 92-619*. F. Young leaf from upper (adaxial) side of the stem; lower (abaxial) suface. G. Upper (adaxial) surface; note ligule at base of leaf blase. H. Young leaf from lower (abaxial) side of the stem, lateral view, shows the somewhat fleshy leaf; most of the fragile seta has broken off. I. Lower (abaxial) suface. J. Upper (adaxial) surface. Illustration by Margaret Pope.

Granitic, north-facing slopes in the Tinajas Altas Mountains and many or perhaps all ranges in Cabeza Prieta, especially at higher elevations, except the eastern margin where it is replaced by *Selaginella arizonica*. In Organ Pipe on mostly north-facing slopes, especially granitic slopes in the western half of the Monument. An exceptional enigmatic collection from the Ajo Mountains (*Cottam 12891*) seems to be a mixed collection with *S. arizonica*. Another possibility is that the Cottam specimen and many from Cabeza Prieta might be hybrids (Yatskievych & Windham 2009).

Spike-moss is surprisingly scarce in the vicinity of the Tinajas Altas waterholes, which is likely a result of grazing by desert bighorn that frequent the waterholes. 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]." It is, however, found elsewhere in the Tinajas Altas Mountains, mostly in small, localized areas and quite common on north-facing slopes near the road through Tinajas Altas Pass, an area perhaps not frequented by desert bighorn.

Selaginella eremophila is the most arid-inhabiting spike-moss in North America and one of the few pteridophytes endemic to the Sonoran Desert. Southwestern and central Arizona, northwestern Sonora, southeastern California, and Baja California.

OP: Alamo Canyon, N side of cliff, 2500 ft, 17 Apr 1952, *Cottam 12891* (mixed collection with *S. arizonica*). Quitobaquito, granitic hill, 29 Mar 1988, *Felger 88-113*. E end of Growler Mts, base of NE-facing tuff cliff, ca. 2000 ft, *Rutman 7 Mar 2003*.

CP: Hill near Sheep Mtn along Camino del Diablo, 1700 ft, 21 Mar 1979, *Mason 3371 & Yatskievych* (MO). Ca. 6 mi. NW of Tule Well, 6 Apr 1979, *Lehto L-23548* (ASU). SW of Buckhorn Tank, one patch on steep N-facing slope, 32º13'54"N, 113º48'30"W, 1230 ft, 20 Mar 1982, *Reichenbacher 921*. Sheep Peak, NE part of Agua Dulce Mts, 1974 ft at summit, steep N-facing slope, common in open, non-vegetated areas, 31 Jan 1992, *Felger 92*-8 (mixed collection with *S. arizonica*). Eagle Tank, Pinta Mts, 1400 ft, abundant on N-facing slopes, 13 Jun 1992, *Felger 92-585*. Canyon S of Heart Tank, Sierra Pinta, 14 Jun 1992, *Felger 92-594* (ASU).

TA: 0.8 mi SE of Tinajas Altas camping area on Camino del Diablo, steep N-facing slope S of road, 32º17'38"N, 114º2'35"W, 1360 ft, a patch, 10 × 10 m, *Reichenbacher & S.F. Hale 28 Mar 1981*. SE side of Tinajas Altas Mts, ca. 2 mi SE of Tinajas Altas, 32º18'N, 114º02'W, 1300 ft, dense, locally extensive mats, not seen elsewhere, 16 Jun 1992, *Felger 92-619*. 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), 19 Mar 1998, *Felger*, observation.

GYMNOSPERMS

Two unrelated families of cone-bearing plants occur in the modern flora of southwestern Arizona and the Pinaceae is represented in the Ice Age flora.

1. Large shrubs or small trees; twigs covered with persistent, alternate, green scale leaves, the internodes very short, not readily visible .... **Cupressaceae**
1. Shrubs; twigs bare with deciduous or semi-persistent, opposite, brown scale leaves between long internodes .... **Ephedraceae**

CUPRESSACEAE – Redwood or Cypress Family

JUNIPERUS – Juniper

Leaves scale-like or slender and pointed (subulate). Pollen and seed cones on separate trees, except *Juniperus osteosperma*. Seed cones semi-fleshy and berry-like, the cone scales not separating. Four species are known for flora area by fossils and one species is common today in the higher mountains in Organ Pipe.

Figure 19A. *Juniperus arizonica.* Ajo Mountains, 20 June 2006. Photo by Howard Morris, all rights reserved, uploaded 1 Feb 2013, from www.flickr.com/photos/8985381@N02/.

†**Juniperus arizonica** R.P. Adams
[*J. coahuilensis* (Martínez) Gaussen ex R.P. Adams var. *arizonica* R.P. Adams. *J. erythrocarpa* Cory, in part]
Arizona juniper; *huata*, *tascate*. Figure 19.

Large shrubs to small trees with thick, sometimes irregular trunks, often branching from near the base. Bark grayish and longitudinally shredding in long ragged strips. Twigs with pointed scale leaves. Pollen and seed cones on separate plants. Seed cones berry-like, rounded, 6–7 mm wide, reddish orange beneath a rosy-glaucous surface, seeds 1 (2) per cone, and maturing in one year. The “berry” pulp is soft, juicy, relatively sweet and edible. Pollen shed December to February. The seed-cone coloration and sweet-tasting flesh are distinctive among junipers of southwestern USA.

Ajo Mountains, higher elevations to the peak and extending down into larger riparian canyons sometimes as low as 2500 ft (760 m) in Alamo Canyon, and also in the Pinkley Peak area in the Puerto Blanco Mountains. In the Puerto Blanco Mountains and at the lower-elevation limits in the Ajo Mountains it often grows hidden among large rock crevices in shady places. In December 1990 Marc Baker and Richard found a gnarled tree in the upper reaches of Arch Canyon (*Felger 90-508*) that had extensive die-back and subsequent recovery. The tree had fallen years earlier and was reclining and about 10 m long with a thick trunk and one live strip of bark. Junipers are common in open, exposed areas along the Ajo Mountain crest. In such places they tend to be large shrubs or compact, small trees. These junipers are often found growing with many desert species such as ocotillo (*Fouquieria splendens*), buckhorn cholla (*Cylindropuntia acanthocarpa*), and jojoba

(*Simmondsia chinensis*), and especially at higher elevations also in the company of turpentine bush (*Ericameria laricifolia*), California rosewood (*Vauquelinia californica*), and scrub oak (*Quercus turbinella*).

The nearest populations are small, isolated groups of several or more plants near the summits of the Sand Tank, Javelina, and Table Top Mountains in Maricopa and Pinal Counties. *Juniperus arizonica* occurs in grassland–oak-juniper woodland ecotone in Arizona, southwest New Mexico, northeast Sonora, and northwest Chihuahua.

Figure 19B. *Juniperus arizonica.* Middle Fork of Alamo Canyon, Ajo Mountains, 26 Mar 2005; photo by Sue Rutman.

This species is the modern juniper and this juniper or a closely related one seems to have migrated into the region at the end of the late Wisconsin and during the early Holocene, as the Utah and Rocky Mountain junipers disappeared. The Arizona populations were known as *Juniperus monosperma* (Engelmann) Sargent and later as *J. erythrocarpa*, and most recently as *J. arizonica*. *Juniperus arizonica*, *J. coahuilensis*, *J. pinchotii* Sudworth (*J. erythrocarpa*), and *J. monosperma* sensu stricto form a complex of related 1-seeded junipers in the southwestern USA and northern and central Mexico.

In his detailed work on junipers, Adams (1994) recognized part of the more broadly interpreted *Juniperus coahuilensis* as the distinct species *J. arizonica*. In addition to the cone color and apparent different time of coning, Adams (1994) distinguished *J. arizonica* as having statistically fewer conspicuous resin glands on the scale leaves and 3-sided branchlets (formed by the scale leaves), while *J. monosperma* has more resin glands and 4-sided branchlets (Adams et al. 2006).

The herbage, bark, seed and pollen cones of a broadly interpreted *Juniperus monosperma* were widely used medicinally by Southwest Native Americans and the seeds cones ("berries") were sometimes prepared as seasoning and a minor food (Moreman 2003).

OP: Alamo Canyon, 17 Dec 1939, *Harbison 26263* (SD). Spring Canyon, *Bean & Fouts 10 Feb 1950* (ORPI). W slopes of Montezuma Head above Pitahaya Canyon, 16 Jan 1976, *Phillips 76-5*. Arch Canyon, N-facing slopes below W side of the arch, with *Vauquelinia, Rhamnus*, *Dodonaea*, 900 m, 2 Dec 1990, *Felger 90-508*. NNE of Pinkley Peak, Puerto Blanco Mts, 32.006222, -112.854139, 2508 ft, ridgeline of high-angle bedrock tuff with low plant cover, *Dodonaea*, 31 Oct 2003, *Rutman 20031031-18*. †Alamo Canyon, twigs, seeds, 1150 to 9570 ybp (4 samples).

†Juniperus californica Carrière
California juniper

Shrubs or small trees; easy to recognize by its large, woody seeds.

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 37,000 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.

OP: †Alamo Canyon, twigs, seeds, 9570 to 29,110 ybp (3 samples). Puerto Blanco Mts, on ridge, twigs, seeds, 9070 to 14,100 ybp (3 samples).

TA: †Butler Mts, twigs, seeds, 10,360 to 11,250 ybp (3 samples). Tinajas Altas, twigs, seeds, 8970 to 18,700 ybp (14 samples), & >37,000 ybp.

†Juniperus cf. **osteosperma** (Torrey) Little
Utah juniper

Shrubs or small trees. The seeds are large but smaller than those of *Juniperus californica*.

This juniper grew in the Ajo Mountains during the Wisconsin Age. The nearest present-day Utah juniper population occurs north of the Mogollon Rim in northern Arizona.

Utah juniper ranges from California to Montana and New Mexico.

OP: †Alamo Canyon, twigs, seeds, 32,000 ybp. Montezuma's Head, twigs, seeds, 13,500 to 21,840 ybp (4 samples).

†Juniperus scopulorum Sargent
Rocky Mountain juniper

Small to medium-sized or even large trees, mostly with pendulous branches and notably slender twigs, small scale leaves, and small, dark-colored seed cones.

It is documented from the Ajo Mountains 13,500 to 32,000 years ago and is probably one of the most mesic Ice Age woodland species in the flora area. The nearest present-day population occurs along the Mogollon Rim. It is the most mesic-inhabiting juniper in the Southwest, often growing in moist canyons.

Widespread in western North America from Canada to northern Mexico in eastern Sonora, western Chihuahua, and Coahuila.

OP: †Alamo Canyon, twigs, 14,500 to 32,000 ybp (3 samples). Montezuma's Head, twigs, 13,500 to 21,840 ybp (4 samples).

EPHEDRACEAE – Joint-fir Family

EPHEDRA – Joint-fir

Shrubs with green twigs and brownish scales leaves. Male and female cones on different plants.

1. Scale leaves 2 at each node, soon deciduous; widespread .... **Ephedra aspera**
1. Scale leaves 3 at each node, relatively persistent; dunes and sand soils near the western margin of the flora area .... **Ephedra trifurca**

Ephedra aspera Engelmann ex S. Watson
[*E. fasciculata* A. Nelson. *E. nevadensis* S. Watson var. *aspera* (Engelmann ex S. Watson) L.D. Benson]
Boundary ephedra, Mormon tea; *canutillo*; ku'ukpalk. Figure 20.

Woody shrubs usually less than 1 m tall, often with short, thick trunks and lower limbs; probably long-lived. Twig color may vary among different plants from yellow-green to glaucous blue-green. Leaves scale-like, 2 per node, soon fraying and deciduous. Seed cones with 1 seed, ripening usually in April. Pollen produced in March.

Widespread on hills and mountains across the flora area, often to the peaks, and sometimes on upper bajadas and washes near mountains.

Widespread in southern Arizona. Southeastern California to Utah and western Texas, Baja California, and northern Sonora to the Chihuahuan Desert region.

Two-leaved ephedras have been prevalent in the region since at least 37,000 years ago. The fossils were originally identified as *Ephedra nevadensis* but are more likely to be *E. aspera*. We are unable to distinguish them on the basis of fossil specimens.

In southern Arizona tea was made from the stems and there were a number of medicinal uses for the stems and roots, although especially for diabetes and venereal disease (e.g., Castetter & Underhill 1935; Curtin 1949; Felger 2007; Owen 1963; Rea 1997; Russell 1908). In northeastern Baja California the seeds, ripe in spring, were roasted, ground into flour, and consumed as *pinole*, which was reported to be bitter (Aschmann 1959; Meigs 1939). Ephedras have an extensive medicinal history, most notably the Eurasian species including *E. equisetina*, and *E. intermedia*, and *E. sinica*, the original source of ephedrine. New World species are reported to lack ephedrine

Figure 20A. *Ephedra aspera*. Butler Mountains, Yuma Co., Arizona, 21 Jan 2013; photo by Jim Malusa.

Figure 20B. *Ephedra aspera*. Male cones. Kuakatch Wash near highway 85, Pima Co., 6 Feb 2005; photo by Sue Rutman.

Figure 20C. *Ephedra aspera*. Female cones. Javelina Mountains, Sonoran Desert National Monument, Maricopa Co., Arizona, 5 Mar 2005; photo by Sue Rutman.

alkaloids although both New and Old World species are rich in biactive secondary compounds (Caveney et al. 2001).

OP: Pitahaya Canyon, 3400 ft, *Nichol 23 Feb 1939* (ORPI). Ajo Valley, 20 Apr 1942, *Cooper 718*. Near Quitobaquito Spring, *Ranzoni 13 Jul 1962* (ORPI). Bull Pasture, 2 May 1978, *Bowers 1266* (ORPI).

Alamo Canyon, 1968–2952 ft, 2 Apr 1982, *Wittmann 2716* (UCR). †Alamo Canyon, twigs, seeds, 1150 to 13,500 ybp. †Montezuma's Head, twigs, seeds, 13,500 ybp. †Puerto Blanco Mts, on ridge, twigs, seeds, 3440 to 15,400 ybp (5 samples).

CP: Buckthorn [Buckhorn] Tank, 20 Mar 1987, *Elias 1078*. Cabeza Prieta Peak, 2550 ft, summit, 24 Mar 1995, *Yeatts 3653*. About ½ mi W of Chico Shunie Well, UTM: 12 317363, 3578235, 1780 ft, in drainage, riparian area but outside the scour zone, 2 Feb 2003, *Rutman 2003-21*. Sierra Pinta, summit, 15 Nov 2003, *James Cain* (observation).

TA: Tinajas Altas: 26 March 1932, *Hinckley 138* (2 sheets: 000138,staminate, 000139 pistillate (F-FS); 12 Feb 1977, *Reeves R-5362* (ASU). 0.3 mi S of Tinajas Altas, 18 Apr 1983, *Hodgson 2100* (DES). Borrego Canyon, 16 Jun 1992, *Felger* (observation). †Butler Mts, twigs, bracts, seeds, 740 to 11,250 ybp (7 samples). †Tinajas Altas, twigs, seeds, 1230 to 18,700 (19 samples), & >37,000 ybp.

Ephedra trifurca Torrey ex S. Watson
Long-leaf joint-fir

This large shrub is not known from the flora area, although we have searched for it in potential places. It is, however, common in nearby areas such as dunes and sand soils in the Butler Mountains about 1.6 km west of the Tinajas Altas Region (also see Felger 2000; Felger et al. 2003).

PINACEAE – Pine Family

†PINUS EDULIS Engelmann var. **FALLAX** Little
Single-leaf pinyon; *piñón*. Figure 21.

Large shrubs or trees. Leaves relatively short, 1 per fascicle. Seed cones small and short, the seeds relatively large, wingless, and dispersed by birds and small mammals.

Figure 21. *Pinus edulis* var. *fallax*. Spring Canyon, Florida Mts, Luna Co., New Mexico; photo by Elroy Limmer, 22 May 2008.

Pinyons grew in the mountains of the flora area from about 11,000 to more than 37,000 years ago. These samples have slender needles characteristic of *Pinus edulis* var. *fallax*. The varieties, however, are often not recognized (e.g., Farjon & Styles 1997; Kral 1993). Nevertheless, samples resembling var. *fallax* are widespread in the lowland late Wisconsin Ice Age woodlands in sub-Mogollon Arizona. Tinajas Altas is the lowest elevation Sonoran Desert record for a pine in the Pleistocene.

Variety *fallax* presently ranges from northwestern to southeastern Arizona in regions of enhanced winter rainfall below the Mogollon Rim and within the Grand Canyon. There are also small populations as far southeast as the Florida and Burro Mountains of southwestern New Mexico. In the Burro Mountains of Grant County, the single-needle *Pinus edulis* var. *fallax* abruptly replaces the two-needle var. *edulis* in limited areas in more xeric, lower-elevation habitats (Felger & Kindscher 2010). Northwest of Arizona is the Great Basin proper and the range of *P. monophylla* Torrey & Frémont. Similar single-needle pinyons had a much greater range during Ice Age times. Single-needle pinyons are presently in Arizona, southwestern New Mexico, Idaho, Nevada, Utah, widespread in California, and mountains in Baja California.

Taxonomy of the *fallax* pinyon is far from settled, with this taxon variously attached to *Pinus edulis* or *P. monophylla* of the Great Basin. The single needle and larger cones are characters that *fallax* shares with both *P. monophylla* of the Great Basin and the single-needle pinyon of southeastern California, *P. californiarum* D.K. Bailey (another disputed taxon), while the very oily seeds (60–67% fat) and thicker seed shells are characters that the *fallax* pinyon shares with *P. edulis* var. *edulis* (Malusa 1992). Studies of the chloroplast DNA of pinyons have only reinforced this ambiguity (Gernandt et al. 2003). Similarly, although the single-needle condition seems an obvious adaptation to drought or drier conditions (Cole et al. 2007; Zavarin et al. 1990), a four-needle pinyon, *P. quadrifolia* Parlatore ex Sudworth, manages on only 140 mm/year of precipitation, easily the most arid pinyon habitat (Malusa 1992).

OP: †Alamo Canyon, leaves, female cone scales, seeds, 14,500 to 32,000 ybp (3 samples). Montezuma's Head, leaves, seeds, female cone scales, 13,500 to 21,840 ybp (4 samples).

TA: †Tinajas Altas, 460 m, leaves, nut fragments, 11,040 to 15,680 ybp (4 samples), & >37,000 ybp.

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