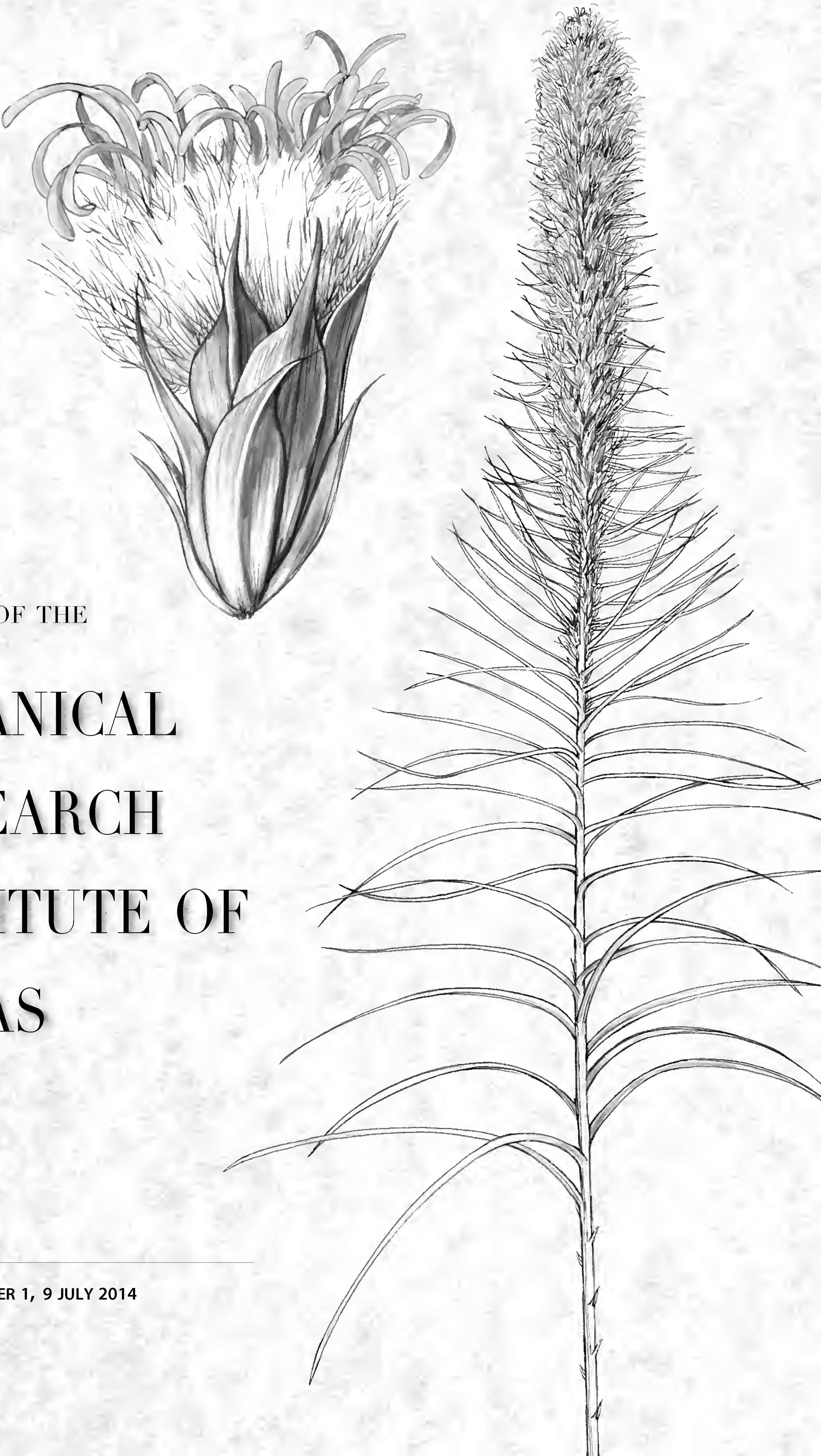

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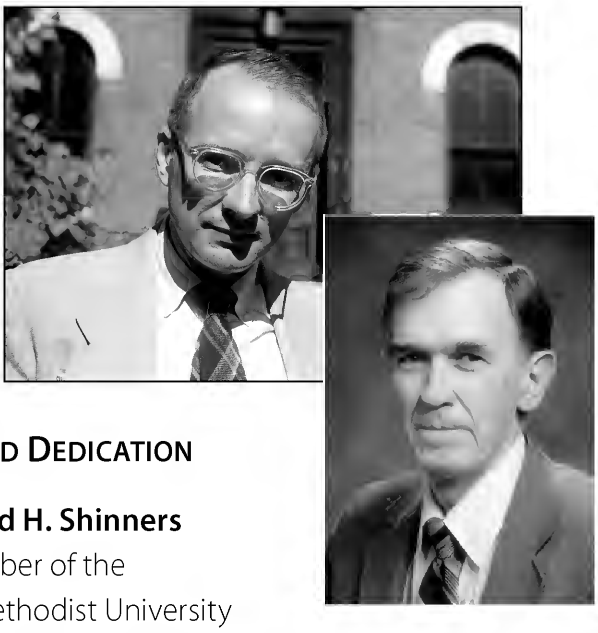

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1993—BRIT becomes publisher/copyright holder.

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817-332-7432; 817-332-4112 fax
Electronic mail: barney@brit.org; jbrit@brit.org

EDITOR: Barney Lipscomb
ASSISTANT EDITOR: Brooke Byerley

CONTRIBUTING SPANISH EDITOR
Félix Llamas (Universidad of León, León, Spain)

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Electronically tinted botanical illustration of *Liatris aestivalis* originally used on BRIT's anniversary poster 2001. Summer gayfeather flowers mid Jul–Aug(–Sep) and is endemic to Oklahoma and Texas. Sida 19:768. 2001. Botanical illustration by Linny Heagy ©2001.

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NEW SPECIES AND COMBINATIONS IN *SOLANUM* SECTION *ANDROCERAS* (SOLANACEAE)

Stephen R. Stern
Department of Biological Sciences
Colorado Mesa University
1260 Kennedy Ave
Grand Junction, Colorado 81501, U.S.A.
sstern@coloradomesa.edu

Lynn Bohs
Department of Biology
University of Utah
257 South 1400 East
Salt Lake City, Utah 84112, U.S.A.

Jeffrey Keeling
Department of Biology
Sul Ross State University
Alpine, Texas 79832, U.S.A.

ABSTRACT

A new species of *Solanum* from Texas is described here. **Solanum cordicitum** S. Stern is a member of *Solanum* section *Androceras*. It is similar to *S. citrullifolium* and *S. davisense* but differs from both in having white corollas, and differs from the latter in having inflorescences with a significantly longer axis and larger flowers. In addition to the new species, three new combinations are proposed for species in *Solanum* section *Androceras,* **Solanum setigeroides** (Whalen) S. Stern, **Solanum novomexicanum** (Bartlett) S. Stern, and **Solanum knoblochii** (Whalen) S. Stern.

RESUMEN

Se describe aquí una especie nueva de *Solanum* de Texas. **Solanum cordicitum** S. Stern es un miembro de *Solanum* sección *Androceras*. Esta especie es similar a *S. citrullifolium* y *S. davisense*, pero se diferencia de ambas por tener flores con corola blanca, y de la última por sus inflorescencias más largas y flores más grandes. También se proponen tres combinaciones nuevas de *Solanum* sección *Androceras*, **Solanum setigeroides** (Whalen) S. Stern, **Solanum novomexicanum** (Bartlett) S. Stern, y **Solanum knoblochii** (Whalen) S. Stern.

INTRODUCTION

A comprehensive project to complete species-level taxonomic treatments and resolve phylogenetic relationships within the genus *Solanum* L., supported by the National Science Foundation Planetary Biodiversity Inventory program, has facilitated detailed systematic study of many little known groups within this giant genus (Knapp et al. 2004; http://www.nhm.ac.uk/solanaceaesource). One of the largest groups within *Solanum*, the Leptostemonum clade, includes approximately 350–400 species (Bohs 2005; Levin et al. 2006; Weese & Bohs 2007; Stern et al. 2011) and is commonly known as the "spiny solanums" due to the presence of prickles. Phylogenetic work on this clade has identified a number of monophyletic groups, one of which corresponds to *Solanum* section *Androceras* (Nutt.) Whalen (Stern et al. 2010).

Solanum section *Androceras* is an unusual group within the spiny solanums due to its floral characteristics, namely its bilaterally symmetrical, heterantherous, and enantiostylous flowers. Most *Solanum* species have fleshy berry fruits, but those of section *Androceras* are dry with a prickly, accrescent calyx. The section has flavenoids that are unique among known flavenoids in other *Solanum* groups and has an atypical north temperate geographic distribution. Whalen (1979) provided a detailed revision of the section and included 12 species and 10 varieties. Stern et al. (2010) used molecular phylogenetic techniques to examine the relationships among these taxa. Results from that study, and further taxonomic work on *Solanum* section *Androceras*, have uncovered an undescribed *Solanum* species from Texas and indicates that some taxa described as varieties should be recognized as distinct species. These new names and combinations are validated here. A revision of Whalen's (1979) species key, including the 16 currently recognized species, is also provided.

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Solanum cordicitum S. Stern, sp. nov. (**Figs. 1–2**). Type: UNITED STATES. Texas. Jeff Davis Co.: Valentine, Blk 76, Bell 2nd Add., 23 Sep 1990 (fl, fr) *H. Elder 46* (holotype: TEX [00402851]).

Similar to *Solanum citrullifolium* and *S. davisense*; differs from both in having white corollas; differs from *S. davisense* in having inflorescences with a significantly longer axis and larger flowers.

Herb to 35 cm. Stems armed with acicular prickles to 5 mm in length, tan to brown, the base to 1 × 0.5 mm, sparsely pubescent with simple, uniseriate, multicellular hairs 1–2 mm long, moderately pubescent with simple, uniseriate, multicellular, gland-tipped hairs 0.5–1 mm long. Flowering portions of stem of difoliate sympodial units, the leaves usually geminate, those of a pair often slightly unequal. Leaves simple, the blades 3–8 × 1.5–4 cm, deeply lobed to pinnatifid or pinnatisect with 3–4 lobes per side, chartaceous, green on both surfaces, the adaxial surface nearly glabrous with occasional simple, uniseriate, unicellular to multicellular hairs 0.5–1 mm long, the abaxial surface sparsely pubescent with stellate hairs, the stalks absent to 0.5 mm, multiseriate, the rays 2–4, 0.5–1 mm long, unicellular to multicellular, the midpoints 0.5–1 mm long; venation pinnate, the secondary veins 3–4 on each side of the midvein and one per lobe, the midrib and larger secondary veins occasionally with a few prickles like those of the stem; base obtuse, often asymmetrical; margin deeply lobed and the lobes with irregularly undulate margins; apex rounded to obtuse; petioles 0.5–3 cm, moderately pubescent with hairs like those of the stem, sparsely armed with prickles like those of the stem. Inflorescence 8–12 cm, extra-axillary, unbranched, with 5–8 flowers, the axes moderately pubescent with hairs like those of the stem, moderately armed with prickles like those of the stem; peduncle 2–3 cm; rachis 6–12 mm; pedicels 4–10 mm in flower, 10–18 mm in fruit, spaced 6–12 mm apart, articulated at the base. Flowers 5-merous, zygomorphic, enantiostylous. Calyx 4–6 mm long, the tube 1.5–3 mm, the lobes 2–4 × 0.5–1.2 mm, narrowly triangular, moderately pubescent abaxially with hairs like those of the stem, moderately armed with prickles like those of the stem; fruiting calyx 9–13 mm, strongly accrescent, completely covering the fruit, densely armed with prickles like those of the stem. Corolla 2–2.5 cm in diameter, chartaceous, white, rotate-stellate, with abundant interpetalar tissue, shallowly lobed, the lobes 2–3 × 0.5–1.5 mm, narrowly triangular, sparsely pubescent on abaxial midveins with hairs like those of the stem, adaxially glabrous. Stamens dimorphic, the lowermost one 10–12 mm, the upper four 5–8 mm; filaments 1–2 mm long, glabrous; lowermost anthers 9–11 × 1–2 mm, opposite the style in alternating right and left-handed flowers, distally curved upward, yellow; upper anthers 5–6 × 1–2 mm, straight, yellow, all anthers linear-lanceolate, tapering, the base cordate, the apex acute, the pores directed slightly introrsely, not opening into longitudinal slits. Ovary glabrous; style 10–14 × 0.5–1 mm, cylindrical, glabrous, opposite the lowermost anther and alternating between right and left-handed flowers; stigma to 1 mm wide. Fruit 10–12 mm in diameter, globose, tightly invested in the prickly accrescent calyx creating a burr-like fruit, green, turning black, drying and tearing apart at maturity, glabrous. Seeds 30–40 per fruit, ca. 1.5 × 1 mm, chocolate-brown, reniform, the surface with raised ridges.

Distribution and Phenology.—Known only from Jeff Davis Co., Texas from 1350–1820 m in elevation. The specimens were flowering in September–November and fruiting in September–November.

Etymology.—*Solanum cordicitum* is taken from the Latin "cordicitus" for "from the heart" referring to the type locality of Valentine, Texas.

Conservation Status.—The conservation status of *S. cordicitum*, according to the IUCN Red List Categories (IUCN 2010) is Data Deficient due to the low number of collections. Despite searching herbaria, including BRIT, NY, TAES, TAMU, TEX, US, and UTEP, and collection efforts near Valentine, Texas in 2010 and 2013, only three collections of *S. cordicitum* are known. It is our hope that this species description will encourage further collecting in Jeff Davis County so that the status of *S. cordicitum* can be determined.

Solanum cordicitum has an overlapping geographic distribution with various members of section *Androceras*, including *S. rostratum, S. davisense,* both varieties of *S. tenuipes*, and *S. citrullifolium* vars. *citrullifolium* and *setigerum*. Unlike any of these species, *S. cordicitum* has white corollas. Additionally, *S. cordicitum* differs from *S. rostratum* in that the latter has stellate hairs on the stem while those of *S. cordicitum* are simple. *Solanum tenuipes* is typically found further south in the Big Bend area of Texas and is a perennial whereas *S. cordicitum* is an annual. The leaves of *S. cordicitum* are not thrice pinnatifid as they are in *S. davisense* and the lowermost

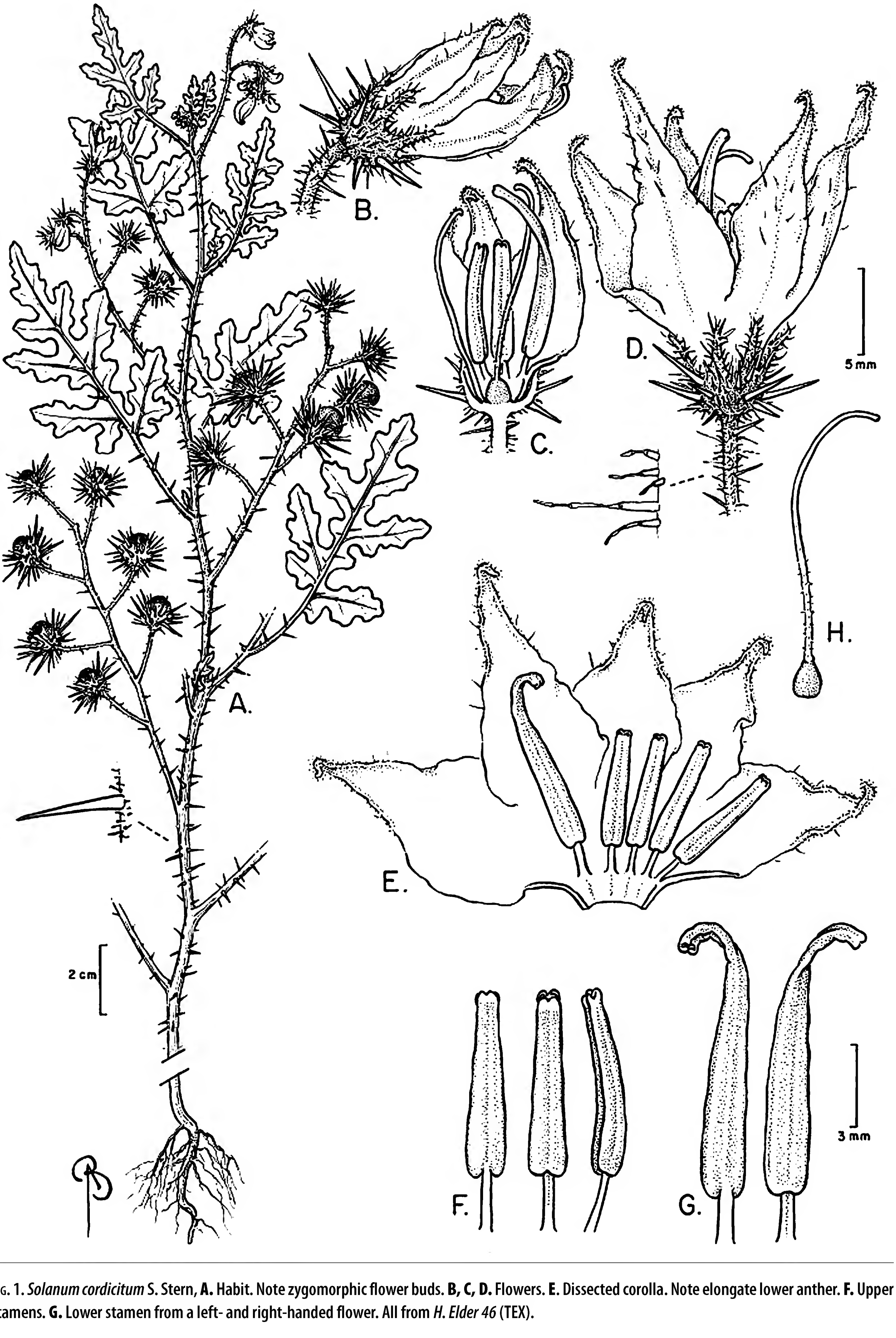

Fig. 1. *Solanum cordicitum* S. Stern, **A.** Habit. Note zygomorphic flower buds. **B, C, D.** Flowers. **E.** Dissected corolla. Note elongate lower anther. **F.** Upper stamens. **G.** Lower stamen from a left- and right-handed flower. All from *H. Elder 46* (TEX).

Solanum grayi Rose var. *grandiflorum* Whalen
Terri Weese June 2006

The University of Texas Herbarium (LL, TEX)
Solanum davisense M. D. Whalen
Det: B. L. Turner, 3 May 1997

PLANTS OF TEXAS

#46 SOLANACEAE
Solanum heterodoxum Dunal

JEFF DAVIS CO. Valentine, TX. BLK 76 BELL 2ND ADD. in open areas under *Prosopis*, *Ephedra*, with *Cucurbita*, *Bouteloua*, *Hilaria*.
Medium annual herb up to 35cm tall; herbage and fruit prickly; petals white, anthers long and yellow; fruit a spiny capsule.

Coll: H. Elder 23 September 1990

Fig. 2. Holotype of *Solanum cordicitum* S. Stern [*Elder 46* (TEX)].

anthers of the latter are shorter (6–8 mm in *S. davisense* versus 9–11 mm in *S. cordicitum*). *Solanum cordicitum* also has longer inflorescences than *S. davisense* (8–12 cm in *S. cordicitum* versus 4–7 cm in *S. davisense*) and larger flowers (2–2.5 cm in diameter in *S. cordicitum* versus 1.3–2 cm in *S. davisense*). The prickles of *S. cordicitum* are more widely spaced (<20 per cm) than those of *S. citrullifolium* var. *setigerum* (>30 per cm). The flowers of *S. cordicitum* are generally smaller (2–2.5 cm in diameter) than those of *S. citrullifolium* var. *setigerum* (2.5–3.5 cm in diameter).

PARATYPES: **UNITED STATES. Texas. Jeff Davis Co.:** 30 mi W of Ft. Davis on US 166, 6000 ft, 17 Oct 1974 (fr), *Heller 24* (UTEP); town of Valentine, Elder property, 30°35'40"N, 104°39'32"W, 1350 m, 7 Nov 2013 (fl, fr), *J. Keeling 445* (MESA).

The three combinations below represent taxa previously recognized as varieties by Whalen (1979). These species each have distinctive morphological characteristics and geographical ranges that distinguish them from other species in sect. *Androceras*. Additionally, molecular phylogenetic analyses (Stern et al. 2010) have shown that they do not form monophyletic groups with the other varieties of their respective species.

Solanum knoblochii (Whalen) S. Stern, comb. & stat. nov. *Solanum citrullifolium* var. *knoblochii* Whalen, Wrightia 5:237. 1976. TYPE: MEXICO. CHIHUAHUA: Mojarachic, 16 Aug 1940, *Knobloch 8006* (HOLOTYPE: US [00027510]).

Whalen (1976, 1979) designated the variety *S. citrullifolium* var. *knoblochii* and distinguished it from *S. citrullifolium* var. *setigerum* by the much denser pubescence of the latter (each cm of stem with over 25 prickles versus scattered prickles ≤ 20 per cm of stem in the former). It is also differentiated from *S. citrullifolium* var. *citrullifolium* by the short (≤ 1.2 mm), uniseriate hairs of the latter versus the presence of much longer (> 2 mm), uniseriate hairs in var. *knoblochii*. The easternmost distribution of var. *setigerum* overlaps with the westernmost distribution of var. *citrullifolium* in west Texas. However, *S. knoblochii* has a disjunct distribution from both of these varieties and is only known from two populations in the Tarahumara country of western Chihuahua, Mexico (Whalen 1976).

These distinct morphological characters, isolated geographical range, and evidence from molecular data (Stern et al. 2010) indicate that *S. citrullifolium* var. *knoblochii* should be recognized as a distinct species. The name *Solanum knoblochii* was retained, honoring Irving Knobloch, the first collector of this species in Chihuahua.

The remaining varieties of *S. citrullifolium*, vars. *citrullifolium* and *setigerum*, did not form a monophyletic group in Stern et al. (2010). Instead, they formed a strongly supported clade with *S. davisense* and *S. heterodoxum* var. *setigeroides*. These species have overlapping distributions and similar morphologies with the main difference being small flowers in *S. heterodoxum* var. *setigeroides* (corolla < 1.5 cm across, large anther < 5 mm), medium-sized flowers in *S. davisense* (corolla ca. 1.7 cm across, large anther 6–8 mm), and large flowers in both varieties of *S. citrullifolium* (corolla > 2 cm, large anther > 10 mm). There is also reported hybridization between *S. citrullifolium* var. *setigerum* and *S. heterodoxum* var. *setigeroides* (Whalen 1979). *Solanum heterodoxum* var. *setigeroides* is recognized as a distinct species below because it is not monophyletic with the other varieties of *S. heterodoxum* in the molecular phylogenetic analyses of Stern et al. (2010). Although *S. citrullifolium* vars. *citrullifolium* and *setigerum* also did not form a clade in Stern et al. (2010), resolution and support is low in this part of the tree. Further morphological and molecular data are needed to assess the taxonomic status of *S. citrullifolium* vars. *citrullifolium* and *setigerum* as well as that of *S. davisense*.

Conservation Status.—The status of *S. knoblochii* using the IUCN Red List Categories (IUCN 2010) is Data Deficient given the few collections and lack of long term monitoring. Recent collections, in addition to the original collections by Knobloch, show that the range of this species is approximately 34,000 km^2. This range is sufficient to place the species out of the Threatened category, but the limited number of collections (only five are known from two populations) is concerning and warrants Near Threatened status.

Two varieties of *S. heterodoxum* are designated as distinct species:

Solanum setigeroides (Whalen) S. Stern, comb. & stat. nov. *Solanum heterodoxum* var. *setigeroides* Whalen, Wrightia 5:237. 1976. TYPE: UNITED STATES. NEW MEXICO. Grant Co.: 12 mi W of Silver City, 4 Aug 1975, *Whalen 201* (HOLOTYPE: LL [LL-00372877]; ISOTYPES: MO [MO-503667], WIS).

Solanum novomexicanum (Bartlett) S. Stern, comb. & stat. nov. *Solanum heterodoxum* var. *novomexicanum* Bartlett, Proc. Amer. Acad. Arts 44:628. 1909. *Androcera novomexicana* (Bartlett) Woot. & Standl., Contr. U.S. Natl. Herb. 16:170. 1913. Type: UNITED STATES. New Mexico: Santa Fe, creek valley, foot of mountains, sunny side, 1847, *Fendler 673* (holotype: GH [GH-00077421]; isotypes: F, GH [GH-00077422], MO [MO-503664]).

Solanum heterodoxum var. *setigeroides* was recognized as distinct from *S. heterodoxum* vars. *heterodoxum* and *novomexicanum* due to the dense, narrow prickles on its stems (≥ 30 prickles per cm, mostly less than 0.5 mm in diameter versus ≤ 20 prickles per cm, often to 1 mm wide in the latter varieties). *Solanum heterodoxum* var. *novomexicanum* was differentiated from var. *heterodoxum* by its pentagonal-stellate corolla with narrow deltoid lobes versus pentagonal corollas with ample interpetalar tissue in the latter. The distributions of these varieties are also disjunct, with var. *heterodoxum* occurring in central Mexico from Veracruz to San Luis Potosí, var. *setigeroides* in northern Chihuahua, Mexico and westernmost Texas to central Arizona and New Mexico, and var. *novomexicanum* in northern New Mexico. Additionally, molecular phylogenetic data in Stern et al. (2010) found that these varieties do not form a monophyletic group and belong in distinct clades.

Etymology.—The name *S. setigeroides* was retained from the Latin word "setiger," meaning "bristly," referring to the bristly prickles of the stem. *Solanum novomexicanum* was originally recognized at the species level as *Androcera novomexicanum*, so the epithet was transferred and refers to fact that this species is endemic to New Mexico.

Conservation Status.—The conservation status of *S. setigeroides* according to the IUCN Red List Categories (IUCN 2010) is Least Concern. This is a widespread, weedy species with no obvious threats. Although *S. novomexicanum* is not as widespread or as frequently collected as *S. setigeroides*, its designation according to the IUCN Red List Categories (IUCN 2010) is also Least Concern due to its relatively weedy nature. Additionally, *S. novomexicanum* is afforded some protection with populations in Pecos Ruin National Historic Park and the Cibola National Forest.

KEY TO THE SPECIES OF *SOLANUM* SECTION *ANDROCERAS*
(REVISED FROM WHALEN 1979)

1\. Cauline hairs stellate or multiangulate; corollas mostly yellow, rarely pale blue or white.

  2\. Corollas pale blue or white **S. tribulosum** S. Schauer

  2\. Corollas yellow.

    3\. Plants perennial, woody-based; cauline stellae echinoid, some of them with 15 or more rays; distribution in eastern Durango, Mexico **S. johnstonii** Whalen

    3\. Plants annual, taprooted; cauline stellae usually with 12 or fewer rays.

      4\. Large anther essentially glabrous.

        5\. Hilum of seed sunken in a deep notch; large anther hardly distinct, less than 6 mm long; corollas less than 2 cm across; cauline prickles broad-based, flattened and often recurved **S. fructo-tecto** Cav.

        5\. Hilum of seed not sunken in a deep notch; large anther very distinct from shorter ones, over 9 mm long; corollas more than 2 cm across; cauline prickles seldom much flattened or recurved **S. rostratum** Dunal

      4\. Large anther bearded on the proximal portion of the ventral surface **S. angustifolium** Mill.

1\. Cauline hairs simple, often glandular, occasionally absent; corollas usually violet, blue, or white, seldom yellow.

  6\. Corollas violet or blue.

    7\. Large anther 6 mm long or more; corollas 1.4 cm or more across; stigma unexpanded or only weakly capitate

      8\. Plants perennial, woody- or corky-based; seeds plump, 2.8 mm long or more **S. tenuipes** Bartlett

      8\. Plants annual, taprooted; seeds lenticular, shorter than 3 mm

        9\. Large anther 6–8 mm long; corollas ca. 1.7 cm across; buds obovoid, more or less radially symmetrical; large leaves often thrice pinnatifid, with acute ultimate lobes **S. davisense** Whalen

        9\. Large anther 10 mm long or more; corollas 2 cm or more across; buds noticeably curved, bilaterally symmetrical; large leaves usually only twice pinnatifid, with obtuse to acute ultimate lobes.

          10\. Cauline hairs mostly <0.3 mm with occasional hairs reaching to 1 mm; distributed from central to west Texas to western Coahuila and eastern Chihuahua, Mexico **S. citrullifolium** A. Braun

          10\. Cauline hairs often reaching 2.5 mm in length; known only from western Chihuahua, Mexico **S. knoblochii** (Whalen) S. Stern

    7\. Large anther 5 mm long or less; corollas 1.5 cm or less across; stigma capitate, twice as thick as the style.

      11\. Stems sparsely pubescent with simple, glandular hairs ca. 0.2 mm long; stems densely prickly, each cm with 30 or more acicular prickles, the bases less than 0.5 mm in diameter **S. setigeroides** (Whalen) S. Stern

      11\. Stems densely pubescent with simple, glandular hairs 0.2–0.4 mm long; stems sparsely prickly, each cm with 20 or fewer acicular prickles, the base up to 1 mm in diameter.

12. Corolla pentagonal, with ample, plicate interpetalar tissue; distribution in Mexico, from Veracruz to San Luis Potosí **S. heterodoxum** Dunal

12. Corolla pentagonal-stellate, with narrowly deltoid lobes; distribution in U.S.A. (northern New Mexico) **S. novomexicanum** (Bartlett) S. Stern

6. Corollas white or yellow.

13. Stems with well-spaced, acicular prickles; corollas pentagonal-stellate with ample, plicate interpetalar tissue, 2 cm or more across; seeds reticulately ridged.

14. Corolla yellow, 2.5 cm or more across; large anther bearded on the proximal portion of the ventral surface; distribution from tropical Mexico east to Honduras **S. angustifolium** Mill.

14. Corolla white, 2–2.5 cm across; large anther glabrous; distribution in western Texas, USA **S. cordicitum** S. Stern

13. Stems with dense, filiform, bristle-like prickles; corollas distinctly stellate with little interpetalar tissue, 2.5 cm or less across; seeds radially ridged at margin.

15. Anthers of three sizes, the longest one flanked by two of intermediate length; mature seeds large, 3 mm or longer, with the hilum sunken in a deep notch; distribution from southern Arizona, USA to northern Sinaloa, Mexico **S. lumholtzianum** Bartlett

15. Stamens dimorphic, one large, the other four smaller and essentially equal; mature seeds small, 3 mm long or less, not deeply notched; distribution from southern Sonora to Puebla and Guerrero, Mexico.

16. Leaves with simple and/or glandular hairs above, or glabrous; plants widespread along the Pacific slope of Mexico **S. grayi** Rose

16. Leaves with stellate hairs above; endemic near Matamoros, Puebla, Mexico **S. leucandrum** Whalen

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BOOK REVIEW

Tracey Parker. 2014. **Árboles Comunes de Nicaragua/Common Trees of Nicaragua.** (ISBN-13: 978-0-9718739-1-9, pbk). The Tree Press, Suite 650, #125, 3300 Bee Cave Road, Austin, Texas 78746, U.S.A. (**Orders:** www.thetreepress.com, 1-800-247-6553). $44.95, 404 pp., 170+ line drawings, 1200+ color photos, map, glossary, index, 6" × 9". Fully bilingual text (Spanish and English).

A fully bilingual guide to the trees and tree-like plants of Nicaragua, this book is packed to the gills with information. Each species is presented over two pages: one for Spanish and English descriptions and one for color photographs. Each description page includes family name, Spanish and English common names, distribution, morphological description, habitat, ethnobotanical or commercial uses, and notes (a section for interesting facts and phenology). In addition, every description page also includes a line drawing and, where appropriate, taxonomic synonyms. The photo page accompanying each species includes anywhere from 5 to 10 color photographs of leaves, fruits, flowers, seeds, bark, habitat, and depiction of usage (e.g., a woman at a market balancing a tray of mango slices on her head).

Organized alphabetically by family, genus, and species (with monocots, dicots, and gymnosperms intermixed), the book also includes an index of both scientific and common names as well as an English and Spanish glossary of botanical terms, making it more novice-friendly. The front matter, however, is bare bones—just a map of Nicaragua and a brief introductory note from the author. Truly, this book is all about the trees, devoting the majority of its 400+-page heft to those wonderfully concise descriptions that manage to clearly depict the essentials of each species and do so in two languages. Personally, I admire the commitment to full dual-language text; by doing so, the author must have had to sacrifice some content, but the resulting text is not only streamlined and elegant but also accessible to a much wider audience.

Though I cannot speak to the quality of the taxonomic presentation, I believe *Common Trees of Nicaragua* to be a well-executed work relevant to the field guide genre. The inclusion of so many color photographs as well as the line drawings really give this book an edge over other field guides, though I would have liked to see the line drawings expanded in size where page content allowed. (Some description pages are completely filled while others have some usable white space remaining. ... Why not use that space to increase figure size?) Other than this, however, the layout is clean and consistent, the organization logical, pleasing, and easy to navigate. Dr. Parker also published *Trees of Guatemala* in 2008, and if it is anything like her current work, I will most assuredly be making a second purchase.—*Brooke Byerley Best, PhD, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

From the publisher: TRACEY PARKER, PhD, forest ecologist, environmental consultant, professor and photographer, holds a bachelor's degree in forestry from Colorado State University, and masters and doctorate from the University of Idaho. Dr. Parker moved with her family from Nepal to Guatemala in 1994, and began teaching dendrology in the Forestry Department at the Universidad del Valle. She held the position of Regional Environmental Advisor at the U.S. Agency for International Development (USAID) where her work took her to all the countries of Central America, expanding her knowledge of the vegetation throughout the isthmus.

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SEDUM KIERSTEADIAE (CRASSULACEAE), A NEWLY DESCRIBED SPECIES FROM THE KLAMATH REGION OF CALIFORNIA, U.S.A.

Barbara L. Wilson, Richard E. Brainerd, Nick Otting

Carex Working Group
1377 Alta Vista Drive
Corvallis, Oregon 97330, U.S.A.
bwilson@peak.org

ABSTRACT

Sedum kiersteadiae is a locally common succulent of rocky, often ultramafic substrates at mid to high elevations, narrowly endemic to the western Klamath region of northern California. It is recognized by its widely spreading yellow petals and its relatively loose rosettes with visible internodes.

RESUMEN

Sedum kiersteadiae en una suculenta localmente común de sustratos rocosos, a menudo ultramáficos en elevaciones de medianas a altas, endémica del oeste de la región Klamath del norte de California. Se reconoce por sus pétalos amarillos ampliamente extendidos y sus rosetas relativamente flojas con internudos visibles.

INTRODUCTION

In the Klamath Region of northern California and southwest Oregon, *Sedum* section *Gormania* has diversified into six morphologically similar species. Two of the species, *S. obtusatum* A. Gray and *S. laxum* (Britton) Berger (Boyd & Denton 2012) have been treated as having four subspecies each (Denton 1982). The section was studied by Clausen (1942, 1975), and its classification was further refined by Denton (1982), who had access to additional specimens. This research was made readily accessible by *Sedum* treatments in the Jepson Manual (Denton 1993; Boyd & Denton 2012). However, as field botanists worked with populations unknown to previous researchers, they found problems with those treatments: similar plants from the same area were often identified as belonging to two or more species, certain supposedly rare plants were encountered frequently, and many plants had combinations of traits that did not fully match any of the published descriptions.

In 2011–2013, we studied variation and classification in this group. Full results of the study, including an identification key, will be published elsewhere. Here we raise to the rank of species one of the more distinctive elements in *Sedum* section *Gormania*. Although the type specimen of *S. obtusatum* subsp. *boreale* R.T. Clausen is an example of this taxon, we find that Clausen's descriptions do not fully match the plant as we understand it, so a full description is provided here. The plant cannot be treated as a species under its original epithet because that is preempted by *Sedum boreale* Hort. ex Guenthart (Guenthart 1902).

Sedum kiersteadiae B.L. Wilson & R.E. Brainerd, sp. nov. (**Figs. 1–2**). Type: U.S.A. California. Shasta Co.: NE of Slate Mountain, W of USFS Road 37N08Y; T36N R6W S2, SW ¼ of NW ¼, 41.01159°, -122.53148°, 4500 ft, 15 Jun 2012, *Lindstrand III & Van Susteren NSR-17* (holotype: OSC; isotypes: CAS, CHSC, DAV, HSC, MO, NY, RSA, UC, WTU).

Sedum obtusatum A. Gray subsp. *boreale* R.T. Clausen, Bull. Torrey Bot. Club 69:32. 1942. *Sedum obtusatum* A. Gray var. *boreale* (R.T. Clausen) H. Ohba, J. Bot. Res. Inst. Texas 1:889. 2007. Type: U.S.A. California. Siskiyou Co.: Mt. Shasta, E side Mud Creek Canyon, 5600 ft, 26 Jul 1940, *R.T. Clausen, W.B. Cooke & H. Trapido 4952* (holotype: BH!; isotype: NY!). Not *Sedum boreale* Hort. ex Guenthart (1902).

Sterile rosettes usually loose, with visible internodes; leaves obovate and usually notched; sepals less than half as long as the petals; petals yellow with midribs usually pink to red, whole petals senescing red, the upper half spreading about 90° from the flower axis.

Description.—Plants succulent, herbaceous, perennial. Rhizomes and stolons to 15 cm long, 3–6 mm diameter; sterile rosettes often numerous. Rosette leaves often loosely arranged with visible internodes, glaucous,

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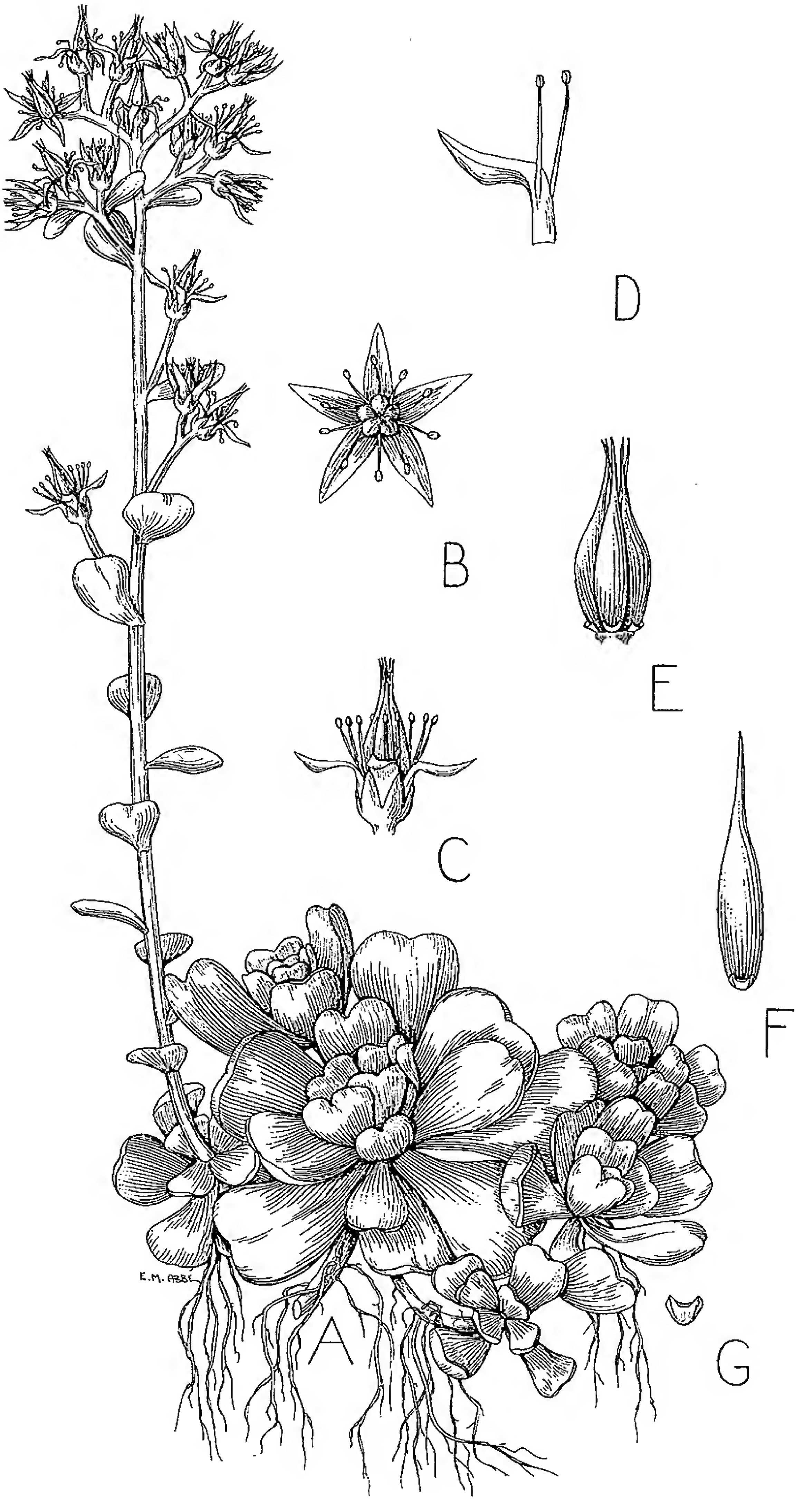

Fig. 1. Type plant of *Sedum obtusatum* subsp. *boreale* from Mud Creek Canyon, Mt. Shasta, Siskiyou Co., California, cultivated in greenhouse, Ithaca New York, May 1943. **A.** Habit. **B.** Flower from above (×1.7). **C.** Flower from side (×1.7). **D.** Petal and two stamens (x 2.6). **E.** Carpels (x 2.6). **F.** Single carpel and nectary (×3.4). **G.** Nectary (×4.3). Drawing by Elfriede Abbe, from Clausen (1975) p. 374. Used with permission from Cornell University Press.

Fig. 2. *Sedum kiersteadiae*. Note widely spreading yellow petals often marked with red on the dorsal surface, and the open spacing of leaves on the sterile shoot. Photo credits: Whole plant and top flower, Julie Kierstead Nelson. Center and lower flower, and sterile shoot, Peter F. Zika.

flattened, broadly obovate to oblanceolate, cuneate at base, 12–32 × 5–18 mm, 1.2–5.3 times as long as wide, apex usually notched, sometimes obtuse or truncate. Flowering shoots often reddish, 7.5–28.5 cm, nodding in bud, erect in flower and fruit. Leaves on flowering shoots usually pink to green, (4–)11–19 × (2–)5–9 mm, 1–3.7 times as long as wide, narrowly obovate, truncate at base, apex usually obtuse. Inflorescences panicle-like cymes 4–13.6 × 2–3(–4) cm, usually cylindrical, proximal branches solitary at nodes, ascending. Flowers 10–30. Calyx greenish, (8–)15–45% as long as the petals, free calyx lobes (0.5–)2–4(–6) mm long, acute. Petals 6–8(–12) mm long, light yellow with midribs usually pink or red dorsally, sometimes white ventrally (sometimes also dorsally) when young, lower half sometimes red, entire petal eventually senescing red, becoming whitish or pale tan when dead. Upper half of petal blade narrow, spreading (70–)80–90(130)° from the flower axis at anthesis, apex acute, usually with subterminal mucro. Stamens 10, shorter than or equaling petals; filaments white or yellow-green, aging red; anthers usually red, rusty, or dark orange aging purple or black, sometimes yellow aging light brown, becoming tan when dead and dried. Follicles erect, green aging red, fused 0.5–1 mm at base.

Chromosome number.—$2n = 30$ (Clausen 1942, based on count for *Clausen et al. 4952*).

Habitat and Range.—Rock outcrops and rocky open forests, usually on serpentine substrates, NE Trinity County and adjacent NW Shasta and S Siskiyou counties, CA, in the Klamath Range, also disjunct on the southeast side of Mt. Shasta (Fig. 3), 1000–2500 m elevation, more common at higher elevations.

Etymology.—The name *S. kiersteadiae* honors California botanist Julie Kierstead Nelson, who was inspired to study the natural world by her father, Robert William Kierstead. Conveniently, the Dutch “kier stead” refers to a place or homestead with cracks; this plant generally grows in cracks in its rocky home.

Classification.—This species belongs in *Sedum* subgenus *Gormania* section *Gormania* (Clausen 1975).

Specimens examined: (KNF = herbarium of the Klamath National Forest; other herbarium acronyms follow Thiers (continuously updated)). **CALIFORNIA: Shasta Co.:** Ridge top N of Sanford Pass; T36N R6W S15, 4600 ft, 15 Jun 2012, *Lindstrand & Van Susteren NSR-15* (CHSC, DAV, HSC, KNF, STNF, UBC); The Incline, Upper Slate Creek watershed; N of USFS Road 36N44; T36N R6W S12, 4200 ft, 15 Jun 2012, *Lindstrand & Van Susteren NSR-18* (CAS, MICH, MO, NY OSC, RSA, WTU, UC). **Siskiyou Co.:** Mount Shasta, Mud Creek, 5716 ft, 7 Aug 2011, *Colberg MEC-1* (MO, OSC, RSA, UC, WTU); on the banks of Mud Creek Canyon, 6500 ft, 22 Aug 2013, *Wm. Bridge Cooke 15459* (OSC); Mount Bradley, in rocks 10–50 m W of lookout, also E of lookout in rocky openings, 5556 ft, 12 Jul 2011, *Lindstrand & Van Susteren NSR-09* (BH, F, GH, NY, US); Gray Rocks Lake, downslope of trail to lake near trailhead, T39N R5W S21, 5830 ft, 20 Jul 2011, *Lindstrand & Van Susteren NSR-11* (CAS, CHSC, DAV, HSC, MO, NY, RSA, UBC, UC); Rattlesnake Hill, on ridge N of USFS road 38N21, T37N R5W S20, 5580 ft, 20 Jul 2011, *Lindstrand & Van Susteren NSR-12* (BH, GH, KANU); along Mount Eddy Trail, ca. 1.75 mi from trailhead, 7000 ft, 29 Jul 2011, *Van Susteren JVS 1* (CAS, OSC, UC); off trail between Heart Lake & Castle Lake below Little Castle, 5950 ft, 30 Jul 2011, *Van Susteren JVS 2* (CHSC, DAV, HSC, UBC); Rail Creek road (road 41N08, to Kanagaroo Lake), 4913 ft, 9 Aug 2011, *Wilson et al. CWG-18* (F, RENO, UC, US); ridge line W of Kangaroo Lake, near loop at end of road, 6604 ft, 9 Aug 2011, *Wilson et al. CWG-19* (CAS, MO, NY, OSC, WTU); 0.9 mi by road E of summit on Highway 3 at Scott Mountain, 5076 ft, 31 Jul 2011, *Zika & Wilson 25677* (CAS, CHSC, OSC, WTU); Shasta-Trinity National Forest; 10.1 mi NW of Highway 3 on road 42N17,5777 ft, 31 Jul 2011, *Zika & Wilson 25680* (F, RENO, UBC, US, WTU); near Pacific Crest Trail, ca. 0.5 km NW of Parks Creek Pass and junction with FS road 42N17C and Route 17, 2.5 air mi NW of the NW Deadfall Lake, 6890 ft, 31 Jul 2011, *Zika & Wilson 25683* (CAS, OSC, UC, US, WTU); South Fork Willow Creek; N end road 42N19, along South Fork, 3691 ft, 21 Jun 2012, *Zika et al. 25901* (DAV, MO, NY, RSA, WTU). **Siskiyou/Trinity Co. border:** Mount Eddy, N side of ridgeline; T40N R5W Section 20, 6600 ft, 7 Aug 2011, *Colberg MEC-2* (CHSC, STNF, WS); Pacific Crest Trail W of Toad Lake, to ridge between Toad and Porcupine lakes, T40N R6W Section 36, ft, 31 Jul 2011, *Nelson JKN-1* (GH, KANU). **Trinity Co.:** ca. 6 mi N on trail to Canyon Creek Lakes, ca. 10 mi N of Dedrick, 4400 ft, 24 Jun 1976, *Denton 3967* (OSC); Little Boulder Lake Trail #8N11, ca. 0.1 to 0.25 mi up from lake, or 0.1–0.25 mi down from intersection with main Boulder Lake Trail, 6200 ft, 28 Aug 2011, *Erwin SE-1* (KNF, MO, NY, RSA, STNF); Parks Creek Summit, Pacific Crest Trail, ca. ⅛ to ¼ mi W of trailhead on Forest Road 17, Shasta Trinity National Forest, 6897 ft, 28 Jun 2013, *Nelson JKN-2013-1* (GH, WS); 3.7 mi up Canyon Creek Trail, 100 ft E of trail on rock outcrop, accessed by Canyon Creek Road off Hwy 299, 4699 ft, 23 Jun 2011, *Stubbs et al. RS-27* (MO, NY); between Cedar and Bear Creeks, Forest Service Road 40N45, 2.7 road mi S of junction with FS Road 17, 1.7 air mi WSW of SE Deadfall Lakes, 6496 ft, 31 Jul 2011, *Zika & Wilson 25687* (US, WTU); Forest Service Road 40N45, 9.1 road mi S of junction with FS Road 17, 2.7 air mi NNW of Picayune Lake, 31 Jul 2012, *Zika 25689* (OSC, UC, WTU), Forest Service road 25 at Horse Heaven Meadows, 3 air km NNW of Grey Rocks Peak, 28 Jun 2013, *Zika 26294* (MO, OSC, RSA, UC, WTU).

DISCUSSION

Most populations of *Sedum kiersteadiae* occur in the western Klamath Region, including Mount Eddy, Scott Mountain, and the Trinity Mountains (Fig. 3). Clausen (1975) referred these plants to *S. obtusatum* subsp. *re-*

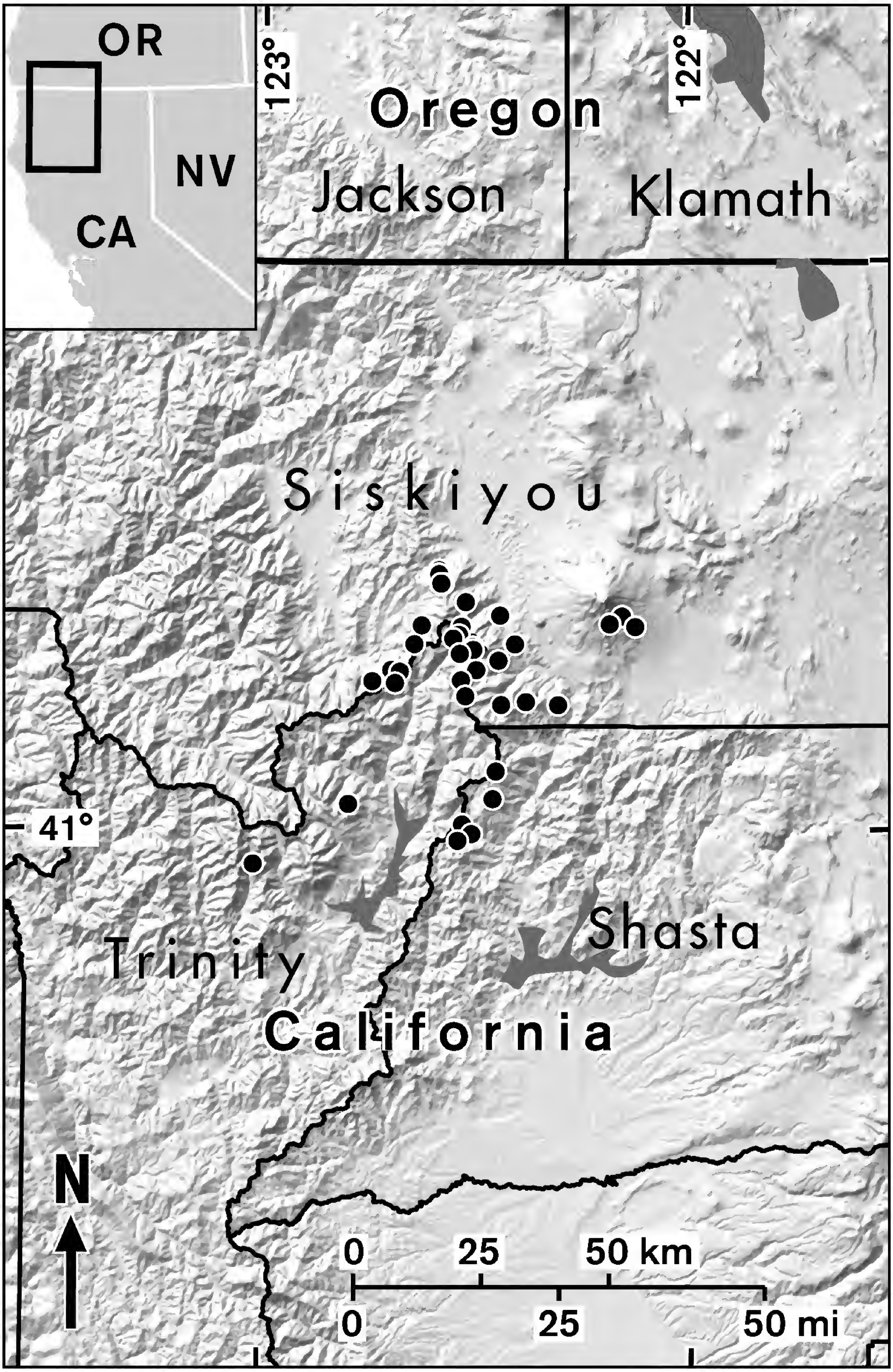

FIG. 3. Distribution of *Sedum kiersteadiae* in northern California.

tusum (Rose) Clausen. Denton recognized that they did not belong with that taxon and treated them as a disjunct population of yellow-flowered *S. obtusatum* subsp. *obtusatum*. We find that they differ from both these taxa in their narrower, more spreading petals and more open rosettes. We feel this combination of traits is convincing taxonomic evidence and unique among *Sedum* section *Gormania,* to treat *S. kiersteadiae* at the species level.

The taxon most similar to *S. kiersteadiae* is the recently described *S. citrinum* Zika, endemic to a small area of Del Norte County, California (Zika 2014). Both species have narrow, widely spreading, yellow petals and open rosettes. *Sedum kiersteadiae* differs from *S. citrinum* in having a panicle-like cyme with elongated lower branches (Fig. 2), rather than a flat-topped cyme, flowering shoots that never branch from the base, and anthers that are usually rusty brown aging black, rather than yellow aging brown. The two do not overlap in range.

The very open rosettes of *S. kiersteadiae* resemble those of *S. oregonense* (S. Watson) M.E. Peck. *Sedum kiersteadiae* differs from *S. oregonense* in having narrower, widely spreading petals that are yellow, often marked with red. Such petals are unusual in section Gormania and resemble those of *S. lanceolatum* Torr., in *Sedum* subgenus *Sedum* section *Lanceolata*. The range of *S. lanceolatum* overlaps *S. kiersteadiae* near Mount Eddy, where the two species are occasionally found on the same slope. We speculate that perhaps *S. oregonense* and *S. lanceolatum*, or their ancestors, hybridized to produce *S. kiersteadiae*. The range of *S. kiersteadiae* approaches that of *S. oregonense* in the Canyon Creek watershed, at the west edge of the range of *S. kiersteadiae* and the south edge of the range of *S. oregonense* (Figure 3). In that drainage grow plants that resemble *S. oregonense* in having yellow anthers and relatively wide, obtuse petals that lack red, and resemble *S. kiersteadiae* in having yellow petals. Petals of these plants spread to about 40°, less than *S. kiersteadiae* and more than is typical of *S. oregonense*. The existence of some intermediate plants in small areas where species ranges overlap is not suprising; all tested pairs of taxa in *Sedum* section *Gormania* can produce F1 hybrids, many of which are fertile (Denton 1979). The presence of potential hybrids in a limited area does not argue against recognizing the easily distinguished *S. oregonense* and *S. kiersteadiae* as distinct species.

The only other taxon of *Sedum* section *Gormania* with a range approaching that of *S. kiersteadiae* is *S. obtusatum* subsp. *paradisum* Denton. It grows in the Canyon Creek watershed at the west edge of the *S. kiersteadiae* range, where both *S. oregonense* and *S. kiersteadiae* also grow. *Sedum paradisum* and *S. kiersteadiae* also grow near each other at the south edge of the range of *S. kiersteadiae*. There, *S. kiersteadiae* can occasionally be found on the north or northwest side of a ridge and *S. paradisum* on the south side; the two were not observed together and morphologically intermediate plants were not observed during this study (Len Lindstrand III, pers. comm.).

The affinities of the plants represented by *Clausen et al. 4952*, the type specimen of *S. obtusatum* subsp. *boreale*, have been interpreted in diverse ways. Originally, *S. obtusatum* subsp. *boreale* was described as having pale to deep yellow, somewhat spreading petals, and the type locality on Mount Shasta, in the southern Cascade Range, was considered the eastern-most population of the taxon (Clausen 1942). We now interpret the type specimen as *S. kiersteadiae* but other specimens cited by Clausen [Siskiyou Co.: Caribou Basin, Salmon-Trinity Alps, 25 July 1937, *J. T. Howell 13450* (CAS); Clausen 1942] are better treated as *S. oregonense* with white to pale yellow petals.

Later, Clausen (1975) and Denton (1982) treated the type specimen from Mount Shasta as the northwestern-most, isolated population of a taxon that was more common in the northern Sierra Nevada. This taxon was characterized by relatively large mats of dense rosettes and by wide, apically obtuse, white petals that are pink at the base and senesce pink throughout. We agree that this is an accurate description of the northern Sierra Nevada plants, but not of *Clausen et al. 4952*.

Plants collected for this study at the type locality, Mud Creek on Mount Shasta (*Colberg MEC-1, Aug 2011*), resemble *S. kiersteadiae* of Mount Eddy and elsewhere in the western Klamath Region in having loose rosettes and yellow, strongly spreading petals that are marked with red. We believe these are representative of the same population as *Clausen et al. 4952* because the taxon was originally described as having yellow petals (Clausen

1942), and strongly spreading petals can be observed on both the holotype specimen and the drawing of a live clone of the holotype (Clausen 1975, p. 374; Fig. 2). *Colberg MEC-1, Aug 2011* and the holotype (*Clausen et al. 4952*) both have relatively loose rosettes. A single location is usually home to a single species of *Sedum* section *Gormania* (Clausen 1975; pers. obs.), and we have not seen plants with white petals or other evidence that more than one species occurs at Mud Creek.

We suspect that the confusion in interpreting the *S. obtusatum* subsp. *boreale* type specimen was caused in part by the necessary reliance on cultivated plants in previous studies. Variation in plant height, rosette density, leaf thickness, and glaucescence has been observed in cultivated plants depending on substrate and vernalization (Denton 1982). Denton (1982) considered the variations in cultivations too minor to affect taxonomic decisions. We have also observed differences in petal color and degree of spreading (Steven Darington, pers. comm.). We have observed some individual *Sedum* that produce pink or yellow flowers in the wild may produce white flowers in cultivation. Also, each taxon in *Sedum* section *Gormania* has a characteristic degree to which petals spread, but petals may spread excessively in cultivated plants, obscuring the differences between taxa. All these variations add a level of confusion to this already difficult group of plants.

ACKNOWLEDGMENTS

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BOOK REVIEW

Michael W. Beug, Alan E. Bessette, and Arleen R. Bessette. 2014. **Ascomycete Fungi of North America: A Mushroom Reference Guide.** The Corrie Herring Hooks Series, Number 69. (ISBN-13: 978-0-292-75452-2, cloth, alk. 128 gsm matte paper, paper permanence: ANSI/NISO Z39-48-1992 (R1997)). University of Texas Press, PO Box 7819, Austin, Texas 78713-7819, U.S.A. (**Orders:** www.utexaspress.com, 1-800-252-3206). $85.00, 502 pp., 843 color photos, glossary, references, index, 3.9 lbs, 7" × 10" × 1.5".

This is a heavy, bigger book format that far exceeds the coverage of anything previously published for the ascomycete fungi. Beautiful color images! Easy to read and understand text! Stunning macroscopic color habit photographs! Easy to use picture keys to different ascomycete groups! A bargain basement price! A special book that falls in the category of "once in a lifetime"! A much needed book that fills a fungal niche vacant for a long time! These are some of the platitudes that highlight the exceptional features of this book.

The durable book binding (round back Smyth Sewn) should stand the test of time, but this book is best used at home, in the laboratory, or at the end of the day at display tables to identify specimens rather than as a field book carried in a backpack. The authors have focused their content on continental United States of America and Canada. The species described and illustrated are macroscopic in size and likely to be seen by mushroom hunters in the field.

There are 12 chapters beginning with an **Introduction** that defines the sexual ascus and ascospore stages, highlighted by Jim Murray's close-up color image of the rare Texas ascomycete *Chorioactis geaster* (Devils's Cigar) caught in the act of puffing a cloud of ascospores. This ascomycete species is represented by habit photographs that were taken associated with dead, decomposing stumps of *Ulmus crassifolia* (Cedar Elm) at River Legacy Parks, Arlington, Texas; the only known locations outside of Japan are in the state of Texas.

Classification of the Ascomycetes would have benefited from a taxonomic rank ordering of the different groups assembled as part of a phylogenetic tree and thus a roadmap for the different families that follow. **Chapter 2** contains the keys that include a combined, mostly dichotomous key with leads interspersed with habit pictures of different species, beginning with the above- and below-ground Ascomycetes. These picture images start with the truffles and morels, some of the choice fungal edibles, and include nearly 550 species in total. This is a lengthy key, extending from page 16 to 69 with 73 leads, so it requires staying power to identify the 12 picture images on the last page of the key.

Chapter 3 treats the hypogeous Ascomycetes with a key to 26 genera. These taxa are represented by picture images along with species descriptions. The color images usually occupy about a half-page, either on the same page as the species description or next to it on the facing page. This conveniently locates both species description and color image visually in the same space but also unfortunately creates blank white spaces that break up the flow of the narrative. Each species narrative includes the topical headings Macroscopic Features, Microscopic Features, Occurrence, and Comments, but unfortunately these topical headings are difficult to see because they lack contrast formatting. The genus *Tuber*, highly prized for its aroma and high quality culinary delicacy, is included here with five species.

Chapter 4 covers the Pezizomycetes (pp. 117–272, the largest chapter), including the Chorioactidaceae with *Chorioactis* and the epigeous (above-ground) Morchellaceae that includes the popular and choice edible morels. Morels are highly prized edible fungi often hunted, collected, and eaten as a culinary delicacy by mycophiles during the spring months in North America and March in Texas. Members of this group are typically operculate (they have asci with lids) and often forcibly eject spores into the air.

Chapter 5, the Sodariomycetes (pp. 272–352), are sometimes referred to as the pyrenomycetes or stone fungi, characterized by a sexual stage, the perithecium, and formation of asexual conidia. Certain

(continued on p. 30)

HEXASEPALUM TERES (RUBIACEAE), A NEW COMBINATION

Joseph H. Kirkbride, Jr.

USDA-ARS, U.S. National Arboretum
Floral & Nursery Plants Research Unit
3501 New York Avenue NE
Washington, DC 20002-1958, U.S.A.
joseph.kirkbride@ars.usda.gov

ABSTRACT

The new combination **Hexasepalum teres** (Rubiaceae) is made for a widespread, New World species distributed from the eastern U.S.A. to Bolivia and Paraguay.

RESUMEN

La nueva combinación **Hexasepalum teres** (Rubiaceae) está hecha para una especie que está ampliamente difundida en el Nuevo Mundo, y distribuida desde el este de los EE.UU. hasta Bolivia y Paraguay.

Small (1913) described the genus *Diodella* Small as a segregate from the genus *Diodia* L. and transferred a single species name into the genus as *Diodella rigida* (Cham. & Schltdl.) Small. Later in the year (Small & Carter 1913) he transferred a second species, as *Diodella teres* (Walter) Small. For the next 85 years, *Diodella* was treated as a junior synonym of the genus *Diodia*. In 1999 Bacigalupo and Cabral revised the genus *Diodia* for the Americas. They treated *Diodia* in a very narrow sense, reducing it to five species, and suggested that 16 species then included in *Diodia* belonged to the genus *Diodella* without making the necessary new combinations. Over the last 14 years most of the new combinations in the genus *Diodella* have been made by various authors.

Recently Cabaña Fader et al. (2012) discovered that *Diodella* and *Hexasepalum* Bartl. ex DC. (1830) are generic synonyms. They proposed that *Hexasepalum* and its single species, *H. angustifolium* Bartl. ex DC., be rejected. They argued that since *Hexasepalum* is older than *Diodella*, the 16 species of *Diodella* would have to be transferred to *Hexasepalum*, which would cause significant nomenclatural disruption. The Nomenclature Committee for Vascular Plants (Applequist 2013) did not recommend rejection of *Hexasepalum* and *H. angustifolium*. The Committee felt that since most usage of the name *Diodella* has only been in the last decade, adoption of the name *Hexasepalum* would not cause excessive nomenclatural disruption.

The taxon known as *Diodia teres* Walter or *Diodella teres* occurs in North America, north of Mexico. For the *Flora of North America*, I will treat it in a genus distinct from *Diodia*, thus it is necessary to transfer the specific epithet of *Diodia teres* into the genus *Hexasepalum*.

RESULTS

Hexasepalum teres (Walter) J.H. Kirkbr., comb. nov. Basionym: *Diodia teres* Walter, Fl. carol. 87. 1788. Type: UNITED STATES. South Carolina: Georgetown Co.: Georgetown, old field, 24 Aug 1939, *R.K. Godfrey & R.M. Tryon 1682* (neotype, designated by Ward 2008:476; GH00277018; isoneotypes: NY1163926! US1838313!).

Distribution.—Native: United States (Alabama, Arizona, Arkansas, California, Colorado, Connecticut, District of Columbia, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Michigan, Mississippi, Missouri, North Carolina, New Jersey, New Mexico, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Vermont, West Virginia, Wisconsin), Mexico, Cuba, Hispaniola, Jamaica, Margarita, Belize, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Guyana, Surinam, French Guiana, Ecuador, Peru, Bolivia, Brazil, Paraguay; introduced: Netherlands, Cape Verde, Gambia, Guinea-Bissau, Senegal, Angola, southeast China, Japan, Korea.

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Fernald and Griscom (1937) discussed *Diodia teres* in the eastern United States and published three new varieties in the species. They presented the following, "Mr. C.A. Weatherby, upon looking for Walter's type, reports that there is no Walter material of it in his herbarium at the British Museum; but he found in Paris that the type of *Spermacoce diodina* Michx., commonly referred to it, is the common and well known weed with fruits 2.9–3.6 mm long, covered with short appressed hairs … and greatly exceeded by the stipules, and the leaves without prominently setiform tips. Since the latter plant is common all the way from Florida to New Jersey we are selecting it to stand as typical of Walter's species." Various authors (Steyermark 1972:798; Delprete 2010:371) have interpreted Fernald and Griscom's text as a neotypification of *Diodia teres* on the Michaux specimen of *Spermacoce diodina* in the Michaux herbarium at P. This is based on a misapplication of Art. 7.10 of the ICN (McNeill et al. 2012), which states "designation of a type is achieved only … if the type element is clearly indicated by direct citation including the term "type" (typus) or an equivalent…" The word "typical" in the last sentence has been interpreted as an equivalent of "type" in the nomenclatural sense, but it is actually used in the sense of the species *S. diodina* being representative of the species *Diodia teres*. Since "typical" was not used in the sense of the word "type," i.e. a single specimen, this was not a neotypification of *Diodia teres*.

Steyermark (1972:798) cited the collection locality of Michaux's specimen as the type of *Diodia teres*, but as he did not clearly indicate the type element, as required by Art. 7.10 (McNeill et al. 2012) for an existing name, he did not achieve typification. This interpretation is consistent with Art. 40, Note 2 for new names, where citation of a collection locality without the collector's name, collection number, or date would not be adequate for typification. In citing the collectors' name and number, the collection locality and date, and the herbarium in which the specimen is deposited, Ward (2008) effectively neotypified the species.

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PASSIFLORA SOLIANA, UNA ESPECIE NUEVA DE *PASSIFLORA* (PASSIFLORACEAE) DEL PACÍFICO SUR DE COSTA RICA

Armando Estrada Ch.
Museo Nacional de Costa Rica
Apartado Postal 749-1000
San José, COSTA RICA
aestrada@museocostarica.go.cr

Gerardo Rivera
grivera@biogenesiscr.com
www.biogenesiscr.com
Biogénesis, COSTA RICA

RESUMEN

Passiflora soliana (subg. *Passiflora*), una nueva especie procedente del cantón de Osa, en el Pacífico Sur de Costa Rica, es descrita e ilustrada. Esta especie nueva es afín a *Passiflora brevifila* Killip de elevaciones mayores, de la cual se distingue por sus flores más pequeñas, sin pedicelos o éstos muy cortos, y principalmente por la morfología y menor tamaño de sus brácteas florales.

ABSTRACT

Passiflora soliana (subg. *Passiflora*), a new species from the cantón of Osa in the South Pacific of Costa Rica is described and illustrated. This new species is closely related to *Passiflora brevifila* Killip of higher elevations, but *P. soliana* is distinguished by its smaller flowers, without or nearly without pedicel, and mainly by morphology and smaller size of the floral bracts.

Passiflora L. con más de 560 especies, es por mucho el género más grande de Passifloraceae; compuesto desde enredaderas o bejucos herbáceos principalmente en vegetación secundaria hasta lianas y algunos arbustos o árboles pequeños de bosques primarios (Hansen et al. 2006; Krosnick et al. 2013). Es un género casi exclusivo del Nuevo Mundo, su distribución se extiende desde el sur de los Estados Unidos hasta el norte de Argentina, incluyendo Las Antillas. Solo 24 especies son endémicas de las regiones tropicales y subtropicales del sureste de Asia, Australia y Nueva Zelanda (Krosnick et al. 2013). En Costa Rica el género está representado por 51 especies (Rodríguez y Estrada 2007).

A nivel infragenérico, Killip (1938) dividido *Passiflora* en 22 subgéneros y más recientemente Feuillet y MacDougal (2003) propusieron reducir la cantidad de subgéneros a cuatro en un nuevo sistema de clasificación: *Astrophea* (DC.) Mast., *Deidamioides* (Harms) Killip, *Decaloba* (DC.) Rchb. y *Passiflora*. Un quinto subgénero llamado Tetrapathea (DC.) P.S. Green, que incluye tres especies del viejo mundo ha sido reconocido por Krosnick et al. (2009, 2013). El subgénero *Passiflora*, al cual pertenece esta especie nueva, incluye cerca de 250 especies y se caracteriza por la presencia de zarcillos, hojas enteras o lobadas, glándulas sobre peciolos, estípulas y márgenes de hojas, flores grandes con múltiples filamentos de la corona, 3 brácteas usualmente foliáceas, opérculo tubular o filamentoso y limen membranáceo (MacDougal y Feuillet 2004; Hansen et al. 2006; Krosnick et al. 2013).

Passiflora soliana A. Estrada & G. Rivera, sp. nov. (**Figs. 1, 2**). TIPO: COSTA RICA: PUNTARENAS: Cantón de Osa, Distrito Piedras Blancas, La Florida, finca Bellavista, a orilla de río Bellavista, 8°46.872'N, 83°12.483'W, 297 m, 17 Feb 2012 (fls.), G. *Rivera & M. Nuñez 4884* (HOLOTIPO: CR; ISOTIPO: MO)

Species nova haec *Passiflora brevifila* Killip propinqua, sed taxon novum per sequentes floribus characteres aberratur: Flores breviores (4–4.3 cm diametro), sine pedicello, bracteae florales breviores (2–2.3 × 2–2.5 cm diametro), ovatae usque ad suborbiculatas, cum marginibus revolutis et in parti proximali connatae, superficie adaxiali papillosa, sine tomento marginali, corona filamentosa biseriata, filamenta externa alba, breviora (7–9 mm longa).

Bejuco leñoso, glabro; tallos cilíndricos, estriados; estípulas de 5–8 × 0.7–1 mm, lineares a subfalcadas, enteras, uno o dos glandular denticuladas en un lado y también con una glándula apicalmente, coriáceas. Hojas con peciolos de 1–2.8 cm, con (4–)6(–7) glándulas, corto-estipitadas en la mitad distal; lámina de 12–17.5(–23) × 4.8–6.5(–8) cm, entera, lanceolada, oblongo-lanceolada a elíptica, acuminada en el ápice, cortamente aristada,

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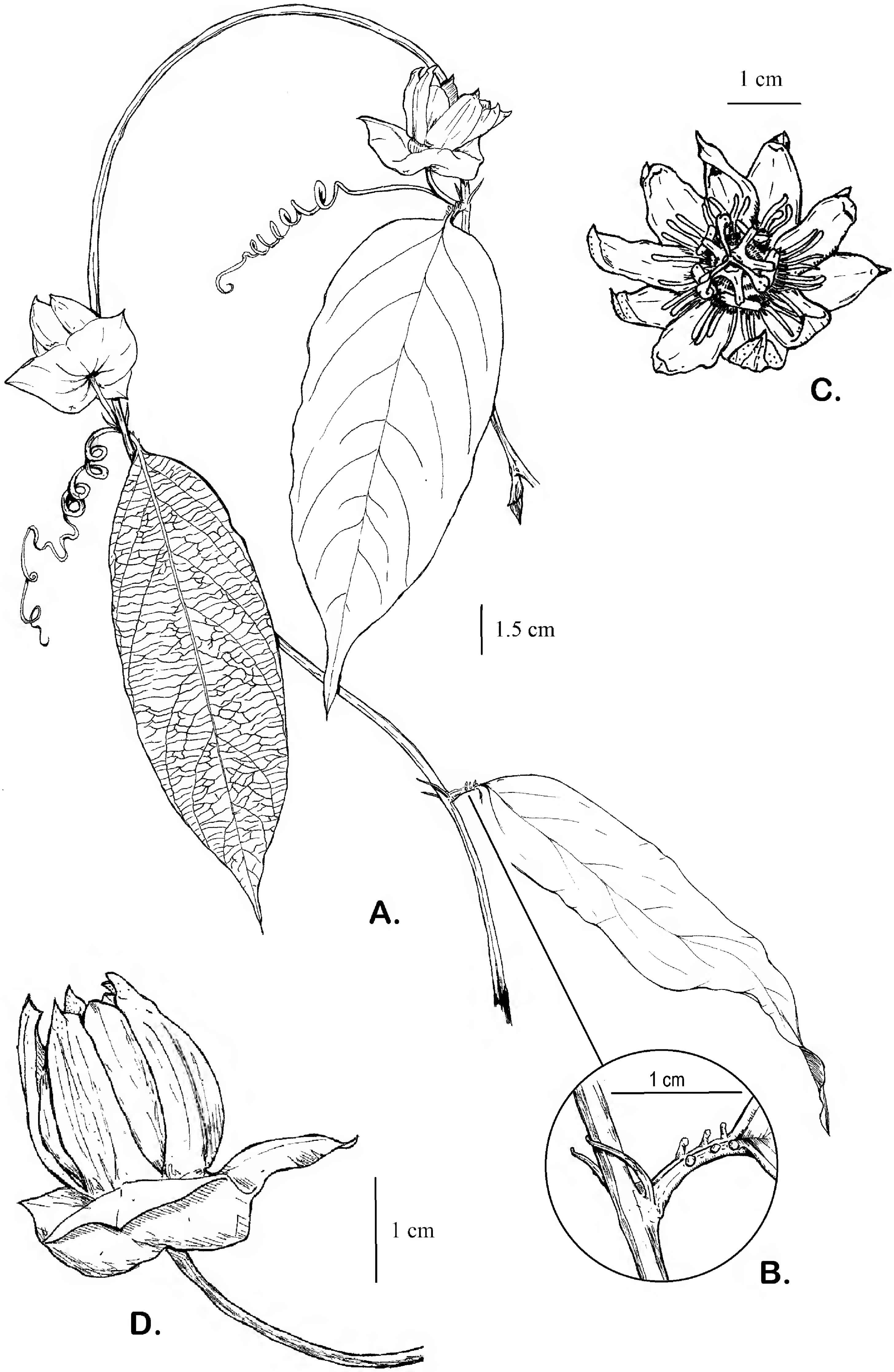

Fig. 1. A–H. *Passiflora soliana*. **A.** Hábito; **B.** Estípulas y glándulas peciolares; **C.** Flor, vista frontal; **D.** Flor y brácteas florales, vista lateral.

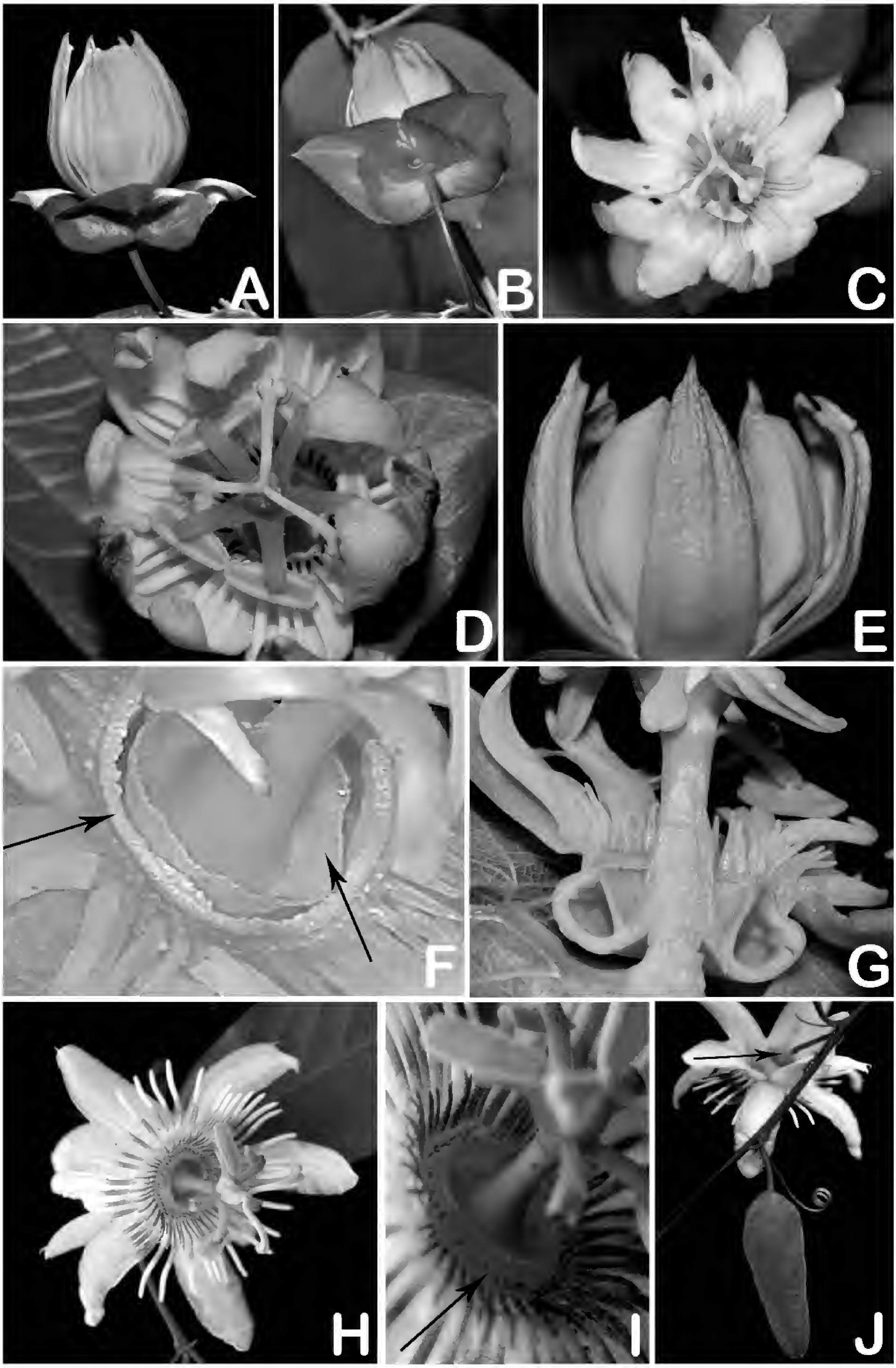

Fig. 2. A–G. *Passiflora soliana* **A.** Vista lateral de botón floral; **B.** Brácteas florales; **C y D.** Vista frontal de flor; **E.** Sépalos y pétalos; **F.** Detalle de opérculo y limen; **G.** Corte longitudinal de flor; **H–J.** *Passiflora brevifila* **H.** Flor; **I.** Detalle de la tercera serie coronal más interna adyacente al opérculo; **J.** Bráctea floral y pedicelo de flor.

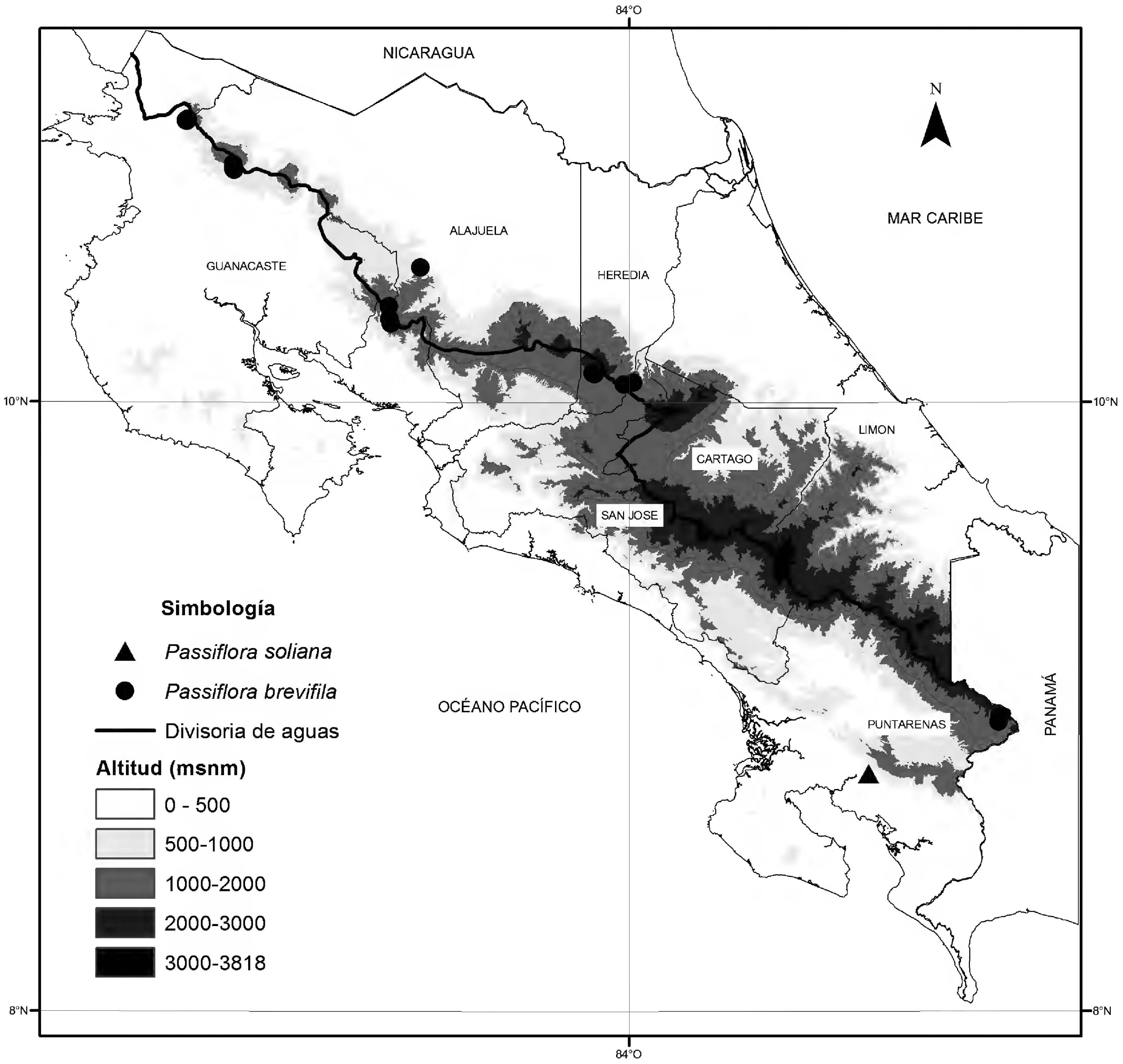

Fig. 3. Distribución de *Passiflora soliana,* sp. nov. y *Passiflora brevifila* en Costa Rica.

obtusa en la base, venación pinnada (nervios laterales 6 a 8 por lado, arqueado-ascendentes), nervios terciarios resaltados y conspicuamente reticulados en el envés, membranáceas a cartáceas, lustrosas, margen entero. Inflorescencias axilares, de una flor solitaria, pedúnculo de 2.6–2.8 cm, solitarios, articulados en el ápice, en la unión con las brácteas, brácteas de 2–2.4 × 2–2.5 cm, foliáceas, enteras, ovadas a sub-orbiculares, agudas en el ápice, connadas en la mitad proximal, márgenes doblados hacia afuera (revolutos), abiertas y desplegado antes de la antesis. Flores 4–4.3 cm de diámetro, sin pedicelo o éste muy corto ca. 2 mm, con el tubo floral campanulado, sépalos de 1.7–1.8 × 0.7–0.8 cm, verde claro externamente, blancos en el interior, corniculados; pétalos de 1.5–1.8 × 0.4–0.6 cm blancos; filamentos de la corona, en dos series, los externos de 7–9 mm, blancos, los internos de 2–3 mm, púrpura-azulados, estrechamente liguliformes; opérculo un estrecho borde adjunto a la corona, liso, margen de ca. 1 mm, crenulado, erecto; limen una delgada membrana en forma de copa, cerrando el opérculo, margen crenulado; androginóforo de 9–10 mm; ovario elipsoide, glabro, verde claro. Frutos desconocidos.

Fenología.—Flores presentes en febrero.

Distribución y Hábitat.—*Passiflora soliana* es una especie endémica de Costa Rica. Se distribuye en

Cuadro 1. Diferencias morfológicas y ecológicas entre *Passiflora soliana* y *Passiflora brevifila*.

Passiflora soliana	*Passiflora brevifila*
Flores sin pedicelo o éste muy corto (max. 2 mm)	Flores pediceladas, pedicelos de 5–7 mm
Flores de 4–4.3 cm de diámetro	Flores de 6–6.5 cm de diámetro
Brácteas florales de 2–2.3 × 2–2.5 cm, sin una banda marginal tomentosa, pero con la superficie papilosa adaxialmente, connadas en toda su mitad proximal, ovadas a sub-orbiculares, abiertas antes de la antesis, con los márgenes revolutos	Brácteas florales de 4–7 × 1.8–3.4 cm, con una estrecha banda marginal tomentosa adaxialmente, superficie no papilosa, connadas solo en la base (máximo ⅒ de su longitud), lanceoladas a estrechamente ovadas, cerradas y cubriendo el botón floral hasta la antesis, con los márgenes rectos, sin doblarse
Corona de filamentos en 2 series. Filamentos más externos de la corona de 7–9 mm, blancos	Corona de filamentos usualmente con una tercera serie de filamentos más interna de ca. 1 mm, adyacente a la base del opérculo. Filamentos más externos 9–14 mm, bicoloros, blancos en la mitad distal y púrpura en la mitad proximal
Distribución alrededor de 300 m, bosques muy húmedos, vertiente pacífica	Distribución de 800–2000 msnm, en bosques nubosos, muy húmedos y pluviales, ambas vertientes

bosques muy húmedos del Pacífico Sur, alrededor de los 300 m de elevación. Se ha recolectado en orillas de ríos en vegetación secundaria (Fig. 3).

Discusión.—Passiflora soliana es una especie afín a *Passiflora brevifila* (Killip 1960; fig. 2, H–J) pero se distingue de ésta por sus flores más pequeñas, sin pedicelos o éstos muy cortos, la coloración y número de filamentos de la corona floral y principalmente por la morfología y menor tamaño de sus brácteas florales (ver Cuadro 1). Adicionalmente *Passiflora soliana* crece en bosques muy húmedos en elevaciones bajas (300 m) del Pacífico Sur, mientras que *P. brevifila* crece en bosques nublados, muy húmedos y pluviales en elevaciones mayores (800–2000 msnm), cerca de la división continental en todas los principales cordilleras, en ambas vertientes. A nivel infragenérico esta especie nueva puede ubicarse, de acuerdo a la clasificación de Feuillet & MacDougal (2003), en el subgénero *Passiflora*, principalmente por sus peciolos con glándulas y sus 3 brácteas florales foliáceas, pero no se ajusta claramente a las supersecciones establecidas dentro de este subgénero, lo cual requiere un estudio más detallado y específico.

Etimología.—El epíteto hace homenaje a Marisol Nuñez, quien con su tiempo, esfuerzo y dedicación fue de gran ayuda para descubrir y recolectar esta nueva especie de passiflora.

Paratipo: **COSTA RICA. Puntarenas. Osa:** Piedras Blancas, La Florida, finca Bellavista, a orillas de río Bellavista, 8°46.872'N, 83°12.483'W, 297 m, 7 May 2012, *G. Rivera & M. Nuñez 5090* (CR, MO, USJ).

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CYPERUS STEWARTII (CYPERACEAE), A NEW SPECIES FROM COCOS ISLAND, COSTA RICA

Gordon C. Tucker

Dept. of Biological Sciences
Eastern Illinois University
Charleston, Illinois 61920, U.S.A.
gctucker@eiu.edu

ABSTRACT

Cyperus stewartii G.C. Tucker, sp. nov. is described. It is known from two collections from Cocos Island (Isla del Coco), Costa Rica, made in 1905. This species is most similar to *C. thyrsiflorus* and *C. lentiginosus*, species of the southern U.S., Caribbean slope of Mexico and Central America, and northern South America. It differs from both in its smaller anthers, shorter and narrower floral scales, closer spacing of scales on the rachilla, and very wide spacing of spikelets on the rachilla.

RESUMEN

Se describe **Cyperus stewartii** G.C. Tucker, sp. nov. Se conoce de dos muestras de la Isla del Coco, Costa Rica, colectadas en 1905. Esta especie es muy similar a *C. thyrsiflorus* y *C. lentiginosus*, especies del sur de EE.UU., vertiente del Caribe de México y América Central y el norte de América del Sur. Se diferencia de ambos en sus anteras pequeñas, escamas florales más cortas y más estrechas, escamas de la raquilla más densamente espaciadas, y una separación muy amplia entre las espiguillas sobre la raquilla.

Key Words: Cocos Island, new species, *Cyperus*, Costa Rica, Central America

INTRODUCTION

The genus *Cyperus* L. includes about 690 species, occurring worldwide in warm temperate and tropical regions (Tucker 1994, 2001). The distribution of individual species ranges from cosmopolitan, e.g., *C. squarrosus* L. and *C. odoratus* L., to regional and narrow endemics found on all continents except Antarctica and Europe (Kükenthal 1935–36). In the New World, areas of high diversity and endemism include the southeastern United States, Mexico, the Greater Antilles, and eastern Brazil (Tucker 2007.)

During the course of this study, and my preceding studies of the Mexican and Central American species of *Cyperus* (Tucker 1983, 1994), I have examined some 30,000 herbarium specimens from, or examined at, the herbaria listed in the acknowledgments. During my earlier studies of *Cyperus* in Costa Rica and Panama (Tucker 1983), I did not encounter any material of this new species. Then, in 2009, a single specimen was noted in a loan of unidentified *Cyperus* from US. I later contacted staff at CAS (California Academy of Sciences) who were able to locate two additional sheets of this species. Fortunately, between these three specimens, a complete description of the species can be made.

TAXONOMIC TREATMENT

Cyperus stewartii G.C. Tucker, sp. nov. (**Figs. 1, 2**). Type: COSTA RICA: Isla del Coco: "Cocos Island, in low ground near Wafer Bay, California Academy of Sciences Expedition to Galapagos Islands," 5–7 Sep 1905, *A. Stewart 268* (holotype: CAS; isotype: US).

Affinis *Cyperus lentiginosus* et *Cyperus panamensis* sed differt in antherarum minor, squamae brevior angustiorique, in apice divertente, propius in rachillarum, et spicularum laxe subsequentes intervallent.

Plants perennial (?), 15–29 cm tall. Rhizome short, 2–3 mm long. Culms 0.7–2.3 mm in diameter, trigonous, smooth. Leaves 2–3, 6–20 cm long, 1.3–2.8 mm wide, inversely w-shaped, the margins scabrellate. Inflorescence bracts 4–6, 4–20 cm long, 0.5–3 mm wide, inversely w-shaped, the margins ciliate-scabrellate, ascendent at 30–45°. Rays 4–8, 1–6 cm long; prophylls 4–8 mm long, truncate. Spikes (10–)18–34 mm long, (12–)18–30

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Fig. 1. *Cyperus stewartii*: inflorescence (from isotype, *A. Stewart 268*, US).

mm wide, loosely ovoid to oblong-ellipsoid; rachis 5–10 mm long (spikelets widely spaced, ca. 6–10 spikelets/cm). Spikelets (7–)10–30, 11–16 mm long, 1.6–1.8 mm wide, linear-lanceolate, compressed; rachilla deciduous, ca. 0.3 mm wide and 0.1 mm thick, flexuous, green, the wings ca. 0.3 mm wide, hyaline, successive scales 2 mm apart. Floral scales persistent, spreading, 6–12, 3.2 mm long, 1.5 mm wide, ellipsoid, subacute, entire to

Fig. 2. *Cyperus stewartii*: habit; (from holotype, *A. Stewart 268*, CAS).

Table 1. Comparison of *Cyperus stewartii* with *C. panamensis* and *C. lentiginosus*.

	Cyperus panamensis	*Cyperus stewartii*	*Cyperus lentiginosus*
Distribution	Pacific coast, Sinaloa to Ecuador	Cocos Island, Costa Rica	Caribbean lowlands, Texas to Venezuela
Spikelet density (# per cm of rachis)	22–34	6–10	20–28
Separation of scales along rachilla (mm)	4–5.6	2.5–3	(2.2–)2.6–3.4
Scale shape	Involute	Conduplicate	Conduplicate
Scale apex	Appressed, cuspidate to mucronulate	Spreading, entire	Appressed, mucronate
Scale color	light brown to golden brown, medially green	silvery-white, reddish toward center, medially green	off-white to stramineous, red speckled, medially green
Anther length (mm)	0.4–0.7	0.3–0.35	0.5-0.8(–1.4)
Achene length (mm)	2.0-2.8 × 0.8-0.9	1.7–2 × 0.5-0.65	1.7-2.0 × 0.6-0.7

mucronulate, laterally 3–4 nerved, silvery-white, reddish toward center, medially green, 3-nerved. Stamens 3; filaments 2.5 mm long; anthers 0.3–0.35 mm long, oblong to ellipsoid, the connective apex not prolonged. Styles 0.8–1.0 mm long; stigmas 3, ca. 1.0 mm long. Achenes 1.7–2 mm long, 0.5–0.65 mm wide, trigonous, oblong-ellipsoid, the apex rounded, apiculate from the dark purple style base, sessile to substipitate, the adaxial face convex, the abaxial flat, the surface papillose, light brown.

Additional specimen: Costa Rica: Cocos Island, in low ground near Wafer Bay, California Academy of Sciences Expedition to Galapagos Islands, 5–7 Sep 1905, *A. Stewart 267* (CAS).

This new species is endemic to Cocos Island (Isla del Coco), in the Pacific Ocean about 400 km W of Costa Rica. It is most similar to *C. panamensis* (Britton) Standl. and *C. lentiginosus* Millsp. & Chase, species of Mexico and Central America, and northern South America (Table 1). It differs from both in its smaller anthers, and very wide spacing of spikelets on the rachilla; additionally the scales of *C. stewartii* are strongly spreading. In general appearance, it is also suggestive of *C. tenuis*, a widespread lowland species of southern Central America, the Caribbean, and northern South America; it has been recorded from Isla del Coco (Tucker 1983); however, *C. tenuis* has longer anthers, and much more densely arranged spikelets, typically 25 per cm of rachis. The holotype was identified in 2002 as "*Cyperus sphacelatus*." However, that pantropical species has annual habit, larger achenes, deciduous floral scales with a large purple spot on each side, and a flexuous, persistent rachilla.

The narrow range and few collections of *Cyperus stewartii* indicate need for conservation. The type collection was made in September. The three available sheets include both flowering and fruiting individuals.

Etymology.—This new species is named for Alban N. Stewart (1875–1940), botanist of the 1905–1906 CAS expedition to the Galapagos Islands, which also visited Cocos Island.

Cocos Island is located in the eastern Pacific Ocean at 5.526°N 87.066°W. The flora consists of 235 vascular plants, of which about 30% are endemic (Trusty et al. 2006). Thus far, only one other endemic of the Cyperaceae has been described from Isla del Coco, *Kyllinga nudiceps* Standl. [*Cyperus nudiceps* (C.B. Clarke ex Standl.) O'Neill] (Tucker 1984). Trusty and colleagues visited Isla del Coco several times. They reported five species of *Cyperus*: *C. aggregatus*, *C. hermaphroditus*, *C. ligularis*, *C. odoratus*, and *C. tenuis*. I have borrowed and examined specimens deposited at FTG. All were correctly identified with the exception of *C. hermaphroditus*, which proved to be *C. tenuis* as well. Another collection of *C. hermaphroditus* (Snodgrass & Heller 946, GH, cited by Trusty et al. 2006), proved to be *C. tenuis* as well. Other than the specimens collected by Stewart in 1905, this newly described species seems to have never been collected again.

ACKNOWLEDGMENTS

The work was completed during sabbatical leave. I am grateful to curators (Debra Trock, Bruce Bartholomew) and library staff at CAS (Rebecca Morrin, Christina Fidler) for locating additional specimens and for providing copies of Alban Stewart's field notes from his visit to Cocos Island, staff at Harvard University Herbaria (Anthony Brach, Kanchi Gandhi, and Emily Wood) for searching for specimens, the Missouri Botanical Garden Library for access to literature, and to Barry Hammel for information on locations of Cyperaceae specimens from Isla del Coco. I appreciate reviews of an earlier draft by Barry Hammel and Barney Lipscomb. Thanks are extended to curators at the herbaria from which specimens were borrowed or examined for my ongoing studies of Neotropical *Cyperus*: AAU, AC, ARIZ, ASU, B, BA, BD, BKL, BH, BM, BR, C, CAS, CGE, CHAPA, CLEMS, CONN, CORD, CU, DAO, DAV, DS, DUKE, E, ECON, ENCB, EIU, F, FLAS, FTG, G, GH, ILL, ILLS, IND, JE, K, LCU, LL, M, MASS, MO, MSC, MT, MTMG, NHA, NY, NYS, P, PENN, PH, PMA, POM, PR, PRC, RSA, S, SD, SIU, SMU, SP, TCD, TEX, TRT, UC, UCR, UEC, US, UTEP, VT, WIS, WRSL, WVA, YU, and Z.

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BOOK REVIEW

MICHAEL W. BEUG, ALAN E. BESSETTE, AND ARLEEN R. BESSETTE. 2014. **Ascomycete Fungi of North America: A Mushroom Reference Guide.** The Corrie Herring Hooks Series, Number 69. (ISBN-13: 978-0-292-75452-2, cloth, alk. 128 gsm matte paper, paper permanence: ANSI/NISO Z39-48-1992 (R1997)). University of Texas Press, PO Box 7819, Austin, Texas 78713-7819, U.S.A. (**Orders:** www.utexaspress.com, 1-800-252-3206). $85.00, 502 pp., 843 color photos, glossary, references, index, 3.9 lbs, 7" × 10" × 1.5".

(continued from p. 16)

fungi in this group merit special recognition, for example, *Claviceps purpurea*, that produces purple sclerotia in rye grass florets (ergot). When sclerotia containing toxic alkaloids are ingested by animals and humans, a horrible gangrenous condition often results in loss of limbs (ergotism). Furthermore, rye flour contaminated with ergot used in historical bread-making often produced symptoms referred to as St. Anthony's Fire with associated erratic behaviors that led to the infamous Salem, Massachusetts, witchcraft trials (victims found guilty were hanged). Another group included here are mostly insect parasites that have important medicinal properties, represented by *Cordyceps militaris*; still another hypocrealean example (*Nectriopsis violacea*) occurs as a teleomorph (sexual stage) parasitizing the fruiting body (aethalium) of Myxomycetes, especially *Fuligo septica*. There are many more examples included that exemplify this group of Ascomycetes.

Chapter 6, the Leotiomycetes (pp. 353–414), includes the diverse Helotiales represented by wood rot fungi, root symbionts, endophytes, terrestrial and aquatic saprotrophs, plant pathogens, mycorrhizae, nematode-trapping fungi, and fungal parasites. Some species are strikingly colorful and fairly common; *Chlorociboria aeruginascens* ssp. *aeruginascens* has distinct bluish-green cups (apothecia) and mycelium that stains bare decaying wood a bright greenish color.

Chapter 7, the Eurotiomycetes, include mostly microscopic molds, with perhaps *Penicillium* species one of the best-known examples because it is the source of the antibiotic penicillin. There is only one taxon described and illustrated, *Onygena corvina*, that grows on keratinous animal remains such as cow and sheep horns.

Chapter 8, the Geoglossaceae or earth tongues, has only seven species included, and members of *Geoglossum* and *Microglossum* are prominent examples. The Neolectomycetes, **Chapter 9,** and the Orbiliomycetes, **Chapter 10,** have the fewest taxa, one each, and Dothideomycetes, **Chapter 11,** has two taxa. **Chapter 12,** the Taphrinomycotina, contains the dimorphic (yeast and filamentous) genus *Taphrina*, the causal agent of peach leaf curl disease

Who should buy this book? Every affiliated club with the North American Mycological Society (NAMA) should have a copy of this book for fungal forays and as a current reference available for member's use. Individual NAMA members that represent more than 80 clubs in Canada, Mexico, and the United States of America should have this reasonably priced book. Professional mycologists as well as amateur mycophiles should consider this book a high priority for their personal library. College, university, and public libraries will want to have this book available for the general public to enjoy the biodiversity of fungi. State, national parks, and conservation agencies should have this book available in their bookstores for visitors, naturalists, and staffers that interact with the general public. The content of this book will be of the utmost interest to outdoor professionals at local nature centers, forest service and state park welcome centers, and for summer campers and hikers who may wish to learn more about the wonderful world of fungi beneath their feet. The authors should be congratulated for producing a book that will be at the top of the must-buy book list of many botanists and mycologists!—*Harold W. Keller, PhD, Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

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CALATHEA GORDONII (MARANTACEAE), A NEW ENDEMIC PANAMANIAN SPECIES

Helen Kennedy

UCR Herbarium, Department of Botany and Plant Science
University of California Riverside
Riverside, California 92521, U.S.A.
ganders@mail.ubc.ca

ABSTRACT

Calathea gordonii H. Kenn., sp. nov., endemic to Panama, is described as new for inclusion in the Flora Mesoamericana. It occurs in both Bocas del Toro and Colón Provinces. *Calathea gordonii* is characterized by the single elliptic leaf per shoot; the single inflorescence per shoot, borne either on a separate, leafless, shoot or on the leafy shoot; the densely appressed tomentose bracts and peduncle; the two membranous, medial, bracteoles and the white flowers. It differs from *Calathea basiflora* H. Kenn. by the elliptic vs. obovate leaf, the firm, coriaceous, densely tomentose vs. thin, herbaceous, pilose bracts and the two medial bracteoles membranous vs. claviculate. It differs from *C. verecunda* H. Kenn. by the broader leaf blades (14.3–22.4 vs. 4–8 cm) and the bracts with rounded to obtuse vs. acute to acuminate apices and from *C. rhizanthoides* H. Kenn. by the generally longer leaves (23.6–41 vs. 17–30 cm), broader angle of divergence of lateral veins from the midrib (41°–46° vs. 28°–39°) and medial bracteoles membranous vs. claviculate.

RESUMEN

Calathea gordonii H. Kenn., sp. nov., endémica de Panamá, es descrita como nueva para inclusión en Flora Mesoamericana. Ella ocurre en las Provincias de Bocas del Toro y de Colón. *Calathea gordonii* se caracteriza por tener solo una hoja elíptica por brote; solo una inflorescencia por brote, en un brote aparte sin hojas o en el brote con la hoja; las brácteas y el pedúnculo densamente tomentosos; las dos bractéolas mediales que son membranáceas y la flor blanca. Se diferencia de *C. verecunda* H. Kenn. por sus láminas foliares más anchas (14.3–22.4 vs. 4–8 cm) y las brácteas con el ápice rotundo u obtuso vs. agudo o acuminado y de *C. rhizanthoides* H. Kenn. por sus láminas foliares generalmente más largas (23.6–41 vs. 17–30 cm), por el ángulo de divergencia de las venas laterales del nervio medio más ancho (41°–46° vs. 28°–39°) y las bractéolas mediales membranáceas vs. claviculadas.

In preparation for the Flora Mesoamericana treatment, the species of Marantaceae from Panama has been a special focus. Additional herbarium studies at the Missouri Botanical Garden and the University of Panama plus more recent collecting in the area of the concession Minera Panamá, Colón Prov., have uncovered additional new species. Since the publication of the Woodson and Schery (1945) treatment for Flora of Panama, listing 23 species, the total has significantly increased. By 1972, Dressler (1972:184) reported a total of 35 species for Panama while four years later, Kennedy (1976:312–313) reported an increase to 49 known species and suggested a possible further increase to 60 or 70. More recently, Kennedy (2011:201) reported a total of 59 species whereas, currently, 68 species are recognized (a 195 per cent increase from the original Flora of Panama treatment). Nineteen species are recognized as endemic, including the one described herein plus one as yet undescribed taxa. Additional collecting, especially in adjacent Colombia, most probably will reduce the number of endemics.

TAXONOMIC TREATMENT

Calathea gordonii H. Kenn., sp. nov. (**Figs. 1, 2**). Type: PANAMÁ. Colón: Distr. de Donoso, Área de concesión Minera Panamá, Coastal Road, 8.5 km, bosque secundario tardío dominado por palmas, 61 m, 8°56'40.94"N, 80°41'38.95"W (UTM 0533622 E, 0988753 N), 16 Nov 2013, *R. Flores 3512* (holotype: PMA!; isotypes: MO!, UCR!).

Haec species a *Calathea basiflora* H. Kenn. foliis ellipticis (vs. obovatis), bracteis crassiusculis coraceis dense tomentosis (vs. tenuibus herbaceis pilosis) atque bracteolis medialibus membranaceis lanceolatis (vs. induratis claviculatis) differt.

Plants rhizomatous, perennial, herbs, 45–80 cm; cataphylls narrowly ovate, apiculate, purple, densely velvety tomentose, the hairs 0.3–0.5 mm, innermost cataphyll 11–25 cm. **Leaves** all basal, 1 per shoot; leaf sheath not

Plantas de Panamá
Herbario de la Universidad de Panamá
Provincia de Colón

Marantaceae
Calathea sp.

3512 RF
Det.

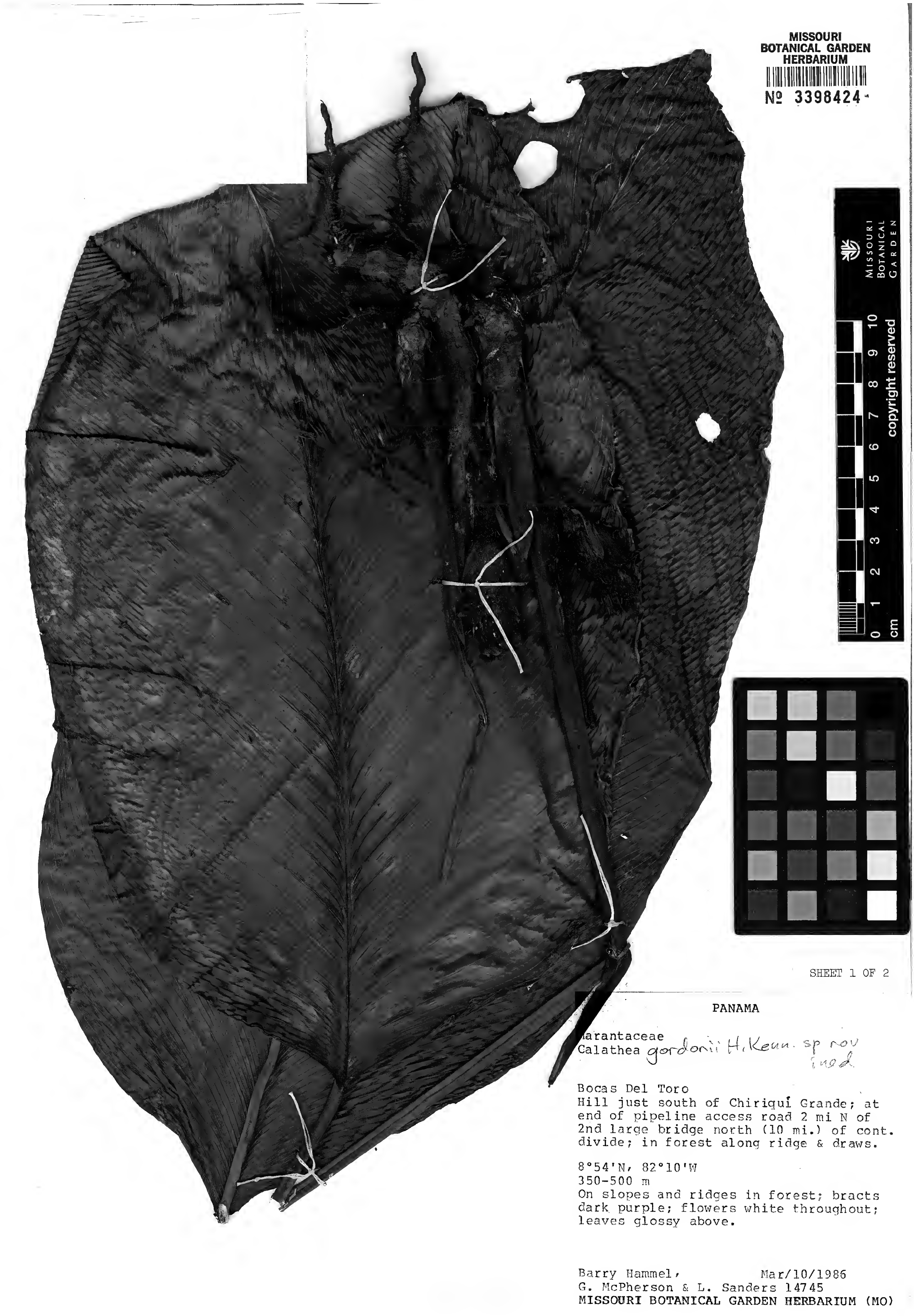
Hierba de c. 1 m. Brácteas chocolates, flores blancas. Provincia de Colón, Donoso. Área de concesión Minera Panamá, Coastal Road, 8 km+500.
Bosque secundario tardío dominado por palmas.

Coordenadas: **UTM 0533622 E, 0988753 N.**
Elevación:61 m

Fecha de colecta: 16 noviembre-2013

Colector: Rodolfo Flores.

Fig. 1. *Calathea gordonii* H. Kenn. Holotype scan provided by Mireya Correa (PMA), (*Flores 3512*, PMA).



SHEET 1 OF 2

PANAMA

arantaceae
Calathea gordonii H. Kenn. sp nov ined

Bocas Del Toro
Hill just south of Chiriquí Grande; at end of pipeline access road 2 mi N of 2nd large bridge north (10 mi.) of cont. divide; in forest along ridge & draws.

8°54'N, 82°10'W
350-500 m
On slopes and ridges in forest; bracts dark purple; flowers white throughout; leaves glossy above.

Barry Hammel, Mar/10/1986
G. McPherson & L. Sanders 14745
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)

Fig. 2. *Calathea gordonii* H. Kenn. Paratype scan provided by Missouri Botanical Garden, (*Hammel, McPherson & Sanders 14745*, MO).

auriculate, green or tinged purple, paler, nearly cream-colored where covered by cataphylls, densely minutely appressed velvety tomentose, 6–15 cm; petiole green, densely minutely appressed velvety tomentose, (13–) 20.6–30.5 cm; pulvinus elliptic in cross-section, deep olive-green, densely minutely appressed velvety tomentose throughout, the hairs 0.1–0.3 mm, 1.5–3.6 cm, articulate, nearly 2× diameter of petiole; leaf blade elliptic, apex obtuse with acumen, base obtuse to rounded, shortly abruptly attenuate, 23.6–41 × 14.3–22.4 cm, (length:width ratios [1.24–]1.65–2.1:1) lateral veins 11–19 per 3 cm, cross veinlets 20–23 per 5 mm (veins measured at midpoint of each side of blade), vein angle from midrib 41°–46°; adaxial surface of blade glossy green, glabrous except acumen tomentose along margins and very tip, midrib concolorous, tomentose along center, the hairs 0.4–0.5 mm; abaxial surface pale grey-green, minutely velvety, appressed tomentose, the hairs 0.2–0.3 mm, midrib light yellowish tan, minutely velvety, appressed tomentose. **Inflorescence** basal, terminal, 1 per shoot, borne on a leafless or a leafy shoot, imbricate, ovoid to ellipsoid, 3–4.7 × (1–) 2–3 cm; peduncle green, densely matted, velvety tomentose, the hairs 0.3–0.6 mm, 5.5–13.4 cm. **Bracts** 4–7, spirally arranged, firm, transverse broadly ovate to broadly ovate in upper bracts, apex rounded with acumen in basal bracts, upper ones obtuse, 2–3.1 × ca. 3 cm, each bract subtending up to 7 flower pairs; abaxial surface of bracts purple to brownish purple, appressed tomentose, more densely so toward base, the hairs 0.6–1 mm, adaxial surface, glabrous; bicarinate prophyll membranous, elliptic, apex obtuse, glabrous, 2–2.2 × 1–1.3 cm, 0.6–0.7 cm from carina to carina; secondary bract membranous, broadly elliptic, apex rounded, glabrous, 2–2.2 × 1.4–1.6 cm; bracteoles 2 per flower pair, medial, membranous, narrowly obovate-elliptic, glabrous, 1.8–1.9 × 0.45–0.5 cm. **Sepals** narrowly elliptic, apex slightly cupped, obtuse to rounded, white, glabrous, 23–31 × 4.5–5 mm. **Corolla** white, tube glabrous, 35–43 mm; corolla lobes subequal, elliptic, obtuse, glabrous, ca. 14 mm. **Staminodes** 3, white; outer staminode obovate, retuse; callose staminode totally callose, subrectangular, apex rounded with an acumen; stamen with lateral petaloid appendage, anther cream-white, 1.5 mm; style and stigma cream-colored; ovary smooth, white, glabrous, 3–3.5 × 2 mm. **Capsule** unknown.

Additional specimens: **PANAMÁ. Bocas del Toro:** Hill just S of Chiriquí Grande, at end of pipeline access road 2 mi N of 2nd large bridge N (10 mi) of Cont. divide, in forest along ridge and draws, 350–500 m, 8°54'N, 82°10'W, 10 Mar 1986, *B. Hammel, G. McPherson & L. Sanders 14745* (MO 3398424) (Fig. 2). **Colón:** Teck Cominco Petaquilla mining concession, forest on slope near coast, 8°58'23"N, 80°45'27"W, 9 Dec 2007, *G. McPherson & H. van der Werff 20036* (MO 6252501); Distr. de Donoso, Zona Minera, Coastal road 17.7 km, bosque secundario tardío, 70 m, (UTM 0533818E 0987741N), 13 Oct 2013, *R. Flores & R. Vergara 3419* (PMA); Distr. de Donoso, área de concesión, Minera Panamá, Coastal road, bosque secundario tardío dominado por palmas, 43 m, 8°56'0.29"N, 80°41'20.01"W (UTM 0534171E 0987505N), 24 Oct 2013, *R. Flores 3440* (PMA).

Distribution and habitat.—*Calathea gordonii* is endemic to Panamá. It is known from the Atlantic coastal forest of both Bocas del Toro and Colón Provinces, from 40–500 m in wet primary or old secondary forest habitat.

DISCUSSION

Calathea gordonii belongs to *Calathea* sect. *Breviscapus* Benth. It is characterized by the single elliptic leaf per shoot; the single inflorescence per shoot, borne either on a separate, leafless shoot or on the leafy shoot; the densely appressed tomentose bracts and peduncle; the two membranous, medial, bracteoles and the white flowers. It differs from *C. basiflora* by the elliptic vs. obovate leaf, the firm, coriaceous, densely tomentose vs. thin, herbaceous, pilose bracts and the membranous, lanceolate vs. indurate, claviculate medial bracteoles. In *C. verecunda* and *C. rhizanthoides* inflorescences are also borne on separate leafless shoots. However, *C. gordonii* differs from *C. verecunda* by the broader leaf blades (14.3–22.4 vs. 4–8 cm) and the bracts with rounded to obtuse vs. acute to acuminate apices and from *C. rhizanthoides* by the broader angle of divergence of the lateral veins from the midrib (41°–46° vs. 28°–39°) and medial bracteoles membranous, lanceolate vs. indurate, claviculate. *Calathea cleistantha* Standl. also has inflorescences borne on separate shoots but has more numerous leaves per shoot, 2–4(–9) vs. 1 and corolla lobes dark purple vs. white.

Etymology.—The specific epithet, *gordonii*, is in honor of Gordon McPherson, Curator, Missouri Botanical Garden and collector of this new species, for his many excellent Panamanian collections—including several other previously undescribed Marantaceae—nearly a hundred of which have been the types of new species in various families in that diverse country.

ACKNOWLEDGMENTS

The Missouri Botanical Garden provided support for my accommodations while working in the MO herbarium (organized, thanks to Olga Martha Montiel). Fred Ganders provided the travel expenses for the trips to MO and UCR. I am very grateful to Rodolfo Flores for his color photos of this species in the field and for collecting additional material, including the types. I also thank Gordon McPherson and Barry Hammel for their collections of this species which first brought it to my attention. Thanks to Gerrit Davidse, James Solomon and Teri Bilsborrow for their help in the MO herbarium and Mireya Correa for her help at PMA and the type scan. I thank Frank Almeda, Barney Lipscomb, and Roy Gereau for helpful suggestions and corrections. Roy Gereau provided the Latin diagnosis. I am grateful to Andrew Sanders for providing facilities at the UCR herbarium and to Teresa Salvado for providing accommodations and transportation in Riverside. Missouri Botanical Garden provided the paratype specimen scan.

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BOOK REVIEW

Serge Payette, ed. 2013. **Flore Nordique du Québec et du Labrador. Vol. 1.** (ISBN-13: 978-2-7637-2079-1, hbk; 978-2-7633-7208-7, pdf). Presses de l'Université Laval, 2180, chemin Sainte-Foy, 1er étage, Québec (Québec) G1V 0A6, CANADA. (**Orders:** www.pulaval.com, 1-800-363-2864). $89.95 CND (~$83.00 USD), 561 pp., 8⅛" × 10¼".

In 1935 Frère Marie-Victorín's *Flore Laurentienne* became the standard work for the flora of the province of Quebec, and now in its third edition, it is still highly regarded and most useful for a large section of the area. As the title indicates, *Flore Nordique* covers the more northern areas, from the 54° parallel to the 63° parallel, that is, from just above James Bay to Hudson Bay, north to the Hudson Strait, and across the provinces to the Labrador Sea on the east, including all the adjacent islands.

The editor, Serge Payette, director of the Herbarium Louis-Marie at the Université Laval, has written very informative, comprehensive, and interesting accounts of the exploration of these territories from the earliest expeditions to settlements such as those of Moravian settlers in Labrador and on to the very important work of twelve botanists in the twentieth century. All in their own way contributed to the work, largely through specimens deposited at the Laval University herbarium and elsewhere. Mr. Payette's explanations of the geology and the geography of the area and its five vegetative zones are essential to the understanding of the area covered in this book. He defines these zones as closed coniferous forest (balsam firs, pines, and a few deciduous trees); open coniferous forest in drier areas with 10% of regional forest flora; the smaller forested tundra with black pine, tamarack, other shrubs, and lichens; the shrubby sub-Arctic tundra; and, northernmost, the Arctic tundra with its mixture of herbaceous plants and scattered shrubs, willows, and Ericaceae. Shaded maps outline each of these regions. Only one species is strictly endemic: *Elatine ojibwayensis* Garneau (Elatinaceae), which does not however fall within the scope of this volume. Other regional endemics are found across the larger Canadian Shield. The editor considers the relative paucity of plants in the region and the rarity of some as he discusses the existing populations of species.

Following a key to all of the plant families represented in the entire *Flore Nordique*, Mr. Payette and six other botanists present the 32 families covered in this volume. The coverage includes the history of the taxon, the vernacular names in French and English, a detailed description of the species, and color photographs of its particular organs or growth patterns, of herbarium specimens, and often of the living plant in habitat. Appended to the discussion of the family is a section of physical maps showing range and distribution of each species and pinpointing where specimens were taken. A bibliography of the literature consulted accompanies the text.

Coverage includes many pteridophytes, the gymnosperms, and some monocots such as Orchidaceae and Iridaceae. There is no indication of which families will be covered in each of the subsequent three volumes nor projected dates of publication.

The appended material is also very valuable. Thirty-three plates offer an entire lexicon of botany, with precise illustrations and the French term for each illustration. For example, there are on four pages (two plates) forty-four illustrations with terms for textures used in botanical literature, from "pubescent" to "alveolate." A glossary in French, each entry with an English equivalent, defines botanical terms used throughout the book. There is also an English-French vocabulary of botanical terms that readers may find useful. Indices include one by scientific name and one by common names, both French and English. Color charts, one bound in and one removable, are helpful in that they indicate the range of color terms used for the plants.

Flore Nordique is an important contribution to the botany of North America. The editor and co-contributors along with the sponsors should be complimented and congratulated on the achievement of this work. While it will be of primary use to those studying the local flora, the book will also be of interest to those studying the ecology of plant growth in severe climatic and geographic conditions around the world.—*Joann Karges, Texas Christian University (retired), Fort Worth, Texas, U.S.A.*

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CALATHEA COFANIORUM AND *C. SHISHICOENSIS*, NEW ENDEMIC SPECIES OF MARANTACEAE FROM ECUADOR

Helen Kennedy

UCR Herbarium, Department of Botany and Plant Science
University of California Riverside
Riverside, California 92521, U.S.A.
ganders@mail.ubc.ca

ABSTRACT

Calathea cofaniorum H. Kenn. and **C. shishicoensis** H. Kenn., both endemic to Prov. Sucumbíos, Ecuador, are described as new species. They are most similar in aspect to the Ecuadorian species *C. neillii* H. Kenn. & *C. fredii* H. Kenn. with several basal leaves and a single cauline leaf or bladeless sheath subtending an inflorescence of bright rose-pink bracts. *Calathea cofaniorum* differs from *C. neillii* in the usually 3 vs. 7 minor veins between the major veins; the narrower angle of divergence of lateral veins from the midrib, 19°–31° vs. 40°–50°; and the red-purple vs. yellow petals and staminodes. It differs from *C. fredii* in the smooth vs. strongly corrugated leaf surface; the narrower, 2.1–4.8 vs. 5.2–10 cm, and abaxially glabrous vs. pilose leaf blades. *Calathea shishicoensis* differs from *C. neillii*, *C. fredii* and *C. cofaniorum* by its inflorescence of spirally arranged bracts and broader leaves (length:width ratios of 1.33–1.75 vs. 4.1–7.45:1).

RESUMEN

Se describe **Calathea cofaniorum** H. Kenn. and **C. shishicoensis** H. Kenn., ambas endémicas a la Provincia de Sucumbíos, Ecuador, como especies nuevas para la ciencia. Las dos especies se semejan a *C. neillii* H. Kenn. y *C. fredii* H. Kenn. de Ecuador con las cuales tienen los caracteres de hojas basales y solo una hoja caulina o una vaina sin lámina foliar que subtiende una inflorescenia con brácteas rosadas brillantes. *Calathea cofaniorum* se distingue de *C. neillii* por sus hojas con 3 vs. 7 venas minores entre las venas majores; por el ángulo de divergencia de las venas laterales del nervio medio más angosto (19°–31° vs. 40°–50°); los pétalos y los staminodios rojo-purpureos vs. amarillos. Se distingue de *C. fredii* por la lámina foliar plana vs. fuertemente plegada; más angosta, 2.1–4.8 vs. 5.2–10 cm, y finalmente, glabra vs. pilosa en la haz. *Calathea shishicoensis* se sobresale de *C. neillii*, *C. fredii* y *C. cofaniorum* por sus inflorescencias con brácteas espiraladas vs. dísticas y las hojas más anchas (la relación largo/ancho es 1.33–1.75:1 vs. 4.1–7.45:1).

Since the publication of the treatment of Marantaceae for the *Flora of Ecuador* (Kennedy et al. 1988) there has been a substantial increase in field work there. Consequently, a number of new species have been collected in the last decade, including the two being described herein. Of the total of 96 species in the 1988 flora publication, 64 were in the genus *Calathea*. Of these, 32 species were noted as endemic. As the two species described herein are known only from the types, in Ecuador, they are considered to be endemic. However, since they are somewhat near the border with Colombia it is possible they could occur there as well but are so far not documented. Currently a total of 69 species of *Calathea* are recognized for Ecuador including the two new species being described. As with the related *C. neillii* H. Kenn. and *C. fredii* H. Kenn., these new species, with their attractive bright rose-pink bracts, would be excellent garden subjects, though probably not for the lowlands. The two species described herein seem most likely to be related to either the "*C. lanicalis* Group" (Kennedy et al. 1988), which includes the red-bracted *C. timothei* H. Kenn., or *C.* section *Calathea*, which has distichous-bracted species.

TAXONOMIC TREATMENT

Calathea cofaniorum H. Kenn., sp. nov. (**Fig. 1**). Type: ECUADOR. Sucumbíos: foothills of the Andes near the Colombian border, access from Bermejo oil field road to Pozo 2, NW between Lumbaquí and Cascales, Río Bermejo to Cerro Sur Pax, Cofan community of Alto Bermejo, steep slopes N of Vista Camp, upper hill forest transition to mountain ridge, steep slopes and rock cliffs, 1300–1600 m, 00°18'13.8"N, 77°24'32"W, 29 Jul 2001, *R. Aguinda, N. Pitman & R. Foster 1415* (holotype: QCNE; isotypes: F 2231893, UCR).

Calathea cofaniorum a *C. neillii* foliis venis minoribus plerumque 3 (vs. 7) inter majores interpositis, lamina foliari adaxialiter glabra (vs. minute tomentosa secus venas majores), venarum angulo majore (59–71° vs. 40–50°) atque lobis corollinis necnon staminodiis rubropurpureis (vs. luteis), a *C. fredii* foliis laevibus (vs. valde corrugatis) abaxialiter glabris (vs. pilosis) differt.

Plants rhizomatous, caulescent, herbs, 30–55 cm; stem green, glabrous except sparsely minutely tomentose adjacent to leaf sheath; cataphylls narrowly ovate, apiculate, innermost cataphyll 5.5–13 cm. **Leaves** 4–8 basal, none or 1 cauline, a cauline leaf or bladeless sheath borne atop a 20.5–30.5 cm stem internode; leaf sheath not auriculate, green, wings glabrous along margin, sparsely minutely hispid abaxially along center and adjacent portion of wing, leaf sheaths 7.5–15.5 cm, bladeless sheath ca. 3 cm, very base of leaf sheath sericeus, the hairs pale straw-colored, 1 mm; petiole green, minutely subhispid apically, subglabrous to glabrous basally, the hairs 0.2–0.5 mm, 1.2–16.5 cm; pulvinus round in cross-section, olive-green, appressed tomentose in narrow band adaxially, the rest glabrous, the hairs 0.5–0.7 mm, articulate, noticeably thicker than petiole, 0.5–0.7 cm; leaf blade narrowly elliptic, apex acuminate-attenuate, base unequal, obtuse; 12.2–24 × 2.1–4.8 cm (length:width ratios [4.1–] 4.58–6.57:1), generally 3 minor veins between major veins, ratio of width of narrower side of leaf to wider 1: 1.30–1.41, vein angle from midrib (measured on inner 1/3 to 1/2 of blade) 19°–31°, vein spacing 0.8–1.7 mm between veins, veinlets 31–40 per 5 mm (measured at midpoint of each side of the blade), adaxial surface green, glabrous, midrib tomentose, hairs along center of midrib, the hairs tan, 0.7–1 mm, subglabrous to glabrous in apicalmost 0.5–1 cm; abaxial leaf surface grayish green, glabrous, midrib olive-green, sparsely tomentose to subglabrous along sides, center portion glabrous, the hairs tan, 0.3–0.5 mm. **Inflorescence** terminal, 1 per shoot, subtended by a cauline leaf or bladeless sheath, imbricate, subrectangular, laterally compressed, 3–5.3 × 2–2.3 cm; peduncle olive-green, apical 1 cm tomentose, subglabrous to glabrous basally, 1.9–9 cm. **Bracts** 6–12, distichous, transverse elliptic, apex retuse, apical margin straight, not recurved, 1.2–1.7 × 2–2.2 cm, each bract subtending 3 or more flower pairs, abaxial surface of bracts rose-red, glabrous, drying with veins prominent, adaxial surface rose-red, glabrous; bicarinate prophyll membranous, ovate, apex obtuse, translucent, glabrous, 1.3–1.4 × 0.6–0.8 cm, ca. 0.5 cm wide, carina to carina; secondary bract membranaceous, ovate-elliptic, apex obtuse, glabrous, ca. 1 × 0.5 cm; bracteole 1 per flower pair, membraneous, narrowly elliptic, ca. 0.9 × 0.2–0.3 cm. **Flowers** opening spontaneously. **Sepals** membranous, narrowly elliptic to narrowly obovate, obtuse to 90°, glabrous, 12–13 × 2–2.5 mm. **Corolla** tube light red-purple, glabrous, 12–14 mm; corolla lobes subequal, elliptic, apex ca. 90°, red-purple, glabrous except for few minute colorless hairs of ca. 0.1 mm at very tip, 5–5.5 × ca. 2 mm. **Staminodes** 3, red-purple; callose staminode totally callose, ca. 4 mm; cucullate staminode, 3–3.5 mm; anther ca. 2 mm, data unavailable on outer staminode due to condition of specimen. **Ovary** glabrous, 1.5–2 mm. **Capsule** obovoid, apical rim irregular, apex concave, glabrous, crowned by a persistent calyx.

Distribution and habitat.—*Calathea cofaniorum* is endemic to Ecuador, known only from the type locality in the Province of Sucumbíos, in the foothills of the Andes near the Colombian border, near the Cofan community of Alto Bermejo. It occurs at 1300–1600 m elevation in the upper hill forest transition to monutain ridge on steep slopes and rock cliffs. The type was collected in flower in July.

Discussion.—*Calathea cofaniorum*, shares the habit of several basal leaves with an inflorescence of distichous bright rose-pink bracts borne above an elongate stem internode with both *C. fredii* and *C. neillii*. *Calathea cofaniorum* differs from *C. neillii* in the usually 3 vs. 7 minor veins between the major veins, the leaf blade adaxially glabrous vs. minutely tomentose along major veins, the steeper vein angle, 19°–31° vs. 40°–50° divergence from midrib, and the red-purple vs. yellow corolla lobes and staminodes. It differs from *C. fredii* in the smooth vs. strongly corrugated leaf surface; the narrower, 2.1–4.8 vs. 5.2–10 cm, and abaxially glabrous vs. pilose leaf blades and shorter, 12–13 vs. 15–16 mm, sepals. It would key out in *Flora of Ecuador* (Kennedy 1988:47) under lead 30A because of the distichous bracts.

Etymology.—The specific epithet, *cofaniorum,* is in recognition of the Cofan community on whose land the plant was collected.

№ 2231893

FIELD MUSEUM
OF
NATURAL HISTORY

SA- EASTERN LOWLANDS
Wet COL/ ECUA/ N.E.PERU

ECUADOR
Prov. de Sucumbíos

MARANTACEAE

Calathea

Rio Bermejo to Cerro Sur Pax: Cofan community of Alto Bermejo. Access from Bermejo oil field road to Pozo 2, NW between Lumbaqui and Cascales. Steep slopes N of Vista Camp.

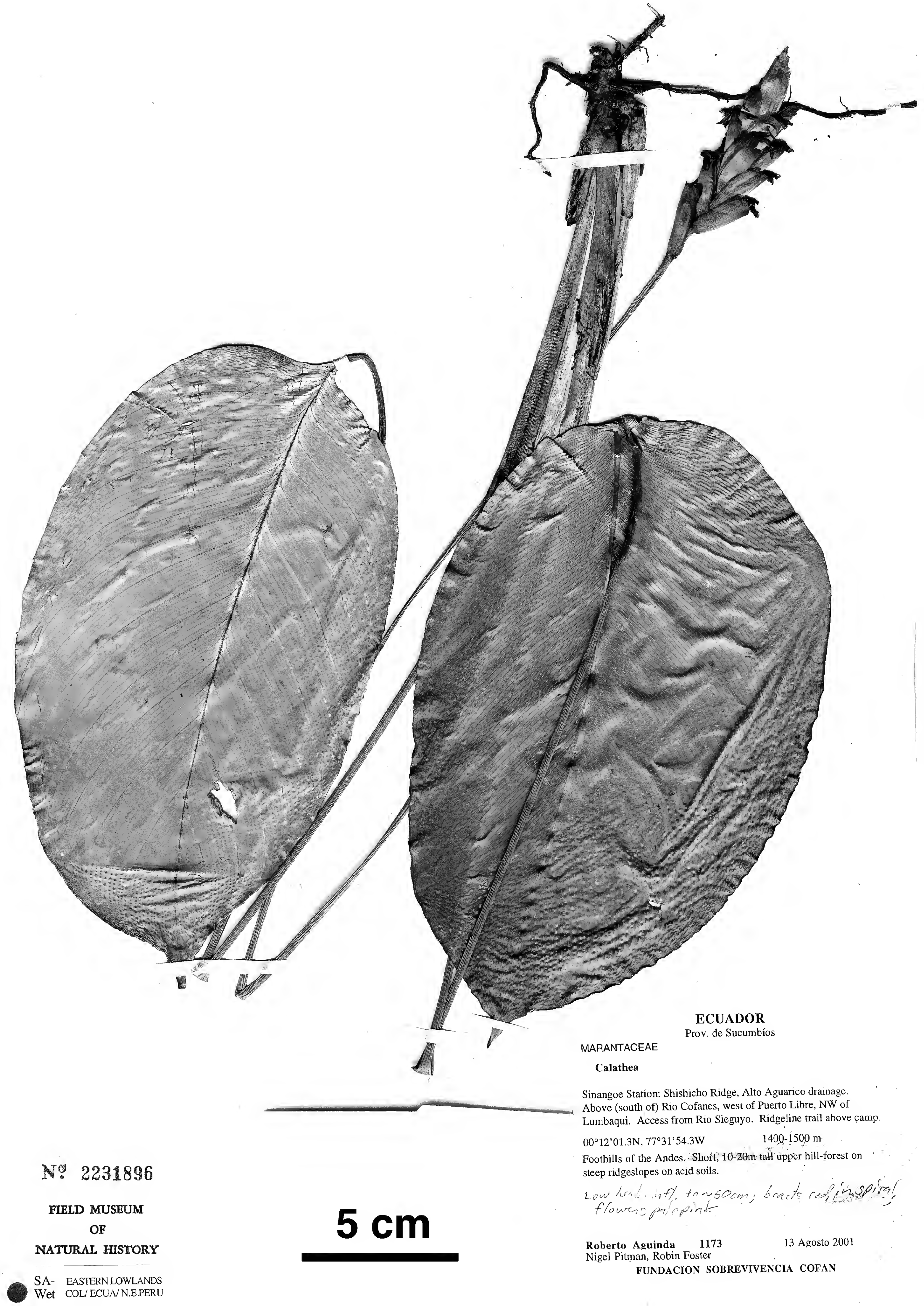
00°18'13.8N, 77°24'32.0W 1300-1600 m

Foothills of the Andes near the Colombian border. Upper hill forest transition to Mountain Ridge. Steep slopes & rock cliffs.

~~Low herb to 30 cm.~~ Bracts red-pink, flowers purple.
short, infl 25cm tall,

Roberto Aguinda 1415 29 Julio 2001
Nigel Pitman, Robin Foster
FUNDACION SOBREVIVENCIA COFAN

Fig. 1. Calathea cofaniorum H. Kenn. Isotype (*Aguinda, Pitmann & Foster 1415* F). Scan provided by Field Museum.



ECUADOR
Prov. de Sucumbíos

MARANTACEAE

Calathea

Sinangoe Station: Shishicho Ridge, Alto Aguarico drainage. Above (south of) Rio Cofanes, west of Puerto Libre, NW of Lumbaqui. Access from Rio Sieguyo. Ridgeline trail above camp.

00°12'01.3N, 77°31'54.3W 1400-1500 m

Foothills of the Andes. Short, 10-20m tall upper hill-forest on steep ridgeslopes on acid soils.

Low herb. Infl. to ~50cm; bracts red, in spiral; flowers pale pink

Roberto Aguinda 1173 13 Agosto 2001
Nigel Pitman, Robin Foster
FUNDACION SOBREVIVENCIA COFAN

Nº 2231896

FIELD MUSEUM
OF
NATURAL HISTORY

SA- EASTERN LOWLANDS
Wet COL/ ECUA/ N.E.PERU

Fig. 2. *Calathea shishicoensis* H. Kenn. Isotype (*Aguinda, Pitmann & Foster 1173* F). Scan provided by Field Museum.

Calathea shishicoensis H. Kenn., sp. nov. (**Fig. 2**). TYPE: ECUADOR. SUCUMBÍOS: foothills of the Andes, access from Río Sieguyo, NW of Lumbaqui, W of Puerto Libre, above (S of) Río Cofanes, Alto Aguarico drainage, Shishico Ridge, Sinangoe Station, ridgeline trail above camp, short, 10–20 m tall, upper hill-forest on steep ridge slopes on acid soils, 1400–1500 m, 00°18'13.8"N, 77°24'32"W, 13 Aug 2001, *R. Aguinda, N. Pitman & R. Foster 1173* (HOLOTYPE: QCNE; ISOTYPES F 2231896, UCR).

Calathea shishicoensis a *C. neillii, C. cofaniorum* et *C. fredii* bracteis spiraliter (vs. distiche) dispositis atque foliis ellipticis (vs. anguste ovato-ellipticis vel anguste ellipticis) longitudinis cum latitudine proportione 1.33–1.75 (vs. 4.10–7.45): 1 differt.

Plants rhizomatous, caulescent, herbs, 50–70 cm; stem green, minutely sparsely tomentose in apical 3 cm (just below cataphyll subtending the inflorescence), glabrous basally; cataphylls narrowly ovate, apiculate, sparsely pilose in upper half, glabrous basally, innermost cataphyll 11–16.5 cm. **Leaves** 2–3 basal, a bladeless sheath borne atop a ca. 51.5–52.5 cm stem internode; leaf sheaths not auriculate, green, glabrous, 9.4–14 cm; petiole green, glabrous, 30–34.5 cm; pulvinus round in cross-section, deep olive-green with a purplish band at junction to petiole or tinged purple throughout, appressed tomentose in narrow adaxial band, the rest glabrous, hairs 0.5 mm, 3.1–4.2 cm; leaf blade coriaceous, elliptic, apex obtuse with acumen, base rounded to subtruncate, shortly abruptly attenuate, 17–21.6 × 9.8–13.1 cm, (length:width ratios 1.33–1.75:1), generally there are 7 minor veins between major veins, vein angle divergence from midrib (measured at midpoint of blade) 36°–48°, 20–30 veins per 3 cm, veinlets ca. 25 per 3 mm (measured at midpoint of each side of the blade); adaxial leaf surface deep matte green except shiny along margin, major veins darker green, glabrous except sparsely minutely (14× magnification) tomentose along major veins and on acumen, the hairs colorless, 0.2–0.3 mm, midrib yellow-green, densely tomentose throughout midrib and just onto adjacent portion of blade, the hairs colorless 0.3–0.5 mm; abaxial leaf surface semi-shiny gray-green, glabrous except sparsely minutely tomentose along major veins, glabrous toward margin and along margin in apical 0.5 cm, midrib green, appressed tomentose but only on sides in basal portion, the hairs colorless 0.5 mm. **Inflorescence** terminal, 1 per shoot, subtended by a bladeless sheath 2.5–3 cm, imbricate, fusiform, 4.8–6.5 × 2–2.2 cm; peduncle green, pink right at junction to lowest bract, sericeous, the hairs colorless 0.25–0.3 mm, ca. 1–1.1 cm. **Bracts** 11–16, spirally arranged, herbaceous, elliptic, apex rounded, dying back and splitting into 2 or 3 irregular segments, outer margin and apex thin, membranous, straight, 2–2.2 × 1.2–1.4 cm, each bract subtending 5 or more flower pairs, abaxial surface of bracts deep rose-pink, minutely pilose toward margin and very tip with tuft of hairs, the rest glabrous, the hairs 0.2–0.3 mm, hairs more evident in lower bracts; bicarinate prophyll membraneous, ovate-elliptic, apex obtuse to rounded, margin deeply pigmented, probably colored when live, the rest translucent, sparsely pilose on carina, the rest glabrous, the hairs colorless 0.3–0.5 mm, 1.6–1.7 × ca. 0.8 cm, 0.5–0.6 cm wide, carina to carina; secondary bracts absent; bracteoles 2 per flower pair, membraneous, medial, both carinate, narrowly oblong-elliptic, translucent with very margin deeply pigmented (dark red-brown when dried), glabrous, 1.3–1.5 × 0.2–0.3 cm. **Flowers** opening spontaneously, pale pink *fide* label, *Aguinda et al. 1173* (F). **Sepals** narrowly oblong-elliptic, obtuse to 90°, margins inrolled appearing acute, 14–16 × 2.5–3 mm; corolla tube glabrous, 15–17 mm; corolla lobes subequal, elliptic, apex acute, darker, purplish pink at apex, pale below, glabrous except tuft of colorless hairs at apex, the hairs ca. 0.1 mm, 7–8 × 1.5–2 mm. **Staminodes** 3; outer staminode ca. 4.5 mm; callose staminode totally callose, 6–6.5 mm; cucullate staminode 3.5–4 mm; anther ca. 1.5 mm. **Ovary** essentially smooth with a thickened, raised rim, apically, the calyx attached in a slight depression. **Capsule** and seeds unknown.

Distribution and habitat.—*Calathea shishicoensis* is endemic to Ecuador, known only from the type locality in the in the foothills of the Andes, Sucumbíos Province, on Shishico Ridge in the Alto Aguarico drainage. It occurs from 1400–1500 m in the short, 10–20 m tall, upper hill-forest on steep ridge slopes on acid soils. The type was collected in flower in August.

Discussion.—*Calathea shishicoensis* shares a similar habit and also the bright rose-pink bracts with *C. neillii, C. cofaniorum* and *C. fredii,* but differs significantly in having spirally arranged bracts and decidedly broader leaves (length:width ratios of 1.33–1.75 vs. 4.1–7.45:1). Like *C. neillii*, it has 7 minor veins between the major veins and also lacks secondary bracts. It would key out in *Flora of Ecuador* (Kennedy 1988:47) with *C. roseo-*

bracteata H. Kenn. under lead 40A because of the spirally arranged rose-pink bracts but is distinguished by the smooth vs. strongly corrugated leaf blade and fewer, 11–16 vs. 25–50, bracts.

Etymology.—The specific epithet, *shishicoensis,* is in reference to the Shishico Ridge from where it was collected.

ACKNOWLEDGMENTS

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GLOSSOLOMA VELUTINUM (GESNERIACEAE), A NEW SPECIES FROM THE CORDILLERA CENTRAL OF THE COLOMBIAN ANDES

Larri A. Rodas
Centro de Estudios e Investigaciones
en Biodiversidad y Biotecnología – CIBUQ
Universidad del Quindío
Armenia, COLOMBIA
maxwellero81@gmail.com

John L. Clark
Department of Biological Sciences
Box 870345
University of Alabama
Tuscaloosa, Alabama 35487, U.S.A.
jlc@ua.edu

ABSTRACT

A new species of *Glossoloma* (Gesneriaceae) is described from the Cordillera Central of the Colombian Andes. The new species, **Glossoloma velutinum** J.L. Clark & L.A. Rodas, is locally endemic to cloud forests in the provinces of Quindío and Tolima. The new species is differentiated from other *Glossoloma* by the presence of an orange corolla, scandent habit with elongate shoots to 3 m tall, and uniformly velutinous indumentum on the stems and leaves.

RESUMEN

Una nueva especie de (Gesneriaceae) es descrita en la cordillera central de los andes de Colombia. La nueva especie, **Glossoloma velutinum** J.L. Clark & L.A. Rodas, es endémica de las nefosilvas del Quindío y el Tolima. La nueva especie es diferente de otras *Glossoloma* por la presencia de una corola de color naranja, de hábito escandente llegando alcanzar longitudes de hasta 3 m. y su indumento velutino en tallos y hojas.

KEY WORDS: Cordillera Central, Episcieae, Gesneriaceae, *Glossoloma*, Quindío, taxonomy

INTRODUCTION

The genus *Glossoloma* Hanst. belongs to the New World subfamily Gesnerioideae and subtribe Columneinae (Weber et al. 2013). *Glossoloma* is distinguished from closely related genera by the presence of resupinate (upside-down) flowers. *Glossoloma* ranges from Mexico south to Bolivia and is most diverse in the northern Andes of Colombia and Ecuador. The genus was recently monographed by Clark (2009) and included 27 species. Expeditions to Colombia during the previous two years (Clark 2012) have resulted in many discoveries and the subsequent publication of new species (Clark & Clavijo 2012; Clavijo & Clark 2012; Clavijo & Clark 2014; Smith et al. 2013). The publication of *Glossoloma velutinum* increases the total number of species in the genus to 28 with additional discoveries that will be published in the near future.

TAXONOMIC TREATMENT

Glossoloma velutinum J.L. Clark & L.A. Rodas, sp. nov. (**Fig. 1**) TYPE: COLOMBIA. QUINDÍO: Municipio de Calarcá, carretera al Campanario, borde de bosque conservado, 4°28'27N, 75°33'25W, 3160–3450 m, 29 Aug 1993, *D. Macías, M.L. Chacón & J.C. Hincapié 101* (HOLOTYPE: HUQ).

Differs from all other *Glossoloma* by the presence of a velutinous indumentum, scandent habit, and elongate shoots to 3 m tall.

Terrestrial or epiphytic scandent subshrub; stems erect, rarely branched, to 3 m tall, to 0.7 cm in diameter, quadrangular, vestiture velutinous to densely villous, woody when mature, succulent to herbaceous when young, internodes 2.5–8 cm long. **Leaves** opposite, equal or subequal in a pair; petioles 1.5–2.5 cm long, sparsely to densely woolly; blades 4–17 × 2.5–7 cm, elliptic-oblong to obovate, base cuneate to acute, occasionally oblique, apex acuminate, margin denticulate to serrate, adaxially green and velutinous, abaxially much lighter green and velutinous, coriaceous when dry, lateral veins 6–8 per side. **Flowers** resupinate, appearing fasciculate with 2–5 flowers per axil, posture pendent at anthesis, bracteoles 0.5–2.0 × 3–6 mm, ovate; pedicels 1–3 cm long, usually velutinous, rarely villous; **calyx** lobes nearly free, conduplicate with each lobe appressed to adjacent lobe and folded lengthwise with the margin curved inward, erect, 4 subequal, 1–3 × 0.6–1.0 cm, broadly ovate, base truncate, apex acuminate, margin serrate to laciniate, red to pink, abaxially densely velutinous, adaxially sparsely velutinous; **corolla** 2.0–3.0 cm long, tubular, gibbous basally on upper surface, long

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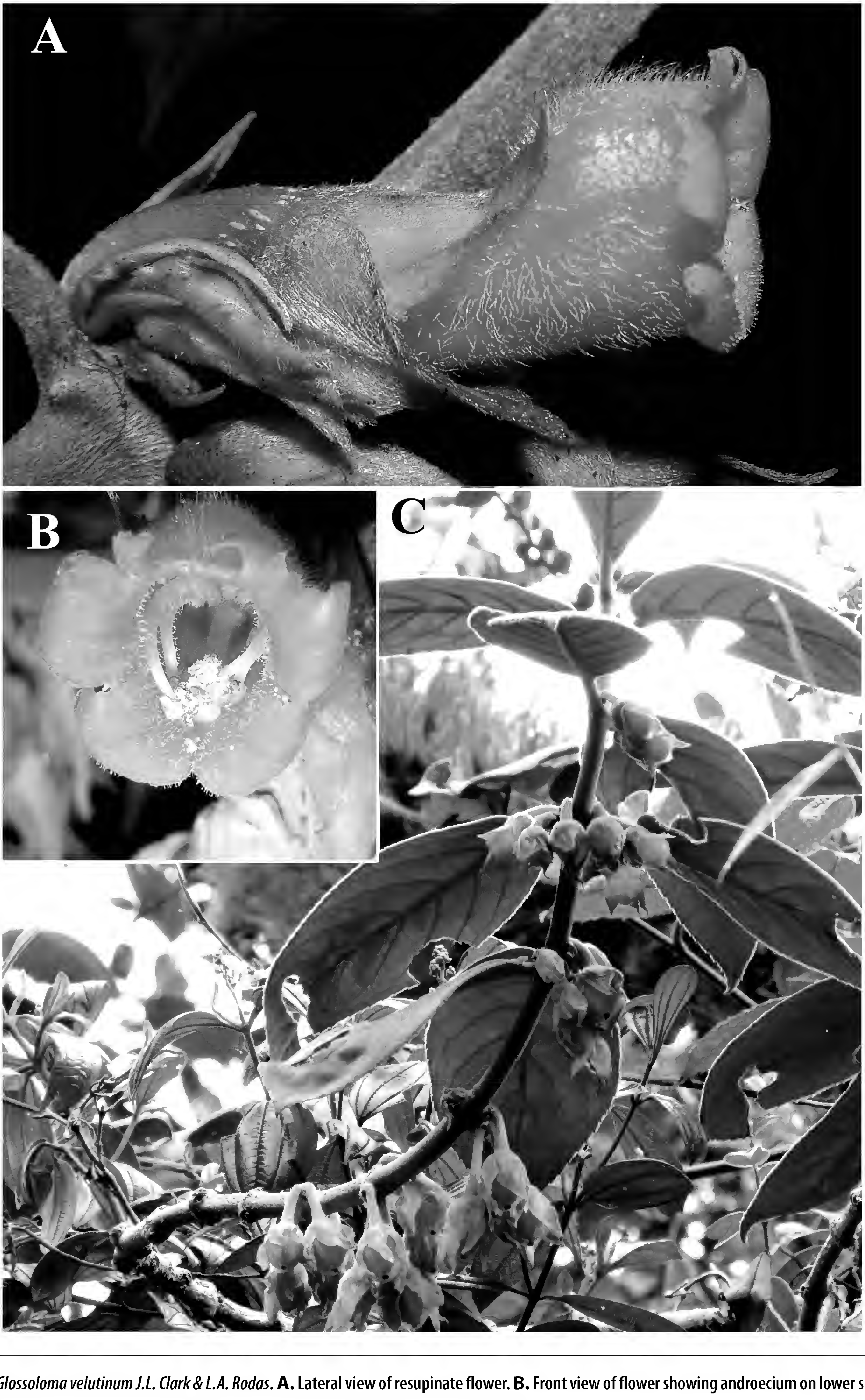

Fig. 1. *Glossoloma velutinum J.L. Clark & L.A. Rodas*. **A.** Lateral view of resupinate flower. **B.** Front view of flower showing androecium on lower surface and medial lobe on upper surface. **C.** Habit. (A–C photographic images of *L.A. Rodas 102*).

axis of corolla oblique relative to calyx; base ca. 8 mm in diameter, middle ampliate, becoming apically ventricose on upper surface, throat slightly constricted, not appearing laterally compressed, ca. 1.5 cm wide (at mouth), outside densely velutinous, inside sparsely velutinous, interior red spotting present, limb spreading, subregular, ca. 8 mm wide, orange becoming yellow, lobes equal, ca. 2 × 6 mm, rotund, spreading, entire; **nectary** a bilobed gland on ventral surface of ovary, sparsely glabrous; **filaments** curved after anthesis, free portion to 1.5 cm long, adnate to base of corolla tube for ca. 3 mm, connate for 2.5 mm, forming an open sheath, glabrous; anthers 1.5 × 3 mm, dehiscing by longitudinal slits; **staminode** present; **ovary** ca. 4.5 × 3 mm, ovoid, densely velutinous, style 0.8–1.5 cm long, glabrous, stigma stomatomorphic. **Fruit** a fleshy capsule, pendent when ripe, 1.4 × 1.1 cm, globose to ovoid when immature, velutinous, loculicidally dehiscent and bivalved when mature, valves not reflexed, reaching a 45°–60° angle when mature. **Seeds** numerous, ca. 1.0 × 0.5 mm, elongate, longitudinally- transversely striate, brown.

Additional specimens studied. **COLOMBIA. Quindío:** municipio de Salento, Reserva Natural Alto Quindío, Acaime, 4°37'85"N, 75°28'0"W, 2780 m, 12 May 1991, *C.A. Agudelo, L.F. Hoyos, D. Macías & A.L. López. 1736* (HUQ); municipio de Calarcá, vereda planadas, microcuenca de la quebrada la Sonadora, finca la Merced, 75°37'N, 04°26'W, 3200–3500 m, 20 May 2007, *L.A. Rodas 21* (HUQ); municipio de Salento, Reserva Forestal Navarco, 04°38'N, 75°34'W, 2920 m, 18 Apr 1989, *G. Arbeláez S., C. Vélez N., N. Carvajal D. & J. Uribe M. 2898* (HUQ); municipio de Salento, vereda Cócora Alto, Área de Conservación la Montaña, 4°37'N, 75°28'W, 3120 m, 20 May 2007, *P. Sepúlveda, O. Martínez & T. Gómez, 157* (HUQ); municipio de Salento, Reserva Natural Alto Quindío, Acaime, 4°37'N, 75°28'W, 2780 m, 12 May 1991, *C.A. Agudelo, L.F. Hoyos, D. Macías & A.L. López. 1736* (HUQ); municipio de Córdoba, vereda las auras, finca el Cedral, 75°37'N, 04°26'W, 2950–3000 m, 14 Dec 1993, *M.C. Vélez, D. Macías & L.F. Hoyos 3750* (HUQ). **Tolima:** municipio de Cajamarca, vereda la luisa, camino hacia la N, 4°28'27"N, 75°33'25"W, 3000–3300 m, 5 Jun 2013, *L.A. Rodas 102* (FAU, HUQ).

Glossoloma velutinum is similar to *Glossoloma ichthyoderma* (Hanst.) J.L. Clark because of the erect shoots and subshrub epiphytic habit. It should be noted that *Glossoloma ichthyoderma* is more frequently found as a terrestrial subshrub in contrast to the epiphytic subshrub habit of *G. velutinum*. The shoots of *G. ichthyoderma* are covered in peltate scales in contrast to the velutinous indumentum and absence of peltate scales in *G. velutinum*.

Distribution and habitat.—*Glossoloma velutinum* is known form the Cordillera Central of the Colombian Andes in the departments Quindío (western slopes) and Tolima (eastern slopes) in cloud forests from 2780 to 3300 m.

Etymology.—The specific epithet reflects the velutinous indumentum that covers the stems and leaves.

Phenology.—Collected in flower during March, April, and December, in fruit during May and August.

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BOOK NOTICE

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SYNOPSIS OF *GALVEZIA* (PLANTAGINACEAE: ANTIRRHINEAE), INCLUDING A NEW CRYPTIC SPECIES FROM SOUTHERN PERU

Michael O. Dillon

Botany Department
The Field Museum
1400 South Lake Shore Drive
Chicago, Illinois 60605, U.S.A.
mdillon@fieldmuseum.org

Victor Quipuscoa Silvestre

Departamento Académico de Biología
Universidad Nacional de San Agustín
Arequipa, PERU

ABSTRACT

A generic synopsis is provided for *Galvezia* Dombey ex Juss. (Plantaginaceae: Antirrhineae), a genus of shrubs with red to white, tubular flowers endemic to coastal Ecuador and Peru and the Galapagos Islands (Ecuador). **Galvezia elisensii** M.O. Dillon & Quipuscoa, a new cryptic species, is described from southern Peru, bringing the total number of species to four.

RESUMEN

Se presenta la sinopsis del género *Galvezia* Dombey ex Juss. (Plantaginaceae: Antirrhineae); se trata de un género pequeño, compuesto por arbustos con flores de rojo a blanco, tubulares, endémico del lado occidental de Ecuador y Perú y de las Islas Galápagos (Ecuador). Se describe además, una nueva especie, **Galvezia elisensii** M.O. Dillon & Quipuscoa, procedente del Sur de Perú, haciendo un total de cuatro especies en la actualidad.

INTRODUCTION

Galvezia Dombey ex Juss. (Plantaginaceae: Antirrhineae) is a genus of shrubs with tubular flowers distributed along the coast of Ecuador and northern to southern Peru, and one species confined to the Galapagos Islands (Elisens 1989, 1992; Wiggins & Porter 1971; Brako & Zarucchi 1993; Jørgensen & León-Yanez 1999). With the addition of the new species described here, the genus is comprised of four species. The North American taxa previously attributed to *Galvezia* are now placed in *Gambelia* Nutt., e.g., *G. speciosa* Nutt. (Sutton 1988; Elisens & Nelson 1993). The phylogeny of the tribe Antirrhineae, including *Galvezia* and *Gambelia*, has been investigated with molecular techniques (Ghebrehiwet et al. 2000; Medhanie et al. 2000; Oyama & Baum 2004; Vargas et al. 2004); however, a more robust sampling will be necessary before relationships can be resolved with confidence.

During the strong El Niño year of 1983, the senior author collected a specimen of *Galvezia* from the *Lomas de Atiquipa* in Department of Arequipa in southern Peru. A duplicate of that collection (*M. Dillon & D. Dillon 3776*) was forwarded to Dr. Wayne Elisens for identification and he indicated that it was potentially a new species, distinct from its northern congeners. He subsequently visited southern Peru and made collections (*Elisens 844, 845, 847*, all OKL) that were included in his study of genetic divergence in *Galvezia* (Elisens 1992). While not included in his 1992 study, the sample of *M. Dillon & D. Dillon 3776* was included in his analysis of *Gambelia* (Elisens & Nelson 1993, p. 456) and termed "*G. sp. nov.*"

The overall morphological variation in the continental species is not profound, with differences typically confined to corolla size, anther filament pubescence, and leaf shape. Attention has been drawn to differences in habit, but these are not useful in species recognition. Authors of recent floras have adopted a broad species concept for *Galvezia* by placing several species into the synonymy of *G. fruticosa* J.F. Gmel (Brako & Zarucchi 1993; Jørgensen & León-Yánez 1999). However, data supporting narrower species circumscriptions have been convincingly presented (Elisens 1992; Elisens & Nelson 1993), even though they prove difficult to quantify and qualify (i.e., cryptic species). Cryptic species represent a situation where speciation has already broken the gene flow between populations, but where evolution has not progressed to a point where easily recognizable adaptations are visually obvious (Bickford et al. 2007; Schlick-Steiner et al. 2007).

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In his discussion of results from allozyme divergence patterns in *Galvezia*, Elisens argued that data supported the taxonomic distinctness of the Galapagos endemic, *G. leucantha* Wiggins, and three mainland species: *G. fruticosa*, *G. grandiflora* (Benth.) Wettst. (as *G. ballii* Munz + *G. lanceolata* Pennell), and a "*sp. nov.*" based upon his collections from southern Peru (referenced above). He stated that the pattern of allozyme variation suggested *G. fruticosa*, *G. leucantha*, *G. sp. nov.*, and *G. grandiflora* (as *G. ballii*) had undergone a gradual genetic divergence following their reproductive isolation. He stated that the recognition of *G. lanceolata* in central coastal Ecuador by Pennell (1946) and Sutton (1988) was not supported by his electrophoretic and morphological data. Rather, the data were most concordant with recognition of only one species in northern Peru and coastal Ecuador (the name *G. grandiflora* has priority). Finally, Elisens suggested that, "systematic data support delimitation of an undescribed species, *G. sp. nov.* In addition to unique leaf and floral characters and an allopatric distribution, *G. sp. nov.* is differentiated from other species in *Galvezia* by three marker alleles."

Elisens (1992) accepted three mainland species, *G. fruticosa*, *G. grandiflora* (i.e., *G. ballii* + *G. lanceolata*) and an additional taxon (*sp. nov.*) described here, based upon southern Peruvian material from the Departments of Ica and Arequipa. We accept Wettstein's (1891) transfer of Bentham's *Galvezia limensis* (Dombey ex Chav.) Benth. var. *grandiflora* Benth. as *Galvezia grandiflora* (Benth.) Wettst. All specimens cited here have been examined unless otherwise indicated (n.v.).

TAXONOMIC HISTORY

Pennell (1946) provided a detailed discussion of the taxonomic history of *Galvezia*, but a summation of the pertinent literature is merited. *Galvezia* was originally proposed by Joseph Dombey, the French botanist who accompanied Ruiz and Pavón during their explorations of Peru and Chile. Dombey left South America in 1784, before Ruiz & Pavón, and, in clear violation of stated protocols, Dombey began publishing selected new taxa he had encountered. The generic description for *Galvezia* appeared in J.F. Gmelin's edition of Linnaeus' Systema Naturae (2: 937) in 1791, where Dombey proposed the genus *Galvezia* in honor of Don José de Gálvez y Gallardo, marqués de Sonora and minister of the Council of the Indies (b. 1720–d. 1787). A note with Dombey's specimen at Kew suggests that his plant was gathered in 1779 near Lima. The alternate spelling, *Galvesia*, has been accepted by some databases, but is here rejected given the origin of the generic name.

Ruiz and Pavón did not accept *Galvezia sensu* Dombey, and believing it to be a species of *Dodartia* L., a Palaearctic genus. They published new name, *Dodartia fragilis* in 1798 based upon the Dombey publication in Jussieu (1789). They considered that the generic name *Galvezia* was open and they described another *Galvezia* in Florae Peruvianae et Chilensis Prodromus, 56 in 1794 in the Rutaceae. Chavannes in his Monographie des Antirrhinees (1833), accepted the generic concept of *Galvezia*, but with Ruiz and Pavón's genus evidentially occupied, he proposed *Agassizia* (p. 180) and described *A. limensis* for Dombey's plant collected near Lima. He provided an illustration (Plate XI) clearly representing *G. fruticosa*.

When Bentham treated the Scrophulariaceae for DeCandolle's Prodromus in 1846, he adopted Dombey's name and attributed it to Jussieu. He also established a varietal name, *Galvezia limensis* ß *grandiflora,* for material gathered further north near the port city of Paita and cited *F. Hall 10* (K000528872). *Galvezia* was accepted in Wettstein's treatment of the Scrophulariaceae in Engler and Prantl's Pflanzenfamilien (1895). Wettstein attempted to provide a new combination for Bentham's variety; however, he appears to attribute the original authorship to "(Kell.)" and mentioned California. These errors led Munz to reject the combination by Wettstein and provide a new name for Bentham's variety, *Galvezia ballii* and citing the type locality as Paita (as Payta), Peru. He based his superfluous name upon *J. Ball s.n.* (US1323500, US251553). In 1946, Pennell described *G. lanceolata* from the region of Manabí, Ecuador, and provided a key to allow for discrimination of *G. fruticosa*, *G. lanceolata*, and *G. ballii*.

TAXONOMY

Galvezia Dombey ex Juss., Gen. Pl. 119. 1789. Type: *G. fruticosa* J.F. Gmel., Syst. Nat. 2:937. 1791. Non *Galvezia* Ruiz & Pav., Fl. Peruv. Prodr. 56. 1794.

Much-branched shrubs to 2 m tall, erect, arching or pendent; glabrous to pubescent. **Leaves** opposite, or occasionally 3 at a node, simple, the blades ovate-lanceolate to elliptic, pinnate-nerved, the margins entire, the bases cuneate to subcordate, the apices acute. **Inflorescences** paniculate. **Flowers** axillary; calyx 5-merous, ovate to lanceolate, the apices acute; corollas red to white, tubular, bilabiate, the tube elongate, subcylindric, the base expanded to subgibbose, the upper lip erect, bilobed, the lobes ovate, the lower lip trilobed, the lobes plane to reflexed; stamens didynamous, 4 fertile, one aborted; anthers bilocular; ovary ovoid to spheric. **Fruit** capsules, globose to subglobose, cartaceous, chambers dehiscent by 1–2 pores, seeds oblong-truncate. Chromosome number: unknown.

Galvezia Dombey ex Juss. is a genus of small shrubs with tubular flowers. Four species are recognized with the addition of this new species from southern Peru; three confined to western Ecuador and Peru and one endemic species to the Galapagos Islands (Ecuador). All continental species possess deep red to crimson corollas, whereas the island species have variously colored corollas (see discussion below).

Wiggins (1968) addressed the difference or loss of floral coloration in some of the island species and attributed the shift to white corollas to the absence of hummingbirds within the islands; however, it has never been fully documented that hummingbirds were the pollination vectors in the mainland species. Information on pollination vectors is now available and possible vectors could be members of the Sphingidae, Lepidoptera (Cock & Boos 2006).

KEY TO *GALVEZIA* SPECIES

The following key will allow for identification of *Galvezia* species (adapted from Pennell 1946)

1\. Galapagos Islands, Ecuador **G. leucantha**Wiggins
1\. Mainland Ecuador and Peru.
  2\. Cauline leaves elliptic to elliptic-lanceolate, 15–25 mm long, 3–5 mm wide, pedicles 8–12 mm long, stout, straight to slightly curved, corollas 8–9 mm long (southern Peru) **G. elisensii** M.O. Dillon & Quipuscoa
  2\. Cauline leaves ovate-lanceolate to lanceolate, 20–25 mm long, 5–15 mm wide; pedicles 8–20 mm or longer, filiform, distally coiled or strongly incurved, corollas 12–22 mm long (central Peru to Ecuador).
    3\. Corolla 12–14 mm long, the lips about ⅓ length of tube; pedicels as long as, or longer than, the subtending leaves, leaf-blades about 2 cm long, on petioles ca. 2 mm long; shrubby (central to northern Peru) **G. fruticosa** J.F. Gmel.
    3\. Corolla 14–22 mm long, the lips about ½ length of tube; pedicels shorter than the subtending leaves, leaf-blades and bracts lanceolate; suffrutescent to herbaceous throughout (northern Peru to Ecuador) **G. grandiflora** (Benth.) Wettst.

1. Galvezia elisensii M.O. Dillon & Quipuscoa, sp. nov. (**Figs. 1–3**). Type: PERU. Arequipa. Caravelí: Lomas of Atiquipa, ca. 10.5 km N of turn-off to Atiquipa, km 584 S of Lima, 150–200 m, 1 Nov 1983, *M. Dillon & D. Dillon 3776* (holotype: F; isotypes: CPUN, GH, HUT, K, MO, NY, OKL, TEX).

Galvezia fruticosa J.F. Gmel. simile, sed foliis brevioribus et angustioribus et pedicellis brevioribus.

Much branched shrubs; branches erect to arching, 0.8–1.2 m long; young stems green, maturing reddish. **Leaves** opposite, the blades elliptic to elliptic-lanceolate, (10–)15–25(–30) mm long, (2–)3–5(–15) mm wide, the base narrowly cuneate, the apex acute, glabrous, semisucculent, occasionally sparsely puberulent; petioles (0.5–)1–2.5(–3) mm long, ca. 0.3 mm in diameter. **Inflorescences** paniculate. **Flowers** axillary; the pedicles stout, (5–)8–12(–18) mm long, glabrous, straight to slightly curved; calyx lobes ovate to lanceolate, c. 2.5 mm long, c. 1.5 mm wide, apices obtuse, glabrous; corollas tubular, (7–)8–9(–10) mm long, 2.5–3 mm wide, outside puberulent, red, slightly ampliate, the limb bilabiate, superior lip 3–4.5 mm, bilobed, erect, purberulent, the lower lip trilobate, 2.5–3.5 mm long, base of lower lip folded, glandular-puberulent; stamens didynamous, dorsal pair 5.5–7 mm long; ventral pair, 7–9 mm long, filaments glabrous distally, glandular-papillate basally; anthers thecae 1–1.4 mm long; fifth stamen sterile, c. 1 mm long; ovary ovate, 1.5–2 mm long, 1–1.5 mm wide, puberulent. **Fruit** subglobose, glabrous, 4–6 mm long, 4.5–7 mm in diameter, deep red at maturity; seeds (40–)140–175 per capsule, subtruncate, black, c. 1 mm long.

Etymology.—This species is dedicated to Dr. Wayne J. Elisens, Professor and Curator of the Robert Bebb Herbarium on the campus of the University of Oklahoma, Norman. His recognition of this taxon, as reflected in its allelic profiles, has led to its description here.

Fig. 1. *Galvezia elisensii*. Photograph of holotype collection, *M. Dillon & D. Dillon 3776* (F1940835).

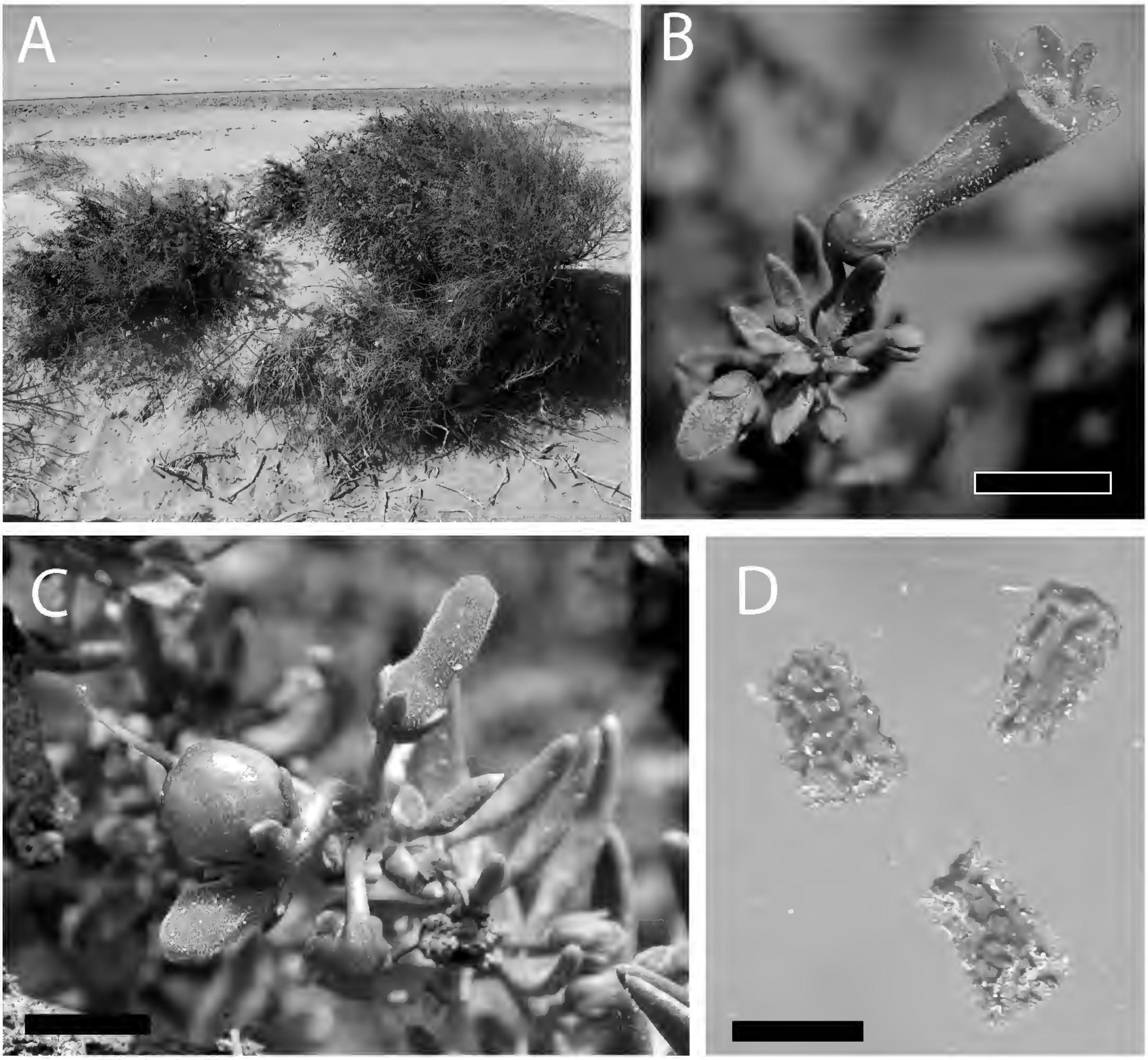

Fig. 2. *Galvezia elisensii.* **A.** Habit in coastal desert of Department of Arequipa, Peru. **B.** Flower at anthesis, bar = 5 mm. **C.** Maturing gynoecium, bar = 2 mm. **D.** Seeds, bar = 1 mm.

Distribution & Biogeography.—The type locality of this new species is in the area of the *Lomas de Atiquipa* (15°48'S, 74°22'W, Department Arequipa), but its distribution extends northward to Palpa (Department Ica).

The presence of endemic taxa in southern Peru is a common pattern. From studies of the distribution of *lomas* plants in coastal Peru and Chile, floristic sectors have been recognized, including a northern Peru unit (7°55'S–12°00'S latitude), a south Peru unit (12°S–18°S), and a north Chile unit (20°S–28°S) (Rundel et al. 1991; Dillon et al. 2009). This pattern is found in several groups, including *Nolana* (Dillon et al. 2009) and hypotheses of pattern formation remain to be tested. Dillon et al. (2009, 2011) discussed the sectoring of coastal environments. Long-term climatic changes have been associated with glacial cycles (13,000–200,000 year cycles); and there have been at least 20 glacial cycles during the Pleistocene, each of approximately 200,000 years. The formation of glaciers on mountains and poles caused sea levels to fluctuate dramatically. Estimates of sea level fluctuation range between 400–750 ft (120–230 m) and this lowering would have significantly changed the position of the seashore 18,000 years ago, in relation to that today. This drop would have exposed a considerable area of the continental shelf and displaced *lomas* formations, especially between 5°S to 15°S latitude. Glacial cycles would also have had a profound influence on the flora of the coastal deserts by provid-

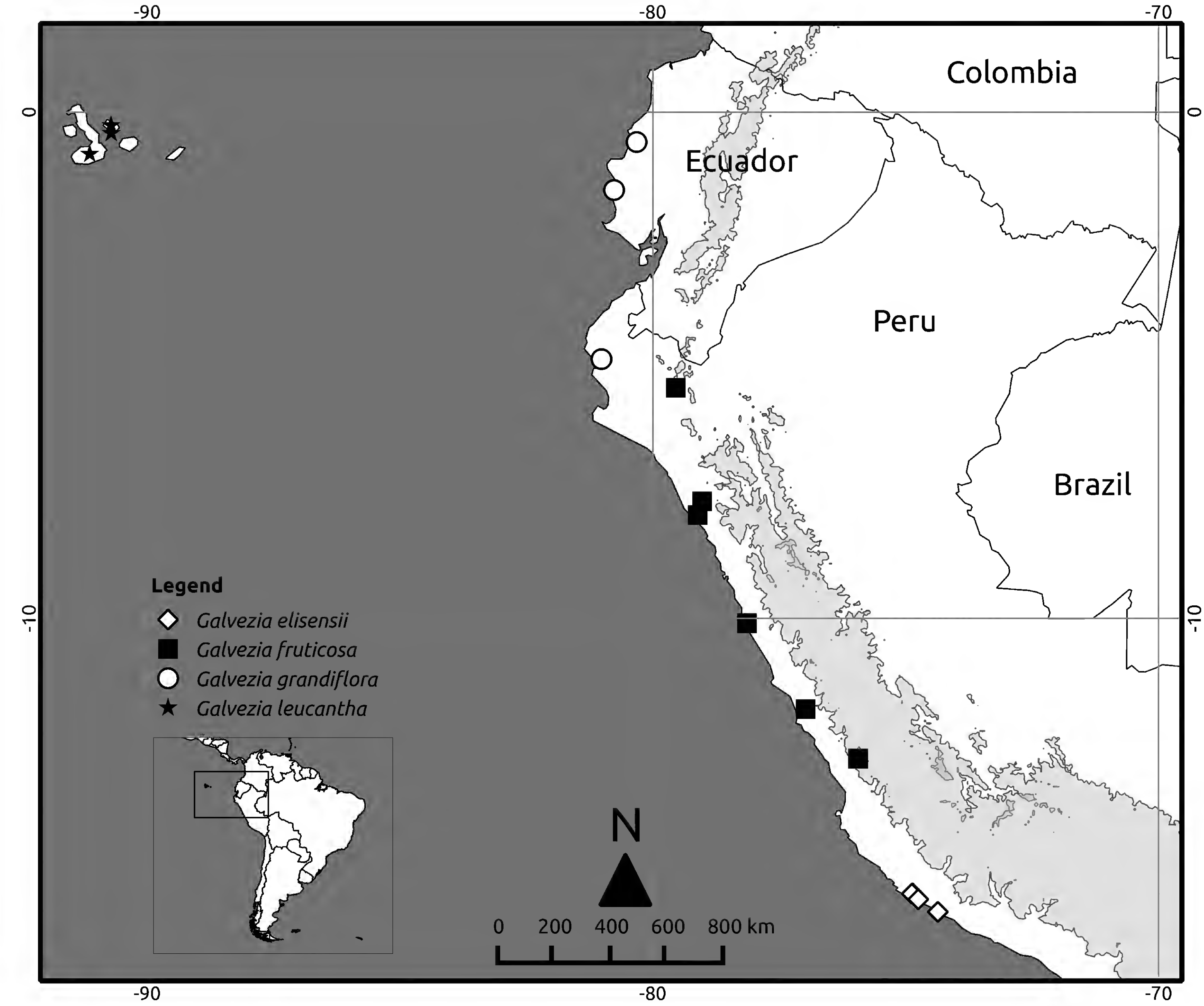

Fig. 3. Distribution of *Galvezia* in western Ecuador and Peru and the Galapagos Islands (Ecuador).

ing geographic isolation at certain times, and at other times, opportunities for merging species, thereby allowing for gene exchange. Paradoxically, this would have also allowed for fragmenting populations, shifting their ranges in relation to the near-ocean environments, adapting to changing conditions *in situ*, or undergoing range reductions and extinction.

The situation in *Galvezia* seems to conform to the pattern of other species reflecting sectoring and influence of past climate changes. The close relationship between *G. fruticosa* (northern sector) and *G. elisensii* (southern sector) suggests a north to south pattern. The relationship with the northern Peruvian and Ecuadorian populations included in *G. grandiflora* (i.e., *G. lanceolata* + *G. ballii*) suggests a pattern influenced by the most recent climatic change during the last glacial cycle (Weng et al. 2006).

Evolutionary Relationships.—Elisens (1992) admitted, that while isozyme data could not resolve evolutionary relationships among *G. fruticosa*, *G. elisensii* (as *G. sp. nov.*), and *G. leucantha*, the close affinity of these species was supported by several shared, advanced, morphological characters, a large number of shared alleles and separation from *G. grandiflora* (as *G. ballii* and *G. lanceolata*) in all networks.

Additional material examined: **PERU. Arequipa:** Provincia Caravelí, Sur de Nazca entre Km 518 y Km 590, 15°26'S, 74°52'W, 80 m, 13 Nov 2005, *M.O. Dillon, V. Quipuscoa, E. Ortiz, M. Corrales & G. Castillo 8792, 8796* (HUSA, F); Distrito Bella Unión: ca. Km 544 Panamericana Sur, entre División Puerto Lomas y Chaviña, 15°33'06.2"S, 74°45'11.4"W, 57 m, 09 Jun 2012, *V. Quipuscoa S., S. Montesinos R., L. Apaza Ch. & F. Miauri Ch. 5058* (HUSA, F, USM, HAO, HUT). **Ica:** Provincia Ica. ¼ mi W of Pan-American Hwy, 15°26'30.5"S, 74°52'50.7"W, 280 m, 19 Feb 1994, *T. Anderson, J. McAulifee, K. & F. Katterman, C. Diaz, C. Ostolaza, G. Lombardi, & W. Hodgson 7874* (ASU0047094, F2144517). Provincia

Nazca, Marcona: Sur de Nazca entre Km 518 y Km 590, 15°26'S, 74°52'W, 80–310 m, 13 Nov 2005, *M.O. Dillon, J. Wen, V. Quipuscoa, E. Ortiz, M. Corrales, & G. Castillo 8792* (F2276589), *8796* (F2276592); Panamericana Km 424 (ca. 2 km S of Mirador Maria Reiche on the Nazca geoglyphs), 700–750 m, 1 Oct 1997, *M. Weigend & H. Förther 97/631* (F2184045). Provincia Pisco, 1 km before Puente Huaytará (Km 73 road Pisco-Ayachucho), 1450 m, 29 Sep 1997, *M. Weigend & H. Förther 97/586* (F2184124).

2. Galvezia fruticosa J.F. Gmel., Syst. Nat. 2:937. 1791. (**Fig. 3**). Type: PERU. Lima: 1779, *J. Dombey 7* (holotype: MPU020307; isotypes: BM, K000528873).

Dodartia fragilis Ruiz & Pav., Syst. Veg. Fl. Peruv. Chile 1:97. 1798. Type. PERU. Lima: *Ruiz López & Pavón s.n.* (holotype: MA815219, based upon *Galvezia* Dombey ex A.L. Jussieu).

Agassizia limensis Dombey ex Chav., Monog. Antirrh. 180, tab 11, 1833. Type. PERU. Lima: *J. Dombey 7* (holotype: MPU020307; isotypes: BM001010978, K).

Galvezia limensis (Dombey ex Chav.) Benth., in DC., Prodr. 10:296. 1846.

Galvezia fruticosa is distributed along coastal Peru from Lima, north to Piura. It exhibits considerable environmental latitude with populations ranging to interior habitats along the western versant of the Andes. Overall, the dimensions of leaves are larger, and the blades wider and ovate to lanceolate with distinct petioles. A few isolated populations in the north have leaf morphologies approaching those exhibited by *G. elisensii* to which it is putatively most closely related (Elisens 1992).

Specimens examined: **PERU. Ancash:** Provincia Casma, ca. 48 km N of Pativilca on PanAmericana Hwy, 10 m, 13 Oct 1984, *M.O. Dillon & M. Whalen 4007* (F1953250). Provincia Huarmey, Panamericana Norte Km 660, 47 m, 10 Oct 2000, *M. Weigend, H. Förther, & N. Dostert 2000/667* (F2229797). Provincia Recuay, Km 46 on road from Pativilca to Recuay, ca. 580 m, 27 Jan 1983, *M. Dillon, U. Molau, & P. Matekaitis 3073* (F1932856). **Cajamarca:** Provincia Contumazá, Ascope – Algarrobal, 150 m, 29 Dec 1983, *A. Sagástegui A. & J. Mostacero L. 11332* (F1942599); El Portachuelo, 780 m, 20 Apr 1984, *A. Sagástegui A. 11388* (F1949672); Rupe – Huertas, 1200 m, 17 Jun 1994, *A. Sagástegui A., S. Leiva G., & P. Lezama A. 15362* (F2145086); Contumazá, La Paloma, 950 m, 5 May 1984, *I. Sánchez Vega 3390* (F1953515); San Miguel, entre Quindén y Platanar, 650–1100 m, 6 Oct 2001, *E. Rodríguez R., E. Alvítez I., E. López M., J. Cabrera C. & J. Chávez G 2411* (F2230009). **La Libertad:** Provincia Trujillo, base Cerro Campana, 150 m, 9 Jun 1985, *J. Mostacero L. et al. 696* (F1994334). **Lima:** Provincia Canta, Canta Valley, 26 km N of Lima, 350 m, 4 Aug 1957, *P.C. Hutchison 1001* (F1569722). Provincia Yauyos, road from Pacaran to Yauyos, Km 35.8 after Pacaran, 1500 m, 12°46'12"S, 77°56'41"W, 6 Oct 2002, *M. Weigend, M. Ackermann, A. Cano, M. I. La Torre 7209* (F2247324).

3. Galvezia grandiflora (Benth.) Wettst., Nat. Pflanzenfam. 4(3b):61. 1891. (**Fig. 3**). *Galvezia limensis* var. *grandiflora* Benth. In: DC., Prodr. 10:296. 1846. Type. PERU. Piura: Payta [Paita], *F. Hall 10* (Holotype: K000528872).

Galvezia ballii Munz, Proc. Calif. Acad. Sci. ser. 4, 15:379. 1926. nom. illeg., superfluous renaming.

Galvezia lanceolata Pennell, Notul. Natl. Acad. Nat. Sci. Philadelphia 179:5. 1946. Type: ECUADOR. Manabí: above Aguas Blancas, on the road from Puerto López to Los Peñas, 9 Jul 1942, *O. Haught 3386* (holotype, PH, n.v.; isotype: US1708104, image 00122131).

Galvezia grandiflora encompasses the species diversity exhibited over a wide range of habitats extending from northern Peru (Province Paita, Department Piura) to central Ecuador (Prov. Manabí, 1°32'S, 80°44'W). It is unclear what factors have maintained genetic differentiation between *G. grandiflora,* with its southernmost distributional terminus in northern Piura, and *G. fruticosa,* which extends north to the Sechura Desert (Elisens 1992).

Munz (1926, p. 379–380) discussed the validity of Wettstein's combination, but rejected it as confusing, and to eliminate confusion, he proposed *Galvezia ballii* Munz with collections by *J. Ball s.n.* types (US251553, image 00122129, US13223550, image 00122130). With the acceptance of Bentham's name as combined by Wettstein, *G. ballii* Munz becomes a superfluous renaming. The acceptance of Bentham's variety at the level of species also encompases the taxa formerly treated under *G. lanceolata* Pennell.

Specimens examined: **ECUADOR. Manabí:** between Bahía de Caráquez and San Agustín, 0–150 m, 9 May 1980, *G. Harling & L. Andersson 18957* (F1930417). **PERU. Piura:** Paita, Amotape, 4°53'S, 81°1'W, 18 Feb 1984, *C.P. Cowan 4487* (F2038375).

4. Galvezia leucantha Wiggins, Occas. Pap. Calif. Acad. Sci. 65:1. 1968. (**Fig. 3**). Type: ECUADOR. Galápagos Islands: Isla Isabela, 29 Jan 1967, E side of ridge near foot of Tagus Cove Mountain, NE of Caleta Tagus (Tagus Cove), ca. 1.5 to 2 km from the beach, about 95 m, *I.L. Wiggins & D. Porter 247* (holotype: CAS633842, image 002778; isotype: K).

Galvezia leucantha, including its various subspecies, is restricted to the Galapagos Islands (Ecuador) and has been discussed and mapped (Elisens 1989; McMullen & Elisens 2000; Tye & Jäger 2000; Jaramillo-Díaz et al. 2014).

Wiggins (1968) described *G. leucantha* subsp. *leucantha* stating (p. 4) the following, "The most striking feature differentiating this species from those heretofore placed in *Galvezia* is the waxy white corolla. All the species of *Galvezia* described previously have deep red corollas, none of the shades within their range even approaching pink or white." However, far from being a discriminating character, corolla color is variable. McMullen (pers. comm.) has observed that on Rabida Island *Galvezia* are described as possessing "... outside of the corolla is completely reddish purple, while the insides ranges from pink to white." (McMullen & Elisens 2000). Further, Tye and Jäger (2000) described the *Galvezia* on Santiago Island with the following corolla description "... exterior magenta with the tips of the upper lobes white, while the interior is pink and white striped." Wiggins went on to state that "... the calyx lobes of *G. leucantha* are considerably more slender, longer in relation to their width, and long in *toto* than those in *G. fruticosa*. Whereas the calyx and pedicles of *G. fruticosa* are closely glandular-puberulent, the calyces and pedicles of *G. leucantha* are wholly glabrous." Obviously, for the discrimination of these subspecies, it is best to rely upon comparative morphology or geography of collections rather than their corolla color.

Galvezia leucantha subsp. **leucantha** Wiggins

Galvezia leucantha subsp. **porphyrantha** Tye & H. Jäger, Novon 10:165. 2000. Type: ECUADOR. Galápagos Islands: Isla Santiago, Cerro entre Bahía Ladilla y Cabo Nepean, 13 Nov 1998, ca. 40 m, *H. Jäger y A. Tye 53* (holotype: CAS1084133, bcode#0002779; isotype: CAS1084015, image 0002780).

Galvezia leucantha subsp. **pubescens** Wiggins, Occas. Pap. Calif. Acad. Sci. 65:6. 1968. Type: ECUADOR. Galápagos Islands: Isla Rábida (Jervis Island), occasional near the shore and from 500–950 ft, 20 Dec 1905, *A. Stewart 3441* (holotype: CAS, n.v.).

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BOOK NOTICE

Paul E. Minnis, ed. 2014. **New Lives for Ancient and Extinct Crops.** (ISBN-13: 978-0-8165-3062-5, hardcover). University of Arizona Press, PO Box 210055, Tucson, Arizona 85721-0055, U.S.A. (**Orders:** www.uapress.arizona.com, 1-800-621-2736). $65.00, 288 pp., 25 photos, 22 illustrations, 13 tables, index, 6" × 9".

From the publisher: Over many millennia, farmers across the world have domesticated literally thousands of species and developed tens of thousands of varieties of these plants. Despite the astonishing agricultural diversity that existed long ago, the world's current food base has narrowed to a dangerous level. By studying the long and dynamic history of farming in the ancient past, archaeology can play a part in helping ensure the stability of the human food supply by identifying once-important crops and showing where and how such crops were grown in the past. Thanks to this work, extinct crops might even be redomesticated from their wild progenitors.

New Lives for Ancient and Extinct Crops profiles nine plant species that were important contributors to human diets and had medicinal uses in antiquity: maygrass, chenopod, marshelder, agave, little barley, chia, arrowroot, little millet, and bitter vetch. Each chapter is written by a well-known scholar, who illustrates the global value of the ancient crop record to inform the present. From eastern and western North America, Mesoamerica, South America, western Asia, and south-central Asia, the contributors provide examples of the unexpected wealth of information available in the archaeological record about ancient and extinct crops.

PAUL E. MINNIS is a professor of anthropology at the University of Oklahoma and former president of the Society of Ethnobiology. He is editor of *Ethnobotany: A reader* and coeditor of *Biodiversity and Native America*.

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A NEW SPECIES OF *CREMOSPERMA* (GESNERIACEAE) FROM NORTHEASTERN PERU

Brian R. Keener
Department of Biological
& Environmental Sciences
The University of West Alabama
Livingston, Alabama 35470, U.S.A.
BKeener@uwa.edu

John L. Clark
Department of Biological Sciences
Box 870345
The University of Alabama
Tuscaloosa, Alabama 35487, U.S.A.

ABSTRACT

Recent fieldwork and investigations of herbarium specimens during a preliminary revision of *Cremosperma* (Gesneriaceae) have resulted in the discovery of a new species. The new species, **Cremosperma inversum** B.R. Keener & J.L. Clark, is distinguished from other species in the genus by a suite of characters including orbicular leaves, stoloniferous habit, and tomentose-wooly indument on the upper leaf surface. The distribution of trichomes on the adaxial leaf surface is clustered in the center of the bullae and away from the more or less glabrous veins and glabrous on the abaxial leaf surface away from the more densely pubescent veins. This species is endemic to sandstone outcrops in the Department of Amazonas in northwestern Peru.

RESUMEN

Expediciones recientes al noroccidente de Perú, y el estudio de las colecciones de herbario como parte de la revisión preliminar del género *Cremosperma* (Gesneriaceae), han dado como resultado el descubrimiento de una nueva especie. La nueva especie, **Cremosperma inversum** B.R. Keener & J.L. Clark, se distingue de las otras especies del género por un conjunto de caracteres que incluye: hojas orbiculares, hábito estolonífero e indumento tomentoso-lanoso en el haz de la lámina. Los tricomas en la superficie adaxial de la lámina están agrupados entre las venas, las cuales son más o menos glabras, mientras que, en la superficie abaxial las venas son pubescentes y el resto de la superficie es más o menos glabra. Esta especie es endémica de los afloramientos rocosos en el departamento de Amazonas, noroccidente peruano.

KEY WORDS: *Cremosperma*, Gesneriaceae, Taxonomy, Flora of Peru, Amazonas Department, Sandstone

INTRODUCTION

Cremosperma is a genus of terrestrial or saxicolous herbs ranging from Costa Rica to Peru. The genus is a strongly supported monophyletic lineage in the New World tribe Beslerieae (Clark et al. 2010; Roalson & Clark 2006; Smith 2000). Taxonomic and phylogenetic information for *Cremosperma* were recently summarized in Clark and Skog (2011). Until now, the only other known *Cremosperma* located south of Ecuador was the endemic Peruvian species *Cremosperma peruvianum* L.E. Skog (Skog 1982).

Kvist and Skog (1988) provided a traditional monograph of the Ecuadorian species and included 14 taxa, several of which also occur in Colombia and estimated the total diversity of *Cremosperma* to be 23 species. The following three *Cremosperma* species have been described since Kvist and Skog (1988): *Cremosperma micropecten* Fern. Alonso from Colombia (Fernández-Alonso 2006); *Cremosperma anisophyllum* J.L. Clark & L.E. Skog from Ecuador (Clark & Skog 2011); and *Cremosperma verticillatum* J.L. Clark & B.R. Keener from Ecuador (Clark & Keener 2011). Recent fieldwork in Ecuador, Panama, and Colombia has resulted in the discovery of additional *Cremosperma* species that will be described in the near future. The description of *Cremosperma inversum* brings the total published diversity of the genus to 27 species and the second species from Peru.

TAXONOMIC TREATMENT

Cremosperma inversum B.R. Keener & J.L. Clark, sp. nov. (**Fig. 1**). TYPE: PERU. AMAZONAS: Bagua district, Cerro Tayu, ca. 1 hour from Chiriaco, 05°15'56"S, 78°22'07"W, 800 m, 19 Mar 2001, *H. van der Werff, R. Vasquez & B. Gray 16240* (HOLOTYPE: US; ISOTYPES: F, MO, NY).

Differs from *Cremosperma peruvianum* by the presence of orbicular leaves (vs. oblong) and tomentose-wooly indument on upper leaf surface (vs. sparsely villous indument).

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Terrestrial herb; stems 5–25 cm long, creeping to stoloniferous proximally, rooting at nodes, ascending to erect distally, rarely branched, slightly angled to sulcate, tomentose with septate, uniseriate trichomes, also with small amber colored glandular protuberances. **Leaves** opposite, isomorphic, petiolate; petioles terete, 4–15 mm long, tomentose; blades widely elliptic to orbicular, 1.0–3.8 × 0.9–3.5 cm, base symmetrical to slightly oblique, rounded to slightly cordate, apex rounded, margin crenate with broad shallow teeth, bullate when fresh, membranaceous and flat when dry, abaxially dark green, tomentose on veins, with glandular protuberances in area between lateral veins, adaxially dark green, densely tomentose in area between veins, slightly tomentose on veins. **Inflorescence** a reduced pair-flowered cyme, appearing clustered and pseudo-umbellate, in upper leaf axils, peduncle 2–3 cm long, (1–)2–5 mature flowers/inflorescence, often with remnant pedicel scars appearing gland-like; bracts absent. **Flowers** pedicellate, pedicels 2–5 mm long, pilose; calyx 3.5–4.5 mm long, lobes 5, fused for 1/2–3/4 of their length, equal, lobes erect during anthesis, persistent and spreading in fruit to form a splash cup, apex rounded to obtuse, uniformly green, outside pilose, inside glabrous; corolla 10–11 mm long, tubular, slightly to strongly curved in lower 1/3, base to mid-region 1.5 mm in diameter, throat 2.5 mm wide at apex, white with yellowish upper region of throat, outer surface of tube glabrous proximally, pilose distally, throat and corolla lobes abaxially pilose, inner surface of tube glabrous, throat and base of corolla lobes pilose, corolla lobes glabrous distally, limb bilaterally symmetrical, lobes reflexed and unequal, oblanceolate to spatulate, lower three lobes ca. 3.1 × 3.0 mm, upper two lobes 2.1 × 2.1 mm, margins entire to slightly crenulate, slightly undulate; stamens 4, didynamous, included; filaments adnate to corolla tube, abaxial filaments free for 1.5 m, adaxial filaments free for 0.8 mm, glabrous; anthers broader than long, ca. 0.5 × 1.0 mm; staminode absent; nectary enclosing the ovary on one side, glabrous, ca. 1.1 mm long; ovary superior, glabrous, ca. 1.1 × 1.5 mm, style and stigma glabrous. **Fruit** a dry bivalved capsule that dehisces laterally as it matures and appears 4-valved, globose, ca. 2.0 mm in diameter; seeds numerous, irregularly elliptic to ovoid, often slightly arched, ca. 0.5 × 0.2 mm, reddish brown, surface shallowly alveolate, cavities usually longer than wide.

Cremosperma inversum is differentiated from other congeners by the small diminutive habit (to 10 cm tall). Other small *Cremosperma* species include *C. muscicola* L.P. Kvist & L.E. Skog, *C. pusillilum* C.V. Morton, and *C. veraguanum* Wiehler. The isophyllous leaves in *C. inversum* differentiate it from the anisophyllous leaves of *C. veraguanum* and *C. muscicola*. The orbicular leaves in *C. inversum* readily differentiate it from congeners with oblong leaves. The only other known species of *Cremosperma* from Peru is *C. peruvianum*. The leaves in *C. peruvianum* are oblong in contrast to the orbicular leaves in *C. inversum*. These two species are geographically separated by 600+ km with *C. peruvianum* in the southern department of Huanuco and *C. inversum* in the northern province of Amazonas. The leaves in *C. inversum* are tomentose-wooly on the adaxial leaf surface with clustered trichomes in the center of the bullae and away from the more or less glabrous veins and glabrous on the abaxial leaf surface away from the more densely pubescent veins (Fig. 1A, B).

Distribution and habitat.—*Cremosperma inversum* is endemic to the Bagua district in the Department of Amazonas of northwest Peru. All of the currently known collections are from sandstone outcrops in a small area (less than 10 km) in mature lowland rainforest (400–800 m).

Etymology.—The new species name "*inversum*" is in reference to the seemingly inverse pubescence pattern on the abaxial and adaxial leaf surfaces. Adaxial surfaces are mostly glabrous along the veins and pubescence between veins. Abaxial surfaces are mostly pubescent only along the veins and glabrous between the veins (Fig. 1A, B).

Conservation and IUCN Red List category.—*Cremosperma inversum* is geographically limited to a small area in northwestern Peru. According to the IUCN Red List criteria (IUCN 2001) the limited geographic range (B2a, less than 10 km^2 and known to exist at only a single location) qualify *Cremosperma verticillatum* for being listed in the category CR (Critically Endangered).

Additional specimens studied: **PERU. Amazonas:** Bagua district, Quebrado El Almendro, 05°14'40"S, 78°21'24"W, 430 m, 9 Mar 1998, *H. van der Werff et al 14567* (US); Imaza, Tayu Mujaji, comunidad de Wawas, 05°15'25"S, 78°21'41"W, 800 m, 23 Oct 1997, *R. Rojas et al 428* (US); Tayu Mujaji, 05°15'56"S, 78°22'07"W, 800 m, 16 Feb 2002, *R. Vásquez 27590* (US).

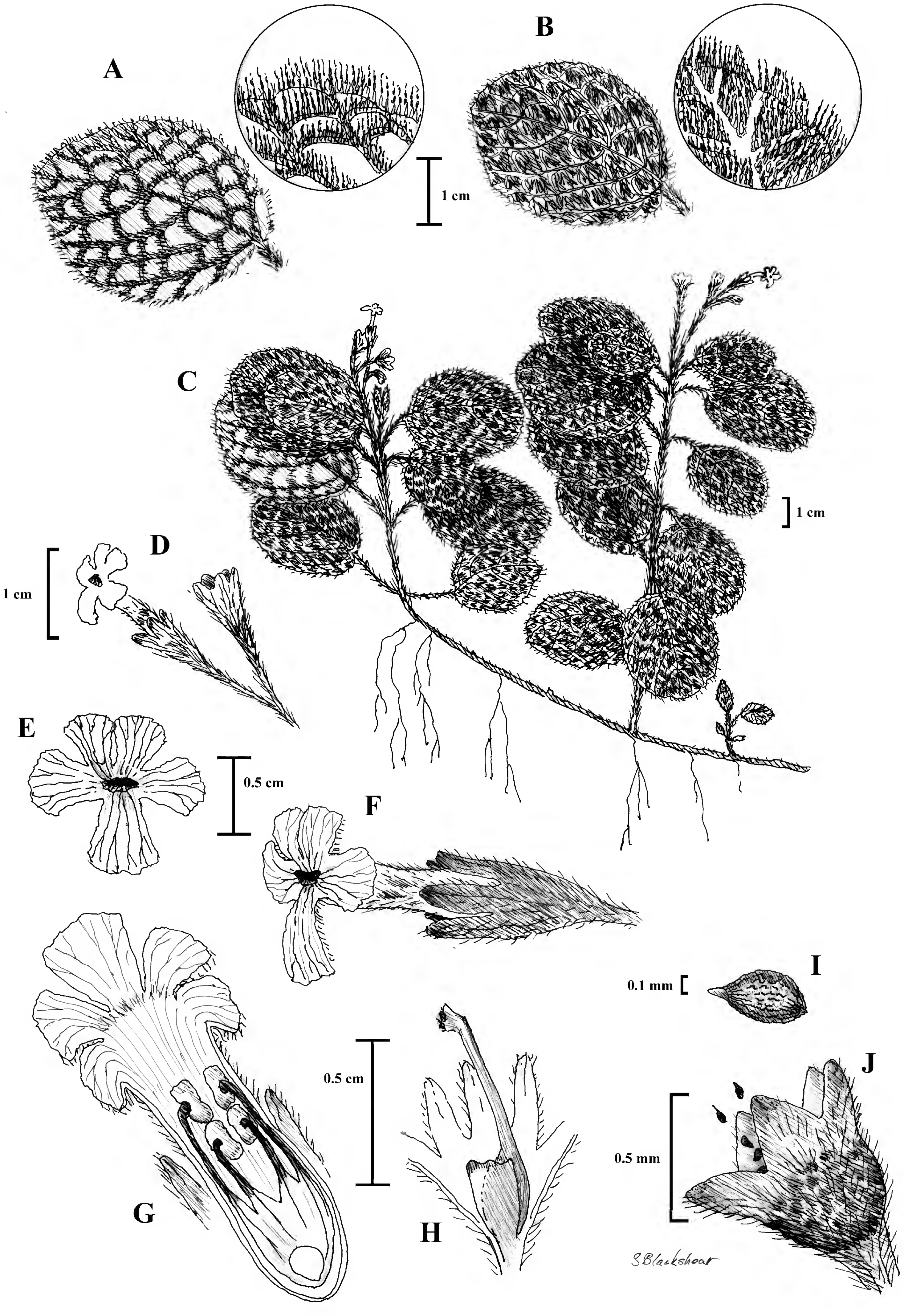

Fig. 1. Illustration of *Cremosperma inversum*. **A.** Abaxial leaf surface showing dense pubescence on veins and glabrous between veins. **B.** Adaxial leaf surface showing glabrous veins and tomentose between veins. **C.** Habit showing stolon. **D.** Inflorescence. **E.** Front view of corolla. **F.** Lateral view of flower. **G.** Lateral view of open flower showing androecium. **H.** Calyx showing truncate scale-like gland. **I.** Seed. **J.** Mature fruit with persistent calyx. (A–J from the holotype, *H. van der Werff et al. 16240* (US).

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THREE NEW SPECIES OF *SENEGALIA* (FABACEAE) FROM BRAZIL

David S. Seigler*
Department of Plant Biology
University of Illinois
Urbana, Illinois 61801, U.S.A.
seigler@life.illinois.edu
**corresponding author*

John E. Ebinger
Department of Biology
Eastern Illinois University
Charleston, Illinois 61920, U.S.A.

Petala Gomes Ribeiro and Luciano Paganucci De Queiroz
Botânica
Universidade Estadual de Feira de Santana
Av. Transnordestina, s/n, Novo Horizonte
44036-900, Feira de Santana, Bahia, BRASIL
petalagribeiro@gmail.com; lqueiroz@uefs.br

ABSTRACT

Senegalia irwinii Seigler, Ebinger, & P.G. Ribeiro from the states of Bahia, Minas Gerais, and Rio de Janeiro; **S. harleyi** Seigler, Ebinger, & P.G. Ribeiro from the states of Bahia, Minas Gerais, and Paraná; and **S. hatschbachii** Seigler, Ebinger, & P.G. Ribeiro from the states of Minas Gerais, Paraná, and São Paulo in Brazil are described, illustrated and compared to their probable nearest relatives, *Senegalia mattogrossensis* (Malme) Seigler & Ebinger, *Senegalia martiusiana* (Steud.) Seigler & Ebinger, and *Senegalia tucumanensis* (Griseb.) Seigler & Ebinger, respectively.

Key Words: Fabaceae, IUCN Red List, Mimosoideae, *Senegalia*

RESUMEN

Se describen, ilustran y comparan, las especies **Senegalia irwinii** Seigler, Ebinger, & P.G. Ribeiro de los estados de Bahia, Minas Gerais, y Rio de Janeiro; **S. harleyi** Seigler, Ebinger, & P.G. Ribeiro de los estados de Bahia, Minas Gerais, y Paraná; y **S. hatschbachii** Seigler, Ebinger, & P.G. Ribeiro de los estados de Minas Gerais, Paraná, y São Paulo de Brasil, con las especies afines, probablemente más cercanas, Senegalia mattogrossensis (Malme) Seigler & Ebinger, *Senegalia martiusiana* (Steud.) Seigler & Ebinger, y *Senegalia tucumanensis* (Griseb.) Seigler & Ebinger, respectivamente.

The genus *Senegalia* has previously been treated as part of *Acacia* s.l., but recent morphological and genetic studies have shown that this large genus is polyphyletic. Relationships within the genus *Acacia* s.l., as well as the position of the genus within the Mimosoideae have been clarified by data from molecular studies (Maslin et al. 2003a; Miller & Bayer 2003; Luckow et al. 2003; Miller et al. 2003; Rico-Arce & Bachman 2006; Seigler et al. 2006a; Bouchenak-Khelladi et al. 2010; Gómez-Acevedo et al. 2010; Murphy et al. 2010; Miller & Seigler 2012; Kyalangalilwa et al. 2013). Based on both morphological and molecular data, *Acacia* s.l. is now regarded as comprising at least five genera, *Acacia* s.s., *Acaciella* Britton & Rose (1928), *Mariosousa* Seigler & Ebinger (Seigler et al. 2006b), *Senegalia* Raf. (1838), and *Vachellia* Wight & Arnott (1834) (see Miller & Seigler 2012 for overview of the new generic classification).

Members of *Senegalia* are shrubs, trees, or lianas, unarmed or armed with prickles, but without stipular spines. The prickles usually are scattered, but less commonly are grouped in twos or threes, usually at or near the nodes (Vassal 1972). Leaves are bipinnate and the petiole and primary rachis have sessile or stipitate glands of variable position. Flowers possess a more or less tubular nectary below the usually stipitate ovary. Inflorescences are globose heads (capitula) or spikes, often grouped into complex terminal pseudo-inflorescences or synflorescences. Pods are dehiscent, separating into two valves at maturity, or less commonly indehiscent or separating into indehiscent one seeded articles. The seeds are uniseriate.

The genus *Senegalia* consists of approximately 100 taxa in the Americas (unpublished data), as well as 69

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in Africa, 43 in Asia, and two in Australia (Maslin et al. 2003a,b). Eight species occur in two or more areas. Approximately half of the American species occur in Brazil. During the course of our work on the genus *Senegalia* Raf. of Brazil, three undescribed species were noted from herbarium materials of Bahia, Minas Gerais, Paraná, São Paulo, and Rio de Janeiro. These taxa are clearly distinctive and are herein proposed as new species.

Senegalia irwinii Seigler, Ebinger, & P.G. Ribeiro, sp. nov. (**Fig. 1**). Type: BRAZIL. Minas Gerais: 40 km E of Belo Horizonte, near BR-31, 1800 m, 16 Jan 1971, *H.S. Irwin, R.M. Harley & E. Onishi 30523* (holotype: MO; isotypes: MBM, NY).

Senegalia irwinii Seigler, Ebinger & P.G. Ribeiro differs from other Senegalia species by leaf size (100–170 mm long), petiolar gland usually one or two, columnar (1.1–3.1 mm) apex 0.5–0.8 mm in diameter, pinnae 5 to 11 pairs/leaf (60–115 mm), 10–18 mm between pinna pairs, leaflets 45 to 85pairs/pinna, midvein subcentral; inflorescence a globose head 14–20 mm across, flowers sessile or subsessile, ovary glabrous.

Climbing **shrub** or small **tree** to 5 m tall; bark not seen; twigs dark purplish brown, not to slightly flexuous, terete to slightly ridged, glabrous to lightly puberulent; short shoots absent; prickles dark purplish brown throughout, flattened, recurved to rarely straight, woody, 1–4 × 1–4 mm at the base, glabrous, scattered along the twig, petiole and rachis. **Leaves** alternate, 100–170 mm long; stipules dark brown, linear, symmetrical, flattened, straight, herbaceous, 2–5 × 0.2–0.5 mm near the base, glabrous to puberulent, early deciduous; petiole adaxially grooved, 20–38 mm long, lightly puberulent; petiolar gland usually 1 or 2, one located near the middle of the petiole, one at or near the first pinna pair, columnar, 1.1–3.1 mm long, apex 0.5–0.8 mm across, orbicular, depressed, glabrous; rachis adaxially grooved, 80–135 mm long, lightly puberulent, a columnar gland 0.6–1.2 mm long usually between the upper, and sometimes other pinna pairs, apex 0.4–0.8 mm across, orbicular, depressed, glabrous; pinnae 5 to 11 pairs/leaf, 60–115 long, 10–18 mm between pinna pairs; paraphyllidia 0.8–1.4 mm long; petiolule 1.9–4.2 mm long; leaflets 45 to 85 pairs/pinna, opposite, 0.6–1.2 mm between leaflets, linear, 6–12 × 1.2–1.8 mm, lightly pubescent with appressed hairs beneath, shiny and glabrous above, lateral veins not obvious, 1 vein from the base, base oblique, truncate on one side, margins lightly ciliate, apex acute, midvein subcentral. **Inflorescence** a densely 20- to 40-flowered globose head 14–20 mm across, in axillary and terminal pseudo-paniculate clusters, the main axis to 300 mm long; peduncles 5–15 × 0.4–0.6 mm thick, puberulent; receptacle not enlarged, slightly elongated; involucre rarely a single small bract located medially on the peduncle, early deciduous; floral bracts spatulate, 0.8–1.2 mm long, puberulent, early deciduous. **Flowers** sessile or subsessile, cream; calyx 5-lobed, 2.5–3.2 mm long, puberulent; corolla 5-lobed, 3.4–4.2 mm long, glabrous or nearly so, lobes one-quarter the length of the corolla; stamens 50 to 70; stamen filaments 8–10 mm long, distinct; anther glands absent; ovary glabrous, sessile to short-stalked. **Fruits** oblong, 75–130 × 22–28 mm, straight, flattened, not constricted between the seeds, chartaceous, transversely striated, puberulent, eglandular, dehiscent along both sutures; stipe 8–12 mm long; apex obtuse, short beaked. **Seeds** not seen.

Distribution and ecology.—Deciduous to evergreen savannas, disturbed second growth forest and thickets from 1,100 to 1,800 m in the states of Bahia, Minas Gerais, and Rio de Janeiro in eastern Brazil.

Phenology.—Flowering Jan–Mar.

Local Names and Uses.—None known.

Etymology.—*Senegalia irwinii* is named after Howard S. Irwin, a well-known authority on Fabaceae, who led eight expeditions to Brazil and Guiana between 1960 and 1972, and collected extensively in northeastern Brazil.

IUCN Red List category.—DD, data deficient. A rare endemic restricted to the states of Bahia, Minas Gerais and Rio de Janeiro, Brazil. As we have seen fewer than 10 collections, the species is possibly threatened (IUCN 2001).

Paratypes: **BRAZIL: Bahia:** 3 km da divisa Minas Gerais, 9 Jul 1964, *L. Duarte & A. Castellanos 297* (NY, RB). **Minas Gerais:** 10 km. by road N of Gouvêia, 1320 m, 11 Apr 1973, *W.R. Anderson 8664* (CM, F, NY, UB); Jardim Botanico, Belo Horizonte, 15 Jan 1934, *M. Barreto 6458* (F); 17 km NE of Diamantina, road to Mendanha, 1250 m, 29 Jan 1969, *H.S. Irwin, R. Reis dos Santos, R. Souza & S.F. da Fonseca 22870* (MO, NY, US); Belo Horizonte, campus da UFMG, 4 May 1995, *J.A.Lombardi & L.G. Temponi 760* (NY); 1879, *J. Miers 241b* (BM); Brumadinho, Inhotim, Borda de mata semi decidua da trilha da Caixa D'Agua, 20°08'21"S, 44°14'13"W, 870 m, 22 Jan 2008, *J.G. Oliveira & F.M. Rodrigues 55* (BHCB). **Rio de Janeiro:** Município de Campos dos Goytacazes, Bom Jesus, Assentamento dos Sem Terra (núcleo 1-N1), mata do Bom Jesus, mato do Caixãou mata da Santa Casa, 3 Oct 2000, *J.M.A. Braga 6340* (RB); Rio das Ostras, Reserva Biológica a União, 50 m, 14 Jun 2001, *J.M.A. Braga 6667* (MBM, NY, RB).

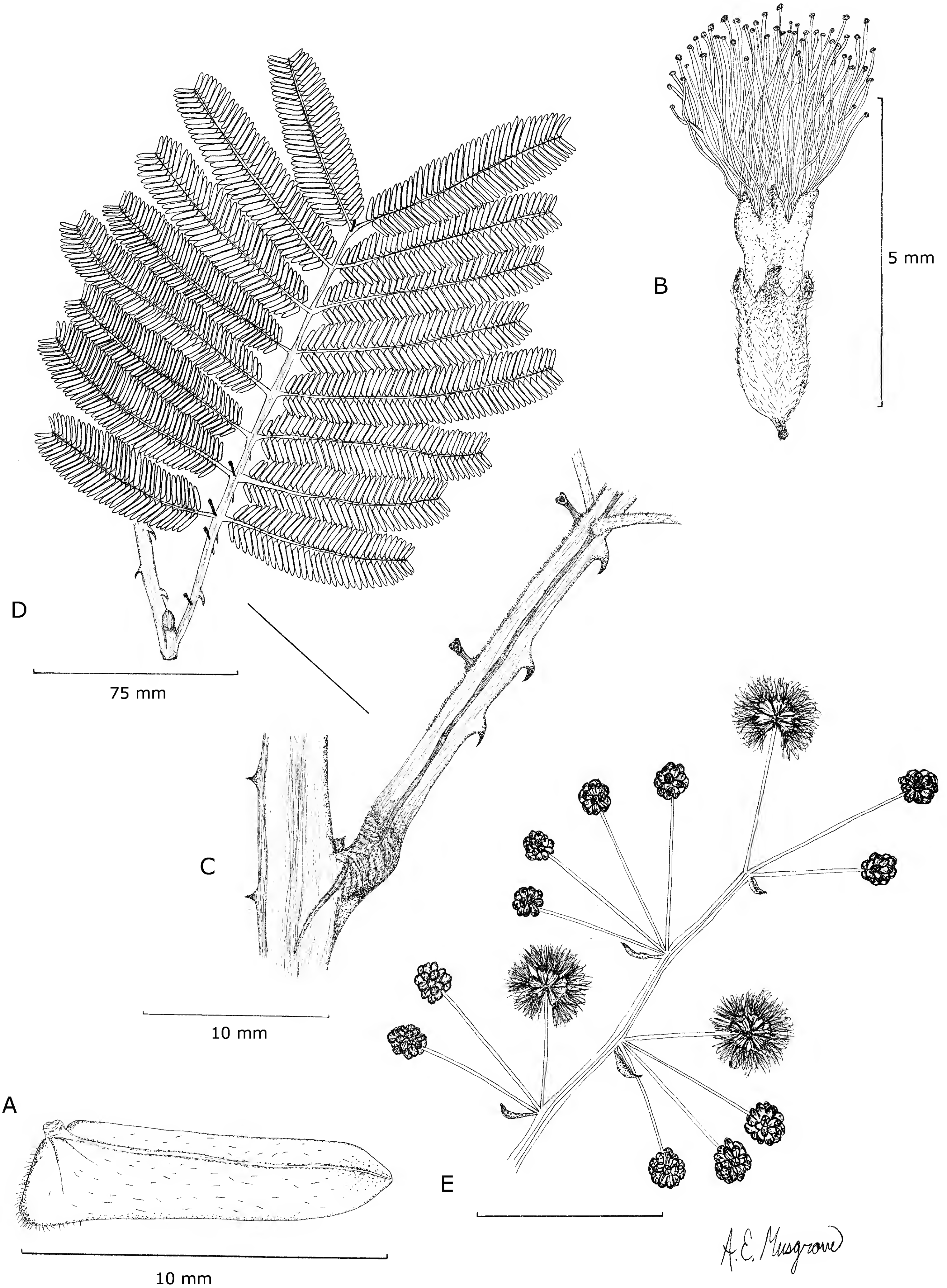

Fig. 1. *Senegalia irwinii* Seigler, Ebinger, & P.G. Ribeiro; **A.** leaflet, adaxial surface; **B.** flower; **C.** portion of twig and petiole with prickles and petiolar glands; **D.** leaf; **E.** pseudo-inflorescence. A, B, D from *Irwin et al. 30523* (NY); C, E from *Irwin et al. 22870* (MO).

Morphologically similar to *Senegalia mattogrossensis* (Malme) Seigler & Ebinger, this new species has a comparable range in eastern Brazil, but grows at a higher elevation, occurring above 1,100 m. *Senegalia mattogrossensis*, in contrast, is found below 1,000 m. Morphologically, these two taxa are distinct with *S. mattogrossensis* being densely pubescent on the twig; petiole and rachis with yellow hairs to 0.8 mm long. *Senegalia irwinii,* in contrast, lacks the yellow pubescence, the twig, petiole, and rachis are glabrous to lightly puberulent with gray hairs. This taxon also has leaflets that are consistently 6–12 mm long whereas *S. mattogrossensis* has leaflets shorter than 6.5 mm in length

Senegalia harleyi Seigler, Ebinger, & P.G. Ribeiro, sp. nov. (**Fig. 2**). Type: BRAZIL. Bahia: 12 km SE of Barra do Choça, road to Itapetinga, 700 m, 30 Mar 1977, *R.M. Harley, S.J. Mayo, R.M. Storr, T.S. Santos & R.S. Pinheiro 20161* (holotype: NY; isotypes: CEPEC, IPA, RB, UEC, US).

Senegalia harleyi Seigler, Ebinger & P.G. Ribeiro differs from other *Senegalia* species by leaf size (60–130 mm long), petiolar glands one to three scattered along the petiole, sessile, oval to orbicular (0.7–2.5 mm across), pinnae 11 to 25 pairs/leaf, distance between pinna pairs (3–7 mm), leaflets 38 to 80 pairs/pinna, distance between leaflet pairs (0.2–0.4 mm), midvein subcentral; inflorescence a globose head 12–16 mm across, flowers sessile, anther glands present, ovary glabrous.

Climbing **shrub** or small **tree** to 5 m tall; bark not seen; twigs dark brown to dark purplish brown, slightly flexuous, terete to slightly ridged, densely pubescent with mostly erect dark brown hairs to 0.6 mm long; short shoots absent; prickles dark brown below, commonly lighter brown above, flattened, commonly recurved, woody, 1–3 × 1–3 mm at the base, densely pubescent with straight hairs, common in lines on the twig ridges, also on petiole and rachis. **Leaves** alternate, 60–130 mm long; stipules dark brown, linear, symmetrical, flattened, straight, herbaceous, 2–5 × 0.3–0.8 mm, densely ciliate, early deciduous; petiole shallowly adaxially grooved, 6–15 mm long, densely pubescent; petiolar glands 1 to 3, scattered along the petiole with one just below the first pinna pair, sessile, oval to orbicular, 0.7–2.5 mm across, apex flattened or the margins raised to form a cup, glabrous; rachis adaxially grooved, 55–120 mm long, densely pubescent, an oval to orbicular gland 0.4–1.2 mm across between the upper 1 to 6, and sometimes other pinna pairs, apex cup-shaped, glabrous; pinnae 11 to 25 pairs/leaf, 23–58 mm long, 3–7 mm between pinna pairs; paraphyllidia 0.4–0.8 mm long, commonly absent; petiolule 0.4–1.1 mm long; leaflets 38 to 80 pairs per/pinna, opposite, 0.2–0.4 mm between leaflets, linear, 2.5–4.4 × 0.4–0.7 mm, glabrous to scattered pubescent below, lateral veins not obvious, 1 vein from the base, base oblique, margins ciliate, apex acute, midvein subcentral. **Inflorescence** a densely 20- to 35-flowered globose head 12–16 mm across, in terminal and axillary pseudo-paniculate clusters, the main axis to 400 mm long; peduncles 4–9 × 0.4–0.7 mm thick, densely pubescent; receptacle elongated, not enlarged; involucre a small bract located on the upper half of the peduncle, early deciduous; floral bracts spatulate, 0.5–0.8 mm long, puberulent, early deciduous. **Flowers** sessile, white to cream; calyx 5-lobed, 1.4–2.1 mm long, puberulent; corolla 5-lobed, 2.3–3.5 mm long, puberulent, lobes one-sixth the length of the corolla; stamens 50 to 79; stamen filaments 6.5–8.0 mm long, distinct; anther glands present; ovary glabrous, sessile to subsessile. **Fruits** oblong, 60–130 × 13–26 mm, straight, flattened, not constricted between the seeds, chartaceous, lightly transversely striated, pubescent, eglandular, dehiscent along both sutures; stipe 6–11mm long; apex acuminate to obtuse, short beaked. **Seeds** 5–6 × 4–5 mm, ovate to elliptic, flattened, smooth; pleurogram U-shaped.

Distribution.—Humid tropical forest, disturbed second growth forests and thickets from 500 to 2200 m in the states of Bahia, Minas Gerais, and Paraná, Brazil.

Phenology.—Flowering Jan–Mar.

Local Names and Uses.—unha-de-gato (Mucugê- Bahia)

Etymology.—Named after Raymond M. Harley, authority on the flora of the caatinga of northeastern Brazil and collector of many legumes from that area.

IUCN Red List category.—DD, data deficient. *Senegalia harleyi* appears to be a relatively common species in eastern Brazil. As we have seen more than 35 collections of this species from Bahia, Minas Gerais, and Paraná, and it often occurs in disturbed second growth forests, it does not seem probable that *Senegalia harleyi* is threatened. However, humid tropical forest is disappearing and additional data concerning the future of *Senegalia harleyi* need to be obtained (IUCN 2001).

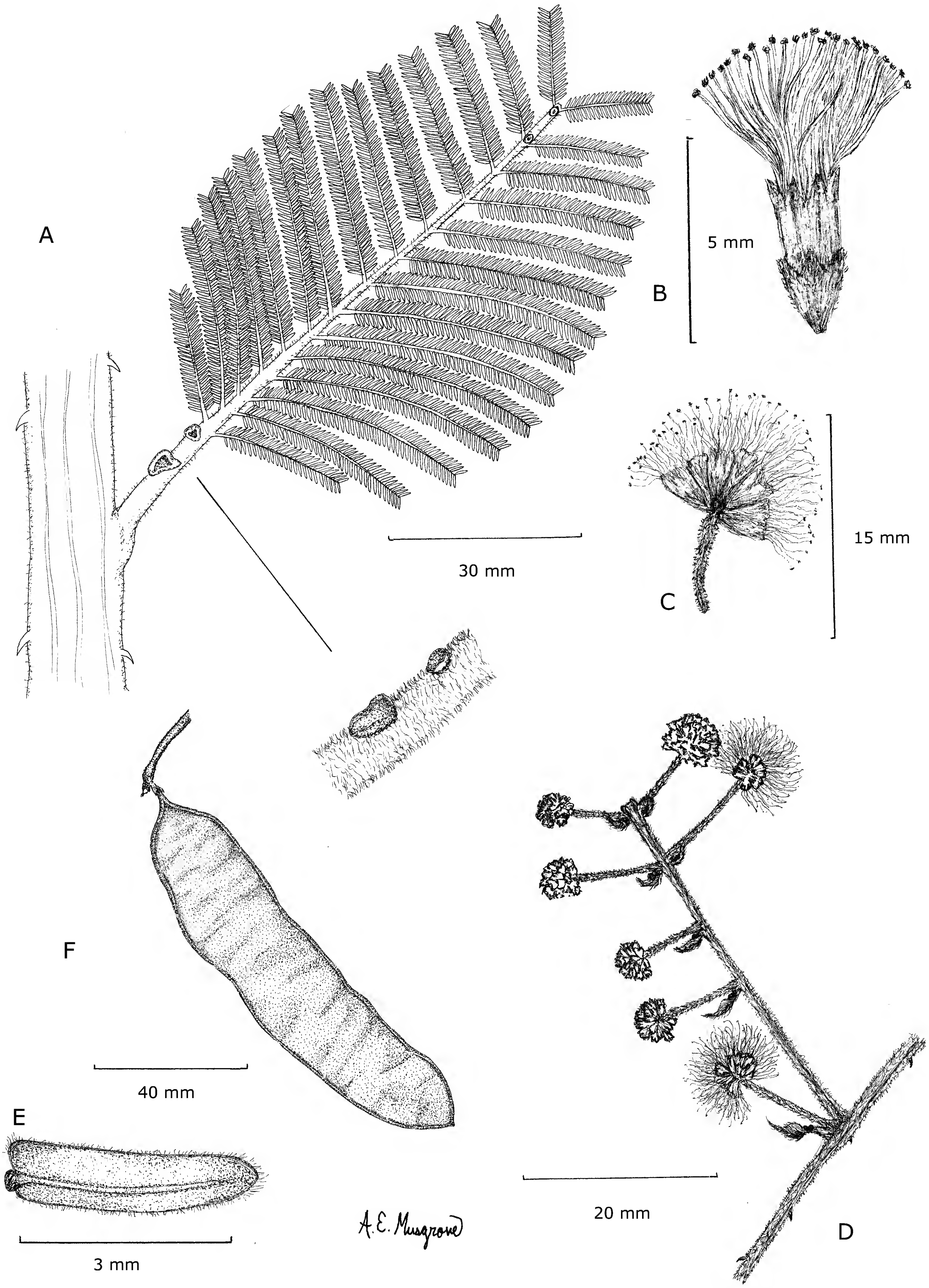

Fig. 2. *Senegalia harleyi* Seigler, Ebinger, & P.G. Ribeiro. **A.** Leaf habit with twig and petiolar glands; **B.** flower; **C.** inflorescence; **D.** pseudo-inflorescence; **E.** leaflet adaxial surface; **F.** fruit. A from *de Queiroz et al. 7118* (HUEFS); B, C, D from *Belém and Méndes 369* (NY); E, F from *de Queiroz et al. 7118* (HUEFS).

Paratypes: BRAZIL: Bahia: Mucugê, s.l., 2 Oct 2005, *J.G. Carvalho-Sobrinho et al. 736* (HUEFS); Estrada para Encruzilhada, ca. 1 km de Divisópolis, 6 Feb 2002, *P.A. Fiaschi et al. 993* (SPF); Ibicoara, Estrada entre Brejo de Cima e a rodovia Mucugê-Barra da Estiva, caminho para Cascavel, 5 Feb 2003, *F. França et al. 4320* (HUEFS); Morrão, encosta, 28 Jan 2003, *F. França et al. 4005* (HUEFS); Mucagê na estrada para Brejo de Campos gerais (cerrado), 31 Jan 2000, *A.M. Giulietti & R.M. Harley 1978* (RB); s.l., 28 Jan 2010, Divisopólis, estrada para Pedra Azul, 900 m, 6 Feb 2002, *M. Groppo, Jr., A.C. Marcato, P. Fiaschi & J.R. Pirani 1062* (F, HUEFS, MBM); *M.L. Guedes et al. 16928* (ALCB); Barra da Estiva, ca. 10 Km N da cidade, rod. p/ Ibicoara, próx. ao Rio Preto, 2 Feb 1974, *R.M. Harley 15865* (CEPEC, RB); 2 km SW of Morro do Chapeu on Utinga road, 1000 m, 3 Mar 1977, *R.M. Harley, S.J. Mayo, R.M. Storr, T.S. Santos & R.S. Pinheiro 19317* (CEPEC, NY, RB); 3 km S de Candido Sales, BR-116, 19 Nov 1984, *G. Hatschbach 47351* (BR, CEPEC, HBG, INPA, MBM, MO, MU, NY, US, RB); 21 km de Ibicoara na rod. para Jussiape, 27 Jan 2000, *J.G. Jardim, W.W. Thomas, S.C. de Sant'Ana, M.V. Albves, A.C. Araújo & B.M. Torke 2562* (CEPEC, NY, RB); rodovia para Utinga, ramal para a torre Telebahia, 8 Sept 1990, *H.C. Lima, S. M. de Faria, & H.S. Brito 3884* (CEPEC, RB); Serra do Gobira, 21 Jan 2005, *J. G.Nascimento, T.S. Nunes, and Milton 331* (HUEFS); Povoado de Água Fria, 16 Feb 2002, *T.S.Nunes 885* (HUEFS); Seabra, 900 m, 13 Feb 1987, *J.R. Pirani, R.M. Harley, B.L. Stannard, I. Cordeiro, C. Kameyama & A.M. Giulietti 2013-A* (HUEFS, NY); Elísio Medrado, Serra da Jiboia, Fazenda Jequitibá, na Estrada para Monte Cruzeiro, 2 Mar 2001, *L.P. Queiroz et al. 6466* (HUEFS); Capão do Correia, 2200 m, 24 Jan 2000, *L.P. Queiroz, L.F.P. Gusmão & B.M. da Silva 5635* (CEPEC, HUEFS); 10 km de Jussiape em direção a Barra da Estiva, 1088 m, 15 Jun 2002, *L.P. Queiroz, E.R. de Souza, J.G. Jardim, J.G. Sobrinho & B.M. da Silva 7118* (HUEFS); s.l., 12 Dec. 2004, *M.T.S. Stradmann & P. Castilho 1005* (ALCB, CEPEC). **Minas Gerais:** 30 km de Curral de Bentro para Águas Vermelhas, 29 Jan 1965, *R.P. Belém & J.M. Mendes 369* (NY, RB); 52 km de Montes Claros para Pirapora, 30 Jan 1965, *R.P. Belém & J.M. Mendes 405* (CEPEC, NY); Biri-Biri, 23 Jan 1978, *G. Hatschbach 40845* (MO, NY, UC); Curtidor, Felisberto Caldeira, 16 Feb 1973, *G. Hatschbach & Z. Ahumada 31675* (NY, TEX); Bem Querer, Cristália, 850 m, 10 Feb 1991, *G. Hatschbach & O.S. Ribas 54089* (BR, CEPEC, HBG, MBM, MO, NY, US); Serra do Cabral. Joaquim Felício, 16 Jan 1996, *G. Hatschbach, M. Hatschbach & J.M. Silva 64078* (NY); Chapada dos Gerais, Fazenda Santa Rita, 14 Jan 1996, *G. Hatschbach, M. Hatschbach & J.M. Silva* 64293 (NY); 3 km SW of Diamantina on road to Gouveia, 1300 m, 13 Jan 1969, *H.S. Irwin, R. Reise dos Santos, R. Souza & S.F. da Fonseça 21859* (CM, MO, NY, UB); 33 km SW of Diamantina near Gouveia, 1150 m, 19 Jan 1969, *H.S. Irwin, R. Reise dos Santos, R. Souza & S.F. da Fonseça 22286* (MBM, MO, NY); 38 km NE of Francisco Sá, road to Salinas, 1000 m, 13 Feb 1969, *H.S. Irwin, R. Reise dos Santos, R. Souza & S.F. da Fonseça 23243* (NY, UB, UEC); 20 km W of Montes Claros, road to Agua Boa, 1000 m, 24 Feb 1969, *H.S. Irwin, R. Reise dos Santos, R. Souza & S.F. da Fonseça 23829* (NY, UB, US); 15 km E of Diamantina, 1100 m, 20 Mar 1970, *H.S. Irwin, S.F. da Fonseça, R. Souza, R. Reise dos Santos & J. Ramos 27981*(NY, UB, US); 2 km N of São João da Chapada, 1200 m, 25 Mar 1970, *H.S. Irwin, S.F. da Fonseça, R. Souza, R. Reise dos Santos & J. Ramos 28314* (GH, NY, UB); Grão-Mogol, 11 Mar 1999, *M.L. Kawasaki & A. Rapini 1086* (NY, SP); Coronel Morta, *M. Magalhães 15212* (NY); Km 938, da BR-4 entre Medina e Limeira, *G. Pabst & E. Pereíra 8341* (R, RB); Km 938 da BR-04, entre Medina e Limeira, 16 Jan 1965, *G. Pabst & E. Pereíra 9452* (ILL, R); 7 km SW de Itamarandiba, BR-120, 970 m, 1 Dec 1984, *B. Stannard, J.D.P. Oliveira & R.M. Harley 36251* (F, NY, RB, SPF). **Paraná:** Campina Grande de Sul, Ribeirão do Cedro, BR-2, 18 Feb 1962, *G. Hatschbach 8940* (UPCB, US); Morro Anhangava, Quatro Barras, 14 Feb 1992, *Y.S. Kuniyoshi 5445* (MBM, NY).

Nearly all of the specimens of this taxon examined were originally identified as *Acacia martiusiana* (Steud.) Burkart [= *Senegalia martiusiana* (Steud.) Seigler & Ebinger]. These taxa are similar and probably related, but are easily separated by the structure of the petiolar gland and sessile vs. pedicellate flowers. The petiolar glands of *S. harleyi* are sessile, oval to orbicular, 0.7–2.5 mm across, with the apex flattened or the margins raised to form a cup; those of *S. martiusiana*, in contrast, have columnar petiolar glands that are 0.5–1.1 mm long, and an apex that is 0.4–0.8 mm across. Further, all specimens of *S. harleyi* have sessile flowers whereas all specimens of *S. martiusiana* have pedicellate flowers, the stalks 0.9–1.5 mm long. These two taxa occur in eastern and southern Brazil, *S. martiusiana* being found in the states of Rio de Janeiro and São Paulo, and *S. harleyi* in Bahia, Minas Gerais and Paraná.

Senegalia hatschbachii Seigler, Ebinger, & P.G. Ribeiro, sp. nov. (**Fig. 3**). Type: BRAZIL. Minas Gerais: Manhumirim, 9 Feb 1973, *G. Hatschbach & A. Ahumada 31392* (holotype: F; isotypes INPA, MBM, MO, MU, NY).

Senegalia hatschbachii Seigler, Ebinger & P.G. Ribeiro differs from other *Senegalia* species by leaf size (90–180 mm long), a solitary columnar petiolar gland (1–2.5 mm), apex 0.2–0.6 mm in diameter, columnar rachis glands between the uppermost 1 to 6 pinna pairs, pinnae 13 to 30 pairs/leaf, 4–9 mm between pairs, leaflets 45 to 65 pairs/pinna, distance between leaflet pairs (0.4–0.7 mm), midvein central to subcentral; inflorescence a globose head (9–15 mm across), ovary pubescent, stipe to 1.1 mm.

Climbing **shrub** or small **tree** to 6 m tall; bark not seen; twigs dark purplish brown to dark purple, slightly flexuous, terete to slightly ridged, lightly puberulent to glabrous; short shoots absent; prickles light brown, apex usually dark brown to purple, somewhat flattened, mostly recurved, woody, 1–4 × 1–6 mm at the base, glabrous, scattered along the twig, petiole and rachis. **Leaves** alternate, 90–180 mm long; stipules light to usually dark brown, linear, symmetrical, flattened, straight, herbaceous, 2–7 × 0.6–1.4 mm near the base, glabrous, early deciduous; petiole adaxially grooved, 7–15 mm long, puberulent; petiolar gland solitary, located on the upper half of the petiole, columnar, 1.0–2.5 mm long, glabrous, apex 0.2–0.6 across, depressed, glabrous; ra-

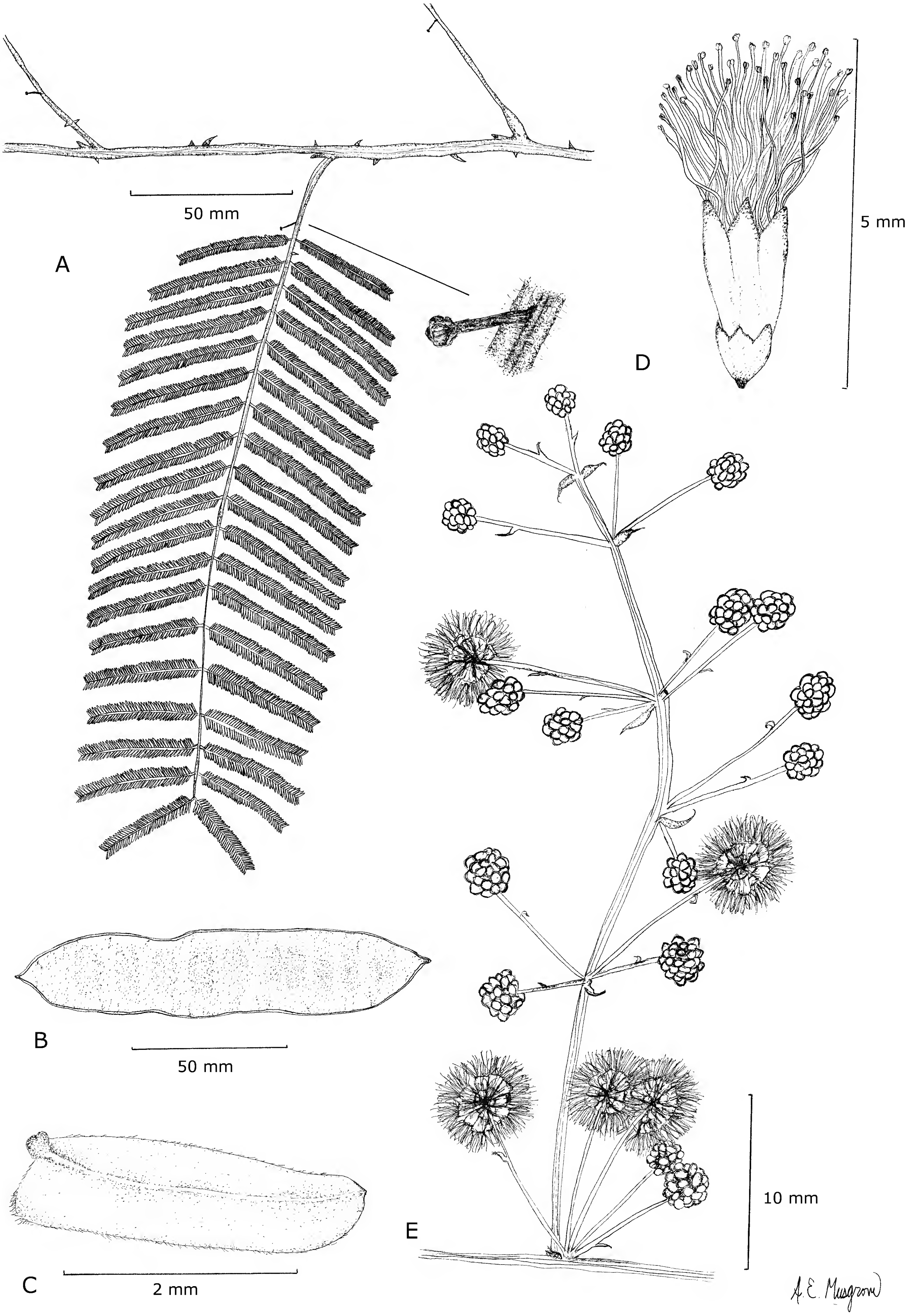

Fig. 3. *Senegalia hatschbachii* Seigler, Ebinger, & P.G. Ribeiro. **A.** leaf habit with petiolar nectary and twig; **B.** fruit; **C.** leaflet, adaxial surface; **D.** pseudo-inflorescence; **E.** Flower. A, B from *Gibbs and Leitão Filho 4029* (F); C, D, E from *de Mello s.n.* (S).

chis adaxially grooved, 80–170 mm long, puberulent, a columnar gland 0.3–1.0 mm long, between the upper 1 to 6 pinna pairs, apex 0.2–0.5 mm across, depressed, glabrous; pinnae 13 to 30 pairs/leaf, 25–45 mm long, 4–9 mm between pinna pairs; paraphyllidia absent; petiolule 0.4–1.2 mm long; leaflets 45 to 65 pairs/pinna, opposite, 0.4–0.7 mm between leaflets, linear, 2.2–4.5 × 0.4–1.0 mm, glabrous to lightly pubescent, lateral veins not obvious, 1 vein from the base, base oblique and obtuse on one side, margins lightly ciliate, apex obtuse, midvein central to subcentral. **Inflorescence** a densely 20- to 35-flowered globose head 9–15 mm across, in axillary and terminal pseudo-paniculate clusters, the main axis to 300 mm long; peduncles 3–14 × 0.3–0.5 mm thick, puberulent; receptacle slightly enlarged; involucre a single small bract located on the upper half of the peduncle, early deciduous; floral bracts spatulate, 0.4–0.8 mm long, puberulent, early deciduous. **Flowers** sessile, white to cream; calyx 5-lobed, 0.8–1.7 mm long, puberulent; corolla 5-lobed, 1.9–3.1 mm long, glabrous, lobes one-quarter the length of the corolla; stamens 50 to 70; stamen filaments 5.5–7.5 mm long, distinct; anther glands absent; ovary pubescent, on a stipe to 1.1 mm long. **Fruits** oblong, 70–140 × 17–27 mm, straight, flattened, not constricted between the seeds, coriaceous, lightly transversely striated, puberulent, eglandular, dehiscent along both sutures; stipe 6–12 mm long; apex obtuse. **Seeds** not seen.

Distribution and ecology.—Gallery forests, disturbed wet second growth forests, and thickets from near sea level to 1,000 m in the states of Minas Gerais, Paraná, and São Paulo, Brazil.

Phenology.—Flowering Dec–Feb.

Local Names and Uses.—None known.

Etymology.—Named for Gert Guenther Hatschbach (1923–2013) Brazilian botanist and taxonomist; Herbarium Director at the Botanical Museum of Curitiba in Paraná.

IUCN Red List category.—DD, data deficient. This species has a limited distribution, being known from only southeastern Brazil. As we have seen fewer than 10 collections, it seems possible that this species presently is threatened. Humid tropical forest is disappearing and additional data concerning the future of *Senegalia hatschbachii* need to be obtained (IUCN 2001).

Paratypes: BRAZIL: Paraná: Patrimônio, 9 Mar 1915, *P. Dusén s.n.* (S); Ponta Grossa, 1904, *P. Dusén s.n.* (G); Capão Grande, 14 Apr 1909, *P. Dusén 7956* (GH, S, US); Jaguariahyva, 770 m, 1 Apr 1915, *P. Dusén 16963* (G, MO, S); Orto Florestal, Maringa, 7 Dec 1965, *G. Hatschbach, J. Lindeman & H. Haas 13247* (F, MBM, NY, UPCB, US); Jaguariahyva, 740 m, 3 Jun 1914, *G. Jönsson 509a* (F, G, GH, MO, S); Ponta Grossa, Vila Velha, 800—920 m, 20 Jan 1965, *L.B. Smith & R.M. Klein 14887* (FLOR, MICH, NY, R, US). **São Paulo:** Fazenda Santa Genebra, 23 Nov 1976, *P. Gibbs & H.F. Leitão Filho 4029* (F, SP, UEC); Campinas, 12 Mar 1871, *J.C. de Mello s.n.* (S); Santa Maria da Serra, 13 Dec 1976, *J.J. Tamashiro 4183* (F, MBM, NY, UEC).

The columnar petiolar gland with a thin stalk to 2.5 mm long and small bulbous apex separates this taxon from most other New World members of *Senegalia*. Quite similar to *S. tucumanensis*, *S. hatschbachii* differs in having twigs that are dark purplish brown to dark purple (usually light brown throughout in *S. tucumanensis*); petioles 7–15 mm long (17–30 mm long in S. tucumanensis); leaflets 2.2–4.2 × 0.5–1.0 mm (5–8 × 1.1–2 mm in *S. tucumanensis*); and lateral veins of the leaflets not obvious (lateral veins obvious in *S. tucumanensts*).

ACKNOWLEDGMENTS

The authors wish to thank several colleagues or advice concerning questions of nomenclature and general taxonomic advice, in particular, K.N. Gandhi (GH). We thank Jennifer Stratton for technical assistance and the artist Alexa Musgrove for preparing drawings. The review comments of Joseph T. Miller and an anonymous reviewer on an earlier draft are greatly appreciated. We wish to acknowledge support by the National Science Foundation (NSF DEB 04-15803), the American Philosophical Society (1992) and the CNPq for financial support to PGR, on her master's degree in the Postgraduate Program in Botany at the Universidade Estadual de Feira de Santana, Bahia, Brazil. We also gratefully acknowledge the assistance of the curators of the herbaria that were visited during this study (ALCB, BHCB, CEN, CEPEC, F, FLOR, G, H, HRB, HST, HUEFS, IBGE, INPA, IPA, K, MBM, MBML, MO, NY, RB, R, SP, SPF, TEX, UB, UEC).

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BOOK NOTICE

James McWilliams. 2013. **The Pecan: A History of America's Native Nut.** (ISBN-13: 978-0-292-74916-0, hbk). University of Texas Press, PO Box 7819, Austin, Texas 78713-7819, U.S.A. (**Orders:** www.utexaspress.com, 1-800-252-3206). $20.00, 192 pp., 3 b&w photos, index, 5½" × 8 ½".

From the publisher: What would Thanksgiving be without pecan pie? New Orleans without pecan pralines? Southern cooks would have to hang up their aprons without America's native nut, whose popularity has spread far beyond the tree's natural home. But as familiar as the pecan is, most people don't know the fascinating story of how native pecan trees fed Americans for thousands of years until the nut was "improved" a little more than a century ago—and why that rapid domestication actually threatens the pecan's long-term future.

In *The Pecan*, acclaimed writer and historian James McWilliams explores the history of America's most important commercial nut. He describes how essential the pecan was for Native Americans—by some calculations, an average pecan harvest had the food value of nearly 150,000 bison. McWilliams explains that, because of its natural edibility, abundance, and ease of harvesting, the pecan was left in its natural state longer than any other commercial fruit or nut crop in America. Yet once the process of "improvement" began, it took less than a century for the pecan to be almost totally domesticated. Today, more than 300 million pounds of pecans are produced every year in the United States—and as much as half of that total might be exported to China, which has fallen in love with America's native nut. McWilliams also warns that, as ubiquitous as the pecan has become, it is vulnerable to a "perfect storm" of economic threats and ecological disasters that could wipe it out within a generation. This lively history suggests why the pecan deserves to be recognized as a true American heirloom.

JAMES McWILLIAMS is a historian and writer whose books include *Just Food: Where Locovores Get It Wrong and How We Can Truly Eat Responsibly* and *A Revolution in Eating: How the Quest for Food Shaped America*. His writing on food, agriculture, and animals has appeared in *The New York Times, Harpers, The Atlantic, The Washington Post, Slate, Forbes, Travel and Leisure, Los Angeles Times, International Herald Tribune, The Christian Science Monitor,* and *The Texas Observer*, where he has been a contributing writer since 2002. McWilliams is also a contributor to freakonomics.com and a winner of the Hiett Prize in the Humanities.

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A NEW VARIETY OF *PHANERA GLAUCA* SUBSP. *TENUIFLORA* (FABACEAE: CAESALPINIOIDEAE) FROM INDIA

Rajib Gogoi
Botanical Survey of India
Arunachal Pradesh Regional Centre
Itanagar 791111, INDIA
rajibdzuko@gmail.com

Subir Bandyopadhyay
Botanical Survey of India
Central National Herbarium
Howrah 711103, INDIA
subirbandyopadhyay@yahoo.com

ABSTRACT

Phanera glauca subsp. **tenuiflora** var. **gandhiana,** var. nov. (Fabaceae: Caesalpinioideae) is described from Arunachal Pradesh, India.

RESUMEN

Se describe **Phanera glauca** subsp. **tenuiflora** var. **gandhiana,** var. nov. (Fabaceae: Caesalpinioideae) de Arunachal Pradesh, India.

Some collections from Anjaw district, Arunachal Pradesh, identified to be of *Bauhinia glauca* (Benth.) Wall. ex Benth. subsp. *tenuiflora* (Watt ex C.B. Clarke) K. Larsen & S.S. Larsen, were seen at ARUN. The collections definitely belong to ser. *Corymbosae* in *Bauhinia* subgen. *Phanera* sect. *Phanera* subsect. *Fulvae* (Wunderlin et al. 1987), but the identification was not correct. These collections have been described here to be of a new variety of *Phanera glauca* Benth. subsp. *tenuiflora* (Watt ex C.B. Clarke) A. Schmitz because recent phylogenetic studies based on DNA sequence data (Lewis & Forest 2005; Sinou et al. 2009) suggest that *Bauhinia* L. subgen. *Phanera* (Wunderlin et al. 1987) should be recognized as a genus distinct from *Bauhinia*.

Phanera glauca Benth. subsp. **tenuiflora** (Watt ex C.B. Clarke) A. Schmitz var. **gandhiana** Gogoi & Bandyop., var. nov. (**Figs. 1, 2 & 3**). TYPE: INDIA. ARUNACHAL PRADESH: Anjaw district, in between Changwanti and Walong, 800 m, 20 May 2011, *R. Gogoi 24374* (HOLOTYPE: CAL 0000025065; ISOTYPES: ARUN, ASSAM).

Differs from *Phanera glauca* Benth. subsp. *tenuiflora* (Watt ex C.B. Clarke) A. Schmitz in having fusiform flower buds and hypanthium shorter than their respective pedicels. In subsp. *tenuiflora* the flower buds are ovoid and hypanthium longer than their respective pedicels.

Lianas with tendrils, ca. 8 m in height; hairs ferruginous when dry; tendrils flattened, pubescent. Leaves 4.7–10 × 3–9 cm, ovate or ovate-orbicular, 7–9-nerved, retuse to tapering or bifid to ⅙ their length into broadly obtuse lobes at apex, truncate or shallowly cordate at base, glabrous above, pubescent beneath, particularly on the nerves, later glabrescent excepting the nerves; petioles 0.9–1.9 cm long, pubescent to glabrescent. Stipules 5–9 × 1 mm, linear-oblong, pubescent outside. Racemes corymbose, axillary or terminal, pubescent. Flower buds 7–7.5 × 3 mm, fusiform, slightly curved at apex, pubescent. Hypanthium ca. 7 mm long, tubular, faintly striate in dried specimens, pubescent. Pedicels 3–3.6 cm long, slender, pubescent. Bracts 8–9 mm long, linear-oblong, pubescent; bracteoles 8–9 mm long, filiform, situated near the middle of pedicel. Flowers ca. 1.8 cm across. Calyx 2–3-lobed. Petals 1–1.1 × 0.4–0.5 cm, white, narrowly to broadly obovate, obtuse at apex, veined, glabrous inside, glabrescent outside, particularly in the median zone; claw ca. 3 mm long, glabrescent outside. Fertile stamens 3; filaments 7–9 mm long, white, glabrous; anthers 2.5–3 mm long, purplish, ellipsoid. Reduced stamens 5, ca. 2.5 mm long, with rudimentary anther at tip, swollen and connate at base; bases bright yellow. Staminodes 2, in between stamens. Gynophore ca. 2 mm long, sparsely pubescent; ovary ca. 5 mm long, greenish white, sparsely pubescent on the sutures at base; style 3 mm long, greenish white, glabrous; stigma ca. 1.5 mm across, green, obliquely peltate. Pod unknown.

Distribution and ecology.—India (Arunachal Pradesh, Anjaw district), common at the place of collection in tropical evergreen forest at an elevation of 800 m. Anjaw district is a newly created district, having been split from Lohit district in 2004.

Flowering.—May.

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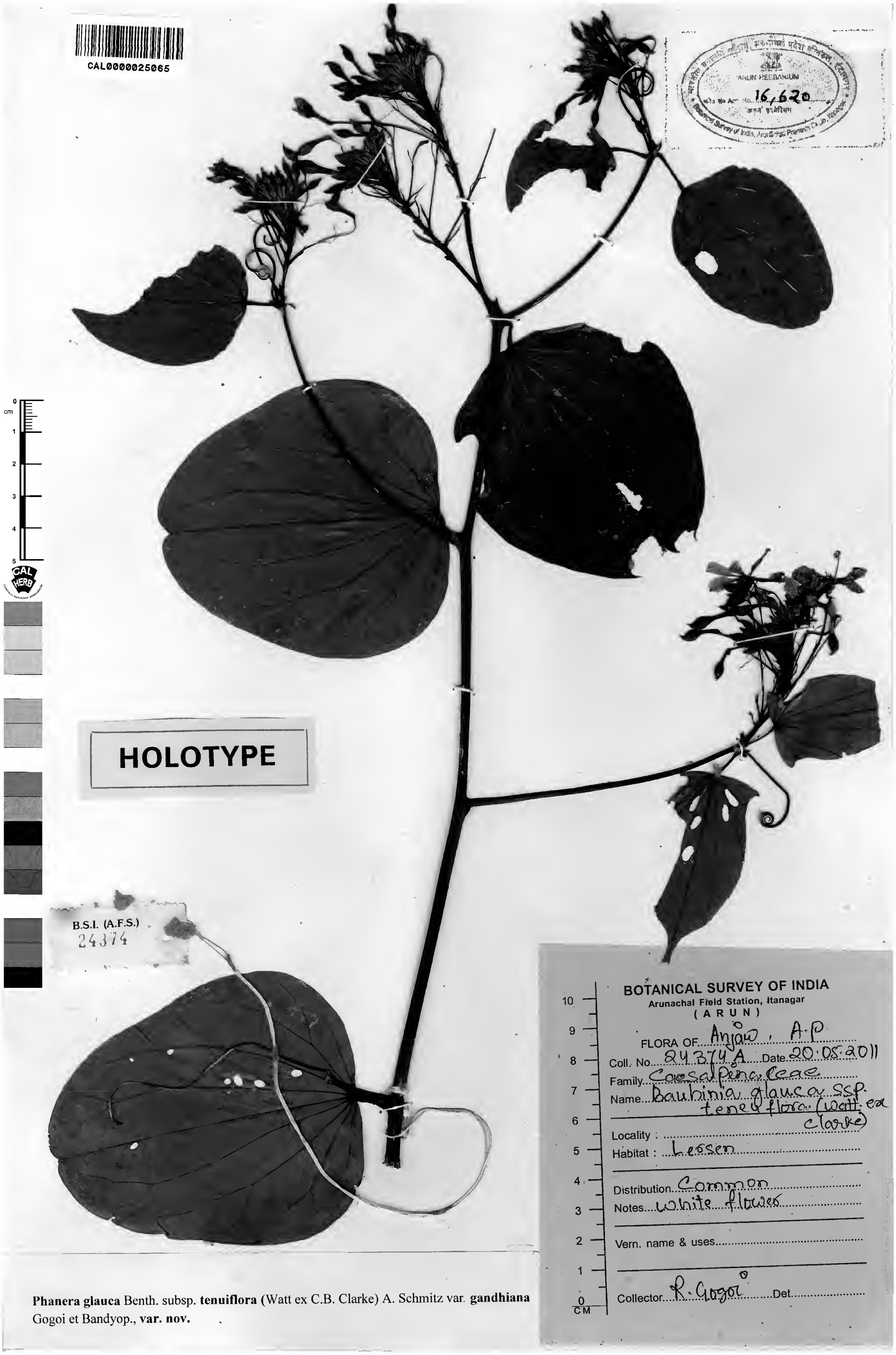

Fig. 1. Holotype of *Phanera glauca* subsp. *tenuiflora* var. *gandhiana*.

Fig. 2. ***Phanera glauca*** **subsp.** ***tenuiflora*** **var.** ***gandhiana*** **in flower (Photo: Rajib Gogoi).**

Etymology.—The variety has been named to honor Dr. K.N. Gandhi for his valuable contribution in the field of plant nomenclature.

Chen et al. (2010) while working on the Chinese *Bauhinia* treated *Bauhinia caterviflora* H.Y. Chen, *B. hupehana* Craib including var. *grandis* Craib and *B. pernervosa* H.Y. Chen as synonyms of '*Bauhinia glauca* var. *tenuiflora* (Watt ex C.B. Clarke) K. Larsen & S.S. Larsen' which were by that time were considered as subspecies or varieties of *Bauhinia glauca*. We are accepting here only two subspecies viz. subsp. *glauca* and subsp. *tenuiflora* under *P. glauca* but at the same time do not agree with the taxonomic treatment of *B. hupehana* including var. *grandis*. Chen et al. (2010) in the key characters of subsp. *tenuiflora* stated that the hypanthium in subsp. *tenuiflora* is 2.5–3 cm in length and longer than their respective pedicels. This is, however, not correct because we have examined the type of *B. hupehana* (China, W. Hupeh, May 1907, *E.H. Wilson 3373* K 000760713 image!) in which of the length of the hypanthium is 1.3–1.6 cm and they are shorter than the their respective pedicels whereas in subsp. *tenuiflora* the hypanthium is longer than the respective pedicels. In the type of *B. hupehana* Craib var. *grandis* (China, Western Szechuan, Tung Valley, near Mt. Wa, 500–1000 m, June 1908 & October 1908, *E.H. Wilson 3372* K 000760712 image!) the length of the hypanthium is 1.5–1.8 cm. The leaves in both these collections are ca. ⅓ bifid at apex whereas in subsp. *tenuiflora* the leaves are ⅙–⅕ bifid at apex. Thus we feel that *B. hupehana* including var. *grandis* from Hupeh, Hunan and Szechuan most probably deserves to be accepted as a variety of subsp. *tenuiflora*. Both these type specimens though annotated by Supee S. Larsen as *Bauhinia glauca* (Wall ex Benth.) Benth. var. *tenuiflora* (Watt ex C.B. Clarke) K. & S.S. Larsen in 1978, the identity was not clear to Supee S. Larsen at that time because in a later publication (Larsen & Larsen 1984) they

Fig. 3. *Phanera glauca* subsp. *tenuiflora* var. *gandhiana* in flower (Photo: Rajib Gogoi).

Table 1. Comparative account of some morphological features between *P. glauca* subsp. *glauca*, *P. glauca* subsp. *tenuiflora* and *P. glauca* subsp. *tenuiflora* var. *gandhiana*

Characters	*Phanera glauca* subsp. *glauca*	*Phanera glauca* subsp. *tenuiflora*	*Phanera glauca* subsp. *tenuiflora* var. *gandhiana*
Leaf	⅓–½(–⅘) bifid at apex	⅑–⅕ bifid at apex	Leaves retuse to tapering or bifid to ⅑ their length at apex
Inflorescence	Short dense corymbs	Elongate corymbs	Almost like subsp. *tenuiflora*
Flower bud	Ovoid; glabrous or with some pubescence at top	Ovoid; pubescent	Fusiform; pubescent
Hypanthium	1–1.5 cm in length, shorter than their respective pedicels, glabrous or sparsely pubescent	2.5–3.2 cm in length, longer than their respective pedicels, pubescent	ca. 7 mm in length, shorter than their respective pedicels, pubescent

stated that *B. hupehana* is very close to subsp. *tenuiflora* and further studies on Chinese material are necessary before reaching a final decision on the taxonomic status of *B. hupehana*.

A comparative account of some morphological features between *P. glauca* subsp. *glauca*, *P. glauca* subsp. *tenuiflora* and *P. glauca* subsp. *tenuiflora* var. *gandhiana* are given in Table 1.

There has been no collection of *P. glauca* subsp. *glauca* from the Indian region (Bandyopadhyay 2001) and so we have preferred to describe this variety to be of subsp. *tenuiflora* which is found in N.E. India.

ACKNOWLEDGMENTS

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BOOK NOTICE

Sula Vanderplank, Benjamin T. Wilder, and Exequiel Ezcurra. 2014. **Descubriendo la Biodiversidad Terrestre en la Región de Cabo Pulmo/Uncovering the Dryland Biodiversity of the Cabo Pulmo Region.** (ISBN-13: 978-1-889878-43-0, pbk). Botanical Research Institute of Texas Press, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A., and Next Generation Sonoran Desert Researchers, nextgensd.com. (**Download:** http://ow.ly/yhaFW). Free pdf, 118 pp., color photos, tables, maps, 8½" × 11".

From the publisher: An international multi-disciplinary team of scientists recently published a report on the terrestrial biodiversity of the Cabo Pulmo region in Baja California Sur, Mexico. These very lands are the site of the proposed mega development project Cabo Dorado. The scientists demonstrate that the desert lands adjacent to Cabo Pulmo, the singular coral reef ecosystem of the Gulf of California, harbor high levels of biodiversity, much of which is only found in this remarkable coastal setting. Their report, *Uncovering the Dryland Biodiversity of the Cabo Pulmo Region*, despite the developers' assessment to the contrary, shows that the project is situated in an area of extreme conservation value, the center of which is Punta Arena, an idyllic beach setting proposed to be completely cleared to make way for 20,000+ hotel rooms.

The November 2013 survey, despite only a week in duration, documented 560 plants and animals (392 species of plants, 44 mammals, 29 reptiles, and 95 birds) on the land surrounding Cabo Pulmo, 400 more than were presented in the "Manifestación de Impacto Ambiental" (environmental impact statement) for the Cabo Dorado project. Among the species overlooked in the MIA are 27 plants and animals on the Mexican endangered species list (NOM-059) and 83 endemic species, those found only in this region and nowhere else in the world.

With an understanding of the biological richness of the beautiful, diverse, and coveted lands of the Cabo Pulmo region in hand, it is hoped that conservation strategies that can balance ecological integrity and development pressures can be established.

TAXONOMIC STATUS OF *KOBRESIA CURVATA* AND *KOBRESIA FRAGILIS* (CYPERACEAE)

Bikash Jana and R.C. Srivastava

Botanical Survey of India
Kolkata – 700 064, INDIA
bikash.janadp@rediffmail.com
rcs_bsi@yahoo.co.in

ABSTRACT

Critical examination of the type specimens of *K. curvata* (isolectotype, CAL) and *K. fragilis* (isotype, CAL) reveals the two taxa are morphologically distinct and should be regarded as distinct species. Noltie (1993) merged *K. curvata* under the *K. fragilis* based on similarities in inflorescence branching. Based on micro-morphotaxonomic characters, scanning electron microscopy studies and field survey of *Kobresia* in Sikkim, *Kobresia curvata* and *K. fragilis* should be considered as distinct species.

RESUMEN

El examen crítico de los tipos de *K. curvata* (isolectotipo, CAL) y *K. fragilis* (isotipo, CAL) revela que los dos taxa son distintos mofológicamente y deben tratarse como especies distintas. Noltie (1993) Incluyó *K. curvata* en *K. fragilis* basándose en similitudes de la ramificación de la inflorescencia. Basándonos en caracteres micro-morfotaxonómicos, estudios de microscopio electrónico de barrido y observaciones de campo de *Kobresia* en Sikkim, *Kobresia curvata* y *K. fragilis* deben considerarse especies distintas.

Boott (1858:2) described *Carex curvata* as a new species from Sikkim. Unfortunately, the name was illegitimate when published (non Knaf 1847) (McNeill 2012; Art. 53.1). Clarke (1908) transferred *C. curvata* to the genus *Kobresia* and thus published *K. curvata* C.B. Clarke as a new name. Perhaps unaware of Clarke's (1908) publication, Kükenthal (1909) also published the same new name *K. curvata* (Boott) Kük., which is treated as an isonym (McNeill 2012; Art. 6, Note 2).

Within the protologue of *Carex curvata*, Boott (1858:2) mentioned the specimen "HAB. in Himalaya Orientali alpine ad Sikkim, alt. 12,000–14,000 ped. (graminosis), *J.D. Hooker s.n.*" Noltie (1993) lectotypified the name *Carex curvata* Boott on the basis of J.D. Hooker's specimens collected from Tungu (Thangu) & Lachen, localities of Sikkim. One specimen of J.D. Hooker (bearing same data as the type) deposited in CAL is very similar to the drawing (t.5) of Boott (1858): it is an isolectotype of *Carex curvata* Boott.

Clarke (1903) provided the following type information for *Kobresia fragilis*: "Szechuen: Tongolo in Kiala (*Soulie* 731). Herb. Kew." One of the duplicate specimens (det. by C.B. Clarke as "n. sp.") bearing the same locality and collection number is deposited in CAL and is the isotype of *Kobresia fragilis*. Based on this type, Kükenthal (1904) published *Schoenoxiphium caricinum* Kük., a superfluous illegitimate name (McNeill 2012; Art. 52.2 (a)). Subsequently, Clarke (1908) transferred *K. fragilis* to *Schoenoxiphium* and made the new combination *S. fragile*.

In his study of the type specimens of *Kobresia curvata* and *K. fragilis*, Noltie (1993) concluded that the inflorescence branches are similar; he mentioned that, except for the curvature of the stem, the type of *K. curvata* is similar to the type of *K. fragilis,* and suggested the curvature of the stem may result from grazing and trampling. Thus, Noltie treated *K. curvata* as a synonym of *K. fragilis* without mentioning any micro-morphological characters. Srivastava (1996) treated *Kobresia curvata* as a separate taxon in *Flora of Sikkim*. During our field survey of North & East Sikkim, we found *K. curvata* with its typical curved stem on hilly slopes (3500–4000 m), where grazing is impossible. Subsequently, we (present authors) critically examined specimens of these species and type specimens both. Our analysis of the micro-morphological characters revealed that similarity in the external appearance of these species is superficial, and we conclude that the two species are distinct (as depicted in Table 1, Fig. 3).

Table 1. Comparison of *K. curvata* C.B. Clarke and *K. fragilis* C.B. Clarke based on the study of the type material.

Characters	*K. curvata*	*K. fragilis*
Culm	Culm curved; base covered with pale brown prominent leaf sheaths	Culm erect; base covered with grayish yellow not prominent leaf sheaths
Inflorescence	Linear-oblong, curved; branches overlapping	Linear, never curved; branches not overlapping
Glume	Glumes of carpellate spikelet aristate or awned, margin pale green	Glumes of carpellate spikelet short mucronate to obtuse, margin hyaline
Prophyll	Oblong-ovate, yellowish brown without any red spots; opening from apex to middle	Utriculate, yellowish-brown in color with prominent red spots; open only at the apex
Racheola	Racheola exserted from prophyll, margin scabrid, longer than style, binerved; nerve brown	Racheola included in the prophyll, margin glabrous, shorter than style, binerved; nerve green
Nut surface (SEM study)	Reticulate, areole without raised, central silica body	Reticulate, areole with raised, central silica body

TAXONOMIC TREATMENT

Kobresia fragilis C.B. Clarke, J. Linn. Soc. 36:267. 1903. (**Figs. 1, 3**). *Schoenoxiphium caricinum* Kük., Bull. Herb. Boiss. 4(1):49. 1904, nom. superfl. & illegit.; *S. fragile* (C.B. Clarke) C.B. Clarke, Bull. Misc. Inform. Kew, Addit. Ser. 8:67. 1908. Type: THIBET ORIENTALI: Tongolo (Principauté de Kiala), 1893, *Soulie 731* (holotype: K; isotype: CAL, acc. no. 512696!)

Perennial herbs. **Culms** erect, 13–31 × 0.08–0.1 cm (excluding inflorescence), trigonous, slender, smooth. **Leaves** basal and sub-basal, 6.6–10 × 0.1 cm, shorter than culm; lamina filiform, involute, keeled, margin scabrid; basal sheaths grayish yellow, not prominent. **Inflorescence** spicate, linear-oblong, 2.6–3 × 0.3–0.5 cm (excluding awn of proximal glume), yellowish green, axis triquetrous, lateral spikes 4–7, non-overlapping. **Spikes** linear, 2.5–4.5 × 1–1.5 mm, proximal spikelets carpellate, 3–5; distal spikelets staminate, 1–3. **Proximal glume** with clasping base, equaling or exceeding the inflorescence, ca. 4.5 cm long (including awn); awn up to 3–3.5 cm long, margin scabrid. **Carpellate spikelets** ovate to ovate-oblong, ca. 3–4 × 1 mm. **Glumes** of the carpellate spikelets ovate, aristate (awned), ca. 4 × 1 mm (including awn); awn slightly scabrid; yellowish brown, margin hyaline, nerve 1, green. **Prophylls** utriculate, ca. 3 × 1 mm, 2-keeled; keels scabrid; yellowish-brown in color with prominent red spots, open only at the apex. **Racheola** ca. 1.5 mm, included in the prophyll, margin glabrous, shorter than style, binerved; nerves green. **Gynoecium** ca. 3 mm long; ovary ca. 2 mm long, oblanceolate; style ca. 1 mm long; stigmas 3. **Staminate spikelet**s lanceolate, 2–3 × 0.5 mm, brown in color; stamens 3. **Nuts** oblong, trigonous, ca. 2 mm, grayish-yellow; appearing smooth at 60× magnification, with SEM at 1000× magnification surface reticulate, areoles with raised, central silica body.

Flowering & Fruiting.—July–Sept.

Distribution.—BHUTAN: Bumthang (above Gortsam) and Mongar (Sengor) districts, Thimphu (Pajoding above Ragyo, mountain E of Thimphu). INDIA: Sikkim (Deosa, Dzongri, Jamlinghang to Bikbari, Lachen, Karponang, Kyanglasha, Mon Lapcha, Nathula, Tsomgo, Tungu). TIBET.

Specimens examined: **INDIA. Sikkim. North Sikkim:** Changu Lake, 3640 m, 8 Jul 1996, *G.P. Sinha & D.G. Long et al. 17737* (BSHC); Yumthang, 3520 m, 13 Jul 1996, *G.P. Sinha & D.G. Long et al. 17822* (BSHC). **TIBET:** Tongolo (Principauté de Kiala), 1893, *Soulie 731* (isotype, CAL, acc. no. 512696!, holotype, K).

Kobresia curvata C.B. Clarke, Kew Bull. Addit. Ser. 8:68. 1908. (**Figs. 2, 3**). *Carex curvata* Boott, Ill. Gen. Carex 1:2, t.5. 1858, non Knaf, 1847. *Kobresia curvata* (Boott) Kük. in A. Engler, Pflanzenr. IV. 20 (Heft 38):48. 1909, isonym. Type: INDIA: Sikkim, 12,000–13,000 ft, *J.D. Hooker s.n.* (lectotype, designated by Noltie 1993): K!, bottom right hand specimen; isolectotype: CAL!).

Perennial herbs. **Culms** curved, 3–4.5 × 0.08–0.1 cm (excluding inflorescence), proximally trigonous, striate. **Leaves** basal, 2.2–6.1 × 0.05–0.1 cm, equaling or sometimes exceeding the culm; lamina filiform, convolute, curved as culm, margin scabrid; basal sheath pale brown, prominent. **Inflorescence** spicate, linear or linear-oblong, 1.2–2.7 × 0.25–0.4 cm (excluding awn of proximal glume), curved, yellowish-green, axis triquetrous; lateral spikes 3–6, overlapping. **Spikes** oblong or slightly ovoid, 4–7 × 2–3 mm; proximal spikelets carpellate, 4–7; distal spikelets staminate, 2–4. **Proximal glumes** leafy, exceeding the inflorescence, ca. 7 mm (including

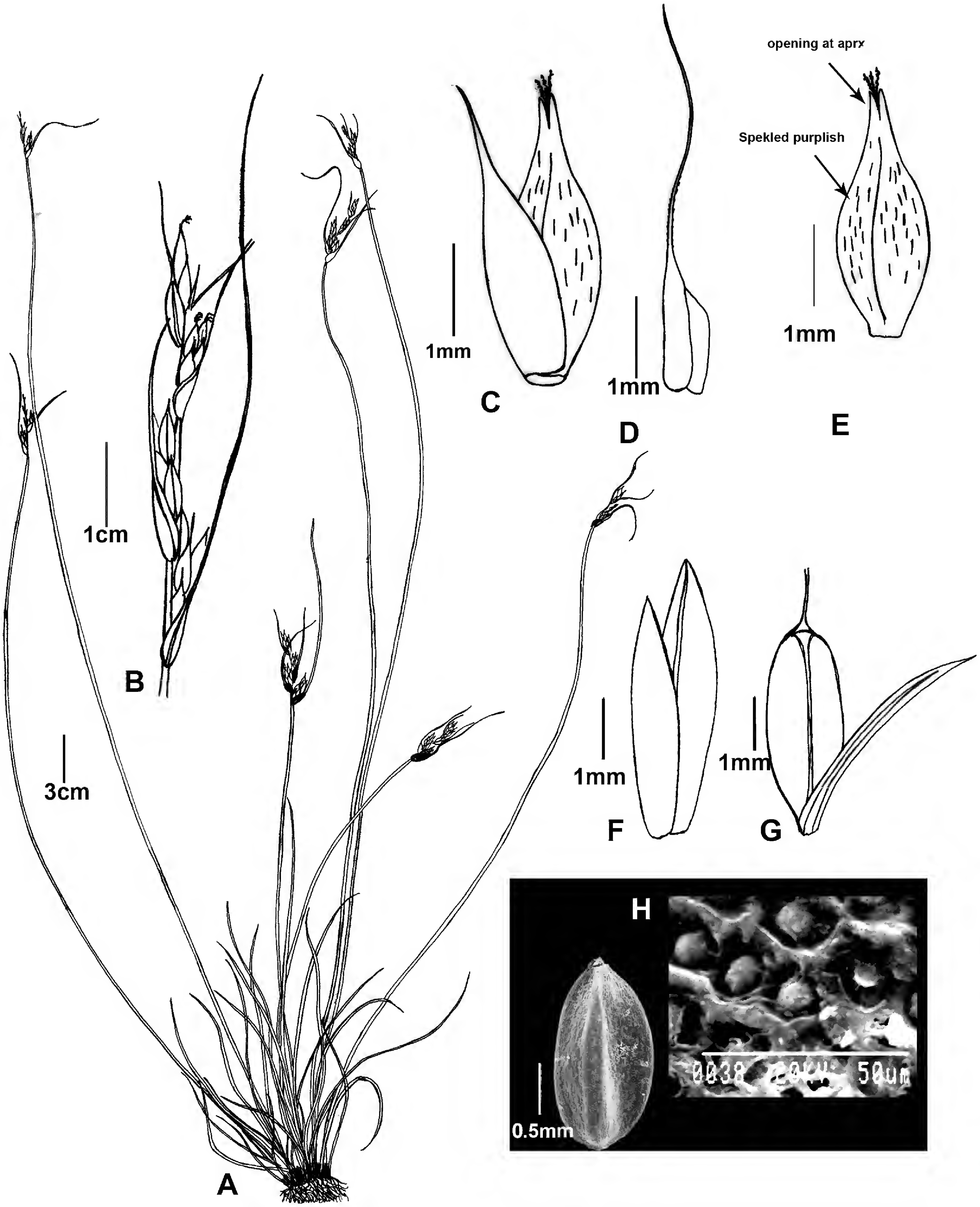

Fig. 1. *Kobresia fragilis* C.B. Clarke. **A.** Habit. **B.** Spike. **C.** Carpellate glume. **D.** Proximal glume. **E.** Prophyll. **F.** Staminate spikelet. **G.** Gynoecium with racheola. **H.** Nut surface under SEM.

awn); awn up to 4 cm long, curved, scabrid. **Carpellate spikelets** ovate, ca. 2.5–3 × 1.2 mm, yellowish. **Glumes** of the carpellate spikelets ovate ca. 2 × 1.5 mm, short-mucronate or obtuse, glabrous, yellowish brown, margin pale green, nerve 1, green. **Prophylls** oblong-ovate, ca. 2.5–3 × 1–1.2 mm, 2-keeled; keels scabrid; yellowish

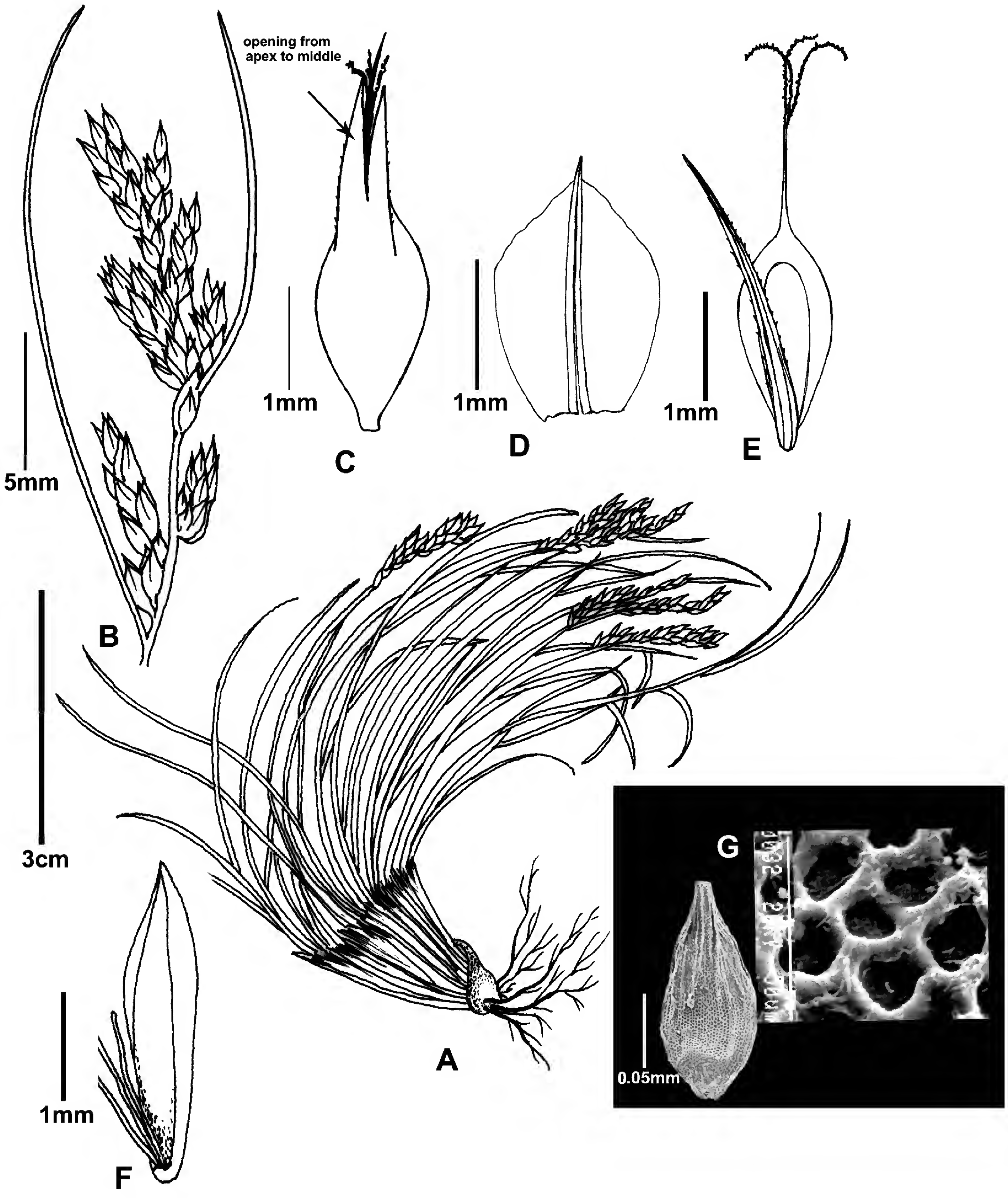

Fig. 2. *Kobresia curvata* C.B. Clarke. **A.** Habit. **B.** Spike. **C.** Carpellate spikelet. **D.** Carpellate glume. **E.** Gynoecium with racheola. **F.** Staminate spikelet. **G.** Nut surface under SEM.

brown, opening from apex to middle. **Racheola** ca. 3 mm long, exserted from prophyll, linear, as long as or longer than prophyll, margin scabrid, binerved; nerve brown. **Gynoecium** 3–3.5 mm long; ovary 2 × 0.75 mm, ovate- elliptic; style 0.5–1 mm long; stigmas 3. **Staminate spikelets** oblong, 2.5–3 × 1 mm, yellow in color, margin hyaline; stamens 3. **Nuts** elliptic to ovoid, trigonous, ca. 1.5 × 1 mm, reddish brown, appearing smooth at 60× magnification, with SEM at 1000× magnification surface reticulate, areoles without central silica body.

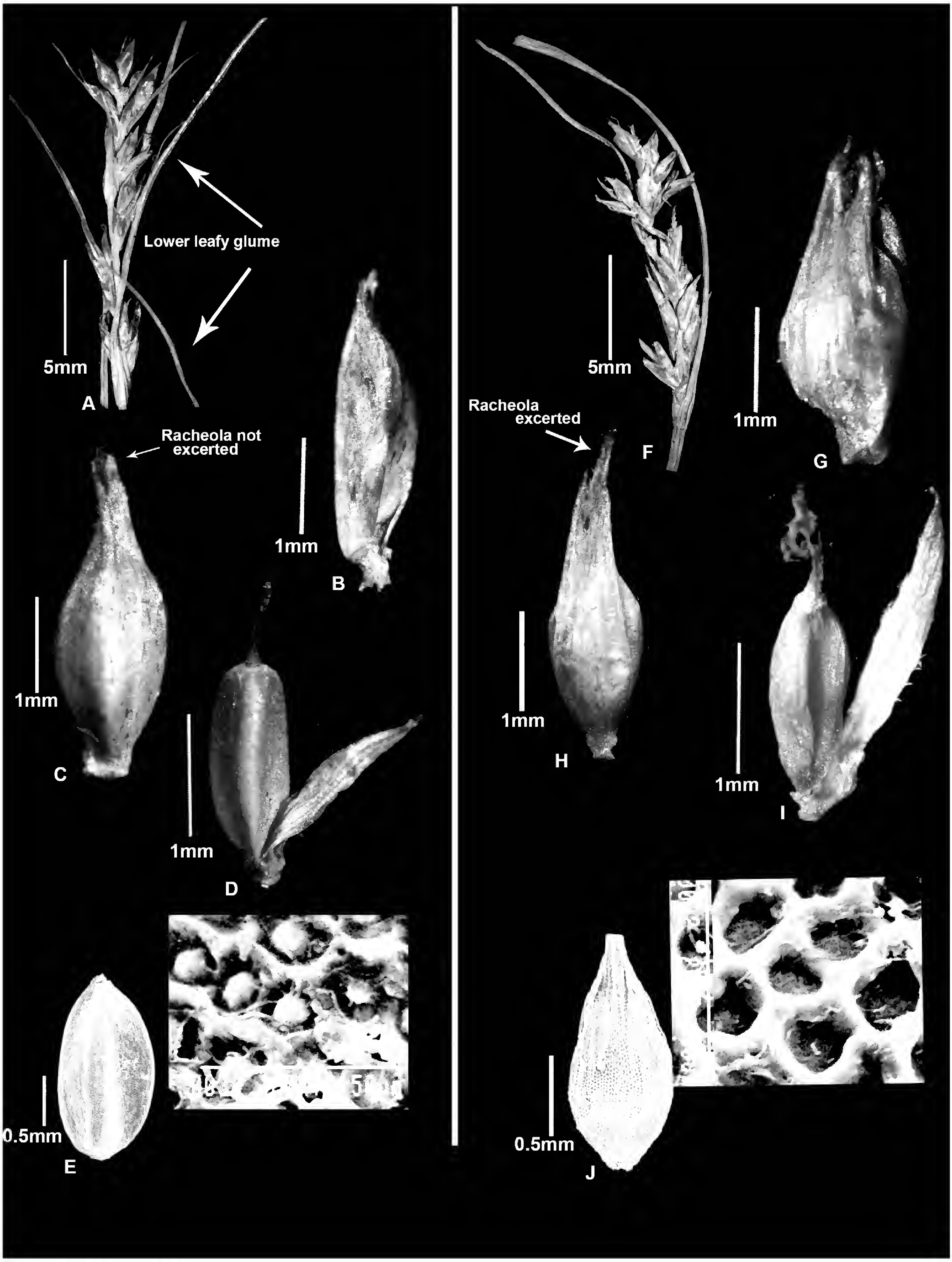

FIG. 3. A–E. *Kobresia fragilis*. **A.** Inflorescence. **B.** Carpellate spikelet. **C.** Prophyll with gynoecium. **D.** Gynoecium with racheola. **E.** Nut & nut surface under SEM. **F–J.** Kobresia curvata. **F.** Inflorescence. **G.** Carpellate spikelet. **H.** Prophyll with gynoecium. **I.** Gynoecium with racheola. **J.** Nut surface under SEM.

Flowering & Fruiting.—July–Aug.

Distribution.—Eastern Himalaya; INDIA: Sikkim (Changu, Karponang, Katao, Kupup, Kyangosla, Lachen, Lachung, Nathula, Thangu, Tsomgo), 3600–4000 m.

Specimens examined: **INDIA. SIKKIM:** Himalaya, Cho-le-la, Jul 1879, *G. King s.n.* (CAL). **East Sikkim:** 6 km above from Zuluk, 3230 m, N27°15. 431'E 088°47. 418', 27 Jul 2012, *Bikash Jana 53134* (CAL); Kupup, 4115 m, N 27°18. 908' E 088°50. 158', 28 Jul 2012, *Bikash Jana 53169* (CAL). **North Sikkim:** Katao, Kala Pahar, 28 Jul 1989, *N.R. Mondal 10133* (BSHC); Lachen, 2550 m, 07 Jun 1999, *D. Maiy 21327* (BSHC, 2 specimens); Thangu, 17 Aug 1989, *R.C.Srivastava 12289* (BSHC); Thangu, 17 Aug 1989, *R.C. Srivastava 10206* (BSHC). **WEST BENGAL:** Darjeeling district, *A.B. Chowdhury 53* (CAL).

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FIRST VALID PLACE OF PUBLICATION OF *DUCHESNEA INDICA* (ROSACEAE: POTENTILLEAE)

James L. Reveal

L.H. Bailey Hortorium
Department of Plant Biology
Cornell University
Ithaca, New York 14853-4301, U.S.A.
jlr326@cornell.edu

Barbara Ertter

University and Jepson Herbaria
1001 Valley Life Sciences Building #2465
University of California
Berkeley, California 94720-2465, U.S.A.
ertter@berkeley.edu

ABSTRACT

The combination *Duchesnea indica* traditionally has been attributed to Focke (1888), who based his name on Andrews's (1807) *Fragaria indica*. When the genus name was published by Smith (1811), he proposed a superfluous and illegitimate species name, *D. fragiformis*, so it was felt that *D. indica* should have been established before 1888. A search of the literature using on-line resources found that indeed the combination was proposed by Teschemacher in 1835. A formal lectotypification of *F. indica* is proposed.

Key Words: *Fragaria indica, Duchesnea fragiformis, Potentilla indica*, nomenclature

RESUMEN

La combinación *Duchesnea indica* ha sido atribuida tradicionalmente a Focke (1888) que basó su nombre en el de Andrews (1807) *Fragaria indica*. Cuando se publicó el nombre del género por Smith (1811), el propuso un nombre de especie superfluo e ilegítimo, *D. fragiformis*, así resultó que *D. indica* habría sido establecido antes de 1888. Una búsqueda bibliográfica usando recursos on-line encontró que realmente la combinación fue propuesta por Teschemacher en 1835. Se propone una lectotipificación formal de *F. indica*.

One of the world's most widely distributed weedy species in the rose family is the mock- or false-strawberry, *Duchesnea indica*. A member of the rose family (*Rosaceae* Juss. trib. *Potentilleae* Sweet), this native of south-central Asia is now found on every continent except (for the moment at least) Antarctica. According to Li et al. (2003), *D. indica* is one of two species in the genus, the other being *D. chrysantha* (Zoll. & Moritzal) Miq. of eastern Asia.

The species was originally described as *Fragaria indica* by Andrews (1807: ad tab 479) who knew the species as "an ornamental plant, but is in no other respect estimable" being grown in an English garden. Although superficially resembling the true strawberries (*Fragaria* L.) in its fleshy red fruit and ternate leaves, it differs in having yellow petals, doubly toothed leaflets, and protruding achenes on an essentially dry, almost tasteless accessory fruit. The genus *Duchesnea* was subsequently established for the plant by Smith (1811: 372) who proposed *D. fragiformis* Smith (1811: 373) as a superfluous and illegitimate name for the species. Since Focke (1888: 33), most treatments have adopted *D. indica* or followed Wolf (1904: 661) in treating the species as *Potentilla indica* (Andrews) T. Wolf based on the obvious similarities (other than the strawberry-like fruit) with *P. reptans* L. and other members of the sect. *Potentilla*.

Wolf's proposed relationship has been confirmed by recent molecular analyses (Erikkson et al. 1998; Lundberg et al. 2009; Dobeš & Paule, 2010), in which *Potentilla* and *Fragaria* fall into two separate clades, with *Duchesnea indica* nested within *Potentilla*. At the same time, however, Ertter (2007) continues to find the arguments against paraphyly *per se* unconvincing and accordingly opts to retain *Duchesnea* (as well as *Ivesia, Horkelia,* and *Horkeliella*) as distinct genera, even though this results in a paraphyletic *Potentilla* s.s.

When we prepared our treatment of the genus for the Flora of North America Project in 2006, we simply followed long-established tradition and credited the name *Duchesnea indica* to Focke and, basically, gave it no more thought. After all, this bibliographic reference was widely used and no one questioned it. Upon receipt of page proofs, however, Reveal decided to take advantage of the proliferation of web-based search tools to see if the combination *D. indica* might have been validly published prior to 1888. The discovery of an abundance of

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overlooked names in the horticultural literature (Reveal 2012) suggested that this was probably the most likely place to find the name effectively published. Therefore, using the resources of Biodiversity Heritage Library (http://www.biodiversitylibrary.org/) and Google search for books (http://books.google.com/), Reveal easily discovered that, indeed, *D. indica* was proposed by Teschemacher (1835) long before 1888; without these resources, finding that place of publication would have been difficult. Thus:

Duchesnea indica (Andrews) Teschem., Hort. Reg. Gard. Mag. 1:460, 1 Dec 1835. TYPE: as "Duchesnia," based on *Fragaria indica* Andr., Bot. Repos. 7: ad t. 479, Oct 1807 (LECTOTYPE, designated here: [icon] Bot. Repos. 7:t. 479. 1807).

In proposing the basionym, Andrews knew the plant from a single individual that flowered in the garden of Charles Francis Greville (1749–1809), probably at his home near Paddington Green in London where he had glasshouses for his more exotic species, although it is possible the plant was seen at Warwick Castle where Greville lived late in his life. Andrews stated that the plant was "native of the north-east parts of Bengal" and this is most likely where Greville obtained his seed having been gathered by one of his many correspondents or friends as he was also an avid collector of ancient artworks and especially minerals. Andrews left no known herbarium but did contribute specimens to the herbarium of Sir James Edward Smith. Unfortunately, no original material of *Duchesnea indica* has been found at the Linnean Society in London. Nonetheless, it seems appropriate that the name be lectotypified to assure application of the name and accordingly we have selected the one original element we are aware of at this point in time.

ACKNOWLEDGMENTS

We wish to thank Luc Brouillet and the staff at the Flora of the North America Project for their patience as we dealt with this problem at the last minute. Kanchi N. Gandhi (GH), John McNeill (E), and Gerry Moore (USDA) are acknowledged for their comments and review of the manuscript.

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ERRATA

FOUR NEW ANNUAL SPECIES OF *EUPHORBIA* SECTION *TITHYMALUS* (EUPHORBIACEAE) FROM NORTH AMERICA

Mark H. Mayfield

Herbarium, Division of Biology
Kansas State University
Manhattan, Kansas, U.S.A. 66506-4901, U.S.A.
markherb@ksu.edu

The following are provided as corrections/additions to Mayfield (2013).

The Perry (1943) reference information was omitted from the references section and it is provided herein.

In Figure 2, the length of the scale bar is 1 mm.

In the key to species on pages 646 and 647, *Euphorbia ouachitana* was inadvertantly omitted from the key. It should have been included in a couplet with E. tetrapora under the first part of couplet 13 on page 647. Below, couplet 13 is revised and a new couplet 14 is added to distinguish *E. tetrapora* and *E. ouachitana*. The entire key is given again for ease of reference and use.

1. Plants biennial; seeds ≥ 1.8 mm long; primary ray bracts about as wide as long or wider, generally suborbicular to broadly ovate; plants occurring outside of Texas.
   2. Seeds rotundly ovoid, strongly pitted, with distinct, round depressions on a generally flat surface; plants of the eastern United States and southern Ontario, Canada (northeastern Oklahoma north to Wisconsin, east to Pennsylvania, and south to Florida and Mississippi) **E. commutata**
   2. Seeds oblong-ellipsoid, weakly dimpled, with shallow, irregularly shaped depressions bordered by weak reticulating ridges, surface nowhere flat; plants of the western United States (southern California to northwestern Oregon, also local in southern Colorado and northern New Mexico **E. crenulata**
1. Plants annual; seeds *mostly* ≤ 1.7 mm long; primary ray bracts *usually* longer than wide; plants often occurring in Texas and elsewhere.
   3. Stem leaves generally erect-ascending at maturity, if lax, the blades less than 3 mm wide at the widest point.
      4. Raylet leaves at least 1.5 × longer than wide, the apices acute.
         5. Seeds rotund; stems mostly strict, erect or virgate **E. austrotexana** var. **carrii**
         5. Seeds oblong; stems laxly ascending.
            6. Seeds with troughlike and rounded pits, the surface not pimpled **E. peplidion**
            6. Seeds without pits, the surface pimpled **E. exigua**
      4. Raylet leaves about as long as wide, or wider than long.
         7. Leaves linear to linear-oblanceolate **E. austrotexana** var. **austrotexana**
         7. Leaves spatulate to oblanceolate.
            8. Seeds uniformly covered with deep, well-defined rounded pits on both surfaces **E. longicruris**
            8. Seeds with 4 (or 5) shallow ventral pits, and 4 rows of indistinct pits on the dorsal surface **E. tetrapora**
   3. Stem leaves generally divergent or lax at maturity, and over 4 mm wide at the widest point.
      9. Stem leaves with petioles or elongated petiole-like bases.
         10. Raylet leaves apically obtuse, subdeltate; plants 8–18 cm tall **E. nesomii**
         10. Raylet leaves apically rotund, subreniform to scarcely deltate; plants 15–35 cm tall.
             11. Capsules with longitudinal wings along the ridges; seeds 1.3–1.5 mm long, bearing two longitudinal sulcae on the ventral facet **E. peplus**
             11. Capsules without longitudinal wings along the ridges; seeds 1.8–2.0 mm long, smooth to pitted, but not sulcate on the ventral facet.
                 12. Seeds smooth (10×), lacking reticulating ridges **E. helleri**
                 12. Seeds not smooth (10×), with reticulating ridges **E. roemeriana**
      9. Stem leaves sessile, or attenuate to a brief, petiole-like base.

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13. Seeds with a few, well-separated pits in vertical rows.
    14. Seeds maturing dull grayish brown, the ventral faces with 4 weakly defined pits; plants of the western Gulf Coastal Plain in Oklahoma, Louisiana and Texas ____ **E. tetrapora**
    14. Seeds maturing lustrous reddish-brown, the ventral faces with 6 strongly defined pits; plants of the Interior Highlands in Arkansas, southwestern Missouri, and central Tennessee ____ **E. ouachitana**
13. Seeds with numerous crowded, deep pits not clearly in vertical rows; plants only occurring on granite outcrops within the Piedmont Province of Georgia ____ **E. georgiana**

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THE GENUS *ECHINACEA* (ASTERACEAE): FLORAL, STEM, AND PETIOLE MORPHOLOGY

Harold W. Keller

Botanical Research Institute of Texas
1700 University Drive
Fort Worth, Texas 76107, U.S.A.
haroldkeller@hotmail.com

ABSTRACT

The genus *Echinacea* (Asteraceae) has importance economically, medicinally, and ornamentally. Endemic to North America, distribution is centered in the states of Arkansas, Kansas, Missouri, and Oklahoma. Native Americans of the central Great Plains used *Echinacea* as a highly prized medicinal plant panacea. This anatomical study is based on R.L. McGregor's taxonomic treatment of the genus *Echinacea* that included 11 taxa: *E. angustifolia* var. *angustifolia*, *E. angustifolia* var. *strigosa*, *E. atrorubens*, *E. laevigata*, *E. pallida*, *E. paradoxa* var. *neglecta*, *E. paradoxa* var. *paradoxa*, *E. purpurea*, *E. sanguinea*, *E simulata*, and *E. tennesseensis*. Anatomy of *Echinacea tennesseensis* was not included because live plants were not available. Plants were collected at the height of anthesis from the experimental gardens at the University of Kansas. Samples were prepared for microtome and free-hand sectioning and staining. Macromorphology and microanatomy are described here, and photomicrographs illustrate the adaxial epidermal cells of ray ligules. Tissue map line drawings illustrate the pattern and distribution of stem trichomes, epidermal cells, cortex, vascular bundles, and pith. Measurements were included for stem diameters, epidermis, collenchyma, parenchyma, xylem vessels, sclerenchyma fibers, xylem and phloem vascularization, protoxylem points, and location and number of secretory canals for each *Echinacea* taxon. Sclerenchyma fibers (sclerotic cells with a black phytomelanin substance) are located in the pith tissue of all the varieties of *E. angustifolia*. Tissue maps and photomicrographs illustrate petiole transections and the presence of brachysclerids (stone cells) in *E. paradoxa* var. *neglecta* which were found nowhere else in this study. Plants resulting from crossings and introgression between *E. atrorubens* and *E. angustifolia* had many intermediate characteristics and were called "race *intermedia*." This name has no nomenclatural standing but the plants were found to have unique ray ligule adaxial epidermal cells. These multicelluar structures consist of an enlarged basal cell with a neck and a catenuliform series of one, two, or three discrete pyramidal cells that have not been described for any member of the Asteraceae or other flowering plant. A key to *Echinacea* taxa that includes the distinctive micromorphology of ray ligule adaxial epidermal cells is presented. A discussion of the structure and function of ray ligule microanatomy is included as this relates to insect pollinators. Questions still remain concerning the constancy of anatomical characters over a broad range of habitats based on statistically sampled populations.

Key Words: dichotomous key, *Echinacea* (coneflower), endangered species, ligule adaxial epidermal cells, macro-and microanatomy, sclerotic and stone cells

RESUMEN

El género *Echinacea* (Asteraceae) tiene importancia económica, medicinal y ornamentalmente. Endémica a Norteamérica, se centra en los estados de Arkansas, Kansas, Missouri y Oklahoma. Los americanos nativos de las Grandes Planicies (Llanuras Centrales), usaron *Echinacea* como una planta muy altamente apreciada como panacea medicinal. Este estudio anatómico se basa en el tratado taxonómico del género de R.L. McGregor que incluyó 11 taxa: *E. angustifolia, E. angustifolia* var. *strigosa, E. atrorubens, E. laevigata, E. pallida, E. paradoxa* var. *neglecta, E. paradoxa* var. *paradoxa, E. purpurea, E. sanguinea, E. simulata* y *E. tenneesseensis.* Las plantas se colectaron durante el pico de la floración en los Jardines Experimentales de la Universidad de Kansas para prepararlas para el micrótomo, seccionado a mano y tinción. En este estudio describimos la macromorfología y la microanatomía, y las fotomicrografías ilustran las células epidérmicas adaxiales de las flores radiales. Los dibujos de las células epidérmicas ilustran los patrones y distribución de los tricomas del tallo, células epidérmicas, córtex, conjuntos vasculares y médula, con medidas de los tipos de células que incluyen diámetro de los tallos, epidermis, colénquima, parénquima, vasos del xilema, fibras de esclerénquima, vascularización del xilema y líber, puntos del protoxilema y la ubicación y número de los canales secretores para cada taxón de *Echinacea*. Las fibras del esclerénquima (con una sustancia fitomelánica negra) se localizan en el tejido medular de *E. angustifolia* var. *angustifolia, E. angustifolia* "raza intermedia" y *E. angustifolia* var. *strigosa*. Los mapas de tejido y fotomicrografías ilustran los cortes transversales de los peciolos y la presencia de braquisclériden (células pétreas) en *E. paradoxa* var. *neglecta* las cuales no se encontraron en ninguna otra parte en este estudio. Otro taxón llamado *E. angustifolia* var. *angustifolia* "raza intermedia" no tiene posición nomenclatural pero también se describió y se encontró que tiene células epidérmicas adaxiales únicas en las flores radiales. Estas células multicelulares consisten de una célula basal agrandada con un cuello y una serie cateluniforme de 1, 2 o 3 células piramidales discretas que no se han descrito para ningún miembro de las Asteraceae o alguna otra planta con flores. Se presenta una clave para los taxa de *Echinacea* que incluye la micromorfología distintiva de las células epidérmicas adaxiales de las hemilígulas. La estructura y función de las células epi-

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dérmicas adaxiales de las hemilígulas tiene implicaciones ecológicas importantes que se relacionan con los insectos polinizadores. *Echinacea tennesseensis* no se incluyó en este estudio anatómico pero se discutió como un taxón de especial interés como una especie en peligro de extinción.

INTRODUCTION

Historical Overview

This study was conducted during a two year period (1960–1962) as part of the partial fulfillment of the requirements for the degree of Master of Arts at the University of Kansas (KU) under the direction of R.L. McGregor (Keller 1962). The author shortly thereafter served as an officer in the United States Army Medical Service Corps and was not able to publish his thesis at that time. Several years later McGregor (1968) published his monograph of *Echinacea* which represented 15 years of field studies throughout the range of the various taxa. This included growing transplants representing most taxa in the KU experimental garden and greenhouse for a period of eight years. Several thousand plants were started from seed both in the garden and greenhouse representing all possible crosses and backcrosses. Chromosome counts were made from over 2100 field collections of buds, root tips from transplants, and root tips from germinating seeds (McGregor 1968).

The Comparative Anatomy section of the paper by McGregor (1968) included a summation of taxonomically significant characters for certain taxa associated with stem, petiole, and adaxial ray ligule epidermal cell anatomy. A key to identify *Echinacea* taxa was constructed based on the combination of these characters. Detailed descriptions and illustrations of micromorphology for stems, petioles, and floral anatomy for each *Echinacea* taxon were not included.

Keller (1962) included a general key based on a combination of anatomical characters that included the number, size, and location of stem secretory canals, overall stem size and tissue patterns of xylem, presence or absence of sclerotic cells in pith tissue, presence or absence of trichomes, and differences in ray ligule adaxial epidermal cells. Additional keys were also included based solely on the marginal ray floret anatomy and stem secretory system. The 95 pages of text, 56 line drawings, and 34 photomicrographs of microanatomy in the thesis are included here in part to document a more complete descriptive anatomy of *Echinacea* taxa (http://hdl.handle.net/1808/11669).

In a study of root anatomy of *Echinacea angustifolia* var. *angustifolia*, *E. pallida*, and *E. purpurea*, Mistríková and Vaverková (2007) noted that "a description of the microscopic characteristics of a cross-section of the aerial parts of the *Echinacea* plants is not available." The question posed here was to determine differences in stem, petiole, and ray floret microanatomy that could separate and identify taxa as well as contribute to a better understanding of aerial plant microanatomy and morphology of the genus *Echinacea*. The purpose of this study was to emphasize both aspects and, where feasible, devise a key using a combination of macro- and microanatomical key characters.

Review of Past Literature

Echinacea Moench, Methodus, 591. 1794, is a member of the Asteraceae, a family that exhibits a wide range of distribution and habit. It is probably the largest family of flowering plants with an estimated 1535 genera and 23,000 species (Bremer et al. 1994) and numbers given as 1353 genera and 23,000 species in Judd et al. (2008). This family is comprised mostly of herbs, although sometimes shrubby and more rarely woody habits occur. *Echinacea* herein is treated as a herbaceous, perennial prairie forb, however, toward the end of the growing season a small amount of secondary growth may develop, not unlike many herbaceous plants. *Echinacea* may also serve as forage for grazing animals and is often an indicator of undisturbed prairies. It is one of many showy wild flowers that are such a familiar part of the landscape of Kansas. An ever-increasing demand for horticultural varieties led to the 'King', a pink variety, and 'White Lustre' among others, both developed from *E. purpurea* (McGregor 1968).

The genus *Echinacea* is native and endemic to central United States of America, extending into Canada, but is unknown from Mexico. Most taxa are more or less restricted to the states of Arkansas, Kansas, Nebraska, Oklahoma, Minnesota, Missouri, North Dakota, South Dakota, and Texas with scattered collections from

Colorado, Georgia, Illinois, Iowa, Kentucky, Louisiana, Massachusetts, Montana, New Mexico, North Carolina, South Carolina, Tennessee, and Virginia. Highest population density and species diversity occurs in the states of Arkansas, Kansas, Missouri and Oklahoma with Missouri heading the list (Richter 2013).

The Economic Importance section of McGregor (1968) discusses the use of *E. angustifolia* and *E. pallida* roots as a source of drug extracts for various medical ailments but was limited to early anglo settlers of the Great Plains region. Uses by Native Americans were not included in his discussion of Economic Importance; however, an excellent review is available in Kindscher (1989). Native Americans used the prairie forb genus *Echinacea* as a general panacea, but some of its reputed medicinal properties were: the root relieved the pain of toothache; the juice soothed burns and aided healing; and plants placed in steam baths acted as vaporizers cooling the body from heat discomfort. It even was thought to be beneficial in the treatment of mumps and distemper in horses. Even today an alcoholic tincture of *Echinacea* root is used for the healing of wounds and cure of sore throat (Stevens 1961).

Probably the best source of indigenous names and anglo folk use is detailed for *E. angustifolia* by Kindscher (1991). The indigenous tribes that had names and uses included the Apache, Cheyenne, Comanche, Crow, Dakota, Hidatsa, Kickapoo, Kiowa, Lakota, Mesquakie, Omaha, Pawnee, Ponca, Potawatomi, and Winnebago. As the most widely used medicinal plant of the plains, as noted by Kindscher (1991), the collective uses based on the aforementioned tribes included: the dried seed head was used to comb or brush hair; as a mushroom medicine because its seed head was similar in shape to a mushroom; root tissues for an eyewash, coughs, sore throat, or to stimulate saliva flow; applications for snake bites (rattlesnakes) and other venomous bites, stings and poisonings; a remedy for hydrophobia, wounds, tonsillitis, stomach ache, pain in bowels; root teas brewed for sore mouths or gums, rheumatism, arthritis, and measles. Coneflower roots were mixed with fungal puffballs (Gasteromycetes, *Lycoperdon* spp.) spores and skunk oil to treat boils. This list of broad medicinal uses of *Echinacea* gives a better idea of the past history of possible potential medical efficacy and future herbal uses in modern human cultures. More recent papers document the enhanced immune-stimulatory and anti-inflammatory activity of *Echinacea* and the impact of overharvesting, especially in areas in the state of Kansas (Kindscher 1989; Price and Kindscher 2007; Kindscher et al. 2008; Axentiev et al. 2010; Upton 2010).

Metcalf and Chalk (1950) in their classic two-volume work, listed numerous anatomical features that characterize the Asteraceae, including secretory canals, lacticiferous canals, glandular and nonglandular hairs, anomalous secondary thickening, and medullary and cortical bundles. Herbaceous stems among members of the family usually exhibit a ring of collateral vascular bundles, each accompanied in the pericyclic region by large strands of fibers, often forming distinct “bundle caps.” Even though *Echinacea* is cited by Solereder (1908) and Metcalf and Chalk (1950), no detailed investigation of anatomical characteristics, either on a comparative or taxonomic basis, has been published. Since that time additional data were published that extends our knowledge of ray floret anatomy in the Asteraceae.

Papers published that relate to *Echinacea* ray ligule anatomical microcharacters (Table 1, Baagøe 1977a; 1977b) evaluate three epidermal types, including the helianthoid type, consisting of papillose and nearly isodiametric cells that come closest morphologically to *Echinacea*. The illustration of these papillose adaxial epidermal cells (see Baagøe 1977a, plate 1b) shows a three-dimensional SEM view of *Rudbeckia* sp. and plate 2 c of an *Aster* sp. ligule in optical plane cross section showing a light photomicrograph with median wall thickening, and plate 2e of a *Rudbeckia* ligule in cross section showing septa. A survey of the 111 genera and 275 species in the Asteraceae did not mention *Echinacea* by name or illustrate any of the taxa (Baagøe 1977a). Another paper by Baagøe (1977b) evaluates ray ligule microcharacters in the Asteraceae as they relate to taxonomic differences that separate taxa and applies them as characters in a key to tribes, sub-tribes, and genera. *Echinacea* is not mentioned in that paper nor was the *Echinacea* monograph of McGregor (1968) cited as a source of anatomical data.

Description of the adaxial epidermal cells of the Sub-tribe Helianthinae that have papillose cells are designated as the helianthoid type. These cells represented by *Rudbeckia hirta* and *R. speciosa* (see Baagøe 1977b, fig. 5a SEM) have the largest cells (length-width ratio) and thicker outer cell walls. In other words these cells are more elongate vertically with a narrow neck and much wider at the base. None of these cells illustrated or described are multicellular.

Dome shaped adaxial epidermal cells with papillae were shown by Baagøe (1980) using SEM for certain members of the Lactuceae. Examples (Table 1) were represented by *Calycoseris wrightii* (fig. 1B) with hooked papillae pointing toward the distal end of the ligule, *Hieracium saxifragum* (fig. 2A) with more upright papillae, and *Rafinesquia neomexicana* (fig. 1I) with papillose ligule surfaces distally as well as several other examples (Baagøe 1980). Unfortunately some of the SEMs show distorted and collapsed adaxial epidermal cells caused by shrinkage after preservation as herbarium specimens. Critical point drying techniques were not used to preserve cell shapes.

The anatomy of ray florets in the Asteraceae is surprisingly understudied and examples must come from other unrelated floral taxa. References and examples are summarized in Table 1. These aforementioned combined images provide a historical context for the different sizes and shapes of ray floret adaxial epidermal cells observed here in *Echinacea* taxa.

An exhaustive review of taxonomic treatments and phylogenetic papers including *Echinacea* is beyond the scope of this paper; therefore, the *Echinacea* taxa discussed by McGregor (1968), the taxonomic treatment by Urbatsch et al. (2006) and by Flagel et al. (2008) will be followed because the anatomical data in Keller (1962) is associated with those names.

MATERIALS AND METHODS

Collections of *Echinacea* used in this study were made at the University of Kansas Experimental Gardens, Lawrence, Kansas, with some additional field collections. A complete list of the taxa with field notes is included under Collections in the thesis of Keller (1962). Voucher specimens were deposited in the R.L. McGregor Herbarium (KANU). Collections were cited by Keller (1962) as the source of live specimens used for this anatomical study of *Echinacea* taxa. All plants studied were collected during anthesis from 19 Jun to 22 Jun1961. Only specific portions of the plants were selected: flower head, stem, and node with attached leaf.

Voucher specimens are listed below for the source populations from which the KU garden collections were grown or from which collections were made.

E. angustifolia var. **angustifolia:** Kansas, Comanche Co., 17 mi E of Coldwater, prairie hillside, 18 Jun1957, *E. Lathrop 3827.*

E. angustifolia var. **angustifolia** race **intermedia:** Kansas, Mitchell Co., 7 mi N of Hunter, rocky prairie hillside, 22 Jun 1961, *B. Menhusen s.n.*

E. angustifolia var. **strigosa:** Oklahoma, Murray Co., 1 mi N of Sulphur, 29 May 1960, *R.L. McGregor 15607.*

E. atrorubens: Kansas, Douglas Co., 1 mi W and ½ mi S of KU Experimental Gardens, 22 Jun 1961, *H.W. Keller s.n.*

E. laevigata: North Carolina, Durham Co., near Durham, grown from seed sent by Bloomquist 5 (*leg. ign. s.n.*)

E. pallida: Kansas, Chautauqua Co., 3 mi E and 3 mi N of Sedan, 19 Aug 1959, *R.L. McGregor 15042.*

E. paradoxa var. **neglecta:** Oklahoma, Murray Co., rocky prairie hillside common in area at Platt National Park, 7 Jun 1959, *R.L. McGregor 14323.*

E. paradoxa var. **paradoxa:** Missouri, Barry Co., rocky hillside, 3 mi SE jct. Hwy 112 and F, Roaring River State Park, 12 Jun 1959, *R.L. McGregor 14367.*

E. purpurea: Arkansas, Baxter Co., wooded hillside, 2 ½ mi SE of Mountain Home, 6 Aug1959, *R.L. McGregor 14961.*

E. sanguinea: Texas, Angelina Co., sandy open bank at edge of pine forest, 2.6 mi S of Lufkin on Hwy 89, 12 May 1960, *R.L. McGregor 15557.*

E. simulata: Missouri, Oregon Co., roadside opening in oak-hickory woods, 2.2 mi N of Greer, Clark National Forest, 3 Jun 1960, *V. Harms 321.*

Live plant samples were based on not more than five plants and at least five transections made of five stems, petioles, and ray florets. Due to a small sample size taken at one point in time, a statistical comparison of population samples was not attempted. Consequently, the anatomical keys constructed herein are practical only within certain limitations with the caveat that recognizing qualitative differences in description of cell types previously unknown merits special consideration.

Table 1. References describing flower petal and ray ligule adaxial epidermal cells. SEM = scanning electron micrograph; LP = light photomicrograph; LD = line drawing.

Family: Tribe	Taxon	Cell shape	Source & illustration type
Asteraceae: Cichorieae	*Calycoseris wrightii*	Hooked papillae	Baagøe (1980, Fig. 1B); SEM
Asteraceae: Cichorieae	*Hieracium saxifragum*	Upright papillae	Baagøe (1980, Fig, 2A); SEM
Asteraceae: Cichorieae	*Rafinesquia neomexicana*	Hooked papillae	Baagøe (1980, Fig, 2I); SEM
Asteraceae: Heliantheae	*Aster* sp.	Papillose, dome-shaped	Baagøe (1977a, Plates 2c, 2e); LP
Asteraceae: Heliantheae	*Helianthus annuus*	Conical	Whitney et al. (2011); SEM
Asteraceae: Heliantheae	*Rudbeckia* sp.	Papillose, conical	Baagøe (1977a, Plate 1b); SEM
Gesneriaceae	*Saintpaulia ionantha*	Rounded papillae	Endress (1994, Fig. 5.10-2); SEM
Lentibulariaceae	*Pinguicula vulgaris*	Nipple-like	Eames & MacDaniels (1947, Fig. 169C); LD
Rosaceae	*Amelanchier laevis*	Hemispherical	Eames & MacDaniels (1947, Fig. 169A); LD
Rosaceae	*Rosa* sp.	Dome-shaped, columnar	Esau (1960, Fig. 20.1-A); LP
Verbenaceae	*Lantana camara*	Long, conical papillae	Endress (1994, Fig. 5.10-3); SEM
Violaceae	*Viola* × *wittrockiana* cultivar	Sharply pointed conical, some with cuticular striation	Weryszko-Chmielewska & Sulborska (2012, Figs. 1C, 5); LP, SEM

Organs such as stem and leaf were collected in the same morphological position on specimens representing each taxon to ensure validity of comparison. This was accomplished by determining a point midway between ground level and flower attachment which served as the source of material for the stem anatomy presented here. The first recognizable leaf (not to be confused with the reduced upper leaf) borne on the stem below the capitulum was selected for study purposes. This corresponds in some cases to a position just above leaves borne in somewhat of a rosette-like fashion, especially in the shorter species.

The leaves have either sheathing bases or, in the narrow-leafed species, are distinctly petiolate. Petiole anatomy was based on samples taken 0.6 cm from the point of departure on the stem axis for sheathing leaf bases and halfway between the stem axis and the leaf base for distinctly petiolate leaves. Floral parts such as ray ligules were sectioned at the approximate midpoint gauged by the overall length of the particular structure. After selection, the designated materials were placed in vials containing formalin-propiono-alcohol (Johansen 1940, p. 42).

Two methods of preparation were employed, each possessing certain merits. Tissue prepared by the free-hand sectioning method gave excellent preservation of detail, especially in the secretory canal system. However, producing sections uniform in thickness, less than 10 µm and truly parallel to the plane of cutting requires practice, skill, and patience. Furthermore, sections should be standardized to a certain thickness to study structural properties on a comparative basis. The microtome method has drawbacks caused by the previous dehydrative treatment before sectioning that tends to collapse and distort the thin-walled epithelial cells that surround the canal cavity. The graded alcohol series and staining in Coplin jars and eventual embedding in paraffin was a long, time-consuming process prior to sectioning with the microtome.

Free-hand transections were made by orienting live plant material in elderberry pith and then thinly slicing sections with a single edge razor blade. Transections of ray ligules were mounted directly into glycerol and photographed with a compound microscope. Stem transections were stained either with safranin and fast green or phloroglucinol in 18 percent HCL. After passing the stained sections through a graded alcohol series, they were permanently mounted in picolyte. Temporary phloroglucinol mounts were made by placing sections in glycerol. Moreover, the true nature of the cells (size, shape, and wall thickness) was greatly enhanced when fresh material could be cut, stained, and passed directly into glycerol without overuse of a harsh dehydrating agent such as alcohol. This holds especially for the collenchyma which is rich in water and tends to undergo a noticeable shrinkage when subjected to dehydration. Shorter preparation time for free-hand sections facilitated more rapid analysis.

Sections prepared by the paraffin method had cortical cells more compact, thinner walled, and intercellular spaces completely occluded. This method more readily demonstrated the vascularization of the stem axis because whole, intact sections could be obtained. Tissue prepared for the microtome was handled according to

Johansen (1940, p.130) using tertiary butyl alcohol as the dehydrating agent. Following impregnation and embedding in paraffin, the material was sectioned with a Spencer Rotary Microtome at blade settings of 10 µm and 15 µm. Difficulty in sectioning was encountered where extensive sclerification occurred throughout the pith region, exhibiting a tough, woody consistency.

Preliminary staining followed the schedule outlined by Johansen (1940, p. 80–82) with slight modifications to fit each taxon. Staining time was altered when safranin stain was used with the counterstain fast green to get brilliant color differentiation. The presence of a carbohydrate compound, presumably starch, was detected by applying Lugol's solution (I_2KI-potassium iodide) to freshly cut sections. Inulin reported in the literature as commonly found in roots, and sometimes in stems, gave a negative test. Phloroglucinol indicated the extent and relative degree of lignification among the taxa.

Macerations of stem material were prepared by slicing the stem longitudinally into small slivers to increase the disintegrating power and lessen the time required to free the cemented cells. Usually thirty minutes was sufficient time to freely suspend the parenchymatous and collenchymatous cells, but vascular elements often were teased apart with a pin probe. The macerating fluid was made according to the formula prescribed by Jeffrey in Johansen (1940, p. 104). The range and average measurements of pericyclic fibers, vessels, collenchyma, and parenchyma cells were tabulated from a minimum of 30 individual cells of each.

Thin strips of epidermal cells were peeled from the stem. These were then projected and drawn in surface view noting the frequency of stomata and trichomes, if any, the cuticle characteristics, epidermal patterns, and cell dimensions. Length in surface view refers to cell elongation and orientation in a vertical plane and width to that measurement in a horizontal plane.

Measurements made of the ray ligule adaxial epidermal cells have a vertical orientation so that length refers to the upward, vertical extension exaggerated by their papillose condition. The basal width is in a horizontal plane parallel with the surface of the ray florets. Trichomes and hairs are terms that also have been used for stem and leaf pubescence and also for ray florets. However, usage of ray florets and ray ligule adaxial epidermal cells will be followed here to be consistent with McGregor (1968).

The Bausch & Lomb TRI-SIMPLEX Micro-projector was used to project images of tissue sections upon white paper conveniently placed on a tabletop and then outlining the image to make tissue maps. This apparatus was equipped with a tri-objective revolving nosepiece that gave magnifications of 2.7×, 5×, and 12×. A special attachment, the 5× Huygenian eyepiece made possible even greater magnifications. Drawings of stem and petiole transections were made at a magnification of 40×. The different tissue systems are represented thusly: the xylem with associated fibers is vertically lined; the phloem is blank or white; the bundle caps are blackened; and stippling between vascular bundles indicates lignification.

Light photomicrographs were taken with a compound microscope with either a low power (10×) or high power (43×) objective lens with a 10× eyepiece at a total magnification of 100× or 430×. Scale bars were not used; magnifications were calculated using cell measurements. Photographic images were recorded using Kodak 35mm Panatomic X black and white negative film. The 35mm negatives were scanned at 6300 dpi using an Imacon Precision II film scanner. The 16-bit gray-scale images were inverted to positive tif images using Photoshop CS6 software.

GENERAL ANATOMICAL BODY PLAN OF *ECHINACEA*

Echinacea is a genus of herbaceous perennials usually occurring in undisturbed prairie or glade ecosystems. Most taxa usually arise from a taproot (only *E. purpurea* has a rhizome and fibrous root system) as a single erect stem, are most often unbranched with hairy to smooth leaves, basal and cauline, alternate, petiolate, and terminating in a single flower head (capitulum). Ray florets (8 to 21) represented by strap-shaped ray ligules are sterile, forming a showy head of dark purple to rose or pale pink, yellow, or white, either spreading, drooping, or reflexed ray florets with either two or three notched tips. The central cone is made up of perfect, fertile, disc flowers that are inconspicuous because of the surrounding colorful paleae (chaffy bracts) with orange to reddish purple ends that create the showy spiny cone.

The generic name is derived from the Greek word *echinos* meaning hedgehog that refers to the prominent spiny cone of disc florets that eventually matures into a bristly seed head. The morphological characters used to describe the general habit in monographic treatments (McGregor 1968; Urbatsch et al. 2006; Yatskievych 2006) do not mention anatomical characters and that includes stem diameters.

Stem anatomy of plants includes the spatial arrangement of cell types represented by parenchyma, collenchyma, sclerenchyma, and primary and secondary xylem and phloem (vascular tissue). The presence or absence, location, size, and number of external cells (trichomes) or internal secretory cells that include cavities, canals, resiniferous or mucilaginous cells, crystals (cystoliths, druse, raphides), and laticifers serve as diagnostic characters useful in taxonomic work (Eames & MacDaniels 1947; Esau 1958, 1960). Specific regions of the stem for example, epidermis, cortex, pericycle, endodermis, vascular bundles, and pith, may show modification due to thickness of cell walls, size, maturation, and taxon-specific differences. The stem tissue is typical of herbaceous perennial dicots with a pith region that occupies about 75 percent of the central core of the plant and collateral vascular bundles, forming a ring nearer the periphery and usually separated by interfascicular parenchyma or sclerenchyma. A descriptive anatomical evaluation of these morphological features has not been published for the stem, petiole, and ray ligule adaxial epidermal cells for *Echinacea* taxa.

Petiole anatomy offers additional sources of comparisons between *Echinacea* taxa as this relates to the number of major or minor collateral vascular bundles, petiole shape in transectional view, presence or absence of lacunae, and presence or absence of secretory cells. In *Echinacea* the petiole is supplied by three major collateral vascular bundles, a manifestation of departing foliar traces from the stem. Due to different methods of fusion, division, or twisting of the leaf traces, the number of vascular bundles traversing the cortex may or may not be the same as the number that enter the leaf. Minor vascular bundles are associated in different numbers with the major vascular bundles (Eames & MacDaniels 1947).

The arrangement of vascular bundles in the petiole is usually constant for a given species and often for families (three for the Asteraceae). In addition petiole shape can be used as a taxonomic character. Transversely cut petioles can be recognized by shapes, for example, horseshoe-shaped, V-shaped, and cylindrical-shaped. Moreover, secretory canals, universally present in the genus, differ in size, number and position in the petiole. Anatomically the petiole contains the same tissues as the stem: epidermis, collenchyma in varying amounts, and vascular bundles with associated fibrous sheaths.

The main emphasis of this study was the anatomy of the ray florets that are the showy parts of the composite flower. Petals are leaf-like in form, but they differ histologically in various ways from the typical leaf. Generally they show some resemblance in their internal structure to mesophytic leaves, although often lacking differentiated palisade and spongy parenchyma tissue. They consist of ground parenchyma (often called mesophyll), a greatly reduced and branched vascular system, and epidermal layers on the adaxial (upper) and abaxial (lower) surfaces. The vascular supply (here termed veins and veinlets) usually bifurcates more noticeably at the ray ligule tips. Thick-walled supporting tissue often is found surrounding each veinlet. Furthermore, the vascular tissue often consists of several large veins and a system of smaller veinlets.

Perhaps the most striking anatomical feature of the ray ligules is the peculiar adaxial epidermal cells that bulge outward, and are modified into various sizes and shapes. The ray ligule adaxial epidermal surface is usually modified into the conical-papillate type as in *Erysimum cheiri* (Weston & Pyke 1999, light photomicrographs figure 1 B, C and figure 2 A SEM shows an adaxial conical-papillate type epidermis with a striated waxy cuticle epidermis) whereas, the cells of the abaxial epidermis in figure 2B, SEM shows lenticular cells with stomata. *Echinacea* closely parallels then the anatomy of most petals as all of the features mentioned previously are exemplified in its ray florets.

In some flowering plants both floral epidermal surfaces are papillose, but in *Echinacea* only the adaxial ligule epidermal surface exhibits this micromorphology. The inner tangential wall is often slightly convex. The outer wall, by comparison, is often more or less convex or papillose. However, in *Viola* and *Nasturtium*, for example, these cells are modified and bear one or more capitate or cone-shaped papillae (not illustrated in Esau 1958, p. 538). Similarly, in *E. angustifolia* “race *intermedia*” the adaxial epidermis of ray ligules partly consists of cells enlarged basally appearing more bulbous, then capped by one or more (not more than three observed) catenulate, pyramidal-shaped cells. In many flowering plants the anticlinal walls appear either straight, wavy, or may bear internal ridges. The undulation and ridging varies widely in degree of expression in different species. Indeed, the epidermis is less simple than its foliar counterpart.

Due to the weak-walled complex nature of the ray ligule adaxial epidermis, a dovetailed arrangement seems to permit the greatest mechanical support. The functional importance of these highly modified cells is open to conjecture, but apparently they form a layer mechanically stronger than one of simpler form. Furthermore, in some plants epidermal anticlinal walls along the veins and at the base of the petal are usually straight, even if wavy elsewhere. In some cases variability in wall structure gives an assortment of shapes. In *Echinacea*, however, the size and shape of ray ligule adaxial epidermal cells remained somewhat constant for each taxon at least in the same capitulum. Stomata were not observed on the ray ligule adaxial epidermal cell surface suggesting these modifications in cell shape play a different functional role perhaps the attraction of insect pollinators. The ray ligule abaxial epidermis resembles the typical epidermal tissue having stomata, trichomes, and a heavy cuticular covering and internally often with dense contents consisting of chromoplasts and small particles. Chromoplasts occur in the cell sap with an array of colors as can be seen in the drooping or spreading ray florets.

RESULTS

Description of Ray Florets, Stem, and Petiole Anatomy in *Echinacea* Taxa

Microanatomy of the following *Echinacea* taxa is summarized in Table 2 (ray florets), Table 3 (stems), and Table 4 (petioles). Distribution maps (Figs. 1, 2) were created using ArcMap 10.2 showing counties in the U.S.A. shaded gray, indicating that the taxon occurs there (McGregor 1968; Kartesz 2013; USDA-PLANTS 2013).

1. Echinacea angustifolia DC. var. **angustifolia** Prodr. 5:554. 1836. (**Figs. 1A; 3A, B, E, I, J; 9B; 10A**). NARROW-LEAVED PURPLE CONEFLOWER, BLACK SAMPSON ECHINACEA, KANSAS SNAKEROOT.

This taxon includes a complex of taxa referred to by various names assigned by McGregor (1968) and followed during the course of this study (Keller 1962). Its distribution occurs throughout the high plains and drier prairie areas, barrens, and rocky to sandy-clay soils of Texas, Oklahoma, Kansas, and north to Canada. The westernmost extension of this taxon includes New Mexico, Colorado, Wyoming, and Montana (Fig. 1A). The strictly low habit (20–70 cm tall), mostly unbranched, moderately to densely hairy, tuberculate-hirsute to tuberculate-hispid stem with ray florets usually purplish to pink, rarely white, yellow pollen, and diploid chromosome number of $2n = 22$ characterize this taxon (Fig. 3A, B).

Ray ligule adaxial epidermal cell microanatomy has a length-width ratio that results in a dome shape with some cells slightly pinched in part way near the top (Fig. 3E). Secretory chambers of four to six epithelial cells are found on the abaxial side of the vascular traces (Table 2).

Stem microanatomy features nonglandular trichomes that thickly cover the stem. Epidermal stem cells have a wide range in length which tends to give an irregular pattern (Fig. 9B). Sclerotic cells with thickened walls occurring throughout the pith are easily seen in free hand transections but secretory canals are lacking (Fig. 3I, J). Stem interfascicular regions are sclerified but show no secondary growth (Fig. 10A). The cortex is largely made up of collenchyma tissue. The secretory system consists of 26 canals restricted to the cortex. Comparatively this taxon has one of the smaller stems in the genus at ~2 mm in diameter, including a pith diameter of ~1 mm (Fig. 10A; Table 3). The *E. angustifolia* complex of taxa all have sclerenchyma cells and lack secretory canals in the pith which differ from all other *Echinacea* taxa.

The petiole is smaller and somewhat V-shaped with sides not steeply inclined (Table 4). Outside the lateral vascular bundles an abrupt delimitation of fundamental tissue occurs, continuing as photosynthetic foliar tissue. The canal system is greatly reduced in number; thus only one canal 40 µm was seen beside the medial vascular bundle. The minimum of three vascular bundles traverse the petiole.

2. Echinacea angustifolia var. **angustifolia** “race **intermedia**” (**Figs. 1C; 3C, D, E; 10B**).

Table 2. Ray ligule micromorphology based on transections. Position of secretory chambers are relative to vascular traces.

	Adaxial epidermal cells					
Taxon	Mean height (μm)	Mean basal width (μm)	Overall shape	Ligule thickness (μm)	No. vascular traces	Secretory chamber position & diameter (μm)
E. angustifolia var. *angustifolia*	58	42	Dome with slight pinching at top	170	13	abaxial (38)
E. angustifolia var. *angustifolia* "race *intermedia*"	100*	45–54	Tapered conical; pyramidal catenulate	286	13	abaxial (31–40)
E. angustifolia var. *strigosa*	65	55	Conical with rounded corners	265	13	few to lacking
E. atrorubens	78	55	Broadened base with "nipplelike" apex	233	13	abaxial (55)
E. laevigata	47	33	Dome nearly isodiametric	184	15	lacking
E. pallida	72	48	Tapering upward to dome or conical	235	12	--
E. paradoxa var. *neglecta*	50	47	Variable tapering upward gradually to a rounded apex	--	--	abaxial & adaxial (42–81)
E. paradoxa var. *paradoxa*	74	52	Dome with parallel sides	312	13	abaxial & adaxial (42–70)
E. purpurea	65	48	Wide ball-like base tapers to rounded apex	--	31	--
E. sanguinea	115	69	Elongate "necked" papilla	267	13	lacking
E. simulata	105	75	Sharply pointed conical apex tapering upward from wide base	270	13	--

*multicellular (1–3 cells); 138–308 μm in total height

This name "race *intermedia*" was used by Keller (1962) but was not validly published. McGregor (1968) noted that crosses between *E. atrorubens* and *E. angustifolia* var. *angustifolia* produced populations of plants as a result of introgression that had many intermediate characteristics, hence the name *intermedia*.

The ray ligule adaxial epidermal cells observed were of two kinds (unicellular and multicellular) and described in detail and illustrated using light photomicrographs (Keller 1962). Unicellular cells have a tapered conical shape (Fig. 3D). These specialized multicellular structures appear in tiers mounted on an enlarged basal cell (Fig. 3C, D). The multicellular structures show a wider range of size: one pyramidal cell (basal cell 90 μm, terminal cell 48 μm, overall length 138 μm (Fig. 3C); two pyramidal cells (basal cell 70 μm, next cell 39 μm, terminal cell 41 μm, overall length 150 μm (Fig. 3C), and three pyramidal cells (overall length 308 μm), (Fig. 3C; Table 2). Ray ligule adaxial epidermal multicellular structures consist of an enlarged basal cell with a neck and a catenuliform series of one, two, or three discrete pyramidal cells (Fig. 3C, D). The multicellular epidermal cells are far fewer in number and scattered among the predominately papillose cells (Fig. 3C). These multicellular, adaxial epidermal cells appear unique and have not been described for any member of the Asteraceae or flowering plant and were not observed in any other *Echinacea* taxa (Table 2). Ray floret secretory chambers are present usually on the abaxial side of each veinlet. A ring of five elliptical epithelial cells surround the chamber lumen.

The stem is heavily covered with trichomes that are shorter, 0.5–1.5 mm, and stouter than in other taxa. Either two or three septa occur with conspicuous lenticular bumps in the trichome wall. A thick cuticle (9 μm) covers the outer tangential wall and cutinization is evident in the inner tangential wall. Prominent short, spike-like projections mark the surface of the cuticle. In surface view the epidermal cells appear rectangular and oblique walled. Stem diameter is ~2.6 mm, including a pith diameter of ~1.3 mm with sclerenchyma cells interspersed throughout. Elliptical pits densely occur in the walls. In transection dark streaks between adjacent sclerotic cells are the result of a black substance (probably phytomelanin seen in the roots) that occludes

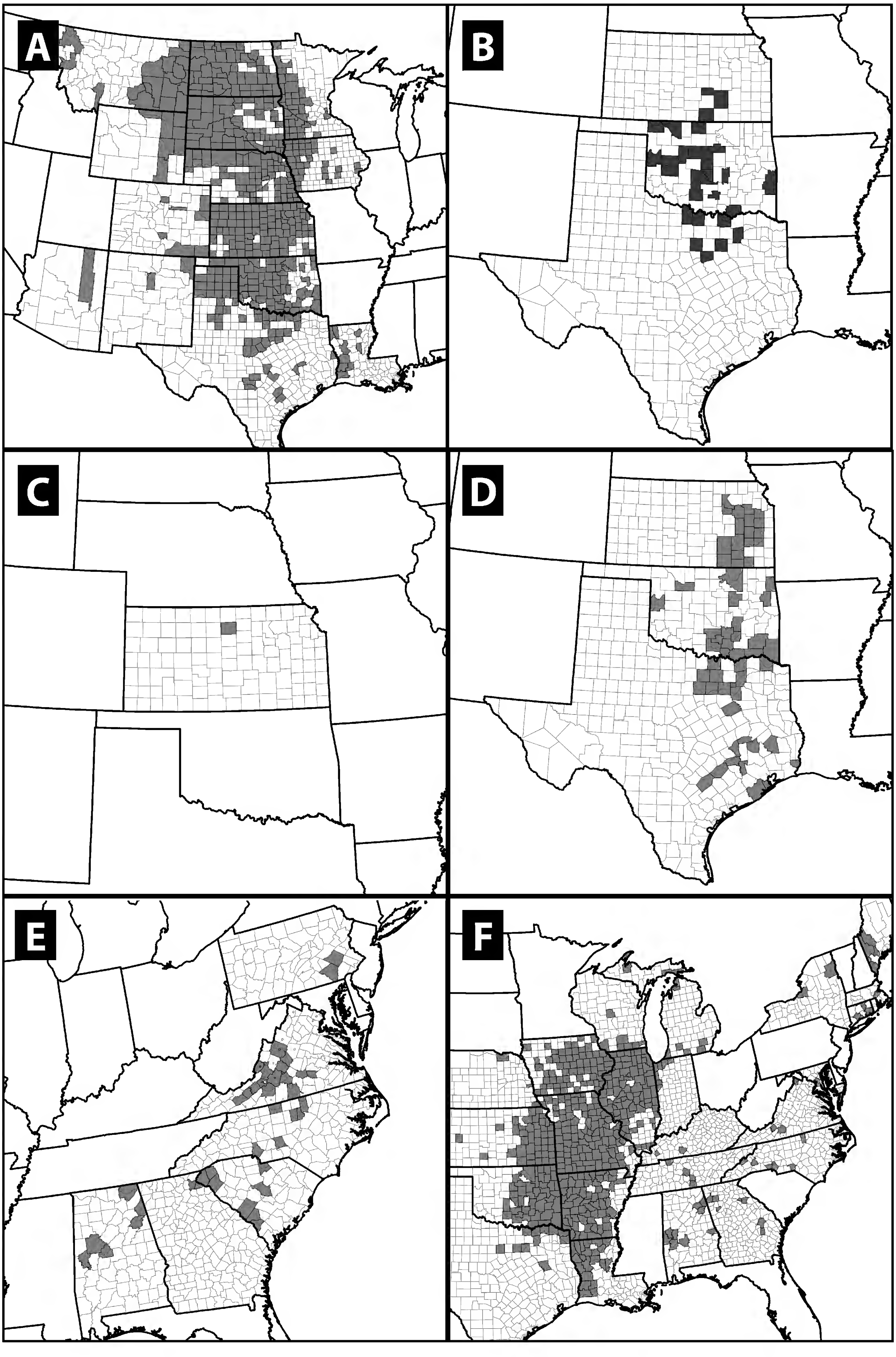


Fig. 1. Distribution maps. **A.** *Echinacea angustifolia* var. *angustifolia*. **B.** *E. angustifolia* var. *strigosa*. **C.** *E. angustifolia* var.*angustifolia* "race intermedia." **D.** *E. atrorubens*. **E.** *E. laevigata*. **F.** *E. pallida*. Maps were recreated from Kartesz (2013).

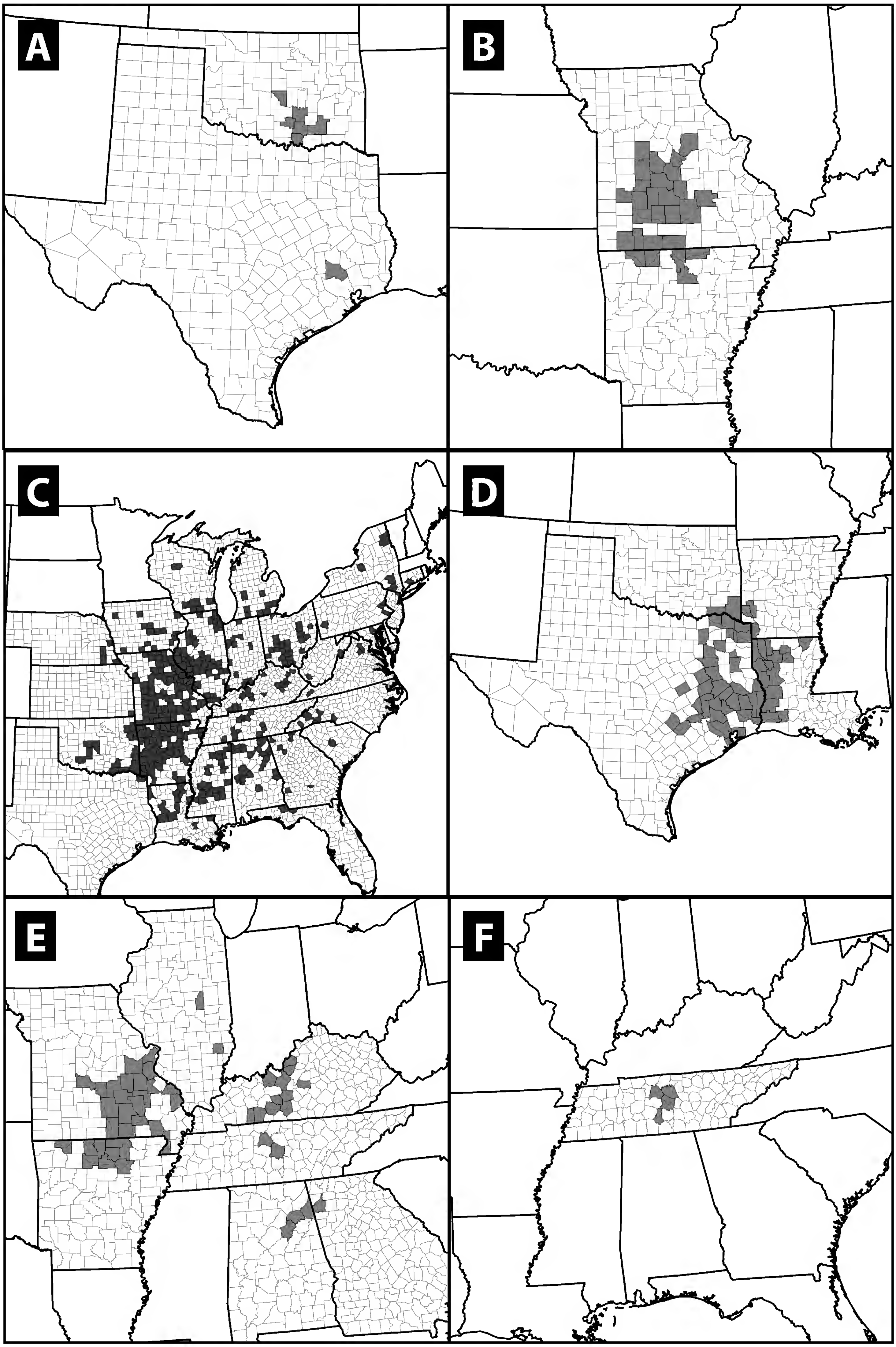
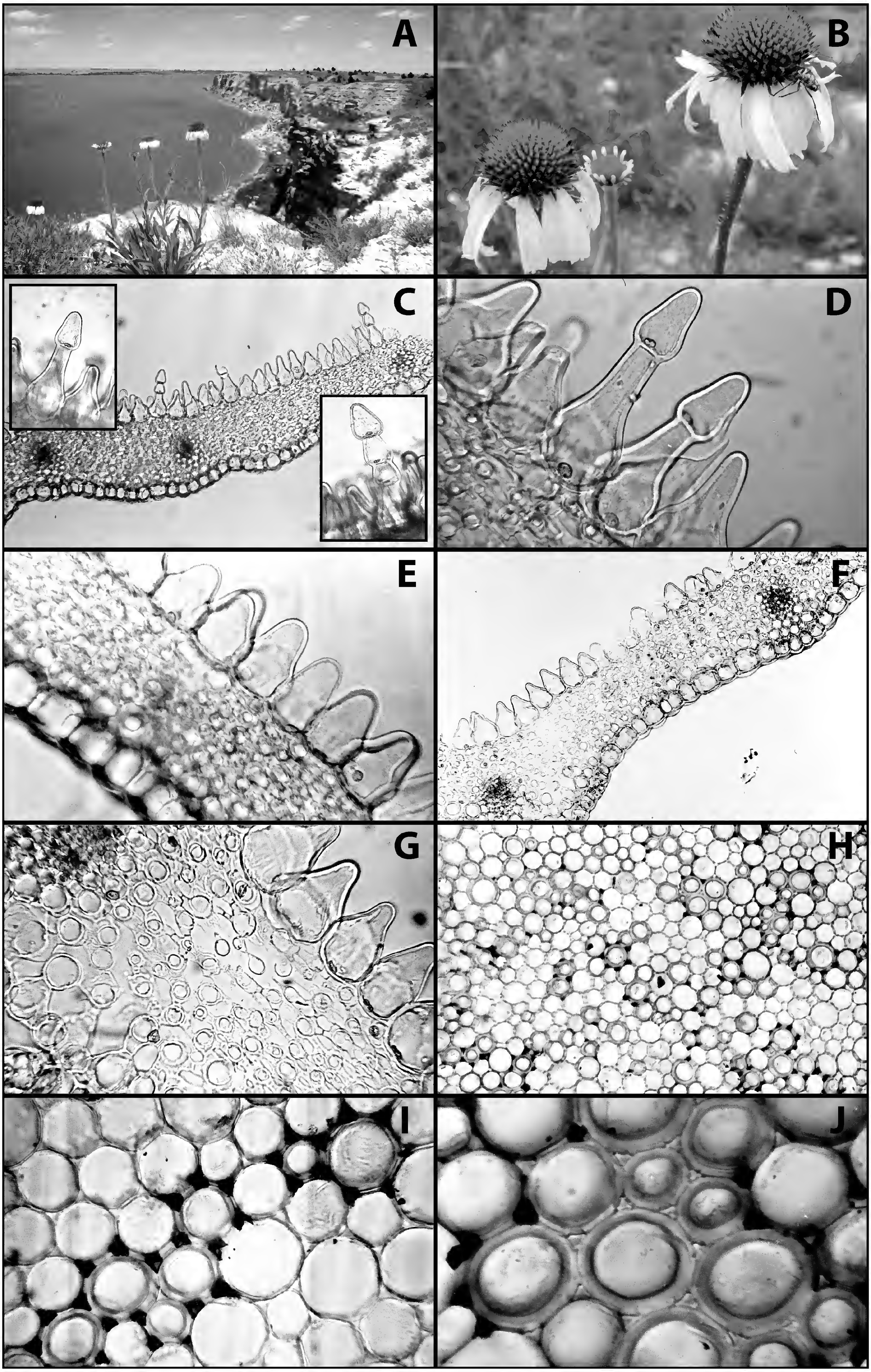


Fig. 2. Distribution maps. **A.** *Echinacea paradoxa* var. *neglecta*. **B.** *E. paradoxa* var. *paradoxa*. **C.** *E. purpurea*. **D.** *E. sanguinea*. **E.** *E. simulata*. **F.** *E. tennesseensis*. Maps were recreated from Kartesz (2013).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angular intercellular spaces (Table 3). A secretory canal system is absent in the pith but present in the cortex opposite the vascular bundle caps and interfascicular region. Five to seven celled epithelial rings surround these smaller canal cavities. Many vessels are tailed with oblique perforations. The vascular bundles are surrounded by a relatively large amount of fibrous tissue. Several vascular bundles seem to have undergone fusion undoubtedly caused by this fibrous tissue (Fig. 10B).

The petiole shows an abaxial convexity which tends to be horizontally flattened on the adaxial surface. A feature readily recognized is the large amount of collenchymatous supporting tissue occupying a position between the vascular bundles and abaxial epidermis. Three major vascular bundles are present in transection (Table 4)

3. **Echinacea angustifolia** DC.var. **strigosa** McGregor, Trans. Kans. Acad. Sci. 70:366–370. 1968. (**Figs. 1B; 3F, G, H; 9C; 10C; 11B**). STRIGOSE CONEFLOWER

McGregor (1968) recognized populations in the Arbuckle Mountains of Oklahoma, extending as far north as Cowley County, Kansas, and as far south as extreme north central Texas as variety *strigosa* (Fig. 1B). Stems 30–60 cm in height, are frequently branched, flexuous and covered with strigose-hirsute trichomes. Variety *strigosa* hybridizes with variety *angustifolia* and *E. atrorubens* yielding morphologically intermediate populations which in some cases are tetraploids.

The ray ligule adaxial epidermal cells are slightly modified into various shapes. Generally these cells tend to be conical with round corners. The outer tangential wall is slightly drawn out into a papilla. Note the lattice-work arrangement of the mesophyll tissue and air spaces between cells (Fig. 3F, G). Trichomes are present on the lower surface of the ray floret. In *Echinacea* the ground (mesophyllous) tissue is homogeneous and simple in structure. The thin-walled mesophyllous cells have a central cavity with radiating interconnected arms. These cells are loosely arranged into a meshwork of lacunose tissue (Fig. 3G). In transection the mesophyllous cell cavity is cylindrical and elongated in a horizontal plane (running parallel with the vascular system). These mesophyllous cells have outgrowths (arms) that become septate at a point of juncture (Table 2).

Nonglandular trichomes thickly cover the stem. In surface view stem epidermal cells consist of relatively small rectangular cells (Fig. 9C). Secretory canals are only present in the cortex. Sclerenchyma cells occur in the pith (Fig. 3H). Unsclerified cells range in size from 38 to 88 µm (65 µm). Stem diameter is ~2.6 mm, including a pith diameter of ~1.6 mm (Fig. 10C). The discrete vascular bundles are widely separated by an interfascicular region (Table 3).

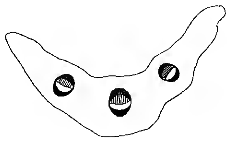
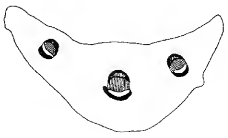
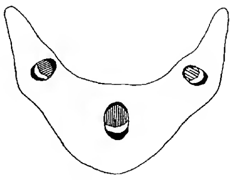
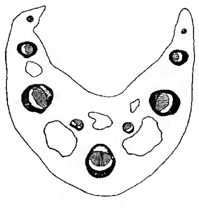
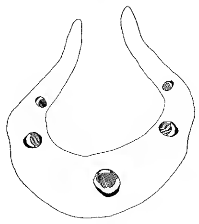
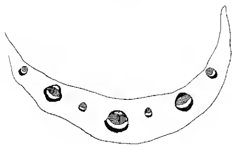
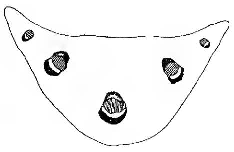
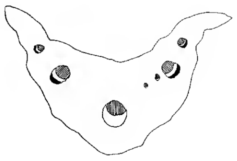
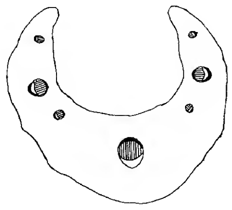
This smaller petiole tends to have the outer margins swinging upward slightly. The “wings” show a leaf-like anatomy made up largely of spongy photosynthetic tissue. Only three vascular bundles supply the petiole. Secretory canals are relatively small, 30 µm, and are sometimes absent from lateral vascular bundles (Table 4).

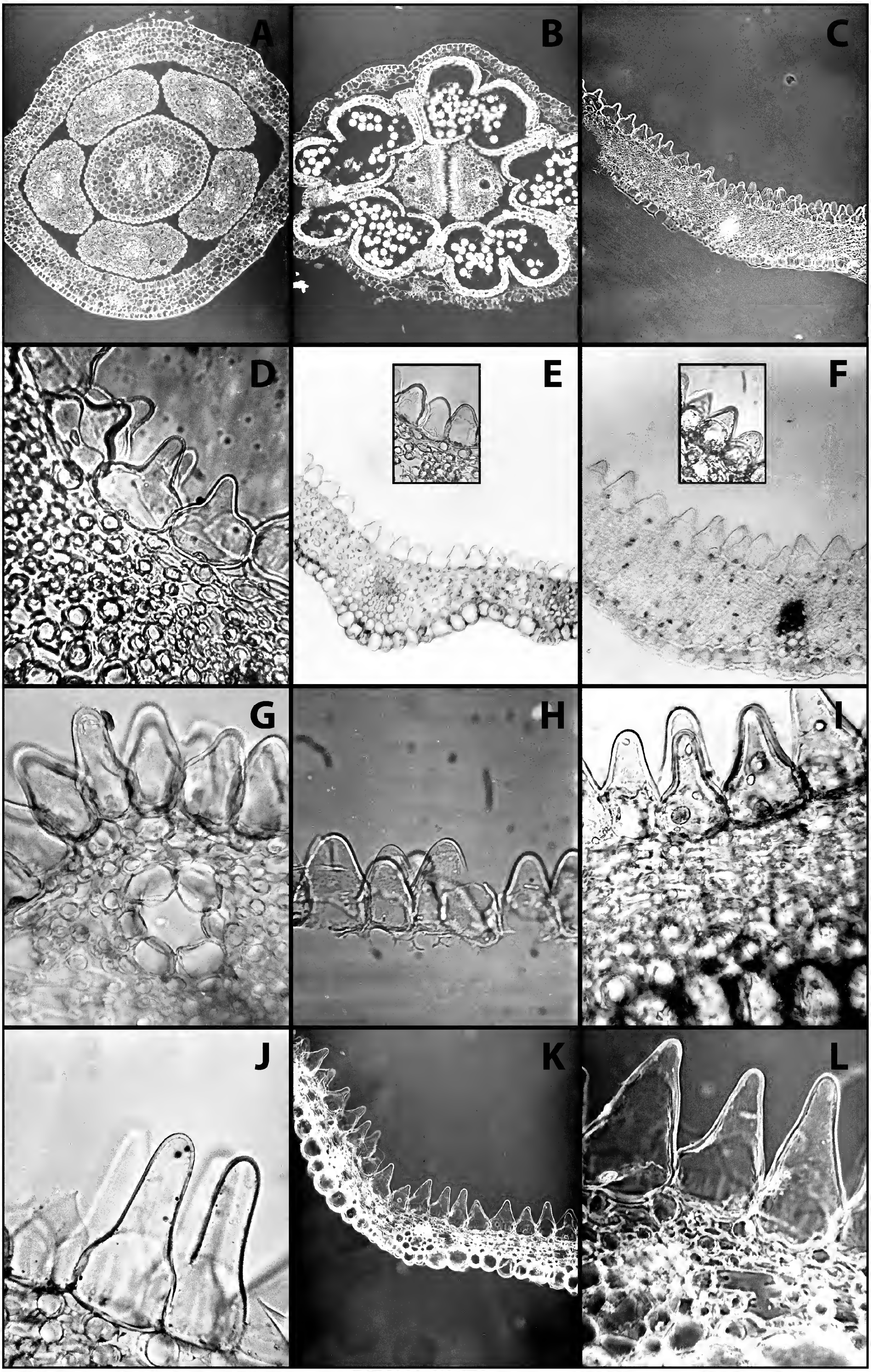
Fig. 3. A,B. *Echinacea angustifolia* var. *angustifolia*. **C, D.** E. *angustifolia* var. *angustifolia* “race intermedia” (free hand transections). Kansas: Mitchell County. Ray ligule showing adaxial epidermal cells of two types (unicellular and multicellular). **A.** Kansas: Trego County, Cedar Bluff Reservoir, on rocky ledge of limestone cliffs. This site has shallow soil where roots find permanent moisture several feet below, 17 Jun 2010. Note the whitish ray flowers reflexed vertically downward surrounding stem. **B.** Kansas: Riley County, Fort Riley Military Reservation on rocky, upland, tallgrass prairie growing in shallow, calcareous soil, 30 Jun 2003. Note shorter and downwardly reflexed pinkish ray florets with two or three notched ends and insect lower right (order Coleoptera, family Cerambycidae, subfamily Lepturinae (flower longhorn beetles), *Typocerus octonotatus*), crawling over the cone of sharply pointed paleae. **C.** Lower magnification showing section of ray ligule with specialized upper epidermis and more typical leaf-like lower epidermis (×53). Close-up insets upper left showing one pyramidal cell and lower right three pyramidal cells. **D.** Close-up of single pyramidal cell atop enlarged bulbous basal cell (×232). **E.** *E. angustifolia* var. *angustifolia*. Kansas: Comanche County. Dome-shaped adaxial ray ligule epidermal cells (×200). **F.** *E. angustifolia* var. *strigosa*. Oklahoma: Murray County. Note modified nearly conical adaxial epidermal ray ligule cells in contrast to the isodiametric shape of abaxial cells more typical of leaf epidermis (×62). **G.** *E. angustifolia* var. *strigosa*. Oklahoma: Murray County. Ray ligule adaxial epidermal cells showing conical shape with rounded corners and lattice-work arrangement of the mesophyll tissue with air spaces between cells (×200). **H.** *E. angustifolia* var. *strigosa*. Oklahoma: Murray Country. Stem microtome transection showing most of pith region with sclerotic cells. Note the black phytomelanin substance deposited in the angles (intercellular spaces) between cells (×70). **I.** *E. angustifolia* var. *angustifolia*. Kansas: Comanche County. Stem microtome transection showing thinner walled pith parenchyma cells lacking phytomelanin and the thicker walled sclerotic cells with discrete phytomelanin black deposits (×177). **J.** *E. angustifolia* var. *angustifolia*. Kansas: Comanche County. Stem oblique free hand transection showing thicker sclerotic pith cells with variable wall thickness with some triangular intercellular spaces free of black phytomelanin and some with heavy deposits filling spaces (×292). Photo credits: Quinn Long (A), Craig Freeman (B).

Table 3. Stem micromorphology based on transections.

Taxon	Nonglandular trichomes	Epidermal cell mean L/W (µm)	Epidermal cell shape	Stem diam (mm)/ size rank	Pith diam (mm)/features	Meta-xylem rows	Proto-xylem points	Vascular bundle width (µm)	Interfascicular region	Secretory canals (µm)
E. angustifolia var. *angustifolia*	hairy tuberculate, hirsute/hispid	115/34	irregular rectangular	2/10	1/sclerenchyma fibers throughout	3–5	21	350–450	sclerified; no secondary growth	cortex only; ~26 total; 38–43 diam
E. angustifolia var. *angustifolia* "race *intermedia*"	short and stout, 0.5–1.5 mm, 2–3 septa	103/33	Rectangular-oblique walls	2.6/9	1.3/sclerenchyma fibers throughout	3–4	24	450–550	fibrous tissue causes bundle fusion	cortex only; 26–28 total; 33–48 diam
E. angustifolia var. *strigosa*	strigose abundant	49/33	smaller rectangular	2.6/8	1.6/sclerenchyma fibers throughout	2–5	24	250–400	discrete; wide; lacking sclerified tissue	cortex only; ~26 total; 38–55 (43) diam
E. atrorubens	sparsely present	77/38	rectangular iso-diametric	4/5	3/parenchyma cells throughout	3–4	38	300–550; prominent bundle caps	discrete; narrow; no sclerification	pith/cortex; ~20 in pith 45–60 (54) diam and cortex 40–52 (46) diam with conspicuous cavity
E. laevigata	glabrous/ glaucous	150/38	largest trap-ezoidal irregular oblique-curved walls	5.2/1	4.2/parenchyma cells throughout	--	44	400–575; prominent bundle caps	discrete, narrow, little sclerification	pith/cortex; ~58 in pith and ~48 in cortex; pith 34–50 (45) diam; cortex 40–57 (50) diam
E. pallida	hirsute, 3–5 septa	113/41	rectangular-angulate, trapezoidal-oblique walls	5/3	3.2/parenchyma cells throughout	3–9	34	500–750	sclerification and secondary growth unite vascular bundles into continuous ring	pith/cortex; pith 32–45 (40) diam; cortex 35–46 diam
E. paradoxa var. *neglecta*	sparsely/ densely strigose	80/33	smaller rectangular-oblique walls	3.8/7	3/parenchyma cells throughout	3–5	42	250–450	highly sclerified; no interfascicular region; no secondary growth	pith 30–70 (55) diam; cortex 45–75 (60) diam
E. paradoxa var. *paradoxa*	sparsely/ densely strigose	90/30	rectangular-straight walls	4/6	3/parenchyma cells throughout	4–8	32	300–600	highly sclerified; no interfascicular region; partial secondary growth	pith 30–65 (50) diam; cortex 40–65 (60) diam
E. purpurea	hirsute/ glabrous	115/30	rectangular-angulate, trap-ezoidal-oblique walls	5/2	3.6/parenchyma cells throughout	5–8	42	250–550; prominent bundle caps	discrete; narrow; little sclerification	pith/cortex; pith ~34; cortex ~48; pith/cortex 34–51 (41) diam
E. sanguinea	hirsute/ glabrous	120/42	mostly rectangu--lar straight walls	1.7/11	0.9/parenchyma cells throughout	3–5	18	200–300	discrete; wide; little sclerification	cortex only; 13–15; 40–48 diam
E. simulata	sparsely/ densely hirsute, 3/5 septa	104/38	rectangular-angulate, trapezoidal-oblique walls	4/4	3.3/parenchyma cells throughout	3–7	31	240–500	sclerification and secondary growth unite vascular bundles	pith/cortex; pith ~36; cortex 20–24; pith 24–50 diam; cortex 41–48 diam

Table 4. Petiole micromorphology based on transections.

Taxon	Shape outline	Shape description	No. vascular bundles	Secretory canals	Canal diam. (µm)	Notable features
E. angustifolia var. *angustifolia*		Somewhat v-shaped	3 throughout	Few (only 1 observed)	40	Sides not steeply inclined
E. angustifolia var. *angustifolia* "race *intermedia*"		More flattened adaxially; abaxially convex	3	Medial	(38)	Collenchyma patches between vascular bundles and abaxial epidermis
E. angustifolia var. *strigosa*		Outer margins swinging upward to become "wings"	3	Small	(30)	"Wings" largely made up of spongy mesophyll
E. atrorubens		Rounded to horse shoe with convex depression	9 (6 minor)	Paired, adjacent to each vascular bundle	--	3 large lacunae running length of petiole from axil to leaf base
E. laevigata		Horseshoe with deep adaxial convexity	5	Poorly developed, medial	(42)	Leaves with sheathing bases account for lengthy "wings"
E. paradoxa var. *neglecta*		Crescent/lunate/ bow	7 (4 minor)	Relatively large, numbering 14	64–84	Brachysclerids (stone cells) scattered throughout fundamental tissue
E. paradoxa var. *paradoxa*		Thickest with nearly flat adaxial surface and exaggerated abaxial curvature	5 (2 minor)	Paired, numerous	40	Chlorenchymatous pockets toward abaxial margin
E. purpurea		Thickened through medial sector with gradual flaring and ascending at ends	5 (2 minor)	Prominent, adjacent to medial vascular bundle	45	Scattered chlorenchymatous tissue creates abaxial bulge
E. sanguinea		Horseshoe nearer stem with ends folded together, unfolding near leaf base	7 (4 minor)	One on each side of abaxial bundle cap	30	Smallest overall size
E. simulata		Lateral margins arch upward, more or less lunate in outline	7 (4 minor)	Few, poorly developed	32	Fan-shaped medial vascular bundle with wide fibrous cap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4. Echinacea atrorubens (Nutt.) Nutt., Trans. Amer. Philos. Soc., n. ser. 7:354. 1840. (**Figs. 1D; 4A, B, C, D; 9D; 10D; 11D, E; 12A**). TOPEKA PURPLE CONEFLOWER.

Plants 50–100 cm tall, mostly unbranched, glabrous below more strigose above, basal leaves petiolate, with the leaf blade oblong-lanceolate. This taxon is found in a narrow band from Houston, Texas, to Ardmore, Oklahoma, northward to Topeka, Kansas (Fig. 1D) (McGregor 1968). It occurs on dry limestone or sandstone outcrops and prairies and is distinguished from *E. paradoxa* var. *paradoxa* and *E. paradoxa* var. *neglecta* by its dark purple to dark red and sharply reflexed ray florets that curve inward to a point where they touch the stem.

Disc florets have the typical Asteraceae floral arrangement. Microtome transections near the base show the style, five stamen filaments, surrounded by a corolla tube (Fig. 4A). Another disc floret transection nearer the top shows the mature five bilocular, united anthers with stained pollen grains that surround the two-parted style. The gamopetalous corolla encloses these reproductive structures (Fig. 4B). Transections were made in June at the height of floral anthesis.

Ray ligule adaxial epidermal cells separate this taxon from all other *Echinacea* taxa. The distinctive squatty shapes feature an adaxial epidermal cell with a broadened base and a short "nipple-like" papilla (Fig. 4C, D). Vascular traces are accompanied by very few abaxial secretory chambers (Table 2).

Stem trichomes are sparsely present and often wanting on portions of the stem. Paradermal sections were peeled easily unlike many other species. The epidermal pattern consisted of rectangular, nearly isodiametric cells, with mostly straight end walls (Fig. 9D). Some walls are slanted so these areas may be more irregular. Cortical tissue consists of an outer collenchymatous zone intergrading into an inner parenchymatous region that extends from 350 to 400 µm. The phloem zone ranges from 42 to 56 µm in radial extent. The pith has parenchyma cells 92 µm in length (68 µm) and widths range from 41 to 110 µm (78 µm). The secretory system consists of canals present in both the pith and cortex (Fig. 11D, E). Moreover, an area of thin-walled accessory tissue is arranged above canals, surrounding canals, and not infrequently in the same morphological positions of the canals. Epithelial rings contain four to eight rectangular or diamond shaped cells (Fig. 11 D, E). Tangential divisions occur halfway around the canal to give a partial double ring. Usually a single well-defined canal is located opposite the protoxylem points and other canals originate opposite the interfascicular region. The stem diameter of ~4 mm includes a pith diameter of ~3 mm (Fig.10D). The stellar pattern has numerous discrete vascular bundles with prominent bundle caps separated by narrow interfascicular regions (Table 3). Sclerified intervening cells between vascular bundles and secondary xylem is lacking as shown in the tissue map (Fig. 10D).

Petiole outline is more or less rounded to horseshoe shaped except for a convex depression on the abaxial side. Each major bundle is associated with two resin canals located one on each side adjacent to the abaxial fibrous cap. The canals that accompany the central vascular bundle are relatively large, 40 µm, with five epithelial cells. Consequently they are conspicuous and well differentiated from the surrounding cells. The vascular bundles are almost perfectly rounded and completely ensheathed by fibrous tissue. Three air spaces or lacunae form passageways throughout the length of this petiole (Fig. 11D; Table 4). Serial sectioning demonstrated air spaces that begin near the stem axis ultimately terminating at the leaf base (Fig. 11D). Although *E. paradoxa* var. *paradoxa* has air spaces, they appear close to the leaf base but beyond the point where sections were made.

Fig. 4. A, B. Microtome transections of *Echinacea atrorubens* capitulum (×50). **C–L.** Free hand transections of ray ligules showing shapes of adaxial epidermal cells. **A.** Disc floret nearer the base showing the style, the five-parted stamen filaments, surrounded by corolla tube. **B.** Disc floret nearer the top showing the two-parted style surrounded by mature five-bilocular, united anthers with stained pollen grains and gamopetalous corolla. Note absence of sclerotic tissue. This floral arrangement is typical of the Asteraceae. **C.** *E. atrorubens* at low magnification showing nipple-like apex in upper left and more variable cells in lower right (×50). **D.** *E. atrorubens* at high magnification of C showing nipple-like apex and broadened base (×200). **E.** *E. laevigata* showing dome shape, undifferentiated mesophyll, lack of secretory chambers, and uniform isodiametric abaxial cells (×50). **F.** *E. pallida* showing dome-shape (×50) and close up inset. **G.** *E. paradoxa* var. *neglecta* tapering upward to rounded apex with secretory chamber below in mesophyll tissue (×200) and close up inset. **H.** *E. paradoxa* var. *paradoxa* showing dome shape (×200). **I.** *E. purpurea* showing ball-like base tapering to rounded apex (×200). **J.** *E. sanguinea* showing elongate "necked" apex and broader base (×200). **K.** *E. simulata* showing sharply pointed apex from a wider base (×50). **L.** *E. simulata* higher magnification detail showing conical cells largest in *Echinacea* (×200).

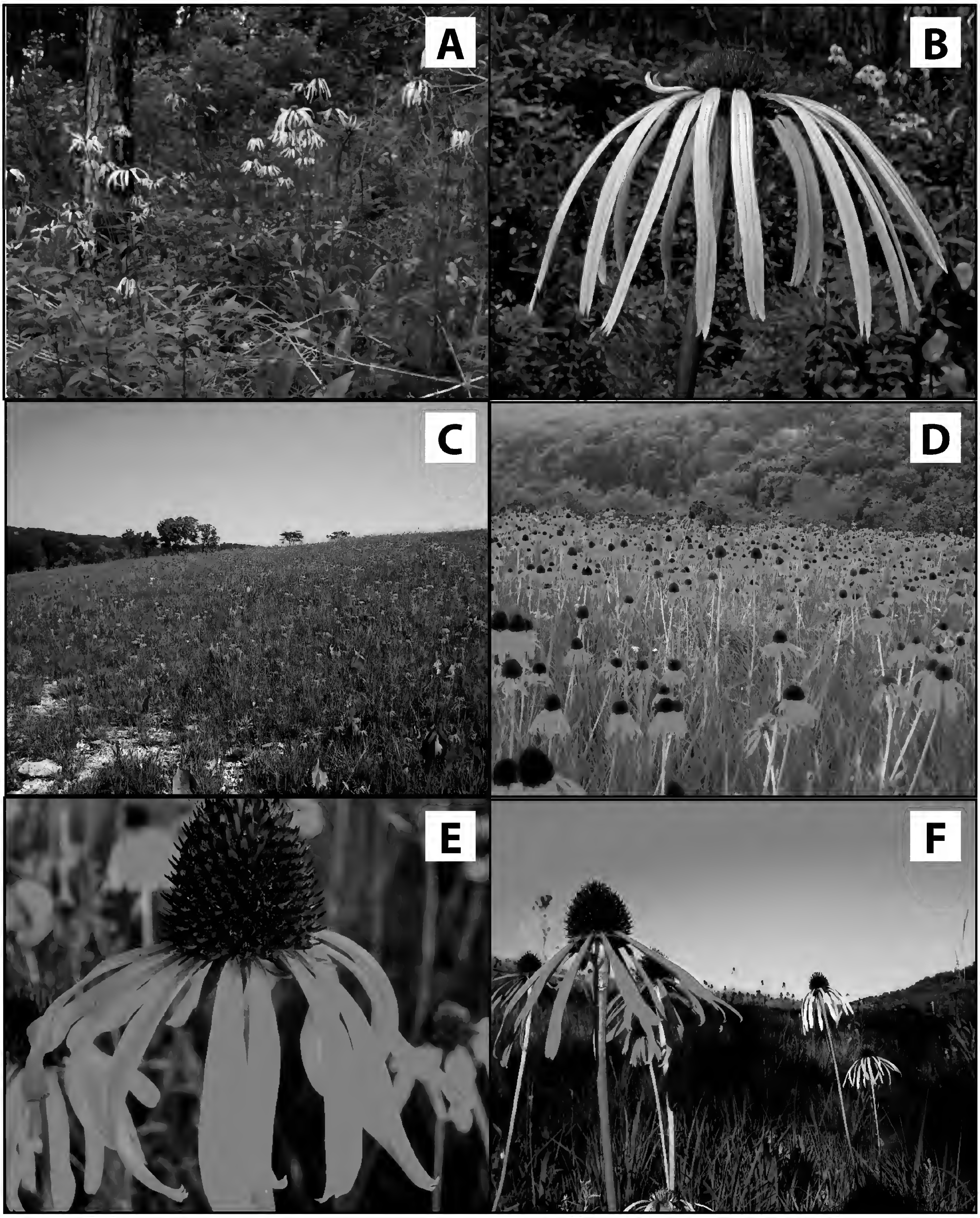

Fig. 5. **A, B.** *Echinacea laevigata* in sunny natural habitats of North Georgia, 28 May 2008. **A.** Stephens County, Chattahoochee National Forest at Currahee Mountain. The plants shown here occur in small groups scattered among other forbs growing in open forest areas on rocky soil mostly of amphibolite. Note the long, narrow purplish to white reflexed ray florets. **B.** Same site as A, showing close up of glabrous stem and long, narrow, drooping, purplish ray ligules with bifid tips. **C–F.** *E. paradoxa* var. *paradoxa* natural habitats include open sunny glades at Ha Ha Tonka State Park, Camden County, Missouri. **C.** Heimbeaugh Hill Glade. This area historically has been maintained with fire and current management includes the removal of *Juniperus virginiana* trees and prescribed burns. This more xerophytic west-southwest facing site is characterized by multiple layers of dolomite dating from the early Ordovician period and these areas are sometimes referred to as "balds" or "barrens." Note that yellow coneflower predominates as a single taxon carpeting the entire area in late May and early June. **D.** Close up of previous site from different direction showing synchronous blooming of the taller *Echinacea* plants forming a canopy over the shorter prairie grasses with tree line in background. **E.** Close up of capitulum with prominent raised cone of paleae and yellow reflexed ray florets with notched ends and crimson coloration at point of insertion shown later in blooming period. **F.** *E. pallida* at glade edge. It typically grows here near the edge or margins of glades with yellow coneflower. Photo credits: Hugh & Carol Nourse (A, B), Christopher D. Crabtree (C–F).

5. Echinacea laevigata (C.L. Boynton & Beadle) S.F. Blake, J. Wash. Acad. Sci. 19:273. 1929. (**Figs. 1E; 5A, B; 9E; 10E**). SMOOTH PURPLE CONEFLOWER.

Stems erect, usually unbranched and glabrous, 55–110 cm high, leaves petiolate, ray florets purplish or light pink to whitish, spreading to reflexed. A distinct taxon found outside the distribution range of most *Echinacea* taxa in open woods of Pennsylvania scattered in the Piedmont area south to the mountains of Georgia. Natural habitats occur in sunny openings in forested areas maintained by wildfires and grazing animals. Thus preferred sites are open woods, glades, cedar barrens, roadsides, clear cuts, dry limestone bluffs, and power line rights-of-way associated with soils rich in magnesium, calcium, dolomite or limestone and rocky substrates of amphibolite (Fig. 5A, B). It is most closely related to *E. purpurea* but differs in having a vertical caudex and taproot, unbranched glabrous and glaucous stems, and leaf blades broadly lanceolate or elliptical mostly glabrous, with ray florets longer and more slender (Fig. 5B). This is the second taxon of *Echinacea* that was Federally listed as an Endangered Species (USFWS 1992).

Ray florets are pale pink to purple and lack trichomes, demonstrating the glabrous character of this taxon. The venation pattern consists of 15 vascular traces in transection supported by abundant thick-walled tissue. The uniformity in size and dome-shape of the ray ligule adaxial epidermal cells is the most obvious character. Secretory chambers are apparently lacking (Table 2).

The smooth and glaucous characters of the stem distinguish this taxon from *E. purpurea* and other taxa of *Echinacea*. In every dimension the epidermal cells are larger than in other species. Moreover, a striking pattern of straight, oblique, and curved walls demonstrates the irregularity in cell shape (Fig. 9E). Only the outermost layers of the cortex consist of typical collenchyma. The greater part of the cortex is parenchymatous tissue with large intercellular spaces (10 µm). The pericyclic fibers give a weak phloroglucinol test. They are mostly thin and needlelike in structure and are easily broken into fragments. The end walls taper to a sharp point with lengths that vary from 360 to 1150 µm (794 µm) and widths from 8 to 20 µm (13 µm). The phloem zone is 60–70 µm in radial extent. Macerated tissue had vessels that range in length from 159 to 450 µm (302 µm) and widths range from 23 to 34 µm (29 µm). Some of the scalariform vessels are tailed with oblique perforation plates. Little sclerification occurs between vascular bundles (Fig. 10E) and none was present in the pith. Measurement of stem diameter was ~5.2 mm, including the pith (~4.2 mm) with pith cell lengths that range from 60 to 174 µm (121 µm) and widths from 60 to 97 µm (80 µm) (Table 3).

The secretory system was represented by canals in the cortex and pith. Those of the cortex are relatively abundant and large with usually five to eight epithelial cells originating opposite the vascular bundles and/or interfascicular region. About half of the vascular bundles have single canals and the others occur in pairs. Canals in the pith form double rings of epithelial cells as a result of a second periclinal division with an outer ring of elliptical cells and inner one of rectangular cells. Pith canals have five to eight epithelial cells that surround the canal cavity (Table 3).

The petiole in transection appears horseshoe-shaped. Leaves of this taxon tend to have sheathing bases and this accounted for the lengthy "wings" (Table 4). Fundamental tissue extends to the very end of each wing which fails to show a graduation into foliar anatomy. A uniseriate layer of cutinized cells underlies the epidermis that is structurally indistinguishable from it. This double-layered tissue forms a definite boundary at the periphery of the petiole. Five vascular bundles are seen in transection (Table 4).

6. Echinacea pallida (Nutt.) Nutt., Trans. Amer. Philos. Soc. II. 7:354. 1840. (**Figs. 1F; 4F; 5F; 6E; 9A (h); 10F; 11C**). PALE PURPLE CONEFLOWER.

This taxon is an apparent segmental allotetraploid possibly derived from a hybrid between *E. simulata* and *E. sanguinea* with a doubling of the chromosome number to $2n = 44$. It has white pollen (Fig. 6E) and the largest pollen grains in the genus, 24–28.5 µm in diameter (26.1 µm) when compared to the most closely related *E. simulata* with pollen grains 22.5–24.5 µm in diameter (24.2 µm) and other *Echinacea* taxa with much smaller pollen grains (McGregor 1968). This taxon flowers in late spring and early summer in rocky prairies, open wooded hillsides, savannas, and glades concentrated in eastern Kansas and Oklahoma, western Arkansas, and throughout Missouri. Plants are rarely branched, 40–90 cm up to 140 cm high, stem trichomes hirsute below

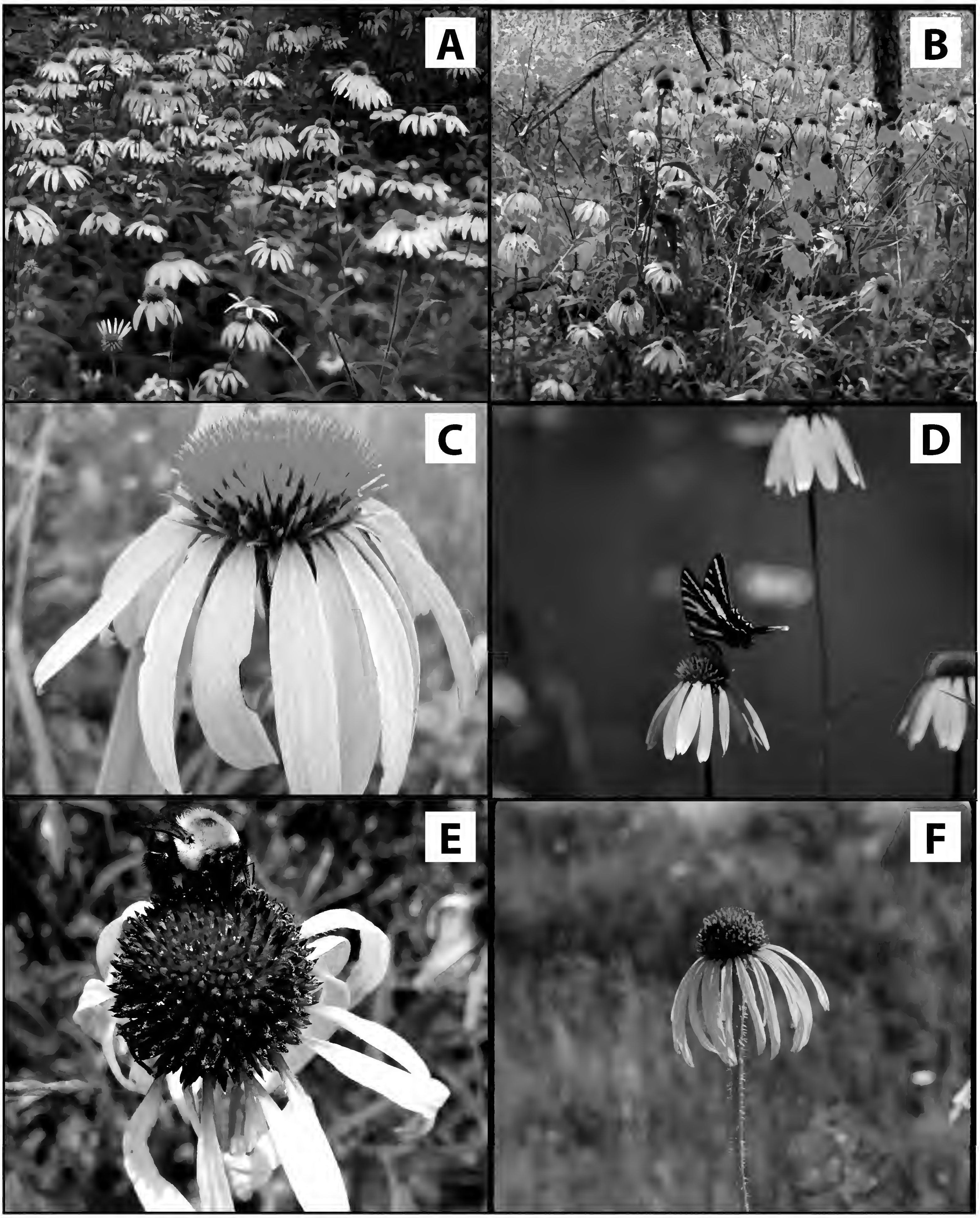

Fig. 6. *Echinacea purpurea* (A–D), *E. pallida* (E), and *E. simulata* growing in natural habitats in Arkansas. **A.** Saline County, open woodland growing in a clustered group, 16 Jun 2003. **B.** Saline County, Ouachita National Forest, open woodland along creek in shale barrens growing with *Rudbeckia grandiflora* var. *grandiflora*, 3 Jul 2003. **C.** Clark County, Terre Noire Natural Area, 6 Jul 2004, close up of capitulum showing brightly colored paleae, broad ray ligules with complex venation pattern, and bifid notched ends. **D.** Saline County, close up of capitulum showing visit of Zebra Swallowtail Butterfly, order Lepidoptera, family Papilionidae, genus *Protographium*, Jun 2001. **E.** *E. pallida*, Arkansas, Boone County, open areas on acidic chert, Baker Prairie Natural Area, 8 Jun 2013. Note bumblebee (*Bombus* sp.) on dark purplish paleae with contrasting traces of white pollen indicative of this tetraploid. **F.** *E. simulata*, Arkansas, Boone County, dolomite glades, Jun 1996. Note the yellow pollen adhering to the paleae and also the hirsute stem. Photo credits: John Pelton (A, B, D, F), Mark Clark (C), Joan Reynolds (E).

and more dense above, ray florets reflexed, sparsely hairy abaxially (McGregor 1968; Urbatsch et al. 2006). Ray florets vary from almost entirely dark rose red to reddish purple in eastern Kansas and throughout Missouri to whitish that predominates in eastern Oklahoma and western Arkansas and farther south to Texas and Louisiana (McGregor 1968). An excellent current source of general macromorphological and medical information is available for *E. pallida*, including color photographic images of habit and root microanatomy (Upton 2010).

Some irregularity in shape was apparent in the ray ligule adaxial epidermal cells, intergrading from a short bullet shape to a more conical or slightly dome-shaped papillose cell (Fig. 4F). Noticeable microscopically were trichomes of various lengths on the abaxial surface. A large amount of thick-walled supporting tissue enveloped the 13 vascular traces (Table 2).

Trichomes are moderately scattered over the stem surface described by McGregor (1968) as "hirsute on both surfaces." Three to five septa divide each trichome into four or five cells at irregular intervals (Fig. 9A, h). Generally the trichome is slender and tapered to a sharp point with lengths that range from 1 to 2 mm. In surface view the epidermis has angulate and rectangular cells; this is expressed in transection notably in the irregularity of epidermal cell size and shape (Fig. 9F). Paradermal sections were difficult to make due to the grooves and thick cuticle. The cuticular layer was 7.0 µm thick, bearing tiny spine-like projections on the surface. The inner tangential walls were heavily cutinized (Table 3).

The cortical zone including the endodermis and epidermis measures 180 µm at the narrowest point and 430 µm at the broadest. Collenchymatous tissue makes up most of the cortex. In macerated preparations collenchyma cells range in length from 110 to 280 µm (189 µm) and in width from 35 to 46 µm (45 µm). Pericyclic fibers as seen in macerated preparations range in length from 450 to 1450 µm (1056 µm) and in width from 40 to 18 µm (27 µm) with a lumen diameter of 8–16 µm. Xylem elements consist of vessels, fibers, and xylem parenchyma. Macerations of vessel elements ranged in length from 215 to 610 µm (378 µm) and in width range from 40 to 51 µm (48 µm). No annular vessels or tracheids are present. All vessels have simple perforation plates. The protoxylem consists mainly of spiral vessels, and the metaxylem, with scalariform to definite reticulate pits, seems to be developmentally more advanced than in *E. simulata*. Pith diameter is ~3.2 mm with no sclerenchyma cells present (Table 3). The stem tissue map shows cambial activity that unites the collateral vascular bundles into a mostly solid ring due to some secondary growth in the interfascicular regions (Fig. 10F). The pith consists wholly of parenchymatous tissue with length of cells ranging from 74 to 135 µm (101 µm) and widths that range from 72 to 110 µm (105 µm) (Table 3).

Secretory canals are present in both cortex and pith. Undeveloped canals have approximately four epithelial cells and a small canal cavity. These arise through radial (anticlinal) divisions sometimes followed by tangential divisions that give a rectangular shape to epithelial cells. With the completion of these divisions, the epithelial ring consists of at least six cells with an enlarged cavity. Canals of the pith appear singly, in pairs, or in triplets opposite the protoxylem points. Three to seven epithelial cells delimit the pith canals with small patches of thin-walled cells (11–15) designated as accessory tissue staining green with fast green stain. The pith canals in this species tend to anastomose, still, however, maintaining their individual identity. Cortical canals are spherical in shape. Each bundle cap has one canal on each side lying adjacent to the endodermis in the interfascicular region.

7. Echinacea paradoxa (Norton) Britton var. **neglecta** McGregor, Trans. Kansas. Acad. Sci. 70:366–370. 1968. (**Figs. 2A; 4G; 10G; 11F–G; 12C–F**). BUSH'S PURPLE CONEFLOWER.

Plant stems 30–80 cm high, usually unbranched, yellowish green, sparsely to densely strigose similar to variety *paradoxa*. This taxon is easily distinguished from var. *paradoxa* by its rose-colored, purple or white ray florets and a geographic distribution confined to the Arbuckle Mountains of southwestern Oklahoma in rocky prairies and open, wooded hillsides (McGregor 1968).

Ray ligule adaxial epidermal cells have one to three secretory chambers arranged on both sides of the vascular trace and scattered throughout the mesophyll tissue. These cells have a wide range in size that nearly corresponds to those of the stem, leaf, and petiole secretory systems. Each secretory chamber has an interior cavity of approximately 50 µm surrounded by three to seven epithelial cells. This is similar to the canals of the stem and petiole, (Fig. 4G). Ray adaxial ligule epidermal cells have outer tangential walls that result in sides that are parallel about three-fourths the way up, sloping gradually into a rounded apex (Fig. 4G). These cells are highly variable and in some cases distinctly papillate. The two varieties, *paradoxa* and *neglecta*, have adaxial ray ligule epidermal cells that are similar in size and shape (Table 2).

Trichomes are sparse or lacking but with distinctive epidermal patterns. In surface view epidermal cells are uniform in shape but significantly smaller in width. The breadth of cortical tissue extends from 230 to 500 µm. Outer portions of the cortex mostly consists of collenchyma while the inner portion intergrades into parenchymatous tissue. The phloem zone extends from 46 to 56 µm. Stem diameter is ~3.8 mm including a pith diameter of ~2.9 (Fig.10G; Table 3). Pith cells range from 137 to 257 µm (189 µm) with widths from 33 to 65 µm (47 µm) and in longisection are densely pitted.

Stem secretory canals are present in both the pith and cortex. Many canals are tangentially flattened especially the larger ones. Canals occur either in ones, twos, or threes opposite protoxylem points (Fig. 11D). Epithelial rings consist of 5–15 cells rectangular in shape. Accordingly the canal cavity is relatively large from 20 to 36 µm surrounded by 8–14 cells (Fig. 11G). Canals originate opposite both the vascular bundle caps and interfascicular regions. The newly formed canals are much smaller and confined to the endodermal layer; while those embedded in the cortical tissue are well developed and relatively large (Table 3).

A lunate to bow-shaped petiole is the result of a greater lateral overall thinness (Fig. 12C). Canals are well formed (distinct epithelial cells surrounding a large cavity) and larger than can be found elsewhere in the genus. Comparatively some of these canals are double the size of even the largest canals of other taxa. The total number of canals present (14) far exceeds counts made for other taxa. These canals are located typically on the abaxial side of the vascular bundles and some atypically on the adaxial side. The medial vascular bundles had pairs of canals on both the abaxial and adaxial sides. Well-formed canals have an extremely large cavity 31–43 µm in diameter surrounded by a well-differentiated ring of epithelial cells (Table 4). In other taxa canals are surrounded by four to six epithelial cells but here 5 to 15 cells make up the epithelial layer. Furthermore, the epithelial cells have a distinctive shape closely approaching a rectangular shape; while others found in different *Echinacea* taxa usually are more elliptic with curved anticlinal walls.

Apparently no taxon in the genus *Echinacea* has brachysclerids or stone cells in aerial plant parts except in the petioles of var. *neglecta* (Fig. 12D, E, F; Table 4). These sclerids occur as single, conspicuous cells with highly refractive thickened walls that make them appear as shiny, glistening structures reminiscent of the clustered stone cells in pear fruit mesocarp (Fig. 12E). More noticeable was the concentric layering of the thickened walls and the branched ramified pit canals revealed by a preferential stain. In this case the walls were heavily lignified (stained with safranin) throughout, including the thickened secondary walls (Fig. 12D). The sclerids were scattered throughout the fundamental tissue as seen in Fig. 12D, E, F). Similar brachysclerids also were found in roots of *E. angustifola* (Axentiev et al. 2010) and *E. pallida* (Upton 2010).

8. **Echinacea paradoxa** (Norton) Britton var. **paradoxa** in N.L. Britton and A. Brown, Ill. Fl. N. U.S. ed. 2, 3:476. 1913. (**Figs. 2B; 4H; 5C, D, E; 9G; 10H**). YELLOW CONEFLOWER.

This taxon is easily recognized by its bright yellow ray florets either drooping or reflexed (Fig. 5E). It differs in color from all other *Echinacea* species that have deep purple, pinkish, to white ray florets. General habit of the plant is 40–90 cm tall, stems usually unbranched, yellowish green, sparsely to densely strigose (McGregor 1968). A relatively small distribution area is restricted to rocky and upland prairies, limestone and dolomite cedar glades, savannas, bald knobs and also roadsides of west-central and southern Ozarks of Missouri and north central Arkansas (Yatskievych 2006). Native wild populations of strikingly beautiful yellow coneflowers sometimes dominate the open field landscape in the Ozark cedar glades, especially in Ha Ha Tonka State Park, Missouri (Fig. 5C, D; Crabtree 2008; Richter 2013; H.W. Keller, pers. obsv.).

Ray ligule adaxial epidermal cells are wide at the base with straight parallel sides that become convex at the apex (Fig. 4H). The overall dome shape and size are similar in both var. *neglecta* and var. *paradoxa*. One chromoplast occurs in each cell. A secretory system is well differentiated in size, frequency, and arrangement. Secretory chambers are associated with vascular traces and occur on both adaxial and abaxial sides; each chamber is conspicuous mainly due to their large cavities and the three to seven peripheral epithelial cells (Fig. 9G). The ray floret secretory system is similar in size and number in both varieties but exceeds in size and greater numbers the canals in all other *Echinacea* taxa, including the closely related *E. atrorubens* (Table 2).

Only a few trichomes were observed. The stem lacks grooves at this position so the paradermal sections show more uniformity in cell shape. This stem morphology results in a fairly constant rectangular shape of the epidermal cells in surface view (Fig. 9G). In transectional view many cells are squarish instead of the typical tabloid epidermal cell. Anticlinal walls of epidermal cells are thin and straight. The cortex is made up of an outer collenchymatous zone and an inner parenchymatous tissue with large intercellular spaces. Lengths of collenchyma cells range from 90 to 228 µm (180 µm) and widths range from 28 to 61 µm (45 µm). Pericyclic fibers range from 475 to 200 µm (1190 µm) and widths range from 16 to 23 µm (20 µm). The average wall thickness is 6 µm with a lumen of 6–10 µm. The phloem zone is 50–95 µm in radial extent. Vessels range in length from 325 to 650 µm (485 µm) and widths range from 23 to 50 µm (33 µm). Some secondary growth was observed in the stem (Fig. 10H). Comparison of stem tissue maps for varieties *neglecta* (Fig. 10G) and *paradoxa* (Fig. 10H) appear almost identical. Vascular bundles are connected by interfascicular activity with some sclerification that results in a more or less solid vascular cylinder without any interfascicular areas (Fig. 10H).

Pith parenchyma cells are 83–215 µm in length (190 µm). No thick-walled sclerotized cells are present in the pith region. The secretory system is represented by canals in both the pith and cortex. Secretory canals occur in the pith next to the protoxylem points and in the cortex opposite the vascular bundle caps and interfascicular regions in both varieties. Secretory canals occur in the pith next to the protoxylem points and in the cortex opposite the vascular bundle caps and interfascicular regions in both varieties. Epithelial rings consist of three to six cells positioned to give an hourglass or star-shaped cavity usually much reduced in size adjacent to the endodermis. Cortical canals originate opposite vascular bundle caps and interfascicular regions. Epithelial rings consist of five to eight cells (Table 3).

This taxon has the thickest petiole studied with an exaggerated curvature on the abaxial side that is discernible even macroscopically. Canals of the secretory system are comparatively numerous occurring in pairs instead of singly. Toward the abaxial margin of the petiole abundant chlorenchymatous pockets are interspersed among the collenchyma tissue. Five vascular bundles are noted in transection (Table 4).

9. Echinacea purpurea (L.) Moench., Methodus 591. 1794. (**Figs. 2C; 4I, 6A, B, C, D; 9H; 10I**). ($2n = 22$). EASTERN PURPLE CONEFLOWER.

This taxon has a deep fibrous root system that distinguishes it from all other *Echinacea* taxa. Distribution is more widespread but concentrated in the central plains states and then north and southeasterly in rocky open woods, thickets, and prairies (Fig. 2C; McGregor 1968). It is the most widely distributed taxon and characterized by its tall branching habit of 60–180 cm; awns of paleae as long as body; lower leaves ovate and often toothed; and dull purple to pinkish ray florets, spreading to recurved, 3–8 cm long 7–14 (–19 mm) wide (Fig. 6A–D). The larger colorful ray florets have encouraged the development of hybrids and cultivars grown commercially and as ornamentals in gardens.

Externally the gross morphology of the ray florets reflects the greater size in breadth but internally size is expressed by the increased degree of venation and the 31 vascular traces in transection. Comparatively *E. purpurea* has the broadest ray florets of all the taxa studied (Fig. 6C). Secretory chambers measure 40 µm in diameter with each canal surrounded by five epithelial cells.

Ray ligule adaxial epidermal cells have a wide ball-like base that gradually taper to a rounded apex (Fig. 4I). This shape contrasts with the shorter, convex shape of *E. laevigata* adaxial epidermal cells. In addition the broader ray florets of *E. purpurea* have a more complex venation pattern that differs from *E. laevigata* with more narrow ray florets and venation greatly reduced (Table 2).

Nonglandular trichomes thickly cover the stem. The base of the trichome is swollen and accentuated by an outgrowth of surrounding epidermal cells. Repeated sectioning was required to get thin paradermal peels. Heavy pubescence along with grooved stems undoubtedly caused this difficulty. In surface view the margin of the cuticle is wavy and rough in outline. Striae or rod-like bodies decorating the surface of the epidermis were

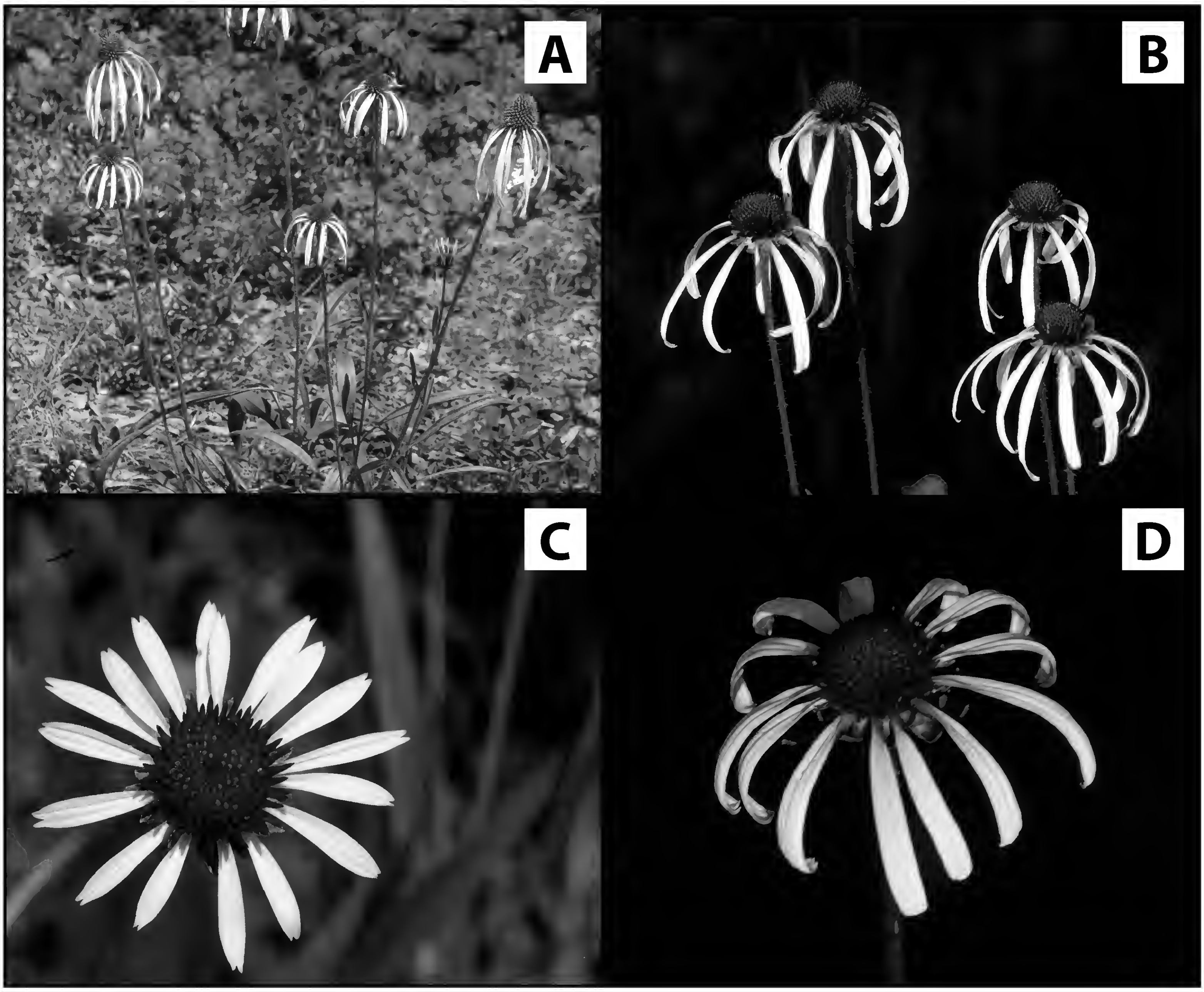

Fig. 7. ***Echinacea sanguinea*** **in sunny open field habitats. A. Wood County, Texas, 3.2 miles southeast of Winnsboro along State Highway 37 at edge of field near roadside ditch. Scattered groups of plants growing on sandy soil known geologically as the Queen City Sand, 22 May 1989. B. Nearby site 9.4 miles southeast of Winnsboro along State Highway 37 showing four capitula with whitish ray flowers and hirsute stems. Note the smallest stem diameter found in** ***Echinacea*** **and spindly habit. C. Same site as B showing close up of a single capitulum in early anthesis with spreading white ray ligules notched at tips. D. Same site as B showing close up of later stage anthesis. Note the reflexed ray florets and faint purplish colors at point of insertion. Photo credits: Bob O'Kennon.**

ascribed to cuticle depositions. Epidermal cells have some rectangular end walls which are usually oblique and angulate (Fig. 9H; Table 3).

The cortex contains an outer, several-layered, narrow zone of collenchyma cells and an inner, many-layered, loosely arranged broad zone of parenchymatous tissue. Collenchyma cell lengths range from 111 to 157 µm (131 µm) and widths from 21 to 37 µm (30 µm). Pericyclic fibers give a moderate phloroglucinol test as shown by the bundle caps. Fibers range in length from 663 to 2400 µm (1288 µm) with widths from 8 to 22 µm (15 µm). The average wall thickness is 5 µm and lumen size is 7 µm. The phloem zone radially extends from 59 to 73 µm. Vessel lengths range from 232 to 680 µm and widths from 20 to 42 µm. Pith diameter is ~3.6 with parenchymatous cell lengths from 92 to 130 µm with widths from 93 to 110 µm. No sclerids are present (Fig. 10I).

The secretory system consists of canals in both the pith and cortex. Those of the cortex tend to be tangentially flattened and are located opposite both vascular bundle caps and interfascicular regions. Epithelial cells are in direct contact with the endodermis and are not well differentiated from surrounding parenchymatous tissue. Epithelial rings of five to eight cells surround canals. Cortical canals number more than 48 in comparison to the less numerous pith canals (~34) centric or excentric in position. Epithelial cells vary from elliptical to subspherical shapes with no tangential divisions. The vascular stele is broken up into a dictyostele. Medullary rays pass out into the cortical tissue (Table 3).

Photosynthetic tissue is scattered among the parenchyma cells that make up the abaxial bulge of the petiole. Secretory canals are prominent when found adjacent to the medial vascular bundle, becoming progressively smaller as the lateral vascular bundle size decreases. Five vascular bundles are evident in sectional views; two more are diminutive but recognizable. The central vascular bundle lacks fibrous tissue on the abaxial side (Table 4)

10. Echinacea sanguinea Nutt., Trans. Amer. Phil. Soc. n. ser. 7:354. 1840. (**Figs. 2D; 4J; 7A–D; 9A-i–j, I; 10J; 12B**). SANGUINE PURPLE CONEFLOWER.

This is a distinct taxon often confused in the past with *E. pallida*. However, it differs in having hemispheric capitula, slender and more spindly stems, 40–90 cm high and sometimes reaching 122 cm in roadside ditches of East Texas (Fig. 7A–D; Bob O'Kennon pers. obsv.). It has narrower ray florets, elliptical leaves, yellow pollen, and is a diploid (*n* = 22). Distribution is more restricted to acidic, sandy soils, open pine barrens, woodlands, and prairies of southeastern Oklahoma, southwestern Arkansas, western Louisiana, and east Texas (McGregor 1968). It flowers in May in East Texas and gradually becomes a more rose color in a cline northward with later anthesis (Fig. 7A–D). Ray florets color and flowering times were genetically fixed from the original habitats while growing in the KU Experimental Gardens (McGregor 1968). This is the only taxon of *Echinacea* that has a more southerly distribution in the central states and thus differs from all other taxa.

Ray ligule adaxial epidermal cells have distinctive elongate, "necked" papillae that differ from all other taxa (Fig. 4J; Table 2). Trichomes are absent. No secretory chambers were present.

Short, stout trichomes thickly cover the stem. The trichome usually has fewer septa with the base heavily cutinized (Fig. 9A-i–k, I). Epidermal patterns consist of straight, mostly rectangular cells (Fig. 9I).

Collenchyma tissue makes up the greater part of the cortex except for several parenchymatous layers outside of the endodermis. Lengths in these elongated, tapered cells range from 151–373 µm (180 µm) and widths range from 40–45 µm (43 µm). Breadth of the cortical region ranges from 190–230 µm. Pericyclic fibers are not fragile or needle-like but are thicker with blunt or truncate ends with lengths from 300–1350 µm (850 µm), and widths 17–21 µm. The phloem zone in radial section is 22–45 µm (Table 3). Vessel lengths range from 275–950 µm (523 µm), and widths range from 20–35 µm (20 µm) (Fig. 11).

Echinacea sanguinea has the smallest stem diameter (~1.7 mm in width and pith diameter of ~0.9 mm) studied which reflects the spindly habit of this taxon (Fig. 10J). No sclerenchyma fibers are present in the pith (Table 3). Pith parenchyma cells ranged from 89–176 µm in length (137 µm), and widths from 41–105 µm (72 µm). The walls of the parenchyma cells are densely marked with elliptical and conspicuous primary pit fields.

The secretory system has canals that are interfascicular in origin with13–15 canals in the cortex. A brownish substance appears in some of the epithelial cells, making their presence conspicuous. Canals range from 40–48 µm with either a five or six-celled epithelial ring (Fig. 11A). The relatively small amount of vascularization reflects in part the spindly habit of the plant. Furthermore, interfascicular rays are sclerified, previously mentioned as a distinguishing character for other species (Table 3).

Gross morphology of the petiole varies based on the location either near or distant to the stem. Close to the stem the petiole is heart-shaped in transection with the ends folded together. Nearer the leaf base the petiole unfolds allowing reorientation of the margins. Secretory canals are relatively small arranged one on each side of the abaxial bundle cap (Fig. 12B). Four minor vascular bundles were present and the medial vascular bundle lacks an abaxial fibrous cap (Table 4).

11. Echinacea simulata McGregor, Sida 3:282. 1968. (**Figs. 2E; 4K–L; 6F; 9A-a–g, k, I; 10K; 11H**). WAVY-LEAF PURPLE CONEFLOWER.

This species was cited as *E. speciosa* McGregor by Keller (1962), but that name was never validly published. In the past it was included in *E. pallida*, but the pollen size in *E. simulata* is smaller and yellow as compared to white in *E. pallida*. Stems 60–120 cm tall are mostly unbranched with sparsely to densely pustular based trichomes. It occupies a distinct geographic area restricted mostly to north central Arkansas, eastern Missouri, western Illinois, and west-central Kentucky (Fig. 2D). The diploid chromosome number of $2n = 22$ contrasts with *E. pallida*, a polyploid with a chromosome number of $2n = 44$ (McGregor 1968).

This taxon has the largest adaxial epidermal ray ligule cells. The distinctive conical shape of the cell with a wide base and sides tapering upward that forms a sharp point, distinguishes this taxon from all other *Echinacea* taxa (Fig. 4K–L). Secretory chambers are present having either four or five epithelial cells. Thickness of the ray ligule is comprised mostly of the larger adaxial and abaxial epidermal cells. Trichomes are present on the abaxial surface and vascular traces number 13 in transection (Table 2).

Nonglandular trichomes are moderately scattered on the stem described by McGregor (1968) as "hirsute or somewhat tuberculate hirsute." These slender, uniseriate hairs gradually taper toward the apex. The terminal cell is highly variable and often structurally modified into a rounded or sharp point. Most of the trichomes have three septa, occasionally five in longer ones (Fig. 9A,-k). Marks sculptured in the trichome wall are lenticular in shape. The ontological sequence of the trichome conforms to the pattern in which only epidermal cells undergo division. However, the trichome is raised on a supporting base formed from both epidermal and sub-epidermal cells (Fig. 9A-a–g). In surface view they appear morphologically distinct from the surrounding epidermal cells and have a highly irregular outline, accounting for the wide range in size (Fig. 9J). This no doubt is due to the grooved surface of the stem which tends to give more rectangular shaped cells in the grooves, and more angulate cells on the ridges. In transection the cross diameter of epidermal cells is uniform, unlike the length, which varies considerably (Table 3).

The cortex has small pockets of thin-walled chlorenchymatous cells that underlie each sub-stomatal chamber. These fan out short distances around the stem and are interrupted at intervals by collenchyma which directly abuts the epidermis. Generally three types of collenchyma cells are recognized: angular, lamellar, and tubular. All three types often intergrade, but, the tubular type with intercellular spaces and angular thickenings is predominant in *E. simulata*. General shapes consist of elongate cells having unevenly thickened walls, with either rectangular, oblique, or tapering ends. A transitional region between cortical collenchyma and parenchyma occurs within one or two rows outside of the endodermis. Size and shape of collenchyma cells were studied from longitudinal sections and maceration: lengths range from 124 to 280 µm and widths range from 27 to 41 µm.

The uniseriate endodermis in transection is recognizable by the elliptic, thin-walled cells lacking pits. A starch test with a potassium iodide solution gave a positive reaction (a dark blue-black color) confined mostly to the endodermal layer. Instead of giving a blue ring, groups of two or three cells were filled with starch grains; then, for some distance, cells were void of starch. The starch granules measure 43 µm in diameter and appear roundish with a roughened surface.

The pericyclic fibers of the bundle caps in transection extended radially from 83 to135 µm (Fig. 4). Macerated tissue produced fibers between 322 and1341 µm (761 µm) in length and width 9.7–31 µm (16 µm) that varied in shape with some tapered to a sharp point, others blunt, and still others, truncate. Lumen diameter ranges from 4 to 24 µm (11 µm). All fibers have slit-like pits and give a strong positive phloroglucinol reaction. The phloem zone measures 51–75 µm in radial extent. No crystals or storage products are present. Stem transections show that the number of rows of metaxylem vessels ranges from three to seven with interspersed fibers (Table 3). Macerated preparations show vessel lengths vary from 197 to 644 µm. The end walls are completely dissolved, resulting in the simple perforation type in end view. Shapes vary from barrel-shaped with horizontal end walls while others are oblique and pointed. No annular vessels were observed and tracheids were absent. Vessel widths range from 24 to 42 µm with spirals either loose to close that range from 364 to 1008 µm and pitted vessels range from scalariform to elliptical.

Stem diameter was ~4 mm, including a pith diameter of ~3.3 mm, with intercellular spaces of 1 µm. Pith cells are nearly isodiametric, loosely arranged, and densely pitted. Cells in the center are larger, merging toward the periphery into smaller thicker-walled cells. The cells supporting vascular bundles tend to become sclerotized, especially surrounding the resin canals. No sclerotic cells are present in the center of the pith. Secretory canals originate adjacent to and through the division of the endodermis forming within the interfascicular region, the exception being where surrounding cells of the vascular system undergo positional rearrangement, tending to relocate the canal along the ascending arc of the bundle caps. Canals also are found either singly or in pairs closely associated with the vascular bundle at the periphery of the pith (Fig. 11H). These appear to be an integral part of the vascular bundle, but they actually form outside of and opposite the protoxylem points, becoming surrounded by cells that are highly lignified (Table 3).

Pith canals number 36 with diameters from 24 to 50 µm. Such a great range can be attributed to the developmental stage of the canal. Smaller canals have reduced cavities, and larger, relatively fewer epithelial cells. The larger canals have an enlarged cavity and smaller, relatively more epithelial cells that range in size from 17 to 22 µm between anticlinal walls. The number of epithelial cells lining the cavity varies from four to seven. Epithelial cell shape varies from square to oblong rectangular, sometimes ovoid but always the walls form an oblique angle. Each epithelial cell has a dense cytoplasmic content with a conspicuous nucleus. When present in pairs they appear in a juxtaposition sometimes spatially separated by as much as 100 µm. Cortical canals tend to be crushed in sectional view and are not well differentiated from the surrounding cortical parenchyma.

Stem diameter is relatively large in part because of sclerification and continuous growth in the interfascicular region (Fig. 10K). Stellar configuration seems to follow a circular design with secondary growth in only a portion of the stem. It is interesting to note that both *E. pallida* and *E. simulata* have interfascicular growth to a degree not seen in other *Echinacea* taxa (Table 3).

A striking feature of the petiole not found in other species is the fan-shaped medial vascular bundle. It has a wide fibrous cap gradually sloping adaxially as the phloem and xylem diminish in lateral extent. Seven vascular bundles can be seen in transection. The canal system is not well developed; in fact, canals associated with the more lateral vascular bundles are reduced greatly in size. The tips of the petiole arch upward and give a more or less lunate-shape in outline. Some petioles have loosely arranged parenchymatous tissue orientated adaxially near the epidermis, however, in *E. simulata*, this area is compacted and constituent cells have smaller intercellular spaces (Table 4).

12. Echinacea tennesseensis (Beadle) Small, Man. Southeast Fl. 1421, 1509. 1933. (**Figs. 2F; 8A–F**). TENNESSEE PURPLE CONEFLOWER.

This taxon's microanatomy was not included here because live plants were not available in the KU Experimental Gardens. McGregor (1968) described its distribution as an endemic restricted to the "dry, gravelly hills and barrens near LaVergne, Tennessee" (Rutherford County). Specimens were only available from herbaria so McGregor (1968) confined his observations to the type specimen. He recognized *E. tennesseensis* as a distinct species most closely related to *E. angustifolia* var. *angustifolia,* noting that it was "a very rare or possibly extinct species endemic to the Cedar Barrens area of central Tennessee." However, it differs morphologically in the smaller stature, 10–50 cm tall, softer pubescence, smaller pollen grains, leafier stem, and ray florets ascending rather than drooping (Fig. 8A–F)

A review article by Walck et al. (2002) notes that *E. tennesseensis* was one of the first plant species listed on the Federal Endangered Species list in 1979. It was listed in Tennessee as endangered and protected under the Rare Plant Protection and Conservation Act of 1985. Five additional populations of this species were found in Davidson, Rutherford, and Wilson counties (Fig. 8A–F) in the vicinity of Nashville as part of the Central Basin region of Tennessee. Several population sites near Nashville were destroyed when land was cleared for housing developments. In these localities it occurs in a general area referred to as the Cedar Glades (*Juniperus virginiana* L.) on outcrops of Ordovician-age Lebanon Limestone. The United States Fish and Wildlife Service removed *E. tennesseensis* from the Federal List of Endangered and Threatened Plants delisted in the Federal Register 2 Sept. 2011 (USFWS 2011). The discovery and recovery of additional populations of this species represent the cooperative efforts of scientists, especially Elsie Quarterman, and conservation groups over the last 30 years.

Nonglandular trichomes are present on the stem either sparsely or thickly covering the surface in all *Echinacea*

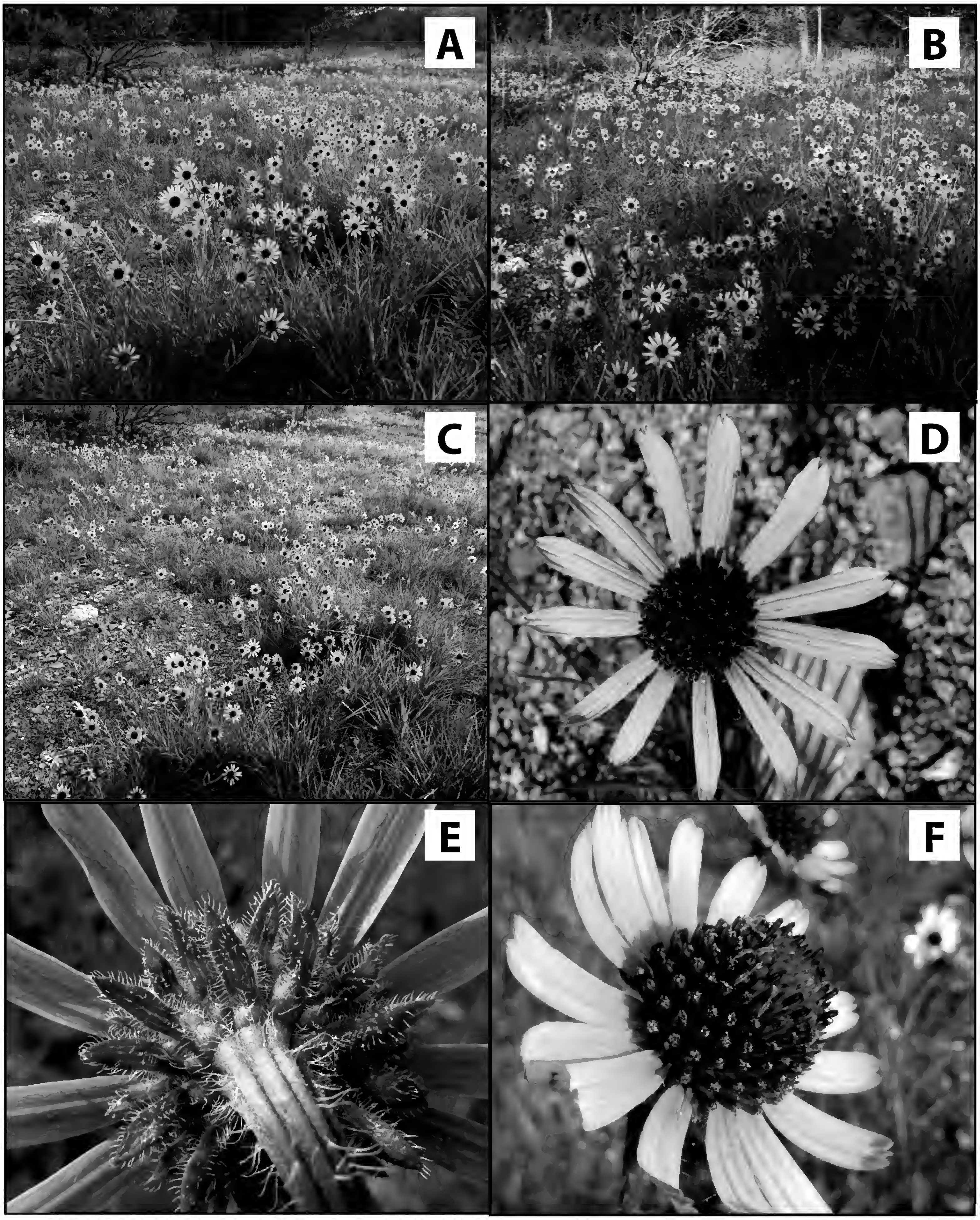

Fig. 8. *Echinacea tennesseensis* in sunny, open natural habitats in Wilson County, Tennessee, on a site derived from soils of Ordivician age limestone (Lane Farm State Natural Area). These areas have shallow soils and more xerophytic conditions referred to as cedar (*Juniperus virginiana*) glades or barrens often interspersed with Little Bluestem grass. Photographs taken the evening of 21 Jun 2013 and the morning of 23 Jun 2013 at the peak of anthesis. **A.** Landscape panoramic view of glade where Eastern Red Cedar trees occur around the marginal edge and *Echinacea* dominates in patches backlit by the evening sun. **B.** Morning hours showing capitula facing the sun. **C.** Patchy distribution on gravelly, rocky site. **D.** Top view of capitulum showing 13 marginal ray florets ascending upward and not reflexed downward with two-notched tips. **E.** Underside view of capitulum showing the hairy whorl of phyllaries subtended by hairy fluted stem. **F.** Side view of entire flower and stem showing ascending ray florets with two and three notched tips. Photo credits: Todd Crabtree.

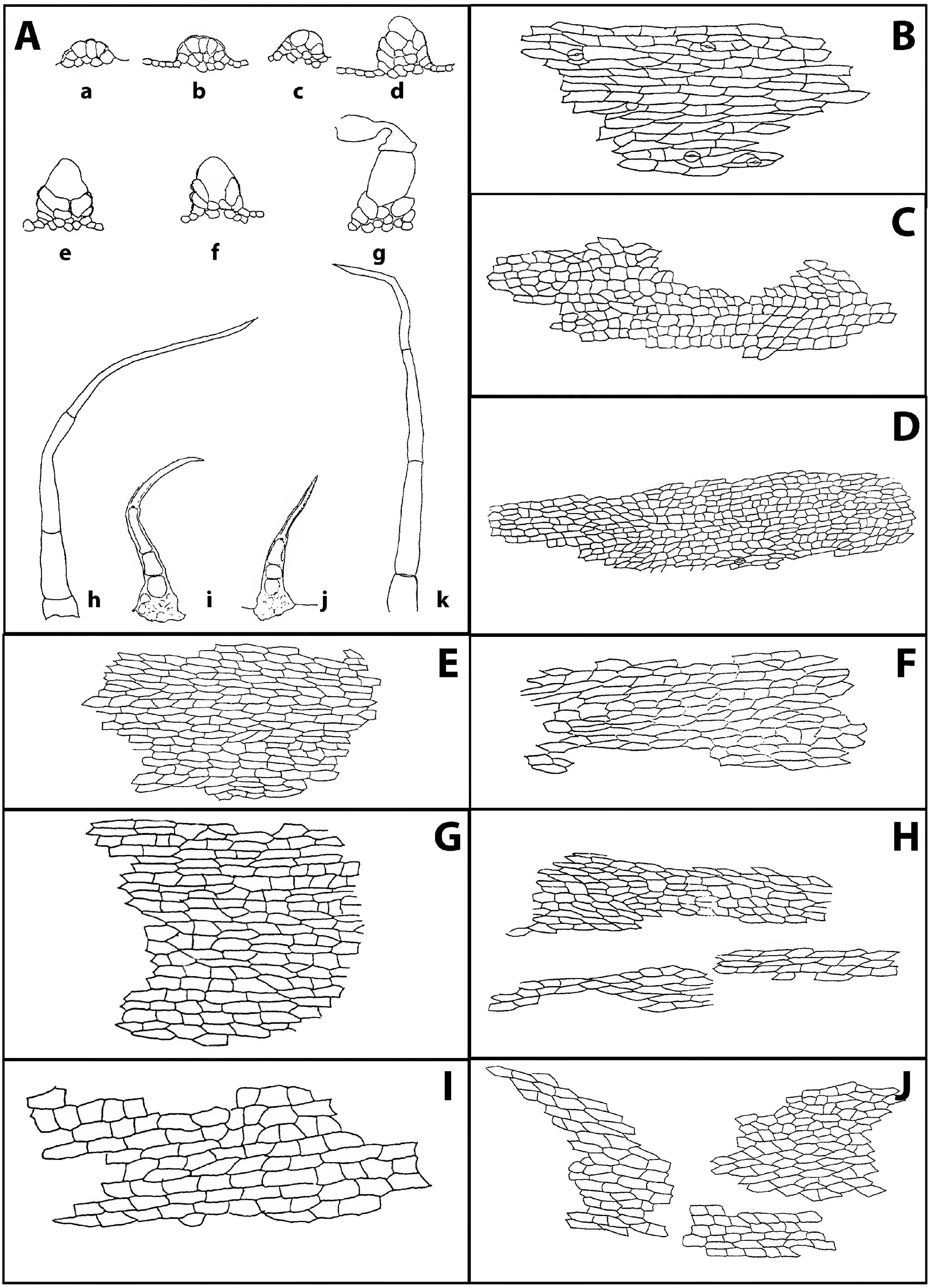

Fig. 9. Stem paradermal peels showing line drawing illustrations of trichomes. **A.** *Echinacea simulata* developmental sequence of nonglandular, uniseriate, multiseptate trichome (a–g). Note that the epidermal and sub-epidermal layers give rise to three to five septate trichomes with sharply pointed ends (h, *E. pallida* with four septa; i–j, *E. sanguinea* with three septa, greatly thickened walls and reduced lumen; k, *E. simulata* with five septa in longer flexuose trichome) (×78). **B–J.** Stem paradermal peels showing line drawing illustrations of epidermal cell shapes and sizes (all images ×30). **B.** *E. angustifolia* var. *angustifolia* showing irregular pattern with four anomocytic type stomata in field of view. **C.** *E. angustifolia* var. *strigosa* showing rectangular cells. **D.** *E. atrorubens* showing mostly rectangular cells with straight end walls in middle portion. **E.** *E. laevigata* showing the largest cells in irregular sizes and shapes with mostly oblique to curved walls. **F.** *E. pallida*. Note irregular angulate and rectangular cells. **G.** *E. paradoxa* var. *paradoxa*. Note mostly rectangular cell shapes. **H.** *E. purpurea*. Note oblique and angulate end walls. **I.** *E. sanguinea*. Note mostly rectangular cells. **J.** *E. simulata*. Note irregular outline from trapezoid to rectangular.

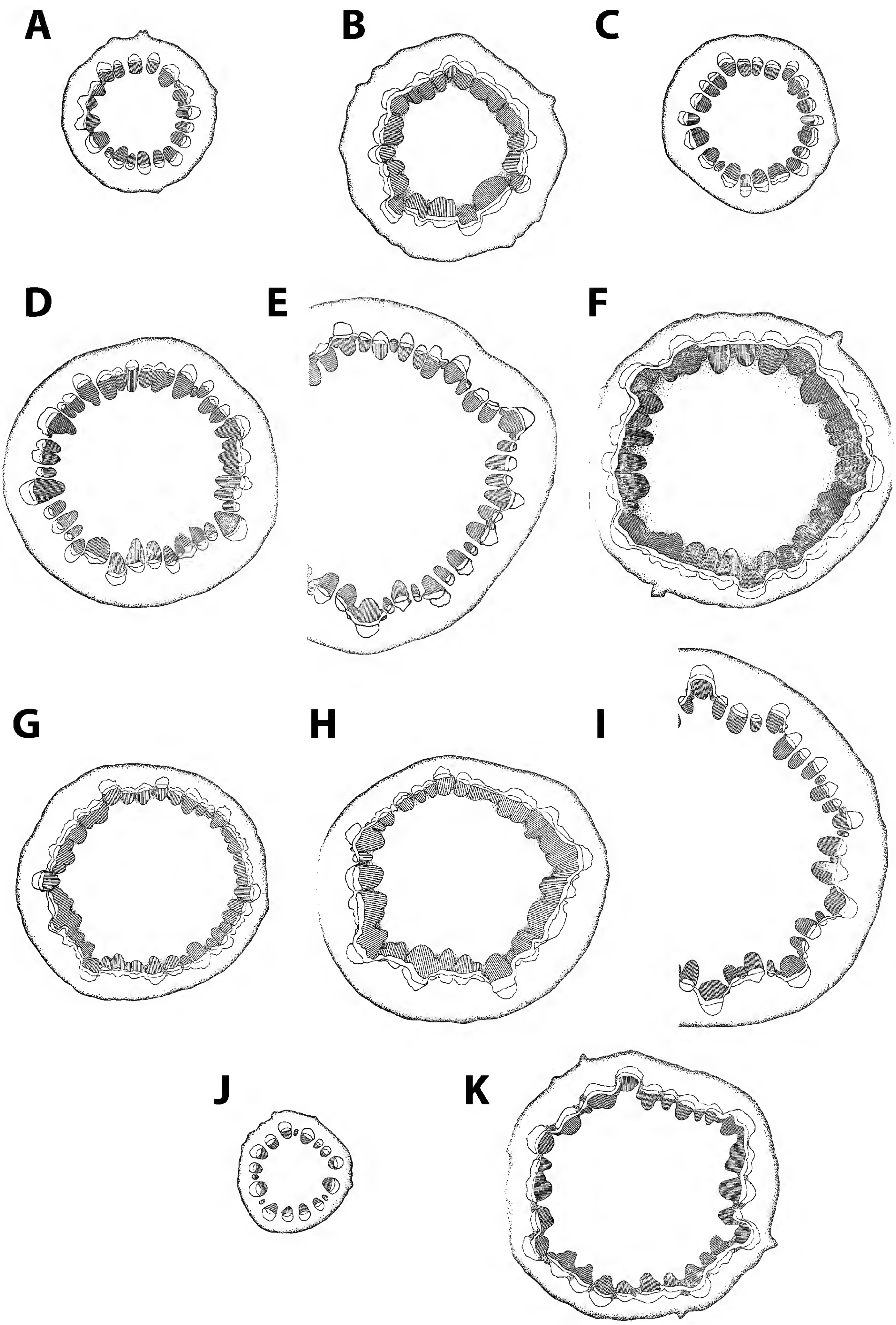

Fig. 10. *Echinacea* stem transections compared as tissue maps at same magnification (×8.8). **A.** *E. angustifolia* var. *angustifolia*. **B.** *E. angustifolia* var. *angustifolia* "race intermedia." **C.** *E. angustifolia* var. *strigosa*. **D.** *E. atrorubens*. **E.** *E. laevigata*. **F.** *E. pallida*. **G.** *E. paradoxa* var. *neglecta*. **H.** *E. paradoxa* var. *paradoxa*. **I.** *E. purpurea*. **J.** *E. sanguinea*. **K.** *E. simulata*.

taxa with the exception of *E. laevigata* where they are lacking. These trichomes are simple but variable in size with three to five septa and usually sharply pointed tips (Fig. 9A). Lenticular markings always appear in the trichome wall. All trichomes form on a morphologically distinct area of the epidermis (Fig. 9A, a–g). The grooved (fluted) stem is extended directly below the capitulum for variable distances in different taxa (Fig. 8E). This grooved surface area accounts in part for the irregular shapes and sizes of stem epidermal cells in paradermal peels (Fig. 9B–J).

Throughout the genus only anomocytic stomata occur which have an irregular outline surrounded by a limited number of cells which cannot be distinguished from other epidermal cells (Fig. 9B). The subsidiary cells usually found in other stomata types are absent. This type of stomata opening is also called the ranunculaceous type because it commonly is found in the family Ranunculaceae (Fig. 9B; Metcalfe & Chalk 1950).

Surface views of stem epidermal cells show more irregular patterns of straight, oblique, and curved cell wall shapes with overall larger dimensions as in *E. laevigata* (Fig. 9E). In striking contrast, *E. angustifolia* var. *strigosa* had the smaller stem epidermal dimensions and a more regular rectangular to squarish cellular pattern (Fig. 9C). *Echinacea paradoxa* var. *neglecta* had a distinctive pattern of rectangular to more trapezoidal-like shapes with slanted end walls (Table 3). Stem epidermal cells of all 11 *Echinacea* taxa studied were illustrated with line drawings by Keller (1962).

Cortical tissue in the near-surface region of the stem outside of the vascular bundles is modified into chlorenchymatous tissue with neighboring amounts of parenchymatous cells with much larger intercellular spaces. This photosynthetic tissue is manifest in the greenness of the stem. The cortical zone is comprised mostly of collenchyma with thickened cell walls that abut on the smaller intercellular spaces (Fig. 11B). All *Echinacea* taxa apparently have collenchyma in this region to strengthen and support the aerial system of the stem. Stem tissue systems in *Echinacea* lack crystals of any type as well as lacticiferous canals and mucilaginous cells. Secretory canals are present adjacent to and originate through the division of the endodermis. All species have secretory canals located either opposite the vascular bundle caps and/or interfascicular region. When secretory canals occur in the pith, they originate opposite the protoxylem points (Table 3).

All *Echinacea* taxa have a distinct, continuous endodermal layer or layers. Carbohydrates appear confined to the endodermal tissue as granular starch grains with roughened surfaces (Fig. 11C). Macerated stem tissues consisted of xylem elements either spiral, scalariform, and reticulate vessels, xylem parenchyma, fibers but no tracheids. Phytomelanin-coated sclerids found in the vascular tissue in the roots of *E. angustifolia* and *E. pallida* were not observed in the stem tissue preparations of the xylem and phloem.

GENERAL DICHOTOMOUS KEY TO *ECHINACEA*

This key to *Echinacea* taxa is based on macro- and microcharacters of ray florets, stems, and petioles. *Echinacea tennesseensis* is not included here and is only known from cedar barrens near Nashville, Tennessee.

1. Stem pith tissue with sclerotic cells scattered throughout ____ **E. angustifolia** var. **angustifolia,** **E. angustifolia** var. **strigosa,** and hybrids

1. Stem pith tissue lacking sclerotic cells.

2. Secretory canals present only in cortex; stems slender, less than 2 mm diameter ____ **E. sanguinea**

2. Secretory canals present in pith and cortex; stems stouter, more than 2 mm diameter.

3. Stem diameters >4.5 mm; >42 protoxylem points.

4. Ray ligules 5–6 mm; ~15 vascular traces; stems and leaves glabrous; plants with a taproot; distribution restricted to southeastern U.S.A. ____ **E. laevigata**

4. Ray ligules 7–12(19) mm wide traversed by ~31 vascular traces; stems and leaves bearing trichomes; plants with fibrous root system and horizontal rhizome; distribution mostly in Missouri and Arkansas with scattered populations farther east ____ **E. purpurea**

3. Stem diameters <4.5 mm; <42 protoxylem points.

5. Petioles with stone cells ____ **E. paradoxa** var. **neglecta**

5. Petioles lacking stone cells

6. Ray florets bright yellow ____ **E. paradoxa** var. **paradoxa**

6. Ray florets purple, red, pink, or white

7. Petioles with three air spaces; ray ligules adaxial epidermal cells with a broadened base and a short "nipple like" apex ____ **E. atrorubens**

7. Petioles lacking air spaces; ray ligules adaxial epidermal cells dome shaped to conical.

8. Ray ligules adaxial epidermal cells distinctly conical and largest in size (83–125 µm in height); pollen yellow ____ **E. simulata**
8. Ray ligules adaxial epidermal cells dome shaped and smaller in size (58–82 µm in height); pollen white ____ **E. pallida**

DISCUSSION

Ray ligules

Baagøe (1977a) assessed and discussed the functional role of ray ligule adaxial epidermal cells in the Asteraceae. Although *Echinacea* was not included in her study, the highly specialized adaxial epidermal cells occurring here and in a broad spectrum of unrelated taxa suggest that this epidermal type is a genetically fixed functional adaptation rather than ontogenetically developed structures based solely on growth rates and other factors.

There are two main morphological properties of ray ligule adaxial epidermal cells: their size and shape. Functionally, these relate to the absorption of visible or ultraviolet light that plays a role in insect pollination biology or the surface-to-volume ratio as the increased height increases the larger surface area to various external physical properties or physiological activity. It is likely that the interaction between these two selection pressures, namely pollination biology and physiological adaptations, play a major role in shaping adaxial ray ligule epidermal cells (Baagøe 1977a).

This was apparent when Noda et al. (1994) reported that petal conical cells in comparison to flat cells increased the proportion of incident light that entered epidermal cells, enhancing light absorption by the pigments (anthocyanins) and thus increasing the intensity of petal color. Experimental evidence came from a *mixta* mutant of *Antirrhinum majus* that had petals composed of flat hexagonal-based cells that changed the mutant cell morphology of petal color to a slightly paler and less velvety surface. Conical adaxial petal cells had more sparkle that attracted bumble bee pollinators and a velvety surface that facilitated clinging to the petal surface.

A more recent review paper by Whitney et al. (2011) noted the variation of conical adaxial epidermal cells of *Geranium procurrens*, *Helianthus annuus*, and *Hibiscus trionum*. These epidermal cells were considered as they relate to petal color, petal reflexing, petal scent production, petal wettability, and insect pollinator grip on the flower surface. They recognized at the outset that conical epidermal cells found on adaxial surfaces of flowers are a special feature of petals rarely found on leaves or any other plant surfaces. Floral conical cells had the ability to focus light into epidermal vacuoles that contain anthocyanins, increasing color saturation of the petal and, with the scattering effect from the mesophyll, was more even than found in flat cells and therefore resulted in a brighter sheen or velvety surface. A series of observations was made noting, (1) petal reflexing with conical cells that stand more upright and presented a larger surface or target area to attract pollinators (bumblebees), (2) flat-celled petals were more wettable than conical-celled petals, (3) conical cells were self-cleaning and aided in removal of dirt particles or potential fungal pathogenic spores, and (4) more recent convincing evidence shows that bumblebees can discriminate by tactile touch alone the difference between conical and flat-celled surfaces on petals but have a clear preference for the conical surface (Whitney et al. 2011).

Echinacea florets are visited and pollinated by bumblebees (*Bombus* spp., H.W. Keller, pers. obs.), butterflies, and longhorn beetles (Figs. 3B; 6D, E). The co-evolution of insect pollinators suggests there is selection pressure toward specialized ray ligule adaxial epidermal cells in *Echinacea* as observed in the variation of cell shapes and sizes. There are no flat adaxial epidermal ray flower cells in any *Echinacea* taxa. The presence of curious multicellular ray ligule adaxial epidermal cells found only in *E. angustifolia* "race *intermedia*," and lacking in the closely related varieties *angustifolia* and *strigosa*, merits special consideration because these anatomical structures previously were not included in publications. Their presence or absence is complicated by a limited sample size that may have overlooked their presence in other related taxa. Not knowing the cause or frequency of such a micromorpholgical character in a colony, hybridized population, or species makes it difficult to interpret its diagnostic significance and utility. A survey of the literature indicates that these trichomes are rarely found on the adaxial surface of petals. Their function may be protective against desiccation or predation, produce secretions, or as in this case of *Echinacea*, their function appears to be unknown. These cells are

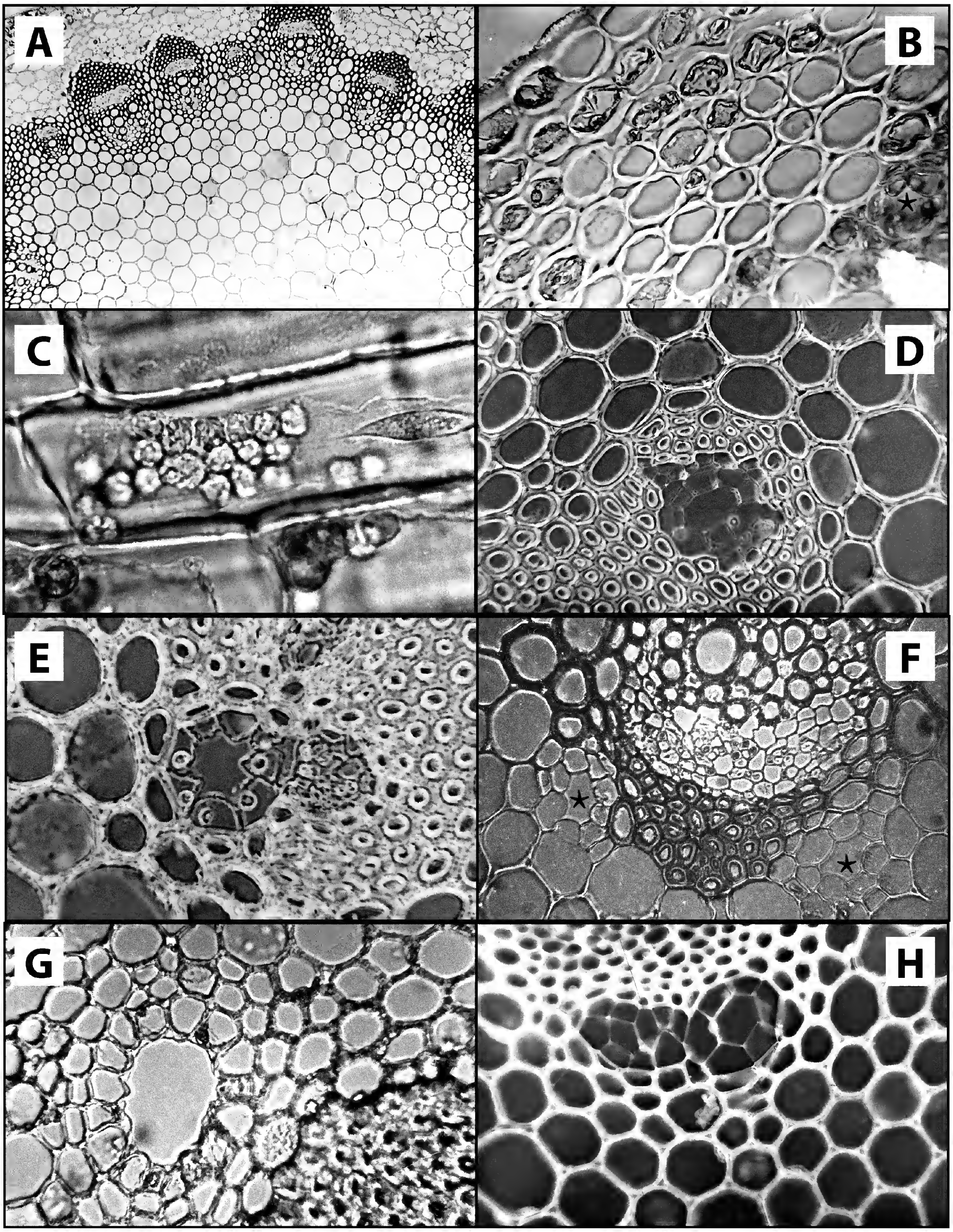

Fig. 11. Stem transections of *Echinacea* taxa. **A.** *E. sanguinea* showing portion of vascular system. Note the absence of secretory canals and sclerotic cells in the parenchymatous pith region, discrete collateral vascular bundles composed of primary tissue with fibrous bundle caps, partially sclerified interfascicular regions, one small secretory canal middle right in cortex composed mostly of collenchyma cells, and chlorenchyma cells underlying the epidermis. This microtome section was stained with safranin and fast green (×50). **B.** *E. angustifolia* var. *strigosa* free hand section showing typical thick-walled, elliptical collenchyma cells of outer cortical region (compare isodiametric parenchyma cells with intercellular spaces in pith see Fig. A). Note secretory canal in lower cortex (star) (×25). **C.** *E. pallida* showing endodermis cell in longitudinal section. Note numerous starch grains with roughened surfaces ~4.6 µm in diameter (×652). **D–H.** Stem transections showing secretory canals. **D.** *E. atrorubens* with secretory canal lumen surrounded by thin-walled, rectangular, eight-celled, epithelial ring embedded in thick-walled sclerified tissue next to the protoxylem points of the vascular bundle (×430). **E.** *E. atrorubens* with secretory canal embedded in vascular bundle cap (×430). **F.** *E. paradoxa* var. *neglecta* showing two secretory canals (stars) opposite the vascular bundle cap near the cortical region (×430). **G.** *E. paradoxa* var. *neglecta* with the largest secretory canal located near the protoxylem points in the pith with a 12-celled epithelial ring (×430). **H.** *E. simulata* with paired secretory canals opposite protoxylem points near the pith (×430).

widely scattered and therefore do not cover extensive areas nor do they appear to be secretory cells. Additional studies are justified to elucidate the occurrence and function of these cells.

Groups of *Echinacea* taxa may share a basic ray ligule adaxial epidermal shape. For example, the dome-shape adaxial epidermal cell with a rounded apex was observed in *E. laevigata*, *E. paradoxa* var. *neglecta*, *E. paradoxa* var. *paradoxa*, and more modified into a rounded but somewhat pointed apex in *E. angustifolia* var. *angustifolia*, *E. angustifolia* "race *intermedia*," *E. angustifolia* var. *strigosa*, *E. pallida*, and *E. purpurea*. These are more or less transitional shapes that could be considered the same basic epidermal cell type. In contrast the distinctive shapes of *E. atrorubens* (apex nipple-like), *E. sanguinea* (apex necked), and *E. simulata* (apex sharply pointed conical) appear different from the dome-shaped epidermal cell type. The question remains, however: how constant will these shapes remain over a broad range of habitats and given statistically significant sampled populations?

Echinacea simulata has the largest (length and width) ray ligule adaxial epidermal cells in the genus (Fig. 4K, L). The similarity between *E. pallida* and *E. simulata* based on macromorphological characters can be distinguished by adaxial ray ligule epidermal cells that appear to have distinctive shapes; the more dome shape in *E. pallida* in contrast to the more conical shape in *E. simulata*. This anatomical character alone distinguishes the two taxa even though the macromorphological characters have created confusion in the past.

Polyploidy, including tetraploids, with the increase in ploidy or sets of chromosomes, usually results in more robust, larger plants in overall size (stem height and diameter, leaf, flowers) and a proportional increase in cell size and volume. This increase in the component parts of the plant is called the "gigas effect." Comparison of ray floret anatomy of *E. pallida* (a tetraploid) with *E. simulata* (a closely related diploid with which it has been confused in the past) resulted in no obvious differences attributed to ploidy. For example, the ligule ray adaxial epidermal cells in *E. pallida* average 72 µm in length and 48 µm in width compared to *E. simulata* that average 105 µm in length and 75 µm in width. There are no other consistent micromorphological characters other than pollen size that suggest any differences in cell size between these two taxa.

Microanatomy of the ray florets of *E. purpurea* described by Upton (2007) noted (1) nonglandular trichomes similar to those on the leaf, (2) papillose epidermal cells of the ligule, (3) secretory ducts along veins, and (4) epidermis with wavy anticlinal walls, anomocytic stomata, and a light area indicating a secretory duct beneath a vein. This ray floret description fails to indicate adaxial and abaxial surfaces of the ray ligule, and indeed, the papillose surfaces in all the *Echinacea* taxa studied here were modified into various shapes and the abaxial surface had more epidermal-like trichomes. The line drawing illustration in 6f shows ray ligule trichomes similar to leaf trichomes (Upton 2007). Marginal ray florets in the Asteraceae usually have three teeth (notched) at the apex with veins outlining the three teeth (Carlquist 1976).

Internal ray floret anatomical characters, apart from epidermal cells—such as the number of vascular traces (usually 13), thickness of ray florets (170–312 µm), and number and location (adaxial or abaxial surfaces) of secretory chambers—are more or less constant for all *Echinacea* taxa except for *E. laevigata* and *E. purpurea*. *Echinacea purpurea* has the broadest ray florets of all the taxa and a more complex venation pattern that distinguishes *E. laevigata* and *E. purpurea* based on ray floret anatomy. Here the difference in the size of the ray floret width is reflected in the number of vascular traces (15 in *E. laevigata* and 31 in *E. purpurea*) and the abundant presence of secretory chambers in *E. purpurea* and apparent absence in *E. laevigata* (Table 3).

Stems

Rank ordering of stem diameters from the smallest to the largest was based on measurements in Table 3: *E. sanguinea*, *E. angustifolia* var. *angustifolia*, *E. angustifolia* var. *angustifolia* "race *intermedia*," *E. angustifolia* var. *strigosa*, *E. paradoxa* var. *neglecta*, *E. paradoxa* var. *paradoxa*, *E. atrorubens*, *E. simulata*, *E. pallida*, *E. purpurea*, and *E. laevigata* that follow a general trend of the higher the stem height the greater the stem width with the exception of *E. sanguinea* that has the smallest stem diameter and a more spindly habit (Fig. 10J; Table 3).

Samples were taken at the height of anthesis. Comparison of stem diameters of all *Echinacea* taxa shows a well-developed pith region usually occupying about 75 percent of the total stem diameter. This contrasts with the findings of Upton (2007) who reported in the general habit description of *E. purpurea* a stem diameter of

2–5 mm in transection with the pith hollow or solid. It is difficult to assess the importance and comparison of these characters with the present study. All of the stem tissue maps and measurements given here show an extensive pith region in all *Echinacea* taxa with no sign of tissue disintegration, which might occur later in the growing season and account for a hollow stem. Transections taken later in the growing season in July and August could possibly result in a hollow pith region and connected interfascicular regions with cambial activity and some secondary growth.

Perhaps the most striking micromorphological characters of the stem is the presence of sclerenchyma fibers (sclerotic cells with phytomelanin) in the pith and the absence of secretory canals in the pith and presence in the cortex of *E. angustifolia* var. *angustifolia*, *E. angustifolia* "race *intermedia*," and *E. angustifolia* var. *strigosa*. This distinguishes the *E. angustifolia* complex from all other *Echinacea* taxa.

The secondary xylem and phloem in roots of *E. angustifolia*, *E. atrorubens*, *E. pallida*, and *E. purpurea* have sclerids with associated phytomelanin deposition (see table 3; figs. 5d, e; 6a, b, c, g in Upton 2010). This is similar to the sclerotic cells with associated black substance in the stem pith tissue of *E. angustifolia* var. *angustifolia*, *E. angustifolia* var. *strigosa* and hybrids (Fig. 3H, I, J). Thus, in a review of all *Echinacea* taxa McKeown (1999) noted that *E. angustifolia* var. *angustifolia* has short plant height, short and broad reflexed ray ligules, yellow pollen color and is a selection candidate for cold hardiness because of adaptation to northern climates. It is also a potential candidate in breeding for stem strength when coupled with the sclerified pith tissue (McKeown 1999).

Stem diameters and secondary growth patterns based on stem anatomy tissue maps appear most similar when *E. pallida* and *E. simulata* are compared. Comparison of *Echinacea* root anatomy in *E. pallida* (Upton 2010, see Table 3) noted the presence of phytomelanin-coated sclerids in the secondary phloem and secondary xylem in roots of *E. angustifolia*, *E. pallida*, and *E. atrorubens*, and the rhizome of *E. purpurea* pith and secondary phloem. Another paper on the root anatomy of *E. angustifolia* (Axentiev et al. 2010, see Table 3) also noted the presence of phytomelanin in the same locations as in *E. pallida* with the added description that this black substance fills the triangular intercellular spaces around the sclerids, causing them to appear star-shaped not unlike the stem anatomy described here for the *E. angustifolia* complex (Fig. 3H–J). Interestingly, in my anatomical study of *E. atrorubens* stem transections, sclerotic cells were not observed, but this taxon is a good candidate to look for stem sclerotic cells since it hybridizes with *E. angustifolia* var. *angustifolia*.

Stem tissue maps for *E. laevigata* and *E. purpurea* show anatomical characteristics that distinguish these two species from other *Echinacea* taxa. Numerous secretory canals in the pith (~58) and in the cortex (~48) of *E. laevigata* compared to *E. purpurea* with (~34) in the pith and (~50) in the cortex are in contrast to all other *Echinacea* taxa with far fewer numbers. These secretory canals originate only opposite the vascular bundles and interfascicular region. Vascular tissue has 44 protoxylem points in *E. laevigata* and 42 protoxylem points in *E. purpurea,* far greater numbers than in all other *Echinacea* taxa (Table 3).

The largest stem diameter of ~5.2 mm with pith diameter of ~4.2 mm occurs in *E. laevigata* (Fig. 10E) compared to stem diameter of ~4.8 mm with pith diameter of ~3.6 mm in *E. purpurea* (Fig. 10I). These two taxa are the tallest and overall largest in the genus *Echinacea*. Stem tissue maps of these two taxa (Fig. 10E, I) are similar in vascularization and spatial arrangement of the secretory system in development, position, and size.

Cortical tissue in both taxa is composed primarily of parenchyma. The epidermis differs in the presence of trichomes in *E. purpurea* and absence in *E. laevigata*. The more robust habit of these two taxa would suggest *a priori* that activity in interfascicular areas would connect the vascular bundles with some degree of sclerification. However, vascular bundles are discrete, surrounded and separated by regions of parenchymatous tissue. Sclerotic cells are lacking in the pith of both species. It appears that macromorphological differences are in contrast to internal microanatomical similarities.

Petioles

In *Echinacea* the petiole is supplied by three major collateral vascular bundles, a manifestation of departing foliar traces from the stem. In addition petiole shape can be used as a taxonomic character. Transversely cut petioles can be recognized by shapes, for example, horseshoe-shaped, V-shaped, and cylindrical-shaped.

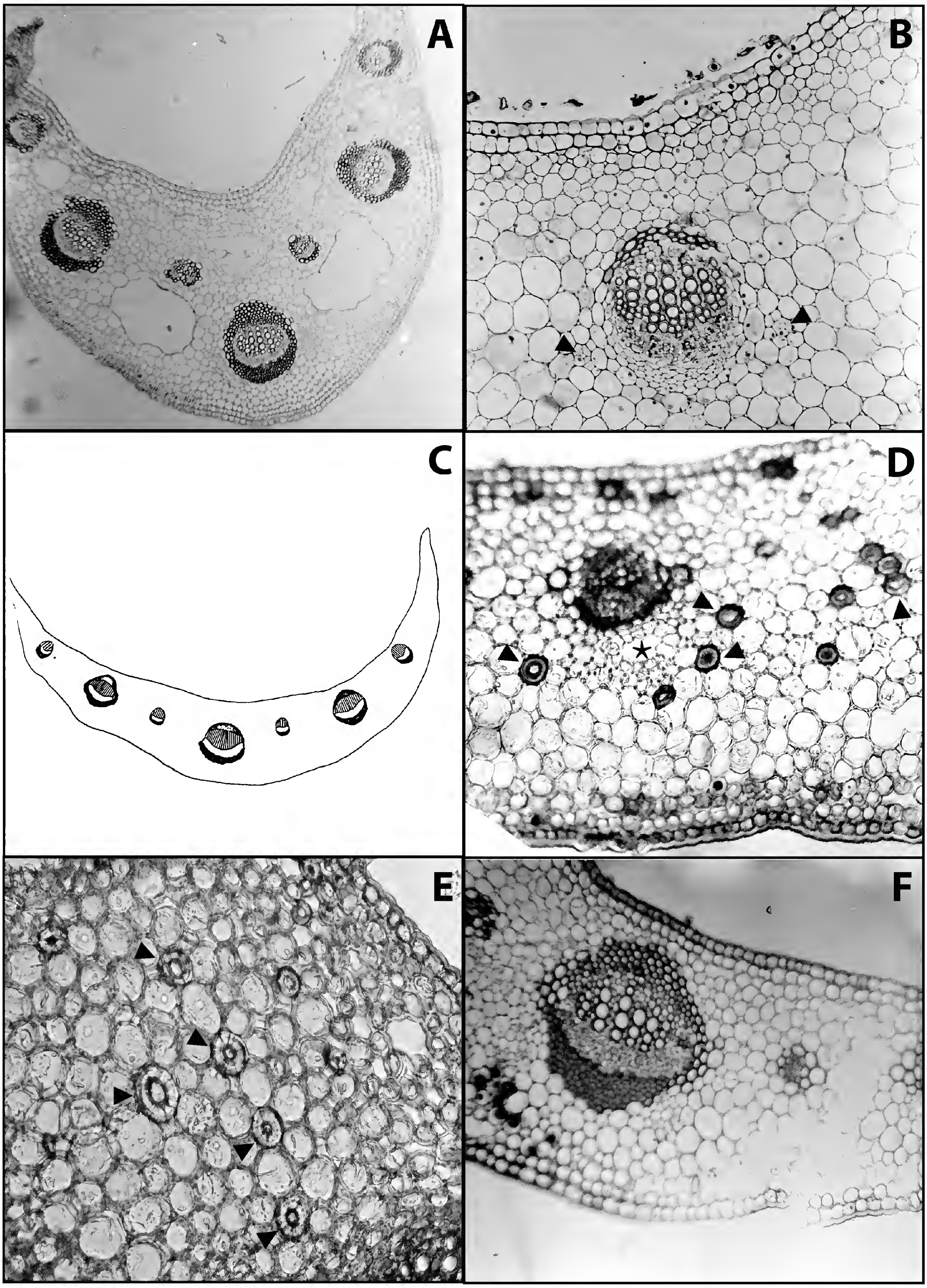

Fig. 12. Petiole transections. **A.** *E. atrorubens*, microtome section showing three major collateral vascular bundles ensheathed by fibrous tissue (vascular traces) typical for the Asteraceae. Note three air spaces that form passageways throughout the length of the petiole (×20). **B.** *E. sanguinea*, microtome section showing central major vascular bundle lacking fibrous tissue on abaxial side and two small secretory canals one on each side (arrows). Note the two-layered epidermis with similar cells and undifferentiated ground mesophyll (×17). **C.** *E. paradoxa* var. *neglecta*, lunate to bow-shape with venation illustrated by line drawing (×12). **D.** *E. paradoxa* var. *neglecta*, oblique microtome section showing brachysclerids (stone cells) as scattered single cells or in rows (arrows). Larger secretory canal (star) visible near vascular trace (×40). **E.** *E. paradoxa* var. *neglecta*, oblique microtome section showing single, isolated stone cells with highly refractive thickened cell walls with reduced central lumen. Note the primary pit fields that radiate like the spokes of a wheel (arrows) (×70). **F.** *E. paradoxa* var. *neglecta*, microtome section stained with red safranin and fast green showing central vascular bundle and cluster of stone cells at lower left (×14).

Moreover, secretory canals, universally present in the genus, differ in size, number and position in the petiole. The petiole contains the same tissues as the stems that include epidermis, collenchyma in varying amounts, and vascular bundles with associated fibrous sheaths. However, significant differences were observed for several taxa, for example, in *E. purpurea* and *E. sanguinea* the medial vascular bundle lacks a fibrous cap (Fig. 12B; Table 4).

Another apparently unique structure found in *E. paradoxa* var. *neglecta* is the brachysclerid or stone cell. They appear either isolated, clustered, or in rows (Fig. 12D–E). Structurally the petiole of *E. atrorubens* has three lacunae situated around the medial vascular bundle (Fig. 12A) and this differs from other *Echinacea* taxa.

General Habit

Echinacea has mostly a scapose habit with above ground stem that persists in to the fall along with the flower head that gradually dies and begins to undergo decay. Stems do not survive the winter in the high plains region of western Kansas due to freezing temperatures and heavy snows that cause lodging, and eventually aerial parts deteriorate into ground litter as part of the annual life cycle. The stems are not stout enough to withstand the elements of nature unlike species of *Yucca* where stems may survive for several years. In grassy habitats such as prairies and glades *Echinacea* populations can dominate the landscape, (Figs. 5C–D; 8A–C) representing the tallest elements not unlike the forest canopy of trees (Kilgore et al. 2009; Richter 2013). This standing cover of stems serves to intercept spores of windblown organisms such as myxomycetes (plasmodial slime molds).

The round spiny cone head also creates a surface area and landing platform for spores. Indeed, a recent study that is the first of its kind (Kilgore et al. 2009) found that *Echinacea* species collected from native prairies in Kansas and Missouri (*E. angustifolia*, *E. pallida*, and *E. paradoxa* var. *paradoxa*) have a distinct assemblage of myxomycete species that were isolated in moist chamber cultures. Reproductive structures of herbaceous plants had greater mean species richness than stems. This study proposed a new term (herbicolous myxomycetes) for herbaceous, perennial grassland plants associated with this group of myxomycete species (Kilgore et al. 2009). This above ground canopy of perennial plants should be explored for potential species diversity and possible myxomycete species new to science.

CONCLUSIONS AND FUTURE CONSIDERATIONS

This study took advantage of more than 15 years of research on the biology of *Echinacea* by Professor Ronald L. McGregor at the University of Kansas. His field experience collecting plants throughout the state of Kansas and as Coordinator of The Flora of the Great Plains research project (Great Plains Flora Association 1986) gave him a "trained eye" for habitats and species identification, especially *Echinacea* taxa involving hybrid swarms, introgressed populations, and pockets of typical taxa in part represented here. All of the plants selected for this study were identified personally by R.L. McGregor. Freshly collected plants were used for this anatomical survey not herbarium specimens. This avoided using material that often shows shrinkage and distortion of cells. Therefore, the names and collections used here carry the accuracy and weight of McGregor's field experience.

All of the plants studied here were collected within a few days at the height of anthesis and for the most part in the same place. This part of the sampling protocol assures that possible variables were at least partially controlled. Nevertheless, the limited sampling lacked a statistically significant number of plant individuals, different populations from different natural habitats, and ray florets from different capitula. The sample size places limitations on the use of anatomical characters in dichotomous keys, and therefore, the combination of macro- and microcharacters used in couplets here. Furthermore, the presence of anatomical characters, while potentially important in separating taxa—for example, sclerotic pith cells, brachysclerids in petioles, and differences in shapes of adaxial ray ligule epidermal cells—suggests that special caution should be used in the assumption that these characters are consistent within and across *Echinacea* taxa. This is especially true of the multicellular, catenulate, adaxial ray ligule epidermal cells observed in the hybrid population of *E. angustifolia* var. *angustifolia* "race *intermedia*" that are present but scattered in small numbers. These epidermal cells were not observed in either of the closely related *E. angustifolia* var. *angustifolia* or *E. angustifolia* var. *strigosa.*

It is apparent that *E. laevigata* and *E. purpurea* are closely related in anatomical characters that include: stem diameter, cortical breadth comprised mostly of parenchyma cells, vascularization and spatial distances of tissue systems, diameter of pith, and position, number and size of secretory canals. In contrast ray florets differ in the number of veins and secretory chambers, but adaxial epidermal cells have similar shapes and sizes noted previously.

Future studies should concentrate on fewer taxa and more critical sampling to more accurately assess the value of anatomical characters useful in the identification of *Echinacea* taxa. Nevertheless, this anatomical study of *Echinacea* aerial plant parts contributes to a better understanding of structure and function that relates to similarities and differences in this medically important herbaceous perennial prairie plant.

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THE FLORAL STRUCTURE OF THREE WEEDY SPECIES OF *SIDA* (MALVACEAE)

Junior Cezar Muneratto
Universidade Estadual de Maringá
Departamento de Biologia
Av. Colombo, 5790
(87020-900) Maringá, PR, BRAZIL

Luiz Antonio de Souza
Universidade Estadual de Maringá
Departamento de Biologia
Av. Colombo, 5790
(87020-900) Maringá, PR, BRAZIL
lasouza@uem.br

Odair José Garcia de Almeida
Instituto de Biociências
UNESP – Univ. Estadual Paulista
Programa de Pós-Graduação em Biologia Vegetal
Av. 24 A, 1515, (13506-900) Rio Claro, SP, BRAZIL
odair1000@hotmail.com

ABSTRACT

Malvaceae sensu lato is monophyletic and is characterized by the presence of nectaries of glandular trichomes, located internally at the base of the calyx. The genus *Sida* has been heterogeneous since its origin; however, there has been a reduction in the size of the genus with the removal of many species to other genera, giving a more natural and definable residual group subdivided into 11 sections. The aims of this work were to describe and compare the floral structure of three weedy species *Sida rhombifolia*, *S. urens,* and *S. regnellii,* using a traditional anatomical approach, along with scanning electron microscopy analysis. The comparative study of the three *Sida* species allows us to suggest that some structural characters are shared, i.e., the hypodermis in the sepal and ovary wall, trichomatous calyx nectary, perianth with homogeneous mesophyll, and anther with a middle layer and plasmodial tapetum type, and they may reinforce the natural residual group of *Sida*. On the other hand, other floral characters have some diagnostic value for classification at the species level, such as the style structure being solid or rift in the center.

Key Words: Floral anatomy, calyx nectary, trichomes, weedy species

RESUMO

Malvaceae sensu lato é monofilética e se caracteriza pela presença de nectários que consistem de tricomas glandulares localizados internamente na base do cálice. O gênero *Sida* é considerado como heterogêneo na sua concepção inicial, mas ultimamente ele tem sido reduzido de tamanho com a remoção de várias espécies para outros gêneros, tornando-o um grupo natural residual subdividido em 11 seções. O objetivo deste trabalho foi descrever e comparar a estrutura floral de três espécies invasoras, *Sida rhombifolia*, *S. urens* e *S. regnellii,* utilizando-se de estudo anatômico tradicional e análise em microscopia eletrônica de varredura. O estudo comparativo das três espécies de Sida permite sugerir que alguns caracteres estruturais são comuns às espécies, como presença de hipoderme na sépala e parede do ovário, nectário calicino tricomatoso, perianto com mesofilo homogêneo, e antera com uma camada média e tapete plasmodial, o que reforça o gênero Sida como um grupo natural residual. Por outro lado, outros caracteres florais têm algum valor diagnóstico para separação das espécies, como, por exemplo, a estrutura do estilete que pode ser sólido ou apresentar fenda na região central.

INTRODUCTION

When circumscribed broadly to include four families (i.e., Tiliaceae, Sterculiaceae, Bombacaceae, and Malvaceae – sensu stricto), Malvaceae sensu lato is monophyletic (Judd et al. 2002). It is characterized by the presence of nectaries of glandular trichomes, located internally at the base of the calyx or, with less frequency, on the petals or on the androgynophore (Judd & Manchester 1997). This circumscription is also supported by adnation of the androecium to the corolla and usually the presence of unilocular anthers, although Tiliaceae and Sterculiaceae often retain numerous stamens with 2-locular anthers (Judd et al. 2002). More recently, Malvaceae sensu lato has been divided into nine subfamilies (as discussed in Tate et al. 2005): Bombacoideae (formerly Bombacaceae, in part), Brownlowioideae, Byttnerioideae, Dombeyoideae, Grewioideae, Helicteroideae, Malvoideae (formerly Malvaceae), Sterculioideae (formerly Sterculiaceae, in part), and Tilioideae (formerly Tiliaceae, in part). The Malvoideae are sometimes called the "core" Malvaceae s.str., and some authors

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continue to retain this family name for this core group alone. Prior to that, Bayer and Kubitzki (2003) divided the subfamily Malvoideae into four tribes: Gossypieae, Hibisceae, Kydieae, and Malveae. Traditionally, members of the Malveae have been characterized by a combination of several morphological characters: schizocarpic fruits (sometimes a capsule), three to over 20 mericarps with an equal number of free styles, antheriferous apex of the staminal column and the absence of lysigenous cavities ("gossypol glands") (Fryxell 1988; Bayer & Kubitzki 2003; Tate et al. 2005).

According to Fryxell (1985), the genus *Sida* has been heterogeneous since its origin as botanists tended to put into *Sida* any member of the Malvaceae that are uniovulate and without an involucel. However, there has been a reduction in the size of the genus with the removal of many species to other genera, giving a more natural and definable residual group. Fryxell (1985) subdivided this residual group into 11 sections.

The aims of this study were to describe and compare the floral structure of three weedy species of *Sida*, namely *S. rhombifolia* L., *S. urens* L., and *S. regnellii* R.E. Fr. Economically, the Malvaceae s.l. are important either ornamentally (for instance, the genera *Alcea, Hibiscus,* and *Malvaviscus*) or in the textile industry (e.g. *Gossypium* and *Urena*), or as weedy plants, such as *Sida,* a genus that can be very detrimental to the agricultural economy (Bovini et al. 2001).

MATERIAL AND METHODS

Plant material

Floral buds and flowers of the three weedy species were collected in the city of Maringá, Brazil (state of Paraná): *S. rhombifolia* at 506 m altitude, 23°24'13.3" latitude and 51°56'21.17" longitude; *S. regnellii* at 559 m altitude, 23°24'43.0" latitude and 51°56'29.6" longitude; and *S. urens* at 518 m altitude, 23°24'13.1" latitude and 51°56'20.4" longitude. Voucher materials were identified by Massimo Giuseppe Bovini (RB) and deposited at HUEM (Herbarium of the Universidade Estadual de Maringá) with these accession numbers: *S. urens:19909* (*J. Muneratto 001*); *S. rhombifolia:19910* (*J. Muneratto 002*); and *S. regnellii:19911* (*J. Muneratto 003*).

Anatomical analysis

The material was fixed in glutaraldehyde (1% in 0.1M phosphate buffer, pH 7.2) and then conserved in 70% ethanol (Johansen 1940). The fixed material was embedded in historesin (Gerrits 1991), sectioned (cross- and longitudinally) in a rotation microtome, and stained in toluidine blue (O'Brien et al. 1964). Specific microchemical tests were done for lipid substances (Sudan IV and Sudan Black), tannins (ferric chloride), starches (iodine-potassium iodide test), lignins (phloroglucin test) and calcium crystals (sulfuric acid) (Sass 1951; Rawlins & Takahashi 1952; Ruzin 1999). Images were taken using Leica ICC50 and Olympus BX50 optical microscopes with digital camera attachments.

Scanning Electronic Microscopy analysis

Micromorphological analysis of the floral buds and flowers was done with material fixed in Karnovsky solution (Karnovsky 1965). Samples were processed and then mounted on aluminum stubs, gold coated, examined using scanning electron microscopy (Shimadzu SS-550 Superscan), and digitally photographed.

RESULTS

Perianth

The flowers (Fig. 1a–c) in all three of the *Sida* species investigated are actinomorphic, hermaphrodite, with yellowish (*S. urens* and *S. rhombifolia* - Fig. 1a,b) and whitish (*S. regnellii* - Fig. 1c) petals, distinct from the green calyx (Table 1).

The five sepals are green in color, connate in the basal half, and with free triangular lobes. The uniseriate adaxial epidermis is made of cuboid or tabular cells with outer and inner periclinal walls thicker than the anticlinal ones (Fig. 2a,a'). The abaxial sepal epidermis is uniseriate with trichomes and stomata in all species and has cells with sinuous anticlinal walls in *S. rhombifolia* and *S. urens*. The stomata found in the sepals of the species are anisocytic and paracytic in *S. regnellii* and *S. rhombifolia* and anisocytic in *S. urens* (Table 1). The trichomes are non-glandular and glandular (Fig. 1d,f,g–i). Unicellular non-glandular trichomes occur only in

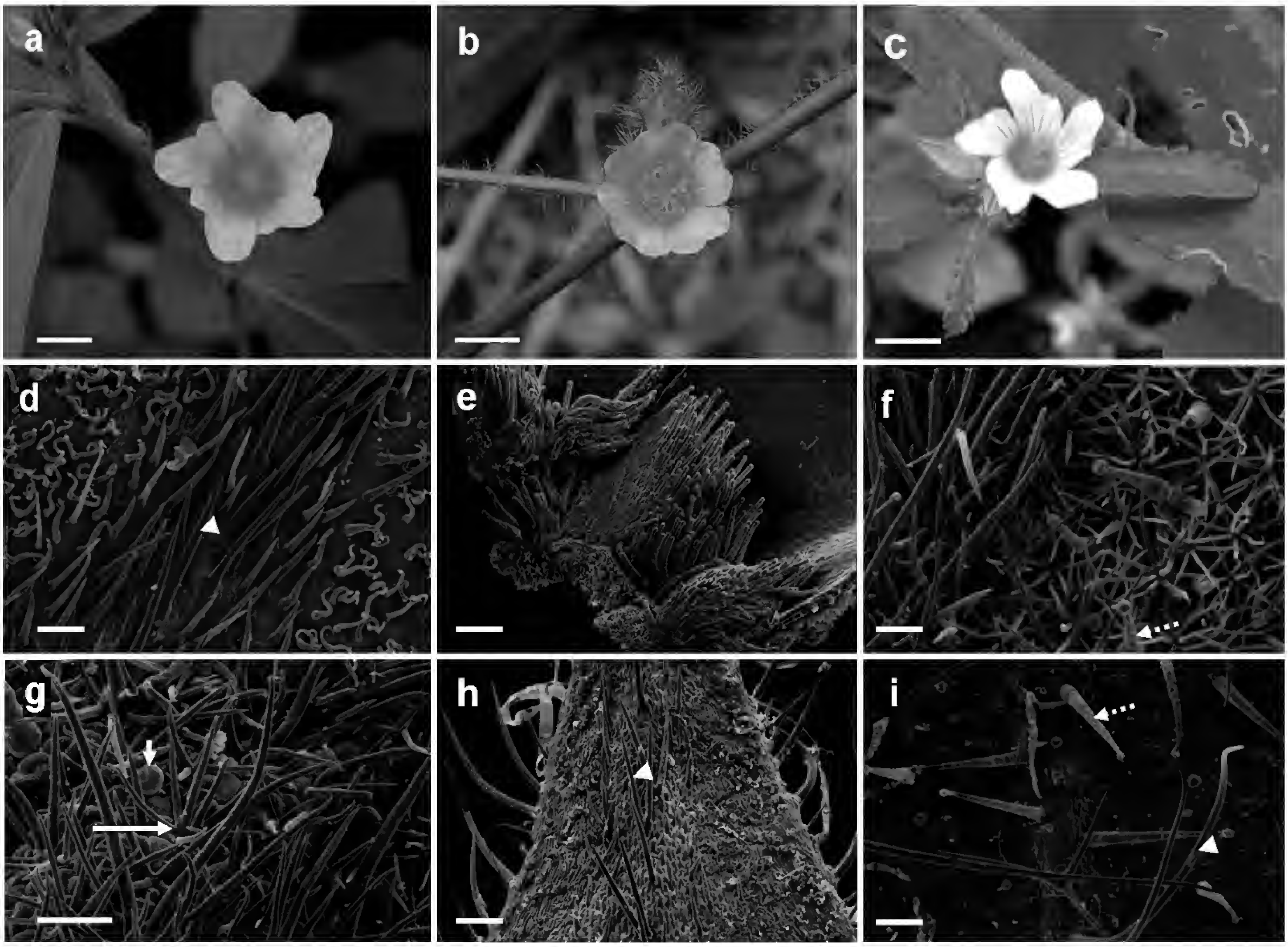

Fig. 1. **General morphology of the flower in frontal view of *Sida rhombifolia* (a), *S. urens* (b), and *S. regnellii* (c); scanning electron micrographs (SEM) of the calyx surface showing trichomes in *S. regnellii* (d–g), d. Abaxial face, apical region. e. Nectary (trichomes). f–g. Abaxial face. *Sida urens* (h–i). h. Adaxial surface. i. Abaxial face. Arrowheads indicate unicellular trichomes, long arrow shows stellate trichomes, and short and interrupted arrows indicate glandular trichomes with a small and long stalk, respectively. Scale bars: 0.5 cm (a,c), 1.5 cm (b), 50 µm (d,f,g), 100 µm (e,h,i).**

Table 1. Flower characters which have diagnostic value for separation of *Sida rhombifolia, Sida urens,* and *Sida regnellii.*

Characters	*Sida rhombifolia*	*Sida urens*	*Sida regnellii*
Flowers	Yellowish	Yellowish	Whitish
Sepal epidermis abaxial	Sinuous anticlinal walls	Sinuous anticlinal walls	Straight anticlinal walls
Sepal stomata	Anisocytic/paracytic	Anisocytic	Anisocytic/paracytic
Unicellular nonglandular trichomes in sepals	Absent	Present	Absent
Sepal spongy parenchyma	2–3 cell layers	2–6 cell layers	4–5 cell layers
Stalk base/glandular trichomes (nectary)	3–4 layers	3–4 layers	1–2 layers
Petal shape	Asymmetric	Obcordate	Asymmetric
Petal fasciculate trichome	Present	Absent	Present
Ovary carpels	9–11	5	5
Ventral vascular bundles of the ovary	9–11	5	5
Style	Hollow/solid in the base	Solid	Solid with reduced rift

S. urens (Fig. 1i), and this species has epidermal cells completely surrounding the base of the trichome. Stellate, multicellular, non-glandular trichomes occur on the sepals of all three species (Fig. 1g). Also occurring in these three species are multicellular glandular trichomes (Fig. 1g–i), consisting of a small stalk and a head of several secretory cells or a long stalk and a unicellular secretory head. In the adaxial surface of the *Sida* sepals are found crystalliferous cells (druses) in the hypodermis, which have a U-shaped wall thickness (Fig. 2a,a').

The *S. rhombifolia* has a lesser developed hypodermis in the abaxial surface (Fig. 2a,a'). The mesophyll (Fig. 2a) has spongy parenchyma with mucilaginous cells and cavities, exhibiting two or three cell layers in *S. rhombifolia*, four or five in *S. regnellii*, and two to six in *S. urens*.

The nectary (Fig. 1e; 2b–c) occurs close to the base of the calyx (Fig. 1e) and is a carpet-like tissue made of multicellular clavate glandular trichomes and a subtending reduced secretory parenchyma, which is supplied by xylem and a greater proportion of phloem elements. The glandular trichomes have a uniseriate or pluriseriate stalk and a unicellular head (Fig. 2c). The trichomes are longer in *S. rhombifolia* than in the other species; the stalk base of this *S. rhombifolia* and *S. urens* has a thickness of three or four cell layers, while *S. regnellii* has a base with one or two layers (Table 1).

The corolla shows adnation to the androecium, and the petal shape varies among the *Sida* species. *Sida urens* has symmetrical obcordate petals (Fig. 1b; 2f), while in *S. rhombifolia* (Fig. 1a) and *S. regnellii* the petals are obcordate but very asymmetrically so. The petal epidermis of *S. rhombifolia* and *S. regnellii* (Fig. 2d,e, respectively) is uniseriate with mucilage idioblasts and glandular and non-glandular trichomes. The mesophyll (Fig. 2d,e) is composed of a homogeneous parenchyma with mucilage cells and cavities. The petal vascularization (Fig. 2d,e) consists of a central bundle and six to nine minor bundles.

Androecium

The androecium consists of filaments joined to form a tube (filament tube) (Figs. 3b; 5e) that surrounds the style (Figs. 4a,c; 5b–f). The anthers (Fig. 3a) are dorsifixed, bisporangiate, longicidal, and septate monothecal. The filament tube is composed of internal and external uniseriate epidermis of cuboid or elongated cells and capitate glandular trichomes; the inner parenchyma has mucilage cells (Fig. 4a,c), and the vascular system consists of 10 collateral vascular bundles arranged in pairs.

The wall of the young anther (Fig. 3c) has epidermis, endothecium with thin-walled cells, a middle layer of elongated cells and a tapetum made of a layer of cells. Later, the cell walls of the tapetum undergo disintegration, and the protoplasts of the tapetum cells remain available among the pollen grains during their development (Fig. 3d). In the developing anther, the endothecium cells acquire thickenings in the anticlinal walls and in the inner periclinal wall, the middle layer disintegrates, and the tapetum protoplast is absorbed (Fig. 3e, f). The connective consists of papillose epidermis, parenchyma with druse idioblasts and one vascular bundle.

Gynoecium

The structure of the style differs among the three species (Table 1) when seen in cross section. In *S. rhombifolia* the style is hollow for the most part (Fig. 4b), being solid only in the base; in *S. regnellii* the style has a reduced rift (Fig. 4c); and *S. urens*, in turn, has an entirely solid style (Fig. 4d). The style is composed of uniseriate epidermis, parenchyma and strands of transmitting tissue, one for each carpel, with 11 in *S. rhombifolia* (Fig. 4b) and five in the other two species (Fig. 4d). The stigma consists of papillate epidermis (Fig. 4e,f).

The ovary presents many carpels and locules (Fig. 5a–e) (five in *S. regnellii* and *S. urens*, and nine to 11 in *S. rhombifolia*) (Table 1). There is one ovule in each locule, and the placentation is axial (Fig. 5b–f). The style consists of a single column (solid or rifted, depending of the species, according to the description above) (Fig. 5b–f). Close to the apex the style starts to lose the fused shape and separates into free branches, which correspond to each stigma lobe, in which the number of stigma lobes and locules is the same. The ovary wall (Fig. 6a–f) has glabrous uniseriate outer epidermis with cuboid cells in *S. regnellii* and *S. urens*, and cuboid to cylindric in *S. rhombifolia*. The ovary mesophyll (Fig. 6a–f) is parenchymatous, spongy and homogeneous with two or three cell layers in the middle region; the remainder (base and apex) of the ovary consists of five cell layers. A crystalliferous hypodermis (druse cells) is present in the wall ovary (Fig. 6b), although some cells lack crystals in *S. urens*. The inner epidermis undergoes cell division periclinally to the ovary surface resulting in a tissue with two or three cell layers (Fig. 6b), the precursor of the endocarp.

In the ovary, all species studied here had septa (Fig. 6a,c,e) made up of an epidermis of one or two layers of cells and bi- to multilayered spongy parenchyma tissue with scattered druse idioblasts. The ovary vasculature is made of a median dorsal bundle (Fig. 6b,d), one or two lateral bundles, and a ventral or placental bundle. The number of ventral bundles differs among the species, with nine to 11 bundles in *S. rhombifolia* (Fig. 6e) and

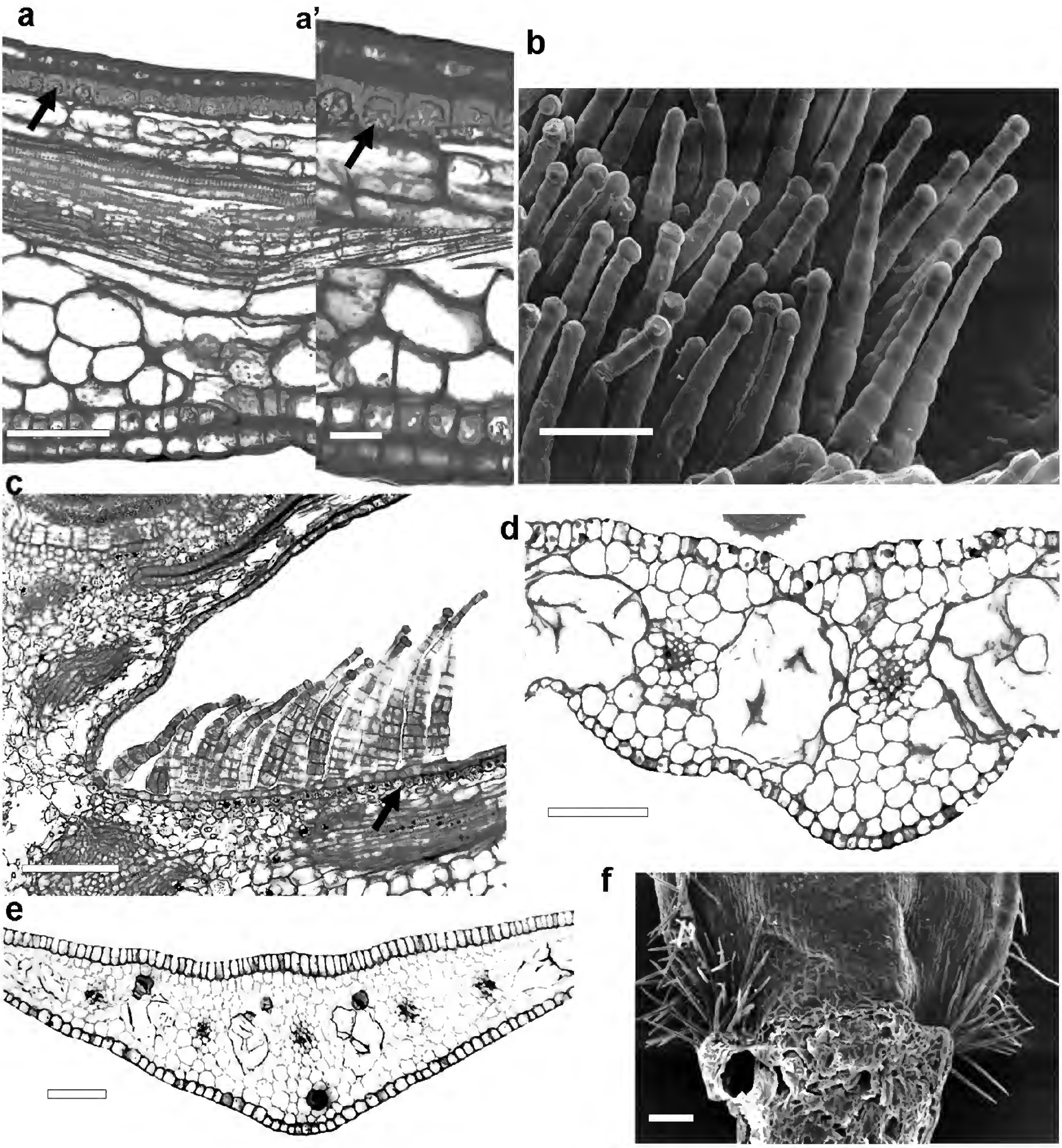

Fig. 2. Perianth structure of *S. rhombifolia* (a,a',d), *S. regnellii* (c,e), and *S. urens* (b,f), in cross-section and scanning electron micrograph (SEM). a. Calyx. **a'.** Details of the epidermis. **b.** Nectary in SEM. **c.** Nectary longitudinal section. **d–e.** Petals. **f.** Petal base in SEM. Arrow indicates hypodermis cells with U-shaped wall thickness. Scale bars: 100 µm (a,c,e,f), 30 µm (a'), 50 µm (b,d).

five in *S. regnellii* (Fig. 6c) and *S. urens*, which corresponds to the same number as the carpels and styles, and the same numbers of mericarps in the developed fruit (Muneratto & Souza 2013). In the parenchyma close to the ventral bundles (Fig. 6a,c,e), there are mucilaginous and druse cells. The ovules (Fig. 6a–f) are bitegmic, crassinucellate, with an outer integument made up of two layers of cell, and multiseriate inner integument.

DISCUSSION

The trichomatous calyx nectary of the *Sida* species analyzed here is one of the features that characterize the core Malvales (Malvaceae s.l. including Bombacaceae, Malvaceae, Sterculiaceae, and Tiliaceae) (Vogel 2000;

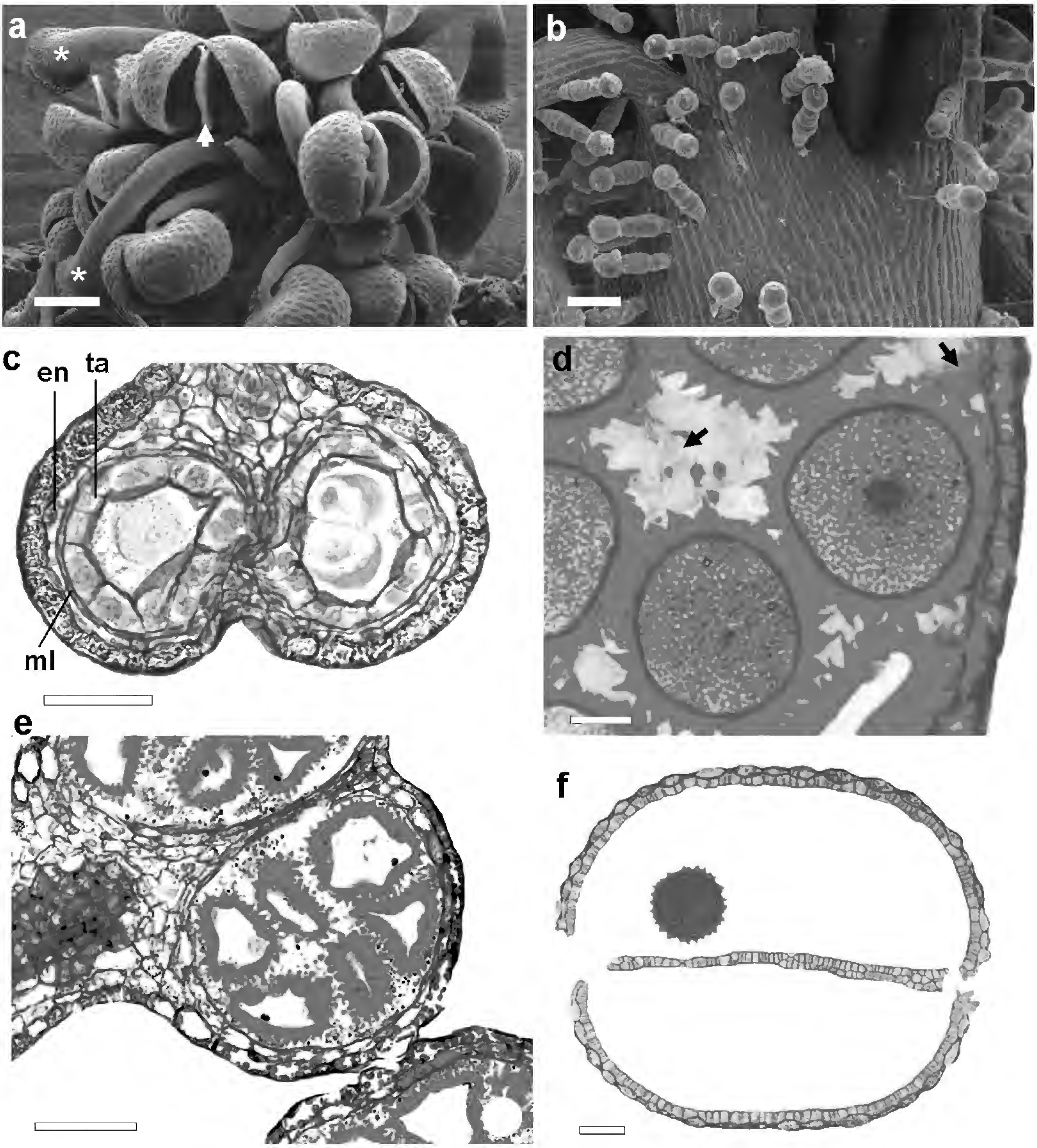

Fig. 3. Anther structure and filament tube of *S. regnellii* (**a,b,f**); anther structure of *S. urens* (**c**) and *S. rhombifolia* (**d,e**). **a.** Mature anthers - SEM. **b.** Apex of the filament tube with glandular trichomes - SEM. **c.** Immature anther in cross-section. **d.** Anther detail visualizing plasmodial tapetum among microspores. **e.** Immature anther in cross-section without middle layer and tapetum. **f.** Mature anther in cross-section with septum. * indicates the stigma branches/lobes. White arrow shows septum of the anther. Black arrow indicates the tapetum protoplast among microspores in development. (en = endothecium; ml = middle layer; ta = tapetum). Scale bars: 200 µm (a), 50 µm (b–f).

Leitão et al. 2005). According to Vogel (2000), the trichomatous calyx nectary may have evolved from hydathodes, which provide moisture to protect floral primordia from desiccation, being active in the bud stage. As discussed by Bernardello (2007), trichomes are by far the most common epidermal nectaries in Angiosperms, and the nectariferous trichomes may have taxonomic importance in defining related plants groups, such as Bombacoideae and Malvoideae.

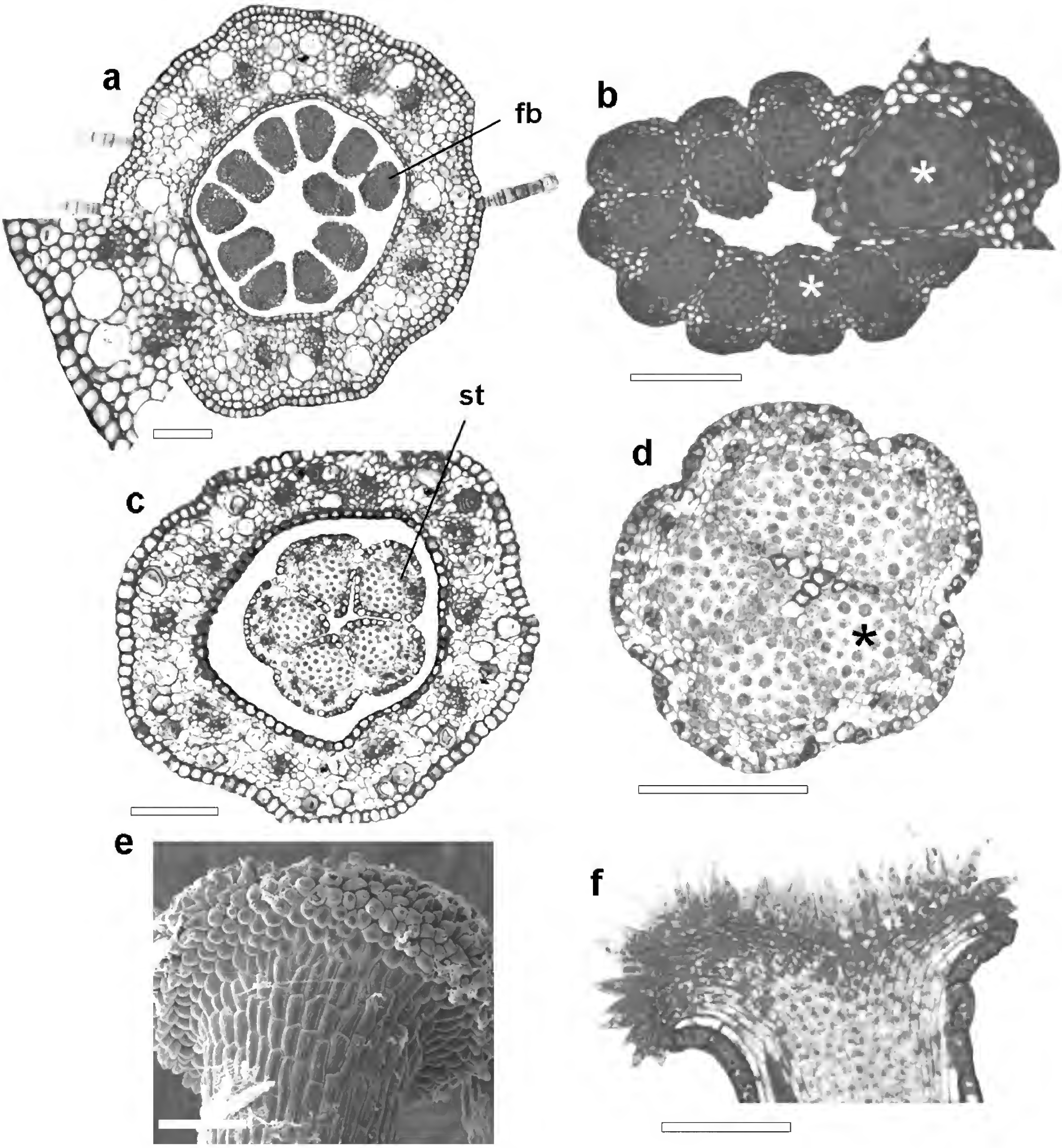

Fig. 4. Filament tube and stigma structure of *S. rhombifolia* (a,b), *S. regnellii* (c,e–f), and *S. urens* (d). a–d. Cross Sections. e. Longitudinal view. f. Longitudinal section. a. Apex of the filament tube surrounding the stigma branches/lobes, with detail of the epidermis and vascular bundles of the filament tube. b. Style in cross sections - middle region - with detail of the transmitting tissue. c. Filament tube surrounding the style – middle region. d. Style – middle region. e. Stigma in SEM. f. Stigma. Asterisk indicates the strands of transmitting tissue. (fb = stigma lobes; st = style). Scale bars: 100 µm (a–d,f), 50 µm (e).

The calyx of the three *Sida* species may develop different functions, acting as a photosynthetic organ, a protective organ of floral bud, or an attraction for pollinators. The photosynthetic function is related to the presence of chlorenchyma in the sepal mesophyll. The protective function of the sepal may be executed by the differentiation of a crystalliferous hypodermis with U-shaped wall thickening cells. Attraction of pollinators may be performed by means of nectaries that consist of glandular trichomes located at the base of the sepals. The broad variety of functions of the calyx is known in some groups of plants, such as Fabaceae, Lamiaceae,

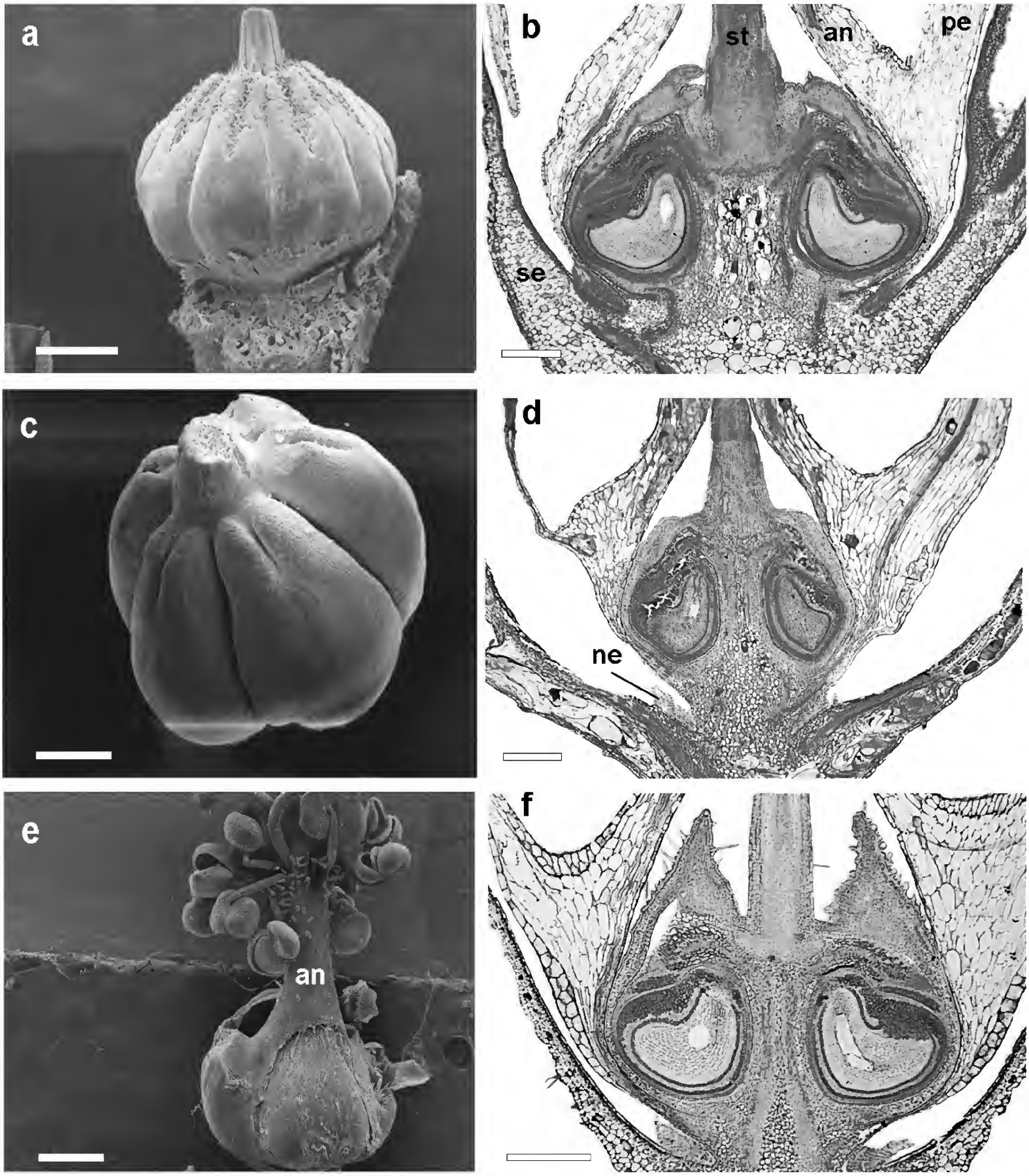

Fig. 5. Morphology of the ovary of *S. rhombifolia* (a,b), *S. urens* (c,d), and *S. regnellii* (e,f). a, c, e. Ovary/gynoecium in SEM. **b, d, f.** Flower in longitudinal section showing ovary and other floral organs. (an = filament tube; ne = nectary; pe = petal; se = sepal; st = style). Scale bars: 500 µm (a,e) 250 µm (b,c,d,f).

Malpighiaceae, and Ranunculaceae (Roth 1977; Weberling 1992; Endress 1994). Unfortunately we do not have supplementary data concerning the time of activity about the trichomatous calyx nectary in the *Sida* species nor information concerning the visitors of these flowers, in order to ascertain the role of these nectaries in the pollination system of these species. However, we can assume a nuptial function (i.e., they are involved in pollination events, sensu Almeida et al. 2013) of the carpet-like nectaries on the sepals of *Sida* species, since the flowers of Malvaceae s.l. (Vogel 2000) do not have an annular nectary (nectariferous disk) to attract the pollina-

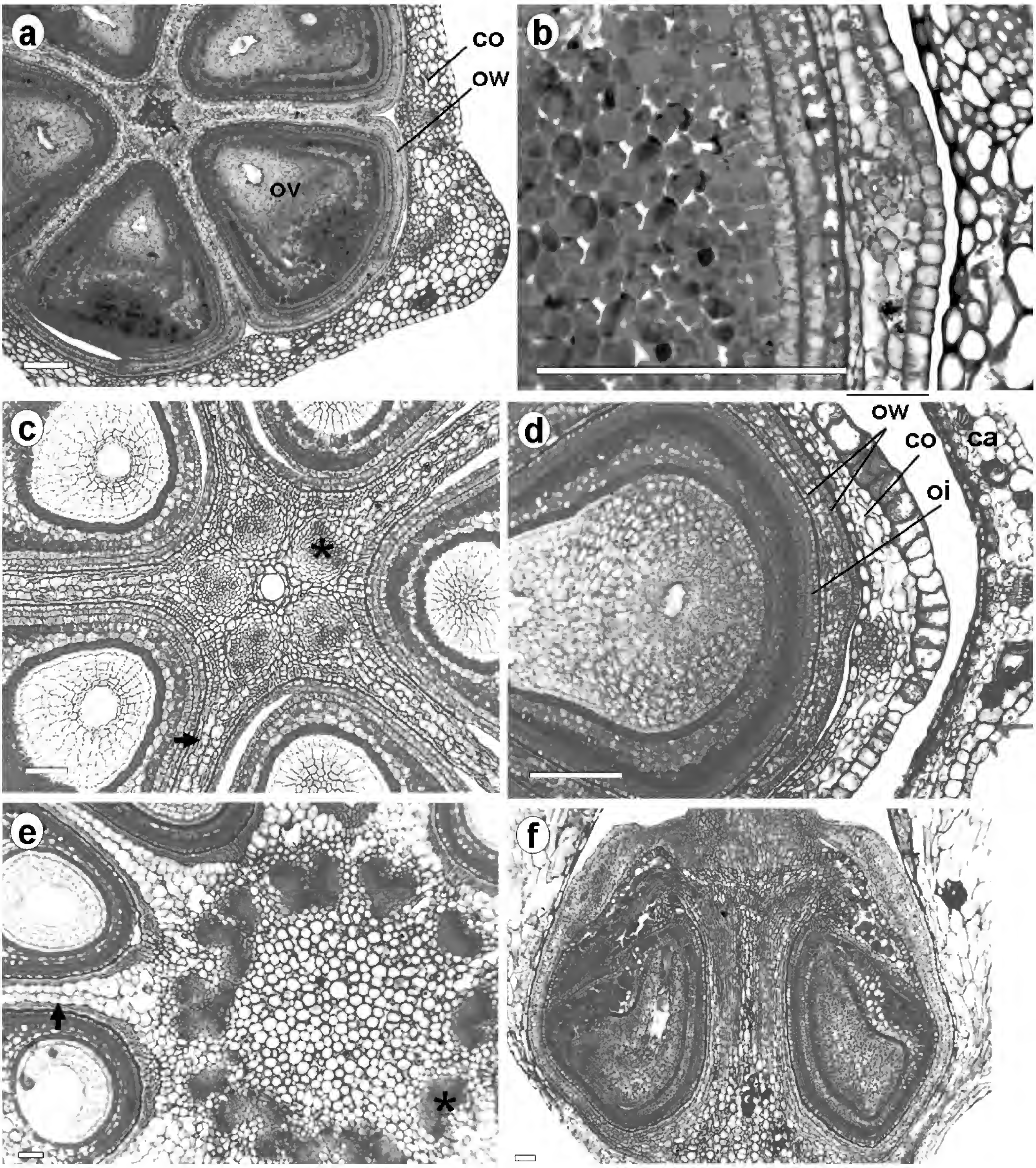

Fig. 6. Ovary and ovule structure of *S. urens* (a,b,f), *S. regnellii* (c, d), and *S. rhombifolia* (e) in cross-sections (a–e) and longitudinal section (f). (ca = calyx; co = corolla; oi = outer integument; ov = ovule; ow = ovary wall). Asterisk indicates the vascular bundle, and the black arrow shows the septum. Scale bars: 50 µm.

tors, and these nectaries can be accessed via the gaps at the base of the corolla lobes in the region of adnation between petals and the filament tube (Vogel 2000; Bernardello 2007).

Dahlgren (1991) introduced a classification based on Davis (1966) of the different types of anther wall formations, in which four types were presented: basic, dicotyledonous, monocotyledonous, and reduced. He reported the basic type of anther wall formation, characterized by two middle layers, for some taxa of Malvales. In contrast, the *Sida* species studied here has only one single middle layer in the anther wall, placing it clearly in the dicotyledoneous type. Other species of Malvaceae also have only one middle layer in the anther wall, such as *Sida cordifolia* L. (Rao 1954) and *Modiolastrum malvifolium* (Griseb.) K. Schum. (Galati et al. 2007), indicating the necessity for new studies concerning the anther development in this group of plants.

In all *Sida* species investigated here, the tapetum is of the plasmodial type, although fusion between protoplasts of the microspores was not observed. Embryological studies in Malvaceae (Rao 1954) showed that as the microspores enlarge, the protoplasts of the tapetum cells become smaller and smaller until they are absorbed; in addition, according to Rao (1954), they may disappear or their remnants may persist until the pollen grains have become 2-nucleate and nearly mature, as shown in *Sida carpinifolia* Mill.

The style may be hollow or solid, depending on the degree of closure of the fused or free carpels (Fahn 1990). The analyzed styles of the *Sida* flowers are quite distinct. The solid type is restricted to *S. urens*, and hollow type with solid base occurs in *S. rhombifolia*. Unlike these two species, *S. regnellii* has a narrow single canal occupying the center of all styles. The style structure might be a reasonable alternative to the identification of the *Sida* species. In fact, there has been little research dealing with the style structure. Nevertheless, Souza et al. (2001) found similar results in three species of *Trichilia* P. Browne (Meliaceae); that is, *T. elegans* A. Juss. has a solid style, *T. catigua* A. Juss. a hollow style, while *T. pallida* Sw. has a narrow canal in its style. This variation in the style structure among species of the same genus may occur in other genera from the clade Eurosids II.

Our results showed mucilaginous cells and cavities in the flowers of the three species, which usually occurs in the Malvaceae (Metcalfe & Chalk 1957; Esau 1974; Fahn 1979). However, there are differing opinions concerning the development of cavities in some taxa, as pointed out by Evert (2006). The cavities present in the flowers of Malvaceae have been reported as both schizogenous and lysigenous (Fahn 1979 and references therein). Metcalfe and Chalk (1957) recorded lysigenous secretory glands (cavities) in the leaves of Malvaceae species. Even though for Evert (2006) the concept of lysigenous cavity development is questionable, here, we consider it as lysigenous since they are formed by the disintegration of mucilaginous cells and surrounding parenchymatous cells.

The comparative study of these three *Sida* species allows us to suggest that some structural characters are shared, i.e., the hypodermis in the sepal and ovary wall, trichomatous calyx nectary, perianth with homogeneous mesophyll, anther with a middle layer and plasmodial tapetum type. These characters may reinforce the natural residual group of *Sida* as proposed by Fryxell (1985). On the other hand, Table 1 shows some floral characters which may have some diagnostic value for classification at the species level, such as the style structure being solid or rift in the center.

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BOOK NOTICE

Roy L. Lehman. 2013. **Marine Plants of the Texas Coast.** (ISBN-13: 978-1-62349-016-4, flexbound). Texas A&M University Press, 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamu-press.com, 1-800-826-8911). $32.00, 224 pp., 304 color photos, map, bibliography, index, 6" × 9".

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ROY L. LEHMAN is professor of biology at Texas A&M University–Corpus Christi, where he is also director of the Laguna Madre Field Station and a Harte Research Associate at the Harte Research Institute for Gulf of Mexico Studies. He is the coauthor of the award-winning book Plants of the Texas Coastal Bend, published by Texas A&M University Press in 2005.

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A GASTEROID FUNGUS, *PALAEOGASTER MICROMORPHA* GEN. & SP. NOV. (BOLETALES) IN CRETACEOUS MYANMAR AMBER

George O. Poinar, Jr.

Department of Integrative Biology
Oregon State University
Corvallis, Oregon 97331, U.S.A.
poinarg@science.oregonstate.edu

Dônis da Silva Alfredo

Graduate Program in Systematics and Evolution
Department of Botany and Zoology Center of Biosciences
Universidade Federal do Rio Grande do Norte
BRAZIL

Iuri Goulart Baseia

Department of Botany and Zoology
Center for Biosciences
Universidade Federal do Rio Grande do Norte
BRAZIL

ABSTRACT

A new genus and species of gasteroid fungus, **Palaeogaster micromorpha** gen. & sp. nov. is described from Early-Mid Cretaceous amber from the Republic of Myanmar. The species is represented by some 25 complete or partial fruiting bodies in various developmental stages. Diagnostic characters for the new taxon are its small size, the globose to pyriform shape of the fruiting bodies, mycelial hyphae with clamp connections and small globose to subglobose spores. It is assigned to the Order Boletales (Sclerodermatineae) and possesses many features of the family Sclerodermataceae, which includes the earthballs and hard skinned puffballs. *Palaeogaster micromorpha* represents the first fossil member of the Sclerodermatineae and the oldest known gasteroid fungus.

RESUMEN

Se describen un género y especie nuevos de hongo gasteroide, **Palaeogaster micromorpha** gen. & sp. nov. del ámbar del cretácico temprano-medio de la República de Myanmar. La especie está representada por unos 25 cuerpos fructíferos completos o parciales en varios estados de desarrollo. Los caracteres diagnósticos del nuevo taxon son su pequeña talla, cuerpos fructíferos de forma globosa a piriforme, hifas del micelio fibuladas y esporas globosos a subglobosas pequeñas. Se asigna al Orden Boletales (Sclerodermatineae) y tiene muchas características de la familia Sclerodermataceae, que incluye los bejines. *Palaeogaster micromorpha* representa el primer miembro fósil de las Sclerodermatineae y el hogo gasteroide fósil más antiguo conocido.

INTRODUCTION

Aside from containing a variety of animal and plant fossils, amber from Myanmar includes some interesting fungal remains, such as the Hymenomycete, *Palaeoclavaria burmitis* Poinar & Brown (2003) and one of the earliest known mushrooms, *Palaeoagaracites antiquus* Poinar and Buckley (2007). The present study describes a gasteroid fungus preserved in Myanmar (Burmese) amber. Fossil gasteroids, which include puffballs, earthballs, earthstars and stinkhorn fungi, are exceedingly rare with previous records limited to *Lycoperdites tertiarius* Poinar (2001), from Tertiary Mexican amber, a Late Cenozoic earthstar (Geasteraceae) from Pueblo, Mexico (Magallon-Pueble & Cervallos-Ferriz 1993) and a subfossil from Holocene deposits in Alaska (Chaney & Mason 1936).

MATERIALS AND METHODS

The amber piece contains some 25 complete or partial fruiting bodies in various developmental stages. Some of the opened fruiting bodies near the edge of the piece were sectioned with a diamond saw and mounted in immersion oil to observe hyphae, and spores. The amber originated from a mine excavated in 2001, in the Hukawng Valley, southwest of Maingkhwan in Kachin State (26°20'N, 96°36'E) in Myanmar. This location, known as the Noije Bum 2001 Summit Site, was assigned to the Early-Mid Cretaceous, Upper Albian, on the basis of paleontological evidence (Cruickshank & Ko 2003) placing the age at 97 to 110 mya. Nuclear mag-

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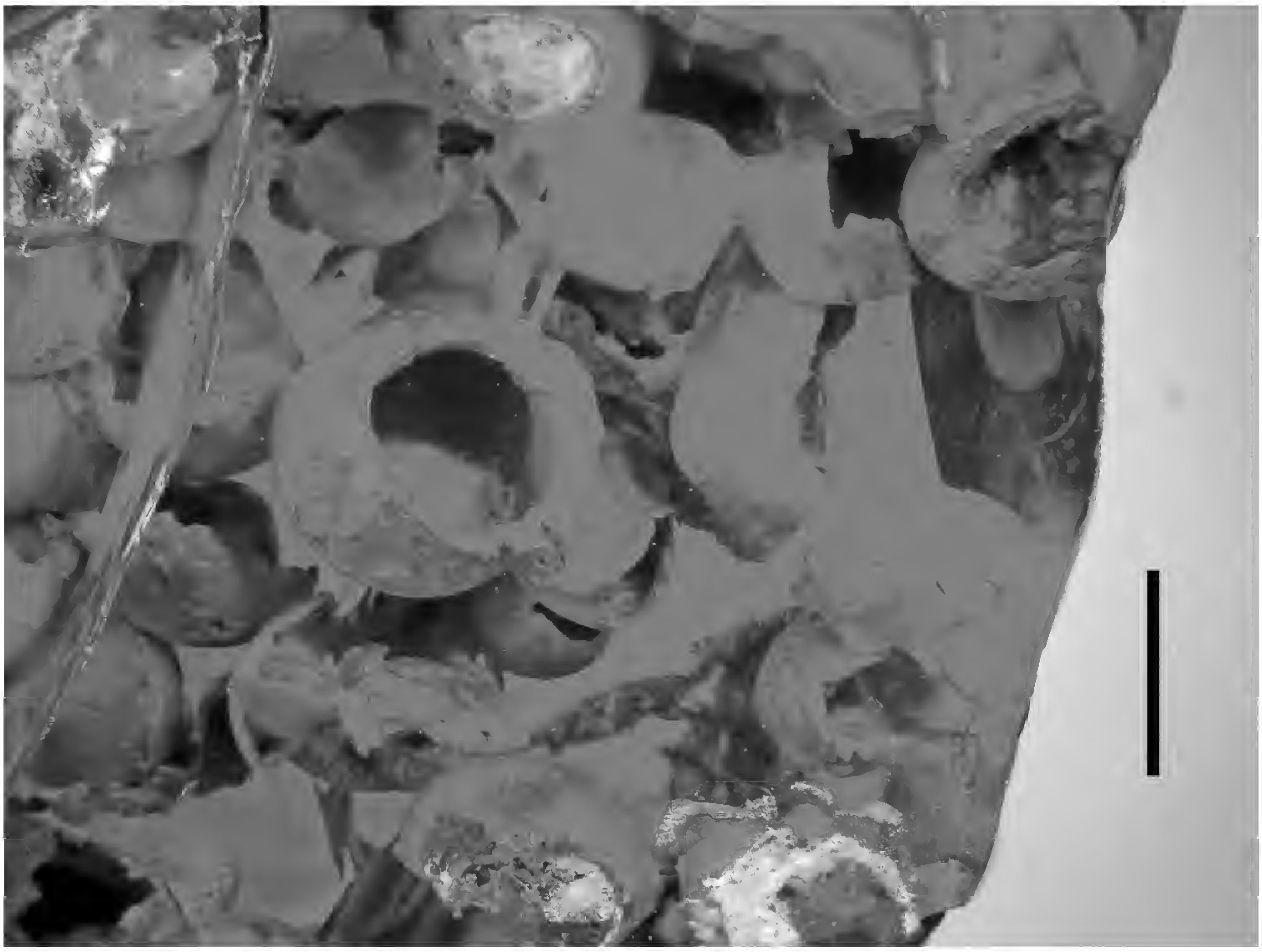

Fig. 1. Group of *Palaeogaster micromorpha* in Myanmar amber. Holotype is the specimen with the large opening in the center of the photo. Scale bar = 3 mm.

netic resonance (NMR) spectra and the presence of araucaroid wood fibers in amber samples from the Noije Bum 2001 Summit Site indicate an araucarian (possibly *Agathis*) tree source for the amber (Poinar et al. 2007). Descriptive terminology and taxonomy is based on Guzmán (1970), Guzmán and Ovrebo (2000), Gurgel, et al. (2008), Alfredo et al. (2012) and Nouhra et al. (2012).

DESCRIPTION

Boletales (Sclerodermatineae)

Palaeogaster Poinar, Alfredo, & Baseia, gen. nov. (**Figs. 1–8**), MycoBank no.: **MB 801127.** Type Species: *Palaeogaster micromorpha* Poinar, Alfredo, & Baseia.

Fruiting bodies small, subglobose to pyriform, spore case filling fruiting body; sterile base absent; peridium brown, hard, thick, splitting irregularly at terminus or subterminally to form large, roundish aperture; gleba firm, then becoming powdery yellow-orange at maturity; spores small, clear at maturity, globose to subglobose, smooth to slightly irregular surface; capillitium, hymenium and peridioles absent.

Palaeogaster micromorpha Poinar, Alfredo, & Baseia, sp. nov. (**Figs. 1–8**), MycoBank no.: **MB 801127.** Type: MYANMAR (BURMA): Amber mine in the Hukawng Valley, SW of Maingkhwan in Kachin State (26°20'N, 96°36'E), 1999, *unknown amber miner s.n.* (holotype: the open, centered specimen in Fig. 1; catalogue number B-F-1 deposited in the Poinar amber collection maintained at Oregon State University, Corvallis, Oregon 97331, U.S.A.).

Fruiting bodies from 5–7 mm in length, 3–4 mm in width; peridium persistent, peridium wall 6–12 µm wide; surface with areas of fine concentric, often intersecting lines; peridium splitting irregularly at terminus or subterminus to form large, roundish apertures ranging from 2–3 mm in diameter; apertures rimmed with fragments of original peridium; mature gleba powdery, yellow-orange; spores clear, globose to subglobose, lacking

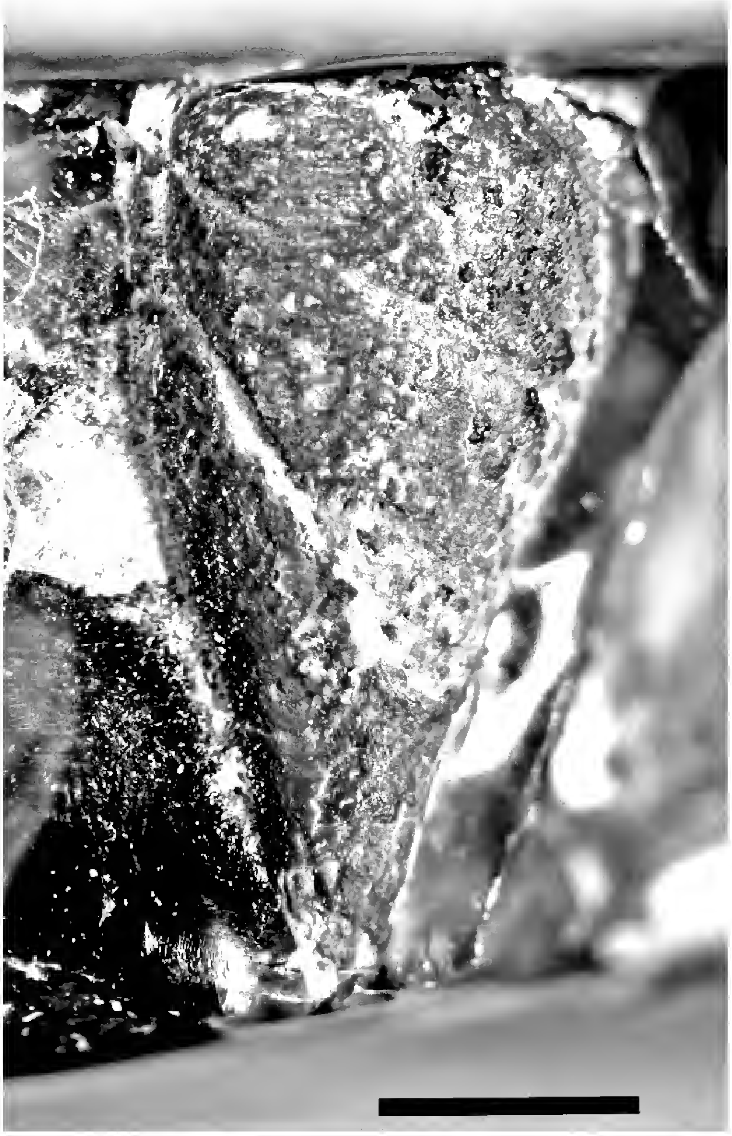

Fig. 2. Lateral view of pyriform fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 2 mm.

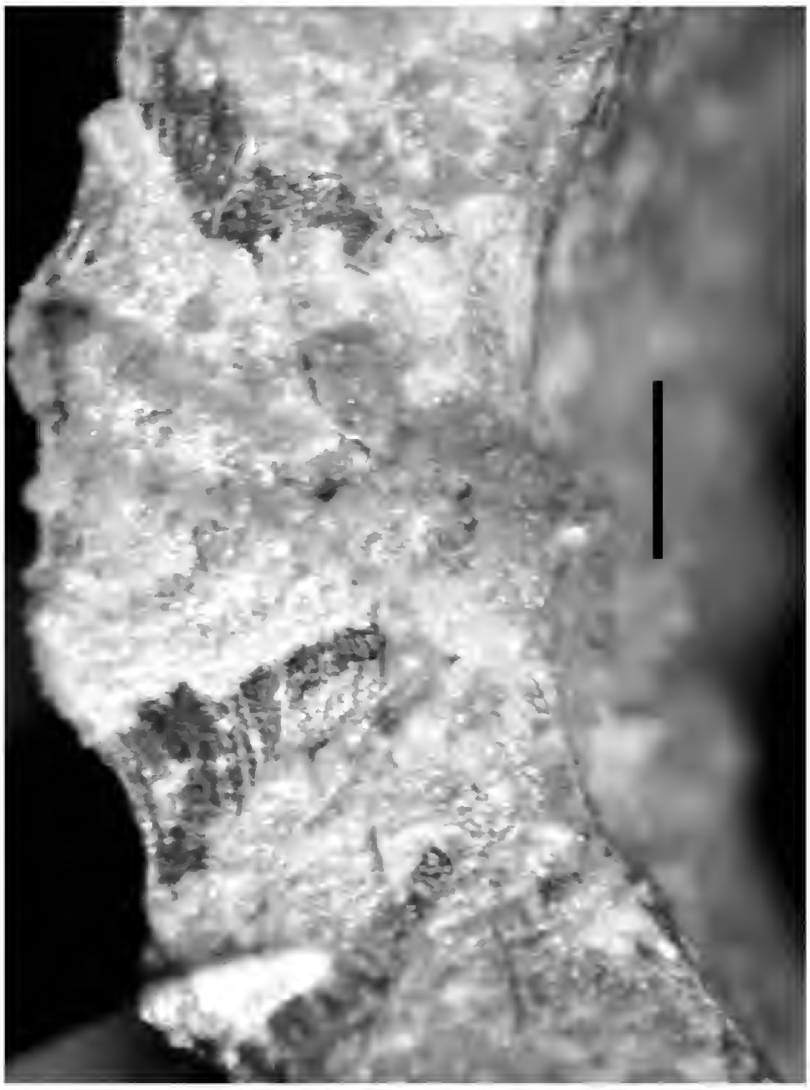

Fig. 3. Cross-section of the peridium of a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 35 µm.

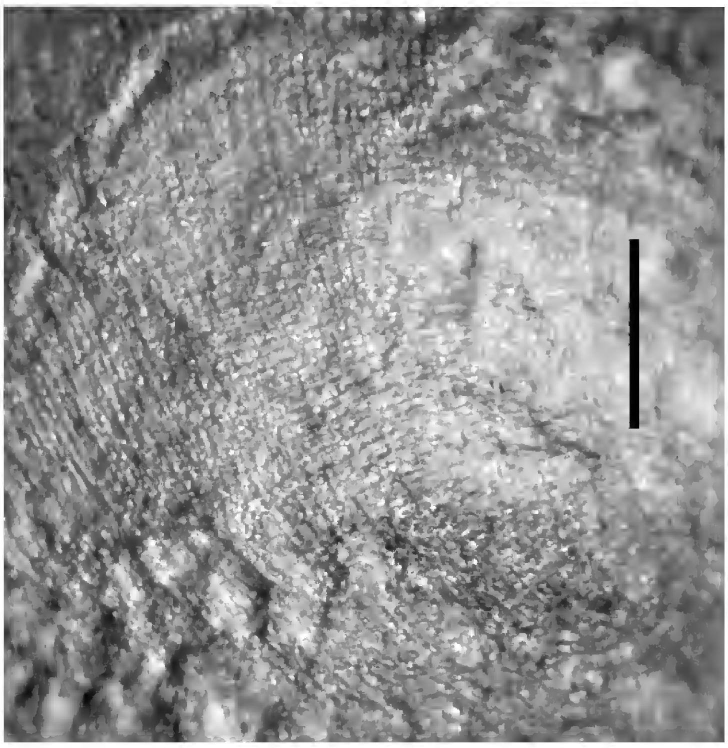

Fig. 4. Intersecting lines on the peridial surface of a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 27 µm.

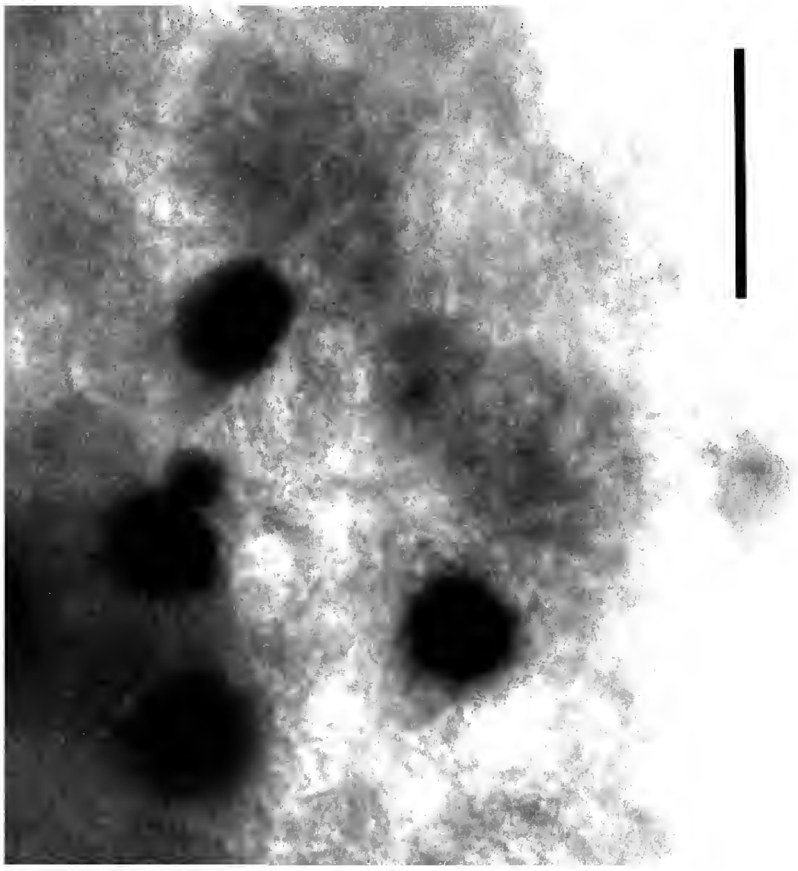

Fig. 5. Group of spores in the gleba of a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 27 µm.

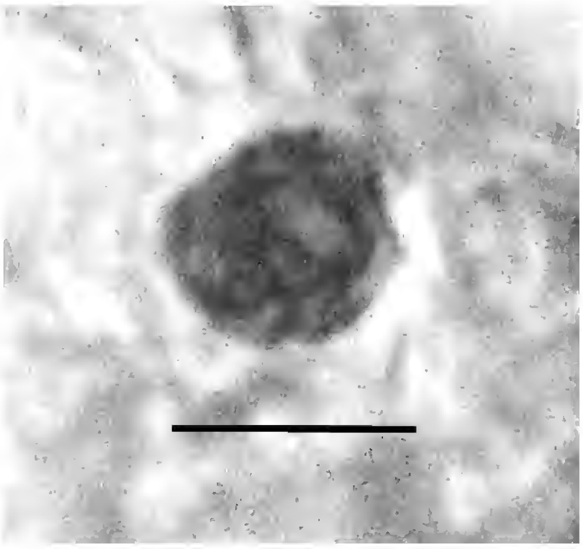

Fig. 6. Detail of a spore in the gleba of a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 8 µm.

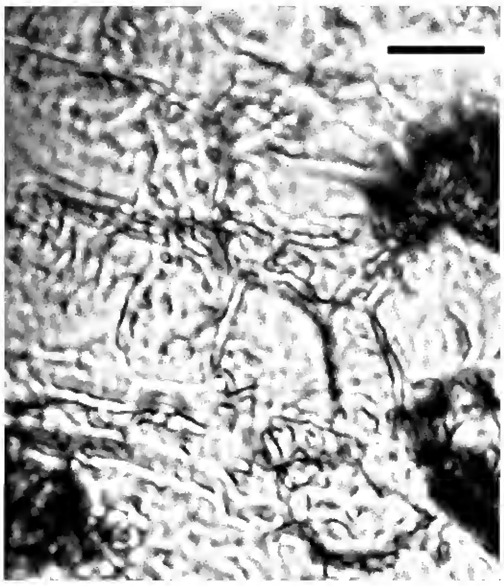

Fig. 7. Mycelial hyphae in a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 100 µm.

Fig. 8. Mycelial hyphae with clamp connections (arrows) in a fruiting body of *Palaeogaster micromorpha* in Myanmar amber. Scale bar = 80 µm

a hilum or pedicel, ranging from 4 –11 µm in greatest dimension; mycelial hyphae from fruit bodies 7 –10 µm in width, unpigmented, occasionally branched, thin-walled, with clamp connections.

Habitat.—Caespitose, probably growing on decaying wood.

Etymology.—The generic epithet is from the Greek "palaios" = ancient and the Greek "gaster" = stomach. The specific epithet is from the Greek "micros" = small and the Greek "morphe" = form.

DISCUSSION

Palaeogaster is distinguished by its small size, shape of the fruiting bodies, large, roundish terminal to subterminal aperture, yellow- orange gleba, non-sculptured spores and absence of a capillitium, hymenium and peridioles. The subglobose to pyriform fruiting bodies, single layered peridium, large irregular aperture, absence of a sterile base, mycelial hyphae with clamp connections and lack of a capillitium align it with the Sclerodermatineae. *Palaeogaster* shares with the extant genus *Diplocystis* (Sclerodermatineae) the habit of forming aggregates of small fruiting bodies, each forming a leathery, cup-shaped peridium (Louzan et al. 2007). However, the fruiting bodies of *Diplocystis* have a powdery umber gleba and the grayish-brown spores are covered with warty or spiny ornamentation. Small fruiting bodies with a mature yellow-orange gleba and globose to subglobose spores as occur in *Palaeogaster* are not found in extant representatives of the Sclerodermatineae (Arora 1986; Zeller 1949). *Palaeogaster micromorpha* represents the first fossil member of the Sclerodermatineae and the oldest known gasteroid fungus.

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BOOK NOTICE

Richard Primack. 2014. **Essentials of Conservation Biology, Sixth Edition.** (ISBN-13: 978-1-60535-289-3, hbk). Sinauer Associates, Inc., PO Box 407, Sunderland, Massachusetts 01375-0407, U.S.A. (**Orders:** www.sinauer.com, 1-413-549-4300). $94.95, 603 pp., 294 illustrations, 8½" × 11".

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Essentials of Conservation Biology, Sixth Edition is beautifully illustrated in full color and is written in clear, non-technical language, making it well-suited for undergraduate courses.

RICHARD B. PRIMACK is a Professor in the Biology Department at Boston University. He received his B.A. at Harvard University in 1972 and his Ph.D. at Duke University in 1976, and then was a postdoctoral fellow at the University of Canterbury and Harvard University. He has served as a visiting professor at the University of Hong Kong and Tokyo University, and has been awarded Bullard and Putnam Fellowships from Harvard University and a Guggenheim Fellowship. Dr. Primack was President of the Association for Tropical Biology and Conservation, and is currently Editor-in-Chief of the journal *Biological Conservation.* Twenty-eight foreign-language editions of his conservation biology textbooks (the *Essentials* and the shorter *Primer of Conservation Biology*) have been produced, with local coauthors. He is an author of rain forest books, most recently *Tropical Rain Forests: An Ecological and Biogeographical Comparison* (with Richard Corlett). Dr. Primack's research interests include: the biological impacts of climate change; the loss of species in protected areas; tropical forest ecology and conservation; and conservation education. He has recently completed a popular book about changes in Concord since the time of Henry David Thoreau, titled *Walden Warming: Climate Change Comes to Thoreau's Woods.*

XYLARIA ANTIQUA SP. NOV. (ASCOMYCOTA: XYLARIACEAE) IN DOMINICAN AMBER

George O. Poinar, Jr.

Department of Integrative Biology
Oregon State University
Corvallis, Oregon 97331 USA
poinarg@science.oregonstate.edu

ABSTRACT

Xylaria antiqua sp. nov. is described from Tertiary Dominican amber. Characters of the stroma, perithecia, ascospores and a white bloom of conidiogenous cells bearing conidiophores and conidia place the fossil in the Xylariaceae and genus *Xylaria*. The preservation of *X. antiqua* is excellent and the morphological characters of the hyphae and spores appear unaltered. This is the first record of a fossil fruiting body of the family Xylariaceae and shows that the basic characteristics of this group were already established some 20–30 million years ago.

RESUMEN

Se describe **Xylaria antiqua** sp. nov. del ámbar dominicano del Terciario. Caracteres del estroma, peritecios, ascosporas y un grupo blanco de células conidiógenas portadoras de conidióforos y conidios colocan al fósil en las Xylariaceae y género *Xylaria*. La preservación de *X. antiqua* es excelente y los caracteres morfológicos de las al hifas y esporas parecen sin alterar. Esta es la primera cita de un cuerpo fructífero fósil de la familia Xylariaceae y muestra que las características básicas de este grupo ya estaban establecidas hace unos 20–30 millones de años.

INTRODUCTION

Members of the genus *Xylaria* are very curious fungi in that their fruiting bodies often resemble decaying plant remains protruding from the ground. One of the more observed species, *X. polymorpha*, has dark brown to black club-shaped fruiting bodies that have been aptly named "Dead-Man's Fingers." Other species, such as *X. hypoxylon*, have antler-like, often arching fruiting bodies that have earned it the common name of "Candle-Snuff Fungus." These fungi are common pathogens, saprobes and endophytes that frequently fruit on dead wood and other plant substrates. They occur in many parts of the world today and are especially interesting since both asexual and sexual stages often occur on the same stroma, albeit usually not at the same time; conidia on mature stromata are remains of the earlier asexual phase.

While examining inclusions in amber from the Dominican Republic, a specimen of *Xylaria* was discovered. This fossil belongs to the group of *Xylaria* that are characterized by flattened thick branches rather than unbranched clubs. This specimen is described and represents the first record of a fossil fruiting body of the family Xylariaceae, to my knowledge, and shows that the basic characteristics of this group were already established some 20–30 million years ago.

MATERIALS AND METHODS

The description presented here is based on one complete and well-preserved stroma in Dominican amber. The specimen was obtained from mines in the Cordillera Septentrional of the Dominican Republic. Dating of Dominican amber is still controversial with the latest proposed age of 20–15 mya based on foraminifera (Iturralde-Vinent & MacPhee 1996) and the earliest as 45–30 mya based on coccoliths (Cêpek in Schlee 1990). Dominican amber was produced by the leguminous tree, *Hymenaea protera* Poinar, and a re-construction of the Dominican amber forest based on amber fossils indicated that the environment was similar to that of a present day tropical moist forest (Poinar & Poinar 1999). The amber piece was repolished to view the conidia and perithecia on the branches of the stroma. Observations and drawings were made with a Nikon SMZ-10 stereoscopic microscope.

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DESCRIPTION

Characters of the stroma, perithecia, ascospores and a white bloom of conidiogenous cells bearing conidiophores and conidia places the fossil in the Xylariaceae and genus *Xylaria* (Rogers 1979, 1983, 1984a, 1984b).

Phylum: Ascomycota
Order: Xylariales
Family: Xylariaceae
Xylaria Hill ex Schrank

Xylaria antiqua Poinar, sp. nov. (**Figs. 1–7**), MycoBank no.: **MB 808649.** Type: DOMINICAN REPUBLIC: amber mines in the northern mountain ranges (Cordillera Septentrional) of the Dominican Republic, Jul 1994, *unknown amber miner s.n.* (holotype: accession # AF-9-12, deposited in the Poinar amber collection, Oregon State University).

Stroma clavate, flattened, broad, many branched from lower third to near apex, with obtuse to blunt apices; length of entire specimen (substrate base + stoma), 15 mm; length of perithecium-bearing stroma, 8 mm, greatest width stroma, 7 mm; stipe short and broad, length stipe, 2 mm; width stipe,1.5 mm; most perithecia embedded in stroma with projecting ostioles; some perithecial elevations exposed on surface of stroma; height of perithecia, 116–130 µm; asci not observed; ejected ascospores single-celled, smooth walled, light brown, ranging from bean-shaped to ellipsoidal, 15–18 µm × 7–11 µm; germ slit faint, longitudinal, slightly curved.

Asexual (anamorph) state occurring as cream-colored, conidiogenous palisades over apices of stromal branches; conidia hyaline, smooth, ovate to elongate elliptical, 3–4 µm × 1–2 µm, borne singly or in pairs on persistent conidiophores covering stroma.

Etymology.—From the Latin "*antiquus*" = old.

Diagnosis.—The broad, flattened, branched, robust stroma with abrupt apices and roughened surface and the short, broad stipe, small conidia, ascospores and age appear to separate *X. antiqua* from extant members of the genus, despite the fact that only one stroma was available and it is unavailable for dissection. The fossil exhibits some similarities with *Xylaria cornu-damae* (Schwein.) Berk. and *X. digitata* (L.) Grev. (Rogers 1984a) from the Americas; however, both of these species have rounded or pointed apices rather than blunt tipped ones as in *X. antiqua*.

The shape of the ascospore and longitudinal germ slit of *X. antiqua* is similar to that of *X. allantoidea* (Berk.) Fr. (Rogers 1984b; p. 918, Fig. 25), a wide ranging species found throughout the Americas and Africa and *X. grandis* Peck (Rogers & Callan 1986; p. 396, Fig. 20) from North America. The germ slit in all of these is depicted under the light microscope by a faint white, somewhat blurred line extending along the side of the spore. However, both of these extant species have unbranched stromata. In their key to the *Xylaria* of North America (Rogers & Callen 1986), which is mainly based on characters of the ascospores, *X. antiqua* aligns with *X. mali* Fromme; however, that species has rounded fertile apices.

DISCUSSION

Xylariaceous fungi are primarily parasites and saprophytes of angiosperms and occur on limbs, standing tree trunks or logs. Most xylariaceous fungi occur in lowland forests, subtropics and cloud forests (Rogers 1979). Some species of *Xylaria* appear to be host-specific (Laessøe & Lodge 1994). These authors discuss two species of *Xylaria* (*X. meliacarum* Laessøe and *X. guareae* Laessøe & Lodge) that occur only on trees in the family Meliaceae, including on the leaves of *Trichilia* species in Puerto Rico. This angiosperm family was represented in the original Dominican amber forest by at least 3 species of *Trichilia* and one species of *Swietenia* (Meliaceae) (Chambers et al. 2011; Chambers & Poinar 2012a, 2012b). However, a few *Xylaria* species (*X. luxurians* (Rehm) C.G. Lloyd, *X. ianthino-velutina* (Mont.) Fr.) occur on leaves and pods of legumes (Laessøe & Lodge 1994; Dennis 1956), which suggests that the Dominican amber legume tree, *Hymenaea protera*, also could have served as host. It is likely that *X. antiqua* was growing on a dead branch of *H. protera* and after becoming dislodged, possibly by some animal, fell into a pool of resin that had collected on one of the lower branches.

The upright stromata of *Xylaria* species are considered to raise the perithecia above the substrate for more

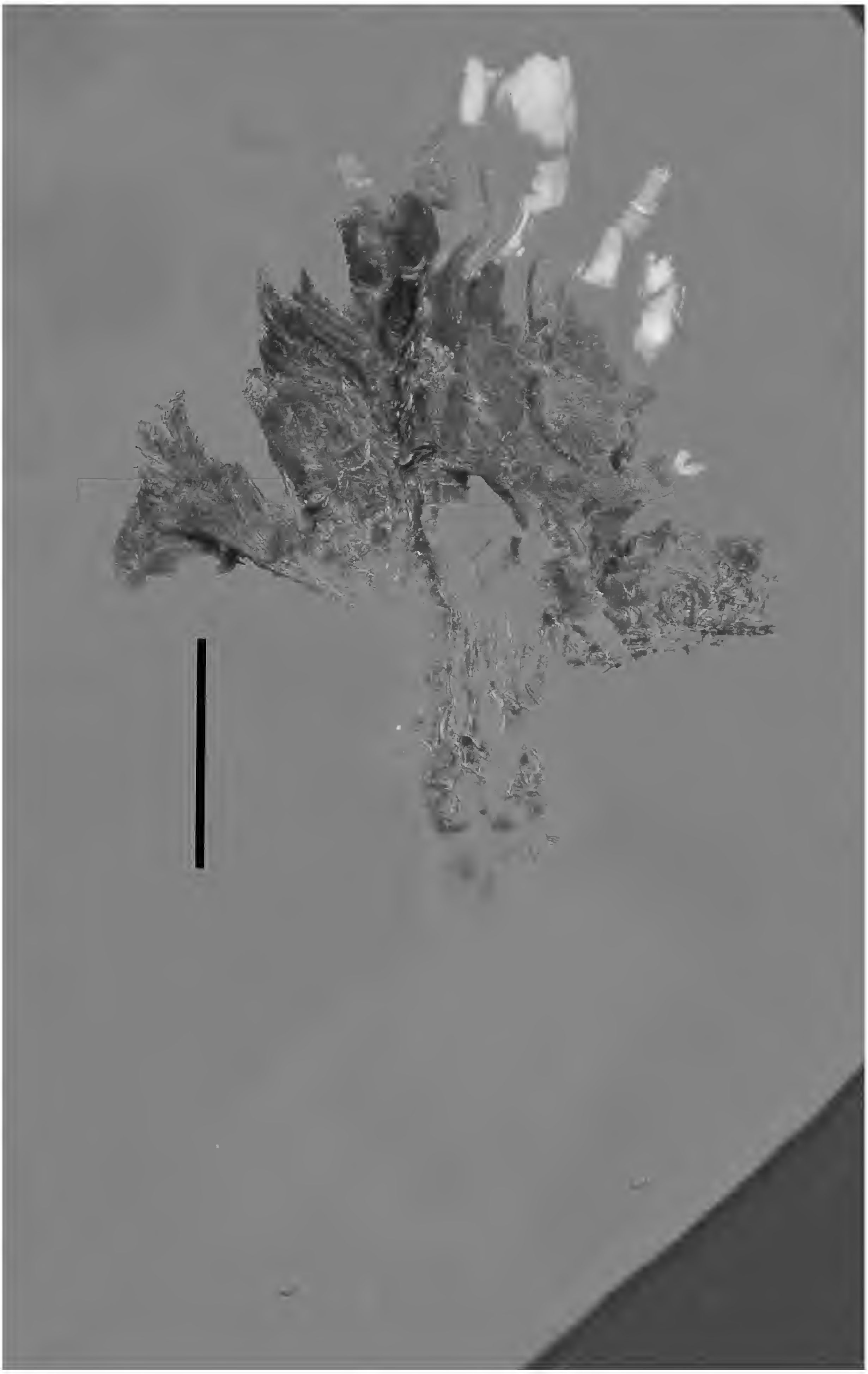

Fig. 1. Entire specimen of *Xylaria antiqua* in Dominican amber. Bar = 2.4 mm.

efficient ejection and dispersal of the ascospores (Rogers 1979). Rogers (1979) considered the small, conidia to represent relictual spermatia and questioned if they were functional. It is now known that conidia of some *Xylaria* species are propagules (for example, see Rogers et al. 2008). On *X. antiqua*, many of the terminal branches of the stroma appear to be immature, bearing conidia that are the remains of the earlier asexual state.

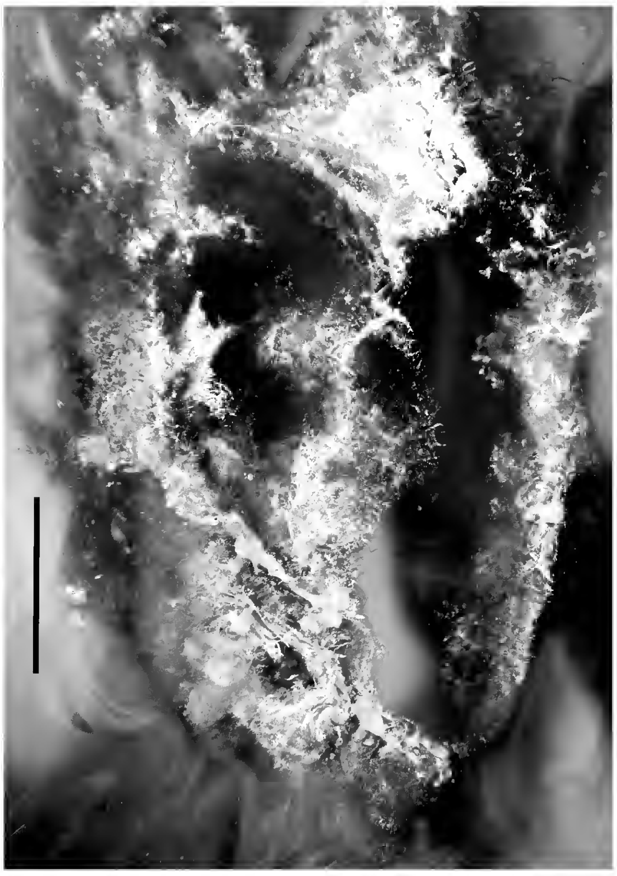

Fig. 2. Mycelial surface of substrate portion of *Xylaria antiqua* in Dominican amber. Bar = 510 µm.

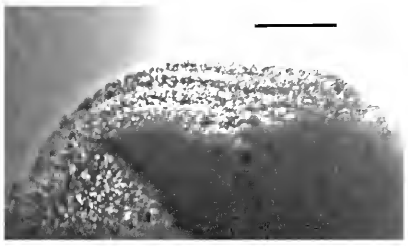

Fig. 3. Layers of conidiophores with conidia on stroma of *Xylaria antiqua* in Dominican amber. Bar = 120 µm.

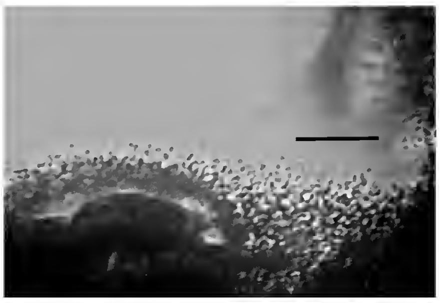

Fig. 4. Single layer of conidiophores with conidia on stroma of *Xylaria antiqua* in Dominican amber. Bar = 40 µm.

Fig. 5. Ostioles of perithecia protruding from stroma of *Xylaria antiqua* in Dominican amber. Bar = 50 µm.

Fig. 6. Perithecium on stroma of *Xylaria antiqua* in Dominican amber. Released ascospore is on right. Bar = 40 µm.

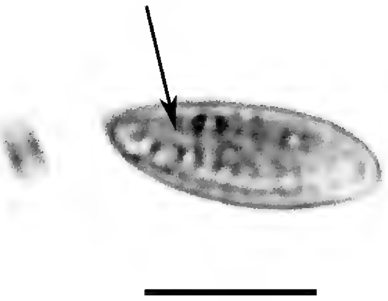

Fig. 7. Ellipsoidal ascospore of *Xylaria antiqua* with faint, longitudinal, germ slit (arrow) in Dominican amber. Bar = 11 µm.

The preservation of *X. antiqua* is excellent and the morphological characters of the hyphae and spores appear unaltered. The pristine condition of amber fossils is thought to be the result of fixation of the tissues from chemicals in the original resin. In amber embedded arthropods, there may be some collapsing of the appendages due to dehydration, which is also an important stage in the preservation process. However, it is rare to find any sign of dehydration or collapsing of the tissues of fungi in amber. Even the pileus of the Early Cretaceous Myanmar amber agaric, *Palaeoagaracites antiquus* Poinar & Buckley (2000) that was partly decomposed by a mycoparasite showed no signs of preservation distortion, nor did the much older spores retained on the phialides of the Early Cretaceous Myanmar amber Hypocreales, *Paleoophiocordyceps coccophagus* Sung, Poinar, & Spatafora (2008).

While this is the first fossil record of a fruiting body of a member of the Xylariaceae, as far as I am aware, the group as a whole has a more extensive history. Bharati et al. (2003) reported xylariaceous, single furrowed amerospores similar to those found in some *Hypoxylonites* and *Spirotremesporite*s from Late Cretaceous and Tertiary sediments of northeastern India.

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JOURNAL NOTICE

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FLORA OF THE HALOPHYTIC GRASSLANDS IN THE VALLE DE JANOS, CHIHUAHUA, MEXICO

José Humberto Vega-Mares and Andrés Eduardo Estrada-Castillón*

Facultad de Ciencias Forestales
Universidad Autónoma de Nuevo León
Km. 145 carr. Nac. Linares-Cd. Victoria
Apartado postal 41
67700 Linares, Nuevo León, MÉXICO
navega_mares@hotmail.com

José Ángel Villarreal-Quintanilla

Departamento de Botánica
Universidad Autónoma Agraria Antonio Narro
Apartado postal Buena Vista
Saltillo, Coahuila, 25315, MÉXICO

Gustavo Quintana Martínez

Facultad de Zootecnia y Ecología
Universidad Autónoma de Chihuahua
Periférico Fco. R. Almada
Kilómetro 1, colonia Zootecnia
Chihuahua, Chihuahua, MÉXICO

ABSTRACT

A study of the flora and plant endemism of the halophytic communities of the Valle de Janos, Chihuahua, was carried out. Documentation of the flora and endemic species was conducted by collecting plants throughout the area during a two-year period. The vascular plant diversity accounts for 57 families, 198 genera, and 328 taxa including infraspecific categories. Asteraceae (40 genera, 55 species), Poaceae (29, 60), Fabaceae (14, 28), and Euphorbiaceae (6, 22) are the most representative families in genera and species, respectively. *Euphorbia* (14 species), *Dalea* (8), *Bouteloua* (8), and *Opuntia* (7) are the most diversified genera. Fifteen of the species recorded are restricted to the Chihuahuan Desert; three of them are endemic to the State of Chihuahua, and only one species, *Dalea janosensis,* is restricted to the Valle de Janos halophytic communities. All species comprise five biological forms, and according to their origin, 96.5% of the genera and 92.1% of the species are authouchtonous; the rest of them are exotic.

Key Words: Valle de Janos, Chihuahua, Mexico, endemism, halophytic communities

RESUMEN

Se estudió la flora y endemismo de las comunidades halófilas del Valle de Janos, Chihuahua. Para la documentación de la flora y endemismo se realizaron recorridos y colectas de material botánico en toda el área de estudio durante un periodo de dos años. La diversidad florística vascular está integrada por 57 familias, 198 géneros y 328 taxones incluyendo categorías infraespecíficas. Asteraceae (40 géneros y 55 especies), Poaceae (29, 60), Fabaceae (14, 28) y Euphorbiaceae (6, 22) son las familias más representativas respecto a número de géneros y especies. *Euphorbia* (14 especies), *Dalea* (8), *Bouteloua* (8) y *Opuntia* (7) son los géneros con mayor número de especies. Quince de las especies registradas están restringidas al Desierto Chihuahuense, tres de ellas son endémicas del Estado de Chihuahua, y sólo una especie, *Dalea janosensis*, está restringida a las comunidades halófilas del Valle de Janos. Todas las especies comprenden cinco formas biológicas principales. De acuerdo con su origen, 96.5% de los géneros y 92.1% de las especies son autóctonos, el resto son exóticos.

Palabras clave: Valle de Janos, Chihuahua, Mexico, endemismo, comunidades halófilas

INTRODUCTION

Halophytic communities are common within the Chihuahuan Desert region of northern Mexico (Henrickson & Johnston 1997), which are mainly comprised of the families Poaceae, Chenopodiceae, Frankeniaceae, and Asteraceae (Rzedowski 1978). These associations constitute an important part of the grasslands, since they are restricted to specific environmental conditions (Herrera 2012), such as species adapted to soils with high salt concentrations, basic pH, silty-clay texture, and poor drainage (Rzedowski 1978; Gay & Dwyer 1980). The edaphic factor is the main determinant in the plant composition in these communities (Miranda & Hernandez-X 1963), which are frequently located at the bottom of closed drainage basins that retain water and intermountain valleys (Rzedowski 1978).

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The Valle de Janos communities have these characteristics, but also, support extensive areas of arid grasslands and associated shrublands composed mainly of mesquite (*Prosopis glandulosa* var. *torreyana*) and ephedra (*Ephedra trifurca*) (COTECOCA 1978; Royo & Báez 2001). Valle de Janos is located in the Chihuahuan Desert ecoregion at the northwestern portion of the State of Chihuahua.

The arid zones in northern Mexico support a high number of endemic plant species (González-Medrano & Chiang 1988; Rzedowski 1991). Its flora and vegetation are of particular interest since they are adapted to specific environmental conditions (Kliem 2000). However, this large region is among the most unknown from a floristic viewpoint (Rzedowski 1992). Several studies of the halophytic communities in northern Mexico have been completed (Johnston 1939), including areas in the State of Chihuahua such as Babícora (Estrada et al. 1997), the central part of Chihuahua (Estrada & Villarreal 2010), Cañón de Santa Elena (SEMARNAT 1997), Campo Experimental La Campana (Royo & Melgoza 2001), Samalayuca (Enríquez 2003), and Presa la Boquilla (González 2005). Undoubtedly, the most important one is the flora of the Chihuahuan Desert (Henrickson & Johnston 1997), where almost 150 of the species cited occur in the halophytic communities of Valle de Janos, highlighting those belonging to the families Asteraceae and Chenopodiacaeae. Valle de Janos is of great importance for natural resource conservation in Mexico and North America (List et al. 2000; Manzano-Fischer et al. 2000), and therefore is a North American Grassland Priority Conservation Area (GPCA) (Karl & Hoth 2005). The National Commission for the Knowledge and Use of Biodiversity (CONABIO) has also identified it as a Priority Terrestrial Region (RTP-45) (Arriaga 2000) and an important Area for Bird Conservation (AICAs-45) (CIPAMEX-CONABIO 1999). Valle de Janos is also part of the complex of priority areas in the Chiricahua-Peloncillo-Sierra Madre for the conservation of wildlife (Dinerstein et al. 2000). It is noteworthy that Valle de Janos has the largest colony of the black-tailed prairie dog (*Cynomys ludovicianus* Ord.) (Ceballos et al. 1993) in North America, which is an endangered species (SEMARNAT 2010). Nevertheless, this area has been impacted by anthropogenic activities that threaten the persistence of the endemic flora in these halophytic communities and the prairie dog populations. These communities have suffered a rapid decline as an ecosystem over the past 25 years (Ceballos et al. 2010). The main causes of deterioration include livestock overgrazing, expansion of mechanized agriculture (Ceballos et al. 1993, 2005), and climate change (Pinedo et al. 2013).

To date, there have been no studies that characterize the plant diversity or the ecology for the region. The aim of this study is to contribute to the knowledge of the regional flora and plant endemism in the halophytic communities in the Valle de Janos.

METHODS

Study area

The study area is about 116,000 ha and is located in the northwestern region of the State of Chihuahua, in the municipality of Janos, 30°54'23"N, 108°38'55"W and 30°53'51"N, 108°13'58"W (Fig. 1). The annual rainfall is 306.7 mm with almost 50% of it occurring between July and September. The mean temperature is 16°C (Rzedowski 1978). The altitude is 1380–1500 m and the topography varies from flat ridges to low round hills with gentle slopes of 1–8%. The main climate is BSoK type, corresponding to dry and temperate climates according to the Köpeen Classification System (modified by García 1973). The hydrology of the area belongs to the North Closed Basin Region, specifically to Río Casas Grandes Basin (CONAGUA 2009). According to the Guide for interpreting soils (INEGI 2004), INIFAP-CONABIO (1995) and INEGI (2005), the most outstanding soil in the Valle de Janos are Luvic Xerosol (with clay accumulation in the subsoil, traces of lime or gypsum, with very low and burdensome physical phase); Haplic Xerosol (with very low organic matter content and very permeable); Haplic Feozem (in flat or gently wavy relief, permeable); Haplic Yermozol (thin soil, poor in organic matter content, high content in calcareous material, permeable); Luvic Yermosol (with high clay content in the B horizon, and below this may have calcic or gypsic horizon); Orthic Zolonetz (clayey, with an alkaline, saline phase, waterproof, and poor in organic matter content); Orthic Solonchak (clay, high concentrations of soluble salts, poor in organic matter and nutrients content, with a sodium phase); Eutric Regosol (coarse texture, poor

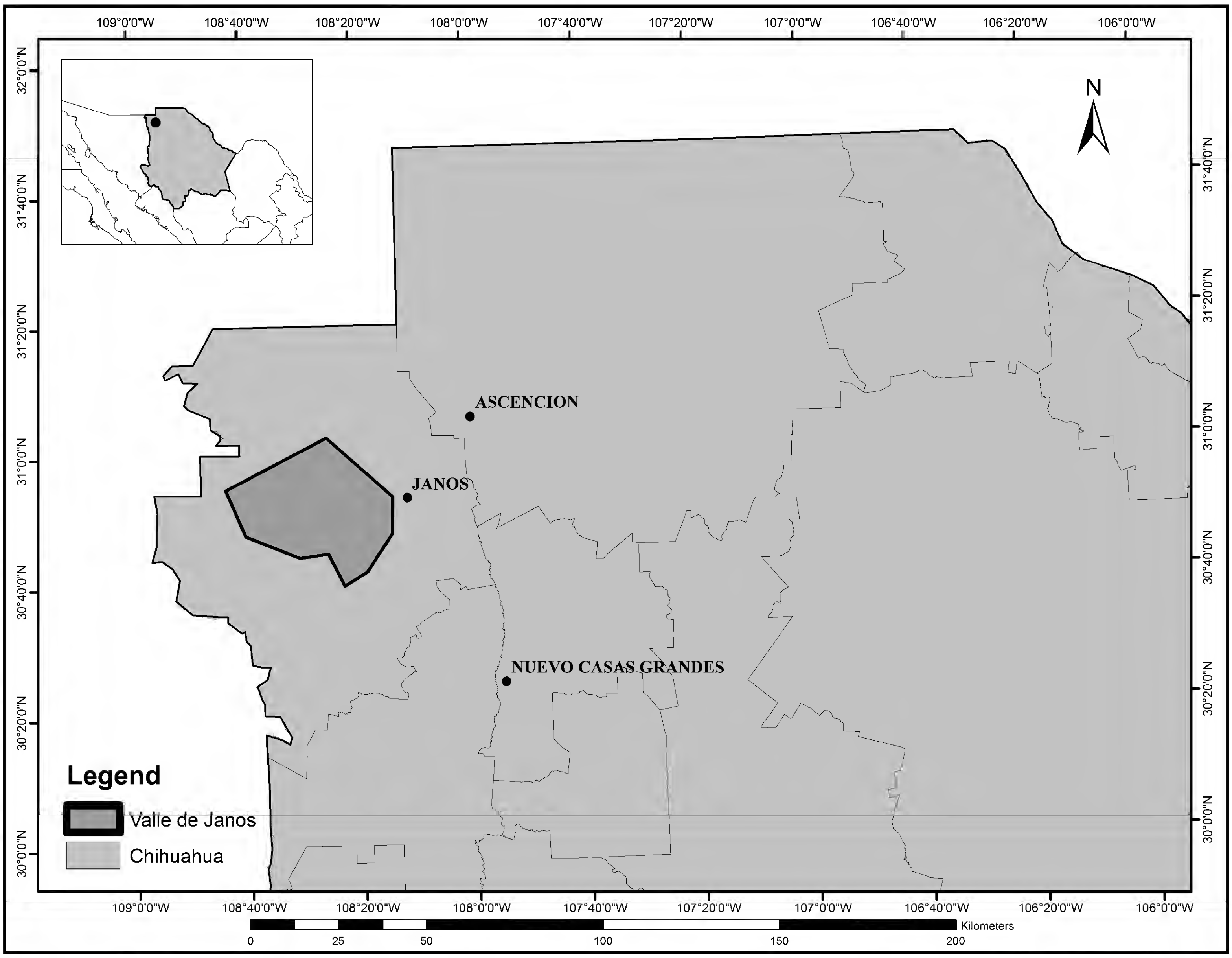

Fig. 1. Study area. The Valle de Janos (darker shaded area) is located at the northwestern portion in the State of Chihuahua, and, it is the area where the largest colony of prairie dogs is located in North America.

in organic matter content, nutrient-rich subsoil, very permeable) and Lithosol (stony and very thin, in steep slopes).

The representative vegetation in the area is salt-tolerant grassland, extensive arid grassland, and microphyllous desert scrub (COTECOCA 1978; Rzedowski 1978) (Fig. 2). The most common shrub species in the microphyllous desert scrub are *Prosopis glandulosa* var. *torreyana, Ephedra trifurca, Opuntia imbricata*, *Mimosa aculeaticarpa*, and *Atriplex canescens*. Also, there are several dominant herbaceous elements such as *Gutierrezia sarothrae, G. microcephala*, *Chenopodium album*, *Muhlenbergia porteri*, *Salsola tragus*, and *Pleuraphis mutica*, while in the natural, undisturbed by agriculture or grazing grasslands, there are *Bouteloua* spp., *Aristida* spp., *Panicum* spp., and *Eragrostis* spp., plus other herbaceous species such as *Machaeranthera* spp., *Sida* sp., *Eriogonum* spp., and *Lepidium* spp. The halophytic grasslands are dominated by species adapted to poorly drained and saline soils, including *Pleuraphis muitca, Sporobolus airoides, Atriplex canescens,* and *Portulaca mundula*.

The study was carried out during the years 2011 and 2012. Specimen collecting was conducted in different seasons in order to document the phenological stages of species in all plant associations. All plants were properly georeferenced, recording the community or dominant association where the plants were found. Plant identification was made by using different monographs for the different genera as well as the *Flora of the Chihuahuan Desert* (Henrickson & Johnston 1997). Herbarium voucher specimens were deposited at ANSM (Saltillo, Coahuila, Mexico) and CFNL (Linares, Nuevo Leon, Mexico) herbaria.

Fig. 2. Habitat of *Pleuraphis mutica,* a dominat herbaceous element in a salt-tolerant grassland escosystem in the Valle de Janos, Chihuahua, México. Other dominates include *Prosopis glanduloso* var. *torreyana* and *Yucca elata*.

RESULTS AND DISCUSSION

Diversity

The flora of the Valle de Janos is represented by 57 families, 198 genera, and 328 species (including infraspecific categories) of vascular plants (Table 1, Appendix 1). Dicots include 50 families, 161 genera, and 259 species, while monocots are represented by five families, 35 genera, and 67 species. Gymnosperms and ferns are represented by only one species each. The families with the highest number of genera and species are Asteraceae (40, 55), Poaceae (29, 60), Fabaceae (14, 28), and Euphorbiaceae (6, 22), and the ten most diversified families include over half of the genera (122, 61.6%) and species (229, 69.8%) (Table 2). The most diversified genera are *Euphorbia* (14), *Dalea* (8), *Bouteloua* (8), *Opuntia* (7), *Aristida* (6), and *Atriplex* (5) (Table 3). According to the plant diversity in Mexico (304 families, 2,804 genera, and 23,424 species) (Villaseñor 2004), the State of Chihuahua encompasses 37.5% (152), 22.2% (890), and 8.1% (4,035) of the families, genera, and species, respectively. The flora of the Valle de Janos represents 18.8% of the families, 7.1% of the genera, and 1.4% of the species existing in Mexico, and represents 37.5%, 22.2%, and 8.1% of the families, genera, and species existing in the State of Chihuahua. The families with the highest diversity in genera and species in most of Mexico are Asteraceae, Poaceae, and Fabaceae (Rzedowski 1992; Villaseñor 2003, 2004), which in turn, have been used as predictors of diversity in this country (Villaseñor et al. 2007). The four genera of Valle de Janos (*Euphorbia*, *Dalea*, *Bouteloua*, and *Opuntia*) are also among the 17 most numerous genera of Mexico (Villaseñor 2004). According to Rzedowski (1992), the grasslands and shrublands support almost 6,000 species (20% of the total flora), and 5.5% of these species are found in the Valle de Janos.

Table 1. Division of the vascular flora recorded in the study area.

Groups	Families	Genera	Species	Infraspecific categories
Ferns	1	1	1	1
Gymnosperms	1	1	1	0
Angiosperms				
Dicotyledons	50	161	259	21
Monocotyledons	5	35	67	1
Total	**57**	**198**	**328**	**23**

Table 2. Families with the highest number of genera and species in the study area.

Family	Number of genera	Number of species
Asteraceae	40	55
Poaceae	29	60
Fabaceae	14	28
Malvaceae	7	13
Euphorbiaceae	6	22
Cactaceae	6	13
Solanaceae	6	12
Brassicaceae	6	9
Nyctaginaceae	4	9
Chenopodiaceae	4	8

Table 3. Genera with the highest number of species in the study area.

Genera	Number of species
Euphorbia	14
Dalea	8
Bouteloua	8
Opuntia	7
Aristida	6
Atriplex	5
Muhlenbergia	5
Sporobolus	5
Asclepias	4
Astragalus	4

Valle de Janos has lower species diversity than other halophytic community areas found in the State of Chihuahua, such as the center of the State of Chihuahua (Estrada & Villarreal 2010), La Campana Experimental Ranch (Royo & Melgoza 2001), and Laguna de Babícora (Estrada et al. 1997). This difference is related to the other plant associations present in these areas and absent in Valle de Janos, such as scrublands and pine-oak forest. However, if we compare the homogenous halophytic communities, such as the areas where prairie dogs inhabit the northeastern and northwestern regions of Mexico, we can see the northwestern halophytic communities support greater plant diversity (Table 4). A fairer comparison of the flora of the Valle de Janos is perhaps the halophytic grassland of northeastern Mexico (Estrada et al. 2010). In both grasslands Asteraceae, Poaceae, and Fabaceae are the dominant plant families, followed by others such as Cactaceae, Brassicaceae, and Solanaceae. Their diversity is low compared with other ecosystems (Rzedowski 1978); both grasslands are home to the prairie dog, *Cynomys mexicanus* (northeast grasslands) and *Cynomys ludovicianus* (northwest grasslands). Despite being similar in composition and structure, both grasslands show contrast in plant diversity: Valle de Janos has 14 families, 24 genera, and 102 species more than the northeast grasslands (53 families,

Table 4. Comparison of the flora in the Valle de Janos against regional floras of Chihuahua and one area from northeastern Mexico. Numbers in parentheses represent the number of shared taxa.

	Families	Genera	Species	Vegetation	Altitude (masl)
Valle de Janos	57	198	328	Grassland and scrublands	1380–1500
Central Chihuahua	112(51)	493(181)	1322(221)	Grassland and oak-pine forest	1450–2300
La Campana (Chih.)	74(43)	258(130)	433(124)	Grassland and oak-pine forest	1500–2500
Babícora (Chih.)	67(41)	244(93)	476(70)	Grassland and oak-pine forest	2150–2700
NE México	53(37)	174(92)	284(73)	Grassland and scrublands	1550–1950

174 genera, and 226 species) (Estrada et al. 2010). Both grasslands share *Dalea, Bouteloua, Opuntia, Aristida,* and *Atriplex* as the most diversified genera, and the herbaceous plants have the highest diversity, followed by shrubs and trees. There is a higher plant endemism in the northeast grasslands (17 species, 6%) than in the northwest ones (1, 0.003%). The influence of the different climate, altitude, topography, soil type, and the presence of endoergic basins in the northeast grasslands areas have undoubtedly favored this speciation phenomenon, compared to the relatively homogeneous landscape found in the northwest grasslands.

Endemism, growth forms, and flora origin

From the total flora, only fifteen of the species are endemic to the Chihuahuan Desert, including the State of Chihuahua and Valle de Janos grasslands (see Appendix I). Three of them are endemic only for the State of Chihuahua: *Matelea chihuahuensis*, *Opuntia orbiculata*, and *Dalea janosensis*. *Dalea janosensis* is a new species recently described for this area (Estrada et al. 2013) that was discovered as part of this work. It is associated only with halophytic communities comprised of *Sporoblus airoides*, *S. cryptandrus*, *Atriplex acanthocarpa*, *A. wrightii*, *A. canescens*, *Prosopis glandulosa* var. *torreyana*, *Malvella leprosa*, *Bouteloua aristidoides*, and *Ipomoea costellata*. According to the NOM-059-SEMARNAT-2010 (SEMARNAT 2010), only one of the species, *Amoreuxia palmatifida,* is protected (special protection, Pr). This species is found only in rocky and undulating ridges associated with *Artemisia frigida*, *Sphaeralcea wrightii*, *Tragia nepetifolia,* and *Heteropogon contortus*.

The total taxa include five growth forms: herbaceous (163 perennials, 106 annuals), shrubs (25 thornless and 8 thorny), fleshy stems (15), rosetophyllous (2), and trees (9). The most abundant annual species in the study area are *Aristida adscensionis*, *Bouteloua barbata*, *B. aristidoides,* and *Panicum hirticaule*. The most common perennial ones are *Pleuraphis mutica*, *Sporobolus airoides*, *Bouteloua eriopoda, B. gracilis, Bothriochloa barbinodis,* and *Aristida divaricata*. The most common annual forbs are *Atriplex wrightii*, *Eriogonum abertianum*, *Portulaca olearacea*, *Talinum aurantiacum*, and *Machaeranthera tanacetifolia*. The most common perennial forbs are *Salsola tragus, Machaeranthera pinnatifida*, *Sida abutifolia, Solanum elaeagnifolium,* and *Evolvulus alsinoides*. The dominant scrublands are comprised of *Prosopis glandulosa* var. *torreyana*, *Epherda trifurca*, *Atriplex canescens*, *Mimosa aculeaticarpa,* and *Ziziphus obtusifolia*. *Salix bonplandiana*, *Populus fremontii,* and *Platanus racemosa* are common in riparian areas. *Cylindropuntia imbricata*, *Opuntia macrorhiza* var. *macrorhiza*, *O. macrocentra,* and *Echinocereus rigidissimus* are the most common cacti. *Dasylirion wheeleri* and *Yucca elata* are scarce in the Valle de Janos, found only in the most arid areas.

Several species such as *Atriplex canescens, A. acanthocarpa, A. elegans, A. obovata, A. wrightii, Pleuraphis mutica, Sporobolus airoides, S. pyramidatus, Eragrostis mexicana,* and *E. neomexicana* are common in areas where sodium or sulfate salt concentrations are very high. These salty soils are frequent in the north of the study area, such as Rancho Las Arenillas and Rancho el Peñasco.

Where there are few hillocks, the topographic diversity highlights the presence of no-saline adpated species, including shrubs such as *Aloysia wrightii* and *Baccharis pteronioides*; grasses such as *Bouteloua curtipendula*, *Heteropogon contortus*, *Bouteloua eriopoda*, *Lycurus phleoides*, *Digitaria califórnica,* and *Aristida divaricata;* and forbs such as *Artemisia frigida*, *Sphaeralcea wrightii*, *Tragia nepetifolia*, *Commelina dianthifolia,* and *Amoreuxia palmatifida*.

In the Valle de Janos, native species (302 = 92.1%) are, by far, more diverse than the introduced ones (26 =

7.9%). Among the most frequent introduced species are *Salsola tragus*, *Chloris virgata*, *Chenopodium album*, *Schismus barbatus*, *Cyperus esculentus*, *Eragrostis cilianensis*, *Urochloa mutica,* and *Mollugo verticillata* (see "i" in Appendix I). Similarly, the native genera (191 = 96.4%) surpass those introduced (7 = 3.5%). The most frequent introduced genera are *Brassica, Eruca*, *Cynodon, Schismus,* and *Salsola.* These elements are very common in abandoned fields in the area. The most common growth forms are herbs (269 species = 82%), shrubs (33 = 10.1%), and trees (10 = 3%). We recorded 76 weed species (23.2% of the total flora), 56 native and 20 exotic ones (see "w" in Appendix I). The most frequent weed species in the area are *Salsola tragus*, *Sida abutifolia*, *Machaeranthera pinnatifida*, *Chloris virgata*, *Pectis prostrata*, *Chenopodium album, Amaranthus retroflexus, Mollugo verticillata, Evolvulus alsinoides,* and *Eragrostis cilianensis.* These species are more frequent in areas with exposure to livestock management (overgrazing) and agriculture (crops abandoned).

CONCLUSIONS

Valle de Janos supports rich plant diversity in spite of its relatively homogenous topography. Its characteristic plant associations are determined by the arid climate, the edaphic factors, and black-tailed prairie dog, allowing it the presence of that particular flora. Halophytic communities of northwestern Mexico have higher plant diversity but lower plant endemism than counterparts found in northeastern Mexico (Estrada et al 2010). When plant diversity of Valle de Janos is compared with several surrounding areas in the State of Chihuahua, it is less diverse, since this study counted only the species inhabiting the plains and excluded the oak and oak-pine forest. This study detected a large quantity of herbaceous species not recorded previously by general botanical studies (COTECOCA 1978). We recommend studies focused in ecology and exotic species replacement and establishment due to soil use and compaction as well as those focused in overgrazing since this ecosystem is currently highly transformed by agricultural activities. The most common grasses such as *Aristida adscensionis*, *Bouteloua barbata*, *B. aristidoides, Panicum hirticaule,* and *Bothriochloa barbinodis* and some herbs such as *Sida abutifolia, Machaeranthera pinnatifida, M. tanacetifolia, Solanum elaeagnifolium,* and *Evolvulus alsinoides* are disturbance indicator plants and are classified as weeds (CONABIO 2013), coupled with some exotic species such as *Salsola tragus, Mollugo verticillata,* and *Chloris virgata* (Villaseñor & Espinosa-Garcia 2004).

The capabilities of the plant species to tolerate drought and salinity are causal factors for the presence of species and communities in different habitat, and the minimum xylem pressure potential are indicative of drought tolerance, and the minimum cell osmotic potential are indicative of the tolerance of plant species to salinity (Branson et al 1988). Several species found in this area such as *Atriplex obovata, A. canescens, Ephedra trifurca, Gutierrezia sarothrae, Krascheninnikovia lanata, Larrea tridentata, Prosopis glandulosa* var. *torreyana,* and *Sporobolus airoides*. There are over 2,000 known plant species worldwide that have some tolerance to salinity (Menzel & Lieth 2003); 27 of them are found in the Valle de Janos, and the most outstanding ones in decreasing order with respect to tolerance of salts are *Atriplex canescens, Sporobolus airoides, Chenopodium album, Prosopis glandulosa* var. *torreyana*, and *Salsola tragus.* At least 60 species found in the Valle de Janos are included into the USDA-ARS data bases (Yensen 2013) as salt-tolerant plants.

The most common forbs associated are *Atriplex wrightii*, *Eriogonum abertianum*, *E. abertianum Machaeranthera pinnatifida*, *M. tanacetifolia*, *Portulaca oleracea*, *Salsola tragus, Sida abutifolia, Solanum elaeagnifolium, Talinum aurantiacum, Zinnia grandiflora,* and several species of the genus *Euphorbia.* It is common to find patches of *Pleuraphis mutica* in areas where Haplic Yeromozol soils (high calcium contents) are present; it is a species that grows in environments with moderately saline soils and soils with calcium carbonate, very resistant to fire and drought (USFS 2014). Several arboreal and shrub species such as *Baccharis salicifolia*, *B. sarothroides, Platanus racemosa, Populus fremontii,* and *Salix bonplandiana* are frequently found in flat or gently rolling relief with Haplic Foezem soils. The Yermozol and Solonchak soils are most common at the north-central part of the study area and support mainly *Pleuraphis mutica-Sporobolus airoides-Atriplex* spp., as well as *S. pyramidatus.* This last species is common in salt meadows in Louisiana (Reid et al 2010). According to Rzewdoski (1978) and COTECOCA (1978), the most important grasses in Valle de Janos in the late 70s and early 80s were *Bouteloua gracilis, B. eripoda, B. hirsuta, B. curtipendula,* and *Aristida divaricata.* This can give an idea of the species replacement, although the extent of it is still unknown. With respect to the main grasses (*Pleuraphis mutica* and *Sporobolus airoides*) in the halophytic communities, the plant physiognomy is almost the same, but the species composition is different. The discovery of a new taxon (*Dalea janosensis*) could imply a new conservation scheme in this unique halophytic community in the arid land of the Chihuahuan Desert. Last, we recommend promoting studies in plant diversity in the surrounding regions to complete the total flora of this interesting and unique area in Mexico.

APPENDIX 1

List of families, genera and species recorded in the Valle de Janos, Chihuahua, Mexico. H.V.M. = Humberto Vega Mares and collection number. Biological growth forms (**t** = tree, **s** = shrub, **h** = herbaceous, **f** = fleshy stems, and **r** = rosetophyllous). Native (**n**), introduced (**i**), weeds (**w**). Endemic to the Chihuahuan Desert (*), endemic for the State of Chihuahua (•), and endemic to the Valle de Janos (§).

FERNS

Pteridaceae

Astrolepis cochisensis (Goodd) D.M. Benham & Windham ssp. *cochisensis* (Goodd.) D.M. Benham & Windham, H.V.M. 1796; h, n

GYMNOSPERMS

Ephedraceae

Ephedra trifurca Torr. ex S. Watson, H.V.M. 1900; s, n

MONOCOTYLEDONS

Asparagaceae

Dasylirion wheeleri S. Watson ex Rothr., H.V.M. 1921; r, n
Yucca elata (Engelm.) Engelm., H.V.M. 1914; r, n

Amaryllidaceae

Allium kunthii G. Don, H.V.M. 1916; h, n

Commelinaceae

Commelina dianthifolia Delile, H.V.M. 1655; h, n

Cyperaceae

Carex filifolia Nutt., H.V.M. 1531; h, n
Cyperus dipsaceus Liebm., H.V.M. 1595; h, n
Cyperus esculentus L., H.V.M. 1679; h, i, w

Poaceae

Aristida adscensionis L., H.V.M. 1562: h, n, w
Aristida divaricata Humb. & Bonpl. ex Willd., H.V.M. 1584; h, n
Aristida havardii Vasey, H.V.M. 1583; h
Aristida pansa Woot. & Standl., H.V.M. 1482, 1604; h, n
Aristida purpurea Nutt. var. *longiseta* (Steud.) Vasey, H.V.M. 1700; h, n
Aristida schiedeana Trinius & Ruprecht, H.V.M. 1784; h, n
Bothriochloa barbinodis (Lag.) Herter, H.V.M. 1489; h, n
Bouteloua aristidoides (Kunth) Griseb., H.V.M. 1526; h, n
Bouteloua barbata Lag., H.V.M. 1458; h, n
Bouteloua curtipendula (Michx.) Torr., H.V.M. 1571; h, n
Bouteloua eriopoda (Torr.) Torr., H.V.M. 1498; h, n
Bouteloua gracilis (Kunth) Lag. ex Griffiths, H.V.M. 1543; h, n
Bouteloua hirsuta Lag., H.V.M. 1462,1703; h, n
Bouteloua parryi (E. Fourn.) Griffiths, H.V.M. 1785; h, n
Bouteloua rothrockii Vasey, H.V.M. 1606; h, n
Bromus anomalus Rupr. ex Fourn., H.V.M. 1786; h, n
Cenchrus incertus M.A. Curtis, H.V.M. 1663; h, n, w
Cenchrus spinifex Cav., H.V.M. 1788; h, n, w
Chloris virgata Sw., H.V.M. 1563; h, i, w
Cynodon dactylon (L.) Pers., H.V.M. 1789; h, i, w
Dasyochloa pulchella (Kunth) Willd. ex Rydb., H.V.M. 1597; h, n
Digitaria californica (Benth.) Henr., H.V.M. 1540; h, n
Digitaria sanguinalis (L.) Scop., H.V.M. 1733; h, i, w
Echinochloa colona (L.) Link, H.V.M. 1725; h, i, w
Echinochloa crusgalli (L.) P. Beauv., H.V.M. 1724; h, i, w
Elyonurus barbiculmis Hack., H.V.M. 1790; h, n, m
Enneapogon desvauxii P. Beauv., H.V.M. 1664; h, n, m
Eragrostis cilianensis (All.) Link ex Vignolo, H.V.M. 1525; h, i, w
Eragrostis lehmanniana Nees, H.V.M. 1607; h, i, w
Eragrostis mexicana (Hornem.) Link, H.V.M. 1560; h, n, w
Eragrostis neomexicana Vasey ex L.H. Dewey, H.V.M. 1561; h, n
Eriochloa gracilis (E. Fourn.) Hitchc., H.V.M. 1723; h, n
Erioneuron avenaceum (Kunth) Tateoka, H.V.M. 1653; h, n
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult., H.V.M. 1652; h, n
Leptochloa dubia (Kunth) Nees, H.V.M. 1612; h, n, w
Leptochloa filiformis (Pers.) P. Beauv., H.V.M. 1588; h, n, w
Lycurus phleoides Kunth, H.V.M. 1791; h, n, w
Muhlenbergia arenacea (Buckley) Hitchc, H.V.M. 1651; h
Muhlenbergia arenicola Buckley, H.V.M. 1699; h, n
Muhlenbergia monticula Buckley, H.V.M. 1792; h, n
Muhlenbergia porteri Scribn. ex Beal, H.V.M. 1603; h, n
Muhlenbergia rigens (Benth.) Hitchc., H.V.M. 1800: h, n
Panicum hirticaule J. Presl, H.V.M. 1564; h, n
Panicum obtusum Kunth, H.V.M. 1585; h, n
Pleuraphis mutica Buckley, H.V.M. 1463; h, n
Schismus arabicus Nees, H.V.M. 1792; h, i, w
Schismus barbatus (L.) Thell., H.V.M. 1678,1726; h, i, w
Scleropogon brevifolius Phil., H.V.M. 1593; h, n, w
Setaria grisebachii E. Fourn., H.V.M. 1605; h, n, w
Setaria leucopila (Scribn. & Merr.) K. Schum., H.V.M. 1673; h, n, w
Sorghum halepense (L.) Pers., H.V.M. 1539; h, i, w
Sporobolus airoides (Torr.) Torr., H.V.M. 1799; h, n
Sporobolus contractus Hitchc., H.V.M. 1608; h, n
Sporobolus cryptandrus (Torr.) A. Gray, H.V.M. 1794; h, n
Sporobolus flexuosus (Thurb. ex Vasey) Rydb., H.V.M. 1702; h, n
Sporobolus pyramidatus (Lam.) Hitchc., H.V.M. 1623; h, n
Tragus berteronianus Schult., H.V.M. 1602; h, i, w
Tridens muticus (Torr.) Nash, H.V.M. 1714; h, n
Urochloa arizonica (Scribn. & Merr.) Morrone & Zuloaga, H.V.M. 1657; h, n
Urochloa mutica (Forssk.) T.Q. Nguyen, H.V.M. 1930; h, i, w

DICOTYLEDONS

Aizoaceae

Trianthema portulacastrum L., H.V.M. 1919; h, n, w

Amaranthaceae

Amaranthus blitoides S. Watson, H.V.M. 1709; h, n
Amaranthus retroflexus L., H.V.M. 1918; h, n, w
**Froelichia arizonica* Thornber ex Standl., H.V.M. 1596; h, n
Gomphrena nitida Rothr., H.V.M. 1593; h, n
Guilleminea densa (Humb. & Bonpl. ex Schult.) Moq., H.V.M. 1544; h, n, w
Tidestromia lanuginosa (Nutt.) Standl., H.V.M. 1917; h, n

*_Tidestromia suffruticosa_ (Torr.) Standl., H.V.M. 1513; h, n

Anacardiaceae

Rhus microphylla Engelm. ex A., H.V.M. 1600; s, n

Apocynaceae

Apocynum androsaemifolium L., H.V.M. 1920; h, n
Asclepias asperula (Decne.) Woodson, H.V.M. 1530; h, n
Asclepias latifolia (Torr.) Raf., H.V.M. 1512; h, n
Asclepias oenotheroides Schltdl. & Cham., H.V.M 1749; h, n
Asclepias subverticillata (A. Gray) Vail, H.V.M. 1717; h, n
•_Matelea chihuahuensis_ (A. Gray) Woodson, H.V.M. 1736; h, n
Sarcostemma cynanchoides Decne. ssp. _hartwegii_ (Vail) R. Holm, H.V.M. 1915; h, n

Aristolochiaceae

Aristolochia longecaudata S. Watson, H.V.M. 1568; h, n
*_Aristolochia wrightii_ Seem., H.V.M. 1701; h, n

Asteraceae

Acourtia nana (A. Gray) Reveal & R. M. King, H.V.M. 1519; h, n
Ambrosia artemisiifolia L., H.V.M. 1559; h, i, w
Ambrosia confertiflora DC., H.V.M. 1627; h, n, w
Aphanostephus ramosissimus DC. var. _humilis_ (Benth.) B.L.Turner & Birdsong, H.V.M. 1743; h, n, w
Artemisia frigida Willd., H.V.M. 1594; h, n
Artemisia ludoviciana Nutt., H.V.M. 1750; h, n, w
Baccharis pteronioides DC., H.V.M. 1670; s, n
Baccharis salicifolia (Ruiz & Pav.) Pers., H.V.M. 1537; s, n
Baccharis sarothroides A. Gray, H.V.M. 1719; s, n
Bahia absinthifolia Benth., H.V.M. 1613; h, n, w
Bahia autumnalis Ellison, H.V.M. 1738; h, n
Bahia pedata A. Gray, H.V.M. 1913; h, n
Baileya multiradiata Harv. & A. Gray ex A. Gray, H.V.M. 1570; h, n
Berlandiera lyrata Benth., H.V.M. 1527; h, n
Bidens bigelovii A. Gray, H.V.M. 1694; h, n, w
Brickellia eupatorioides (L.) Shinners var. _chlorolepis_ (Wooton & Standl.) B.L.Turner, H.V.M. 1741; h, n
Brickellia lemmonii A.Gray var. _conduplicata_ (B.L. Rob.) B.L. Turner, H.V.M. 1730; h, n
Chaetopappa bellioides (A. Gray) Shinners, H.V.M. 1912; h, n
Chaetopappa ericoides (Torr.) G.L. Nesom, H.V.M. 1640 y 1739; h, n
Cirsium texanum Buckley, H.V.M. 1485; h, n
Conoclinium greggii (A. Gray) Small, H.V.M. 1574; h, n
*_Flourensia cernua_ DC., H.V.M. 1599; s, n
Grindelia squarrosa (Pursh) Dunal, H.V.M. 1630; h, n
Gutierrezia microcephala (DC.) A. Gray, H.V.M. 1922; s, n
Gutierrezia sarothrae (Pursh) Britton & Rusby, H.V.M. 191; s, n
Helianthus ciliaris DC., H.V.M. 1506; h, n, w
Helianthus petiolaris Nutt., H.V.M. 1751; h, n
Heliomeris longifolia (B.L. Rob. & Greenm.) Cockerell, H.V.M. 1923; h, n
Heterotheca subaxillaris (Lam.) Britton & Rusby, H.V.M. 1545; h, n
Hymenoxys richardsonii (Hook.) Cockerell, H.V.M. 1910; h, n
Laennecia coulteri (A. Gray) G.L. Nesom, _H.V.M_ 1536; h, n
Leuciva dealbata (A. Gray) Rydb., H.V.M. 1616; h, n, w
Machaeranthera pinnatifida (Hook.) Shinners, H.V.M. 1481; h, n, w
Machaeranthera tanacetifolia (Kunth) Nees, H.V.M. 1508; h, n
Parthenium incanum Kunth, H.V.M. 1541; s, n
Pectis papposa Harv. & A. Gray, H.V.M. 1677; h, n
Pectis prostrata Cav., H.V.M. 1618; h, n, w
Porophyllum ruderale (Jacq.) Cass., H.V.M. 1695; h, n
Psilactis asteroides A. Gray, H.V.M. 1742; h, n, w
Psilostrophe tagetina (Nutt.) Greene, H.V.M. 1549; h, n
Sanvitalia abertii A. Gray, H.V.M. 1547; h, n
Senecio flaccidus Less. var. _douglasii_ (DC.) B.L. Turner & T.M. Barkley, H.V.M. 1509; h, n
Senecio longilobus Benth., H.V.M. 1517; s, n, w
Stephanomeria pauciflora (Torr.) A. Nelson, H.V.M. 1516; h, n
Thelesperma megapotamicum (Spreng.) Kuntze, H.V.M. 1478; h, n
Thymophylla acerosa (DC.) Strother, H.V.M. 1636; h, n
*_Thymophylla aurea_ (A. Gray) Greene var. _polychaeta_ (A. Gray) Strother, H.V.M. 1617; h, n
Tithonia tubiformis (Jacq.) Cass., H.V.M. 1740; h, n, w
Trixis californica Kellogg, H.V.M. 1671; s, n
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray, H.V.M. 1518; h, n, n
Viguiera cordata (Hook. & Arn.) D'Arcy, H.V.M. 1737; h, n
Viguiera linearis (Cav.) Sch.Bip. ex Hemsl., H.V.M. 1747; h, n, w
Xanthisma gracile (Nutt.) D.R. Morgan & R.L. Hartm., H.V.M. 1936; h, n
Xanthium strumarium L., H.V.M. 1909; h, n
Zinnia grandiflora Nutt., H.V.M. 1484; h, n

Bignoniaceae

Chilopsis linearis (Cav.) Sweet, H.V.M. 1689; t, n

Bixaceae

Amoreuxia palmatifida DC. H.V.M. 1665; h, n

Boraginaceae

Cryptantha cinerea (Greene) Cronquist, H.V.M. 1643; h, n
Cryptantha micrantha (Torr.) I.M. Johnst., H.V.M. 1752; h, n
Nama hispida A. Gray, H.V.M. 1908; h, n

Brassicaceae

Brassica rapa L., H.V.M. 1690; h, i, w
Brassica tournefortii Gouan, H.V.M. 1674; h, i, w
Descurainia pinnata (Walter) Britton, H.V.M. 1907; h, n, w
Dimorphocarpa wislizeni (Engelm.) Rollins, H.V.M. 1669; h, n
Eruca sativa (L.) Mill., H.V.M. 1727; h, i, w
Lepidium lasiocarpum Nutt., H.V.M. 1460; h, n
Lepidium montanum Nutt., H.V.M. 1460; h, n
Lepidium virginicum L., H.V.M. 1924; h, n, w
Physaria gordonii (A. Gray) O'Kane & Al-Shehbaz, H.V.M. 1935; h, n

Cactaceae

Echinocereus fendleri (Engelm.) Sencke ex J.N. Haage var. _fendleri_, H.V.M. 1906; f, n
*_Echinocereus rigidissimus_ (Engelm.) F. Haage., H.V.M. 1753; f, n
*_Coryphantha scheeri_ (Kuntze) L.D. Benson var. _robustispina_ (Schott ex Engelm.) L.D. Benson, H.V.M. 1925; f, n
Cylindropuntia imbricata (Haw.) F. M. Kunth, H.V.M. 1926; f, n
Mammillaria heyderi Muehlenpf., H.V.M. 1934; f, n
Opuntia discata Griffiths, H.V.M. 1904; f, n
Opuntia macrocentra Engelm., H.V.M. 1939; f, n
Opuntia macrorhiza Engelm.var. _macrorhiza_, H.V.M. 1927; f, n
Opuntia macrorhiza Engelm. var. _pottsii_ (Salm-Dyck) L.D. Benson, H.V.M. 1938; f, n
•_Opuntia orbiculata_ Salm-Dyck ex Pfeiff., H.V.M. 1903; f, n
Opuntia polyacantha Haw. var. _trichophora_ (Engelm. & J.M. Bigelow) J.M. Coult., H.V.M. 1928; f, n
Opuntia spinosior (Engelm.) Toumey, H.V.M. 1933; f, n
Thelocactus bicolor (Galeotti) Britton & Rose var. _bicolor_, H.V.M. 1902; f, n

Chenopodiaceae

Atriplex acanthocarpa (Torr.) S. Watson, H.V.M. 1619; a
Atriplex canescens (Pursh) Nutt., H.V.M. 1503; s, n
Atriplex elegans (Moq.) D. Dietr. H.V.M. 1469; s, n
Atriplex obovata Moq., H.V.M. 1620; s, n
Atriplex wrightii S. Watson, H.V.M. 1631; h, n
Chenopodium album L., H.V.M. 1502; h, i, w
Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smith, H.V.M. 1504; s, n
Salsola tragus L., H.V.M. 1634; h, i, w

Convolvulaceae

Convolvulus equitans Benth., H.V.M. 1656; h, n
Dichondra argentea Humb. & Bonpl. ex Willd., H.V.M. 1491; h, n, w
Evolvulus alsinoides (L.) L, H.V.M. 1488; h, n, w
Evolvulus sericeus Sw., H.V.M. 1487; h, n
Ipomoea costellata Torr., H.V.M. 1582; h, n
Ipomoea cristulata Hallier f., H.V.M. 1686; h, n

Crassulaceae

Sedum wrightii A. Gray, H.V.M. 1754; h, f

Cucurbitaceae

Apodanthera undulata A. Gray, H.V.M. 1468; h, n, w
Cucurbita digitata A. Gray, H.V.M. 1467; h, n
Cucurbita foetidissima Kunth, H.V.M. 1901; h, n, w
Ibervillea tenuisecta (A. Gray) Small, H.V.M. 1644; h, n

Ericaceae

Arbutus xalapensis Kunth, H.V.M. 1755; t, n

Euphorbiaceae

Acalypha neomexicana Müll. Arg., H.V.M. 1713; h, n
Acalypha ostryifolia Riddell, H.V.M. 1587; h, n
Argythamnia humilis (Engelm. & A. Gray) Müll. Arg. var. *humilis*, H.V.M. 1745; h, n
Argythamnia neomexicana Mull. Arg., H.V.M. 1661; h, n
Croton pottsii (Klotzsch) Müll. Arg., H.V.M. 1712; h, n
Croton suaveolens Torr., H.V.M. 1633; h, n
Euphorbia albomarginata Torr. & A. Gray, H.V.M. 1459; h, n
Euphorbia capitellata Engelm., H.V.M. 1464; h, n
Euphorbia cinereascens Engelm., H.V.M. 1889; h, n
Euphorbia davidii Subils, H.V.M. 1591; h, n, w
Euphorbia dentata Michx., H.V.M. 1554; h, n, w
Euphorbia dioeca Kunth, H.V.M. 1721; h, n, w
Euphorbia exstipulata Engelm., H.V.M. 1555; h, n
Euphorbia heterophylla L. H.V.M. 1522; h, n
Euphorbia hyssopifolia L., H.V.M. 1580; h, n, w
Euphorbia micromera Engelm., H.V.M. 1720; h, n
Euphorbia setiloba Engelm. ex Torr., H.V.M. 1680; h, n
Euphorbia serpyllifolia Pers., H.V.M. 1579; h, n
Euphorbia stictospora Engelm., H.V.M. 1888; h, n
Euphorbia tomentulosa S. Watson, H.V.M. 1685; h, n
Jatropha macrorhiza Benth., H.V.M. 1465; h, n
Tragia ramosa Torr., H.V.M. 1756; h, n

Fabaceae

Acacia angustissima (Mill.) Kuntze, H.V.M. 1471; s, n
Astragalus crassicarpus Nutt., H.V.M. 1632; h, n
Astragalus mollissimus Torr., H.V.M. 1470; h, n, w
Astragalus nuttalianus DC., H.V.M. 1698; h, n
Astragalus sp., H.V.M. 1722; h, n
Caesalpinia jamesii (Torr. & A. Gray) Fisher, H.V.M. 1472; h, n
Chamaecrista nictitans (L.) Moench, H.V.M. 1494; h, n
Crotalaria pumila Ortega, H.V.M. 1550; h, n, w
Dalea brachystachys A.Gray, H.V.M. 1691; h, n
Dalea candida Willd. var. *oligophylla* (Torr.) Shinners, H.V.M. 1635; h, n
Dalea formosa Torr., H.V.M. 1641; s, n
Dalea jamesii (Torr.) Torr. & A. Gray, H.V.M. 1705; h, n
§*Dalea janosensis* A.E. Estrada, Villarreal & H. Vega, H.V.M. 1675; h, n
Dalea nana Torr. var. *nana*, H.V.M. 1704; h, n
Dalea pogonathera A. Gray, H.V.M. 1565; h, n
Dalea polygonoides A. Gray, H.V.M. 1575; h, n
Desmodium neomexicanum A. Gray, H.V.M. 1598; h, n
Eysenhardtia spinosa Engelm., H.V.M. 1887; s, n
Hoffmannseggia glauca (Ortega) Eifert, H.V.M. 1493; h, n, w
Macroptilium gibbosifolium (Ortega) A. Delgado, H.V.M. 1457; h, n, w
Mimosa aculeaticarpa Ortega, H.V.M. 1505; s, n
Mimosa dysocarpa Benth., H.V.M. 1886; s, n
Prosopis glandulosa var. *torreyana* Torr., H.V.M. 1495; s, n
Rhynchosia senna Gillies ex Hook. & Arn., H.V.M. 1535; h, n
Rhynchosia senna Gillies ex Hook. & Arn. var. *angustifolia* (A. Gray) Grear, H.V.M. 1704; h, n
Senna bauhinioides (A. Gray) H.S. Irwin & Barneby, H.V.M. 1520; h, n
Senna durangensis (Rose) H.S. Irwin & Barneby var. *durangensis*, H.V.M. 1490; h, n
Senna lindheimeriana (Scheele) H. S. Irwin & Barneby, H.V.M. 1521; s, n

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Fouquieria splendens Engelm., H.V.M. 1758; s, n

Geraniaceae

Erodium cicutarium (L.) L'Hér. ex Ait., H.V.M. 1885; h, i, w

Hydrophyllaceae

Phacelia crenulata Torr. ex S. Watson, H.V.M. 1984; h, n

Krameriaceae

Krameria lanceolata Torr., H.V.M. 1639; h, n

Lamiaceae

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Salvia pinguifolia (Fernald) Wooton & Standl., H.V.M. 1883; s, n
**Salvia subincisa* Benth., H.V.M. 1589; h, n
Tetraclea coulteri A. Gray, H.V.M. 1557 y 1628; h, n

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Loasaceae

Cevallia sinuata Lag., H.V.M. 1667; h, n
Mentzelia multiflora (Nutt.) A. Gray, H.V.M. 1507; h, n

Malpiguiaceae

Janusia gracilis A.Gray, H.V.M. 1610; s, n

Malvaceae

Abutilon palmeri A. Gray, H.V.M. 1609; s, n
Abutilon parvulum A.Gray, H.V.M. 1746; h, n
Abutilon wrightii A. Gray, H.V.M. 1515; h, n
Anoda cristata (L.) Schltdl., H.V.M. 1552; h, n, w
Anoda thurberi A.Gray, H.V.M. 1744; h, n
Hibiscus denudatus Benth., H.V.M. 1659; s, n
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Eriogonum wrightii Torr. ex Benth., H.V.M. 1510; h, n
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Sapindaceae
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Lycium pallidum Miers, H.V.M. 1615; s, n
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PRIMER REGISTRO DE *ASTROCASIA PELTATA* (EUPHORBIACEAE) EN COSTA RICA

Irene Calderón Sanou

Escuela de Biología
Universidad de Costa Rica
11501-2060 San Jose, COSTA RICA
irecalsa@gmail.com

RESUMEN

Se documenta una población aislada de *Astrocasia peltata* Standl. creciendo a orillas de la quebrada Brasil en el Parque Nacional Diriá, en Costa Rica. Este es el primer registro de esta especie fuera de México de donde se creía endémica. Se incluye una descripción actualizada de la especie, se presenta una clave para distinguir las dos especies de *Astrocasia* en Costa Rica y se discuten posibles explicaciones de la distribución geográfica disyunta que se revela para *A. peltata* con este nuevo descubrimiento.

Palabras Clave: *Astrocasia peltata*, Euphorbiaceae, Costa Rica, Parque Nacional Diriá, distribución disyunta

ABSTRACT

The discovery of an isolated population of *Astrocasia peltata* Standl., growing on the banks of Brasil Creek in Parque Nacional Diriá, in Costa Rica, is documented. This is the first record of the species outside of Mexico where it was believed endemic. An updated morphological description of the species is presented and possible explanations for the disjunct geographical distribution are discussed.

Key Words: *Astrocasia peltata*, Euphorbiaceae, Costa Rica, Parque Nacional Diriá, disjunct distribution

El género *Astrocasia* B.L. Rob. & Millsp. está representado por seis especies neotropicales y tiene una distribución disyunta desde México y Cuba hasta el sur de Bolivia y Brasil (Webster 1992; Jiménez & Martínez 2001). Pertenece a la subfamilia Phyllanthoideae, que igual que Oldfieldioideae incluye los géneros de Euphorbiaceae con dos óvulos por lóculo del ovario (Webster 1994). *Astrocasia* se puede distinguir por la combinación de las siguientes características: la ausencia de pubescencia en las plantas, hojas deciduas, flores con largos pedicelos, una corola bien desarrollada con pétalos libres, un androceo peltado, discos femeninos en forma de una cúpula y frutos capsulares (Burger & Huft 1995). En Costa Rica se conocía una sola especie, *A. tremula* (Griseb.) G.L. Webster, de la cual solo hay un registro recolectado por Jorge Gómez Laurito en un bosque residual a orillas de la quebrada Pavas de Bajo Rodríguez, en San Ramón de Alajuela (*Gómez Laurito 12368*, USJ).

En una expedición realizada en julio de 2012, se recolectaron ejemplares con frutos de una planta arbustiva a orillas de la quebrada Brasil, en el Parque Nacional Diriá, en Santa Cruz de Guanacaste, que se identificó como *A. peltata* Standl. y resultó ser un nuevo registro para Costa Rica y América Central (Grayum et al. 2012). Esta especie se consideraba endémica de México, donde se ha hallado en las costas de Jalisco, las Islas Tres Marías y una población aislada en Sinaloa cerca de Mazatlán (Webster 1992). Una distribución disyunta se ha observado en otras especies de *Astrocasia* y este nuevo hallazgo, junto con los descubrimientos recientes de especímenes de *A. tremula* en Costa Rica, Panamá, Colombia y Venezuela, sugieren que la distribución bimodal del género observada por Webster (1992), con un centro en México-Guatemala y otro en Sudamérica, puede no reflejar su distribución, sino la falta de información en las regiones ubicadas entre estos dos grandes centros.

En una segunda expedición realizada en mayo de 2013, se visitó el mismo sitio donde se habían encontrado los primeros ejemplares y se observaron plantas en estado reproductivo, con flores femeninas y masculinas enteras. Webster (1992) y los autores anteriores no conocieron los pétalos ni los sépalos en flores pistiladas, que sí se observaron en varias plantas de Costa Rica (*Calderón Sanou 59*, USJ, duplicado en CR). A continuación

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se ofrece una descripción que combina la información de Webster, quien trabajó con los ejemplares de México, y las medidas realizadas en los ejemplares de Costa Rica.

Astrocasia peltata Standl., Contr. Dudley Herb. 1:74, pl.1, fig. 4. 1927 (**Fig. 1**). Tipo: MEXICO. Nayarit: Islas Tres Marías, Isla María Madre, *Ferris 5571* (holotipo: DS).

Arbusto o árbol pequeño, 2–5 m de altura, caducifolio, monoico. Tallo leñoso, con ramas delgadas y largas; ramitas glabras. Hojas maduras peltadas, con estípulas de 3.5–7.5 mm de largo; pecíolo (1.5)4–7.4 cm de largo; lámina cartácea o subcoriácea, orbicular u ovado-orbicular, 2–10 cm de largo y 1.6–8.5 cm de ancho, envés pálido; venación reticulada. Flores axilares, fasciculadas (2–3) o solitarias. Flores estaminadas: pedicelo 6–10 mm de largo; sépalos oblongo-elípticos, 1.5–2.5 mm de largo y 1.8–2 mm de ancho; pétalos obovados, 3 mm de largo y 2 mm de ancho; estambres 5; androceo ca. 1.1 mm de ancho; columna estaminal ca. 1.7 mm de alto; pistilodio ca. 0.8 mm transversalmente. Flores pistiladas: pedicelo (25)30–74 mm de largo, menos de 1 mm de diámetro, sépalos oblongos, 2–2.5 mm de largo y 2 mm de ancho; pétalos obovados, 4.5–5 mm de largo y 3 mm de ancho; gineceo ca. 1.3 mm de largo y 1 mm de ancho; estilos bipartitos, ovario con 3(4) carpelos. Frutos oblados, ca. 8 mm de largo y 10–11.2 mm de ancho; columela ca. 4 mm de largo; semillas plano-convexas, lisas, 3.9–4.8 mm de largo, 3.1–3.9 mm de ancho.

Astrocasia peltata se diferencia de las otras especies del género por tener hojas fuertemente peltadas, aunque se ha observado que otras especies de *Astrocasia* pueden presentar algunas hojas levemente peltadas (Webster 1992), entre éstas *A. tremula*, por lo que se recomienda tener cuidado si se va a utilizar esta característica para diferenciar estas especies. La clave siguiente permite distinguir las especies de *Astrocasia* de Costa Rica:

1. Hojas maduras peltadas; lámina foliar orbicular u ovado-orbicular; pétalos de flores estaminadas elipticos a oblongo-lanceolados, 2.5–3.5 mm de largo, 0.8–1.1 mm de ancho; hábitat bosque seco **A. peltata**

1. Hojas maduras basifijas; lámina foliar ovada u ovado-elíptica; pétalos de flores estaminadas obovados, 3 mm de largo, 2 mm de ancho; hábitat bosque muy húmedo **A. tremula**

Distribución y hábitat de Astrocasia peltata.—En México, en laderas de bosques deciduos y semideciduos de la costa de Jalisco, Islas Tres Marías y Sinaloa (Webster 1992, Fig. 5). En Costa Rica, una pequeña población aislada creciendo en bosque seco a orillas de la quebrada Brasil, Parque Nacional Diriá.

Material examinado: ***Astrocasia peltata*** Standl. **COSTA RICA. Guanacaste:** Parque Nacional Diriá, Distrito El Arado, Santa Cruz, a orillas de la quebrada Brasil, 10°09'40"N, 85°36'07"W, 360 m, 21 Jul 2012, *I. Calderón 9* (CR, USJ); loc. cit., 4 May 2013, *I. Calderón 59* (CR, USJ). **MEXICO. Nayarit:** María Madre, Tres Marías Islands, 21 Oct 1925, *R.S. Ferris 5571* (MO-251998, foto en www.tropicos.org).

Astrocasia tremula (Griseb.) Webster. **COSTA RICA. Bajo Rodríguez:** Alajuela, San Ramón, Coope-Zamora, bosque residual a la orilla de la Quebrada Pavas, 10°18'32"N, 85°32'07"W, 300 m, 23 Mar 1993, *J. Gómez-Laurito et al. 12368* (USJ).

DISCUSIÓN

La distribución geográfica disyunta de *Astrocasia peltata* que revela este nuevo descubrimiento podría tener varias explicaciones. Por un lado, tanto en México como en Costa Rica se ha encontrado en laderas rocosas, por lo que es de esperar que las plantas que crecen en estos ambientes de difícil acceso se mantengan ocultas a los ojos de los botánicos y exploradores durante las expediciones. Poblaciones pequeñas de *A. peltata* podrían permanecer escondidas en otras partes de América Central, esperando ser descubiertas. Así, lo que se nos presenta ahora como una distribución disyunta sería, entonces, sólo una parte del mapa de distribución de la especie, aun incompleto debido a la falta de información entre estos dos puntos. Por otro lado, es posible que la destrucción del hábitat por causa del ser humano o de fenómenos naturales en el pasado hayan provocado la desaparición de poblaciones de *A. peltata* en el resto de Centroamérica. En este caso la observación del escenario completo se dificulta, porque nos encontraríamos frente al problema de las especies que poseen poblaciones relictuales, como menciona Webster (1992).

La distribución disyunta observada en *A. peltata* nos hace recordar otros descubrimientos recientes en la flora costarricense, como es el caso de *Pleodendron costaricense* N. Zamora, Hammel & R. Aguilar (Canellaceae), una rara especie de árbol encontrada en el bosque lluvioso de bajura del Pacífico Sur de Costa Rica, a 2000 km de distancia de la única otra especie del mismo género, *P. macranthum* en Puerto Rico (Hammel & Zamora

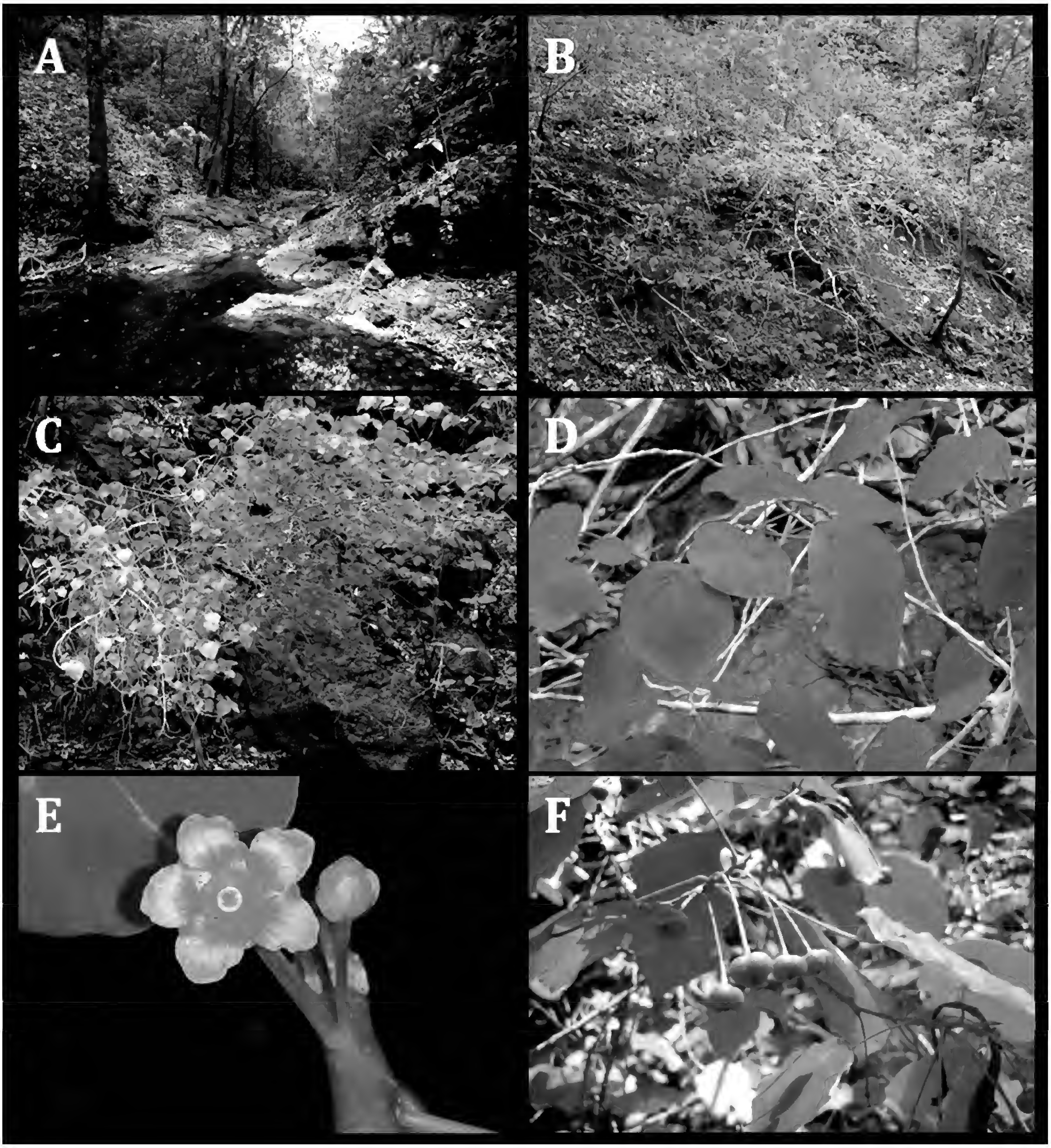

Fig. 1. ***Astrocasia peltata:*** **A)** **Quebrada Brasil, en cuyas orillas se halla esta especie** **B)** **Pequeña población creciendo en laderas rocosas** **C)** **Hábito** **D)** **Hojas y ramitas** **E)** **Rama con flor estaminada y botón floral en fascículos** **F)** **Rama con frutos verdes colgantes.**

2005). Otro ejemplo interesante de disyunción en el continente americano es *Chiangiodendron mexicanum* T. Wendt (Flacourtiaceae), que se halló en Costa Rica cuando solamente se conocía del extremo sur del estado de Veracruz en México (Zamora et al. 2004). El descubrimiento de *A. peltata* y de otras especies de plantas disyuntas es información valiosa para entender el complejo origen que pudieron haber tenido los bosques de Centroamérica.

Astrocasia peltata y *A. tremula* se han considerado como especies hermanas por compartir el mismo hábitat y por la presencia de *A. tremula* en las mismas regiones donde se creía endémica *A. peltata* en Jalisco, México (Webster 1992). En Costa Rica, los hábitats en que se han encontrado difieren considerablemente. *Astrocasia* *peltata* crece en un bosque caducifolio, similar a su hábitat en México; en cambio, *A. tremula* se halla en un bosque muy húmedo, diferente a lo que se hubiera esperado. Además, Webster (1992) menciona que la mayoría de especies de *Astrocasia,* incluida *A. peltata*, parecen estar exclusivamente asociadas a suelos calcáreos según las observaciones de los recolectores. Sin embargo, hasta ahora no sabemos si los especímenes de *A. peltata* recolectados en el Parque Nacional Diriá estaban asociados a este tipo de suelo.

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Agradezco a Carlos O. Morales por su gran apoyo y por su ayuda en la revisión del manuscrito y la identificación de la especie. Igualmente a Barry E. Hammel y a Daniel Santamaría, quienes mediante comunicación vía electrónica (cuando Daniel se hallaba en el Herbario MO) en un solo día pudieron hacer la determinación. Este descubrimiento no hubiera sido posible sin la participación y el apoyo de Elmer G. García, que me permitió conocer la localidad, en el marco del Trabajo Comunal Universitario-54 de la Universidad de Costa Rica. Un sincero agradecimiento también a un revisor anónimo por sus sugerencias y comentarios.

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PLEURISANTHES FLAVA (ICACINACEAE): A NEW RECORD FOR BRAZIL

Bruno S. Amorim
Laboratório de Morfo-Taxonomia Vegetal Dept. Botânica
Universidade Federal de Pernambuco
CEP: 50670-901, Recife, Pernambuco, BRAZIL
brunosarim@yahoo.com.br

Rodrigo Duno de Stefano
Centro de Investigación Científica de Yucatán
A.C. Colonia Chuburná de Hidalgo
CP 97200, Mérida, Yucatán, MÉXICO

Marccus Alves
Laboratório de Morfo-Taxonomia Vegetal Dept. Botânica
Universidade Federal de Pernambuco
CEP: 50670-901, Recife, Pernambuco, BRAZIL

ABSTRACT

Pleurisanthes flava Sandwith is reported here for the first time from the Brazilian lowland Amazon Rainforest based on unreported collections from 1936, 1968, and 1975. The species can be recognized by the elliptic to ovate leaves with entire margin, the axillary or supra-axillary and racemose inflorescence, sessile or shortly pedicellate, and 5-merous flowers.

Key Words: Biodiversity, lowland Amazon Rainforest, South America

RESUMO

Pleurisanthes flava Sandwith é citada aqui pela primeira vez para a Floresta Amazônica brasileira baseada em coletas dos anos de 1936, 1968 e 1975 previamente não publicados. A espécie pode ser reconhecida pelas folhas elípticas a ovadas com margens inteiras, pela inflorescência racemosa axilar a supra-axilar com pedicelo curto ou séssil e flores 5-meras.

Palavras chave: América do Sul, Biodiversidade, Floresta Amazônica de terras baixas

Icacinaceae (s.l.) comprises approximately 52 genera and 400 species worldwide. It occurs predominantly in the Tropics and rapidly decreasing in number toward the subtropics. In the Neotropics, the family is represented by 12 genera and 54–57 species (Duno de Stefano 2004). Morphological and molecular studies (Kårehed 2001) showed Icacinaceae (s.l.) as of polyphyletic origin and under a new circumscription, it was segregated in four distinct families [Icacinaceae s.s., Cardiopteridaceae Blume, Stemonuraceae (M. Roem.) Kårehed, and Pennantiaceae J. Agardh].

Icacinaceae s.s. has a pantropical distribution with 30 genera and 140 species (Duno de Stefano 2004; Duno de Stefano & Amorim 2012; Kårehed 2001). *Pleurisanthes* Baill. is a small genus of woody vines to climbing shrubs and restricted to the Neotropics. Seven species of *Pleurisanthes* are recognized from the rainforests of Venezuela, Guyana, Suriname, French Guiana, Ecuador, Peru, and Brazil (Duno de Stefano 2004; Howard & Duno de Stefano 1999; Duno de Stefano & Amorim 2012). The genus is characterized by the flowers not being articulated at the distal portion of the pedicels (Duno de Stefano et al. 2002) and the species have smaller and less attractive flowers and fruits than other species in Icacinaceae s.s. The highest diversity of *Pleurisanthes* species is found in Brazil which comprises five species distributed in the Amazon and Atlantic Forest (Duno de Stefano & Amorim 2012). *Pleurisanthes* has a problematic taxonomy and needs a further review. The genus is poorly known mainly because of the general lack of collections from the Amazon Forest. We publish here the new record of *Pleurisanthe flava* from the Amazon forest of Brazil.

Pleurisanthes flava Sandwith has previously been recorded from Guyana (de Roon 1994; Keloff et al. 2011) and its occurrence in the Brazilian Amazon was suggested by de Roon (1994). However, no Brazilian collections were cited by de Roon (1994). In a recent herbarium survey, four vouchers of *P. flava* from Brazil were discovered and verified, and are here reported from Brazil for the first time, distant ca. 700 Km from the southern record of the species in Guyana, expanding the known distribution of the species.

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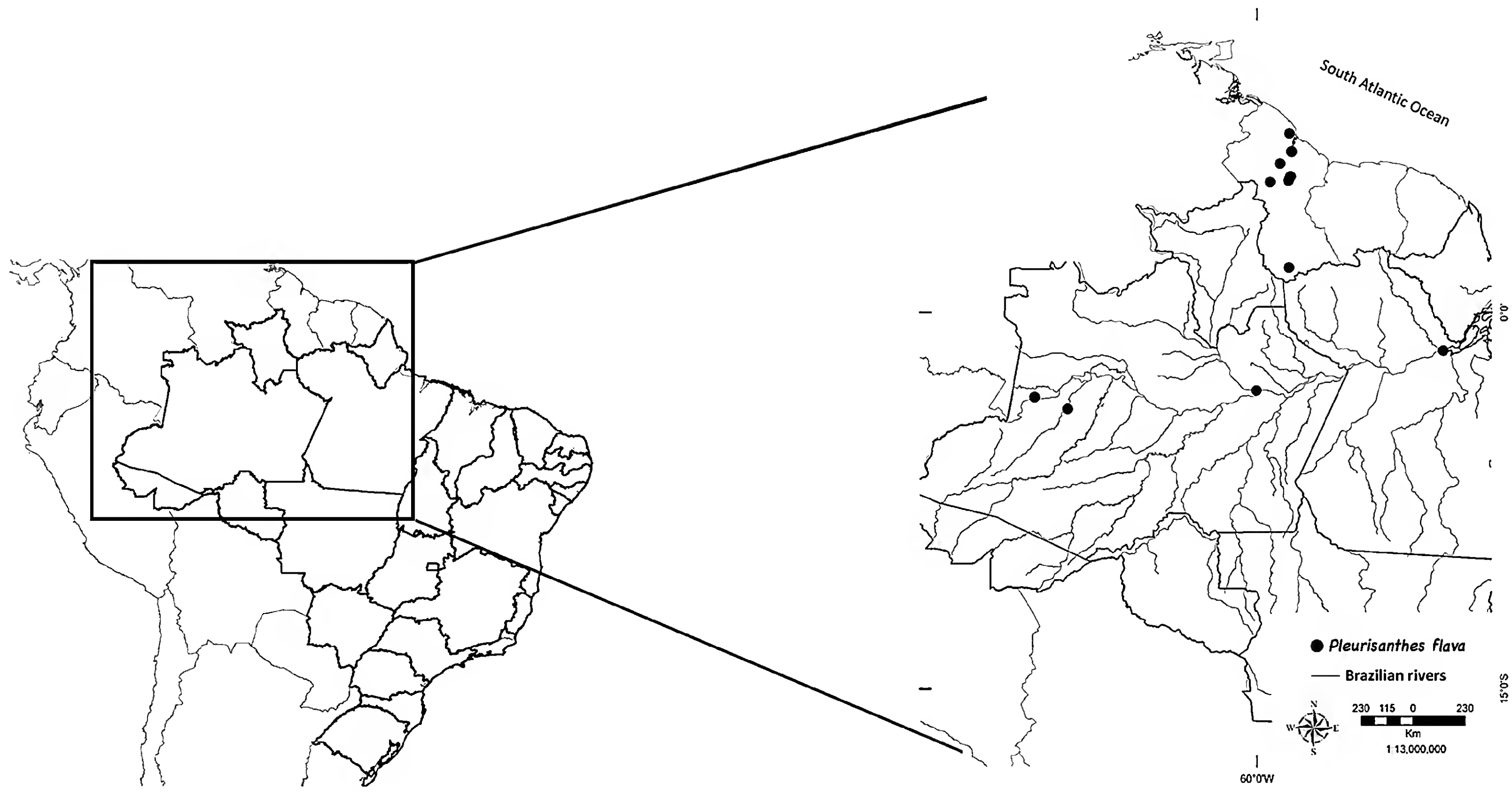

Fig. 1. Distribution map of *Pleurisanthes flava* Sandwith in South America, showing records in Guyana and Brazil (States of Amazonas and Pará).

MATERIAL AND METHODS

This study was based on herbarium collections of *Pleurisanthes* from the Amazon rain forest. Specimens from 16 herbaria were studied (BM, C, F, G, IAN, INPA, K, MIRR, MO, NY, P, PH, RB, SP, UFRR, US, and VEN) (herbarium abbreviation follows Thiers 2013). Morphological studies of the herbarium collections were carried out using a stereomicroscope.

RESULTS AND DISCUSSION

A short description with the main diagnostic characters is provided. A more complete description of *Pleurisanthes flava* can be found in de Roon (1994) and Sandwith (1931).

Pleurisanthes flava Sandwith, Bull. Misc. Inform. Kew 1931 (10):467–468. 1931. (**Figs. 1, 2**). Type: GUYANA: Bartica, Essequibo River, Moraballi Creek, near sea level, 11 Nov 1929 (fl), *N.Y. Sandwith 590* (holotype: K!; isotype: K!, NY!).

Woody vines. Leaves 7.5–19.5 × 4–6 cm, elliptic to ovate, apex apiculate, rarely emarginate, basecuneate to rounded, margin entire, bicolor (dried samples), adaxial surface with midveinsulcate, secondary veins 8–10 pairs, abaxial surface fulvo-stringose; petiole 1–2 cm long. Inflorescence axillary or supra-axillary, simple or compound racemes, main axis ca. 5–7.5 cm long; flowers sessile to shortly pedicellate, 0.1–0.2 cm long; calyx 5-lobed, 0.05–0.1 cm long, triangular, apex acute, pubescent; corolla 5-lobed, petals oblong to laceolate, 0.2–0.3 cm long; stamens 5, ca. 2 mm long; ovary 0.1 diam., ovoid, tomentose; style 0.1 cm long, tomentose; stigma punctate. Fruits drupaceous, 1–1.2 cm diam., ovoid, apex apiculate, shortly hirsute, reddish-brown, wrinkled when dried.

Voucher specimens/material examined: **BRAZIL. Amazonas:** Jutaí, Rio Solimões, rio Biá, afluente do rio Jutaí, 04 Nov 1975 (fl), *L. Coêlho* et al. *313* (INPA); Lajes, 17 Km from Manaus, 18 Feb 1975 (fr), *G.T. Prance & J.F. Ramos P23278* (INPA, MO, NY); São Paulo de Olivença, basin of creek Belém, 26 Oct–Nov 1936 (fl), *B.A. Krukoff 8683* (G, K, P, US). **Pará:** Rio Jarí, Planalto do Monte Dourado, 22 Jan 1968 (fl), *E. Oliveira 3939* (IAN). **GUYANA.** Bartica, Essequibo river, Moraballi Creek, near sea level, 11 Nov 1929 (fl), *N.Y. Sandwith 590* (K-3 sheets, NY); Mazaruni Station, 07 Nov 1943 (fl), *D.C.O. 67853* (NY); Pomeroon-Supenaam, Mabura, 22 Sep 1992 (fl), *B. Hoffman & L. Roberts 2806* (US); Potaro-Siparuni: Paramakatoi and vicinity, 13 Mar 1989 (fr.), *W. Han et al. 5661* (K, US); Kaieteur Falls National Park, 28 Jan 1987 (fr), *J.J. Pipoly & G. Gharbarran 10168* (NY, P, US); Upper Demerara, 19 Nov 1986 (fl), *J.J. Pipoly & R. Boyan 8845* (FDG, NY, P, US); ibid, 19 Nov 1986 (fl), *J.J. Pipoly & R. Boyan 8933* (FDG, NY, P, US); Upper Takutu-Upper Essequibo, 24 May 1997 (fr), *D. Clarke 4932* (NY, US); ibid,15 May 1997 (fl),

Fig. 2. *Pleurisanthes flava*. **A.** Fertile branch (from *J.J. Pipoly & R. Boyan 8845*); **B.** Inflorescence (from *D.C.O. 67853*); **C.** Flower (from *J.J. Pipoly & R. Boyan 8845*); D. Fruit (from *J.J. Pipoly & G. Gharbarran 10168*).

D. Clarke 4552 (US); ibid., 12 Nov 1998 (fl), *D. Clarke et al. 7788* (US); Waraputa Compartment, ca. 25 Km of Mabura, 05 Nov 1991 (fl bud), *M. Polak & P.J.M. Maas 506* (K, NY, U, US).

In Brazil, *Pleurisanthes flava* occurs in the states of Amazonas and Pará and in different areas from the Brazilian Amazon Forest. The species is recorded in lowland Amazon Forest and usually collected near streams and river banks. The species could possibly be found in the states of Amapa and Roraima based on the current knowledge and geographic distribution of the species. *Pleurisanthes flava* is most similar to *P. howardii* R. Duno, Riina & P.E. Berry, which is endemic to Venezuela, but the leaves of *P. flava* are bicolorous, less coriaceous and with the abaxial surface fulvo-strigose and the fruits are smaller, ovoid, shortly hirsute, reddish-brown, and with the apex noticeably apiculate (Duno de Stefano et al. 2002). *Pleurisanthes flava* differs from *P. artocarpi* Baill. and *P. emarginata* Tiegh. by the entire margin (clearly dentate in the other two species), from *P. parviflora* (Ducke) R.A. Howard by the shorter pedicel, broader petals, and tomentose style (de Roon 1994; Sandwith 1931), and from *P. simplicifolia* by the oblong and membranaceous to chartaceous leaves, with entire margin, and 8–10 secondary veins, (elliptic or suborbicular, coriaceous to subcoriaceouswith denticulate margin and 6 secondary veins, in *P. simplicifolia*).

KEY TO SPECIES OF *PLEURISANTHES* BAILL. FROM THE BRAZILIAN AMAZON RAINFOREST [BASED ON HOWARD (1942) AND DE ROON (1994)]

1. Leaves coriaceous to subcoriaceous, margin denticulate to dentate; flowers 4–5-merous.
    2. Leaves obovate to obovate-elliptic, broadest at the base ________ **P. artocarpi**
    2. Leaves elliptic to widely elliptic, broadest at the middle.
        3. Leaves with 7–9 secondary veins, flowers 4-merous ________ **P. emarginata**
        3. Leaves with 6 secondary veins, flowers 5-merous ________ **P. simplicifolia**
1. Leaves membranaceous to chartaceous, margin entire; flowers 5-merous.
    4. Flowers distincly pedicellate (1 cm long) ________ **P. parviflora**
    4. Flowers short pedicellate (0.1–0.2 cm long) ________ **P. flava**

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JOURNAL NOTICE

Douglas J. Futuyma, H. Bradley Shaffer, and Daniel Simberloff, eds. 2013 (Dec). **Annual Review of Ecology, Evolution, and Systematics, Volume 44.** (ISSN: 1543-592X; ISBN: 978-0-8243-1444-6, hbk). Annual Reviews, Inc., 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303, U.S.A. (**Orders:** www.AnnualReviews.org, science@annualreviews.org, 1-800-523-8635, 1-650-493-4400). $92.00 indiv., 658 pp., 7⅞" × 9⅜".

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ECOLOGY AND CONSERVATION OF *ACACIA* AND *PROSOPIS* (FABACEAE) WOODLANDS OF THE MOJAVE DESERT, U.S.A.

Scott R. Abella[1] and Kenneth L. Chittick

Department of Environmental and Occupational Health
University of Nevada, Las Vegas
Las Vegas, Nevada 89154-3064, U.S.A.
abellaNRC@gmail.com
[1]Present address: Natural Resource Conservation LLC, Boulder City, Nevada 89005, U.S.A.

ABSTRACT

Woodlands of *Acacia greggii*, *Prosopis glandulosa*, and *Prosopis pubescens* are of conservation-priority in the Mojave Desert because of their wildlife and watershed values. We measured plant community composition, environmental variables (e.g., slope gradient, soil), and ecological condition (e.g., tree recruitment) in 50, 0.1-ha woodland plots within 449,000-ha Lake Mead National Recreation Area in the eastern Mojave Desert in Arizona-Nevada. We classified community types, analyzed vegetation-environment relationships, developed ecological species groups (species sharing similar distributions), and evaluated woodland condition. Cluster analysis identified 5 community types at the finest hierarchical level, which were quite distinct floristically (53% mean Sørensen similarity within communities), and included an *A. greggii* community occupying dry washes, 2 *P. glandulosa* communities, a mixed community, and a *P. pubescens* community inhabiting drainage outflows of springs. We recorded a total of 201 taxa. Mean species richness varied significantly among communities from 10 in *P. pubescens* to 35 species/0.1 ha in mixed communities. Environmental variables such as soil texture and cations were related to community gradients, distributions of tree species, and frequency of the tree parasite desert mistletoe (*Phoradendron californicum*). We classified 73 species into 14 species groups, ranging from groups characteristic of uplands (e.g., *Larrea tridentata* group) to those most frequent in lowlands (e.g., *Allenrolfea occidentalis* group). Ecological condition of the woodlands was characterized by well-distributed tree density among size classes (except for *P. pubescens* communities which were dominated by large trees), dominance by native species (94% of total taxa were native), mistletoe infection on 66% of plots, and infrequent evidence of perceived threats (e.g., woodcutting).

RESUMEN

Los bosques de *Acacia greggii*, *Prosopis glandulosa*, y *Prosopis pubescens* tiene prioridad de conservation en el desierto de Mojave por sus valores ambientales. Se midieron la composición de la comunidad vegetal, variables ambientales (ej., gradiente de la ladera, suelo), y condiciones ecológicas (ej., reclutamiento de árboles) en 50 parcelas, de 0.1-ha en las 449,000-ha del Lake Mead National Recreation Area en el este del desierto de Mojave entre Arizona y Nevada. Se clasificaron los tipos de comunidad tipos, se analizaron las relaciones de la vegetación con el ambiente, se desarrollaron grupos ecológicos de especies (especies que comparten distribuciones similares), y se evaluó la condición del bosque. El análisis cluster identificó 5 tipos de comunidad en el nivel jerárquico más fino, que fueron bastante distintos florísticamente (53% de media en el índice de similitud de Sørensen en las comunidades), e incluyó una comunidad de *A. greggii* que ocupa humedales secos, 2 comunidades de *P. glandulosa*, una comunidad mixta, y una comunidad de *P. pubescens* que vive en drenajes de manantiales. se registraron un total de 201 taxa. La riqueza media de especies varió significativamente entre comunidades de 10 en *P. pubescens* a 35 especies/0.1 ha en comunidades mixtas. Las variables ambientales tales como textura del suelo y cationes estaban relacionadas con los gradientes de la comunidad, distribuciones de especies arbóreas, y frecuencia de muérdago parçasito de los árboles (*Phoradendron californicum*). Se clasificaron 73 especies en 14 grupos de especies, variando desde grupos característicos de las tierras altas (ej., grupo de *Larrea tridentata*) a los más frecuentes en tierras bajas (ej., grupo de *Allenrolfea occidentalis*). Las condiciones ecológicas de los bosques se caracterizaron por su densidad de árboles bien distribuida entre las clases de tamaño (excepto las comunidades de *P. pubescens* que estaban dominadas por árboles grandes), dominancia de las especies nativas (94% del total de taxa fueron nativos), infección de muérdago en el 66% de las parcelas, y evidencia infrecuente de amenazas percibidas (ej., talas).

INTRODUCTION

Riparian plant communities in the arid American Southwest occupy small portions of landscapes but have disproportionately large habitat value, productivity, and services to humans (Sada et al. 2001; Patten et al. 2008). The valuable functions that riparian ecosystems provide—such as water to sustain human habitations, agriculture, and ranching—and their native biota are threatened by past and present intensive human use of these habitats (Deacon et al. 2007). In the eastern Mojave Desert, for instance, *Acacia greggii*, *Prosopis glandulosa*, and *P. pubescens* riparian woodlands have been destroyed or altered through hydrologic changes and ur-

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ban development in Clark County containing metropolitan Las Vegas, Nevada (Crampton & Sedinger 2011). Now covered under a multiple species habitat conservation plan (MSHCP) to forestall U.S. Endangered Species Act listing of associated species, conservation goals for *Acacia* and *Prosopis* woodlands in this region include restoring and maintaining the land area occupied by the woodlands in 2000 (inception of MSHCP), sustaining protected communities in a healthy ecological condition (e.g., well-distributed tree size classes, moderate infection of the tree parasite desert mistletoe [*Phoradendron californicum*], and dominance by native species), and maintaining species affiliated with the woodlands (Crampton et al. 2006).

However, significant knowledge gaps in our understanding of the ecology and conservation needs for these woodlands hinder development of conservation strategies (Crampton et al. 2006). For example, community structure, vegetation-environment relationships, understory composition, and ecological condition of the woodlands including exotic plant invasion status, tree recruitment, desert mistletoe infection, and disturbances such as fire or woodcutting, are poorly understood. Some community classification has been performed in parts of the California Mojave Desert (Evens 2003; Thomas et al. 2004; Keeler-Wolf et al. 2007), but little vegetation-environment research for these communities in the American Southwest has been conducted and conclusions have varied. Some reports in the literature have included that distribution of *Prosopis pubescens* communities was unrelated to gradients in soil pH, soluble salts, or texture along the Rio Grande River in central New Mexico (Campbell and Dick-Peddie 1964). Along the San Pedro River in the Chihuahuan and Sonoran Deserts, *Prosopis velutina* patches occupied sites with low frequency of flooding and highest elevations away from the active flood channel (Bagstad et al. 2006). In Mojave Desert ephemerally moist washes, Evens (2003) noted that *Acacia greggii* occurrences correlated to elevation and amount of topographic protection (concave sites exhibit high protection).

Distinguishing ecological species groups is another means to understand species distributions and vegetation-environment relationships (Goebel et al. 2001). Species groups consist of co-occurring species that share similar environmental affinities and are based on classifying species (rather than communities) into groups usually of 2–10 species displaying similar distributions (Kashian et al. 2003). For example, on a northern Arizona *Pinus ponderosa* forest landscape to the east of the Mojave Desert, we previously classified 18 species groups ranging from plants inhabiting xeric, volcanic cinder soils, to those typifying moist, silt loam soils (Abella & Covington 2006). Species groups are based on a premise that once the groups are developed, presence of some species of a group suggests that environmental characteristics of a site are within the realized niche of the group (Kashian et al. 2003). Ecological species groups have been little developed in southwestern deserts. Species groups have been valuable on other landscapes for understanding vegetation-environment relationships and for management applications such as matching species for ecological restoration to environments where they are best adapted (Goebel et al. 2001).

Exotic plant invasion, tree recruitment, mistletoe infection, and disturbance are additional features related to ecology and condition of *Acacia* and *Prosopis* communities (Stromberg 1993). For example, riparian communities can be highly invadable because of their location along seed dispersal corridors and their resource-rich environment favorable for plant growth (Tabacchi & Planty-Tabacchi 2005). Exotic plant abundance is important to evaluate if dominance by native species is considered a measure of woodland health. Presence of a range of tree size classes is another feature considered desirable for high-quality habitat conditions (Crampton & Sedinger 2011). Tree size and age are not always correlated, but size class analyses are useful for identifying trees that became established more recently than the current largest trees (Miller et al. 2001). Moreover, tree size distribution is important for several other reasons such as suitability of nesting sites for avian species and amount of parasitic mistletoe a tree can support as a food resource for wildlife (Crampton & Sedinger 2011). Mistletoe extracts water and nutrients through a vascular connection to the host tree, with larger trees generally supporting more mistletoe (Watson 2001). Mistletoe is a key food and nesting resource for *Phainopepla nitens*, a conservation-priority bird species covered by the MSHCP, so intermediate amounts of mistletoe are a good indicator of habitat value at a level sustainable to avoid killing trees (Crampton & Sedinger 2011). Disturbances such as fire or woodcutting also can affect ecological condition of woodlands. The woodland tree species have some resprouting ability when burned or cut, but these disturbances can reduce their abundance (Stromberg 1993; Busch 1995; Abella 2010).

To help fill knowledge gaps in the ecology of *Acacia* and *Prosopis* woodlands and support development of conservation strategies, we examined plant community structure, vegetation-environment relationships, and ecological condition of these communities on a Mojave Desert landscape of Lake Mead National Recreation Area. Under National Park Service protection, this landscape is viewed as a core conservation area by the MSHCP, which indicates that maintaining quality woodland habitat on this landscape is a key part of conserving these communities in the eastern Mojave Desert (Crampton et al. 2006). Specific study objectives were to: (1) develop a hierarchical classification and identify diagnostic species for *Acacia* and *Prosopis* woodlands; (2) identify vegetation-environment relationships of communities and distributions of tree species; (3) develop ecological species groups; (4) examine species richness relationships with community types, environmental gradients, and exotic species; and (5) assess current woodland condition, including tree recruitment, mistletoe infection, and evidence of disturbances such as fire or woodcutting.

METHODS

Study Area

We conducted this study in Lake Mead National Recreation Area, a 449,000-ha unit (excluding full-pool areas of Lakes Mead and Mohave) of the National Park Service, in southeastern Nevada and northwestern Arizona in the eastern Mojave Desert (35°59'N, 114°51'W; Fig. 1). The centrally located Boulder City, Nevada, weather station has reported the following averages: 14 cm/yr of precipitation, 4°C January daily low temperature, and 39°C July high temperature (768 m elevation, 1937–2004 records; Western Regional Climate Center, Reno, Nevada). Consistent with the Mojave Desert's status as a winter rainfall desert (Keeler-Wolf et al. 2007), 70% of precipitation falls from September through April. Predominant landforms include low mountain ranges, bajadas (coalesced alluvial fans), relatively flat plains, washes serving as intermittent drainageways, and playas (dry lakes). Mapped soil types include Aridisol and Entisol orders (Lato 2006). Uplands, which occupy >90% of the area, are dominated by shrublands of *Larrea tridentata* and *Ambrosia dumosa* (Abella et al. 2012a). Communities containing *Acacia* or *Prosopis* are associated with washes, springs, and topographically protected sites (Fig. 2). Major large herbivores include exotic *Equus asinus* in some areas and native *Ovis canadensis* and smaller animals such as *Lepus californicus*. Some unauthorized cattle grazing occurs in the northeastern part of the study area. Human recreation use is concentrated along access points of Lake Mead's shoreline and Colorado River south of Hoover Dam and along major roads (Fig. 1).

DATA COLLECTION

We used an existing map of *Acacia greggii*, *Prosopis glandulosa*, and *Prosopis pubescens* distribution within the study area (Crampton et al. 2006), combined with our own field reconnaissance, to identify 118 polygons ≥0.25 ha and containing ≥2% cover of one or more of these species. This cover criterion excluded sampling sites containing only an individual tree. We randomly selected 50 of these polygons for sampling, ranging in size from 0.25–89 ha. We generated a random Universal Transverse Mercator (UTM) coordinate using a geographic information system (ArcMap, Esri Corporation, Redlands, California) within each polygon (subdivided by tree species) at which to establish a plot. Plots were 0.1 ha and were 20 m × 50 m (45 of the 50 plots) where the landform allowed; otherwise 33.3 m × 33.3 m (5 plots). We sampled plots from July–October 2011, during the leaf-on period for the deciduous *Acacia* and *Prosopis*.

We measured the plant community on each plot by visually categorizing areal cover of vascular plant species using cover classes: trace (assigned 0.2% for analyses), < 1% (assigned 0.5%), 1% intervals to 5%, and thereafter 5% intervals. The same botanist measured all plots for consistency in cover categorization. Along with live plants, standing dead annual plants, noted to persist for 1–2 years in the Mojave Desert (Beatley 1966), were included in sampling to more thoroughly characterize the annual plant community. Plants not identifiable in the field were collected, pressed, and keyed to the finest taxonomic level possible. Four speci-

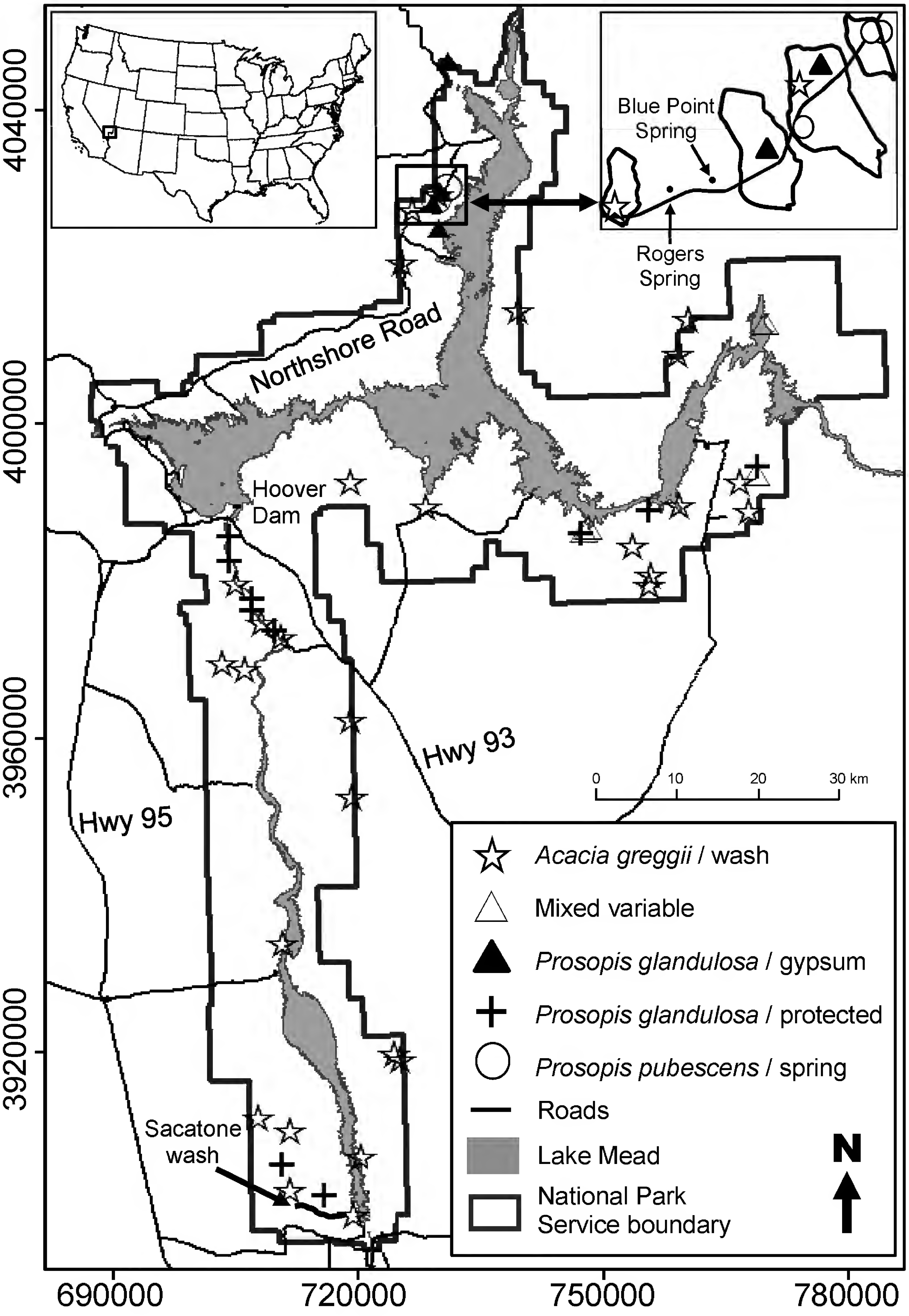

Fig. 1. Distribution of 50 sample plots displayed by community type and locations mentioned in the text for *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. The inset at the top right includes mapped polygons of the tree species with randomly located plots within. Coordinates are Universal Transverse Mercator (m), North American Datum 1983.

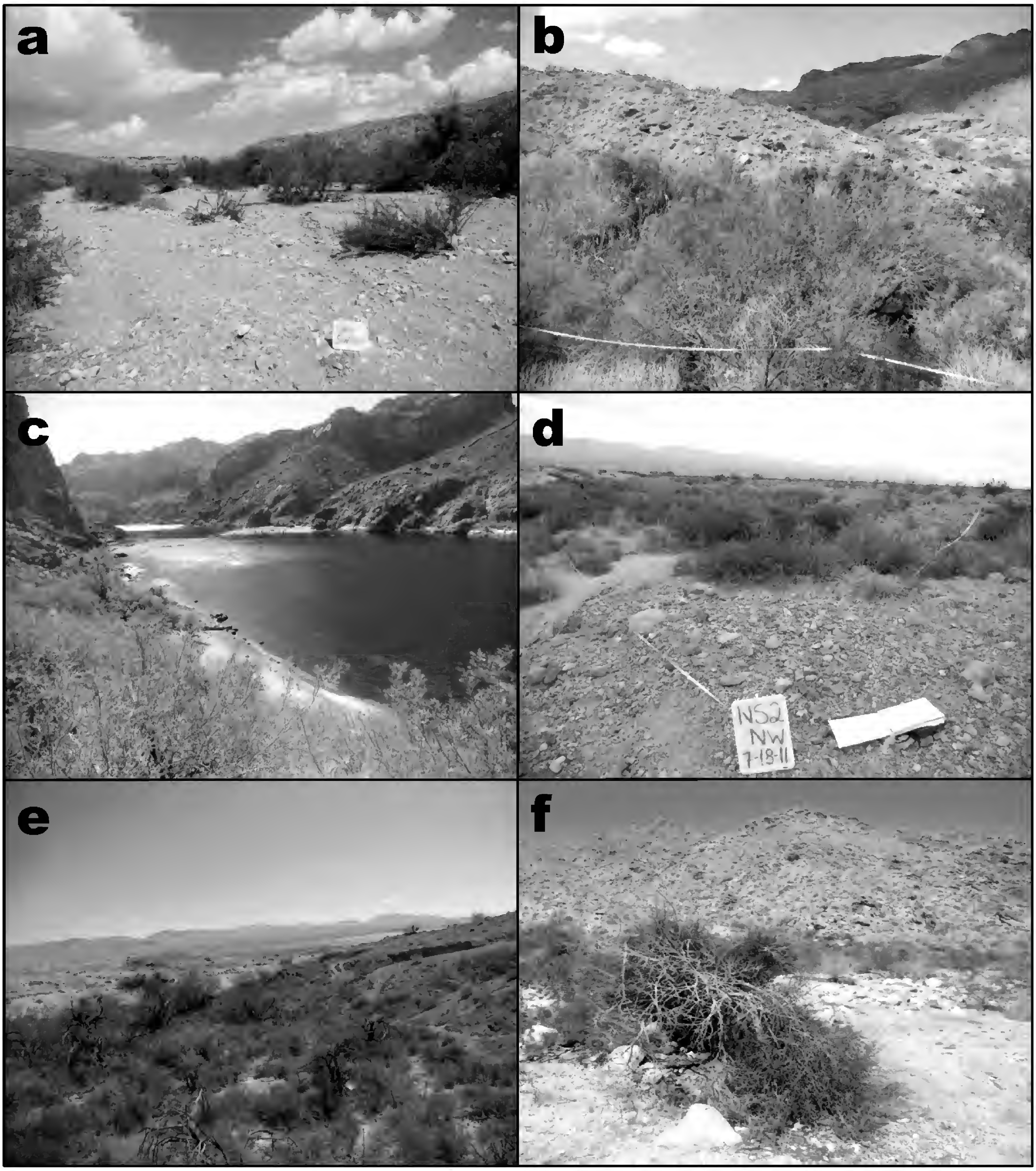

Fig. 2. Examples of woodland community types of the eastern Mojave Desert, USA: **(a)** *Acacia greggii*/wash, **(b)** Mixed/variable, **(c)** *Prosopis glandulosa*/protected, **(d)** *Prosopis glandulosa*/gypsum, and **(e)** *Prosopis pubescens*/spring. Desert mistletoe is shown in the foreground of **(f)** parasitizing an *Acacia greggii* tree.

mens out of 1385 total plant records across plots were not identifiable to at least family and were deleted from the data set. Classification of taxa to growth form (forb, shrub, or tree), life span (e.g., annual), and native/exotic status to North America followed USDA, NRCS (2012).

Live and dead individuals (of all sizes including seedlings) for all tree species were counted on each plot and their height was determined using a measuring pole. We measured diameter at root collar for the largest stem for all individuals and diameter at breast height (137 cm) for each tree taller than breast height. To measure mistletoe infection on each tree, we used the Hawksworth (1977) 6-class mistletoe rating. Infection was recorded as none (assigned 0), light (≤50% of branches infected, assigned 1), or heavy (>50% of branches infected, assigned 2) for each third of the tree. The values were summed to result in a 0 (no infection) to 6 (heavy) rating (Hawksworth 1977).

Data regarding depth to groundwater and ground-water chemistry would be desirable. These data were not available for the study area (Gary Karst, Hydrologist, Lake Mead National Recreation Area, pers. comm.) and were difficult or not permissible to obtain through drilling monitoring wells. We were able, however, to collect a variety of environmental data for each plot including location, topography, disturbance, and soil. We recorded elevation and location (UTM, using a global positioning system, at the southwestern plot corner), slope gradient (clinometer), aspect (compass), and landform type (e.g., wash; following Lato [2006]). In addition to capturing possible variation unaccounted for by other environmental variables, location can represent influences such as historical disturbance difficult to detect but potentially influencing site-specific vegetation patterns. We linearized aspect to range from 0 (southwest) to 2 (northeast; Beers et al. [1966]). We obtained 1971–2000 mean annual precipitation and temperature for each plot location from PRISM (Daly et al. 2008). We qualitatively noted visual evidence of disturbance, such as fire, off-road vehicle tracks, woodcutting, and livestock presence (animals or dung).

We collected 3 subsamples of the 0–5 cm mineral soil from each of 3 different interspaces ≥1 m from the outermost edge of a tree canopy. To measure bulk density, we collected a sample of approximately 400 cm^3 from the same interspaces. Soil samples were composited by plot. We sieved air-dried analytical samples to pass a 2-mm sieve and analyzed the fine fraction for texture (hydrometer method) following Tan (2005); pH and electrical conductivity (1:1 soil:water); available P (Olsen sodium-bicarbonate extraction); $CaCO_3$ (manometer method); total C, N, and S (dry combustion, CNS analyzer); organic C (difference between total and inorganic C); NO_3, SO_4, and Cl (ion chromatography); and the water-soluble concentrations of Na, K, Mg, Ca, Mn, Fe, Ni, Cu, Zn, Co, B, Mo, Pb, and Cd (1:3 soil:water extracts, inductively coupled plasma mass spectroscopy) following Burt (2004). We estimated bulk density by sieving through a 2-mm sieve, oven drying the <2-mm fraction at 105°C for 24 h, and including volume of coarse fragments >2 mm in the total soil volume. We used bulk density to convert nutrient concentrations to volumetric contents (Burt 2004). Because concentrations and contents were strongly correlated (e.g., $r = 0.95$ for organic C, 0.92 for total N, and 1.00 for total S), we report concentrations.

DATA ANALYSIS

We conducted multivariate plant community and soil analyses using version 6.07 of PC-ORD software (McCune and Mefford 1999). We used hierarchical cluster analysis (Sørensen index and flexible beta [$\beta = -0.25$] linkage method) to classify plots by species composition based on relative cover (cover of $species_i$/cover of all species on a plot). To identify species with the greatest fidelity to each hierarchical plot grouping, we used indicator species analysis to produce an indicator value ranging from 0 (no fidelity) to 100% (highest fidelity) based on relative cover and relative frequency among the groups (Dufrêne & Legendre 1997). We ordinated species composition (relative cover) with non-metric multi-dimensional scaling through PC-ORD's autopilot, slow and thorough routine. Environmental variables and species displaying the strongest correlations with community compositional patterns were displayed as vectors scaled to the strength and direction of correlations. We ordinated soil composition using principal components analysis, with the cross-products matrix derived from correlation to account for different measurement scales of soil variables.

We used SAS 9.2 software (SAS Institute 2009) to conduct univariate and bivariate analyses. We used a Kruskal-Wallis test followed by Tukey's test on ranks for multiple comparisons to compare species richness among plant community types at the finest level of the cluster analysis community classification. We used Pearson correlation to assess the relationship of native and exotic species richness.

To identify biophysical correlates with distribution of community types, tree species, and measures of ecological condition (exotic species richness and cover, tree recruitment, and mistletoe), we used classification (for categorical response variables) and regression trees (for continuous response variables) in JMP 9 software (SAS Institute 2010). Regression trees are nonparametric models that partition data into increasingly homogenous subsets and provide dichotomous keys to estimate a dependent variable at different levels of explanatory variables (Breiman et al. 1984). Dependent variables were screened for inclusion in models based on a criterion of minimizing total sums of squares at different splits. Splitting stopped when adding more explanatory variables increased r^2 by <0.05 or when the minimum node size (n = 5 for most analyses) was reached. There is essentially no limit to the number of independent variables that can be input to each model because a screening process identifies variables with the strongest explanatory power for inclusion in final models (SAS Institute 2010). We employed JMP's *k*-fold crossvalidation (*k* = 3 or 5) to compute a cross-validated r^2. We explored modelling several tree recruitment (e.g., trees/ha or percent of total trees by height and diameter at root collar and breast height classes) and mistletoe (e.g., proportion of infected trees, infected trees/ha, total Hawksworth rating) measures. The final model for recruitment portrayed percent of trees in the 1–9 cm root collar diameter class, because root collar differentiated trees with large stems that might be short in height yet still old (Miller et al. 2001) and the model displayed the highest r^2 among recruitment measures. We chose the final mistletoe model to portray infected trees/ha because Crampton and Sedinger (2011) found that this measure was correlated to *Phainopepla nitens* nesting preference and this response variable also yielded the highest model r^2 in our study.

We constructed ecological species groups by: (1) including only species occupying ≥3 plots; (2) relativizing species cover by species sums of squares to emphasize habitat preferences, avoiding groupings based on the commonness or rarity of species (McCune et al. 2000); and (3) grouping species through cluster analysis (Sørensen distance and -0.25 Flexible Beta group linkage) in PC-ORD (McCune & Mefford 1999). We used Pearson correlation to relate average cover of species groups to principal components and environmental variables.

RESULTS

Community Classification

At the coarsest grouping, cluster analysis classified plots into an *Acacia greggii*-dominated group and those containing *Prosopis* spp. (Fig. 3). Finer groupings distinguished *Prosopis pubescens*, two types of *Prosopis glandulosa* communities, and a mixed community of *A. greggii*, *Prosopis* spp., and other species. Sørensen similarity among plots within a community at the finest level ranged from 42% (*Acacia greggii*/wash) to 66% (*Prosopis glandulosa*/protected) and averaged 53 ± 10% (± SD, n = 5 community types). We named the 5 community types at the finest hierarchical level according to dominant tree species and either a commonly associated topographic feature or soil parent material (Table 1).

There were significant indicator species at each level of the community hierarchy. At the finest level, understory species such as *Hymenoclea salsola* were significantly associated with the *Acacia greggii*/wash community; cacti species and *Baccharis salicifolia* with Mixed/variable; *Isocoma acradenia*, *Atriplex confertifolia*, and *Suaeda moquinii* with *Prosopis glandulosa*/gypsum; and *Allenrolfea occidentalis* and *Distichlis spicata* with *Prosopis pubescens*/spring. Cluster analysis combined with indicator species analysis suggested that the vegetation was readily distinguishable into community types at multiple hierarchical levels.

Species Richness

A total of 201 taxa (90% identified to species) were detected on plots. This flora consisted of 61 annual forb (30%), 47 shrub (23%), 41 perennial forb (20%), 14 annual-perennial forb (7%), 9 cactus (4%), 9 perennial graminoid (4%), 7 tree (3%), 6 annual grass (3%), 5 annual-biennial forb (2.5%), 1 annual-perennial grass (0.5%), and 1 perennial fern (0.5%). Species richness varied significantly (Kruskal-Wallis $\chi^2 = 18.4$; P = 0.001) among communities from 10 (*Prosopis pubescens*/spring) to 35 species/0.1 ha (Mixed/variable; Fig. 4A). Even including dead annual plants, richness in all communities was dominated by perennials.

Vegetation and Soil Gradients

The vegetation ordination corroborated cluster analysis with distinct community groupings evident in the ordination (Fig. 5A). Whereas *Acacia greggii*-dominated plots clearly separated from those of other communities, plots within this community displayed a large spread consistent with their low similarity (42%) in cluster analysis. *Acacia greggii* plots in the lower part of the ordination grouping had the greatest relative cover of *Aca-*

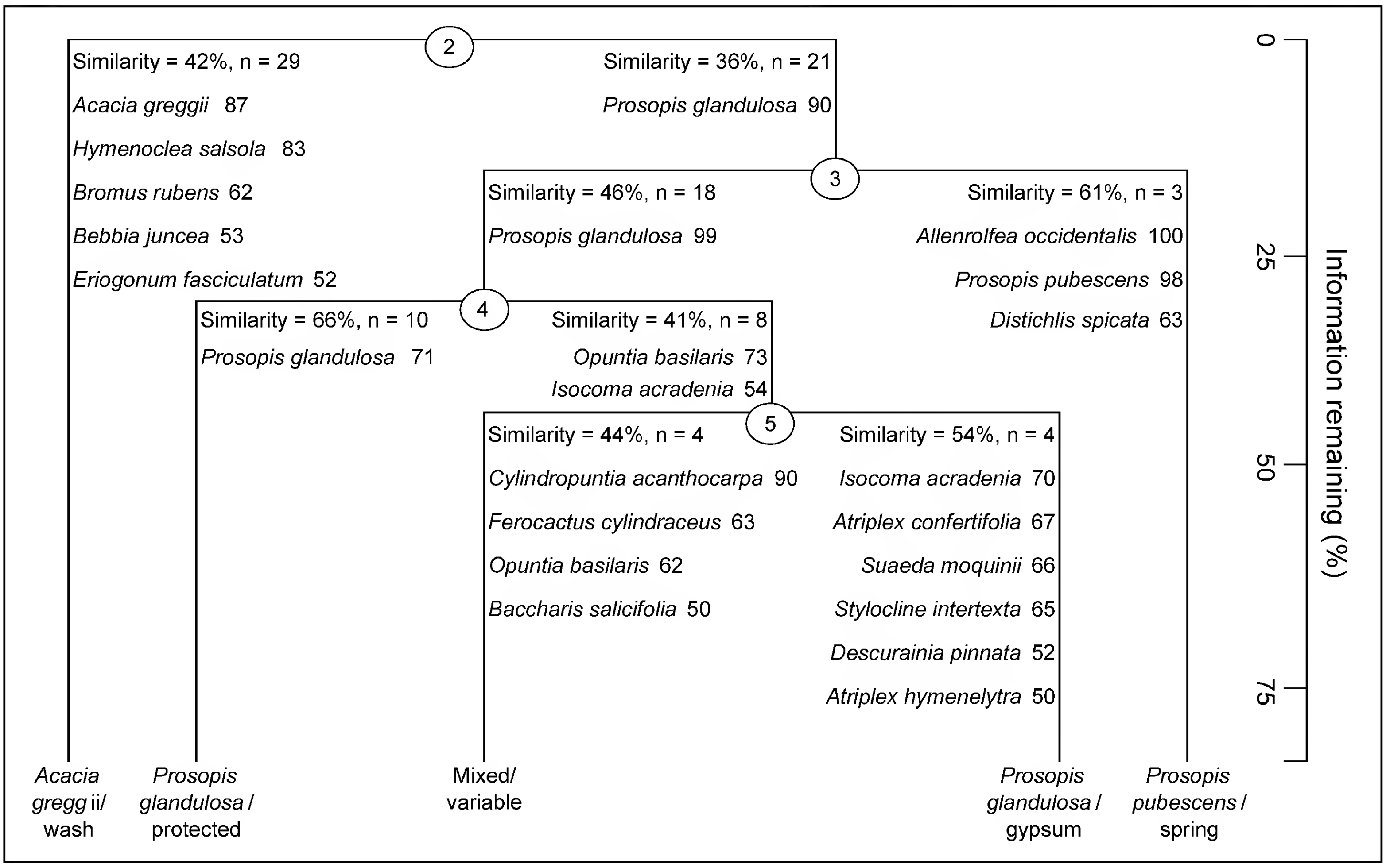

Fig. 3. Hierarchical community classification of *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. Internal Sørensen similarity, number of plots, and indicator species and indicator values significant at P <0.05 and ≥50 are shown at each division. Community types at the finest level of the classification are named according to dominant tree species and environmental features.

cia, whereas plots in the upper part exhibited greater relative cover of species such as *Ambrosia dumosa*, *Hymenoclea salsola*, and *Eriogonum fasciculatum*. Some environmental variables were correlated with vegetation gradients. Coarse-textured soil, for example, was associated with *A. greggii* communities, and total S and several cations correlated with *Prosopis glandulosa*/gypsum communities.

In contrast to vegetation that clearly grouped into community types, ordination of soil properties did not display strong grouping (Fig. 5B). Some plots, associated with gypsum, were correlated with soil electrical conductivity, SO_4, and various elements along axis 1. Axis 2 displayed few relationships.

Whereas multivariate variation in soil properties was not strongly linked to plant community gradients, examining means in individual soil properties suggested several findings (Table 2). Variability across communities differed among properties, with some properties (e.g., B) displaying extreme variation in orders of magnitude. Certain properties, such as total S, were highly variable within communities (e.g., 398% coefficient of variation for S in *Acacia greggii*/wash), yet some of these properties like S were still orders of magnitude greater in one or more communities. A community could occupy a range of values in soil properties, but there were some properties exhibiting especially large or small values in particular communities.

Community and Tree Species Distribution

Effectiveness of classification or regression tree models and variables they included differed for portraying distributions of communities and tree species (Fig. 6). A classification tree selected UTM coordinates and sand concentration as most important for differentiating communities. High sand concentration was again related to *Acacia greggii*/wash communities, as in the ordination. The UTM coordinates corresponded with distribution of soil parent materials, such as gypsum, which occupied the northeastern part of the study area, and topographic features like Black Canyon (below the Hoover Dam; Fig. 1). A classification tree of *Prosopis pubescens* with gypsum). A regression tree for *A. greggii* canopy cover illustrated that soil of low electrical conductivity

Table 1. Characteristics of *Acacia* and *Prosopis* woodland community types of Lake Mead National Recreation Area, Mojave Desert, USA.

	Acacia greggii/ wash	Mixed/ variable	*Prosopis glandulosa*/ protected	*Prosopis glandulosa*/ gypsum	*Prosopis pubescens*/ spring
Number of plots	29	4	10	4	3
Live trees/ha (mean±SD)	230±126	330±88	239±79	508±319	197±124
Live trees/ha (range)	50–600	200–390	120–370	170–910	120–340
Acacia greggii (%)	99	39	44	0	0
Prosopis glandulosa (%)	1	59	56	100	0
Prosopis pubescens (%)	0	2	0	0	100
Live trees infected (%, mean±SD)	19±23	16±15	19±16	11±13	50±25
Live trees infected (%, range)	0–86	0–35	0–48	2–29	21–67
Elevation (m, mean±SD)	581±255	457±93	370±170	424±47	460±9
Elevation (m, range)	201–1154	381–590	198–685	379–469	455–471
Slope gradient (%, mean±SD)	4±6	10±6	17±19	3±11	6±3
Slope gradient (%, range)	1–31	3–18	2–52	2–4	3–9
Topography	Washes	Variable	Canyons, concave	Washes, depressions	Spring drainages
Soil classification (great group)	Torriorthents Haplocalcids	Torriorthents Haplocalcids	Torriorthents	Haplogypsids Haplocalcids	Petrogypsids Haplogypsids

had the greatest canopy cover. On soil with higher conductivity, the greatest *A. greggii* canopy cover occurred on soil with low SO_4 and high gravel concentration. Canopy cover of *Prosopis glandulosa* exhibited a different pattern: it was greatest on soil rich in NO_3, or on sites with steep slopes when soil NO_3 was low.

Ecological Condition and Species Groups

Thirteen exotic species were detected, including the annual grasses *Bromus rubens* (86% of plots), *Schismus* spp. (76%), *Polypogon monspeliensis* (10%) and *Bromus tectorum* (8%); annual forbs *Brassica tournefortii* (6%), *Salsola tragus* (6%), *Malcolmia africana* (4%), and *Sonchus asper* (2%); annual-biennial forbs *Erodium cicutarium* (28%), *Lactuca serriola* (2%), and *Sisymbrium altissimum* (2%); the perennial forb *Marrubium vulgare* (2%); and the tree *Tamarix ramosissima* (22%). *Prosopis pubescens*/spring contained no plots with exotic species, and average exotic richness ranged from 2–4 species/0.1 ha in the other communities. Native and exotic species richness were positively related (r = 0.47; Fig. 4B). This correlation was larger than the next highest correlations that exotic richness exhibited (r = 0.35 with precipitation and 0.34 with UTM*x*).

A regression tree portraying exotic species richness accounted for 40% of variance upon crossvalidation (Fig. 7A), which was higher than the 17% for exotic cover (not shown). The regression tree indicated that sites with ≥16 cm/yr of precipitation and silty soil contained the most exotic species. The least exotic rich were drier sites, especially those with high soil S.

Mistletoe was present on 33 of 50 plots (66%), and the percentage of trees infected was 50% in the *Prosopis pubescens*/spring community and lower (11–19%) in other communities (Table 1). The greatest density of infected trees portrayed by a regression tree occurred on soil with low $CaCO_3$ concentration, or, if $CaCO_3$ concentration was high, on higher elevation sites with high tree canopy cover (Fig. 7B).

Tree size-class distributions revealed that densities were variable within diameter classes among sites within communities (Fig. 8). This resulted from some sites containing few or no trees in some size classes. Communities as a whole exhibited good representation of small trees, with generally as many or more trees in small as large size classes. The exception was the *Prosopis pubescens*/spring community, which mostly contained large trees. Density of trees in the smallest size class (1–9 cm diameter at root collar) was positively correlated with total tree density (r = 0.73). A regression tree showed that the greatest percentage of small trees occurred on sites with high precipitation and in areas other than the northeastern part of the study area (Fig.

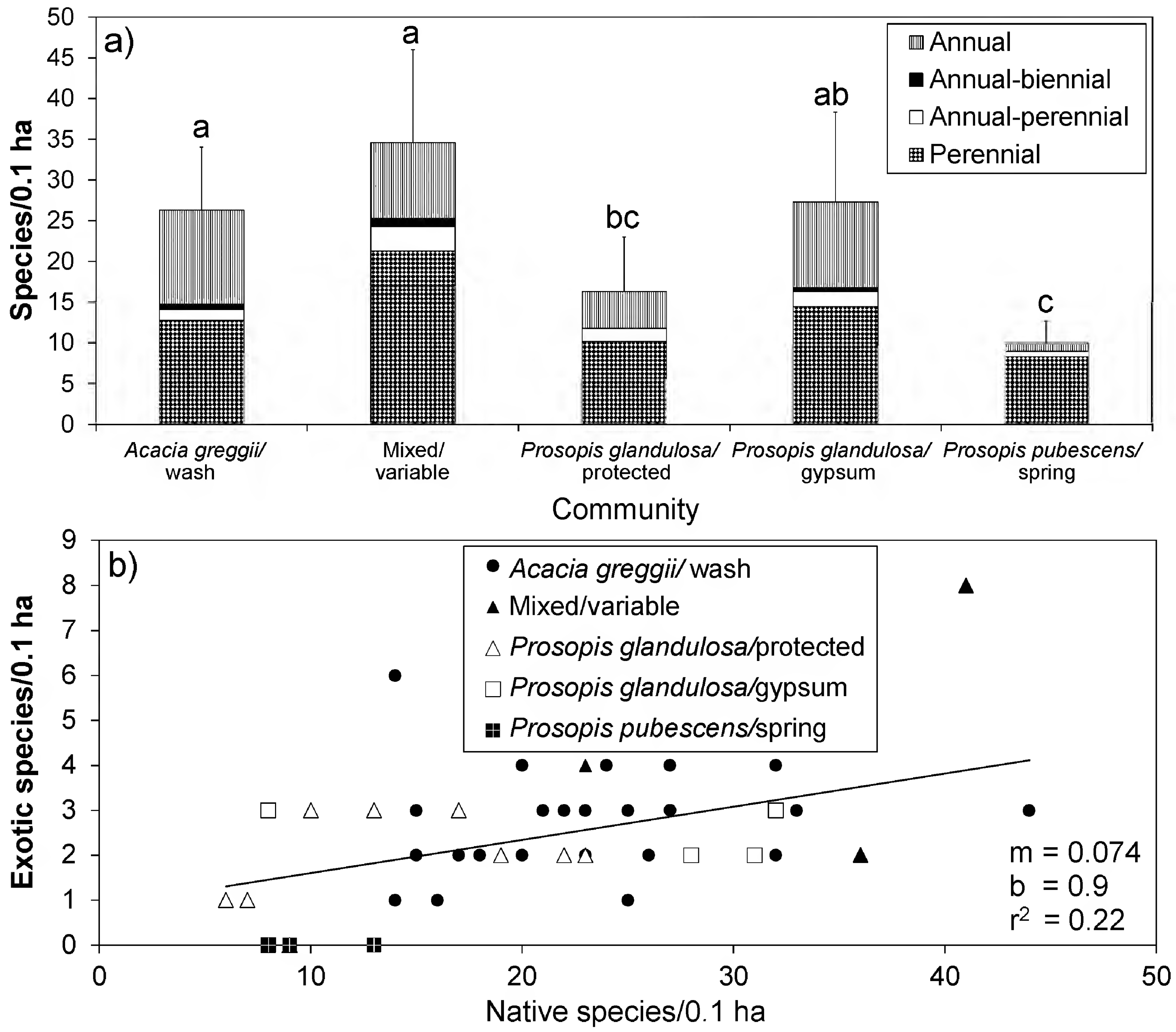

Fig. 4. **(a)** Species richness by lifeform for *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. Error bars are 1 SD for total mean richness, and means without shared letters differ at $P < 0.05$. **(b)** Relationship between native and exotic species richness, with a slope and y intercept for a regression line shown for descriptive purposes.

7C). *Prosopis pubescens*/spring communities, which were dominated by large trees, occurred in the study area's northeastern corner.

We classified a total of 73 species into 14 species groups comprised of 2–8 species (Appendix 1). Amplitude and fidelity to community types varied among species groups, with some groups most frequent in one or a few communities (e.g., *Allenrolfea occidentalis* group most frequent in *Prosopis pubescens*/spring) and others more widespread yet still often sparse or absent from one or more communities. Examples of species group distributions include: the *Acacia greggii* group of *Hymenoclea salsola* and annual species like *Eriogonum palmerianum* that occupy washes; *Larrea tridentata* group of dry-site species inhabiting xeric areas within or on the edges of the sampled riparian patches; *Encelia farinosa* group of *Acacia greggii*/wash but also of other communities, excepting *Prosopis pubescens*/spring; *Pluchea sericea* group with a distribution difficult to characterize; *Suaeda moquinii* principally of gypsum soil, including *Prosopis glandulosa*/gypsum and *Prosopis pubescens*/spring, although some species of the group also frequented other communities; and the *Allenrolfea occidentalis* group primarily of *Prosopis pubescens*/spring or *Prosopis glandulosa*/gypsum, indicating that this group inhabits extreme soil properties. Exotic species did not group together (only one species group contained more than one exotic species) and instead occurred in a range of species groups with native species.

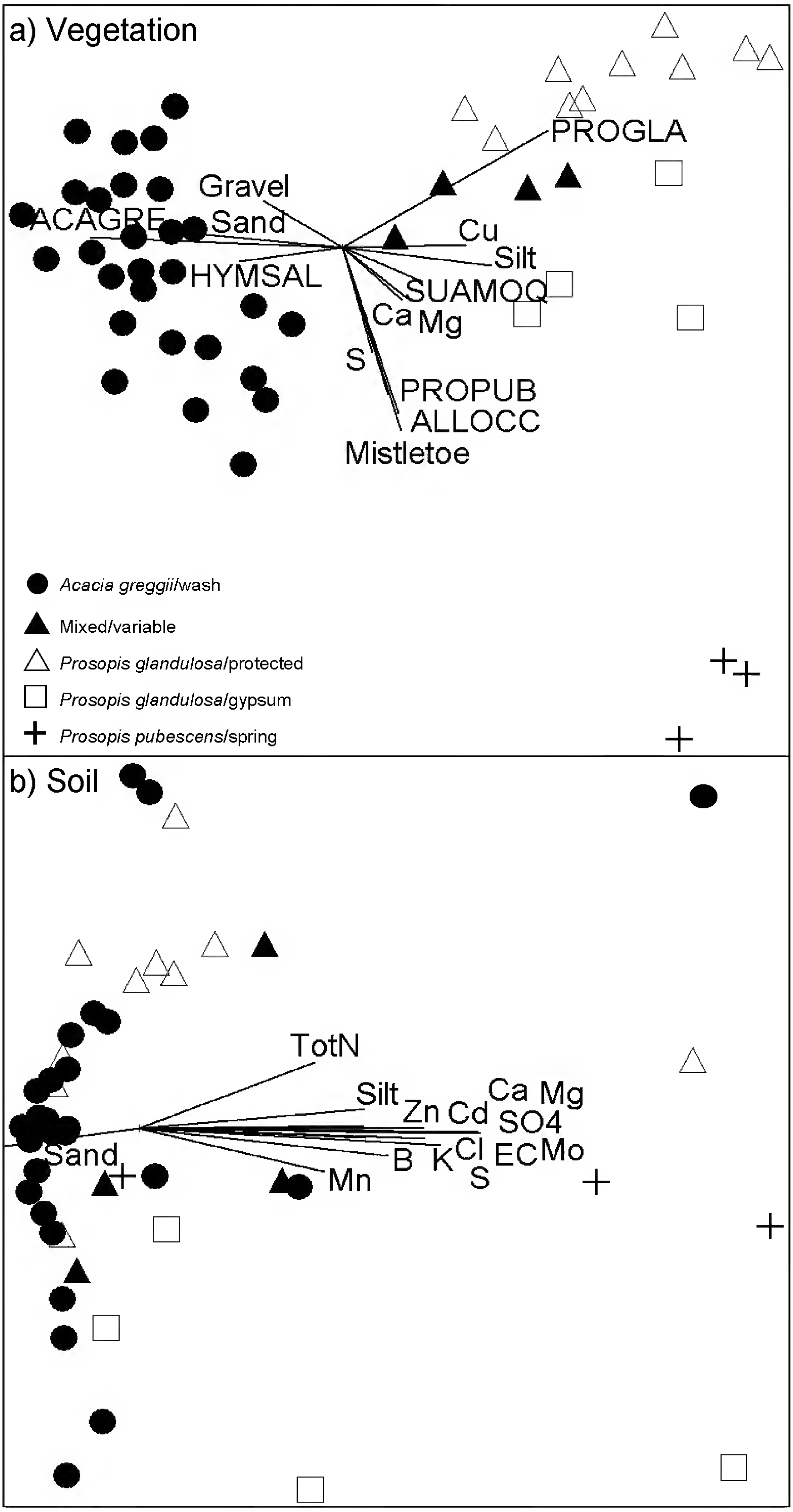

Fig. 5. Ordination of **(a)** vegetation and **(b)** soil composition with plots displayed according to community type for *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. Vectors are scaled in proportion to their correlation with ordination axes. Vectors are shown with $r^2 \geq 0.20$ for (a) and ≥ 0.50 for (b). Abbreviations for vectors: ACAGRE = *Acacia greggii*, ALLOCC = *Allenrolfea occidentalis*, HYMSAL = *Hymenoclea salsola*, PROGLA = *Prosopis glandulosa*, PROPUB = *Prosopis pubescens*, and SUAMOQ = *Suaeda moquinii*.

Table 2. Soil properties (0–5 cm) of *Acacia* and *Prosopis* woodland community types of Lake Mead National Recreation Area, Mojave Desert, USA.

	AG/wash[a]	M/variable	PG/protected	PG/gypsum	PP/spring
Physical properties			Mean ± SD		
Gravel (% weight)	46±14	37±17	43±17	21±21	3±3
Gravel (% volume)	28±10	19±17	24±11	13±15	1±1
Bulk density (g/cm^3)	0.78±0.23	0.83±0.2	0.70±0.13	0.93±0.1	0.67±0.06
Sand (%)	86±13	72±7	72±16	75±18	53±22
Silt (%)	8±9	22±7	20±13	14±7	40±19
Clay (%)	6±4	7±2	9±4	11±11	7±4
Chemistry					
EC[b] (mS/cm)	2.5±11.0	2±2.3	3.3±8	9.5±10.9	16.9±14.2
pH	8.0±0.3	8±0.5	7.7±0.3	8±0.6	8.4±0.3
Chemical composition					
$CaCO_3$ (%)	9.1±15.6	13.6±5.1	7.4±7.0	26.1±12.0	2.7±0.6
Organic C (%)	0.6±0.8	0.7±0.6	0.7±0.5	0.7±0.5	1.1±0.6
Inorganic C (%)	1.1±1.9	1.6±0.6	0.9±0.8	3.1±1.4	0.3±0.1
Total C (%)	1.6±2.1	2.3±1.0	1.5±0.8	3.8±1.1	1.4±0.5
NO_3 (mg/kg)	0.7±0.6	4.9±8.5	6±7.6	18.6±36.3	5.1±7.6
Total N (%)	0.04±0.04	0.08±0.06	0.06±0.04	0.07±0.07	0.10±0.05
Olsen P (µg/g)	6±5	15±15	9±7	19±18	13±11
SO_4 (mg/kg)	400±1924	253±417	533±1593	627±611	2243±1935
Total S (%)	0.20±0.81	0.12±0.13	0.15±0.36	0.07±0.04	3.39±2.92
K (mg/kg)	235±834	181±178	142±152	376±259	470±336
Ca (mg/kg)	523±1142	1008±1416	543±864	2498±1506	2870±2218
Mg (mg/kg)	81±196	173±210	105±195	314±258	497±384
Na (mg/kg)	449±1586	466±532	302±525	752±761	1230±846
Fe (µg/kg)	114±144	55±45	119±103	57±31	100±41
Mn (µg/kg)	0.03±0.04	0.05±0.02	0.03±0.03	0.12±0.09	0.09±0.02
Cu (µg/kg)	33±25	53±20	82±60	59±23	69±25
Zn (µg/kg)	18±44	15±18	46±77	24±18	69±53
Mo (µg/kg)	3.8±17.8	2.5±3.2	3±7.2	3±3	13.7±12.7
B (µg/kg)	657±2537	629±803	1094±2964	2953±4712	19469±24806
Cl (mg/kg)	251±1314	138±250	148±402	856±1256	1264±1130
Ni (µg/kg)	11±8	17±7	10±7	16±12	12±10
Co (µg/kg)	0.7±1.0	1.3±1.3	1.5±1.6	1.8±2	1.1±0.6
Cd (µg/kg)	0.09±0.33	0.06±0.04	0.09±0.15	0.11±0.06	0.25±0.24
Pb (µg/kg)	0.4±0.4	0.2±0.1	0.6±0.4	0.2±0.1	0.4±0.2

[a] From left to right, full names of community types are: *Acacia greggii*/wash, Mixed/variable, *Prosopis glandulosa*/protected, *Prosopis glandulosa*/gypsum, and *Prosopis pubescens*/spring

[b] Electrical conductivity

Nine of the 14 species groups had correlation coefficients ≥ |0.40| with at least one principal component or environmental variable. Among the strongest correlations included the *Acacia greggii* group with precipitation (r = 0.55), sand (r = 0.60), and total N (r = -0.46); *Pluchea sericea* group with Cu (r = 0.72); and the *Allenrolfea occidentalis* group with total S (r = 0.64).

DISCUSSION

Community Classification and Gradients

Plant species composition was distinct for each community type, and distributional overlap among the three tree species was low at our 0.1-ha plot scale. With an internal similarity of 44%, even the mixed/variable community was not merely a collection of sites unable to be classified, but rather was a community of unique species composition. Uniqueness of community composition was illustrated by internal similarities of 42–66% and segregation of community groupings in ordination. Only 1 (2%) of 50 plots contained all three focal tree species and 10 (20%) contained two species (all co-occurrences of *Acacia greggii* and *Prosopis glandulosa*), suggesting relatively strong partitioning of species distributions. Based on soil texture and landforms, we surmise

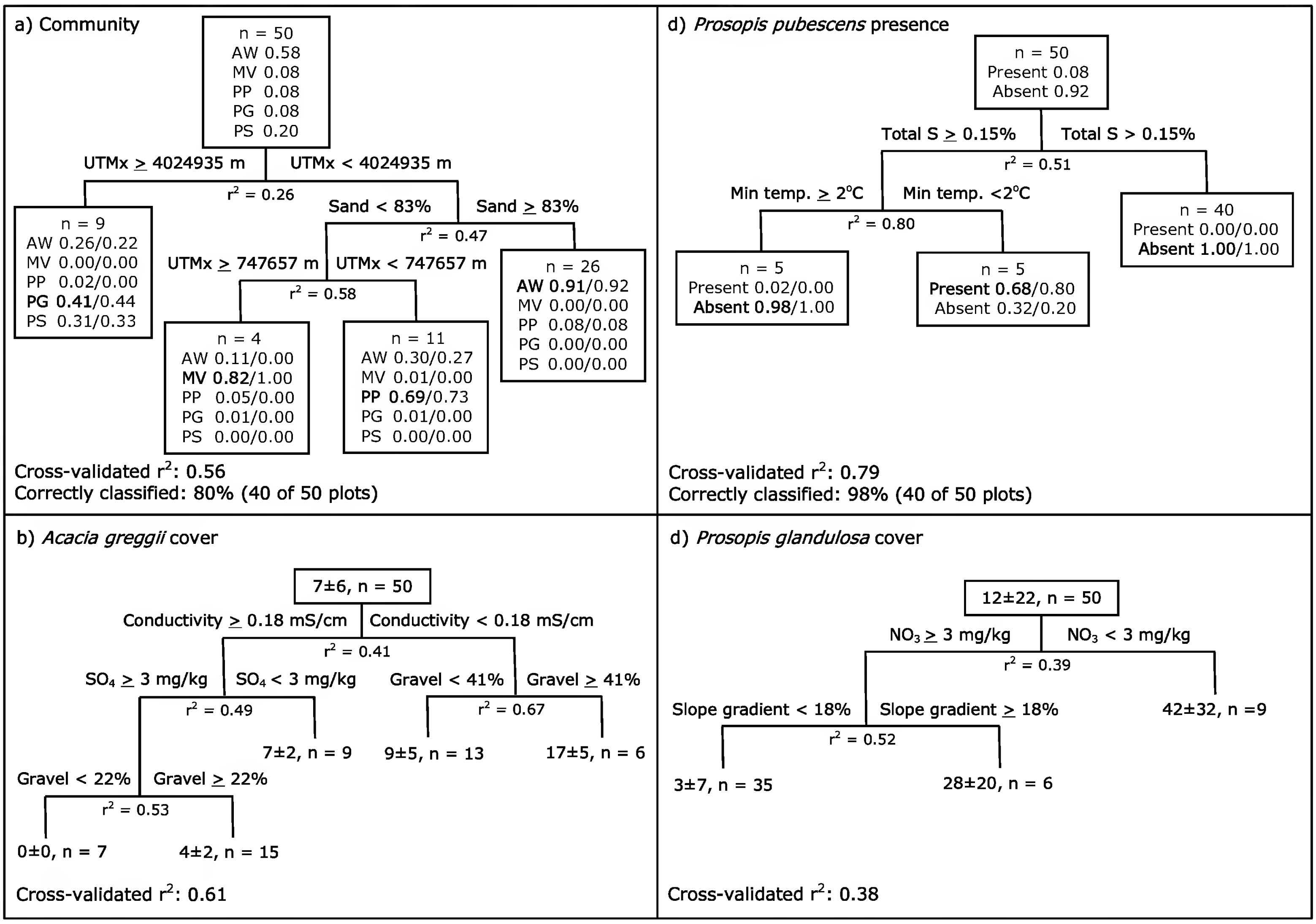

Fig. 6. Distribution of community types and tree species as a function of environmental variables for *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. (a) Classification tree for distribution of community types, abbreviated as: AW = *Acacia greggii*/wash, MV = Mixed/variable, PP = *Prosopis glandulosa*/protected, PG = *Prosopis glandulosa*/gypsum, and PS = *Prosopis pubescens*/spring. The actual proportion of plots is shown at the top of the tree. For each division, the estimated probability is shown on the left and the actual proportion on the right, with bold font highlighting the community with the highest estimated probability. (b) Regression tree with estimated mean (± SD) *Acacia* canopy cover at terminal nodes. (c) Classification tree of *Prosopis pubescens* presence/absence, with estimated probability of presence shown on the left and actual proportion of presence on the right for each division. (d) Regression tree with estimated mean (± SD) *Prosopis glandulosa* canopy cover at terminal nodes.

that *A. greggii* generally occupied the driest sites (coarsest soil and dry washes), *P. glandulosa* intermediate (topographically protected and moister washes), and *Prosopis pubescens* the wettest (outflow of springs, often with visible surface water). Comparative ecohydrological research (Smith et al. 1998) may be useful for evaluating if water balances were consistent with this perceived distribution.

Ordinations suggested that vegetation grouped more strongly than did the suite of 31 measured soil variables and that plant communities inhabited a range of environmental properties. However, there were some environmental correlates for the communities and tree species. Coarse-textured soil was associated with *Acacia greggii*, reflecting this species' affinity for dry washes. These washes have coarse soil because periodic floods carry away fine soil particles, while depositing coarse material from higher elevations (Schwinning et al. 2011). UTM, expressing location, was also an important variable, suggesting that certain communities had affinity to particular sections of the study area. *Prosopis pubescens*/spring communities, for example, were located in the northeastern part of the study area where hydrological conditions associated with outflow of springs were apparently favorable for development of this community. These areas were also affiliated with gypsum soil, likely accounting for relationships of *Prosopis pubescens*/spring communities with variables such as total S. Gypsum, comprised of $CaSO_4{\cdot}2H_2O$, produces soils high in S and salts (Meyer 1986) and can have extreme properties compared to the rest of the landscape, as we observed in our study. *Prosopis pubescens* occupies non-gypsum soil in other parts of its range (Busch 1995), and it is unclear if *P. pubescens* simply is toler-

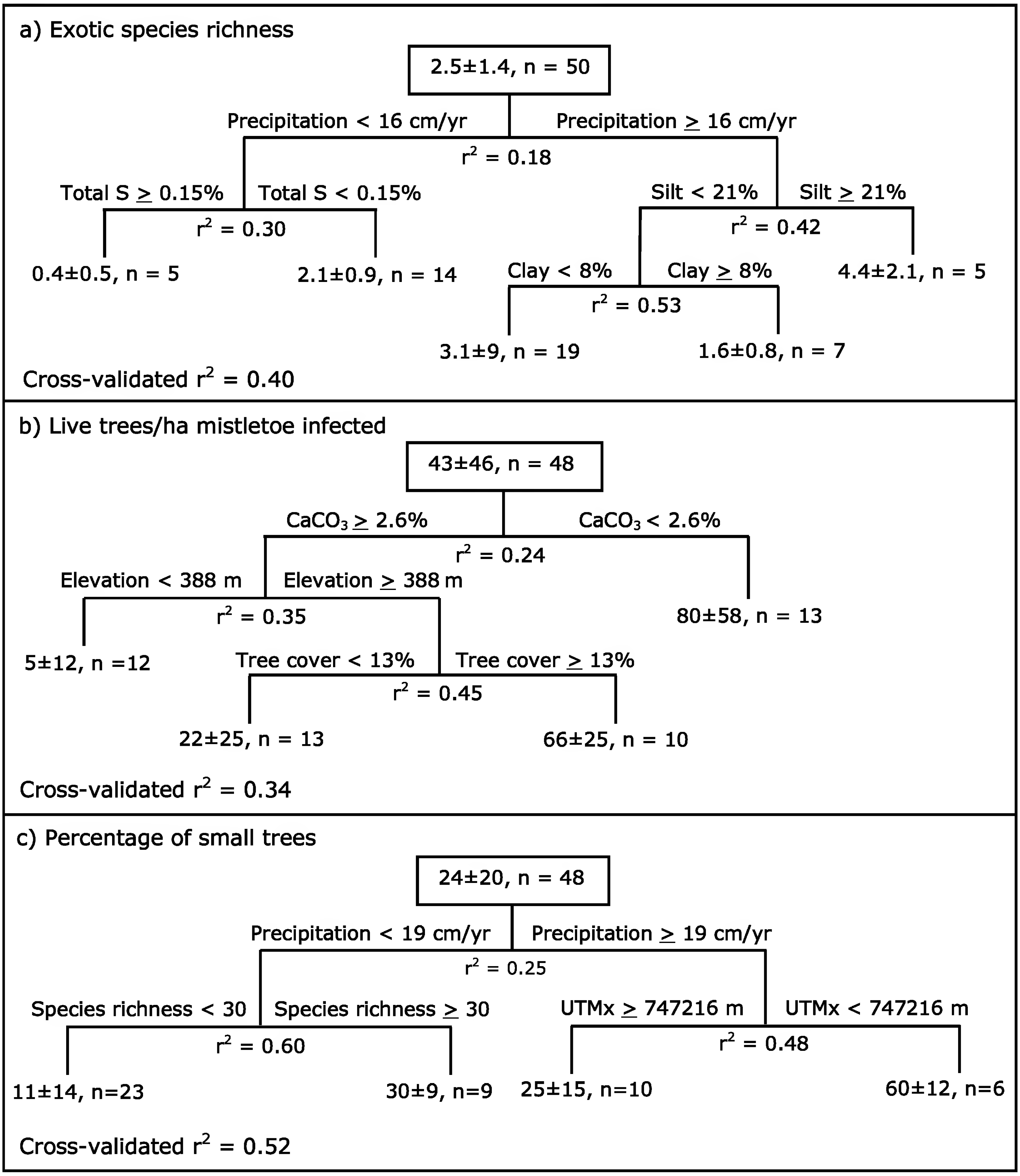

Fig. 7. Regression trees for ecological condition variables of *Acacia* and *Prosopis* woodlands of the eastern Mojave Desert, USA. Cumulative r^2 is shown for each division and estimated means (± SD) of response variables at terminal nodes. Trees could not be counted due to inaccessibility at 2 plots so sample size is 48 for (b) and (c).

ant of the extreme properties of gypsum in our study or if environmental conditions favorable for its occurrence were related to gypsum soil properties.

Although potential importance of plant correlations with soil variables should not be dismissed, data on ground-water depth and chemistry might help to account for additional variance in community and tree species distribution. Few data on groundwater exist for the study area (Gary Karst, Hydrologist, Lake Mead National Recreation Area, pers. comm.). An unpublished report using six wells found that depth to groundwater was <1

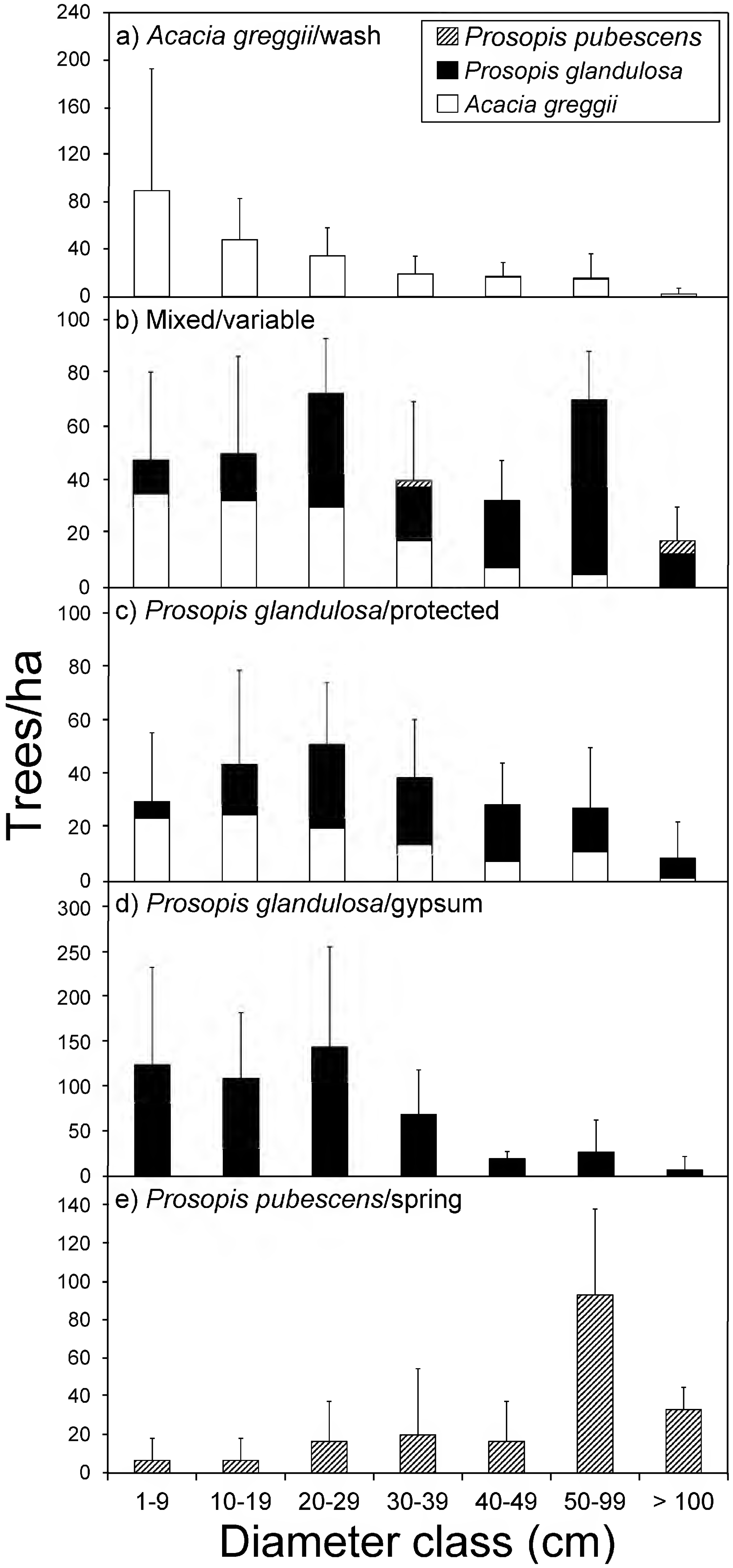

Fig. 8. Diameter at root collar distribution by tree species for *Acacia* and *Prosopis* community types of the eastern Mojave Desert, USA. Error bars are 1 SD. Note the difference in *y*-axis scales among the graphs.

m in summer 1992 to 1994 in the drainage of Sacatone Wash containing *Prosopis glandulosa* and *Prosopis pubescens* in the southern part of the study area (Inglis et al. 1996). In an area of the Bluepoint Spring outflow supporting *P. pubescens*, we also directly observed that depth to groundwater was approximately <2 m based on "sinkholes" where flowing groundwater was visible. Groundwater might be predicted to be deeper in *Acacia greggii* communities because they occupied dry washes characterized by more ephemeral, rather than perennial, water fluxes (Schwinning et al. 2011). Relationships of groundwater depth with *P. glandulosa* are unclear because some locales of this species were in topographically protected sites where shading might reduce evaporation and surface water might collect (Schwinning et al. 2011). Observed distributional differences in these communities afford opportunities for ecophysiological and hydrological research to improve understanding of habitat partitioning (Busch & Smith 1995). This is especially important for conservation given concerns about potential for groundwater pumping to lower regional water tables coupled with climate change (Deacon et al. 2007). Whereas Judd et al. (1971) concluded that established *P. glandulosa* could survive pumping-related lowering of water to 13 m below the surface before the trees died, Patten et al. (2008) suggest that declines in water depths of even a meter for near-surface groundwater can dramatically impact tree recruitment and associated species.

In addition to depth, groundwater chemistry might affect plant distribution by influencing composition of water that roots access (Springer et al. 2008). Near springs in Death Valley National Park in the western Mojave Desert, Hunt (1966) concluded that groundwater chemistry rather than soil chemistry more strongly correlated with distribution of *Prosopis glandulosa*.

Species Groups

Little research has examined ecological species groups in arid environments, but our results are consistent with some general principles of species groups in temperate regions. For instance, our finding that a species group was not restricted to one community type concurs with the common observation that most groups inhabit multiple communities but are quantitatively most abundant in only a few communities (Kashian et al. 2003). Species groups in temperate regions were more strongly correlated with multivariate environmental gradients than single-factor gradients (Goebel et al. 2001). We also found few strong correlations of groups with individual environmental variables, and occurrences instead were likely related to multivariate gradients in groundwater depth, chemistry, soil moisture under textural and topographic control, flooding frequency, and soil chemistry such as the presence of gypsum (Hunt 1966; Patten et al. 2008; Springer et al. 2008).

Obligate wetland species (e.g., *Juncus* and *Scirpus* spp.) were not well represented in the species groups or in the flora as a whole at these sites. Instead, the flora was dominated by species characterized as transitional between wetlands and uplands (Patten et al. 2008). Additionally, species of the *Acacia greggii*/wash community in particular are associated with disturbance. For example, abundance of *Hymenoclea salsola* and *Sphaeralcea ambigua* often increases following fire and other anthropogenic disturbances (Abella 2010), consistent with their occurrence in natural washes that are periodically disturbed by flooding.

Ecological Condition and Conservation Implications

Based on features of favored habitat described by Crampton and Sedinger (2011) for the conservation-priority bird *Phainopepla nitens*, many sites in the study area demonstrate favorable characteristics. Almost all nests of *P. nitens* are in mistletoe-infected trees (Crampton & Sedinger 2011), and we found that 66% of our 0.1-ha plots contained ≥1 infected tree. *Phainopepla nitens* nest suitability also is correlated with the number of infected trees, which we found averaged 62 ± 44 trees/ha on plots where mistletoe was present. Surveying abundance of *P. nitens* and other priority wildlife species across this network of woodland sites might help improve understanding of landscape-scale distributional relationships of wildlife species with plant communities.

Communities were dominated by native species, which comprised 94% of the total 201 taxa detected. In regression analysis, native species richness accounted for 22% of the variability in exotic richness, more than any other variable and consistent with the often-observed positive relationship between native and exotic richness (Tabacchi & Planty-Tabacchi 2005). The least species-rich community (*Prosopis pubescens*/spring) was least invaded, whereas the most species-rich sites generally were most invaded.

Of the 13 total exotic species detected, 3 are of greatest current concern to resource managers. *Bromus rubens* is a major concern because it increases fine fuel loads to facilitate spread of fire, which is a recent, novel disturbance to which native Mojave Desert flora is not considered well adapted (Abella 2010). At our study sites, however, *B. rubens* cover was low, exceeding 10% (and never more than 20% cover) at only 6 of its 43 occupied plots even including cover of dead stalks. Our study landscape as a whole is at a lower elevation than the middle elevations where *B. rubens* abundance is greatest in the Mojave Desert, suggesting that *B. rubens* even in riparian areas with supplemental moisture at low elevations does not attain the dominance it does in uplands at higher elevations (Abella et al. 2012b). Although we included dead plants as a measure of cumulative recent cover, *B. rubens* cover can vary dramatically between multi-year wet and dry periods (Steers et al. 2011) such that periodic monitoring of these riparian areas is warranted. The second species of greatest concern is *Brassica tournefortii*, which also can provide fuel and compete with native plants and predominates at low elevations (Barrows et al. 2009). We detected this species at only 3 sites, suggesting it is not presently a major component of these woodlands. The third species, *Tamarix ramosissima*, can outcompete native species and alter soil properties through production of salt-rich litter and exudates (Smith et al. 1998). Although we detected *T. ramosissima* at 22% of sites, this species and the native trees typically comprised different patches, as was also noted by Bagstad et al. (2006) along the San Pedro River in Arizona. Future management of this species might be guided by effectiveness of the biocontrol *Diorhabda carinulata* (tamarisk leaf beetle), presently moving south and reaching the northern boundary of the study area (Bateman et al. 2010). Although further monitoring is warranted, these riparian communities have lower exotic plant abundance in comparison to many other areas of the Mojave Desert including those that have burned by wildfire (Dudley 2009; Steers et al. 2011).

Other observations also suggested that threats to these woodlands were less prevalent in our study than observed in some other areas (Crampton et al. 2006). Qualitative observations indicated no evidence of fire or woodcutting at most sites, with only minimal (e.g., some branches) and localized cutting noted on plots near anthropogenic camping locations. Some observation of probable evidence (by recording browsed plants) of unauthorized livestock grazing was noted in the northeastern part of the study area, but effects to the woodlands are unclear. Lack of tree recruitment is considered a major problem in other areas (Crampton et al. 2006), but we observed tree densities well distributed among size classes, except in the *Prosopis pubescens*/spring community, which was dominated by large trees. Further investigation of recruitment potential in this community is warranted. If desired, it is feasible to actively facilitate establishment of *P. pubescens* and the other tree species through planting nursery grown seedlings (Abella & Newton 2009).

In summary, the data suggest that these woodlands were: readily classified into community types that might exhibit different conservation needs; correlated with some measured environmental variables, but further investigation into groundwater depth and chemistry could be informative; dominated by native species; inhabited by suites of annual and perennial plants classifiable into species groups displaying unique distributions; typified by well-distributed tree density across size classes at most sites; and characterized by low evidence of threats such as fire noted in other regions.

APPENDIX 1

Ecological species groups for *Acacia* and *Prosopis* woodlands of Lake Mead National Recreation Area, Mojave Desert, USA.

	Community type				
Species group[a]	AGW[b]	MV	PGP	PGG	PPS
Acacia greggii			Frequency (%)[b]		
***Acacia greggii*––catclaw acacia**	**100**	100	70	25	0
Bromus arizonicus––Arizona brome	**24**	25	10	0	0
Camissonia boothii––Booth's evening primrose	**21**	0	0	0	0
Eriogonum palmerianum––Palmer's buckwheat	**31**	0	0	0	0
Erodium cicutarium––redstem stork's bill*	**45**	25	0	0	0

APPENDIX 1

Continued

	Community type				
Species group^{a}	AGW^{b}	MV	PGP	PGG	PPS
Acacia greggii	Frequency (%)^{b}				
***Hymenoclea salsola*––cheesebush**	**86**	25	40	0	0
Pectocarya setosa––moth combseed	**21**	0	0	0	0
Salvia columbariae––chia	**45**	0	20	0	0
Eriogonum fasciculatum					
***Eriogonum fasciculatum*––eastern Mojave buckwheat**	**55**	**50**	10	0	0
***Encelia virginensis*–Virgin River brittlebush**	**14**	**0**	0	0	0
Phacelia vallis-mortae––Death Valley phacelia	**28**	**0**	0	0	0
***Porophyllum gracile*––slender poreleaf**	**21**	**25**	0	0	0
***Sphaeralcea ambigua*––desert globemallow**	**38**	**50**	10	25	0
***Xylorhiza tortifolia*––Mojave woodyaster**	**14**	**0**	0	0	0
Ephedra viridis					
***Ephedra viridis*––mormon tea**	**38**	**25**	20	0	0
Amsinckia tessellata––bristly fiddleneck	**28**	**25**	10	0	0
Draba cuneifolia––wedgeleaf draba	**10**	**50**	0	0	0
Nemacladus glanduliferus––glandular threadplant	**14**	**25**	0	0	0
***Viguiera parishii*––Parish's goldeneye**	**21**	**50**	10	0	0
Tamarix ramosissima					
Tamarix ramosissima*––saltcedar	**10**	**50**	**50**	0	0
***Funastrum cynanchoides*––fringed twinevine**	**3**	**0**	**30**	0	0
***Nicotiana obtusifolia*––desert tobacco**	**14**	**50**	**40**	0	0
***Stillingia linearifolia*––queen's-root**	**7**	**0**	**20**	0	0
Ephedra torreyana					
***Ephedra torreyana*––Torrey's jointfir**	**10**	0	10	**50**	0
Bromus rubens––red brome*	**93**	75	80	**100**	0
Chorizanthe brevicornu––brittle spineflower	**34**	25	0	**50**	0
Cryptantha pterocarya––wingnut cryptantha	**24**	25	0	**50**	0
***Cuscuta denticulata*––desert dodder**	**17**	25	0	**25**	0
Guillenia lasiophylla––California mustard	**14**	0	0	**75**	67
Lepidium lasiocarpum––shaggyfruit pepperweed	**21**	0	0	**50**	0
Schismus spp.––Mediterranean grass*	**83**	75	50	**100**	0
Ephedra nevadensis					
***Ephedra nevadensis*––Nevada jointfir**	**21**	**0**	**20**	0	0
***Acamptopappus sphaerocephalus*––rayless goldenhead**	**14**	**0**	**0**	0	0
***Ambrosia eriocentra*––woolly fruit bur ragweed**	**17**	**0**	**10**	0	0
Amsinckia menziesii––Menzies' fiddleneck	**14**	**0**	**20**	0	0
Bromus tectorum––cheatgrass*	**14**	**0**	**0**	0	0
Eriogonum thomasii––Thomas' buckwheat	**17**	**25**	**20**	0	0
***Pleuraphis rigida*––big galleta**	**10**	**50**	**0**	0	0
Ericameria paniculata					
***Ericameria paniculata*––Mojave rabbitbrush**	**14**	**25**	**20**	0	0
Cryptantha circumscissa––cushion cryptantha	**28**	**0**	**0**	0	0
***Echinocereus engelmannii*––hedgehog cactus**	**7**	**50**	**20**	0	0
***Echinocereus polyacanthus*––Mojave mound cactus**	**3**	**50**	**10**	0	0
Eriogonum deflexum––flatcrown buckwheat	**17**	**25**	**10**	25	0
***Yucca schidigera*––Mojave yucca**	**10**	**0**	**10**	0	0
Larrea tridentata					
***Larrea tridentata*––creosote bush**	**86**	**100**	**90**	**100**	0
***Cylindropuntia acanthocarpa*––buckhorn cholla**	**3**	**100**	**10**	**0**	0
***Eriogonum inflatum*––desert trumpet**	**21**	**75**	**20**	**75**	0
***Ferocactus cylindraceus*––California barrel cactus**	**7**	**75**	**10**	**0**	0
***Krameria erecta*––littleleaf ratany**	**14**	**50**	**0**	**75**	0
***Opuntia basilaris*––beavertail pricklypear**	**21**	**100**	**10**	**75**	0
Encelia farinosa					
***Encelia farinosa*––brittlebush**	**45**	**50**	**70**	**75**	0
***Bebbia juncea*––sweetbush**	**55**	**0**	**30**	**0**	0

APPENDIX 1

Continued

	Community type				
Species group[a]	AGW[b]	MV	PGP	PGG	PPS
Encelia farinosa	Frequency (%)[b]				
***Chamaesyce polycarpa*––smallseed sandmat**	**45**	**25**	**20**	**25**	0
***Krameria grayi*––white ratany**	**24**	**25**	**0**	**50**	0
***Stephanomeria pauciflora*––brownplume wirelettuce**	**41**	**50**	**10**	**25**	0
Ambrosia dumosa					
***Ambrosia dumosa*––burrobush**	**62**	**100**	**10**	**75**	0
Polypogon monspeliensis––annual rabbitsfoot grass	**3**	**50**	**20**	**0**	0
Prosopis glandulosa					
***Prosopis glandulosa*––honey mesquite**	3	**100**	**100**	**100**	33
***Baccharis emoryi*––Emory's baccharis**	0	**0**	**30**	**0**	33
Pluchea sericea					
***Pluchea sericea*––arrowweed**	7	**25**	**40**	0	**67**
***Phragmites australis*––common reed**	0	**25**	**20**	0	**33**
***Pleurocoronis pluriseta*––bush arrowleaf**	7	**0**	**20**	0	**0**
Suaeda moquinii					
***Suaeda moquinii*––Mojave seablite**	0	0	0	**100**	**67**
***Atriplex confertifolia*––shadscale saltbush**	0	0	0	**75**	**33**
Chorizanthe rigida––devil's spineflower	7	0	0	**50**	**0**
***Descurainia pinnata*––western tansymustard**	34	50	50	**75**	**33**
***Isocoma acradenia*––alkali goldenbush**	0	25	0	**100**	**67**
Plantago ovata––desert Indianwheat	17	50	10	**75**	**0**
Stylocline intertexta––Morefield's neststraw	7	0	0	**75**	**0**
Vulpia octoflora––sixweeks fescue	86	50	40	**75**	**0**
Allenrolfea occidentalis					
***Allenrolfea occidentalis*––iodinebush**	0	0	0	25	**100**
***Distichlis spicata*––saltgrass**	0	25	0	50	**67**
***Prosopis pubescens*––screwbean mesquite**	0	25	0	0	**100**

[a] Bold = perennial, not bold = annual or biennial, and * = exotic

[b] Abbreviations and numbers of plots for community types: AGW = *Acacia greggii*/wash (n = 29), MV = Mixed/variable (n = 4), PGP = *Prosopis glandulosa*/protected (n = 10), PGG = *Prosopis glandulosa*/gypsum (n = 4), and PPS = *Prosopis pubescens*/spring (n = 3). Bold values signify where a species group is overall most frequent

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BOOK NOTICE

Johnnie L. Gentry, George P. Johnson, Brent T. Baker, C. Theo Witsell, and Jennifer D. Ogle, eds. 2014. **Atlas of the Vascular Plants of Arkansas.** (no ISBN given, pbk). University of Arkansas, Department of Printing Services, University Services Building, 2801 S. University Ave., Little Rock, Arkansas 72204, U.S.A. (**Orders:** University of Arkansas Herbarium, Attn: Jennifer Ogle, Biomass Research Center 141, University of Arkansas, Fayetteville, Arkansas 72701, U.S.A., www.uark.edu/~arkflora, herb@uark.edu, 1-479-575-4372). $43.90 ($7.15 shipping, Arkansas Native Plant Society members receive a 10% discount), 709 pp., 2892 maps, some color introduction maps, size unknown.

From the publisher: The *Atlas* includes 2,892 taxa representing 187 families, 936 genera and 2,715 species. Each species is presented with a county-level distribution map along with family and common names; numerical codes representing special status for certain taxa (nonnative, invasive, endemic, or species of conservation concern) are also included. This publication also includes the following chapters, featuring full-color maps and plates.

This 709-page paperback publication features distribution maps for each of the 2,892 native and naturalized vascular plants in Arkansas, representing 2,715 species, 936 genera, and 187 families, introductory chapters, featuring full-color maps and plates, provide information on the following subjects:

General introduction
History of botanical exploration in Arkansas
An overview of the geology of Arkansas
Effects of physical factors on the distribution of native flora and vegetation in the natural divisions of Arkansas

Additional sections include:

Floristic summary
Arkansas endemic taxa
Additional taxa reported for Arkansas
Arkansas vascular plants of conservation concern

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NOTEWORTHY VASCULAR PLANT COLLECTIONS FROM THE RED RIVER OF ARKANSAS AND LOUISIANA, U.S.A.

Christopher Reid

Louisiana Department of Wildlife & Fisheries
2000 Quail Drive
Baton Rouge, Louisiana 70898, U.S.A.
creid@wlf.la.gov

M. Jerome Lewis

Department of Biological Sciences
Louisiana State University in Shreveport
One University Place
Shreveport, Louisiana 71115, U.S.A.
lewism06@lsus.edu

ABSTRACT

A plant collecting excursion by boat on a ca. 50 km stretch of the Red River straddling the Arkansas-Louisiana state line yielded several interesting botanical discoveries. The second record of *Loeflingia squarrosa* from Arkansas was documented. Collections of *Dalea lanata* and *Heliotropium convolvulaceum* were made from both states. These collections extend the ranges of these taxa several hundred river-km downstream on the Red River. Our collections of *D. lanata* and *H. convolvulaceum* in Louisiana represent the first records of these species for that state.

RESUMEN

Una excursión de recogida de plantas en bote en un trecho de ca. 50 km en el Red River a caballo en la frontera estatal Arkansas-Luisiana produjo varios descubrimientos botánicos interesantes. Se documentó la segunda cita de *Loeflingia squarrosa* de Arkansas. Se realizaron colecciones de *Dalea lanata* y *Heliotropium convolvulaceum* en ambos estados. Estas colecciones extendieron los rangos de estos taxa varios cientos de kilómetros río abajo en el Red River. Nuestras colecciones de *D. lanata* y *H. convolvulaceum* en Luisiana representan las primeras citas de estas especies para el estado.

INTRODUCTION

We carried out a plant collecting excursion by boat on the Red River in southwestern Arkansas and northwestern Louisiana on 15 and 16 August 2012. The objective was to explore the habitats along the river, particularly sand bars on the river in its present course and relict sand bars abandoned when the river shifted course. In our region, plant collections from streams and rivers seem to frequently be from easily accessible points such as bridges and boat launches (pers. obs.). It was hoped that our approach using a boat would yield some interesting records that may otherwise not be documented.

METHODS

We launched at the Arkansas Highway 160 bridge (latitude and longitude in decimal degrees: 33.089622, -93.858549) and proceeded upstream for ca. 20 km, then turned around and explored downstream into Louisiana, terminating at the Louisiana Highway 2 bridge (latitude and longitude in decimal degrees: 32.892751, -93.820295). A stretch of approximately 50 river-km was covered during our field work (Fig. 1). A 14-foot flat bottom aluminum boat with a shallow water marine drive "go-devil" motor was used for our study. Capable of navigating water 45 cm deep and handling the occasional underwater sandbar or mudflat, this set-up seemed most useful. Water levels were slightly below average for that time of the year.

RESULTS AND DISCUSSION

Our field work on the Red River yielded several noteworthy plant records. The diminutive *Loeflingia squarrosa* Nutt. was collected from an abandoned point bar in Arkansas. This species is very rare in Arkansas and Louisiana and is ranked as S1 in both states (NatureServe 2013). Previous records of *L. squarrosa* from Arkansas and Louisiana are from xeric sandhill woodlands associated with Tertiary formations (Singhurst & Holmes 1999; Reid & Faulkner 2006). Our record, only the second from Arkansas, was from a dry sandy grassland

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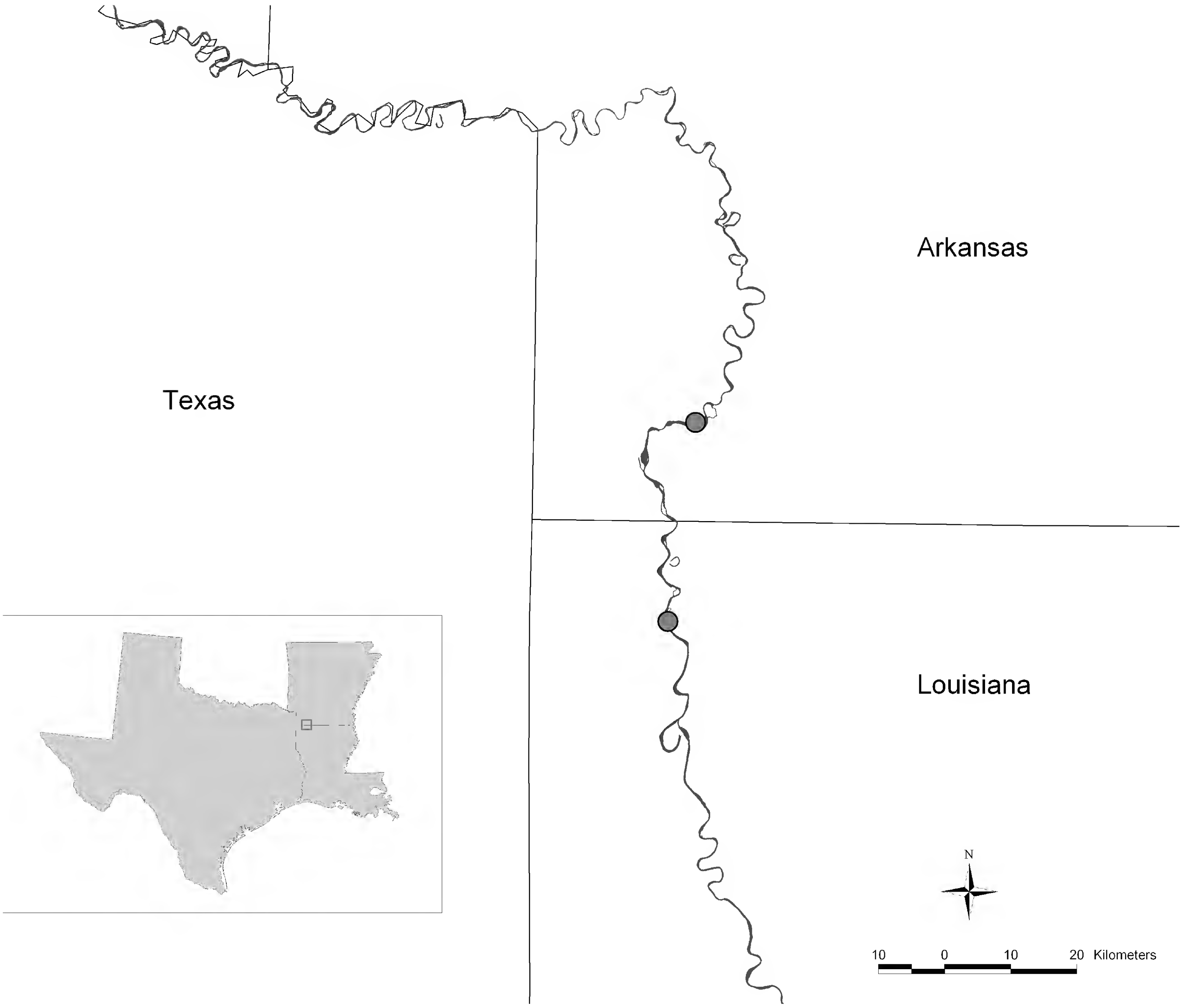

Fig. 1. Map showing Red River in northwestern Louisiana and southwestern Arkansas, U.S.A. The yellow circles delimit the stretch of the River that was botanically explored on 15–16 August 2012.

developed on recently-deposited sediment. This grassland was dominated by *Sporobolus cryptandrus* (Torr.) A. Gray and *Eragrostis secundiflora* J. Presl on the highest driest areas. Thickets of *Prunus angustifolia* Marshall were conspicuous. Other characteristic species included *Heterotheca subaxillaris* (Lam.) Britton & Rusby, *Croptilon divaricatum* (Nutt.) Raf., and *Diodia teres* Walter. Lower slopes of this abandoned bar had heavy cover of the exotic *Cynodon dactylon* (L.) Pers.

Collections of *Dalea lanata* Spreng. and *Heliotropium convolvulaceum* (Nutt.) A. Gray were made from Arkansas and Louisiana. Collections of these taxa in both states are significant. *Dalea lanata* is state-rare, ranked as S2, in Arkansas (NatureServe 2013) and was previously known only from sand bars on the Arkansas River in the central part of the state (Smith 1988; Gentry et al. 2013). In Arkansas, we collected *Dalea lanata* from the same site as *Loeflingia squarrosa*. It was observed at one additional site on a less stable and sparsely-vegetated sand bar farther upstream. In Louisiana, one population of *D. lanata* was documented from a dry sand dune field which is apparently shaped by seasonal flooding. Since this species had not previously been reported for Louisiana by MacRoberts (1984, 1989), Thomas and Allen (1998), USDA, NRCS (2013), or NatureServe (2013), our Louisiana record of *D. lanata* is regarded as the first for the state. *Dalea lanata* is a species of the southwestern U.S. that occurs on sand dunes and in sandy river valleys, with known occurrences on the Red River in Oklahoma and Texas (Correll & Johnston 1970; McGregor 1986; Hoagland et al. 2004). Our records of *D. la-*

FIG. 2. **Top:** Sandbar on Red River in Miller County, Arkansas, at latitude/longitude 33.149814, -93.779734 (decimal degrees). *Heliotropium convolvulaceum* was collected at this site and a small population of *Dalea lanata* was observed. Image was taken facing downstream (west-northwest) where river channel is visible in background. **Bottom:** Open dry sand dune field in Bossier Parish, Louisiana, at latitude/longitude 32.956424, -93.831097 (decimal degrees). This dune-like area was associated with a portion of a point bar apparently where seasonal flood waters pass to the east of the most stable part of the bar which is wooded. Image was taken oriented roughly southwest and facing the tree line on the most stable part of the bar. *Heliotropium convolvulaceum* (a few plants flowering in foreground) and Dalea lanata were present on this site.

nata are approximately 500 river-km downstream from nearest reported populations in Bryan Co., Oklahoma, and Grayson Co., Texas (Turner et al. 2003; Hoagland et al. 2004).

Heliotropium convolvulaceum has a similar distribution as *Dalea lanata* and is similar ecologically, preferring dry loose sands (Correll & Johnston 1970; Kaul 1986). As with *D. lanata*, it is rare in Arkansas with a ranking of S2 (NatureServe 2013) and was previously known only from sand bars on the Arkansas River (Smith 1988; Gentry et al. 2013). It is herein reported in Louisiana for the first time as other floristic references do not include it in the state (MacRoberts 1984, 1989; Thomas & Allen 1998; NatureServe 2013; USDA, NRCS 2013). Our collections of *H. convolvulaceum* are approximately 300 river-km downstream from previously documented stations along the Red River in McCurtain Co., Oklahoma, and Lamar Co., Texas (Turner et al. 2003; Hoagland et al. 2004).

Dalea lanata and *Heliotropium convolulaceum* were sympatric on sparsely vegetated sand bars and dunes (Fig. 2). Close associates of these species included *Cycloloma atriplicifolia* (Spreng.) J.M. Coult., *Cyperus esculentus* L., *Heterotheca subaxillaris*, and *Sporobolus cryptandrus*.

VOUCHER SPECIMENS

Loeflingia squarrosa (Caryophyllaceae)

Voucher Specimen: **ARKANSAS. Lafayette Co.:** Slay Bend on Red River, ca. 8 river-km upstream from AR 160 bridge, ca. 8.8 air-km NE of Doddridge, 33.1424840, -93.8342270, abandoned point bar supporting sandy grassland, with *Sporobolus cryptandrus*, *Eragrostis secundiflora*, *Heterotheca subaxillaris*, *Diodia teres*, *Croptilon divaricatum*, and *Prunus angustifolia* thickets, common and scattered, 15 Aug 2012, *Reid and Lewis 8278* (ANHC, LSU).

Dalea lanata (Fabaceae)

Voucher Specimens: **ARKANSAS. Lafayette Co.:** Slay Bend on Red River, ca. 8 river-km upstream from AR 160 bridge, ca. 8.8 air-km NE of Doddridge, 33.1424840, -93.8342270, abandoned point bar supporting sandy grassland, with *Sporobolus cryptandrus*, *Eragrostis secundiflora*, *Heterotheca subaxillaris*, *Diodia teres*, *Croptilon divaricatum*, and *Prunus angustifolia* thickets, abundant in small area, 15 Aug 2012, *Reid and Lewis 8275* (ANHC, LSU). **Miller Co.:** sandbar on Red River S of Haley Lake, ca. 14 river-km upstream from AR 160 bridge, ca. 13 air-km WNW of Bradley, 33.1494510, -93.7790070, only a few plants seen in small area, no voucher specimen collected. **LOUISIANA. Bossier Parish:** Red River ca. 10 river-km upstream from LA 2 bridge, ca. 6 air-km E of Mira and ca. 8.7 air-km NE of Hosston, 32.9532900, -93.8315800, open sparsely vegetated sandy dune field on east side of river bed, dry loose sand with *Heterotheca subaxillaris*, one large plant ca. 1 m radius and a few smaller satellite plants, 16 Aug 2012, *Reid and Lewis 8299* (LSU).

Heliotropium convolvulaceum (Boraginaceae)

Voucher Specimens: **ARKANSAS. Miller Co.:** Sandbar on Red River S of Haley Lake, ca. 14 river-km upstream from AR 160 bridge, ca. 13 air-km WNW of Bradley, 33.1494510, -93.7790070, common on high dry sand bar with *Sporobolus cryptandrus*, *Strophostyles helvola* (L.) Elliott, *Heterotheca subaxillaris*, and *Cycloloma atriplicifolia*, 15 Aug 2012, *Reid and Lewis 8293* (ANHC, LSU). **LOUISIANA. Bossier Parish:** Red River ca. 10 river-km upstream from LA 2 bridge, ca. 6 air-km E of Mira and ca. 8.7 air-km NE of Hosston, 32.9532900, -93.8315800, open sparsely vegetated sand dune field on east side of river bed, dry loose sand, common and scattered with *Heterotheca subaxillaris*, *Cycloloma atriplicifolium*, and *Cyperus esculentus*, 16 Aug 2012, *Reid and Lewis 8300* (LSU).

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BOOK NOTICE

Paul Dowlearn. 2013. **The Lazy Man's Garden. Maximum Return; Minimum Input.** (ISBN-13: 978-1-491060889, pbk). Published by the author, www.wvlandscape.com. (**Orders:** available at Amazon.com). $14.95, 156 pp., 6" × 9".

From the publisher: The Lazy Man's Garden: Maximum return; Minimum input, a nonfiction work of 58,600 words, explains practical approaches to gardening with emphasis on xeriscape and adjusting attitudes to practical gardening. Dowlearn writes, "Americans are intensively growing millions of acres of lawn grasses. We are also attempting to grow mostly non-native exotic hybrids for ornamentals. Much of this traditional culture is not sustainable. Vegetable gardening is one of the few things that survived our landscaping ethic to give the homeowner benefits that go beyond aesthetics. Utilizing native plants, creating habitat for wildlife, and seeking out old tried and true heirloom plants are current trends that promise a more relaxed, eco-friendly style."

The author, PAUL DOWLEARN, is co-owner of Wichita Valley Landscape (Wichita Falls, TX). He does landscape design and installation through his nursery and has focused on xeriscape and low maintenance landscapes for the last twenty years. Dowlearn has authored numerous articles on native and well adapted plants, plus organic gardening methods for newspapers and magazines, as well as speaking to many organizations throughout Texas and Oklahoma. He has hosted local radio and TV call-in shows and teaches landscaping courses at Vernon College. He is past president of the Red River Chapter of the Native plant Society of Texas, member of the Ladybird Johnson Wildflower Research Center, Riverbend Nature Center, Texas Organic Farmers & Gardeners Association and several other non-profit organizations.

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VEGETATION AND VASCULAR FLORA OF TALLGRASS PRAIRIE AND WETLANDS, BLACK SQUIRREL CREEK DRAINAGE, SOUTH-CENTRAL COLORADO: PERSPECTIVES FROM THE 1940s AND 2011

Sylvia Kelso

Department of Biology, Carter Herbarium
Colorado College
Colorado Springs, Colorado 80903, U.S.A.
tkelso@coloradocollege.edu

Leah Fugere

Environmental Program
Colorado College
Colorado Springs, Colorado 80903, U.S.A.

Miroslav Kummel

Environmental Program
Colorado College
Colorado Springs, Colorado 80903, U.S.A.
mkummel@coloradocollege.edu

Sebastian Tsocanos

Environmental Program
Colorado College
Colorado Springs, Colorado 80903, U.S.A.

ABSTRACT

We examined a tallgrass prairie-wetland complex of the Black Squirrel Creek drainage in south-central Colorado to compare the current grassland composition to its documentation by Robert Livingston in the early 1940s. Livingston considered these grasslands as probable Pleistocene relicts analogous to Midwestern tallgrass prairie with respect to dominant grasses and forbs. Using Livingston's methodology, we assessed an area near his original plots to determine whether the dominant grass species had changed in their contributions to cover or frequency. We found an almost identical suite of species to those documented in the 1940s, with modest differences in frequency and relative contribution to cover by the key grasses. We also characterized wetland habitats occurring within the grassland matrix, documented the vascular flora of mesic and hydric habitats, and analyzed the extent to which they contain species of conservation concern, Midwest prairie elements, or montane species typically occurring regionally at higher elevations. The tallgrass communities here differ from others in Colorado and the Midwest in having a lower abundance of *Andropogon gerardii,* and being dominated by *Sporobolus heterolepis* along with xeric species like *Bouteloua gracilis* and *Calamovilfa longifolia*, and montane species like *Muhlenbergia montana*. Although the structure of the extant vegetation remains similar to what existed in the 1940s and continues to be supported by ample groundwater, these grasslands are now reduced in extent. The vegetation mosaic of tallgrass prairie and wetlands holds a rich flora with numerous elements of phytogeographic and conservation interest.

RESUMEN

Examinamos el complejo de praderas de hierbas altas y humedales del desagüe de Black Squirrel Creek, en el sur-centro de Colorado, para comparar la composición actual de las praderas con la que Robert Livingston documentó a principios de los años cuarenta. Livingston consideró que estas eran análogas a las praderas de hierbas altas del Medio Oeste, con respecto a los pastos y formas dominantes, probables relictos de la vegetación del Pleistoceno. Usando la metodología de Livingston, evaluamos un área cercana a las parcelas originales para determinar si las especies dominantes de pastos han cambiado en su contribución a la cobertura o en su frecuencia. Encontramos un conjunto de especies casi idéntico al de las documentadas en los cuarenta, con diferencias pequeñas en frecuencia y contribución a la cobertura por parte de pastos clave. También caracterizamos los humedales presentes en el marco de la pradera, documentamos las plantas vasculares de hábitats mésicos e hídricos, y analizamos en qué medida estos contienen especies de interés para la conservación, elementos de las praderas del Medio Oeste o especies montanas comunes en regiones de mayor altitud. Las comunidades de pastos altos en este lugar difieren de otras en Colorado y en el Medio Oeste por la menor presencia de *Andropogon gerardii* y la presencia dominante de *Sporobolus heterolepis,* junto con especies áridas o montanas, como *Bouteloua gracilis*, *Calamovilfa longifolia* y *Muhlenbergia montana*. Aunque la estructura de la vegetación existente sigue siendo similar a la de los años cuarenta y aún cuenta con el soporte de abundantes aguas subterráneas, la extensión de estas praderas se ha reducido. El mosaico de vegetación de praderas de hierbas altas y humedales conserva una rica flora con numerosos elementos de interés para la geobotánica y la conservación.

INTRODUCTION

Over the past century, Colorado prairies changed and diminished as urban, suburban, and exurban development expanded while fire suppression, invasion of exotic species, and overgrazing altered grassland compo-

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nents. Prairie vegetation overall, and tallgrass communities in particular, now elicits special conservation focus amid widespread concerns about accelerating loss, fragmentation, and degradation throughout the Midwest and West (Nicholson & Hulett 1969; Samson & Knopf 1996; Bachand 2001; Colorado Natural Heritage Program 2005; Rondeau et al. 2011). In the early 1940s, ecologist Robert Livingston undertook a detailed study of tallgrass prairie in south-central Colorado north of Colorado Springs (Fig. 1). He profiled this vegetation in his graduate theses and related publication (1941, 1947, 1949, 1952) as unique remnant vegetation with strong floristic similarities to the Midwest prairies. This work provided a portrait of regionally anomalous vegetation as it existed nearly seventy years ago.

In this study, we reanalyzed the grassland vegetation in the Black Squirrel Creek drainage (Fig. 2) that was the focus of Livingston's work. We compared its current composition to the earlier descriptions and added additional documentation of associated wetland communities and the vascular flora. Although these additional components were not a focus in the original Livingston studies, contemporary conservation interest in these elements suggested their importance as part of the regional ecological profile. The objectives of our study were to:

1) Document the flora of the mesic and hydric communities and assess the extent to which this flora contains elements from the Midwest prairie or other regional components such as montane species typically occurring in the foothills, and highlight species of concern.
2) Document the types of wetland habitats occurring in the grassland matrix and their signature flora, plant associations and hydrogeomorphic profiles.
3) Compare the current dominant species and composition of the vegetation to the 1940's profile considered representative of Midwestern tallgrass prairie. In particular, we examined whether the relative rank of the dominant grass species had changed with respect to contribution to cover and frequency.

Regional vegetation contexts: shortgrass, mixed grass and tallgrass prairie

The eastern plains of Colorado encompass a wide range of grassland communities across diverse topography and edaphic substrates (Ramaley 1919; Shantz 1923; Weaver & Fitzpatrick 1934). These grasslands represent the western edge of the Great Plains, where collective vegetation types and many individual biotic components have been diminished from their historic presence (Rondeau et al. 2011). Shortgrass prairie (also known as shortgrass steppe senus Lauenroth et al. 2008) with its signature species *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths (nomenclature herein follows the U.S. Dept. of Agriculture National Resources Conservation Service Plants Database 2013 (www.plants.usda.gov); see Appendix 1 for full citations and exceptions) is the dominant regional vegetation (Weaver 1954; Neeley et al. 2006; Lauenroth et al. 2008). Shortgrass prairie south of Denver typically lacks extensive amounts of *Buchloe dactyloide*s, a codominant elsewhere in shortgrass prairie, although it occurs sporadically in the shortgrass matrix here. In the piedmont east of the Colorado Front Range foothills, a mixed grass prairie prevails, where grama grass is present in conjunction with a high representation of species in *Elymus*, *Hesperostipa*, *Muhlenbergia,* and *Poa* along with *Schizachyrium scoparium* (Michx.) Nash), *Sporobolus cryptandrus* (Torrey) A. Gray, and *Koeleria macrantha* (Ledeb.) Schult. This vegetation is extensive north and east of Colorado Springs, where the topographic watershed known as the Palmer Divide separates the drainages of the South Platte River to the north and the Arkansas River to the south.

Limited occurrences of tallgrass prairie vegetation (Vestal 1914, 1917, 1919; Moir 1972; Bock & Bock 1998) exist just east of the Front Range in areas where edaphic conditions enhance soil moisture (Branson et al. 1965). The Colorado Natural Heritage Program (2012) tracks four tallgrass communities of conservation concern: xeric tallgrass prairie dominated by *Andropogon gerardii* Vitma and *Sporobolus heterolepis* (A. Gray) A. Gray), or *A. gerardii* and *Schizachyrium scoparium* (Michx.) Nash), and mesic tallgrass prairie dominated by *A. gerardii* and *Calamovilfa longifolia* (Hook.) Scribn.), or *A. gerardii* and *Sorghastrum nutans* (L.) Nash). These associations are part of mixed vegetation that comprises the collective Western Great Plains Foothill and Piedmont Grasslands (Colorado Natural Heritage Program 2005).

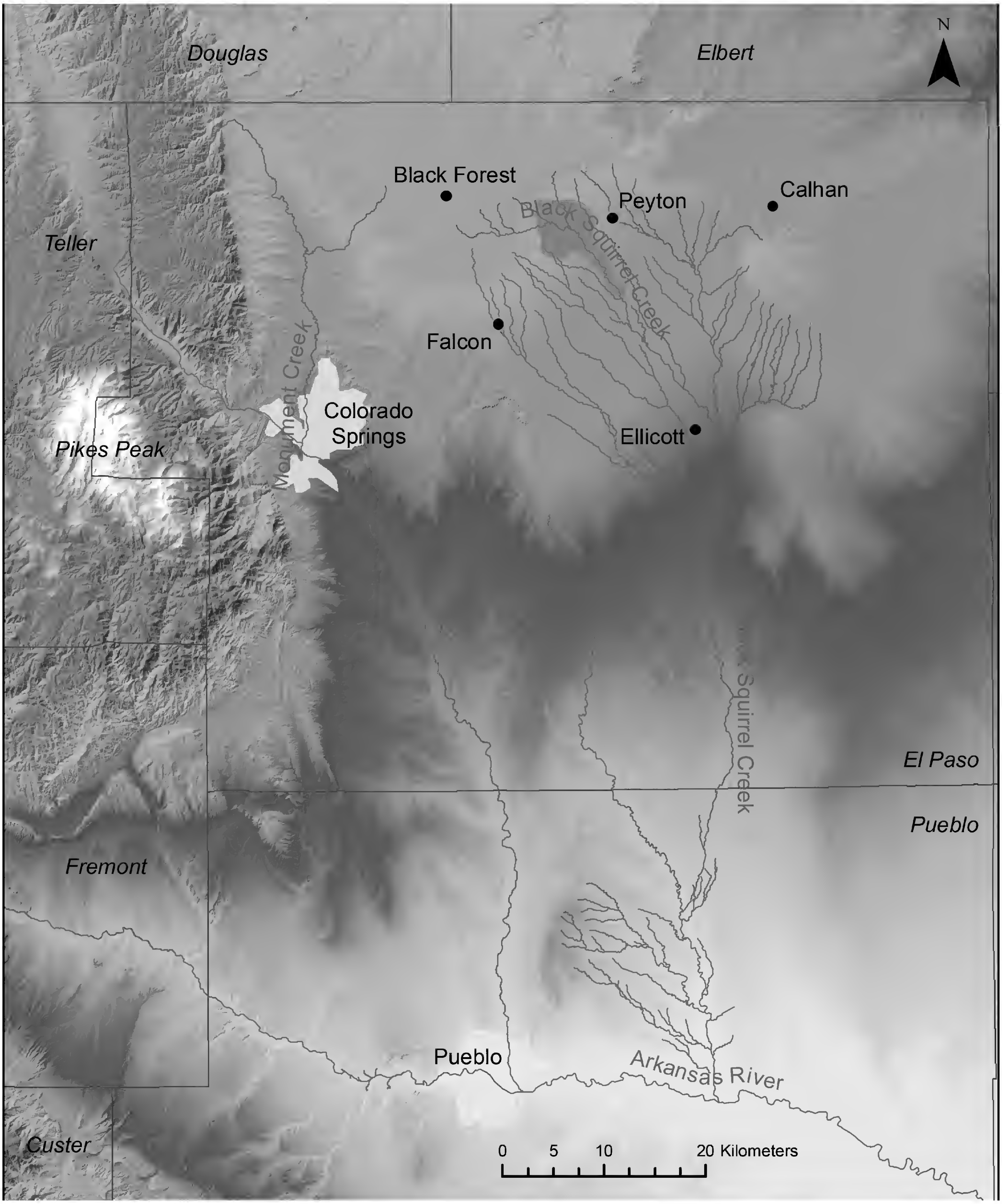

Fig. 1. Generalized area of study and Black Squirrel Creek drainage. Main study site is noted in red shading. The Palmer Divide is the region between El Paso and Douglas Counties, and represents the hydrological divide between the Platte and Arkansas Rivers.

At the species level, Colorado tallgrass prairies parallel those found in the Midwest where signature taxa include *Andropogon gerardii*, *Hesperostipa spartea* (Trin.) Barkworth), *Panicum virgatum* L., *Sorghastrum nutans*, and *Sporobolus heterolepis*, as well as the sand prairie tallgrass species *Calamovilfa longifolia* (e.g., Weaver 1954; Freeman 1998). The relative amounts of these species typically differ among central and western states (Weaver 1954; Weaver & Albertson 1956) according to precipitation and temperature regimes and soil types; in

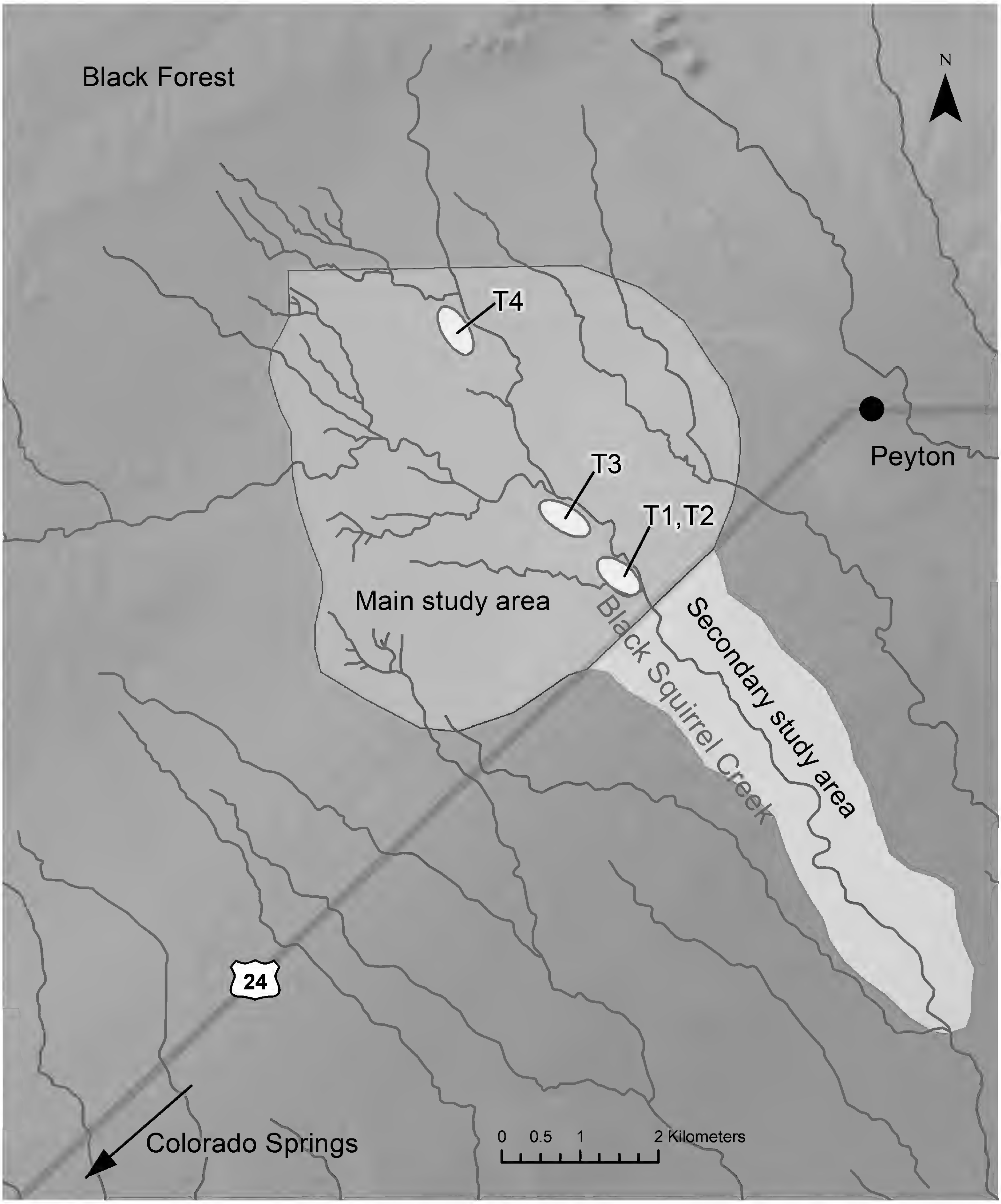

Fig. 2. Core study site along upper Black Squirrel Creek drainage, east of Colorado Springs. Transect locations are indicated by numbered ellipses; sizes are exaggerated for clarity.

Colorado, it has long been recognized that these communities similarly vary along a north-south gradient (Robbins 1910; Vestal 1914, 1917, 1919).

South of the Palmer Divide, isolated examples of tallgrass prairie occur within a ponderosa pine forest-grassland matrix known as the Black Forest (Shaddle 1939; Fig. 1). Studies by Vestal (1917), Shaddle (1939), and Williams and Holch (1946) noted the unusual vegetation and flora here. This region and surrounding grasslands became the focus of studies in which Livingston (1941, 1947, 1949, 1952) highlighted the similarity of the grassland vegetation and flora to Midwestern "true prairie", and suggested it represented fragmented relict communities from the Pleistocene (Livingston 1952; Weaver and Albertson 1956). Although relatively recent studies of tallgrass vegetation in eastern Colorado have been conducted in the Boulder area ca. 150 km north of the Black Forest (e.g., Moir 1972; Baker & Galatowitch 1985; Bock & Bock 1998; Neid et al. 2009), no assessment of the Black Squirrel Creek vegetation has been done since those of Livingston, although surveys by the Colorado College Herbarium and the Colorado Natural Heritage Program (Doyle et al. 2001a; 2001b) have shown the area to be rich in rare species and ecological communities.

Study Site

The Black Squirrel Creek system, a complex anastomosed network of drainages into the main creek channel, begins near the summit of the Palmer Divide (Figs. 2, 3) in the Black Forest and extends southeast, ultimately draining into the Arkansas River east of the city of Pueblo. In the upper quarter of the drainage, the creek typically has perennial flow, but this becomes intermittent aboveground to the south. Our primary study area was located on the upper Black Squirrel drainage between the municipalities of Falcon and Peyton, with an elevation range of ca. 2000 to 2200 m (6500 to 7100 ft). Quantitative data were taken on the core area covering ca. 770 ha (1900 acres) on a ca. 3100 ha (7700 acre) ranch that encompasses the main stem of Black Squirrel Creek with perennial flowing water, as well as with subsidiary drainages with intermittent flow and standing water. We took additional floristic and qualitative information south of the core area for a distance of ca. 10 km in order to encompass the area utilized in the 1940's studies. The topography consists of gently rolling uplands of mixed grass prairie on Quaternary deposits of aeolian sand (Morgan & Barkmann 2012) separated by lowland drainages and swales with small discontinuous wetlands, seeps, springs, and seasonal ponds supported by groundwater. Our study focused on the mesic and hydric flora and vegetation occurring in these drainages, the associated wetlands, and streambeds of Black Squirrel Creek and its tributaries rather than the xeric and mixed grass vegetation of the uplands that is widely represented on the plains.

Climate

Longterm annual precipitation since 1956 for this region averages ca. 38 cm (17 in; Western Regional Climate Center, data for Eastonville, CO) with ca. 75% of this occurring from spring rains in April to May and a July–August pulse from thunderstorms. Interannual variation in precipitation can be extreme in Colorado, with severe droughts occurring in the 1950s, 1970s, early 1980s, and early 2000s (Henz et al. 2004). Local rainfall tracks the topographic gradient, where higher elevations near the top of the drainage receive more rainfall in the summer and more winter storm events; these are often highly localized and precipitation events can vary over short distances. Longterm temperature records (Western Regional Climate Center; data for Colorado Springs 1948–2005) indicate an average daily high of 26.6° C (79.9° F) – to an average low of 12.7° C (54.8° F) in the growing season months of June to August, while January temperatures range from an average high of 5.9° C (42.6° F) to a low of 16.6° F (-8.5 C°). These climatic parameters do not differ significantly from those reported by Livingston (1947).

Geology

Livingston (1952) and Branson et al. (1965) noted the relationship between soils of perennial high moisture and the persistence of tallgrass prairie vegetation in Colorado; these azonal conditions are promoted by soil composition and water table dynamics. In our study area, two aquifers play a significant role in local hydrology and soil moisture: the alluvial Black Squirrel Creek aquifer and the underlying andesitic sandstone Dawson Formation bedrock aquifer (Bittenger 1976; Robson 1988; Topper 2008; Morgan & Barkmann 2012). Subsurface topography slopes steeply south, shaped by the ancestral Black Squirrel Creek now covered with glacial alluvium that forms the Black Squirrel Creek aquifer of Pleistocene gravels and coarse sand. This aquifer ranges in depth from 0–215 m; close to the headwaters of Black Squirrel Creek it is relatively shallow but it becomes deeper to the southeast. The alluvial aquifer is a significant source of well water for domestic, agricultural, and municipal uses (Topper 2008) and provides localized high water table occurrences. However, in our

Fig. 3. Main stem of Black Squirrel Creek. Upland areas contain mixed grass prairie vegetation and tallgrass vegetation occurs along the side banks.

study area the alluvial layer is relatively thin or absent, and much of the subsurface water here that supplies the seeps and springs is likely to be primarily a result of the Dawson Formation bedrock aquifer (R. Topper, pers. comm.), a late Cretaceous-Tertiary sandstone widely exposed along the Palmer Divide and close to the surface in the upper Black Squirrel Creek drainage. Becausethe aeolian and alluvial surface deposits of the area are highly permeable, runoff is low, and both aquifers receive recharge from precipitation (Topper 2008). The interface of the alluvial and bedrock aquifers is regionally complex with no detailed mapping of localized hydrological regimes yet available, and it is likely that both the alluvial and bedrock aquifers supply groundwater across the entirety of the drainage.

MATERIALS AND METHODS

The study area was surveyed intensively from May to August 2011 throughout the growing season, although floristic collections occurred regularly since 2000 and sporadically since the 1970s. We conducted qualitative surveys of topography and floristic composition of significant plant communities on each section of the main and subsidiary drainages every two weeks during 2011. We documented the vascular flora as completely as possible, combining new collection with existing recent ones at the Carter Herbarium of Colorado College (COCO); primary voucher specimens for all taxa are at COCO, with duplicates at COLO and CS. Vegetation communities and significant species and wetland features along the main drainage and its key tributaries were mapped using geospatial coordinates.

Our initial surveys along the drainage of Upper Black Squirrel Creek provided qualitative assessments of the current extent and condition of grassland communities in sites as close as possible to those in the original Livingston studies, for which only generalized location information was available. Due to landscape modification in housing developments and roads or inability to obtain permission for access, the most intact communities in which we were able to take quantitative data were located ca. 10 km north of the original Livingston plains sites, and a similar distance south of his forest-grassland interface plots (Livingston 1947; 1952) within the same hydrologic system in comparable topography. We were able to access the general area where his original sites were located for floristic information, although we did not take quantitative data due to disturbance from intensive grazing and anthropogenic surface alterations.

Livingston utilized nine 100m line transects in seven locations: four sites, each with a single transect, were in the Black Forest within a ponderosa pine-savannah community at 2200–2300 m (7200–7500 ft.), and three locations (one with 3 transects) were along the Black Squirrel Creek drainage in grasslands at ca. 2000 m (6500 ft). The original transects each encompassed ten quadrats of 1 × 0.5 m; in comparison, we used four 105 m transects, each with 20 similarly sized quadrats spaced 5 m apart. This modification allowed us to assess the small-scale heterogeneity characteristic of the region. All 2011 transects were located at approximately 2100 m (7000 ft) in elevation.

Transects 1 and 2 were located along the north-facing bank of the main stem of Black Squirrel Creek (Figs. 2, 3) in vegetation that met our criteria for sufficient length with the presence of tallgrass indicator species *Sporobolus heterolepis*, *Andropogon gerardii*, *Hesperostipa spartea*, or *Sorghastrum nutans*. These transects were parallel, ca. 10 m apart, and offset so that they overlapped by one half their length. We located two additional transects (Fig. 2) along subsidiary drainages in vegetation with similar criteria: Transect 3 was in a side drainage ca. 1 km north of transects 1 and 2, and Transect 4 was located in a tributary drainage, ca. 3 km north of transect 3. To match the protocol, timing, and data format of Livingston, we surveyed the vegetation in late August following his methodology for assessing basal and relative cover and frequency of dominant taxa.

Basal Cover and Relative Cover

In each quadrat, we estimated the total basal cover as a percentage of the total area, as well as the percent cover of bare ground and litter combined, then averaged these over each transect of 20 quadrats. For each quadrat we estimated the total cover of all plants, the relative cover of combined graminoids (Poaceae, Cyperaceae, Juncaceae and Juncaginaceae) as a percentage of the total vegetative cover, and the contribution of each identifiable species to the total graminoid cover.

Frequency

In each quadrat we recorded the presence of all graminoid species and calculated a frequency metric and rank of the dominant taxa by summing the quadrat data for each transect individually. We also calculated the mean frequency and rank frequency of each species across all transects.

RESULTS

Vascular Flora

The flora reported here (Appendix 1) represented only the hydric and mesic habitats and does not encompass species restricted to the more xeric uplands. Some components of this upland vegetation extended into the drainages, particularly in the open gravels of stream banks and terraces, and are included on the species list, noted as a xeric component. We defined notable elements (Table 1) in four categories. Rare taxa were those tracked as being of conservation concern by the Colorado Natural Heritage Program. Regionally uncommon taxa were those with few regional herbarium records COCO and so categorized in prior studies by Kelso (2012), Culver and Lemly (2013) or Weber and Wittmann (2012). Foothills/Montane elements were topographic disjuncts that typically occur in higher elevation locations of the Pikes Peak or Front Range foothills as noted by Weber and Wittmann (2012) and herbarium records at COCO. Midwestern elements were taxa associated with the characteristic Midwest Prairie flora as explicitly noted by Shantz (1928), Weaver and Fitzpatrick (1934), Weaver (1954), or Livingston (1952).

In the current study, we documented almost 300 taxa representing 62 families as currently recognized in the U.S.D.A. Plants Database (www.plants.usda.gov). The highest species richness was in the Asteraceae (50 species), Poaceae (43 species), Cyperaceae (18 species), and Juncaceae (12 species). Additional families with high species richness included the Fabaceae, Polygonaceae, Rosaceae, and Scrophulariaceae (s. lat.). The flora included relatively few noxious weeds; *Lythrum salicaria*, which existed sporadically in a side drainage of Black

Table 1. Notable plant taxa in the upper Black Squirrel Creek drainage. See Appendix 1 for full nomenclature. Midwest Prairie affiliated species are those so noted by Shantz (1928), Weaver and Fitzpatrick (1934), Weaver (1954) and Livingston (1952). Foothills/Montane distributions in Colorado by Weber and Wittman (2012), and Kelso (2012). Locally uncommon species are from records in COCO and prior fieldwork by Kelso but not tracked statewide by Colorado Natural Heritage Program (CNHP); Rare species are those tracked by the Colorado Natural Heritage Program (2012) as being of conservation concern. CNHP state rarity ratings are as follows: S1= Critically imperiled due to extreme rarity, or factors making it vulnerable to extirpation; 5 or fewer occurrences or less than 1000 remaining individuals; S2=Imperiled, 6–20 occurrences or between 1000–3000 remaining individuals; S3= Vulnerable, 21–100 occurrences or between 3000–10,000 remaining individualsl S4: Apparently secure, uncommon but widespread, with possible longterm concern (www.cnhp.colostate.edu).

Family	Species	Foothills/Montane	Midwest Prairie	Locally Uncommon	Rare
Anacardiaceae	*Toxicodendron rydbergii*	X	X		
Apiaceae	*Cicuta douglasii*		X		
Asclepiadaceae	*Asclepias hallii*	X			X:S3
Asteraceae	*Artemisia ludoviciana*	X	X		
	Cosmos parviflorus			X	
	Erigeron lonchophyllus	X			
	Helenium autumnale	X	X		
	Helianthus pauciflorus		X		
	Liatris ligulistylis		X		X:S1/S2
	Oligoneuron albidum		X		X:S2/S3
	Oligoneuron rigidum		X		
	Packera pseudaurea	X			
	Rudbeckia hirta	X	X		
	Solidago missouriensis		X		
	Solidago nana	X			
	Symphotrichum ericoides		X		
	Symphotrichum laeve	X	X		
	Tripleurospermum perforatum	X			
Brassicaceae	*Arabis holboelii* var. *retrofracta*	X			
	Draba nemorosa	X			
Cactaceae	*Pediocactus simpsonii*	X			
Campanulaceae	*Campanula rotundifolia*	X			
	Lobelia siphilitica		X	X	
Caryophyllaceae	*Stellaria longifolia*	X			
Clusiaceae	*Hypericum scouleri*	X		X	
Cyperaceae	*Carex aurea*	X		X	
	Carex crawei	X			X:S1
	Carex disperma	X			
	Carex echinata	X		X	
	Carex simulata	X		X	
	Eleocharis quinqueflora	X		X	
Equisetaceae	*Equisetum arvense*	X			
Fabaceae	*Astragalus canadensis*		X	X	
	Dalea candida		X		
	Dalea purpurea		X		
	Glycyrrhiza lepidota		X		
Gentianaceae	*Gentianopsis amarella* (*strictiflora* type)	X			X* (not yet CNHP rated)
	Gentianopsis virgata		X		
Hippuridaceae	*Hippuris vulgaris*	X			
Iridaceae	*Hypoxis hirsuta*		X		X:S1
Juncaceae	*Juncus brachycephalus*		X		X:S1
	Juncus brevicaudatus		X		X:S1
Juncaginaceae	*Triglochin palustris*	X			
Lamiaceae	*Lycopus americanus*		X		
	Monarda fistulosa		X		
	Scutellaria galericulata			X	
Lentibulariaceae	*Utricularia minor*	X			X:S2
Liliaceae	*Lilium philadelphicum*	X	X		X:S3/S4
Malvaceae	*Sidalcea neomexicana*	X		X	
Onagraceae	*Gayophytum diffusum*	X			
	Oenothera flava			X	

Table 1. Continued

Family	Species	Foothills/Montane	Midwest Prairie	Locally Uncommon	Rare
Orchidaceae	*Platanthera aquilonis*	X			
	Spiranthes romanzoffiana	X		X	
Poaceae	*Agropyron cristatum*		X		
	Agrostis scabra	X			
	Alopecurus aequalis	X			
	Andropogon gerardii		X		
	Bouteloua curtipendula		X		
	Calamagrostis stricta	X			
	Calamovilfa longifolia		X		
	Elymus canadensis		X		
	Glyceria elata	X			
	Glyceria striata	X			
	Hesperostipa spartea		X	X	
	Koeleria macrantha	X	X		
	Muhlenbergia montana	X			
	Panicum virgatum		X		
	Poa fendleriana	X			
	Poa nemoralis ssp. *interior*	X	X		
	Poa pratensis				
	Schizachyrium scoparium		X	X	
	Sorghastrum nutans		X	X	
	Sporobolus heterolepis		X	X	
Polygonaceae	*Polygonum amphibium*		X		
Primulaceae	*Dodecatheon pulchellum*	X			
	Lysimachia ciliata		X	X	
Ranunculaceae	*Anemone canadensis*	XX	X		
	Anemone cylindrica	X	X		
Rosaceae	*Agrimonia striata*	X		X	
	Geum aleppicum	X			
	Potentilla arguta	X			
	Rosa arkansana		X		
Rubiaceae	*Galium boreale*	X			
	Galium trifidum	X			
Salicaceae	*Populus angustifolia*	X			
	Salix irrorata	X			
Selaginaceae	*Selaginella densa*	X			
Scrophulariaceae	*Nuttallanthus canadensis*			X	
	Pedicularis canadensis	X			
	Penstemon glaber	X			
	Penstemon gracilis		X	X	
	Veronica serpyllifolia	X			
Sparganiaceae	*Sparganium angustifolium*	X			
Valerianceae	*Valeriana edulis*	X			
Violaceae	*Viola sororia*	X	X		

Squirrel Creek, is the only A list species. Although a detailed floristic list was not an objective of the Livingston studies, we found almost all taxa he noted as still present, with only a few exceptions (Appendix 1).

Over one fifth of the flora was regionally associated with foothills/montane habitats, and at least a comparable proportion was characteristic of the Midwest prairies. By contemporary phytogeographic perspectives and greater documentation of the Great Plains flora, the Midwest association was almost certainly an underestimate, but to simplify comparison, we used for reference only those species explicitly listed in early studies as characteristic of the Midwest. Eight of the "Midwest" species were also locally characteristic of the foothills/montane zone. Eighteen plant species occurring in the Black Squirrel Creek drainage were locally uncommon, and nine were tracked by the Colorado Natural Heritage Program for being of conservation concern.

Wetland habitat Classifications

We identified eight general wetland habitat types characterized by distinct hydrogeomorphic characteristics and floristic profiles (Table 2). Our classification follows the Colorado Natural Heritage Program (Carsey et al. 2003) and includes general categories of Riverine Wetlands sourced by ongoing streamflow, Slope Wetlands supported by groundwater on gentle to moderate slopes, and Depressional Wetlands supported by ground water filling a depression on a permanent or intermittent basis. Each habitat type occurs in multiple instances throughout the Black Squirrel drainage. Vegetation associations listed for each hydrogeomorphic class follow those used by the Colorado Natural Heritage Program (Carsey et al. 2003; Culver & Lemley 2013) classifications as closely as possible.

Riverine Wetlands

Stream Channel Tall Willow Shrubland.—This community occurred in a limited extent on the northwestern edge of the main Black Squirrel Creek drainage, covering about a kilometer in length; shrub cover diminished further downstream, but reoccured in patches along the drainage in wide stream meanders with shallow subsurface water. The primary vegetation community was sandbar willow-mesic graminoid shrubland dominated by *Salix exigua* with occasional occurrences of other tree and shrub species of willow (e.g., *S. irrorata, S. ligulifolia,* and *S. amygdaloides*); the forb component was limited but included patchy occurrences of *Agrimonia striata*, *Cirsium canadensis*, *Glycyrrhiza lepidota*, *Helianthus nuttallii*, *Monarda fistulosa*, and *Rudbeckia hirta*.

Stream Channel Herbaceous Vegetation.—Open gravels of the main channel and occasional side drainages supported a linear strip of obligate wetland forbs, sedges, and rushes where stream flow formed riffles around gravel banks and sandbars. The gravel stream channels were notable for their abundance and diversity of rushes, including the rare *Juncus brachycephalus*, as well as *Gentianopsis virgata*. Both of these species are Midwest prairie elements known in Colorado only from this region. Although dominated by non-woody vegetation, the stream channels also supported occasional occurrences of young saplings of *Populus deltoides* or species of *Salix*.

Slope Wetlands

Moist Shelves.—These heterogeneous surfaces were located primarily in the main drainage above the creek channel depression and along some subsidiary drainages. Surfaces were flat to gently sloping, with moisture accumulating from springs and runoff above. Moister areas held a greater abundance of facultative or obligate wetland species interspersed with xeric elements. Vegetative cover was primarily composed of graminoids and mixed forbs with occasional shrub patches. *Sporobolus heterolepis* was particularly widespread here, and the shelves supported extensive occurrences of a *Sporobolus heterolepis* dominated community with occasional instances of *Andropogon gerardii*, along with patches of *Andropogon gerardii-Sorghastrum nutans* associations. The *Sporobolus*-dominated communities ranged in width from 5 m to almost 40 m; depending on the topography, lengths could be short patches of 10 m to longer extents over 50 m. Drier areas included heterogeneous mixed grass vegetation with *Calamovilfa longifolia, Koeleria macrantha, Muhlenbergia montana, Poa pratensis,* and *Schizachyrium scoparium*.

Moist Banks.—These encompassed a significant portion of the drainage system and held some of the highest diversity of forbs. One of the most significant species occurring here was the locally abundant, state-rare *Liatris ligulistylis*. The moist banks typically occurred on side drainages with a U-shape profile and received consistent subsurface moisture from seeps and springs; their surfaces were steeper than moist shelf habitats, and they usually included seeps that oozed perennial moisture. Plant associations included mixed mesic tallgrass communities with components of *Calamovilfa longifolia, Schizachyrium scoparium, Sorghastrum nutans, Sporobolus heterolepis,* and *Stipa spartea*. *Andropogon gerardii* clumps were common, but did not form a dominant component of the vegetative cover. Like moist shelf communities, bank communities sometimes occurred as lengthy strips to 50 or more meters, or as shorter patches interspersed with depressional wetlands.

Depressional wetlands

Nebraska Sedge Bogs and Meadows.—These associated habitats were both dominated by *Carex nebrascensis* and

Table 2. Common floristic elements in wetland communities of the Black Squirrel Creek drainage. For full nomenclature see Appendix 1.

	Graminoids	Forbs	Shrubs
RIVERINE WETLANDS			
Stream Channel Tall Willow Shrubland		*Agrimonia striata*	*Salix exigua*
		Helianthus nuttallii	*Salix irrorata*
	Monarda fistulosa		*Salix ligulifolia*
	Rudbeckia hirta		
‘Stream Channel Herbaceous Wetlands	*Juncus alpinoarticulatus*	*Epilobium ciliatum*	
	Juncus brachycephalus	*Gentianella strictiflora*	
	Juncus dudleyi	*Gentianopsis virgata*	
	Juncus interior	*Onosmodium bejariense*	
	Juncus saximontanus	*Veronica anagallis-aquatica*	
	Juncus torreyi		
SLOPE WETLANDS			
Moist Shelves	*Andropogon gerardii*	*Antennaria microphylla*	*Rosa arkansana*
	Calamagrostis stricta	*Astragalus canadensis*	*Symphoricarpos occidentalis*
	Elymus lanceolatus	*Erigeron bellidiastrum*	
	Juncus arcticus	*Fragaria vesca*	
	Poa pratensis	*Geum aleppicum*	
	Schizachyrium scoparium	*Glycyrrhiza lepidota*	
	Helianthus nuttallii		
	Monarda fistulosa		
	Pedicularis canadensis		
	Ratibida columnifera		
	Rudbeckia hirta		
‘Moist Banks	*Andropogon gerardii*	*Collomia linearis*	
	Poa pratensis	*Geum aleppicum*	
	Sorghastrum nutans	*Helenium autumnale*	
	Stipa spartea	*Helianthus nuttallii*	
	Liatris ligulistylis		
	Potentilla arguta		
	Prunella vulgaris		
	Rudbeckia hirta		
	Thermopsis montana		
	Viola sororia		
DEPRESSIONAL WETLANDS			
Sedge Meadows & Bogs	*Carex nebrascensis*	*Epilobium leptophyllum*	
	Glyceria elata	*Lobelia siphilitica*	
	Glyceria striata	*Mentha arvensis*	
	Juncus nodosus	*Polygonum pensylvanicum*	
	Juncus saximontanus	*Polygonum punctatum*	
	Juncus torreyi	*Scutellaria galericulata*	
	Poa leptocoma	*Stellararia longifolia*	
Open Seeps	*Carex aurea*	*Hypoxis hirsuta*	
	Carex crawei	*Spiranthes romanzoffiana*	
	Carex xerantica	*Dodecatheon pulchellum*	
	Eleocharis quinqueflora	*Gentianopsis virgata*	
	Juncus alpinoarticulatus	*Parnassia palustris*	
	Triglochin maritima	*Platanthera aquilonis*	
	Triglochin palustris	*Sisyrinchium montanum*	
Fens	*Carex simulata*	*Helenium autumnale*	
	Eleocharis acicularis		
	Scirpus pungens		
Ponds	*Scirpus microcarpus*	*Alisma triviale*	
		Hippuris vulgaris	
		Polygonum amphibium	
		Potamogeton natans	
		Ranunculus trichophyllus	
		Sagittaria cuneata	
		Sagittaria latifolia	
		Sparganium angustifolium	
		Utricularia minor	

typically occurred adjacent to streams and marshy areas with a high water table overlain by a layer of sediment and organic material. In the bogs, *Glyceria* was often present, along with a limited number of forbs such as members of the Polygonaceae and *Helenium autumnale.* Tributary channels above the water flow of drainage bottoms supported the more abundant sedge meadow community, which also occurred along shallow channels with no visible surface water. Sedge meadows were drier and more floristically diverse in hydrophytic graminoids, with Nebraska sedge occurring along with *Juncus arcticus*, other sedge species such as *Carex disperma*, as well as bulrush species in *Scirpus* and *Schoenoplectus*. Forbs included hydrophytes such as *Lobelia siphilitica* and *Scutellaria galericulata*, both regionally uncommon but locally abundant here, as well as the widespread *Mentha arvensis* and representatives of the Polygonaceae.

Open Seeps.—Open seeps underlain by clay lenses occurred frequently throughout the drainage system. Groundwater emerged through the soil to create a shallow layer of standing water 1–2 cm deep over saturated clay-rich mud with little to no vegetative cover. Seeps ranged from ca. 1 m^2 to 100 m^2 in area and were located above stream level along shallow bank margins. The surfaces were dotted with low hummocks, vegetation-covered mounds from 10 to 50 cm in height and width. These habitats encompassed an unusual flora composed of species more typical of higher elevations (e.g., *Dodecatheon pulchellum, Eleocharis quinqueflora,* and *Parnassia palustris*) along with a number of state-rare species, all Midwest prairie elements, such as *Carex crawei*, *Gentianopsis virgata,* and *Hypoxis hirsuta*.

Fens.—This habitat type was a significant wetland community because only a few are known east of the Front Range, although diverse types occur commonly in higher elevations. Fens are characterized by a deep, subsurface peat layer (Culver & Lemly 2013) and abundant *Carex simulata*. A *C. simulata* matrix is characteristic of higher elevation fens and indicative of peatland development (Culver and Lemly 2013). The largest Black Squirrel Creek fen covered ca. 400 m^2 in a subsidiary drainage north of the main channel below a large open seep. It was characterized by *Carex simulata* mats with occasional occurrences of *Eleocharis acicularis, Carex nebrascensis,* and *Schoenoplectus pungens*. The few forbs present included *Helenium autumnale* and *Parnassia palustris*. Soils were highly saturated and visibly quaked when stepped upon; the underlying peat layer was over a meter thick. Smaller apparent fens where the vegetation was dominated by *C. simulata* occurred sporadically in subsidiary wet drainages.

Ponds.—A number of small ponds occurred throughout the drainages. These are generally less than 9.3 m^2 (ca. 100 ft. ^{2}) in area, with a depth of 0.3 m (1 ft) to over 1.5 m (4 ft), depending on precipitation. The ponds supported abundant amphibians, aquatic insects, crustaceans, and other larger vertebrates such as minnows, along with diverse floating and emergent plant species. Pond associations included an emergent *Typha* marsh community, and a floating aquatic community with the carnivorous species *Utricularia minor* in shallow ponds, along with more common aquatics such as *Sagittaria*, *Alisma*, *Sparganium*, and *Potamogeton*.

Vegetation transects

Vegetative and Graminoid Cover.—Transects were situated primarily on moist banks and moist shelves, although they also encompassed Nebraska sedge meadows and bogs as well as open seeps (Fig. 2). They varied in their vegetative cover and the relative cover of graminoids, forbs, or litter/bare ground (Table 3; Fig. 4). On average, total basal vegetative cover was slightly over 50%, and graminoids constituted almost 80% relative cover. The dominant grass contributors to cover (in order of prominence: *Sporobolus heterolepis*, *Muhlenbergia montana*, *Schizachyrium scoparium*, *Sorghastrum nutans*, and *Calamovilfa longifolia;* Table 4) parallelled key components documented by Livingston (1952). Common but lesser contributors in both studies included *Andropogon gerardii*, *Hesperostipa spartea*, and *Panicum virgatum*.

Variation among the transect quadrats reflected the characteristic local heterogeneity of patchy clumps of vegetation interspersed with open soil. Transect 1 was the most hydric, with abundant subsurface water and a small seep dominated by *Juncus arcticus*. It had the highest overall cover, primarily *Sorghastrum nutans*, *Sporobolus heterolepis*, and *Schizachyrium scoparium,* with lesser components of *Muhlenbergia montana, Bouteloua gracilis, Calamovilfa longifolia, Panicum virgatum,* and *Koeleria macrantha*.

Although adjacent to transect 1, transect 2 showed somewhat different community structure where the

Table 3. Comparison of total vegetative cover and relative cover of dominant graminoid species, 2011 and Livingston studies of the 1940s. T1–T4 represent 2011 transects. L1–L7 represent data from Livingston (1947, 1952; 1952 transect numbers modified from those used in 1947).

	T 1	T 2	T 3	T 4	Mean All Transects
Total % Vegetative Cover	63.8	58.8	46.5	43.8	53.2
Relative % Cover All Graminoids	69.5	77.7	86.5	85.7	79.9
Dominant Grasses (% Relative Cover)	*Sorghastrum nutans* (12) *Sporobolus heterolepis* (9) *Schyzachyrium scoparium* (7.5) *Bouteloua* sp. (4.5) *Muhlenbergia montana* (4.2) *Calamovilfa longifolia* (3.2) *Panicum virgatum* (2.8) *Koeleria macrantha* (0.7)	*Sorghastrum nutans* (25.3) *Schizachyrium scoparium* (20.2) *Muhlenbergia montana* (8.9) *Calamovilfa longifolia* (7.4) *Sporobolus heterolepis* (7.2) *Bouteloua gracilis* (1.3) *Hesperostipa spartea* (1.2) *Nasella viridula* (1)	*Sporobolus heterolepis* (27.1) *Calamovilfa longifolia* (20) *Andropogon gerardii* (12) *Bouteloua gracilis* (8.9) *Muhlenbergia montana* (4.9) *Schizachyrium scoparium* (0.9)	*Muhlenbergia montana* (36.8) *Sporobolus heterolepis* (18.7) *Schizachyrium scoparium* (17.5) *Hesperostipa spartea* (3.9) *Sorghastrum nutans* (3)	*Sporobolus heterolepis* (15.1) *Muhlenbergia montana* (13.2) *Schizachyrium scoparium* (11) *Sorghastrum nutans* (10.7) *Calamovilfa longifolia* (7.8)
Forest	**L1**	**L2**	**L3**	**L4**	**Mean**
Dominant Grasses (% Relative Cover)	*Poa pratensis* (31.4)	*Bouteloua gracilis* (14.2)	*Sporobolus heterolepis* (33.9)	*Sporobolus heterolepis* (73.4)	*Sporobolus heterolepis* (36.7)
	Sporobolus heterolepis (29.1)	*Poa compressa* (10.5)	*Muhlenbergia montana* (9.3)	*Poa pratensis* (4.6)	*Poa pratensis* (9)
	Muhlenbergia montana (4.9)	*Sporobolus heterolepis* (10.1)	*Bouleloua gracilis* (6.8)		*Bouteloua gracilis* (5.3) *Muhlenbergia montana* (3.5)
Plains	**L5**	**L6**	**L7U/M/L**		**Mean**
Dominant Grasses (% Relative Cover)	*Andropogon gerardii* (28.2)	*Sporobolus heterolepis* (30.7)	*Schizachyrium scoparium* (47.2/28.7/55.8)		*Sporobolus heterolepis* (35)
	Bouteloua gracilis (19.8)	*Schizachyrium scoparium* (25.3)	*Bouteloua gracilis* (31.0/4.9/15)		*Schizachyrium scoparium* (31.4)
	Sporobolus heterolepis (12.5)	*Elymus trachycaulus* (8.0)	*Calamovilfa longifolia* (10.6/0/0.8)		*Bouteloua gracilis* (15)
	Calamovilfa longifolia (8.1)	*Andropogon gerardii* (5.2)	*Sorghastrum nutans* (0.3/30.7/2.1)		*Calamovilfa longifolia* (7.6) *Andropogon gerardii* (6.7)

microtopography of the terraces contributed to variable soil moisture and texture. This transect was also dominated by *Sorghastrum nutans*, contributing ca. 25% of the vegetative cover, with *Schizachyrium scoparium* contributing an additional 20%. *Sporobolus heterolepis* contributed considerably lesser cover here (7%). In general, this transect showed a greater presence of more xeric elements such as *Muhlenbergia montana* and *Calamovilfa longifolia* than transect 1 above it, and somewhat less overall cover.

Transect 3, in a side drainage adjacent to the main channel, had comparatively lower cover than transects 1 and 2, less than 50% overall; 90% of this cover was composed of grasses dominated by *Sporobolus heterolepis, Calamovilfa longifolia* and *Andropogon gerardii*. Together these species accounted for ca. 59% relative cover. This was the only transect in which *A. gerardii* appeared to a notable extent, contributing 12% relative cover.

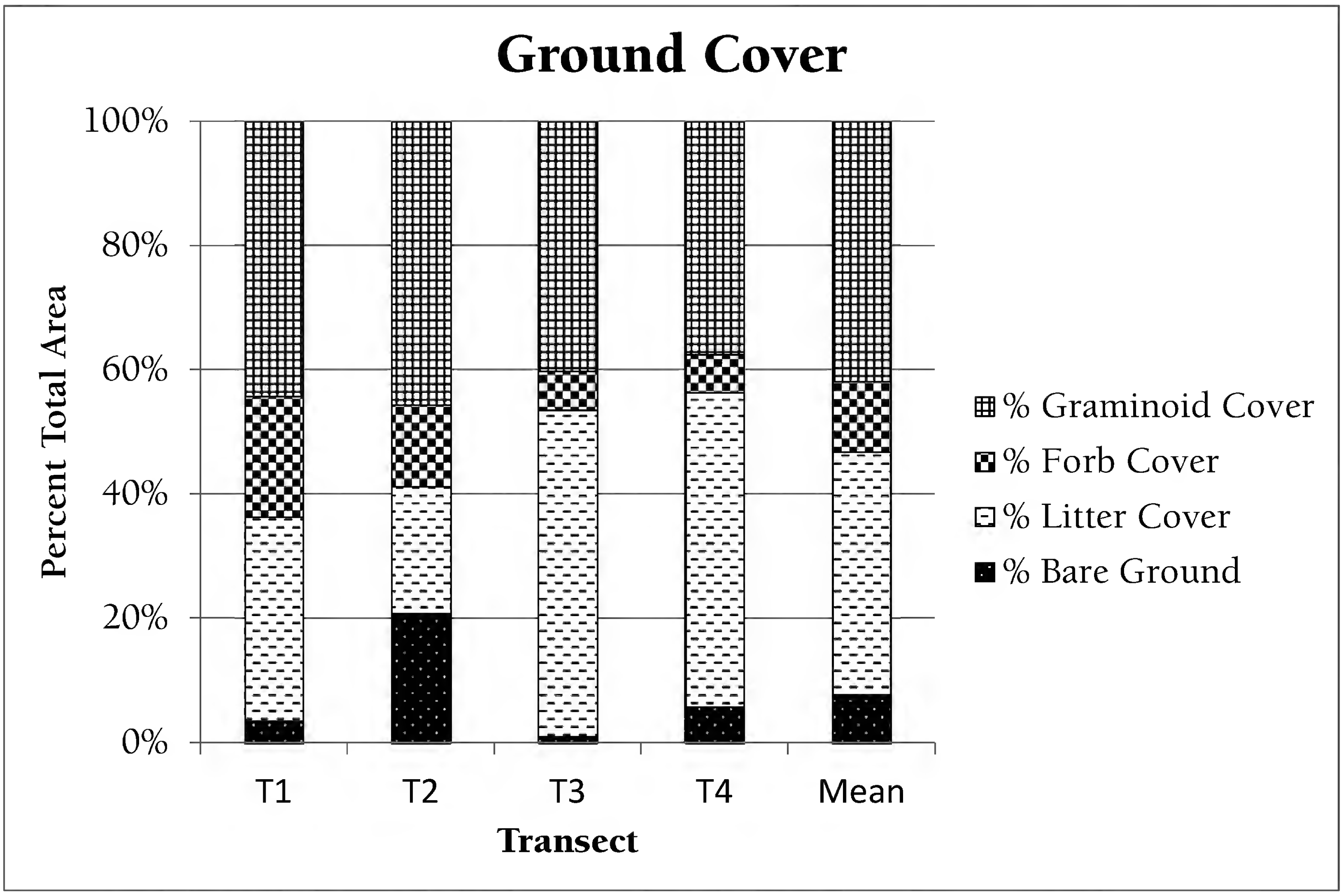

Fig. 4. Percent ground cover of graminoids, forbs, litter and bare ground for 2011 transects. T1–4 refers to transect numbers as described in the text.

Table 4. Comparison of the highest frequency grasses in the Livingston (1947; 1952) study and 2011. T1–T4 are 2011 transects; L1, L4, L5, and L6 are Livingston data from 1947, republished in 1952. No frequency data were given for transects L2, L3, and L7. Livingston stations L1–L4 were located in the Black Forest ("forest stations" sensu Livingston) and stations L5–L6 were "plains" transects. 2011 transects were located midway in distance and elevation between the forest and plains transects.

Species	T1	T2	T3	T4	Mean %F in 2011 (rank)	L1	L4	Mean %F-forest 1952 (rank)	L5	L6	Mean %F – plains 1952 (rank)
Andropogon gerardii	0	0	35	0	9(8)	10	10	10(6)	70	30	50(4)
Bouteloua gracilis	0	20	30	10	15(6)	0	0	0	100	30	65(2)
Calamovilfa longifolia	20	50	50	20	35(4)	0	0	0	90	30	60(3)
Hesperostipa spartea	0	15	0	50	11(7)	40	10	25 (5)	0	0	0
Koeleria macrantha	15	0	0	0	4(9)	10	50	30(4)	30	10	20(6)
Muhlenbergia montana	15	40	35	80	43(1)	80	20	50(3)	40	0	20 (6)
Panicum virgatum	5	0	5	0	3(10)	0	0	0	10	30	20(6)
Poa pratensis	5	10	0	20	9(8)	80	40	60(2)	0	0	0
Schizachyrium scoparium	30	60	10	50	38(2)	10	0	5(7)	95	90	93(1)
Sorghastrum nutans	55	80	0	10	36(3)	0	0	0	15	30	23(5)
Sporobolus heterolepis	25	25	50	35	34(5)	70	100	85(1)	40	100	60(3)

In transect 4, located in a large subsidiary drainage with a perennial secondary stream, vegetative cover was also less than 50%, and composed primarily of *Muhlenbergia montana*, *Sporobolus heterolepis*, and *Schizachyrium scoparium*; together these species comprised 73% of the graminoid cover. *Hesperostipa spartea* and *Sorghastrum nutans* were more frequent here than in the other transects, although they contributed relatively little to cover. Both species are regionally uncommon to rare (but not considered rare statewide), and when present, they typically occur in disparate clumps. This characteristic pattern was apparent in transect 4, and underscored the decoupled metrics of a species contribution to cover from overall frequency of occurrence for individual species in these communities.

Grass Species Frequency Rankings

Across all transects, the most common species (Table 3) were *Muhlenbergia montana* (frequency of ca. 42% of all quadrats), *Schizachyrium scoparium* (37% frequency), *Sorghastrum nutans* (36% frequency), *Calamovilfa longifolia* (35% frequency), *Sporobolus heterolepis* (34% frequency), and *Juncus arcticus* (32% frequency). Grass taxa of second tier frequency included *Hesperostipa spartea* (16% frequency), *Bouteloua gracilis* (15% frequency), *Andropogon gerardii* (9% frequency), and *Poa pratensis* (9% frequency). The highest frequency non-graminoid taxa (data not shown) included a high representation of Midwest prairie elements, notably *Artemisia ludoviciana, Dalea purpurea, Equisetum arvense, Glycyrrhiza lepidota, Helenium autumnale, Oligoneuron rigidum, Rosa arkansana, Symphotrichum ericoides,* and *Symphotrichum laeve.* These species were common components of the regional mixed grass prairie; only *Helenium autumnale* is an elevational disjunct more common in the Foothills/Montane zone than on the plains.

DISCUSSION

Comparison of Grassland Vegetation Structure: 1940s and 2011

Both studies document considerable variation within and among transects and the overall means cover wide ranges at both time frames (Table 3). We found considerably higher basal vegetative cover (typically over 50%) than what Livingston reported (typically less than 20%). In 2011, graminoids constituted ca. 80% of this cover, while on the Livingston forest-grassland plots, 85% of this cover was constituted by graminoids, and on the plains plots, 55%. The dominant grasses were similar, with *Sporobolus heterolepis* being the top contributor to cover in both studies. In 2011, *Muhlenbergia montana, Schizachyrium scoparium, Sorghastrum nutans,* and *Calamovilfa longifolia* were also important components; jointly these provided 60% relative cover. In the Livingston study, in addition to *S. heterolepsis* (55% relative cover), *Poa pratensis, Bouteloua gracilis,* and *M. montana* contributed most highly on the forest transects while *S. scoparium, B. gracilis, C. longifolia, and A. gerardii* played key secondary roles on the plains (95% relative cover).

Comparison of the frequency of species occurrence (Table 4) provides a similar picture of a consistent suite of species common to both time frames, albeit with different rankings for individual frequencies. *Muhlenbergia montana, Schizachyrium scoparium, Sorghastrum nutans, Calamovilfa longifolia,* and *Sporobolus heterolepis* were the most commonly occurring species in 2011, each present in over 30% of the quadrats. On the Livingston forest plots, *S. heterolepis, Poa pratensis, M. montana,* and *Koeleria macrantha* were most frequently encountered, while on the plains, *S. scoparium, B. gracilis, S. heterolepis, C. longifolia,* and *A. gerardii* each occurred in at least 50% of the quadrats.

The 2011 structure of the tallgrass vegetation of Black Squirrel Creek remained strongly comparable to what Livingston described in the 1940s with respect to the most frequent grass species and those that contributed the most cover. Key species in the 1940s (in particular, *Sporobolus heterolepis, Muhlenbergia montana, Schizachyrium scoparium,* and *Sorghastrum nutans*) remained important now. *Andropogon gerardii* seems to have diminished in both frequency and contribution to cover since the 1940s, although even then it was not a dominant component of the vegetation. However, because the Livingston transects could not be precisely relocated, our transect positions did not match his sample sites, and at least some of these differences may be artifacts of different transect positions. Other differences may result from limited sampling in a landscape mosaic where topography, edaphic factors, and at least to some extent, current and past grazing practices, create patchy vegetation or bare ground. Because our plots had light grazing and no mowing (in comparison to the Livingston plots that were subjected to grazing and seasonal mowing), this may have allowed for greater cover to develop in some areas. Alternatively, these differences may reflect real changes in species abundance. Possible considerations include recovery lag from the 1930s Dust Bowl decade that might have exerted a lingering effect during the 1940s, or the converse, when several substantial drought episodes in the intervening decades since the Livingston work may have influenced the response and recovery of individual species.

Although Livingston's characterization of Midwestern grasslands as "true prairie" may be arguable, his analogy of the Black Squirrel Creek vegetation to the Midwestern grasslands was then, and remains now, appropriate with respect to the major grasses present and their relative contributions to cover, as well as to the forb and shrub elements in the flora and vegetation structure. However, this vegetation is not identical to iconic tallgrass associations of the central prairies and identified elsewhere in Colorado, where *Andropogon gerardii* is the signature species with the highest cover and frequency (Moir 1972; Bock & Bock 1998; Neid et al. 2009). In the Black Squirrel Creek associations, while *A. gerardii* never contributed highly to cover, it occurred relatively frequently. The most prominent grass was *Sporobolus heterolepis,* occurring with foothills/montane species such as *Muhlenbergia montana* and xeric or mixed grass prairie species such as *Calamovilfa longifolia* and *Bouteloua gracilis.* The Black Squirrel Creek vegetation may be better described as *Sporobolus heterolepis–Muhlenbergia montana* grasslands with subsidiary components of *Calamovilfa longifolia, Schizachyrium scoparium,* or *Sorghastrum nutans* rather than the more classical model of tallgrass communities defined by the dominance of *A. gerardii.* No comparable associations dominated by *Sporobolus heterolepis* are currently listed by NatureServe (2013), or documented in Colorado, although Weaver (1954) described prairie dropseed communities as a distinctive, albeit minor, component of xeric upland prairie on the midwestern plains.

The Wetland-Grassland Mosaic

We concur with the conclusion reached by Livingston (1952) specifically for the Black Squirrel Creek/Black Forest area, and Branson et al. (1965) more broadly for the Colorado mountain front, that adequately high soil moisture is the key factor responsible for the occurrence of mesic tallgrass prairie. As transitional zones between aquatic and terrestrial habitats, wetlands play vital roles in linking ecological and hydrological systems (Culver and Lemly 2013) and are widely recognized for having high biological significance due to their variety of biodiversity and community types; this is particularly true in the arid Arkansas River drainage of Pueblo and El Paso Counties (Doyle et al. 2001b) where few wetlands presently occur. In the Black Squirrel Creek drainage, the wetlands were a critical part of the vegetation mosaic of hydric and mesic communities and entwined biota. As noted in other prairie systems (Semlitsch and Bodie 1998; Leibowitz 2003), even small and superficially discontinuous imbedded wetlands support metapopulation, corridor, seasonal or annual habitat dynamics for flora and fauna by connecting subsurface geology and hydrology. In the Black Squirrel Creek drainage, this connectivity sustains the anomalous vegetation and flora and is certainly part of their longevity.

A conclusion of botanical stasis along Black Squirrel Creek is not appropriate, however. Change has occurred, perhaps with respect to change in frequency of certain species, but certainly visibly with respect to extent of these grasslands, which now exist as remnants reduced in both number and size since the 1940s, and even by then probably reduced from their former extent prior to extensive ranching (Livingston 1952). Where widespread mesic grasslands once prevailed, housing developments and infrastructure or altered grasslands with adventive, grazing- tolerant, or xeric species sometimes now dominate. In spite of these alterations and diminished extent of communities flagged as noteworthy 70 years ago, the Black Squirrel Creek drainage remains a remarkable center of biotic diversity increasingly significant for its numerous rare or uncommon species, and its elevational and longitudinal disjuncts. Its unique grasslands show clear affiliation to their geographically and temporally distant cousins that are not structurally identical but nonetheless strongly conspecific in their floristic profiles.

Although it remains speculative that these communities are *in situ* Pleistocene relicts, they have endured substantial climatic vicissitudes. In the past century, interannual droughts have occurred regularly, and severe droughts within the context of these comparative studies show little apparent major impact in areas directly supported by ground water. Where this vegetation remains, the Black Squirrel Creek drainage testifies to the capacity of hydrogeomorphic systems to sustain relative stasis in prairie plant communities and their constituent flora through fluctuating temperature and moisture regimes. Whether this system can be self-sustaining through accelerating anthropogenic and climatic pressures remains an open question and concern.

APPENDIX 1

ANNOTATED CHECKLIST OF THE VASCULAR FLORA
UPPER BLACK SQUIRREL CREEK DRAINAGE, EL PASO CO., COLORADO

Species list for vascular flora occurring in mesic and hydric communities of the upper Black Squirrel Creek drainage from 7000–6500 feet in elevation. The list includes some upland species occurring sporadically in the drainage system and gravel stream channels, but which are more typically found in the surrounding xeric mixed grass and shortgrass matrix in the surrounding uplands. Nomenclature (including family designations) and common names follow the National Resource Conservation Service database (www. Plants.USDA.gov: accessed 8/2013) except as noted. Nomenclature used in Colorado (e.g., Weber & Wittmann 2012) is given in curly braces as {name} prior to the common name. Alternative Angiosperm Phylogeny Group familial designations (APG; www.mobot.org/MOBOT/Research/APweb) are included for each family. Voucher specimens for all taxa are at COCO. Noteworthy species are coded as follows:

FM Species generally occurring in Foothills/Montane zone 2000–3200 m (ca. 7000–10,500 ft). Distributions follow Weber and Wittman 2012; Culver and Lemly 2013; Kelso, 2012); occurrence on the prairie is restricted.

MWP Species prominent in Midwest prairie as explicitly noted by Shantz (1923), Weaver and Fitzpatrick (1934: Tables 15; 16), Weaver (1954), and Livingston (1952). Earlier nomenclature used in these publications cross-referenced with NRCS Plants Database synonyms.

R Rare species listed as of conservation concern and tracked by the Colorado Natural Heritage Program (2012): State Conservation rankings are as follows: S1: Critically Imperiled, S2: Imperiled, S3: Vulnerable

U Locally or regionally uncommon or local endemic (Kelso 2012; Weber & Wittmann 2012)

X Xeric element of uplands extending into mesic vegetation

L indicates a species noted in the Livingston studies; square brackets indicates a species observed but not recollected in our study. Unless otherwise noted, these are locally common components of the xeric plains flora. Livingston species not observed are so indicated.

Species with no coding are locally widespread components of regional vegetation.

Amaranthaceae
Froehlichia gracilis (Hook.) Moq. (slender snakecotton) **X**

Alismataceae
Sagittaria cuneata Sheldon (arumleaf arrowhead)
Sagittaria latifolia Willd. (broadleaf arrowhead)
Alisma triviale Pursh (northern water plaintain)

Anacardiaceae
Toxicodendron rydbergii (Small) Greene (poison ivy) **FM, MWP**

Apiaceae
Cicuta douglasii (D.C.) J.M. Coulter & Rose (western water hemlock) **MWP**
Berula erecta (Hudson) Coville (cutleaf water parsnip)

Apocynaceae
Apocynum cannabinum L. (Indianhemp)

Asclepiadaceae (APG Apocynaceae)
Asclepias hallii A. Gray (Hall's milkweed) **R (S3), FM**
Asclepias speciosa Torr. (showy milkweed)

Asteraceae
Achillea millefolium L. (common yarrow) **L**
Agoseris glauca (Pursh) Raf. (pale agoseris)
[*Ambrosia artemisiifolia* L. (annual ragweed) **L]**
Ambrosia psilostachya DC. (Cuman ragweed) **X**
Antennaria microphylla Rydb. (littleleaf pussytoes) **X; L** as *A. parviflora*
[*Artemisia campestris* L. ssp. *caudata* (Michx.) Hall & Clements (field sagewort) **L**]
Artemisia frigida Willd. (prairie sagewort) **X, L**
Artemisia ludoviciana Nutt. (white sagebrush) **MWP, L** as *A.gnaphalodes*
Bahia dissecta (A. Gray) Britton (ragleaf bahia) **X**
Bidens tenuisecta A. Gray (slimlobe beggarticks)
Carduus nutans L. (nodding plumeless thistle) Noxious weed of limited occurrence on the study site; few individuals.
Cirsium arvense (L.) Scop. {*Breea arvense*} (Canada thistle) Noxious weed of limited occurrence on the study site
Cirsium flodmanii (Rydb.) Arthur (Flodman's thistle)
Conyza canadensis (L.) Cronquist (Canadian horseweed) **L** as *Leptilon canadensis*
Cosmos parviflorus (Jacq.) (southwestern cosmos) **U** Southwestern species known primarily as regional endemic to the Black Forest region; locally common along Black Squirrel Creek on gravelly stream channels.
Erigeron bellidiastrum Nutt. (western daisy fleabane)
Erigeron compositus Pursh (cutleaf daisy) **FM**
Erigeron divergens Torr. & A. Gray (spreading fleabane)
Erigeron flagellaris A. Gray (trailing fleabane)
Erigeron glabellus Nutt. (streamside fleabane)
Erigeron lonchophyllus Hook. {*Trimorpha lonchophylla*} **FM**
Erigeron subtrinervis Rydb. ex Porter & Britton (threenerve fleabane)
Erigeron vetensis Rydb. (early bluetop fleabane) **FM**
Grindelia squarrosa Dunal (curlycup gumweed)
Helenium autumnale L. (common sneezeweed) **FM, MWP, L**
Helianthus annuus L. (common sunflower)
Helianthus nuttallii Torr. & A. Gray (Nuttall's sunflower)
Helianthus petiolaris Nutt. (prairie sunflower) **L**

Helianthus pumilus Nutt. (little sunflower)
Helianthus pauciflorus Nutt. ssp. (Rydb.) O. Spring. & E. Schilling {*Helianthus rigidus*} (stiff sunflower) **MWP, L**
Heterotheca canescens (D.C.) Shinners (hoary false goldenaster) **L** as *Chrysopsis villosa*
Lactuca tatarica (L.) Meyer (blue lettuce)
Liatris ligulistylis (A. Nelson) K. Schum. (Rocky Mountain blazingstar) **R (S1/S2), MWP, L** Common in seeps and tallgrass communities on the study site.
Liatris punctata Hook. (dotted blazingstar) **MWP, L**
Lygodesmia juncea (Pursh) D. Don ex Hook. (rush skeletonplant)
Oligoneuron album (Nutt.) G.L. Nesom {*Unamia alba*} (prairie goldenrod) **R (S2/S3), MWP, L**
Oligoneuron rigidum (L.) Small (stiff goldenrod) **MWP, L** as *Solidago rigidum*
[Packera neomexicana (A. Gray) W.A. Weber & Á. Löve var. mutabilis (Greene) W.A. Weber & Á. Löve (New Mexico groundsel) **L** as *Senecio mutabilis*)
Packera pseudaurea (Rydb.) W.A. Weber & A. Löve (falsegold groundsel) **FM**
Packera tridenticulata (Rydb.) W.A. Weber & A. Löve (threetooth ragwort)
Pseudognaphalium canescens (D.C.) W.A. Weber (Wright's cudweed)
Ratibida columnifera (Nutt.) Woot. & Standl. (upright prairie coneflower)
Rudbeckia hirta L. (black eyed Susan) **FM, MWP, L**
[*Salsola tragus* L. (prickly Russian thistle) **L** as *Salsola pestifer*]
Schkuhria multiflora Hook. & Arn. (manyflower false threadleaf) **X**
Senecio spartioides Torr. & A. Gray (broomleaf ragwort)
Solidago gigantea Aiton (giant goldenrod)
Solidago missouriensis Nutt. (Missouri goldenrod) **MWP, L**
Solidago nana Nutt. (baby goldenrod) **FM**
Solidago nemoralis Aiton (gray goldenrod) **L**
Solidago velutina D.C. (three-nerve goldenrod)
Symphotrichum ericoides (L.) A. Löve & D. Löve (white heath aster) **MWP, L** as *Aster multiflorus*
Symphotrichum laeve (L.) A. Löve & D. Löve (smooth aster) **FM, MWP, L** as *Aster geyeri*
Symphotrichum lanceolatum (Willd.) G.L. Nesom (white panicle aster)
[*Thelesperma megapotamicum* (Spreng.) Kuntze (Hopi tea greenthread) **L** as *Thelesperma gracile*]
Tragopogon dubius Scop. (yellow salsify)
Tripleurospermum perforatum (Merat) M. Lainz (scentless false marigold) **FM**
Tetraneuris acaulis (Pursh) Greene (stemless four-nerve daisy)

Boraginaceae

Cryptantha cinerea (Greene) Cronquist {*Oreocarya suffruticosa*} (James' cryptantha) **X** [*Lappula occidentalis* (S. Watson) Greene (flatspine stickweed) **L**]
Mertensia lanceolata (Pursh) D.C. (prairie bluebells)
Onosmodium bejariense DC var. *occidentale* (Mack.) B.L. Turner {*Onosmodium molle* ssp. *occidentale*} (softhair marbleseed)
Plagiobothrys scouleri I.M. Johnst. (Scouler's popcorn flower)

Brassicaceae

Arabis holboelii Hornem. var. *retrofracta* Rydb. {*Boechera retrofracta*} (second rockcress) **FM**
Barbarea orthoceras Ledeb. (American yellowrocket)
Draba nemorosa L. (woodland draba) **FM**
Sisymbrium loeselii L. (small tumbleweed mustard)

Cactaceae

Pediocactus simpsonii (Engelm.) Britton & Rose (mountain ball cactus) **FM**
Opuntia polyacantha Haworth (plains prickly pear) **L**

Campanulaceae

Campanula rotundifolia L. (bluebell bellflower) **FM**
Lobelia siphilitica L. (great blue lobelia) **U, MWP, L** Common on the study site; regionally uncommon species

Caprifoliaceae

Symphoricarpos occidentalis Hook. (western snowberry)

Caryophyllaceae

Arenaria hookeri Nutt. {*Eremogone hookeri*} (Hooker's sandwort)
Stellaria longifolia Muhl. ex. Willd. (longleaf starwort) **FM**
Paronychia jamesii Torr. & A. Gray (James' nailwort) **X**
[*Silene scouleri* Hook. (simple campion) **L**] Species common in the foothills/montane zone but not currently known from this location

Chenopodiaceae (APG Amaranthaceae)

Chenopodium graveololens Willd. {*Teloxis graveolens*} (fetid goosefoot)
Chenopodium leptophyllum (Moq.) Nutt. (narrowleaf goosefoot), **L**
Cycloloma atriplicifolium (Spreng.) J.M. Coulter (winged pigweed)
Suaeda calceoliformis (Hook.) Moq. {Suaeda depressa} (Pursh seepweed)

Clusiaceae

Hypericum scouleri Hook. {Hypericaceae: *Hypericum formosum*} (Scouler's St. Johnswort) **FM**

Commelinaceae

Tradescantia occidentalis (Britton) Smythe (prairie spiderwort)

Crassulaceae

Sedum lanceolatum Torr. (spearleaf stonecrop)

Cyperaceae

Carex aurea Nutt. (golden sedge) **FM, U, L**
Carex brevior (Dewey) Mack. (shortbeak sedge) **L**
Carex crawei (Dewey) (Crawe's sedge) **R (S1), FM**
Carex disperma Dewey (softleaf sedge) **FM**
Carex douglasii Boot (Douglas' sedge)
Carex echinata Murray {*Carex angustior*}(star sedge) **FM, U**
[*Carex filifolia* Nutt. (threadleaf sedge) **L**]
[*Carex heliophila Mack. = C. inops* L.H. Bailey ssp. *heliophila* (Mack.) Crins (sunsedge) **L**]
[**Carex oreocharis* T. Holm (grassyslope sedge) **L-** not observed this study]
Carex pellita Muhl. {*Carex lanuginosa*} wooly sedge
Carex nebrascensis Dewey (Nebraska sedge) **L**
[**Carex hallii* Olney [*C. parryana* Dewey ssp. *hallii* [specimen coll. *R.B. Livingston 1430*: @COCO;] (deer sedge)]
[**Carex praegracilis* W. Boott) **L**-not observed this study]
Carex simulata Mack. (analogue sedge)
Carex xerantica L.H. Bailey (whitescale sedge)
Eleocharis acicularis (L.) Roemer & Schultes (needle spikerush)
Eleocharis obtusata (Willd.) Schult. (blunt spikerush)
[*Eleocharis palustris* (L.) Roem. & Schult. (common spikerush) **L**]
Eleocharis quinqueflora (Hartmann) O. Schwartz (fewflower spikerush) **FM**
Cyperus schweinitzii Torr. (Schweinitz' flatsedge) {*Mariscus schweinitzii*}
Schoenoplectus acutus (Muhl.) A. Löve & D. Löve {*Scirpus acutus*} (hardstem bulrush)
Schoenoplectus pungens (Vahl) Palla (common threesquare)
Schoenoplectus tabernaemontani (C.C. Gmelin) Palla (softstem bulrush) {*Scirpus lacustris*}
Scirpus microcarpus Presl. & C. Presl (panicled bulrush)

Equisetaceae

Equisetum arvense L. (field horsetail) **MWP, L**
Equisetum laevigata A. Brown (smooth horsetail) **MWP**

Euphorbiaceae

Chamaesyce glyptosperma (Engelm.) Small (ribseed sandmat) **L** as Euphorbia glyptosperma
Euphorbia brachycera Engelm. (horned spurge) **X**

Fabaceae

Amorpha fruticosa L. var. *angustifolia* Pursh (false indigo bush)
Astragalus canadensis L. (Canadian milkvetch) **U, MWP**
Dalea candida Michx. ex Willd. (white prairieclover) **MWP**
Dalea purpurea Vent. (purple prairieclover) **MWP, L** as *Petalostemon purpureus*
Gleditsia triacanthos L. (honeylocust) A single tree occurring on edge of study site near old ranch buildings.
Glycyrrhiza lepidota Pursh (American licorice) **MWP, L**
Lathyrus polymorphus Nutt. (manystem pea)
Lupinus pusillus Pursh (rusty lupine)
[*Melilotus officinalis* (L.) Lam. (sweetclover) **L** as *M. alba*]
Oxytropis multiceps Nutt. (Nuttall's oxytrope)
Robinia neomexicana A. Gray (New Mexico locust) Occasional trees occurring on edges of study site near old ranch buildings.
[*Thermopsis montana* Nutt. (mountain goldenbanner) **L**]
[*Trifolium pratense* L. (red clover) **L**]
[*Trifolium repens* L. (white clover) **L**]
[*Vicia americana* Muhl. ex Willd. (American vetch) **L**]

Gentianaceae

[*Gentiana affinis* Griseb. (pleated gentian) **L**]
Gentianella amarella (L.) Borner ssp. *acuta* (Michx.) Gillette {*Gentianella strictiflora*} (autumn dwarf gentian) **FM, L** As noted by Weber and Wittmann (2012), the densely white flowered form with a stiffly erect inflorescence is very distinctive in this region in the montane zone and in higher elevations on the plains; it is easily recognized as separate from the *amarella/acuta* form. The form occurring in the Black Squirrel Creek region is the "strictiflora" form, rather than the purple flowered, smaller "acuta" form.
Gentianopsis virgata (Raf.) Holub {*Gentianopsis procera* ssp. *crinita; G. crinita*} [lesser fringed gentian] **R (CHNP-Not rated), MWP** This species, recently confirmed by Flora of North America experts in the genus, is only known to occur in the upper Black Squirrel Creek drainage. Although not yet listed by Colorado Natural Heritage Program, its state rarity and disjunct connection to the Midwest prairie flora is notable.

Geraniaceae

Geranium atropurpureum A. Heller. {G. *caespitosum* ssp. *atropurpureum*}(western purple crane's bill) **FM**

Grossulariaceae

Ribes aureum Pursh (golden currant)

Haloragaceae

Myriophyllum sibiricum Kom. (shortspike watermilfoil)

Hippuridaceae (APG Plantaginaceae)

Hippuris vulgaris L. (common mare's tail) **FM**

Hypoxidaceae

Hypoxis hirsuta (L.) Coville (common goldenstar) **R (S1), MWP**

Iridaceae

Iris missouriensis Nutt. (wild iris)
Sisyrinchium montanum Greene (strict blue eyed grass) **FM, L** as S. angustifolium

Juncaceae

Juncus alpinoarticulatus Chaix (northern green rush)
Juncus arcticus Willd. ssp. *littoralis* (Willd.) Hultén {*J. arcticus* ssp. *ater*} (mountain rush), **L** as *J. balticus*
Juncus brachycephalus (Engelm.)Buchenar (smallhead rush) **R(S1), MWP,** L
Juncus brevicaudatus* (Engelm.) Fernald: narrowpanicle rush **R (S1); MWP A specimen of this species under the name *J. brachycephalus* (*Penland 4935*; COCO; OSH) was collected by in the Black Squirrel Creek drainage) and later verified by N. Harriman and F. Herrmann (Herrmann, 1975) as the very similar *J. brevicaudatus*. We have tentatively identified one of our collections as this species. It grows intermixed with *J. brachycephalus.*
Juncus bufonius L (toad rush)
Juncus dudleyi Wieg. (Dudley's rush)
Juncus interior Wieg. (inland rush)
Juncus longistylis Torr. (longstyle rush) **L**
Juncus marginatus Rostk. (grassleaf rush)
Juncus nodosus L. (knotted rush)
Juncus saximontanus A. Nelson (Rocky Mountain rush)
Juncus torreyi Coville (Torrey's rush) **L**

Juncaginaceae

Triglochin maritima L. (seaside arrowgrass) **L**
Triglochin palustris L. (marsh arrowgrass) **FM**

Lamiaceae

Lycopus americanus Muhl. ex Bartram (American water horehound) **MWP**
Mentha arvensis L. (wild mint)
Monarda fistulosa L. (wild bergamot) **MWP**
Prunella vulgaris L. (common selfheal) **L**
Scutellaria galericulata L. (marsh skullcap) **U**
Stachys palustris L. (marsh hedgenettle)

Lemnaceae

Lemna minor L. (common duckweed)

Lentibulariaceae

Utricularia minor L. **R(S2), FM**

Liliaceae s.l. (APG Amaryllidaceae)

Allium cernuum Roth (nodding onion) [Alliaceae] **L**
Calochortus gunnisonnii S. Watson (Gunnison's sego lily)
Lilium philadelphicum L. (wood lily) **R(S1), FM, MWP**

Lythraceae

Lythrum salicaria L. (purple loosestrife) This A list noxious weed has invaded a subsidiary drainage of Black Squirrel Creek, and is the only significant weed issue. It currently is not a monoculture, and many of the rare and unusual species are intermixed with it, making chemical controls problematic.

Malvaceae

Sidalcea neomexicana A. Gray (saltspring checkerbloom) **U, FM**

Najadaceae (APG Hydrocharitaceae)

Najas guadalupensis (Spreng.)Magnus (spring water nymph)

Nyctaginaceae

Abronia fragrans Nutt. ex Hook. (snowball sand verbena) **X**
Mirabilis linearis (Pursh)Heimerl {*Oxybaphus lanceolatus; Oxybaphus linearis*}(narrowleaf four o'clock)

Oleaceae

Forestiera pubescens Nutt. {*Forestiera neomexicana*} (stretchberry)

Onagraceae

Calylophus serrulatus (Nutt.) P. H. Raven (yellow sundrops)

Epilobium ciliatum Raf. *ssp. glandulosum* (Lehm.) Hoch & P. H. Raven (fringed willowherb)
Epilobium leptophyllum Raf. (bog willowherb)
Gaura coccinea Nutt. ex Pursh (scarlet beeblossom)
Gayophytum diffusum Torr. & A. Gray (spreading groundsmoke) **FM**
Oenothera coronopifolia Torr. & A. Gray (crownleaf evening primrose)
Oenothera flava (A. Nelson) Garrett (yellow evening primrose) **U**
Oenothera nuttallii Sweet (Nuttall's evening primrose)
Oenothera villosa Thunb. {*Oenothera strigosa*} (hairy evening primrose) **L** as *Anogra strigosa*

Orobanchaceae (s.str.)

Orobanche ludoviciana Nutt. (Lousiana broomrape) **X**

Oxalidaceae

Oxalis dillenii Jacq. (slender yellow wood sorrel)

Orchidaceae

Platanthera aquilonis Sheviak {*Limnorchis hyperborea, Platanthera hyperborea*} (northern green orchid) **FM**
Spiranthes romanzoffiana Cham. (hooded lady's tresses) **FM, U**

Plantaginaceae (s. str.; see also Scrophulariaceae s.l.)

Plantago elongata Pursh (prairie plantain)
Plantago patagonica Jacq. (woolly plantain) **L** as *P. purshii*)

Poaceae

Achnatherum nelsonii (Scribn.) Barkworth (Columbia needlegrass)
Agropyron cristatum (L.) Gaertn. (crested wheatgrass) **MWP**
Agrostis gigantea Roth. (redtop) **L** as *A. alba*
Agrostis scabra Willd. (rough bentgrass) **FM, L** as *A. hiemalis*
Alopecurus aequalis Sobol (shortawn foxtail) **FM**
Andropogon gerardii Vitman (big bluestem) **U, MWP, L** as *A. furcatus*. Generally occurring on the study site in dispersed patches; common but sporadic across plains and mesic drainages.
[*Andropogon hallii* Hack. **L]** Occurs sporadically in the area on deep sandy soils, but not present in our site.
Beckmannia syzigachne (Steud.) Fernald (American sloughgrass)
Bouteloua curtipendula (Michx.) Torr. (sideoats grama) **MWP**
Bouteloua gracilis (Willd. ex Kunth) Lag. ex. Griffiths {*Chondrosum gracile*} (blue grama) **L**
Bouteloua hirsuta Lag.) {*Chondrosum hirsutum*} (hairy grama)
Bromus carinatus Hook. & Arnott {*Ceratochloa carinata*} (California brome)
Bromus inermis Leyss. {*Bromopsis inermis*} (smooth brome)
Calamagrostis stricta (Timm.) Koeler (slimstem reedgrass) **FM**
Calamovilfa longifolia (Hook.) Scribn. (prairie sandreed) **MWP, L**
Hordeum jubatum L. {*Critesion jubatum*} (foxtail barley) **L**
Hordeum brachyantherum Nevski {*Critesion brachyantherum*} (meadow barley)
Distichlis spicata (L.) Greene (saltgrass) **L** Occurring with *Sporobolus airoides* along shallow alkaline drainages, lower portion of study site only and increasingly common to the south.
Elymus canadensis L. (Canada wildrye) **MWP**
Elymus lanceolatus (Scribn. & J.G. Sm.) Gould (thickspike wheatgrass)
Elymus trachycaulus (Link) Gould ex Shinners (slender wheatgrass) **L** as *Agropyron pauciflorum*
Glyceria striata (Lam.) Hitchc. (fowl mannagrass) **FM**
Hesperostipa comata (Trin. & Rupr.) Barkworth {*Stipa comata*} (needle and threadgrass) **X, L**
Hesperostipa spartea (Trin.) Barkworth {*Stipa spartea*} (porcupinegrass) **U, MWP, L**
[*Hordeum jubatum* L. (foxtail barley) **L]**
Koeleria macrantha (Ledeb.) Schult. (prairie junegrass) **MWP, L** as *K. cristata*
Muhlenbergia asperifolia (Nees & Meyer) Parodi (scratchgrass) **L**
Muhlenbergia minutissima (Steud.) Swallen (annual muhly)
Muhlenbergia montana (Nutt.) Hitchc. (mountain muhly) **FM**
Muhlenbergia richardsonis (Trin.) Rydb. **L** as *M. squarrosa*
Nassella viridula (Trin.) Barkworth {*Stipa viridula*} (green needlegrass)
Panicum virgatum L. (switchgrass) **MWP, L**
Pascopyrum smithii (Rydb.) Barkworth & D.R. Dewey {*Agropyron smithii, Elytrigia smithii*} (western wheatgrass **L**
Phleum pratense L. (timothy) **L**
Poa annua L. (annual bluegrass)
Poa fendleriana (Steud.) Vasey (muttongrass) **FM, L**
Poa leptocoma Trinius (marsh bluestem) **FM**
Poa nemoralis L. ssp. *interior* (Rydb.) W.A. Weber (inland bluegrass) **FM**
Poa pratensis L. (Kentucky bluegrass) **MWP, L**
Schizachyrium scoparium (Michx.) Nash (little bluestem) **MWP, L** as *Andropogon scoparius*
Sorghastrum nutans (L.) Nash (Indiangrass) **U, MWP, L**
Spartina pectinata Link (prairie cordgrass) **L]**
Sporobolus airoides (Torr.) Torr. (alkali sacaton)
[*Sporobolus cryptandrus* (Torrey) A. Gray (sand dropseed) **L**
Sporobolus heterolepis (A. Gray) A. Gray (prairie dropseed) **U, MWP, L**
Thinopyrum ponticum (Podp.) Z.W. Liu & R.C. Wang {*Elytrigia elongata*} (tall wheatgrass)

Polemoniaceae

Aliciella pinnatifida (Nutt. ex A. Gray) J.M. Porter (sticky gilia) **X, L** as *Gilia pinnatifida*
Collomia linearis Nutt. (tiny trumpet)

Polygonaceae

Eriogonum alatum Torr. {*Pterogonum alatum*} (winged buckwheat) **L**
Eriogonum annuum Nutt. (annual buckwheat) **L**
Polygonum amphibium L. {*Persicaria amphibian*} (water knotweed) **MWP**
Polygonum convolvulus L. {*Fallopia convolvulus*}(black bindweed)
Polygonum douglasii Greene (Douglas' knotweed)
Polygonum pensylvanicum L. (Pennsylvania knotweed)
Polygonum lapathifolium L. {*Persicaria lapathifolia*} (curlytop knotweed)
Polygonum punctatum Elliott {*Persicaria punctata*} (dotted knotweed)
Rumex crispus L. (curly dock)
Rumex acetocella L. {*Acetocella vulgaris*} (common sheep sorrel)

Portulacaceae

Phemeranthus calycinus (Engelm.) Kiger {*Talinum parviflorum*} (largeflower fameflower) **L**

Potamogetonaceae

Potamogeton natans L. (floating pondweed)
Potamogeton foliosus Raf. (leafy pondweed)

Primulaceae

Dodecatheon pulchellum (Raf.) Merr. (darkthroat shooting star) **FM**
Lysimachia ciliata L. (fringed loosestrife) **U, MWP**

Ranunculaceae

Anemone canadensis L. (Canadian anemone) **FM, MWP**
Anemone cylindrica A. Gray (candle anemone) **FM, MWP**
Myosurus minimus L. (tiny mousetail)
Ranunculus cardiophyllus Hook. (heartleaf buttercup) **FM**
Ranunculus trichophyllus Chaix (threadleaf crowfoot)

Rosaceae

Agrimonia striata Michx. (roadside agrimony) **U, FM**
Fragaria virginiana Miller (Virginia strawberry) **MWP**
Geum aleppicum Jacq. (yellow avens) **FM**
Potentilla arguta Pursh {*Drymocallis arguta*}(tall cinquefoil) **FM**
Potentilla hippiana Lehm. (woolly cinquefoil)

Potentilla norvegica L. (Norwegian cinquefoil)
Potentilla plattensis Nutt. (Platte River cinquefoil)
Prunus pumila L. var. *besseyi* (L.H. Bailey) Gleason {*Prunus besseyi*; *Cerasus pumila*} (western sandcherry)
Prunus virginiana L. {*Padus virginiana*} (chokecherry) **FM**
Rosa arkansana Porter (prairie rose) **MWP**

Rubiaceae
Galium boreale L. {*Galium septentrionale*} (northern bedstraw) **FM**
Galium trifidum L. (threepetal bedstraw) **M**F

Salicaceae
Populus × *acuminata* Rydb. (lanceleaf cottonwood)
Populus angustifolia James (narrowleaf cottonwood) **FM**
Populus deltoides Bartram ex Marsh. (plains cottonwood)
Salix amygdaloides Andersson (peachleaf willow)
Salix exigua Nutt. (narrowleaf willow)
Salix irrorata Andersson (deweystem willow) **FM**
Salix ligulifolia (C.R. Ball) C.R. Ball (strapleaf willow)

Santalaceae
Comandra umbellata (L.) Nutt. (bastard toadflax) **X, L** as *C. pallida*

Saxifragaceae
Parnassia palustris L. var. *parviflora* (DC) Boivin {*Parnassia parviflora*} (smallflower grass of Parnassus) **FM**

Selaginellaceae
Selaginella densa Rydb. (lesser spikemoss) **FM**

Scrophulariaceae (s. lat.; APG see also Callitrichaceae, Orobanchaceae, Phrymaceae)
Mimulus glabratus Kunth (roundleaf monkeyflower)
Nuttallanthus canadensis (L.) D.A. Sutton {*Linaria canadensis*} (Canada toadflax) **U**
Orthocarpus luteus Nutt. (yellow owlclover) **L**
Pedicularis canadensis L. (Canadian lousewort) **FM**
[*Penstemon angustifolius* Nutt. ex. Pursh (broadbeard beardtongue) **L**]
Penstemon auriberbis Pennell (Colorado beardtongue) **X** This species is extremely common south in the Arkansas River drainage but occurs only sporadically around Colorado Springs.
Penstemon glaber Pursh (sawsepal pentstemon) **FM**
Penstemon gracilis Nutt. (lilac penstemon)**U, FM, MWP** Species uncommon in the foothills and pine savannah regions of the Black Forest area; found once on our study site.
Penstemon virgatus ssp. *asa-grayi* Crosswhite (one-sided penstemon)
Veronica anagallis-aquatica L. (water speedwell) {*Veronica catenata*}
Veronica peregrina L. (neckweed) **L**
Veronica serpyllifolia L. ssp. *humifusa* (Dicks.) Syme (thymeleaf speedwell) **FM**

Solanaceae
Physalis virginiana Mill. (Virginia groundcherry)

Sparganiaceae (APG Typhaceae)
Sparganium angustifolium Michx. (narrowleaf bur-reed) **FM**

Typhaceae
Typha latifolia L. (broadleaf cattail)

Valerianaceae (APG Caprifoliaceae)
Valeriana edulis Nutt. ex Torr. & A. Gray (tobacco root) **FM**

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BOOK NOTICE

Emma Short and Alex George. 2013. **A Primer of Botanical Latin with Vocabulary.** (ISBN-13: 978-1-107-69375-3, pbk). Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473, U.S.A. (**Orders:** www.cambridge.org, 1-845-353-7500). $39.99, 304 pp., 102 tables, 21 exercises, index, 6" × 9".

From the publisher: Latin is one of two acceptable languages for describing new plants, and taxonomists must be able to translate earlier texts in Latin. Providing a simple explanation of Latin grammar along with an in-depth vocabulary, this is an indispensable guide for systematic botanists worldwide. All relevant parts of speech are discussed, with accompanying examples as well as worked exercises for translating diagnoses and descriptions to and from Latin. Guidelines for forming specific epithets are also included. The authors cross-reference their grammar to Stearn's *Botanical Latin* and to articles in the *International Code of Nomenclature for Algae, Fungi and Plants*. The comprehensive vocabulary is enhanced with terms from recent glossaries for non-flowering plants – lichens, mosses, algae, fungi and ferns – making this an ideal resource for anyone looking to hone their understanding of Latin grammar and to translate botanical texts from the past 300 years.

EMMA SHORT worked for 5 years at the Royal Botanic Gardens, Kew, UK, on the *Index Kewensis* database and with R.K. Brummitt on *Authors of Plant Names*. She checked Latin for *Australian Systematic Botany* for 18 years, worked as a freelance translator, and has taught courses in Botanical Latin.

ALEX GEORGE is an Adjunct Associate Professor at the School of Biological Sciences and Biotechnology, Murdoch University, Perth. He was a botanist with the Western Australian Herbarium for 21 years, then Editor of the *Flora of Australia* for 12 years. He studied Latin to Tertiary level and has used it in describing some 400 new taxa, translating for others and editing.

A FLORISTIC INVENTORY OF DAGNY JOHNSON KEY LARGO HAMMOCK BOTANICAL STATE PARK AND IMMEDIATELY ADJACENT LANDS (MONROE COUNTY), FLORIDA, U.S.A.

George J. Wilder

Naples Botanical Garden
4820 Bayshore Drive
Naples, Florida 34112-7336, U.S.A.
gwilder@naplesgarden.org

Susan V. Sprunt

P. O. Box 66
Tavernier, Florida 33070, U.S.A.
Spruntsv@gmail.com

Janice A. Duquesnel

Florida Park Service
77200 Overseas Highway
Islamorada, Florida 33036, U.S.A.
Janice.Duquesnel@dep.state.fl.us

Susan F. Kolterman

30 Poinciana Drive
Key Largo, Florida 33037, U.S.A.
sforrest6@bellsouth.net

ABSTRACT

Individuals of ninety-nine families, 302 genera, 417 species, and 421 infrageneric taxa of vascular plants grow wild in Dagny Johnson Key Largo Hammock Botanical State Park and on immediately adjacent lands (Key Largo, Monroe Co., Florida). Three hundred (71.3%) of the 421 infrageneric taxa are native to Florida. Herein, eight main kinds of habitats are recognized within the study area, and individual taxa inhabit one or more of these habitats. Fifty-nine presently reported species are listed as Endangered (38 species) or Threatened in Florida (21 species). For South Florida, one species listed as Extirpated and eight species listed as Critically Imperiled were documented during this study.

Key Words: Dagny Johnson Park, Key Largo, floristic inventory, vascular plants

RESUMEN

Individuos de noventa y nueva familias, 302 géneros, 417 especies, y 421 taxa infragenéricos de plantas vasculares crecen nativos en Dagny Johnson Key Largo Hammock Botanical State Park y en lugares inmediatamente adyacentes (Key Largo, Monroe Co., Florida). Trescientos (71.3%) de los 421 taxa infragenéricos son nativos de Florida. Por ello, se reconocen ocho tipos principales de hábitats en el área de estudio, y los taxa individuales habitan uno o más de estos hábitats. Cincuenta y nueve de las especies citadas están listadas como En Peligro (38 especies) o Amenazadas en Florida (21 especies). Se documentan para South Florida en este estudio, una especie listada como Extinguida y ocho especies listadas como Críticamente Amenazadas.

INTRODUCTION

This is the fourth of a series of papers focused on the flora of south Florida (Wilder & McCombs 2006; Wilder & Roche 2009; Wilder & Barry 2012). Presented, herein, are the results of a floristic inventory of the native and the exotic taxa of vascular plants growing wild in Dagny Johnson Key Largo Hammock Botanical State Park and on immediately adjacent lands. We call the studied locations, collectively, "the study area." These locations are situated within northern Key Largo (Monroe Co., Florida). Key Largo ranks as the largest and among the northernmost of the Florida Keys (Weiner, 1977–1986).

Dagny Johnson Key Largo Hammock Botanical State Park (hereafter, called the Park) was established in 1982 and additional lands were added later on. The Park is managed by the State of Florida Department of Environmental Protection Division of Recreation and Parks (DEP). It exhibits diverse habitats, including the largest remnant of West Indian hardwood hammock (a kind of rockland hammock) remaining within the continental United States (SFDEPDRP 2004).

The Park consists of discontinuous properties that, collectively, define an approximately linear contour oriented from southwest to northeast (Fig. 1, areas depicted in green and orange). Privately owned lands and

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associated roads occupy spaces between the Park properties. The Park is centered at 25°14'21"N and 80°19'12"W, it is ca. 7.3 miles long (including spaces between properties), it exhibits a maximum width of ca. 0.75 miles, and it occupies 2454 acres (SFDEPDRP 2004). The maximum altitude is ca. 13 feet above sea level.

Most of the Park is situated within an eastern sector of northern Key Largo (Fig. 1, area colored green). This portion of the Park is bounded to the east by the Straits of Florida (a body of water contiguous eastward with the Atlantic Ocean). To the west, this portion is demarcated, jointly, by three entities that are contiguous with, and that extend parallel to, one another (Fig. 1, the three entities are represented, collectively, by a single red line). Listed in an order extending from west to east, these entities include: (1) County Route 905 (CR 905), (2) ruderal land situated east of CR 905, and (3) a right-of-way that includes power lines. A discontinuous linear clearing extends beneath the power lines. The right-of-way is owned by Monroe County, but it is assigned as a utility easement to the Florida Keys Electric Cooperative (FKEC).

A northwestern sector of the Park is unique, because it occurs by the western side of CR 905 and because its western boundary abuts Card Sound (a body of water that connects, via Florida Bay, to the Gulf of Mexico; Fig. 1, area colored orange).

Those portions of the study area that lie immediately adjacent to, but that do not belong to, the Park include the linear clearing, aforementioned, certain ruderal lands, and oceanic habitat situated at the eastern terminus of Valois Blvd. (see below, for additional comment about the latter two portions).

Numerous botanists—independently or in small groups—have collected, and deposited in herbaria, voucher specimens from northern Key Largo. Examples of previous workers include: T.R. Alexander, F. Almeda, D. Austin, G.N. Avery, K.A. Bradley, C.R. Broome, G.R. Cooley, D.S. Correll, F.C. Craighead, J. De Boer, J.A. Duquesnel, G.D. Gann, O. Lakela, R.W. Long, J.E. Poppleton, R.P. Sauleda, A.G. Shuey, W.L. Stern, R.F. Thorne, P.B. Tomlinson, and D.B. Ward (Gann et al. 2002; IRC 2013; Wunderlin & Hansen 2013).

Taylor Alexander (1953, 1968 [1969]) wrote two papers about the vascular flora of the Park. The first paper was a floristic study of land that was initially pine rockland (land that was also studied presently). The second paper reported *Acacia choriophylla* (Fabaceae) as a species new to Florida.

Arthur Weiner (1977–1986) authored a voluminous monograph about the ecology of rockland hammocks of the Florida Keys. Therein, he presented, in part, the results of 26 surveys of different sectors of rockland hammock in Key Largo, that were undertaken by Weiner and Karen Anchor during/between May, 1977 and Feb. 1986. Weiner (1977–1986) included a separate plant list among the results of each survey.

After the Park was established, DEP staff members compiled lists of the plant species found there (SFDEPDRP 2004). The most recent list, not yet formally approved, was assembled while current research was still underway (SFDEPDRP, Unit Management Plan in preparation); that list reports certain species that were first observed by us in the study area. In addition, the Institute of Regional Conservation (IRC 2013) maintains a separate list of species attributed to the Park.

The present study was undertaken for four reasons. (**1**) Weiner's (1977–1986) plant lists and DEP's lists specified no voucher specimens, and the IRC list specified a limited number of them; thus, each list was impossible, or was possible only in part, to verify. (**2**) The Park list did not stipulate, and the IRC list stipulates inconsistently, which workers had identified particular species. (**3**) For many of the herbarium specimens collected by previous workers, the specimen labels did not specify—or they specified imprecisely—where in northern Key Largo (or in Key Largo, overall) collections were made; thus, it was not possible to definitely link such specimens to lands currently under investigation. (**4**) We aspired to document species previously unreported within the study area.

Voucher specimens or photographs are cited herein of all infrageneric taxa (species and varieties) reported presently. Indicated, also, are taxa collected by previous workers in northern Key Largo that were not observed during the present study. Reported, too, are the habitat(s) noted for each infrageneric taxon during current fieldwork.

Climate, Geology and Soils

Key Largo manifests long, hot, humid summers (with frequent cooling by sea breezes) and warm winters (with

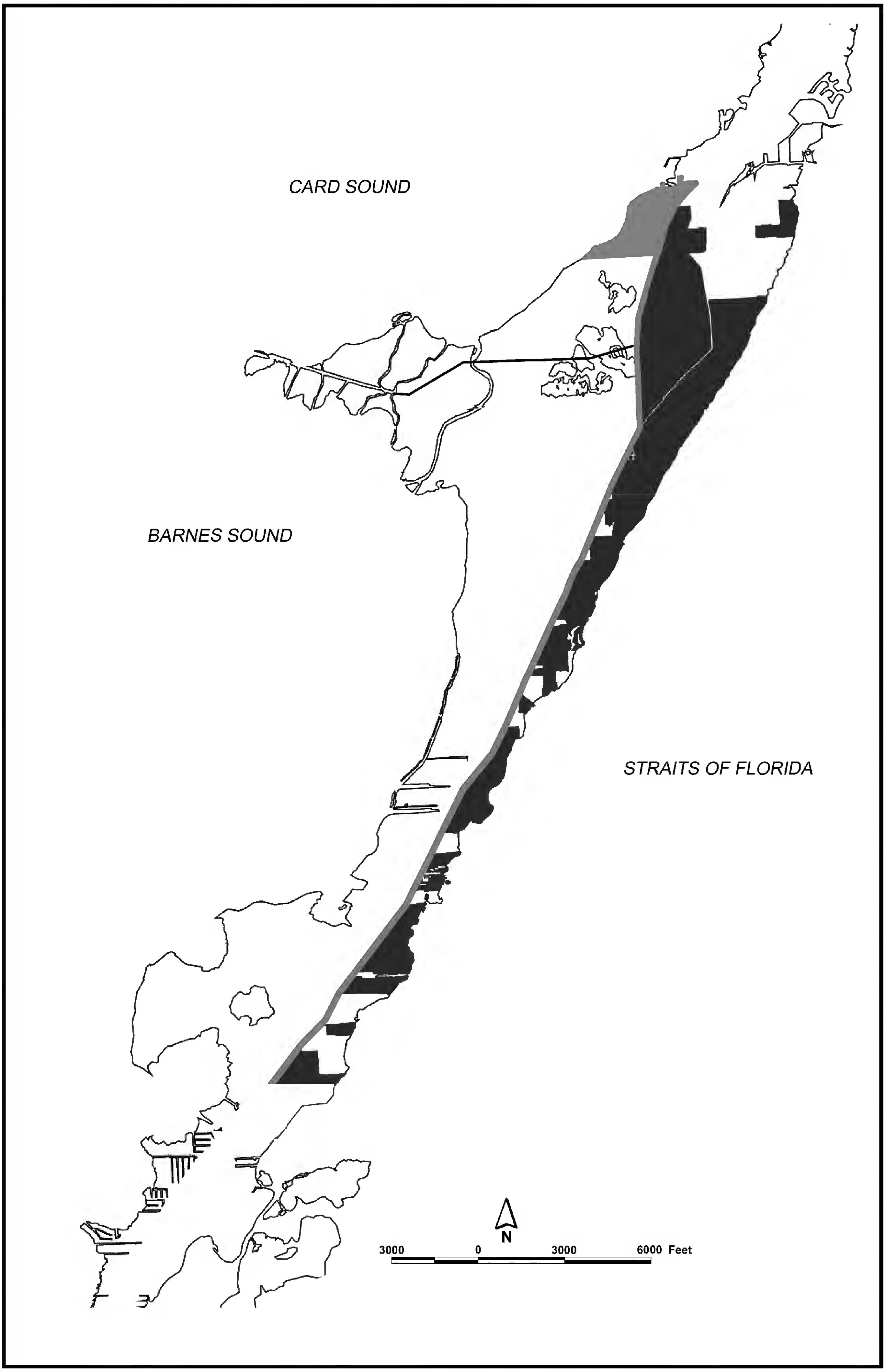

Fig. 1. Map depicting northern Key Largo and surrounding bodies of water. Green and orange signify the eastern portion and the northwestern portion, respectively, of Dagny Johnson Key Largo Hammock Botanical State Park. The red line represents, collectively, CR 905, ruderal land situated east of CR 905, and the right-of-way that includes power lines. This map is from State of Florida Department of Environmental Protection Division of Recreation and Parks (2004) and was modified by Nathan Mitchell.

occasional cooling by intrusions of air from the north). Average monthly temperatures vary from 75° F (January) to 90° F (July, August). Rainfall occurs throughout the year. Average precipitation is highest in September and is lowest from/including December through April (Hurt et al. 1995; The Weather Channel 2014).

Key Largo Limestone—a "raised coral reef" of Pleistocene origin—is the uppermost bedrock within Key Largo (Randazzo & Halley 1997). The limestone is eroded, and here and there large solution holes extend downward from its surface. The holes are commonly wider than deep, they may exceed five feet deep, and they may contain disproportionate numbers of individuals of particular plant species (*Acrostichum aureum, Annona glabra*). The holes develop naturally because of rainfall, and they sometimes hold standing water. Also, humans have excavated the limestone in places, producing basins and canals (SFDEPDRP 2004; George Wilder, personal observations).

Dispatch Slough, a body of shallow saltwater, extends through the northeastern sector of the Park and connects Card Sound with the Straits of Florida (SFDEPDRP 2004).

Six soil types occur within the study area: **(1)** Pennekamp gravelly muck, 0–2% slopes, extremely stony; **(2)** Matecumbe muck, occasionally flooded; **(3)** Rock outcrop, Tavernier complex, tidal; **(4)** Islamorada muck, tidal; **(5)** Keylargo muck, tidal; and **(6)** Udorthents-Urban land complex. Soil type nos. **1** and **2** are associated with upland and subtropical hardwood hammock; type nos. **3–5** occur within mangrove swamps, exhibit elevations of less than two feet, and are subject to daily flooding by tides; and type no. **6** occurs within "constructed upland areas adjacent to areas of water" (Hurt et al. 1995).

Habitats

Recognized, herein, are eight main kinds of habitats within the study area: rockland hammock, mangrove, rock barren, coastal berm, submerged habitat, ruderal land, the linear clearing situated beneath power lines, and non-ruderal disturbed land (Appendix 1).

Rockland hammock.—This is subtropical, upland forest. Its name signifies the underlying limestone, which either is exposed (especially in solution holes) or which lies very near the surface (FNAI 2010). In hammock situated within the study area, dicotyledons comprise the majority, both of individuals and of species, of trees and shrubs; however, one or more palm species also abound(s) in places. The hammock varies from being young second-growth forest to being older growth. A thick, soft layer of leaf litter characterizes the higher-quality portions of hammock.

Before the Park was established, a 15-acre tract - now situated within the northeastern sector of the Park - was pine rockland habitat; however, during the early 1900s the pines were logged and living pines are now absent (SFDEPDRP 2004). Subsequent to logging, renewed growth transformed this tract. Today most of it appears, essentially, as rockland hammock, and that majority is here classified as such.

Mangrove.—This is variously dense forest. It comprises fringing vegetation along the coast and also occurs sporadically a little inshore of the coast (where it may intergrade with rock barren). Too, it occupies Dispatch Slough. Four species of trees dominate: *Avicennia germinans* (Black Mangrove), *Conocarpus erectus* (Buttonwood), *Laguncularia racemosa* (White Mangrove), and *Rhizophora mangle* (Red Mangrove).

Rock barren.—Grouped together here, under this heading are three previously recognized habitat types: keys tidal rock barren, keys cactus barren, and portions of terrain elsewhere called a "rocky area of scrub mangroves" (by the SFDEPDRP 2004). The first two habitat types were described by the Florida Natural Areas Inventory (FNAI 2010).

The "portions of terrain," aforementioned, occur somewhat inshore of fringing mangrove habitat, they are insolated, they are relatively free of mangrove species, and they abound with *Batis maritima* and chenopodiaceous species. Aside from having rocky substrate, they resemble *Batis* marsh (a habitat which manifests marl soils; Craighead 1971). The three habitat types are grouped together here: (A) for purposes of simplicity, (B) because all are considerably insolated, (C) because certain species abound in all three types, and (D) because some of the types may abut one another (i.e., Keys cactus barren [which has slightly higher elevation] and the portions of terrain, aforementioned [which have slightly lower elevation]).

Rock barren is widespread at low elevations of the Park. Aside from occurring inshore of the coast, it lines both sides of Dispatch Slough. The substrate is intact- or broken-up limestone. The least elevated parts of rock barren are commonly flooded, whereas flooding is infrequent in higher parts. Rock barren located by the western side of Dispatch Slough abuts rockland hammock to the west and mangrove habitat to the east.

The Florida Natural Areas Inventory (FNAI 2010) ranks the Park as an "exemplary site" for Keys tidal rock barren and, also, for coastal berm.

Coastal berm.—The Florida Natural Areas Inventory (FNAI 2010) defines coastal berm as "… a short forest or shrub thicket found on long narrow storm-deposited ridges of loose sediment …" Within the Park a geographically limited, forested ridge of berm exists just landward of the fringing mangrove habitat. At high elevations (of ca. a few feet) leaf litter covers the surface, but massive quantities of trash surmount less elevated berm sectors (see below).

Submerged habitat.—Submerged, aquatic plant species were noted growing in ocean water (at the eastern terminus of Valois Blvd. [a road traversing a space between Park properties]), in Dispatch Slough, and within an excavated basin of limestone containing shallow water. The first location actually occurs within a peripheral-most portion of John Pennekamp Coral Reef State Park.

Ruderal land.—We define this in a strict sense as disturbed land bordering or on roads. Ruderal land was investigated (A) along the eastern side of CR. 905, (B) along roads penetrating the spaces between Park properties, and (C) along, and on, roads located within the Park.

The linear clearing situated beneath power lines.—This clearing extends for nearly the entire length of the Park; however, it is interrupted mainly at two places where the power lines extend especially close to CR 905. At those places the power lines overlie land confluent with, and outwardly indistinguishable from, ruderal land bordering CR 905. At those places land beneath the power lines is classified as ruderal land, rather than as part of the linear clearing. Most portions of the clearing are bordered on both sides by rockland hammock.

The linear clearing is mowed once yearly (personal communication from Sara Hamilton of FKEC, of 15 Aug 2013), so that herbaceous vegetation predominates. Depauperate woody plants occur, but the periodic mowings prevent them from becoming dominant. Because of their restricted development, it was considered misleading to list for the clearing—and we do not do so here—certain species of the depauperate woody plants (Appendix 1). Also, the clearing is mowed less frequently than are the ruderal lands associated with the Park, so that it often manifests more robust vegetation than do the ruderal lands.

Non-ruderal disturbed land.—This habitat includes variously extensive clearings within the Park. Concurrent with the present study, DEP acted to restore some clearings (by bulldozing and, sometimes, by applying mulch). Those efforts, apparently, promoted the arrival of certain species within the Park that were previously absent (*Ipomoea hederifolia, Trianthema portulacastrum*).

Flotsam-derived Trash

Massive trash accumulations clearly deposited during storms and/or high tides occur a little inshore from the Straits of Florida. These accumulations appear within portions of fringing mangrove habitat, of coastal berm at low elevation, and of rock barren. Trash includes glass bottles, plastic bottles, additional plastic objects (e.g., styrofoam slabs), buoys, ropes, metal cans, buckets, fishing gear, shoes, boards, poles, etc.

Historical Sketch

Northern Key Largo has a long history of human occupation and of human-induced disturbances. Native American Indians inhabited "Key Largo Hammock" between 1600 BC and 1200 AD, and they continued their activities there until the mid-18th century. Included, were members of the Calusa tribe, of Timucuan culture, and settlers from the Bahamas. Prehistoric Indian sites remain within the Park. They tend to be located near the water and mainly include shell middens (SFDEPDRP 2004).

The Spanish first explored the northern Florida Keys in 1516. Thereafter, and continuing throughout the 16th, 17th, and 18th centuries, certain species of hardwoods were logged aggressively within rockland hammock situated there. Examples included *Colubrina elliptica* (Soldierwood), *Eugenia rhombea* (Red Stopper), *Guaiacum sanctum* (Lignumvitae), *Hypelate trifoliata* (White Ironwood), and *Swietenia mahagoni* (Mahogany).

Logs were extracted, partly, for shipbuilding, home construction, and cabinetry (Rothing 2009; Weiner 1977–1986). Later on in northern Key Largo, *Pinus elliottii* (Slash Pine) and *Quercus virginiana* (Live Oak) were also logged (see below; Alexander 1953; SFDEPDRP 2004). Today, within the Park one may still observe in rockland hammock the old trunks of previously cut trees.

The first European settlers arrived during the mid-18th century.

During the 1800s, individuals established homesteads and farmed in northern Key Largo (SFDEPDRP 2004; Wilkinson 2013b). For example, Samuel Lowe purchased and homesteaded 900 acres of land. A farmer, he likely grew pineapples, a crop which most historians believe was then the crop of choice in the northern Florida Keys. If Lowe raised pineapples, he probably practiced slash-and-burn agriculture and cleared considerable land (Wilkinson 2013b). We emphasize Lowe, because his land would have been located partly or entirely within the current study area (a conclusion that we base on Wilkinson's [2013b] statement that Lowe's property encompassed land that was much later developed into a missile base [see below]).

During the 1900s, significant attempts were made to create housing developments within areas now incorporated within the Park. Two examples are provided. (1) The Port Bougainville site, the largest such area, encompasses ca. 100 acres within a southern sector of the Park. During the late 1970s and early 1980s this site was subjected to land clearing, road building, and the construction of lakes, a marina, various buildings, an entrance archway, a tunnel, etc. The site was subsequently restored somewhat, but it still exhibits considerable cleared land, roads, and additional artifacts. (2) The Carysfort Yacht Club site includes over 40 acres of land within a northern sector of the Park. That site was cleared to house the Carysfort Yacht Club, but was later utilized as a campground. A marina was also built. Subsequent restoration attempts entailed removal of the campground and marina, partial reforestation with native vegetation, and remodeling of the landscape (SFDEPDRP 2004).

In June 1965, nearly three years after the Cuban missile crisis, the U.S. government made operational the Key Largo HM-40 Nike Hercules missile base in northern Key Largo. That facility, which housed 120 individuals, was closed in June 1979. It had two main parts: the Integrated Fire Control area (radar/administrative area) and the Launcher area (which housed missiles in hardened storage bunkers). Today the two parts are separated by CR 905 and are situated within the Park and within the adjacent Crocodile Lake National Wildlife Refuge, respectively (Wilkinson 2013a, 2013b). Within the Park, the defunct Integrated Fire Control area occupies ca. 13 acres and manifests deteriorating buildings, pavement, and degraded habitat (SFDEPDRP 2004; George Wilder, personal observations). Hammock vegetation overgrows parts of the area.

The Park contains portions of two highways: Old CR 905 and Old Card Sound Rd. Below, we apply the names Old CR 905 and Old Card Sound Rd., solely, to those portions rather than to the entire highways. Old CR 905 and Old Card Sound Rd. are now closed to ordinary traffic. During the late 1960s, Old CR 905 (which demarcated the southern boundary of the Integrated Fire Control area) was replaced by a portion of CR 905 oriented west of Old CR 905 (Fig. 1, upper portion of red line). Also, Old Card Sound Rd. once extended eastward to the Straits of Florida, where it culminated in "Dynamite Docks" (a pier utilized for unloading and transporting explosives). Initially, Old CR 905 and Old Card Sound Rd. traversed Dispatch Slough at two separate locations; however, in 2000, roadway was removed at each location, and the locations are now submerged (SFDEPDRP 2004; Wilkinson 2013a, 2013b).

Plant-collecting combined with logging during the 20th century have also taken a toll (Roger Hammer, personal communications of 6 Jan and 10 Jan 2014). Weiner (1977–1988), referring to "upper keys high hammocks", including rockland hammock in Key Largo, commented as follows. There are "… very few remaining populations of lignum vitae, white ironwood, manchineel [*Hippomane mancinella*], soldierwood, red stopper, satinleaf [*Chrysophyllum oliviforme*] and other tropical hardwoods. Orchids and bromeliads … are now represented by vestigial populations. The dollar orchid [*Prosthechea boothiana*] has all but disappeared. … Populations of bromeliads are found in only the remotest and least accessible areas surveyed. All of these air plants are suffering from over-collection and habitat alteration." (Names between brackets were added by us.)

METHODS

The study area was visited 109 times, beginning on 19 March 2012 and ending on 20 Feb 2014. Multiple visits were made during each month of the year. George Wilder vouchered all but six infrageneric taxa with dried herbarium specimens; because of their rarity, Susan Kolterman vouchered those six taxa solely with numbered photographs (*Opuntia corallicola, Phoradendron rubrum, Prosthechea boothiana, Tillandsia fasciculata, Tillandsia utriculata,* and *Vanilla barbellata*). All specimens but one and all photographs were deposited in the Herbarium of Southwestern Florida (SWF), housed at the Naples Botanical Garden (Appendix 1). The exceptional specimen (of *Sida* sp., a species possibly new to Florida) was donated to the USF Herbarium (USF). Examined, also, were herbarium specimens that previous workers had collected, or had apparently collected, in northern Key Largo (at Virtual Herbarium 2013, at Wunderlin and Hansen 2013, at FTG, and at SWF). We inventoried solely wild individuals, i.e., plants which - except in three cases - were deemed to have originated naturally within the study area. Exceptional, were *Acacia choriophylla*, *Opuntia corallicola*, and *Phoradendron rubrum*; those species, extirpated from Key Largo years ago, were introduced into the Park by previous workers. We call the introduced plants wild because they grew in natural habitats, because they were not being maintained artificially, because some were robust and many years old, and because the three species were formerly native to Key Largo. Species are characterized as native, exotic, or endemic to Florida, according to Wunderlin and Hansen (2011, 2013). Mostly, present nomenclature follows Wunderlin and Hansen (2013); however, Appendix 1 (footnote 1) specifies nomenclatural differences between that work and the present paper.

RESULTS AND DISCUSSION

Taxonomic analysis of present data

The study area exhibited 99 families, 302 genera, 417 species, and 421 infrageneric taxa (species and varieties) of vascular plants (Appendix 1). Between parentheses, the numbers of families, genera, and infrageneric taxa are indicated, respectively, for each of the following major groups: pteridophytes (6, 10, 12), angiosperms (93, 292, 409), monocotyledons (14, 62, 102), and dicotyledons sensu lato (79, 230, 307). For infrageneric taxa of each of these major groups, their percentage of all 421 infrageneric taxa is listed: pteridophytes, 2.9%; angiosperms, 97.1%; monocotyledons, 24.2%; and dicotyledons sensu lato, 73.1%.

The five largest families of monocotyledons, as gauged by the numbers of infrageneric taxa present, are Poaceae (56), Cyperaceae (15), Arecaceae (8), Bromeliaceae (8), and Orchidaceae (5) (for each family the number of infrageneric taxa is listed between parentheses). The families Poaceae and Cyperaceae, collectively, exhibited 16.9% of all 421 infrageneric taxa listed (i.e., 71 infrageneric taxa).

The eleven largest families of dicotyledons sensu lato are Fabaceae (43), Asteraceae (29), Euphorbiaceae (21), Rubiaceae (16), Convolvulaceae (14), Malvaceae (9), Verbenaceae (8), Boraginaceae (7), Cactaceae (7), Scrophulariaceae (7), and Solanaceae (7). The families Fabaceae and Asteraceae, collectively, exhibited 17.1% of all 421 infrageneric taxa listed (i.e., 72 taxa).

No gymnosperms were observed, and pteridophytes were noted solely within the Park. Most fern species were rare or uncommon; however, numerous individuals were observed of *Acrostichum aureum* (localized primarily within solution holes) and of *Pleopeltis polypodioides* (localized within and bordering other portions of hammock).

Infrageneric taxa situated within the Park vs. on immediately adjacent land

Three hundred and eighty three infrageneric taxa (91.0% of all 421 infrageneric taxa reported) occurred solely within the Park or both within, and external to, the Park. The remaining 38 taxa grew solely outside of the Park. Of all 143 infrageneric taxa reported presently for ruderal land, 63 taxa grew on ruderal land that was located either solely within the Park or that occurred both within, and external to, the Park; the remaining 80 taxa inhabited ruderal land located solely outside of the Park.

Infrageneric taxa and habitats

Habitats are listed for all 421 infrageneric taxa reported here (Appendix 1).

Within the entire study area, non-ruderal disturbed land exhibited the highest percentage of infrageneric taxa. Intermediate percentages of taxa grew in each of rockland hammock and ruderal land. Lowest percentages occurred within each of the linear clearing situated beneath power lines, berm, rock barren, mangrove habitat, and underwater habitat.

Supporting data are presented. Each number, below, refers solely to the infrageneric taxa that we noted inside of a habitat, not to taxa whose sole association with the habitat was occurence at the habitat boundary. For each habitat indicated, listed between parentheses are the number of infrageneric taxa observed therein and the percentage which that number represents of all 421 infrageneric taxa reported here: non-ruderal disturbed land (231; 54.9%); rockland hammock (143, 34.0%); ruderal land (143, 34.0%); the linear clearing situated beneath power lines (87, 20.7%); berm (56, 13.3%); rock barren (52, 12.4%); mangrove habitat (34, 8.1%); and underwater habitat (3, 0.71%).

Also, noted were (A) 50 infrageneric taxa situated at the boundaries between rockland hammock and other habitats, that were not located inside the hammock itself, and (B) 27 infrageneric taxa situated at the boundaries between mangrove habitat and other habitats (excluding rockland hammock), that were not located inside the mangrove habitat itself (Appendix 1).

As was stated above, most of that locale which in previous years was pine rockland is classified presently as rockland hammock. (Hereafter, we designate as Locality **A** that portion which is now hammock). Accordingly, we have—in the previous two paragraphs—subsumed within the tallies of taxa of rockland hammock the counts of all taxa situated within Locality **A**.

Sixty-seven infrageneric taxa were noted as being situated within, or in several cases bordering, Locality **A** (Appendix 1). Although, Locality **A** is currently interpreted as rockland hammock, that locality differs from other hammock within the study area, because certain species characteristic of pine rockland persist there. Within the study area, those species are either confined to Locality **A** (*Quercus virginiana, Serenoa repens*) or they are represented there disproportionately (*Byrsonima lucida, Myrica cerifera*).

Approximately, 60 years ago Taylor Alexander, together with a plant ecology class, investigated Locality **A.** They delineated an east-west transect through Locality **A,** along which they recorded 25 species (Alexander 1953). Noted, presently within Locality **A** were 22 of those 25 species. Two more of the species were observed elsewhere in the Park (*Guettarda scabra, Simarouba glauca*); however, Alexander (1953) listed one species, *Psychotria sulzneri*, that was not observed presently within the study area. Coordinate with present findings, Alexander (1953) reported that Locality **A** "… showed little difference …" from other areas of typical Key Largo hammock.

Native and endemic taxa inventoried during the present study

Within the study area 300 (71.3%) of the 421 infrageneric taxa recorded were native to Florida (this calculation does not include *Chenopodium* sp., which was insufficiently mature to identify). Between parentheses, the number and percentage of native infrageneric taxa within each major group of vascular plants are listed, respectively: pteridophytes (10, 83.3%), angiosperms (290, 70.9%), monocotyledons (66, 64.7%), and dicotyledons sensu lato (224, 73.0%).

Five taxa were endemic to Florida: *Agave decipiens, Argythamnia blodgettii, Chamaesyce conferta, Harrisia fragrans,* and *Opuntia corallicola*.

Exotic species inventoried during the present study

One hundred and twenty-one infrageneric taxa observed within the study area are exotic within Florida (not counting *Chenopodium* sp.; Appendix l).

The Florida Exotic Pest Plant Council (FLEPPC 2013) has recognized two categories of plant species exotic within Florida, that pose especial threats to the ecology of the State, overall, i.e., Category I and Category II (those categories indicate decreasing degree of threat; FLEPPC 2013). Noted presently were 16 Category I species (*Albizia lebbeck, Asparagus aethiopicus, Casuarina equisetifolia, Colubrina asiatica, Ficus microcarpa, Jasminum dichotomum, Lantana camara, Manilkara zapota, Melinis repens, Nephrolepis brownii, Neyraudia reyn-*

audiana, Panicum repens, Pennisetum purpureum, Scaevola taccada, Schinus terebinthifolia, and *Thespesia populnea*) and 19 Category II species (*Cocos nucifera, Dactyloctenium aegyptium, Eulophia graminea, Flacourtia indica, Hyparrhenia rufa, Leucaena leucocephala, Macroptilium lathyroides, Panicum maximum, Pennisetum setaceum, Pteris vittata, Richardia grandiflora, Ricinus communis, Ruellia blechum, Sansevieria hyacinthoides, Sphagneticola trilobata, Stachytarpheta cayennensis, Terminalia catappa, Tradescantia spathacea*, and *Tribulus cistoides*).

Possibly, there were four additional Category II species: *Chamaedorea seifrizii, Phoenix reclinata, Pittosporum pentandrum,* and *Washingtonia robusta*. We did not identify those species, but we did observe sterile plants or seedlings that are identified here as *Chamaedorea* sp., *Phoenix* sp., *Pittosporum* sp., and *Washingtonia* sp. The 16 Category I species and the 19 Category II species comprised 20.8% and 23.5% of all 77 Category I species and 81 Category II species recognized for Florida, respectively.

Within the study area *Leucaena leucocephala, Manilkara zapota,* and *Thespesia populnea* ranked among the most abundant of exotic species listed by FLEPPC (2013). *Eulophia graminea*, a Category II species native to Asia and to subtropical islands in the Pacific Ocean, was first observed in Florida in ca. 2006 (Pemberton et al. 2008). Since its discovery in south Florida, *E. graminea* has spread invasively there, and during the present investigation it has become considerably more abundant within the study area.

Staff members of DEP and of FKEC, as well as individuals unaffiliated with those entities, routinely destroy exotic plants within the study area. They have, apparently, extirpated *Bucida buceras* × *Bucida spinosa, Peltophorum pterocarpum* (two taxa that were previously listed for the Park [SFDEPDRP 2004]), *Hylocereus undatus,* and *Melia azedarach.*

Native species listed as rare in Florida

The study area manifests an extraordinary number of rare species (Table 1). Fifty-nine presently reported species are State-listed as Endangered (38 species) or Threatened in Florida (21 species; Weaver & Anderson 2010). Within the study area, all but one of these species are confined to the Park; *Argythamnia blodgettii*, the sole exception, comprises a small, localized population located in/by the linear clearing situated beneath the power lines. For South Florida, one species listed as Extirpated and eight species listed as Critically Imperiled (Gann et al. 2002) were documented during this study.

Herein, two listed species are newly reported for the Park: *Celosia nitida* and *Vallesia antillana*.

Two species of Cactaceae are State-listed: *Acanthocereus tetragonus* and *Harrisia fragrans*. Excluding cacti, 38 of the State-listed species grow as shrubs (including *Phoradendron rubrum*) or trees (including *Thrinax* spp.); however, other species develop as erect herbs (*Acrostichum aureum, Argythamnia blodgettii, Prosthechea boothiana, Tillandsia* spp., *Scleria lithosperma, Voyria parasitica*) or as herbaceous- or woody vines (*Dalbergia brownei, Jacquemontia* spp., *Microgramma heterophylla, Passiflora multiflora, Rhynchosia swartzii, Vanilla barbellata*).

Four of the State-listed species are considered in greater detail, below.

Acacia choriophylla.—Taylor Alexander reported a single tree of *A. choriophylla*, apparently of natural origin, in northern Key Largo. The discovery area was "… forested by species of West Indian affinity" … and was "… typical of the ecotone between salt water mangrove swamps and high hammock..." (Alexander 1968 [1969]). His report was the first and only indication that *A. choriophylla* is native to the United States; however, Gann et al. (2002) concluded that *A. choriophylla* was likely extirpated in northern Key Largo during the 1970s and early 1980s. Many years ago a Park biologist planted the individuals of *A. choriophylla* reported presently.

Hippomane mancinella.—Ten years ago SFDEPDRP (2004) reported fewer than twelve individuals of this species in the Park. Observed, during the present study were only one mature individual and several seedlings of that species that grew beneath it. The plants were situated within berm habitat. *Hippomane mancinella* is poisonous to humans, a circumstance that has led to dramatic human-induced destruction of this species. Thus, within Florida *H. mancinella* is now "… only sparsely scattered throughout the Keys as well as near Flamingo in Everglades National Park" (Nelson 1994).

Table 1. List of the species of rare plants of Dagny Johnson Key Largo Hammock Botanical State Park and immediately adjacent lands. Rankings of rarity are for Florida (Weaver & Anderson 2010) and for south Florida (Gann et al. 2002). **Crit. Imp.** = critically imperiled; **End.** = endangered; **Ext.** = extirpated; **Hist.** = historical; **Threat.** = threatened.

Taxon	Weaver & Anderson (2010)	Gann et al. (2002)
Acacia choriophylla	End.	Ext.
Acanthocereus tetragonus	Threat.	
Acrostichum aureum	Threat.	
Argusia gnaphalodes	End.	
Argythamnia blodgettii	End.	
Bourreria succulenta	End.	
Byrsonima lucida	Threat.	
Calyptranthes pallens	Threat.	
Calyptranthes zuzygium	End.	
Canella winterana	End.	
Celosia nitida	End.	
Chrysophyllum oliviforme	Threat.	
Colubrina elliptica	End.	
Crossopetalum ilicifolium	Threat.	
Crossopetalum rhacoma	Threat.	
Dalbergia brownei	End.	
Dodonaea elaeagnoides	End.	
Drypetes diversifolia	End.	
Drypetes lateriflora	Threat.	
Erithalis fruticosa	Threat.	
Ernodea cokeri	End.	Crit. Imp.
Eugenia confusa	End.	
Eugenia rhombea	End.	Crit. Imp.
Exostema caribaeum	End.	
Gossypium hirsutum	End.	
Guaiacum sanctum	End.	Crit. Imp.
Harrisia fragrans	End.	
Hippomane mancinella	End.	
Hypelate trifoliata	End.	
Jacquemontia havanensis	End.	Crit. Imp.
Jacquemontia pentanthos	End.	
Jacquinia keyensis	Threat.	
Manilkara jaimiqui	Threat.	
Maytenus phyllanthoides	Threat.	
Microgramma heterophylla	End.	
Opuntia corallicola	End.	Crit. Imp.
Opuntia stricta	Threat.	
Passiflora multiflora	End.	
Phoradendron rubrum	End.	Crit. Imp.
Pithecellobium keyense	Threat.	
Prosthechea boothiana	End.	
Psychotria ligustrifolia	End.	
Reynosia septentrionalis	Threat.	
Rhynchosia swartzii	End.	Crit. Imp.
Schaefferia frutescens	End.	
Scleria lithosperma	End.	
Smilax havanensis	Threat.	
Solanum donianum	Threat.	
Swietenia mahagoni	Threat.	
Thrinax morrisii	Threat.	
Thrinax radiata	End.	
Tillandsia balbisiana	Threat.	
Tillandsia fasciculata	End.	
Tillandsia flexuosa	Threat.	
Tillandsia utriculata	End.	
Trema lamarckiana	End.	
Vallesia antillana	End.	Crit. Imp.
Vanilla barbellata	End.	
Voyria parasitica	End.	

Phoradendron rubrum.—Plants of *P. rubrum* parasitize stems of *Swietenia mahagoni*. During March, 1998, Josef Nemec discovered a previously unknown population (here called Population A) of *P. rubrum* within the Park; it was the last remaining original population known to occur there. Janice Duquesnel collected seeds from that population and planted them onto mahogany trees situated within the Park and elsewhere. The seeds yielded numerous offspring that persist today. Population A itself died-out in 2004, concomitant to death of the host trees.

Gann et al. (2002) concluded that wild plants of *P. rubrum* were known with certainty from South Florida, solely, from the Park; however, in 2002, IRC staff members discovered *P. rubrum* on Sands Key (Miami-Dade Co., FL; SFDEPDRP 2004). Subsequently, in May 2013, Larry Manfredi discovered *P. rubrum* growing at another site in Key Largo.

Opuntia corallicola.—John K. Small (1930) reported *O. corallicola* from Key Largo, but thereafter the species was extirpated there. Subsequently, staff members of Fairchild Tropical Botanic Garden (particularly, Christopher Kernan), of the Florida Park Service (including Janice Duquesnel), and of other institutions collaborated to introduce plants of *O. corallicola* into the Park. To the present day, Janice Duquesnel—with the assistance of other individuals—monitors *O. corallicola and Phoradendron rubrum* within the Park.

Gann et al. (2002) reviewed the history of discovery of *O. corallicola* in south Florida, and they indicated efforts to introduce that species in other Florida Keys.

Taxa that are rare or localized within the study area

One hundred and twenty-nine infrageneric taxa (30.6% of all infrageneric taxa reported presently) are judged to be rare within the study area (Appendix 1). We deem a taxon to be rare there (**A**) if no more than five individuals, thereof (or five clumps of individuals, in the case of herbaceous species), were observed, or (**B**) if, regardless of the number of individuals observed, the species occupied an area not larger than a housing lot.

Twelve native species are listed here as rare, that were also characterized above as Endangered or Threatened in Florida (Weaver & Anderson 2010) or as Critically Imperiled in south Florida (Gann et al. 2002): *Acacia choriophylla, Argythamnia blodgettii, Celosia nitida* (1 to several), *Crossopetalum ilicifolium, Eugenia rhombea, Hippomane mancinella, Jacquemontia havanensis, Jacquemontia pentanthos, Solanum donianum* (1), *Trema lamarckiana* (1), *Vallesia antillana* (2), and *Vanilla barbellata* (the numbers between parentheses indicate the number of individuals noted presently for certain species). Another species, *Sporobolus pyramidatus,* is not classified as Endangered, Threatened, or Critically Imperiled, but is rare in the study area and was also considered rare in Florida, overall (Wunderlin & Hansen 2011).

In contrast to the aforementioned species, various native/non-native species that are rare in the study area vary from occasional to frequent in Florida, overall (e.g., *Amaranthus spinosus, Ambrosia artemisiifolia, Chamaecrista nictitans, Cyperus flavescens, Echinochloa colona, Eclipta prostrata, Eleocharis flavescens, Erechtites hieraciifolius, Erythrina herbacea, Gaura angustifolia, Launaea intybacea, Leptochloa fusca subsp. fascicularis, Monanthochloe littoralis, Muhlenbergia capillaris, Oldenlandia corymbosa, Nephrolepis exaltata, Pilea microphylla, Solanum americanum, Sonchus asper,* and *Toxicodendron radicans* (Wunderlin & Hansen 2011).

Some native species that are not rare within the study area exhibit conspicuously restricted distributions, therein. (**1–4**) *Eugenia confusa*, *Schoepfia chrysophylloides*, *Thrinax morrisii*, and *Thrinax radiata* are limited to rockland hammock situated within the northern portion of the Park (excluding planted individuals of *T. radiata* that grow on a plot of disturbed land located elsewhere within the study area); (**5**) *Tillandsia setacea* is confined to the northwestern sector of the Park, where plants grow at/near the boundary between mangrove habitat and rockland hammock; (**6**) *Argusia gnaphalodes* grows wild within disturbed land on a spoil island bordering the Straits of Florida (albeit, apparently planted individuals occupy disturbed land situated elsewhere); (**7**) *Harrisia fragrans* grows primarily at/near the boundary between rockland hammock and either mangrove habitat or rock barren; and (**8**) *Ernodea cokeri* is confined almost entirely within/along that portion of rockland hammock that was formerly pine rockland (Locality **A**).

Comparisons with previous studies

Examined at FTG and USF, collectively, were herbarium specimens of 26 species and one hybrid that were not currently observed within the study area, but that previous workers had collected, or had apparently collected, in northern Key Largo (imprecise language on some herbarium-specimen labels made it uncertain whether the corresponding specimens were from northern Key Largo; Appendix 1). According to the labels, overall, of the 27 taxa, specimens of solely five species and of the hybrid were collected within the Park: *Ayenia euphrasiifolia*, *Cyperus croceus*, *Datura metel*, *Pectis* ×*floridana*, *Thelypteris kunthii*, and *Vitex trifolia*. We could not ascertain whether any other of the 27 taxa were collected from the study area. Fifteen (55.5%) of the 27 taxa are native to Florida.

SFDEPDRP (2004) listed 347 infrageneric taxa of vascular plants for the Park. Documented, presently were all but 34 (9.8%), but possibly up to 37, of those taxa (this imprecision reflects the uncertain identifications of some taxa). Of those 34 taxa, nine (26.4%) were native to Florida; remaining taxa were listed as non-native or cultivated. The Institute for Regional Conservation (IRC 2013) maintains a database that summarizes previous floristic work undertaken within the Park and which reports ca. 458 species of vascular plants for the Park. Documented, during current research were 339 to 345 of those species (six species of four genera were questionable, because we observed solely sterile adults or seedlings of those genera).

The nature of the data assembled here differs in certain ways from that provided by the latter two sources—a circumstance which helps to explain the differences in the numbers of taxa reported presently and by those sources. **A.** Inventoried, presently were taxa located both within the Park and on immediately adjacent land, whereas, both other sources listed taxa solely for the Park. **B.** Taxa that grew solely under cultivation are not reported presently, whereas, both other sources reported such taxa. **C.** Our inventory is conclusive. In contrast, the IRC database lists certain species as present, but describes other species as being reported (24), as assumed to be present (10), as doubtfully present (5), as recorded as present in error (12), as possibly extirpated (6), and as presumed extirpated (13). (Each number between parentheses is the number of species that IRC assigns to the associated descriptor, that were not presently observed and/or that could not presently be identified with certainty [the six species, aforementioned]).

The aforementioned differences in the numbers of reported taxa also reflect the circumstance that certain taxa, apparently, died-out in, or were extirpated from, the study area before current research began. For example, we repeatedly visited the original collection locality of *Ayenia euphrasiifolia* (i.e., the Integrated Fire Control area), but we never observed that species. We speculate that it was shaded-out by growing woody vegetation. At least one species first recorded for the Park during current research, *Turbina corymbosa*, was inadvertently extirpated there during restoration efforts by DEP.

APPENDIX 1[1]

Table of species, varieties, a hybrid, and higher-level taxa documented during the present study and by previous workers. Non-bold font signifies infrageneric taxa (species and varieties) documented within the study area during the present investigation. Infrageneric taxa that previous workers documented, or apparently documented in northern Key Largo, overall, but that were not observed during the present study are listed with bold font. For certain species, listed after a species name is/are a relevant synonym (between brackets), an indication of whether the species is rare within the study area, and/or the designation of the species by the Florida Exotic Plant Pest Council (FLEPPC 2013). Presented after a species name is the five-digit Wilder and McCombs collection number[2] of a voucher specimen or of a voucher photograph of that species. Habitat data are provided within the eight vertical columns at the right of this table. For infrageneric taxa documented solely by previous investigators, data are provided as follows after the Latin name of a taxon: relevant synonym, if any (between brackets); collector(s); collection number; year of collection; and acronym of the herbarium where the specimen is on deposit.[3] After the name of each family and suprafamilial taxon, between parentheses are included two or four numbers; the two numbers not in italics—if present—signify, respectively, the numbers reported presently of genera and infrageneric taxa within that family or suprafamilial taxon; the two numbers in italic—if present—signify, respectively, the sums of numbers reported presently and by previous workers, of such genera and infrageneric taxa. * = alien to Florida; ? = a taxon that was not identified with sufficient precision to ascertain whether it is native to, or exotic within, Florida; ¤ = endemic to Florida; **Berm** = berm habitat; **Dist** = non-ruderal disturbed land; FLEPPC I and FLEPPC II = taxa recognized as Category I or Category II species by the Florida Exotic Plant Pest Council (2013); **Man** = mangrove habitat; **Pow** = linear clearing beneath power lines; **RH** = rockland hammock; **Rock** = rock barren; **Rud** = ruderal land; **Subm** = underwater habitat; X = occurrence of a taxon within a habitat, away from a habitat boundary (except for X^{bp} and X^{pi}). For ruderal land, X signifies occurrence on ruderal land within the Park, whereas, X^{bp} signifies occurrence on ruderal land outside of the Park; for rockland hammock, X^{pi} signifies rockland hammock which was pine rockland prior to the onset of current research. The following symbols signify occurrences at habitat boundaries: X^{d} = boundary with non-ruderal disturbed land; X^{man} = boundary with mangrove habitat; $X^{pi\text{-}man}$ =

boundary between mangrove habitat and rockland hammock that was formerly pine rockland; X$^{pi\text{-}r}$ = boundary between ruderal land and rockland hammock that was formerly pine rockland; X$^{pi\text{-}rb}$ = boundary between rock barren and rockland hammock that was formerly pine rockland; X^{po} = boundary with linear clearing beneath power lines; X^{r} = boundary with ruderal land; X^{rb} = boundary with rock barren.

[1] We follow the nomenclature of Wunderlin and Hansen (2013), with two exceptions. (1) We recognize families which they submerged within, or divided into, other families. Between parentheses, after the name of each family that we recognize is listed the corresponding family(ies) of Wunderlin and Hansen (2011): Asclepiadaceae (Apocynaceae), Capparaceae (Brassicaceae), Chenopodiaceae (Amaranthaceae), Euphorbiaceae (Euphorbiaceae *sensu stricto*, Phyllanthaceae, Putranjivaceae), Scrophulariaceae (Orobanchaceae, Plantaginaceae, Scrophulariaceae *sensu stricto*), and Sterculiaceae (Malvaceae). (2) We recognize varieties of *Conocarpus erectus* L., *Digitaria ciliaris* (Retz.) Koeler, *Eragrostis ciliaris* (L.) R. Br., *Paspalum setaceum* Michx, and *Schizachyrium sanguineum* (Retz.) Alston as did Long and Lakela (1976), Wipff (2003a), Peterson (2003), Allen and Hall (2003), and Wippf (2003b), respectively. Wunderlin and Hansen (2011) did not do so.

[2] Ms. Martha McCombs contributed importantly to SWF; hence, on the label of each herbarium sheet from SWF George Wilder's name and Martha McCombs' name precede the collection number of each specimen, a circumstance not duplicated in this appendix.

[3] Data for previous collections were compiled from Virtual Herbarium (2013), from Wunderlin and Hansen (2013), and during visits to FTG and USF.

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
PTERIDOPHYTES (10, 12; *11, 13*)								
DENNSTAEDTIACEAE **(1, 1)**								
Pteridium aquilinum var. *caudatum* (L.) Sadeb.; 34212	X^{pi}					X		
NEPHROLEPIDACEAE **(1, 2)**								
Nephrolepis exaltata (L.) Schott; **Rare;** 34468	X^{pi}							
Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.; remnant of cultivation; **Rare; 33548						X		
POLYPODIACEAE **(4, 4)**								
Campyloneurum phyllitidis (L.) C. Presl; **Rare;** 34416	X							
Microgramma heterophylla (L.) Wherry; 34527	X							
Phlebodium aureum (L.) J. Sm.; 34366	X,X^{man},X^{pi}							
Pleopeltis polypodioides (L.) E.G. Andrews & Windham; 33622	X,X^{man},X^{pi},X^{rb}							
PSILOTACEAE **(1, 1)**								
Psilotum nudum (L.) P. Beauv.; 34498	X,X^{pi}					X		
PTERIDACEAE **(2, 3)**								
Acrostichum aureum L.; 34255	X,X^{pi}	X						
Acrostichum danaeifolium Langsd. & Fisch.; **Rare;** 34467	X$^{pi\text{-}m}$							
**Pteris vittata* L.; FLEPPC II; 33816						X		
THELYPTERIDACEAE **(*1, 1*)**								
***Thelypteris kunthii* (Desv.) C.V. Morton; G.A. Gann, J.A. Duquesnel 1154; 2003 (FTG)**								
VITTARIACEAE **(1, 1)**								
Vittaria lineata (L.) Sm.; 34470	X, X^{pi}							
MONOCOTYLEDONS (62, 102; *64, 108*)								
AGAVACEAE **(2, 2; *2, 3*)**								
¤ *Agave decipiens* Baker; **Rare;** 33875	X							
****Agave sisalana* Perrine; R.W. Long, F. Almeda, J. De Boer, C.R. Broome 1860; 1966 (USF)**								
Yucca aloifolia L.; 33876	X,X^{pi}					X		
AMARYLLIDACEAE **(1, 1)**								
Hymenocallis latifolia (Mill.) M. Roem.; 33853	X^{d}				X	X		X
ARECACEAE **(7, 8)**								
Chamaedorea* sp. (sterile); **Rare; 34244	X							
**Cocos nucifera* L. (seedlings); FLEPPC II; 34957	X^{r}							X
Phoenix* sp. (sterile); **Rare; 35409	X							
Sabal palmetto (Walter) Lodd. ex Schult. & Schult. f.; 33546	X, X^{pi}							X
Serenoa repens (W. Bartram) Small; 34214	X^{pi}							
Thrinax morrisii H. Wendl.; 33511	X, X^{pi}							
Thrinax radiata Lodd. ex Schult. & Schult. f.; 34820	X							
Washingtonia* sp. (seedlings); **Rare; 35237						X		
ASPARAGACEAE **(1, 1)**								
Asparagus aethiopicus* L.; **Rare; FLEPPC I; 33736	X							

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
ASPHODELACEAE **(*1, 1*)**								
***_Aloe vera_ L.; R.W. Long, F. Almeda, J. DeBoer, C.R. Broome 1859; 1966 (USF)**								
BROMELIACEAE **(1, 8)**								
Tillandsia balbisiana Schult. & Schult. f.; 34838	X,X^{man},X^{pi}	X	X					
Tillandsia fasciculata Sw.; 35497 (photograph)	X,X^{pi},X^{rb}	X	X					
Tillandsia flexuosa Sw.; 34410	X^{pi}	X,X^{r}	X					
Tillandsia paucifolia Baker; 34411	X^{pi}	X	X					X
Tillandsia recurvata (L.) L.; 34504		X	X					X
Tillandsia setacea Sw.; 34800	X,X^{man}	X						
Tillandsia usneoides (L.) L.; 33735	X,X^{pi},X^{r}	X	X					
Tillandsia utriculata L.; 35498 (photograph)	X^{pi},X^{rb}	X	X					
COMMELINACEAE **(1, 1)**								
*_Tradescantia spathacea_ Sw. [*Rhoeo discolor* (L'Hér.) Hance]; FLEPPC II; 33718	X					X		
CYMODOCEACEAE **(1, 1)**								
Halodule wrightii Asch.; 34167							X	
CYPERACEAE **(5, 15; *5, 16*)**								
Cladium jamaicense Crantz; 33455	X^{pi}	X	X					
Cyperus compressus L.; **Rare;** 33822				X				
***Cyperus croceus* Vahl; G.A. Gann, J.A. Duquesnel 1146; 2003 (FTG)**								
*_Cyperus esculentus_ L.; 34280				X^{bp}		X		
Cyperus flavescens L.; **Rare;** 33986				X				
Cyperus ligularis L.; 33657						X		
Cyperus odoratus L.; **Rare;** 33987				X		X		
Cyperus ovatus Baldwin [*Cyperus retrorsus* Chapm.]; 34801				X^{bp}				
Cyperus planifolius Rich.; 33951	X^{r}					X		
Cyperus polystachyos Rottb.; 33348						X		
*_Cyperus rotundus_ L.; 34105						X		
Eleocharis flavescens (Poir.) Urb.; **Rare;** 34098				X^{bp}				
Eleocharis geniculata (L.) Roem. & Schult.; **Rare;** 35500				X				
Fimbristylis cymosa R.Br.; 33349				X		X		
Fimbristylis spadicea (L.) Vahl [*Fimbristylis castanea* (Michx.) Vahl]; 33588	X^{pi}		X			X		
Scleria lithosperma (L.) Sw.; 34903	X			X^{bp}	X	X		
HYDROCHARITACEAE **(1, 1)**								
Thalassia testudinum Banks & Sol. ex J. König; 34168							X	
ORCHIDACEAE **(5, 5)**								
Encyclia tampensis (Lindl.) Small; 33826	X,X^{pi}	X	X					
*_Eulophia graminea_ Lindl.; 33658	X			X^{bp}		X		
*_Oeceoclades maculata_ (Lindl.) Lindl.; 33827	X,X^{pi}			X^{bp}		X		X
Prosthechea boothiana (Lindl.) W.E. Higgins; 35496 (photograph)	X,X^{pi}							
Vanilla barbellata Rchb. f.; **Rare;** 35499 (photograph)	X							
POACEAE **(34, 56; *35, 59*)**								
Andropogon glomeratus (Walter) Britton et al.; 33925		X^{r}				X		
Andropogon virginicus L.; 34101	X^{r}			X				
Aristida purpurascens Poir.; 34213				X	X			
*_Bothriochloa ischaemum_ (L.) Keng; 33926				X^{bp}	X	X		
*_Bothriochloa pertusa_ (L.) A. Camus; 33449				X	X	X		
Cenchrus echinatus L.; 33952			X^{r}	X^{bp}	X	X		
Cenchrus spinifex Cav. [*Cenchrus incertus* M.A. Curtis]; 33817				X^{bp}	X	X		
***Chloris elata* Desv.; G.N. Avery 1936; 1978 (USF)**								
*_Cynodon dactylon_ (L.) Pers.; 33768				X^{bp}		X		
*_Dactyloctenium aegyptium_ (L.) Willd. ex Asch. & Schweinf.; FLEPPC II; 33344				X, X^{bp}	X	X		
Digitaria ciliaris (Retz.) Koeler var. *ciliaris*; 33345	X^{r}			X^{bp}	X	X		
***Digitaria insularis* (L.) Fedde [*Trichachne insularis* (L.) Nees]; O. Lakela & L. Pardue 31593; 1968 (USF)**								
Distichlis spicata (L.) Greene; 34731			X					

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Echinochloa colona* (L.) Link; **Rare; 34558				X,X^{bp}				
Echinochloa crus-galli* (L.) P. Beauv.; **Rare; 34559				X^{bp}		X		
**Eleusine indica* (L.) Gaertn.; 33346				X,X^{bp}	X	X		
Eragrostis amabilis* (L.) Wight & Arn. ex Hook. & Arn.; **Rare; 34868				X				
**Eragrostis ciliaris* (L.) R.Br. var. *ciliaris* ; 34579				X,X^{bp}	X	X		
Eragrostis ciliaris* (L.) R.Br. var. *laxa* Kuntze; **Rare; 34163				X^{bp}				
Eragrostis elliottii S. Watson; 34082				X^{bp}	X	X		
**Eremochloa ophiuroides* (Munro) Hack.; 34103				X^{bp}				
Eustachys petraea (Sw.) Desv.; 33655	X^{r}			X^{bp}	X	X		
**Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.; 33734				X^{bp}	X			
**Hyparrhenia rufa* (Nees) Stapf; FLEPPC II; 34473	X^{r}				X			
Lasiacis divaricata (L.) Hitchc.; 33517	X			X^{bp}	X	X		
Leptochloa fusca (L.) Kunth subsp. *fascicularis* (Lam.) N. Snow; **Rare;** 35160						X		
Leptochloa dubia (Kunth) Nees; 33451					X	X		
**Melinis repens* (Willd.) Zizka [*Rhynchelytrum repens* (Willd.) C.E. Hubb.]; FLEPPC I; 33821				X,X^{bp}	X	X		
Monanthochloe littoralis Englem.; **Rare;** 35399						X		
Muhlenbergia capillaris (Lam.) Trin.; **Rare;** 34164				X				
**Neyraudia reynaudiana* (Kunth) Keng ex Hitchc.; FLEPPC I; 34368	X^{d}			X^{bp}		X		
Oplismenus hirtellus (L.) P. Beauv.; 35232	X							
Panicum dichotomiflorum Michx. var. *bartowense* (Scribn. & Merr.) Fernald; **Rare;** 34557				X^{bp}	X			
'**Panicum maximum* Jacq.; FLEPPC II; 34278	X^{r}				X	X		
Panicum repens* L.; **Rare; FLEPPC I; 34104						X		
Panicum virgatum L.; **Rare;** 34369	X							
Paspalum blodgettii Chapm.; 33818				X^{bp}	X	X		
Paspalum caespitosum Flüggé; **Rare;** 34477				X^{bp}				
****Paspalum fimbriatum* Kunth; O. Lakela & F. Almeda 30463; 1966 (USF)**								
**Paspalum notatum* Flüggé var. *notatum*; 33820				X^{bp}				
Paspalum setaceum Michx. var. *longipedunculatum* (Leconte) Alph. Wood; 34419				X^{bp}				
Paspalum setaceum Michx. var. *stramineum* (Nash) D.J. Banks; 33452					X	X		
Paspalum vaginatum Sw.; 33769						X		
Pennisetum purpureum* Schumach.; **Rare; FLEPPC I; 34398				X^{bp}				
Pennisetum setaceum* (Forssk.) Chiov.; **Rare; FLEPPC II; 34537				X^{bp}				
**Rottboellia cochinchinensis* (Lour.) Clayton; 33552				X^{bp}	X	X		
Schizachyrium sanguineum (Retz.) Alston var. *sanguineum*; 33642					X	X		
Setaria macrosperma (Scribn. & Merr.) K. Schum.; 34736	X							X, X^{rb}
Setaria parviflora (Poir.) Kerguélen [*Setaria geniculata* P. Beauv.]; 33454				X^{bp}	X	X		
Sorghum halepense* (L.) Pers.; **Rare; 34985				X				
Spartina spartinae (Trin.) Merr. ex Hitchc.; 33972		X^{r}	X					
Sporobolus domingensis (Trin.) Kunth; 33832						X		
**Sporobolus jacquemontii* Kunth; 33927				X^{bp}	X			
Sporobolus pyramidatus (Lam.) Hitchc.; 33928						X		
Sporobolus virginicus (L.) Kunth; 33553		X	X			X		
Stenotaphrum secundatum (Walter) Kuntze; **Rare;** 33547						X		
Urochloa adspersa (Trin.) R.D. Webster; 34799					X	X		
**Urochloa distachya* (L.) T.Q. Nguyen [*Urochloa subquadripara* (Trin.) R.D. Webster]; 33656					X	X		
**Zoysia pacifica* (Goudswaard) M. Hotta & Kuroki; 34400	X^{r}			X^{bp}		X		

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
RUPPIACEAE **(1, 1)**								
Ruppia maritima L.; 33512							X	
RUSCACEAE **(1, 1)**								
**Sansevieria hyacinthoides* (L.) Druce; FLEPPC II; 33738	X,X^{po},X^{rb}				X			
SMILACACEAE **(1, 1)**								
Smilax havanensis Jacq.; 34904	X^{pi},X^{r}							
DICOTYLEDONS SENSU LATO (230, 307; *245,327*)								
ACANTHACEAE **(2, 3; *3, 4*)**								
****Asystasia gangetica*** **(L.) T. Anderson; K.A. Bradley 1367; 1998 (FTG)**								
Dicliptera sexangularis (L.) Juss.; 34450	X^{r}					X		
Ruellia blechum* L. [*Blechum pyramidatum* (Lam.) Urb.]; **Rare; FLEPPC II; 34539				X^{bp}		X		
Ruellia ciliatiflora* Hook.; **Rare; 34106				X^{bp}				
AIZOACEAE **(2, 2)**								
Sesuvium portulacastrum (L.) L.; 33482			X	X		X		X
Trianthema portulacastrum L.; **Rare;** 35193						X		
AMARANTHACEAE **(4, 6; *5, 7*)**								
Alternanthera flavescens Kunth; 33516	X,X^{r}		X	X		X		X
Amaranthus dubius* Mart. ex Thell.; **Rare; 34401						X		
Amaranthus spinosus* L.; **Rare; 34562				X^{bp}				
**Amaranthus viridis* L.; 34600				X	X	X		
Blutaparon vermiculare (L.) Mears; 33483			X			X		
Celosia nitida Vahl; **Rare;** 35362	X							
Iresine diffusa **Humb. & Bonpl. ex Willd.; R.W. Long 2981; 1969 (USF)**								
ANACARDIACEAE **(3, 3)**								
Metopium toxiferum (L.) Krug & Urb.; 33286	X^{pi}, X^{r}		X,X^{r}	X		X		X
**Schinus terebinthifolia* Raddi; FLEPPC I; 33484	X, X^{pi}					X		X
Toxicodendron radicans (L.) Kuntze; **Rare;** 33772	X^{r}					X		
ANNONACEAE **(1, 1)**								
Annona glabra L.; 34420	X,X^{pi}							
APIACEAE **(1, 1)**								
**Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & P. Wilson; 34454				X,X^{bp}				
APOCYNACEAE **(5, 5; *7, 7*)**								
****Carissa macrocarpa*** **(Eckl.) A. DC.; R.W. Long, F. Almeda, J. De Boer, C.R. Broome 1769; 1966 (USF)**								
Catharanthus roseus* (L.) G. Don; **Rare; 33554						X		
Echites umbellatus Jacq.; 33645	X^{r}				X	X		
****Nerium oleander*** **L.; F. Almeda, J. De Boer, C.R. Broome, R.W. Long 1764; 1966 (USF)**								
Pentalinon luteum (L.) B. F. Hansen & Wunderlin; 33385	X^{pi},X^{r}	X^{r}				X		
Rhabdadenia biflora (Jacq.) Müll. Arg.; 33623	X		X					
Vallesia antillana Woodson; **Rare;** 34541	X							
ASCLEPIADACEAE **(2, 3; *3, 4*)**								
****Cryptostegia madagascariensis*** **Bojer ex Decne.; F. Almeda, J. De Boer, C.R. Broome, R.W. Long 1761; 1966 (USF)**								
Cynanchum angustifolium Pers.; 33386		X,X^{r}				X		
Cynanchum scoparium; **Rare;** 35111	X							X^{rb}
Sarcostemma clausum (Jacq.) Roem. & Schult.; **Rare;** 33555	X^{r}					X		
ASTERACEAE **(23, 29; *24, 33*)**								
Ambrosia artemisiifolia L.; **Rare;** 33773						X		
Baccharis angustifolia Michx.; 34171		X^{r}						
Baccharis glomeruliflora Pers.; **Rare;** 34289						X		
Baccharis halimifolia L.; 34109		X^{r}				X		
Bidens alba (L.) DC.; 33828				X,X^{bp}	X	X		
Borrichia arborescens (L.) DC.; 33387		X^{r}	X					
Borrichia frutescens (L.) DC.; 33350		X	X	X		X		X
**Calyptocarpus vialis* Less.; 34650				X		X^{bp}		
Chromolaena odorata (L.) R.M. King & H. Rob.; 34421	X					X		
Conyza canadensis (L.) Cronquist; 34907				X	X	X		
Cyanthillium cinereum* (L.) H. Rob. [*Vernonia cinerea* (L.) Less.]; **Rare; 34823					X	X		

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Eclipta prostrata (L.) L.; **Rare;** 33829				X				
Emilia fosbergii Nicolson; **Rare;** 33905						X		
Erechtites hieraciifolius (L.) Raf. ex DC.; **Rare;** 34824				X^{bp}				
Eupatorium capillifolium (Lam.) Small ex Porter & Britton; 34293						X		
***Eupatorium serotinum* Michx.; R.W. Long, F. Almeda, J. De Boer, C.R. Broome 1781; 1966 (USF)**								
Flaveria linearis Lag.; 33667				X		X		
Flaveria trinervia (Spreng.) C. Mohr; 33669				X		X		
***_Helianthus annuus_ L.; D.S. Correll 48116; 1977 (FTG)**								
Launaea intybacea* (Jacq.) Beauverd; **Rare; 35410						X		
Melanthera nivea (L.) Small; 33668						X		
Mikania scandens (L.) Willd.; **Rare;** 35307		X^{r}						
**Parthenium hysterophorus* L.; 33351				X^{bp}		X		
Pectis glaucescens (Cass.) D.J. Keil; 33830						X		
***Pectis ×floridana* D.J. Keil; G.A. Gann, K.A. Bradley 151; 1995 (FTG)**								
Pluchea carolinensis (Jacq.) G. Don; 33877				X^{bp}		X		
***Pluchea odorata* (L.) Cass.; R.W. Long, F. Almeda, J. De Boer, C.R. Broome 1841; 1966 (USF)**								
Sonchus asper* (L.) Hill; **Rare; 34565				X^{bp}				
**Sonchus oleraceus* L.; 33352				X^{bp}		X		
**Sphagneticola trilobata* (L.) Pruski [*Wedelia trilobata* (L.) Hitchc.]; FLEPPC II; 33721				X				
Symphyotrichum bahamense (Britton) G.L. Nesom [*Symphyotrichum subulatum* var. *elongatum* (Bosserdet ex A.G. Jones & Lowry) S.D. Sundberg.]; 34108				X				
Symphyotrichum tenuifolium (L.) G.L. Nesom [*Symphyotrichum bracei* (Britton ex Small) G.L. Nesom]; 34107		X^{r}						
**Tridax procumbens* L.; 33879				X,X^{bp}		X		
AVICENNIACEAE **(1, 1)**								
Avicennia germinans (L.) L.; 34183	X	X	X			X		X^{man}
BATACEAE **(1, 1)**								
Batis maritima L.; 33545		X	X			X		X
BIGNONIACEAE **(1, 1)**								
Tecoma stans* (L.) Juss. ex Kunth; **Rare; 33556	X^{d}							
BORAGINACEAE **(5, 7)**								
Argusia gnaphalodes (L.) Heine; 34651						X		
Bourreria succulenta Jacq. [*Bourreria ovata* Miers]; 34070	X					X		
**Cordia sebestena* L.; 34944	X^{rb}		X					X
Heliotropium angiospermum Murray; 34456	X^{r}			X^{bp}	X	X		X
Heliotropium curassavicum L.; 33847		X	X	X		X		
Heliotropium procumbens* Mill.; **Rare; 34528				X^{bp}		X		
Tournefortia volubilis L.; 33337	X^{r}				X	X		
BRASSICACEAE **(2, 2)**								
Brassica juncea* (l.) Czern.; **Rare; 34637						x		
Lepidium virginicum L.; 33627				X^{bp}	X	X		
BURSERACEAE **(1, 1)**								
Bursera simaruba (L.) Sarg.; 33543	X,X^{r}					X		X
CACTACEAE **(5, 7)**								
Acanthocereus tetragonus (L.) Hummelinck; 34494	X,X^{man},X^{r}		X					X
¤ *Harrisia fragrans* Small ex Britton & Rose; 34493	X,X^{man},X^{rb}		X					
Hylocereus undatus* (Haw.) Britton & Rose; **Rare; 35090	X^{r}							
Opuntia cochenillifera* (L.) Mill.; **Rare; 34249						X		
¤ *Opuntia corallicola* (Small) Werderm.; 35494 (photograph)	X							
Opuntia stricta (Haw.) Haw.; 34435	X,X^{rb}	X	X			X		X
Selenicereus pteranthus* (Link & Otto) Britton & Rose; **Rare; 34825	X^{d}							
CANELLACEAE **(1, 1)**								

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Canella winterana (L.) Gaertn.; 34250	X,X^{man},X^{po}							
CAPPARACEAE **(1, 2)**								
Capparis flexuosa (L.) L.; 34422	X,X^{man},X^{r},X^{rb}	X	X					X
Capparis jamaicensis Jacq. [*Capparis cynophallophora* L.]; 33806	X,X^{man},X^{po}	X	X					X
CARICACEAE **(1, 1)**								
Carica papaya L.; 33629	X,X^{po}				X			X
CASUARINACEAE **(1, 1)**								
Casuarina equisetifolia* L.; **Rare; FLEPPC I; 33671						X		
CELASTRACEAE **(4, 5)**								
Crossopetalum ilicifolium (Poir.) Kuntze; **Rare;** 34372	X^{pi}							
Crossopetalum rhacoma Crantz; 34583	X,X^{pi},X^{r},X^{rb}							
Hippocratea volubilis L.; 33628	X,X^{man},X^{pi}	X						
Maytenus phyllanthoides Benth.; 34543		X						
Schaefferia frutescens Jacq.; 34194	X, X^{po}, X^{r}							
CELTIDACEAE **(1, 2)**								
Trema lamarckiana (Schult.) Blume; **Rare;** 34334						X		
Trema micrantha (L.) Blume; 33509	X^{r}			X^{bp}		X		
CHENOPODIACEAE **(5, 5)**								
Atriplex pentandra (Jacq.) Standl. [*Atriplex cristata* Humb. & Bonpl. ex Willd.]; 33490	X^{rb}		X					
?*Chenopodium* sp. (Nonfruiting specimen); **Rare;** 35170						X		
Salicornia bigelovii Torr.; 33357						X		
Sarcocornia ambigua (Michx.) M.A. Alonso & M.B. Crespo [*Sarcocornia perennis* (Mill.) A.J. Scott]; 33356		X	X	X		X		
Suaeda linearis (Elliott) Moq.; 33491			X			X		X
CHRYSOBALANACEAE **(1, 1)**								
Chrysobalanus icaco L.; **Rare;** 34999	X^{pi}							
COMBRETACEAE **(3, 4; *4, 5*)**								
Conocarpus erectus L.; 33492	X,X^{pi}	X	X	X		X		X^{man}
Conocarpus erectus L. var. *sericeus* DC.; **Rare;** 34373		X				X		
Laguncularia racemosa (L.) C.F. Gaertn.; 34185		X	X			X		
***Terminalia buceras (L.) C. Wright [Bucida buceras* L.]; F.C. Craighead s.n.; 1961 (USF)**								
Terminalia catappa* L.; **Rare; FLEPPC II; 33742	X^{d}							
CONVOLVULACEAE **(6, 14)**								
Dichondra sp. (sterile); **Rare;** 34620				X^{bp}				
Evolvulus alsinoides (L.) L.; 34735				X^{bp}	X			
Ipomoea alba L.; 33558					X	X		
Ipomoea hederifolia L.; **Rare;** 35412						X		
Ipomoea imperati (Vahl) Griseb.; **Rare;** 33673						X		
Ipomoea indica (Burm.) Merr.; 34374	X, X^{r}			X^{bp}	X	X		
Ipomoea pes-caprae (L.) R.Br.; 33646			X	X		X		
Ipomoea sagittata Poir.; **Rare;** 33390	X^{pi}	X^{r}						
**Ipomoea triloba* L.; 33674				X^{bp}	X	X		
Ipomoea violacea L.; 33743		X^{r}						X
Jacquemontia havanensis (Jacq.) Urb.; **Rare;** 33391	X^{r}							
Jacquemontia pentanthos (Jacq.) G. Don; **Rare;** 34322						X		
Merremia dissecta* (Jacq.) Hallier f.; **Rare; 33861	X^{r}					X		
Turbina corymbosa (L.) Raf.; **Rare;** 35309						X		
CRASSULACEAE **(1, 1)**								
**Kalanchoe delagoensis* Eckl. & Zeyh.; 33863						X		
EUPHORBIACEAE **sensu lato (10, 21)**								
¤ *Argythamnia blodgettii* (Torr. ex Chapm.) Chapm.; **Rare;** 34926					X			
Caperonia castaneifolia (L.) A. St.-Hil.; **Rare;** 33956				X^{bp}				
Chamaesyce blodgettii (Engelm. ex Hitchc.) Small; 33881				X,X^{bp}	X	X		
¤ *Chamaesyce conferta* Small; 34883				X,X^{bp}		X		
Chamaesyce hirta (L.) Millsp.; 33882				X,X^{bp}	X	X		

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Chamaesyce hypericifolia (L.) Millsp.; 33907				X,X^{bp}	X	X		
*_Chamaesyce mendezii_ (Boiss.) Millsp.; 34405				X^{bp}	X	X		
Chamaesyce mesembrianthemifolia (Jacq.) Dugand; 34072		X^{d}				X		
Chamaesyce ophthalmica (Pers.) D.G. Burch; 33358				X,X^{bp}	X	X		
Chamaesyce prostrata (Aiton) Small; 33395				X,X^{bp}	X	X		
Drypetes diversifolia Krug & Urb.; 33542	X,X^{pi},X^{po},X^{r}					X		X
Drypetes lateriflora (Sw.) Krug & Urb.; 34487	X							
*_Euphorbia graminea_ Jacq.; 33885				X^{bp}	X	X		
*_Euphorbia trigona_ Haw.; **Rare;** 34412	X							
Gymnanthes lucida Sw.; 34681	X, X^{po}, X^{r}							
Hippomane mancinella L.; **Rare;** 34692								X
*_Phyllanthus amarus_ Schumach. & Thonn.; 33397				X^{bp}		X		
*_Phyllanthus tenellus_ Roxb.; 33632						X		
Poinsettia cyathophora (Murray) Bartl.; 33497				X,X^{bp}	X	X		
Poinsettia heterophylla (L.) Klotzsch & Garcke ex Klotzsch; **Rare;** 34587				X^{bp}	X			
*_Ricinus communis_ L.; **Rare;** FLEPPC II; 33633				X^{bp}		X		
FABACEAE (31, 43; _32, 44_)								
Acacia choriophylla Benth.; **Rare;** 34628	X							
Acacia farnesiana (L.) Willd.; 33729	X							
Acacia pinetorum F.J. Herm.; **Rare;** 34529	X^{r}							
*_Albizia lebbeck_ (L.) Benth.; **Rare;** FLEPPC I; 34458	X^{d}							
*_Alysicarpus vaginalis_ (L.) DC.; 34910				X^{bp}				
Caesalpinia bonduc (L.) Roxb.; 33779	X	X				X		X
*_Cajanus cajan_ (L.) Huth; **Rare;** 34659						X		
Canavalia rosea (Sw.) DC.; 33780		X^{r}				X		
Centrosema virginianum (L.) Benth.; F. Almeda, J. De Boer, C.R. Broome, R.W. Long 1742; 1966 (USF)								
Chamaecrista nictitans (L.) Moench var. _aspera_ (Muhl. ex Elliott) H.S. Irwin & Barneby; **Rare;** 34199					X			
*_Clitoria ternatea_ L.; **Rare;** 33560						X		
*_Crotalaria incana_ L.; **Rare;** 34721					X	X		
Crotalaria pumila Ortega; 33293				X				
*_Crotalaria spectabilis_ Roth; **Rare;** 33908						X		
Dalbergia brownei (Jacq.) Schinz; 34295	X, X^{r}	X^{r}	X					
Dalbergia ecastaphyllum (L.) Taub.; 33398	X,X^{man}	X^{r}						
*_Delonix regia_ (Bojer ex Hook.) Raf.; **Rare;** 34912	X^{po},X^{r}							
*_Desmanthus leptophyllus_ Kunth; 33539					X			
Desmanthus virgatus (L.) Willd.; 33701				X^{bp}	X			
*_Desmodium incanum_ DC.; 34888				X^{bp}	X	X		
*_Desmodium tortuosum_ (Sw.) DC.; 33746					X	X		
*_Desmodium triflorum_ (L.) DC.; 34739				X^{bp}				
Erythrina herbacea L.; **Rare;** 35383	X							
Galactia striata (Jacq.) Urb.; 34299	X^{r}				X	X		X
*_Indigofera spicata_ Forssk.; 34520				X,X^{bp}		X		
*_Indigofera tinctoria_ L.; **Rare;** 34325						X		
*_Leucaena leucocephala_ (Lam.) de Wit; FLEPPC II; 34187						X		
Lysiloma latisiliquum (L.) Benth.; 33959	X,X^{pi},X^{r}					X		
*_Macroptilium lathyroides_ (L.) Urb.; 34117			X^{r}			X		
*_Melilotus albus_ Medik.; 34544				X^{bp}		X		
Neptunia pubescens Benth.; 33537				X,X^{bp}				
*_Parkinsonia aculeata_ L.; **Rare;** 34238				X				
Piscidia piscipula (L.) Sarg.; 33886	X			X^{bp}	X	X		
Pithecellobium keyense Britton ex Britton & Rose; 34459	X,X^{pi},X^{r}		X			X		
Pithecellobium unguis-cati (L.) Benth.; 34691	X,X^{r}		X			X		X
Rhynchosia minima (L.) DC.; 33363				X^{bp}	X	X		
Rhynchosia swartzii (Vail) Urb.; 34376	X,X^{d},X^{po},X^{r}					X		
Senna ligustrina (L.) H.S. Irwin & Barneby; 34803					X			
*_Senna obtusifolia_ (L.) H.S. Irwin & Barneby; **Rare;** 33912				X^{bp}				

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Sesbania vesicaria (Jacq.) Elliott; **Rare;** 35183					X			
Sophora tomentosa L.; 33535	X^{pi},X^{r}	X^{r},X^{rb}	X					
**Stylosanthes hamata* (L.) Taub.; 34407						X		
Tamarindus indica* L.; **Rare; 34950	X							
Vigna luteola (Jacq.) Benth.; 33784						X		
FAGACEAE **(1, 1)**								
Quercus virginiana Mill.; 34200	X^{pi}							
GENTIANACEAE **(3, 3)**								
Eustoma exaltatum (L.) Salisb. ex G. Don; 33887				X^{bp}		X		
Sabatia stellaris Pursh; 33677	X^{pi}			X				
Voyria parasitica (Schltdl. & Cham.) Ruyters & Maas [*Leiphaimos parasitica* Schltdl. & Cham.]; 34026	X							
GOODENIACEAE **(1, 2)**								
**Scaevola taccada* (Gaertn.) Roxb. var. *sericea* (Vahl) H. St. John; FLEPPC I; 34607						X		
Scaevola taccada* (Gaertn.) Roxb. var. *taccada*; **Rare; FLEPPC I; 33869		X^{r}				X		
HYDROPHYLLACEAE **(1, 1)**								
Nama jamaicensis* L.; **Rare; 34517				X^{bp}				
LAMIACEAE **(2, 2; *3, 3*)**								
Callicarpa americana L.; 33902					X	X		
Hyptis mutabilis* (Rich.) Briq.; **Rare; 34666				X^{bp}				
******Vitex trifolia*** **L.; G.A. Gann, J.A. Duquesnel 1159; 2003 (FTG)**								
LAURACEAE **(1, 1)**								
Ocotea coriacea (Sw.) Britton; 33915	X^{r}							
MALPIGHIACEAE **(1, 1)**								
Byrsonima lucida (Mill.) DC.; 34812	X^{pi}, X^{r}							
MALVACEAE **(7, 9)**								
Abutilon permolle (Willd.) Sweet; **Rare;** 34773						X		X
Gossypium hirsutum L.; 34379	X^{rb}	X				X		
Herissantia crispa (L.) Brizicky; 34829				X,X^{bp}	X	X		
Hibiscus rosa-sinensis* L. var. *rosa-sinensis*; **Rare; 34326	X^{r}							
Malvastrum corchorifolium (Desr.) Britton ex Small; 34423				X	X	X		
Sida antillensis Urb.; 34591				X^{bp}	X	X		
Sida ciliaris L.; 34891				X^{bp}		X		
Sida* sp. (apparently new to Florida); **Rare; 33747						X		
**Thespesia populnea* (L.) Sol. ex Corrêa; FLEPPC I; 33401	X	X^{r}	X					X,X^{rb}
MELIACEAE **(1, 1; *2, 2*)**								
******Melia azedarach*** **L.; R.P. Sauleda, D.K. Sauleda 4742; 1981 (FTG)**								
Swietenia mahagoni (L.) Jacq.; 33617	X, X^{pi}	X^{r}	X			X		X
MORACEAE **(1, 3)**								
Ficus aurea Nutt.; 34188	X,X^{pi},X^{r}	X^{d}				X		X^{man}
Ficus citrifolia Mill.; 34382	X^{r}							X
Ficus microcarpa* L. f.; **Rare; FLEPPC I; 34462	X							
MYRICACEAE **(1, 1)**								
Myrica cerifera L.; 34202	X^{pi}					X		
MYRSINACEAE **(2, 2)**								
Ardisia escallonioides Schiede & Deppe ex Schltdl. & Cham.; 33618	X,X^{pi}					X		
Myrsine cubana A. DC. [*Rapanea punctata* (Lam.) Lundell]; 33712	X, X^{pi}							
MYRTACEAE **(2, 6)**								
Calyptranthes pallens Griseb.; 33580	X,X^{pi},X^{po},X^{r}					X		
Calyptranthes zuzygium (L.) Sw.; 34056	X,X^{pi}							
Eugenia axillaris (Sw.) Willd.; 34439	X,X^{pi},X^{r}					X		X
Eugenia confusa DC.; 34208	X,X^{man}					X		
Eugenia foetida Pers.; 33891	X,X^{pi}		X			X		X
Eugenia rhombea Krug & Urb. ex Urb.; **Rare;** 34531	X							

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
NYCTAGINACEAE (4, 4)								
Boerhavia diffusa L.; **Rare;** 34029				X, X^{bp}				
Bougainvillea glabra* Choisy; **Rare; 34440	X^{r}							
Guapira discolor (Spreng.) Little; 34032	X, X^{d}, X^{pi}, X^{r}	X^{d}, X^{r}	X, X^{r}			X		X
Pisonia aculeata L.; 34953	X, X^{r}				X			X
OLEACEAE (1, 1)								
Jasminum dichotomum* Vahl; **Rare; FLEPPC I; 33785	X^{r}							
ONAGRACEAE (1, 1)								
Gaura angustifolia Michx.; **Rare;** 33786						X		
OXALIDACEAE (1, 1)								
Oxalis corniculata L.; 33637				X^{bp}		X		
PAPAVERACEAE (1, 1)								
Argemone mexicana L.; 33750				X^{bp}		X		
PASSIFLORACEAE (1, 2)								
Passiflora multiflora L.; 34514	X, X^{po}, X^{r}					X		
Passiflora suberosa L.; 33529	X			X, X^{bp}	X	X		X
PHYTOLACCACEAE (1, 1; *2, 2*)								
***Phytolacca americana* L.; R.W. Long, F. Almeda, J. De Boer, C.R. Broome 1843; 1966 (USF)**								
Rivina humilis L.; 33814	X^{r}, X^{man}		X			X		X
PITTOSPORACEAE (1, 1)								
Pittosporum* sp. (sterile); **Rare; 33880	X^{d}							
PLANTAGINACEAE (1, 1)								
Plantago major* L.; **Rare; 34549				X^{bp}				
PLUMBAGINACEAE (1, 1)								
Limonium carolinianum (Walter) Britton; 33870		X	X			X		
POLYGONACEAE (1, 2)								
Coccoloba diversifolia Jacq.; 33916	X, X^{pi}, X^{r}					X		X
Coccoloba uvifera (L.) L.; 33527	X^{man}, X^{pi}, X^{r}	X^{r}						X
PORTULACACEAE (2, 2)								
Portulaca oleracea L.; 33680				X, X^{bp}		X		
Talinum fruticosum* (L.) Juss.; **Rare; 34071						X		
RHAMNACEAE (4, 5; *4, 6*)								
**Colubrina asiatica* (L.) Brongn.; FLEPPC I; 33754	X		X	X^{bp}		X		X
***Colubrina cubensis* (Jacq.) Brongn. var. floridana M.C. Johnst.; F.C. Craighead s.n.; 1961 (USF)**								
Colubrina elliptica (Sw.) Brizicky & W.L. Stern; 34175	X^{r}							
Gouania lupuloides (L.) Urb.; 33502	X^{po}, X^{r}				X	X		X
Krugiodendron ferreum (Vahl) Urb.; 33713	$X, X^{man}, X^{po}, X^{r}$	X^{d}				X		X
Reynosia septentrionalis Urb.; 34834	$X, X^{man}, X^{pi}, X^{r}, X^{rb}$					X		
RHIZOPHORACEAE (1, 1)								
Rhizophora mangle L.; 33815	X^{1}	X	X					X
RUBIACEAE (12, 16)								
Chiococca alba (L.) Hitchc.; 33917	X, X^{d}, X^{pi}, X^{r}			X	X	X		X
Erithalis fruticosa L.; 34489	X^{pi}, X^{r}	X^{r}	X			X		
Ernodea cokeri Britton ex Coker; 34394	$X^{pi}, X^{pi\text{-}r}$							
Exostema caribaeum (Jacq.) Schult.; 34445	X^{po}, X^{r}							
Guettarda elliptica Sw.; 33892	X, X^{po}, X^{r}					X		
Guettarda scabra (L.) Vent.; 33757	X, X^{po}, X^{r}					X		
Hamelia patens Jacq.; 33730	X^{r}				X			
Morinda royoc L.; 33461	X, X^{pi}, X^{r}			X	X	X		
Oldenlandia corymbosa* L.; **Rare; 34409				X^{bp}				
Psychotria ligustrifolia (Northr.) Millsp. [*Psychotria bahamensis* Millsp.]; 34816	X, X^{pi}, X^{po}, X^{r}					X		
Psychotria nervosa Sw.; 33919	X, X^{r}					X		
Randia aculeata L.; 33410	X, X^{man}, X^{pi}	X, X^{r}						
Richardia grandiflora* (Cham. & Schltdl.) Schult. & Schult. f.; **Rare; 34918				X^{bp}	X			
Spermacoce remota Lam. [*Spermacoce assurgens* Ruiz & Pav.]; 33893				X^{bp}	X	X		
Spermacoce tetraquetra A. Rich.; 33564					X			
**Spermacoce verticillata* L.; 33897				X	X	X		

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
RUTACEAE (3, 3)								
Amyris elemifera L.; 33966	X,X^{po},X^{r}							X
Citrus* sp. (sterile); **Rare; 34428	X^{r}							
Zanthoxylum fagara (L.) Sarg.; 33524	X,X^{man},X^{po},X^{r}					X		X
SALICACEAE (1, 1)								
Flacourtia indica* (Burm. f.) Merr.; **Rare; FLEPPC II; 34461	X							
SAMOLACEAE (1, 1)								
Samolus ebracteatus Kunth; **Rare;** 33369						X		
SAPINDACEAE (5, 6; *5, 7*)								
Cardiospermum corindum L.; 33797	X^{d},X^{r}				X	X		X
Cardiospermum microcarpum **Kunth.; F.C. Craighead s.n.; 1962 (USF)**								
Dodonaea elaeagnoides Rudolphi ex Ledeb. & Alderstam; 33799	X^{pi},X^{r}	X^{r}						
Dodonaea viscosa Jacq.; **Rare;** 33507	X^{r}							
Exothea paniculata (Juss.) Radlk.; 34465	X, X^{r}					X		X
Hypelate trifoliata Sw.; 34598	X,X^{po},X^{r}					X		
Sapindus saponaria L.; 33731	X,X^{po},X^{r},X^{rb}							X
SAPOTACEAE (3, 6)								
Chrysophyllum oliviforme L.; 33523	X,X^{r}							
Manilkara jaimiqui (C. Wright ex Griseb.) Dubard; 33698	X,X^{pi}	X^{r}	X					
**Manilkara zapota* (L.) P. Royen; FLEPPC I; 34432	X							
Sideroxylon celastrinum (Kunth) T.D. Penn.; 33412	X,X^{pi}	X	X					X
Sideroxylon foetidissimum Jacq. [*Mastichodendron foetidissimum* (Jacq.) H.J. Lam.; 34364	X,X^{po}							
Sideroxylon salicifolium (L.) Lam.; 33800	X,X^{r}					X		
SCHOEPFIACEAE (1, 1)								
Schoepfia chrysophylloides (A. Rich.) Planch.; 34267	X							
SCROPHULARIACEAE sensu lato (7, 7)								
Agalinis maritima (Raf.) Raf.; 34067	$X^{pi\ (in\ opening)}$	X						
Bacopa monnieri (L.) Pennell; 34068				X^{bp}				
Buchnera americana L.; **Rare;** 34047						X		
Capraria biflora L.; 33371				X,X^{bp}	X	X		
Mecardonia procumbens (Mill.) Small; **Rare;** 34777				X^{bp}				
**Russelia equisetiformis* Schltdl. & Cham.; 33899						X		
Scoparia dulcis L.; **Rare;** 35251				X				
SIMAROUBACEAE (1, 1)								
Simarouba glauca DC.; 33900	X					X		
SOLANACEAE (3, 7; *6, 10*)								
Capsicum annuum **L. var. *glabriusculum* (Dunal) Heiser & Pickersgill; J.E. Poppleton & A.G. Shuey s.n.; 1974 (USF)**								
****Datura metel*** **L.; G.A. Gann, J.A. Duquesnel 1152; 2003 (FTG)**								
Lycium carolinianum Walter; 33874		X,X^{r}	X			X		X
****Nicotiana tabacum*** **L.; F. Almeda, J. De Boer, C.R. Broome, R.W. Long 1758; 1966 (USF)**								
Physalis pubescens L.; **Rare;** 34978								X
Solanum americanum Mill.; **Rare;** 33762						X		X
Solanum bahamense L.; **Rare;** 34727						X		
Solanum donianum Walp.; **Rare;** 33801						X		
Solanum erianthum D. Don; 34835				X	X	X		
Solanum lycopersicum* L. [*Lycopersicon esculentum* Mill.]; **Rare; 33732						X		
STERCULIACEAE (2, 2; *3, 3*)								
Ayenia euphrasiifolia **Griseb.; G.A. Gann, J.A. Duquesnel 1140; 2003 (FTG)**								
Melochia corchorifolia* L.; **Rare; 35181				X				
Waltheria indica L.; 34850				X^{bp}	X	X		
STRYCHNACEAE (1, 1)								
Spigelia anthelmia L.; 34189				X,X^{bp}	X			
SURIANACEAE (1, 1)								
Suriana maritima L.; 33802		X^{d}				X		
TETRACHONDRACEAE (1, 1)								

	RH	Man	Rock	Rud	Pow	Dist	Subm	Berm
Polypremum procumbens L.; 33489				X,X^{bp}				
THEOPHRASTACEAE **(1, 1)**								
Jacquinia keyensis Mez; 35034	X^{pi}		X					
TILIACEAE **(1, 1)**								
Corchorus siliquosus L.; 34524						X		
TURNERACEAE **(1, 1)**								
**Turnera ulmifolia* L.; 33689					X	X		
URTICACEAE **(2, 3)**								
Parietaria floridana Nutt.; **Rare;** 34629				X^{bp}				
Parietaria praetermissa Hinton; **Rare;** 33766		X^{r}						
Pilea microphylla (L.) Liebm.; **Rare;** 35182				X				
VERBENACEAE **(6, 8)**								
Citharexylum spinosum L.; 33804	X^{r}					X		
Duranta erecta* L.; **Rare; 33693	X^{r}							
**Lantana camara* L.; FLEPPC I; 33415	X^{r}				X	X		
Lantana involucrata L.; 33372	X^{po},X^{r}					X		
Phyla nodiflora (L.) Greene; 33903				X^{bp}		X		
Priva lappulacea (L.) Pers.; 33767				X^{bp}		X		
Stachytarpheta cayennensis* (Rich.) Vahl; **Rare; FLEPPC II; 34550						X		
Stachytarpheta jamaicensis (L.) Vahl; 34610				X	X			
VISCACEAE **(1, 1)**								
Phoradendron rubrum (L.) Griseb.; 35495 (photograph)	X, X^{pi-r}							
VITACEAE **(3, 3)**								
Cissus verticillata (L.) Nicolson & C.E. Jarvis; **Rare;** 34980								X
Parthenocissus quinquefolia (L.) Planch.; 33510	X,X^{r}				X	X		
Vitis rotundifolia Michx.; 33904	X			X^{bp}	X	X		
XIMENIACEAE **(1, 1)**								
Ximenia americana L.; 34243	X,X^{pi},X^{r}					X		X
ZYGOPHYLLACEAE **(3, 3)**								
Guaiacum sanctum L.; 33921	X, X^{po}							
Kallstroemia maxima (L.) Hook. & Arn.; **Rare;** 34045				X^{bp}				
Tribulus cistoides* L.; **Rare; FLEPPC II; 33665						X		

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BOOK NOTICE

Paul Wilkin and Simon J. Mayo, eds. 2013. **Early Events in Monocot Evolution. Systematics Association Special Series, Volume 83.** (ISBN-13: 9781107012769, hbk). Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473, U.S.A. (**Orders:** www.cambridge.org, 1-845-353-7500). $99.00, 378 pp., 88 b&w illus., 40 color illus., 9 tables, taxonomic and subject indices, 7½" × 10".

From the publisher: Tracing the evolution of one of the most ancient major branches of flowering plants, this is a wide-ranging survey of state-of-the-art research on the early clades of the monocot phylogenetic tree. It explores a series of broad but linked themes, providing for the first time a detailed and coherent view of the taxa of the early monocot lineages, how they diversified and their importance in monocots as a whole. Featuring contributions from leaders in the field, the chapters trace the evolution of the monocots from largely aquatic ancestors. Topics covered include the rapidly advancing field of monocot fossils, aquatic adaptations in pollen and anther structure and pollination strategies and floral developmental morphology. The book also presents a new plastid sequence analysis of early monocots and a review of monocot phylogeny as a whole, placing in an evolutionary context a plant group of major ecological, economic and horticultural importance.

- The first detailed modern account of the early evolution of the monocots, a plant group of major ecological, economic and horticultural importance which includes grasses, cereals, palms, orchids and yams.
- Leading scientists in the field provide up-to-date reviews, showing readers how iconic plants like orchids, lilies and palms originated from largely aquatic ancestors.
- Includes the first survey of early monocot fossils and the new insights they yield on the evolution of flowering plants, providing an accessible account of the latest advances in this rapidly developing field.

PAUL WILKIN is Lilioid and Alismatid Monocots and Ferns Team Leader in the Herbarium, Library, Art and Archives Directorate of the Royal Botanic Gardens, Kew. His main research foci are systematics of Dioscoreales (yams and their allies) and Dracaenoids (dragon trees and mother-in-law's tongues), lilioid monocots widely used in human diet and horticulture, with taxa of high conservation and ecological importance. He is principal investigator of the eMonocot biodiversity informatics project.

SIMON J. MAYO is an Honorary Research Associate at the Royal Botanic Gardens, Kew. Since 1977 he has worked on the systematics and phylogeny of the Araceae, the largest plant family of the early divergent clades in monocots. He has been active in postgraduate teaching in Brazilian universities since 1988, focusing on monocot families and especially the Araceae.

Contributors: W.J.D. Iles, S.Y. Smith, S.W. Graham, D.D. Sokoloff, M. . Remizowa, P.J. Rudall, C.A. Furness, F.A. Jones, B. Sobkowiak, C.D.L. Orme, R. Govaerts, V. Savolainen, D.H. Les, N.P. Tippery, N.Tanaka, K. Uehara, J. Murata, S.J. Mayo, J. Bogner, N. Cusimano, D. Barabé, R.W. Scotland, M.G. Sajo, R. Mello-Silva, J.I. Davis, J.R. McNeal, C.F. Barrett, M.W. Chase, J.I. Cohen, M.R. Duvall, T.J. Givnish, G. Petersen, J.C. Pires, O. Seberg, D.W.M. Stevenson, J. Leebens-Mack

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A QUANTITATIVE STUDY OF THE VEGETATION SURROUNDING POPULATIONS OF *ZIGADENUS DENSUS* (MELIANTHIACEAE) AT FORT POLK IN WEST CENTRAL LOUISIANA, U.S.A.

Jacob Delahoussaye, Charles Allen, Stacy Huskins, and Ariel Dauzart

Colorado State University-Fort Polk
1645 23rd Street
Fort Polk, Louisiana 71459, U.S.A.
charles.m.allen1.ctr@mail.mil

ABSTRACT

Osceola's plume (*Zigadenus densus* (Desr.) Fern) is a rare species (S2) in Louisiana with reports from Natchitoches, St. Tammany, Vernon, and Washington parishes. Quantitative data from 40 populations (clumps) are reported, and the plant community associated with *Z. densus* is described. In west central Louisiana, *Z. densus* is found along the natural levee of baygall streams and is associated with the tree species: *Magnolia virginiana*, *Pinus palustris*, and *Nyssa biflora*; the shrub species *Morella caroliniensis*, *Rhododendron oblongifolium*, and *Acer rubrum*; the woody vine species *Rubus argutus*, *Gelsemium sempervirens*, and *Smilax laurifolia*; and the herbaceous species *Dichanthelium dichotomum* var. *tenue*, *Eupatorium rotundifolium*, and *Osmunda regalis*.

RESUMEN

Zigadenus densus (Desr.) Fern es una especie rara (S2) en Luisiana con citas en la parroquias de Natchitoches, St. Tammany, Vernon, y Washington. Se citan datos cuantitativos de 40 poblaciones (matas), y se describe la comunidad vegetal asociada con *Z. densus*. En el centro oeste de Luisiana, *Z. densus* se encuentra a lo largo de las riveras naturales de torrentes y está asociado con tres especies: *Magnolia virginiana*, *Pinus palustris*, y *Nyssa biflora*; las especies arbustivas *Morella caroliniensis*, *Rhododendron oblongifolium*, y *Acer rubrum*; Las especies trepadoras *Rubus argutus*, *Gelsemium sempervirens*, y *Smilax laurifolia*; y las especies herbaceas *Dichanthelium dichotomum* var. *tenue*, *Eupatorium rotundifolium*, y *Osmunda regalis*.

INTRODUCTION

Osceola's Plume (*Zigadenus densus* (Desr.) Fern) is a rhizomatous herbaceous perennial, 4 to 20 dm in height with a distinct blue-green foliage color, flowering from March to July. Other common names include black snakeroot, death camasa, and crow poison. It is reported from Alabama, Delaware, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia (USDA NRCS 2013; Nature Serve 2013). In *Flora of North America North of Mexico* (Schwartz 2003), it is also reported from Kentucky, New Jersey, New York, and West Virginia. Globally, Osceola's plume is ranked G5, but it can be rare in certain parts of its range; it is ranked S1 in VA, S2 in LA, S3S4 in GA, and S4 in NC (Nature Serve 2013). In Louisiana, this S2 species is found in Natchitoches, St. Tammany, Vernon, and Washington parishes (Louisiana Natural Heritage Program 2011; MacRoberts et al. 2002; Thomas & Allen 1993). In Texas, *Z. densus* is reported from Anderson, Henderson, and Tyler counties (Diggs et al. 2006).

This species is reported from hillside bogs and longleaf flatwoods savannahs in Louisiana (Louisiana Natural Heritage Program 2011) and from wet areas, damp pinelands, and bogs in east Texas (Diggs et al. 2006). The habitats reported for this species in the Flora of North America are pine bogs and flatlands (Schwartz 2003). In the Carolinas, it is reported from savannahs and pocosins (Radford et al. 1968) and Godfrey and Wooten (1979) report it from pine savannahs, flatwoods, and bogs.

The objectives of this study were to document the species associated with *Z. densus* and to describe its habitat in west central Louisiana. Several populations of *Z. densus* are known from Fort Polk in Vernon Parish, west central Louisiana.

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METHODS

In May to mid-June 2013, 40 populations (clumps) of *Z. densus* were surveyed on Fort Polk; most populations (clumps) had previously been found during vegetation surveys. Most (23) of the 40 sampling sites were located on Ruston fine sandy loam, others were found on Osier loamy fine sand (5/40), Malbis fine sandy loam (4/40), Eastwood silt loam (4/40), Betis loamy fine sand (2/40), and Guyton-Iuka complex (2/40) (Soil Survey Division 2003). The area around each population was examined and the 5 nearest individuals were identified and recorded for each of 5 categories including herbaceous, woody vine, shrub (woody non-vines shorter than 1.83 m), shrub/sapling (woody non-vines taller than 1.83 m and dbh less than 5 in), and tree (woody non-vines taller than 1.83 m and dbh larger than 5 in). The total number of individuals recorded for each plant category was 200 (40 populations and 5 individuals per population). The relative abundance was calculated by dividing the number of times a species was recorded by 200, the total number of observations. This was done for all 5 categories and converted to a percent (Allen et al. 2006).

During the same survey, we also recorded the presence of all herbaceous species within 1 m of the center of the *Z. densus* population. We didn't record the sizes of the clumps, but we approximate the average size of the clumps was about one square meter, with each clump having on average ten to fifteen stems. All woody vine and all shrub species within 4 m of the center were recorded. All tree or shrub/sapling species within 15 m of the center were recorded. The relative frequency was calculated by dividing the number of occurrences for a species by the total number of occurrences recorded for the category. This value was converted to a percent.

Importance value (total = 200) for herbaceous, woody vines, and shrubs was calculated by adding the relative frequency and the relative abundance (Megyeri & Allen 2011). Importance value (total = 300) for trees/shrub saplings was calculated by adding the relative abundance for each species in the shrub/sapling category and tree category to the relative frequency of each species in the tree/shrub/sapling category.

RESULTS AND DISCUSSION

A total of 168 species were recorded including 81 herbaceous, 12 woody vines, and 75 woody non-vines (39 shrubs and 36 trees; note overlap in categories). The species are listed by decreasing importance value. The most important herbaceous species were *Dichanthelium tenue* (27.74), *Eupatorium rotundifolium* (14.74), and *Osmunda regalis* (13.55) (Table 1). The woody vine species with the highest importance value were *Rubus argutus* (52.38), *Gelsemium sempervirens* (32.62), and *Smilax laurifolia* (32.42) (Table 2). The most important shrub species were *Morella caroliniensis* (22.12), *Rhododendron oblongifolium* (20.29), and *Acer rubrum* (19.44) (Table 3). The shrub/sapling and tree species with the highest importance value were *Magnolia virginiana* (54.39) and *Pinus palustris* (53.53) (Table 4).

The *Zigadenus densus* habitat in west central Louisiana is best described as the natural levee and seepage areas upslope of baygall streams with the vegetation being typical of such a stream. We found the tree canopy vegetation associated with *Z. densus* to be *Magnolia virginiana, Pinus palustris, Nyssa biflora, and Acer rubrum* var. *drummondii* and the shrub canopy to be *Morella caroliniensis, Rhododendron oblongifolium*, and *Acer rubrum*. These woody species are similar to the species reported for baygalls in the area (Allen et al. 2004), in east Texas (Diggs et al. 2006), and in central Louisiana (MacRoberts et al. 2004).

Allen et al. (2013) and MacRoberts et al. (2004) report two (*Magnolia virginiana* and *Nyssa biflora)* of the top three tree/shrub species in importance value to be the same as in our study. Our study shares 10 of the top 20 species of shrub/saplings with Allen et al. (2013)'study of yellow root. Allen et al. (2013) shares 8 of the 12 woody vine species with our study, but the 3 most important woody vines in association with *Z. densus* are the 3 least important woody vines in association with yellow root. Allen et al. (2013) has 6 of the top 15 herbaceous species in common with our study of *Z. densus* in their yellow root study.

Our data are the first quantitative report on the vegetation surrounding *Zigadenus densus*. The vegetation around the other populations of *Zigadenus densus* throughout its range should be sampled for comparison with our data so as to get a better idea of the variation, if any, of its habitat.

Table 1. Relative abundance, relative frequency, and importance value for herbaceous species recorded from 40 *Zigadenus densus* sites at Fort Polk in west central Louisiana.

Species	Relative Abundance	Relative Frequency	Importance Value
Dichanthelium dichotomum (L.) Gould var. *tenue* (Muhl.) Gould & C.A. Clark	19.50	8.24	27.74
Eupatorium rotundifolium L.	6.50	8.24	14.74
Osmunda regalis L.	9.00	4.55	13.55
Scleria spp.	7.50	3.69	11.19
Mitchella repens L.	5.00	3.41	8.41
Dichanthelium scabriusculum (Ell.) Gould & C.A. Clark	5.00	2.84	7.84
Osmunda cinnamomea L.	3.50	4.26	7.76
Symphyotrichum lateriflorum (L.) A.& D. Löve	2.50	4.26	6.76
Woodwardia virginica (L.) Sm.	4.00	2.27	6.27
Viola × *primulifolia* L. (pro sp.)	1.00	4.26	5.26
Solidago rugosa P. Mill.	3.00	1.70	4.70
Solidago patula Muhl. ex Willd.	1.50	3.13	4.63
Doellingeria sericocarpoides Small	2.50	1.99	4.49
Coreopsis tripteris L.	2.00	2.27	4.27
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *acuminatum*	2.50	1.14	3.64
Woodwardia areolata (L.) T. Moore	2.50	1.14	3.64
Sarracenia alata Wood.	1.50	1.99	3.49
Rhexia alifanus Walt.	2.50	0.85	3.35
Centella erecta (L. f.) Fern.	1.50	1.70	3.20
Oxypolis rigidior (L.) Raf.	0.50	2.56	3.06
Chasmanthium laxum (L.) Yates	1.00	1.99	2.99
Pteridium aquilinum (L.) Kuhn	1.50	1.42	2.92
Carex lonchocarpa Willd.	2.00	0.57	2.57
Helianthus angustifolius L.	1.00	1.42	2.42
Schizachyrium scoparium (Michx.) Nash	1.00	1.42	2.42
Dichanthelium dichotomum (L.) Gould var. *dichotomum*	0.50	1.70	2.20
Scleria pauciflora Muhl. ex Willd.	1.00	1.14	2.14
Carex glaucescens Ell.	0.50	1.42	1.92
Eupatorium leucolepis (DC.) Torr. & A. Gray	0.50	1.42	1.92
Melanthium virginicum L.	1.00	0.85	1.85
Panicum virgatum L.	1.00	0.85	1.85
Eupatorium fistulosum Barratt	0.50	1.14	1.64
Rudbeckia scabrifolia L.E. Brown	1.00	0.57	1.57
Lobelia puberula Michx. var. *puberula*	0.00	1.42	1.42
Mitreola sessilifolia (J.F. Gmel.) G. Don	0.00	1.14	1.14
Elephantopus nudatus A. Gray	0.50	0.57	1.07
Eupatorium perfoliatum L.	0.50	0.57	1.07
Gentiana saponaria L.	0.50	0.57	1.07
Ptilimnium costatum (Ell.) Raf.	0.50	0.57	1.07
Scutellaria integrifolia L.	0.00	0.85	0.85
Xyris spp.	0.00	0.85	0.85
Ambrosia psilostachya DC.	0.50	0.28	0.78
Dichanthelium laxiflorum (Lam.) Gould	0.50	0.28	0.78
Paspalum spp.	0.50	0.28	0.78
Scleria oligantha Michx.	0.50	0.28	0.78
Ambrosia artemisiifolia L.	0.00	0.57	0.57
Athyrium filix-femina (L.) Roth	0.00	0.57	0.57
Ctenium aromaticum (Walt.) Wood	0.00	0.57	0.57
Dichanthelium sphaerocarpon (Ell.) Gould	0.00	0.57	0.57
Oldenlandia uniflora L.	0.00	0.57	0.57
Rhexia petiolata Walt.	0.00	0.57	0.57
Rhynchospora spp.	0.00	0.57	0.57
Aristida purpurascens Poir. var. *purpurascens*	0.00	0.28	0.28
Asclepias rubra L.	0.00	0.28	0.28
Calopogon tuberosus (L.) B.S.P.	0.00	0.28	0.28
Centrosema virginianum (L.) Benth.	0.00	0.28	0.28
Chamaecrista fasciculata (Michx.) Greene	0.00	0.28	0.28
Chaptalia tomentosa Vent.	0.00	0.28	0.28

Table 1.continued

Species	Relative Abundance	Relative Frequency	Importance Value
Coreopsis gladiata Walt.	0.00	0.28	0.28
Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A. Clark	0.00	0.28	0.28
Dichanthelium commutatum (J.A. Schultes) Gould	0.00	0.28	0.28
Dichanthelium polyanthes Schult	0.00	0.28	0.28
Eryngium integrifolium Walt.	0.00	0.28	0.28
Euphorbia corollata L.	0.00	0.28	0.28
Galactia volubilis (L.) Britt.	0.00	0.28	0.28
Liatris spicata (L.) Willd.	0.00	0.28	0.28
Linum medium (Planch.) Britt. var. *texanum* (Planch.) Fern.	0.00	0.28	0.28
Ludwigia glandulosa Walt.	0.00	0.28	0.28
Ludwigia hirtella Raf.	0.00	0.28	0.28
Lycopodiella caroliniana (L.) Pichi Sermolli	0.00	0.28	0.28
Lycopus rubellus Moench	0.00	0.28	0.28
Muhlenbergia capillaris (Lam.) Trin.	0.00	0.28	0.28
Oligoneuron nitidum (Torr. & A. Gray) Small	0.00	0.28	0.28
Plantanthera spp.	0.00	0.28	0.28
Pluchea rosea Godfrey	0.00	0.28	0.28
Rhexia mariana L.	0.00	0.28	0.28
Rhynchosia latifolia Nutt. ex Torr. & A. Gray	0.00	0.28	0.28
Solidago odora Ait.	0.00	0.28	0.28
Tephrosia onobrychoides Nutt.	0.00	0.28	0.28
Vernonia texana (A. Gray) Small	0.00	0.28	0.28
Total	**100.00**	**100.00**	**200.00**

Table 2. Relative abundance, relative frequency, and importance value for woody vine species recorded from 40 *Zigadenus densus* sites at Fort Polk in west central Louisiana.

Species	Relative Abundance	Relative Frequency	Importance Value
Rubus argutus Link	33.67	18.71	52.38
Gelsemium sempervirens (L.) St. Hil.	20.92	11.70	32.62
Smilax laurifolia L.	14.29	18.13	32.42
Toxicodendron radicans (L.) Kuntze	8.67	11.11	19.78
Bignonia capreolata L.	7.65	11.11	18.76
Smilax glauca Walt.	6.63	9.36	15.99
Smilax rotundifolia L.	3.06	8.19	11.25
Vitis rotundifolia Michx.	1.53	5.26	6.79
Smilax smallii Morong	3.06	2.92	5.98
Smilax walteri Pursh	0.00	2.34	2.34
Parthenocissus quinquefolia (L.) Planch.	0.51	0.58	1.09
Berchemia scandens (Hill) K. Koch	0.00	0.58	0.58
Total	**100.00**	**100.00**	**200.00**

Table 3. Relative abundance, relative frequency, and importance value for shrub/sapling (< 1.83 m) species recorded from 40 *Zigadenus densus* sites at Fort Polk in west central Louisiana.

Species	Relative Abundance	Relative Frequency	Importance Value
Coreopsis gladiata Walt.	0.00	0.28	0.28
Morella caroliniensis (P. Mill.) Small	16.00	6.12	22.12
Rhododendron oblongifolium (Small) Millais	16.00	4.29	20.29
Acer rubrum L. var. *drummondii* (Hook. & Arn. ex Nutt.) Sarg.	12.50	6.94	19.44
Photinia pyrifolia (Lam.) Robertson & Phipps	10.00	5.51	15.51
Persea palustris (Raf.) Sarg.	8.00	5.71	13.71
Hypericum crux-andreae (L.) Crantz	4.00	4.08	8.08
Alnus serrulata (Ait.) Willd.	3.50	4.49	7.99
Magnolia virginiana L.	2.00	5.71	7.71
Ilex coriacea (Pursh) Chapman	3.00	4.69	7.69
Toxicodendron vernix (L.) Kuntze	1.50	5.31	6.81
Morella cerifera (L.) Small	3.00	3.06	6.06
Nyssa biflora Walt.	3.00	2.86	5.86
Vaccinium elliottii Chapman	2.00	3.67	5.67
Vaccinium fuscatum Ait.	0.50	4.69	5.19
Viburnum nudum L. var. *nudum*	0.50	4.29	4.79
Hypericum hypericoides (L.) Crantz ssp. *hypericoides*	2.50	2.04	4.54
Itea virginica L.	2.50	2.04	4.54
Callicarpa Americana L.	0.50	3.47	3.97
Liquidambar styraciflua L.	1.50	2.04	3.54
Pinus taeda L.	1.50	1.84	3.34
Lyonia lucida (Lam.) K. Koch	1.00	1.63	2.63
Rhododendron canescens (Michx.) Sweet	1.00	1.63	2.63
Viburnum nudum L. var. *cassinoides* (L.) Torr. & A. Gray	0.50	1.84	2.34
Rhus copallinum L.	1.00	1.22	2.22
Ilex opaca Ait.	0.50	1.43	1.93
Hypericum galioides Lam.	0.50	1.22	1.72
Quercus laurifolia Michx.	0.50	1.22	1.72
Quercus falcata Michx.	0.50	1.02	1.52
Chionanthus virginicus L.	0.00	1.22	1.22
Symplocos tinctoria (L.) L'Hér.	0.00	1.02	1.02
Ilex vomitoria Ait.	0.00	0.82	0.82
Sassafras albidum (Nutt.) Nees	0.00	0.82	0.82
Hypericum frondosum Michx.	0.50	0.20	0.70
Quercus alba L.	0.00	0.61	0.61
Pinus palustris P. Mill.	0.00	0.41	0.41
Quercus hemisphaerica Bartr. ex Willd. var. *hemisphaerica*	0.00	0.20	0.20
Quercus nigra L.	0.00	0.20	0.20
Vaccinium arboreum Marsh.	0.00	0.20	0.20
Vaccinium virgatum Ait.	0.00	0.20	0.20
Total	**100.00**	**100.00**	**200.00**

Table 4. Relative abundance, relative frequency, and importance value for tree/shrub/sapling (> 1.83 m) species recorded from 40 *Zigadenus densus* sites at Fort Polk in west central Louisiana.

Species	<5" dbh Relative Abundance	>5"dbh Relative Abundance	Relative Frequency	Importance Value
Magnolia virginiana L.	23.50	20.00	10.89	54.39
Pinus palustris P. Mill.	7.00	36.50	10.03	53.53
Nyssa biflora Walt.	7.50	25.00	10.32	42.82
Acer rubrum L. var. *drummondii* (Hook. & Arn. ex Nutt.) Sarg	19.50	5.00	10.32	34.82
Persea palustris (Raf.) Sarg.	17.50	2.50	8.02	28.02
Ilex coriacea (Pursh) Chapman	8.50	0.00	5.44	13.94
Pinus taeda L.	1.50	6.50	4.58	12.58
Liquidambar styraciflua L.	2.50	3.00	4.58	10.08
Toxicodendron vernix (L.) Kuntze	4.00	0.00	4.87	8.87
Ilex opaca Ait.	0.00	1.00	4.01	5.01
Alnus serrulata (Ait.) Willd.	1.00	0.00	3.72	4.72
Viburnum nudum L. var. *nudum*	1.50	0.00	2.29	3.79
Morella caroliniensis (P. Mill.) Small	0.50	0.00	2.29	2.79
Callicarpa americana L.	1.00	0.00	1.72	2.72
Quercus laurifolia Michx.	0.00	0.00	2.58	2.58
Symplocos tinctoria (L.) L'Hér.	1.50	0.00	0.57	2.07
Morella cerifera (L.) Small	0.50	0.00	1.43	1.93
Vaccinium fuscatum Ait.	0.50	0.00	1.43	1.93
Ilex vomitoria Ait.	0.50	0.00	1.15	1.65
Quercus falcate Michx.	0.00	0.50	1.15	1.65
Quercus alba L.	0.00	0.00	1.43	1.43
Vaccinium elliottii Chapman	0.50	0.00	0.86	1.36
Lyonia lucida (Lam.) K. Koch	0.00	0.00	1.15	1.15
Photinia pyrifolia (Lam.) Robertson & Phipps	0.50	0.00	0.57	1.07
Viburnum nudum L. var. *cassinoides* (L.) Torr. & A. Gray	0.50	0.00	0.57	1.07
Rhododendron canescens (Michx.) Sweet	0.00	0.00	0.86	0.86
Castanea pumila (L.) P. Mill. var. *pumila*	0.00	0.00	0.57	0.57
Chionanthus virginicus L.	0.00	0.00	0.29	0.29
Itea virginica L.	0.00	0.00	0.29	0.29
Pinus echinata P. Mill.	0.00	0.00	0.29	0.29
Prunus serotina Ehrh.	0.00	0.00	0.29	0.29
Quercus hemisphaerica Bartr. ex Willd. var. *hemisphaerica*	0.00	0.00	0.29	0.29
Quercus incana Bartr.	0.00	0.00	0.29	0.29
Quercus marilandica Muenchh.	0.00	0.00	0.29	0.29
Quercus nigra L.	0.00	0.00	0.29	0.29
Vaccinium arboreum Marsh.	0.00	0.00	0.29	0.29
Total	**100.00**	**100.00**	**100.00**	**300.00**

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BOOK NOTICE

Peter Wyse Jackson. 2014. **Ireland's Generous Nature: The Past and Present Uses of Wild Plants in Ireland.** (ISBN-13: 978-0915279784, hbk). Missouri Botanical Garden Press, P.O. Box 299, St. Louis, Missouri 63166-0299, U.S.A. (**Orders:** www.mbgpress.org). $60.00 (leather bound $75.00), 768 pp., illustrated.

From the publisher: Dr. Peter Wyse Jackson's *Ireland's Generous Nature* is the first ever comprehensive account of the historical and present-day uses of wild plant species in Ireland. It records a wealth of traditional knowledge about Irish plant use, knowledge that has been disappearing fast. More than 1500 wild plants are detailed in a systematic list, which gives both their Irish and English names. Many historical references have been included from a wide range of Irish literature. This lively and scholarly book shows how plants have been used in virtually every aspect of human life in Ireland: food, clothes, medicine, construction, drinks, veterinary medicine, human health and beauty, and even death. The book is richly illustrated with photographs, as well as botanical paintings by Irish artist Lydia Shackleton (1828–1914). Its blend of scientific and historic facts with myths, superstition and tales offers an unrivalled account of the rich heritage of Irish plants.

Set offshore at the far fringe of Europe, its historic subsistence rural culture so long remote from industrial development or bourgeois mores, Ireland should offer an encyclopedic heritage of the use of wild plants as food and medicine, for everyday utility or symbolic ritual. For early centuries, indeed, the importance of plant knowledge was tempered as much by a continuing pagan respect for nature as by the herb gardens of the many monasteries. … More than half of the 925 native plants of this island have been useful to its people, but nowhere, until now, have their stories been gathered together so systematically, both for Irish readers and the wider cultural and scientific audience.

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A QUANTITATIVE STUDY OF THE VEGETATION SURROUNDING POPULATIONS OF *UVULARIA SESSILIFOLIA* (COLCHICACEAE) AT FORT POLK IN WEST CENTRAL LOUISIANA, U.S.A.

Ariel Dauzart, Charles Allen, Stacy Huskins, and Jacob Delahoussaye

Colorado State University, Fort Polk
1645 23rd Street
Fort Polk, Louisiana 71459, U.S.A.

ABSTRACT

Sessile leaf bellwort (*Uvularia sessilifolia*) is a rare species (S2) in Louisiana with reports from Caddo, Claiborne, Grant, Lincoln, Morehouse, Ouachita, Union, and Vernon parishes. Quantitative data from 4 populations (56 samples) in Vernon Parish are reported, and the plant community associated with *U. sessilifolia* is described. In west central Louisiana, *U. sessilifolia* is found along baygall streams and is associated with the tree species: *Ilex vomitoria*, *Hamamelis virginiana*, and *Liquidambar styraciflua*; the shrub species *Vaccinium elliottii*, *Acer rubrum* var. *drummondii*, and *Pinus taeda*; the woody vine species *Smilax smallii*, *Vitis rotundifolia*, and *Smilax glauca*; and the herbaceous species *Woodwardia areolata*, *Chasmanthium laxum*, and *Mitchella repens*.

RESUMEN

Uvularia sessilifolia es una especie rara (S2) en Luisiana con citas de la parroquias de Caddo, Claiborne, Grant, Lincoln, Morehouse, Ouachita, Union, y Vernon. Se citan datos cuantitativos de 4 poblaciones (56 muestras) en la parroquia de Vernon, y se describe la comunidad vegetal asociada con *U. sessilifolia*. En el cenro oeste de Louisiana, *U. sessilifolia* se encuentra a lo largo de torrentes y está asociada con las especies: *Ilex vomitoria*, *Hamamelis virginiana*, y *Liquidambar styraciflua*; las especies arbustivas *Vaccinium elliottii*, *Acer rubrum* var. *drummondii*, y *Pinus taeda*; las especies trepadoras *Smilax smallii*, *Vitis rotundifolia*, *Smilax glauca*; y las especies herbáceas *Woodwardia areolata*, *Chasmanthium laxum*, y *Mitchella repens*.

INTRODUCTION

Sessile leaf bellwort (*Uvularia sessilifolia* L.) is a native rhizomatous herbaceous perennial in the Colchicaceae. It is reported from the following states in the US: AL, AR, CT, DC, DE, FL, GA, IA, IL, IN, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NH, NJ, NY, OH, OK, PA, RI, SC, SD, TN, TX, VA, VT, WI, and WV; and from the following provinces in Canada: MB, NB, NS, ON, and QC (USDA NRCS 2013). NatureServe (2013) has a similar distribution but also reports this species for Kansas but not for Texas, and in the *Flora of North America* treatment for this species, it is not reported for South Dakota (Utech & Kawano 2003). Sessile leaf bellwort is listed globally as G5 and S1 in KS, ND, and OK; S2 in LA; S3? in IL; S3 in IA; S4 in DE, NC, and WV; and S5 in KY, NJ, NY, and VA (NatureServe 2013). In Canada, it is listed as S2 in MB, S4 in ON, S4S5 in NS, and S5 in NB and QC. In Louisiana, this S2 species is reported from Caddo, Claiborne, Grant, Lincoln, Morehouse, Ouachita, Union, and Vernon parishes (Louisiana Natural Heritage Program 2011; Thomas & Allen 1993). In east Texas, it is reported from Cass, Jasper, and Newton counties (USDA NRC 2013; Diggs et al. 2006). In Mississippi and especially in Arkansas, this species is widespread with reports from several counties (USDA NRCS 2013).

This species is reported from forested seeps and bayhead swamps in Louisiana (Louisiana Natural Heritage Program 2011) and from deep ravines and mesic forests in east Texas (Diggs et al. 2006). The habitats reported for this species in the *Flora of North America* are moist hardwood coves, alluvial bottomlands, thickets, and xeric woods northwards (Utech & Kawano 2003). In the Carolinas, it is reported from alluvial woods and coves (Radford et al. 1968).

The objectives of this study were to document and quantitatively characterize the dominance of the vascular plant species associated with sessile leaf bellwort and to describe its habitat in west central Louisiana. Twenty-eight different clumps of sessile leaf bellwort are reported from Fort Polk in Vernon Parish. Some of

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these are small with only a few or only one stem(s). The four largest populations were selected for this study. Three of the populations were on Guyton-Iuka complex and one was partially on Briley loamy fine sand and partially on the Guyton-Iuka complex (Soil Survey Division 2003).

METHODS

The four largest *Uvularia sessilifolia* populations included two along Bird's Creek and one each along Ouiska Chitto Creek and East Fork Sixmile Creek. At each population, a macroplot that encompassed the entire *U. sessilifolia* was created with the width of all macroplots being 8 m and the length variable depending on the population size. Each macroplot was subdivided into the maximum number of samples (0.5 m × 8 m). A random number generator was used to select which of the samples would be used. At each location, 50 % (½) of the samples were selected for sampling and resulted in a total of 56 samples in the four macroplots.

The plant categories sampled included herbaceous plants, woody vines, shrubs and saplings (woody non-vine species shorter than 6 ft = 1.83 m), and trees and shrubs (woody non-vine species taller than 6 ft = 1.83m). During the sampling period, the number of stems in a sample for each species were counted and recorded. For herbaceous plants, woody vines, and shrubs and saplings, cover was determined by measuring the area occupied by the plant(s) in the sample. The cover percent was calculated by multiplying the area times the density and then dividing by the area of the sample (40,000 cm^2). The cover was converted to a percent by multiplying by 100. For the trees and shrubs taller than 1.83 m, the dbh (diameter breast high) was measured at the standard 1.37 m height using a diameter tape and recorded to the nearest 0.1 cm.

All data were entered into a Microsoft Excel spreadsheet for storage and calculation of variables. The mean diversity (richness-species per sample) and mean density (stems per sample) were calculated for all plants and for each of the four plant categories. Mean cover percent was calculated for herbaceous plants, woody vines, and shrubs/saplings, and mean dbh (cm per sample) was calculated for trees/shrubs.

The frequency was calculated for each species in a sample group by dividing the number of samples of occurrence by the total number of samples (56). It was converted to a percent by dividing by 100. The mean density was calculated for each species in a sample group by totaling the densities from all samples and dividing by 56. Mean cover percent for each herbaceous, woody vine, and shrub/sapling species was calculated by totaling the cover percent from all 56 samples and dividing by 56. The mean dbh was calculated for the tree/shrub species by totaling the dbh from all samples and dividing by 56.

The relative values for each of these variables (frequency, mean density, mean dbh, and mean cover percent) were calculated by dividing the value for a species by the total for all species within the plant category. Each relative value was converted to a percent by multiplying by 100. The relative frequency, relative density, and relative cover percent were totaled to produce the importance value for each herbaceous, woody vine, and shrub/sapling species. The relative frequency, relative density, and relative dbh were totaled to produce the importance value for each tree/shrub species.

RESULTS

A total of 90 (31 herbaceous, 14 woody vines, and 45 trees/shrubs/saplings) species were observed in all 56 samples with a mean number of species per sample of 21.79 (Table 1). The mean diversity per sample ranged from 1.46 species per sample for trees/shrubs to 9.88 species for shrubs/saplings. The mean number of stems per sample (density) for all plants was 151.32 stems and ranged from 1.91 stems per sample for trees/shrubs to 85.23 for herbaceous plants. The mean cover percent for all plants was 68.43 percent and ranged from 4.76 percent for woody vines to 43.40 percent for herbaceous plants. The dbh averaged 9.17 cm per sample.

The frequency, mean density, relative mean cover percent, and importance value for each herbaceous species (listed in descending importance value) are in Table 2. Since the macroplots for sampling were centered on *Uvularia sessilifolia*, it is not surprising that it has the highest importance value. The three species with the next highest importance value are *Woodwardia areolata*, *Chasmanthium laxum*, and *Mitchella repens*. The frequency, mean density, mean cover percent, and importance value for each woody vine species (listed in descending importance value) are in Table 3. The three species with the highest importance value are *Smilax smallii*, *Vitis*

Table 1. Communityvariables for 56 sample plots around four *Uvularia sessilifolia* macroplots on Fort Polk in West Central Louisiana.

			DIVERSITY		
	All Plants	**Herbaceous Plants**	**Shrubs/ Saplings**	**Trees/ Shrubs**	**Woody Vines**
Mean	21.79	6.63	9.88	1.46	4.73
Std Dev.	4.75	2.11	2.43	1.44	1.84
Range	11–29	1–10	4–15	0–6	0–9
Total Number	90	31	45	24	14
			DENSITY		
	All Plants	Herbaceous Plants	Shrubs/ Saplings	Trees/ Shrubs	Woody Vines
Mean	151.32	85.23	1.91	45.18	19.00
Std Dev.	79.48	58.38	2.12	21.59	17.17
Range	33–361	9–265	0–9	10–107	0–108
		COVER PERCENT		**DBH CM**	
	All Plants	Herbaceous Plants	Shrubs/ Saplings	Trees/ Shrubs	Woody Vines
Mean	68.43	42.40	21.27	4.76	9.17
Std Dev.	30.77	29.58	15.96	5.28	11.23
Minimum	14.88–154.31	1.37–131.7	2.20–73.32	0–24.05	0–44.4

Table 2. Frequency, mean density, mean cover percent, and importance value for herbaceous species in 56 sample plots around four *Uvularia sessilifolia* macroplots on Fort Polk in West Central Louisiana.

Species	**frequency**	**mean density**	**mean cover %**	**importance value**
Uvularia sessilifolia	82.14	31.86	5.39	62.49
Woodwardia areolata	44.64	11.30	12.76	50.10
Chasmanthium laxum	82.14	12.04	9.23	48.29
Mitchella repens	80.36	14.77	1.63	33.30
Osmunda cinnamomea	37.50	1.13	8.02	25.89
Dichanthelium commutatum	60.71	2.86	0.58	13.88
Scleria spp.	46.43	3.05	1.25	13.55
Carex debilis	32.14	2.48	0.98	10.08
Osmunda regalis	21.43	0.46	1.22	6.65
Solidago caesia	23.21	1.63	0.36	6.25
Viola × primulifolia	25.00	0.89	0.08	5.01
Dichanthelium dichotomum	19.64	0.59	0.13	3.95
Chasmanthium latifolium	16.07	0.54	0.32	3.80
Aster lateriflorus	14.29	0.23	0.08	2.63
Dichanthelium boscii	12.50	0.27	0.07	2.37
Athyrium filix-femina	8.93	0.21	0.14	1.92
Tipularia discolor	10.71	0.21	0.01	1.89
Arisaema triphyllum	10.71	0.14	0.00	1.79
Elephantopus tomentosus	5.36	0.07	0.02	0.94
Solidago arguta	5.36	0.09	0.01	0.93
Pteridium aquilinum	3.57	0.13	0.07	0.85
Dioscorea villosa	3.57	0.09	0.02	0.70
Dichanthelium spp.	3.57	0.05	0.00	0.61
Carex intumescens	1.79	0.02	0.02	0.33
Lilium michauxii	1.79	0.02	0.01	0.31
Diodia teres	1.79	0.04	0.00	0.31
Dichanthelium laxiflorum	1.79	0.02	0.00	0.30
Pleopeltis polypodioides	1.79	0.02	0.00	0.29
Bidens aristosa	1.79	0.02	0.00	0.29
Botrychium biternatum	1.79	0.02	0.00	0.29
Total	**662.50**	**85.23**	**42.40**	**300.00**

Table 3. Frequency, mean density, mean cover percent, and importance value for woody vine species in 56 sample plots around four *Uvularia sessilifolia* macroplots on Fort Polk in West Central Louisiana.

Species	frequency	mean density	mean cover %	importance value
Smilax smallii	55.36	3.43	0.87	47.94
Vitis rotundifolia	51.79	1.36	1.34	46.20
Smilax glauca	80.36	2.88	0.50	42.56
Smilax laurifolia	32.14	4.52	0.04	31.41
Gelsemium sempervirens	44.64	0.96	0.73	29.82
*Smilax pumi*la	44.64	1.95	0.41	28.21
Parthenocissus quinquefolia	37.50	1.02	0.36	20.82
Smilax rotundifolia	33.93	0.64	0.15	13.65
Toxicodendron radicans	30.36	0.63	0.16	13.12
Bignonia capreolata	26.79	0.95	0.10	12.77
Rubus argutus	17.86	0.29	0.05	6.39
Smilax spp.	7.14	0.29	0.03	3.63
Berchemia scandens	8.93	0.09	0.01	2.59
Smilax bona-nox	1.79	0.02	0.02	0.89
Total	**473.21**	**19.00**	**4.76**	**300.00**

rotundifolia, and *Smilax glauca*. The frequency, mean density, mean cover percent, and importance value for each shrub/sapling species (listed in descending importance value) are in Table 4. The three shrub/sapling species with the highest importance value are *Vaccinium elliottii*, *Acer rubrum* var. *drummondii*, and *Pinus taeda*. The frequency, mean density, mean dbh, and importance value for each tree/shrub species (listed in descending importance value) are in Table 5. The three tree/shrub species with the highest importance value are *Ilex vomitoria*, *Hamamelis virginiana*, and *Liquidambar styraciflua*.

DISCUSSION

The habitat for *Uvularia sessilifolia* in west central Louisiana is along the edge of baygalls as indicated by the association with *Woodwardia aerolata*, *Chasmanthium laxum*, and *Acer rubrum* var *drummondii* but in the slightly higher and dryer sites within the baygall as indicated by the association with *Mitchella repens*, *Smilax smallii*, *Ilex vomitoria*, and *Hamamelis virginiana*. Allen et al. (2013) reports *Chasmanthium laxum* and *Mitchella repens* as two of the top three herbaceous species in baygalls associated with *Xanthorhiza simplicissima* Marsh. These authors also list *Vitis rotundifolia* and *Smilax glauca* as two of the top three woody vines in their study. *Vaccinium elliottii*, *Liquidambar styraciflua*, and *Acer rubrum* var. *drummondii* were in the top five species of trees/shrubs/saplings in their study.

We found the tree canopy/subcanopy vegetation associated with *Uvularia sessilifolia* to be *Ilex vomitoria*, *Hamamelis virginiana*, *Liquidambar styraciflua*, *Magnolia virginiana* L., *Acer rubrum* var. *drummondii*, *Quercus alba* L., *Persea palustris* (Raf.) Sarg., and *Fagus grandifolia* Ehrh. *Magnolia virginiana* and *Persea palustris* are very typical baygall plants (Allen et al. 2004; Diggs et al. 2006; MacRoberts et al. 2004), and *Ilex vomitoria*, *Hamamelis virginiana*, *Quercus alba*, and *Fagus grandifolia* are indicators of higher dryer sites. The shrub/sapling layer (Table 4) also had a mixture of typical baygall plants (*Vaccinium elliottii*, *Acer rubrum* var. *drummondii*, *Rhododendron canescens* (Michx.) Sweet, and *Persea palustris*) plus species of higher dryer sites (*Pinus taeda*, *Ilex vomitoria*, *Carpinus caroliniana* Walt., *Hamamelis virginiana*, and *Symplocos tinctoria* (L.) L'Hér.).

The herbaceous associates of *Uvularia sessilifolia* in our study that are baygall species were *Woodwardia areolata*, *Chasmanthium laxum*, *Osmunda cinnamomea* L., *Carex debilis* Michx., *Osmunda regalis* L., *Viola* × *primulifolia* L., and *Dichanthelium dichotomum* L. And the associate species that are typical of higher dryer sites like natural levees are *Mitchella repens*, *Dichanthelium commutatum* (J.A. Schultes) Gould, *Scleria* spp., and *Solidago caesia* L. Two woody vine species, *Vitis rotundifola* and *Smilax laurifolia* L., were associated with

Table 4. Frequency, mean density, mean cover percent, and importance value for shrub/sapling species in 56 sample plots around four *Uvularia sessilifolia* macroplots on Fort Polk in West Central Louisiana.

species	frequency	mean density	mean cover %	importance value
Vaccinium elliottii	60.71	1.84	5.68	36.91
Acer rubrum var. *drummondii*	87.50	8.80	1.56	35.70
Pinus taeda	53.57	6.91	0.20	21.68
Ilex vomitoria	60.71	2.18	1.39	17.51
Carpinus caroliniana	37.50	4.45	0.63	16.62
Hamamelis virginiana	48.21	2.16	1.37	16.12
Symplocos tinctoria	39.29	1.61	1.65	15.29
Rhododendron canescens	51.79	2.39	0.39	12.37
Persea palustris	50.00	1.07	0.79	11.16
Ilex opaca	57.14	1.66	0.33	11.01
Quercus hemisphaerica	42.86	1.13	0.61	9.69
Nyssa biflora	44.64	2.02	0.11	9.52
Quercus alba	37.50	1.20	0.43	8.48
Fagus grandifolia	23.21	0.45	1.08	8.43
Vaccinium virgatum	16.07	0.66	1.05	8.02
Halesia diptera	25.00	0.43	0.87	7.55
Quercus laurifolia	35.71	1.07	0.20	6.91
Hypericum hypericoides	23.21	1.41	0.17	6.25
Morella caroliniensis	10.71	0.50	0.47	4.41
Prunus serotina	26.79	0.43	0.09	4.09
Lyonia lucida	7.14	0.16	0.60	3.89
Crataegus marshallii	10.71	0.20	0.36	3.23
Viburnum dentatum	17.86	0.46	0.03	2.97
Magnolia virginiana	12.50	0.23	0.20	2.71
Ilex coriacea	16.07	0.29	0.04	2.46
Callicarpa americana	14.29	0.21	0.06	2.20
Cornus florida	12.50	0.20	0.06	2.00
Ostrya virginiana	5.36	0.23	0.19	1.96
Itea virginica	5.36	0.07	0.13	1.33
Liquidambar styraciflua	7.14	0.07	0.09	1.32
Magnolia grandiflora	3.57	0.07	0.13	1.13
Styrax americanus	7.14	0.11	0.03	1.10
Vaccinium fuscatum	3.57	0.09	0.05	0.82
Styrax grandifolius	5.36	0.09	0.01	0.80
Carya texana	5.36	0.05	0.02	0.73
Vaccinium arboreum	1.79	0.02	0.10	0.69
Carya alba	3.57	0.04	0.01	0.48
Sassafras albidum	3.57	0.04	0.00	0.45
Ilex longipes	1.79	0.04	0.03	0.41
Chionanthus virginicus	1.79	0.05	0.02	0.39
Ligustrum sinense	1.79	0.04	0.00	0.26
Viburnum acerifolium	1.79	0.02	0.00	0.24
Triadica sebifera	1.79	0.02	0.00	0.23
Euonymus americana	1.79	0.02	0.00	0.23
Viburnum nudum	1.79	0.02	0.00	0.22
Total	**987.50**	**45.18**	**21.27**	**300.00**

sessilifolia and are typical baygall species. The other woody vine associates, *Smilax smallii*, *Smilax glauca*, *Gelsemium sempervirens* (L.) St. Hil., and *Smilax pumila* Walt., are more typically found in higher dryer sites.

Our data are the first quantitative description on the vegetation surrounding *Uvularia sessilifolia*. The vegetation around the other populations of *U. sessilifolia* throughout its range should be sampled for comparison with our data so as to get a better idea of the variation, if any, of its habitat.

Table 5. Frequency, mean density, mean dbh, and importance value for tree/shrub species in 56 sample plots around four *Uvularia sessilifolia* macroplots on Fort Polk in West Central Louisiana.

species	frequency	mean density	mean dbh (cm)	importance value
Ilex vomitoria	19.64	0.36	0.84	41.26
Hamamelis virginiana	17.86	0.32	0.74	37.06
Liquidambar styraciflua	10.71	0.13	1.54	30.67
Magnolia virginiana	5.36	0.13	1.35	24.90
Acer rubrum var. *drummondii*	10.71	0.13	0.50	19.33
Quercus alba	3.57	0.04	0.99	15.10
Persea palustris	7.14	0.09	0.51	15.08
Fagus grandifolia	8.93	0.09	0.27	13.75
Carpinus caroliniana	7.14	0.07	0.39	12.84
Nyssa biflora	5.36	0.05	0.58	12.73
Quercus laurifolia	7.14	0.09	0.24	12.22
Prunus serotina	7.14	0.07	0.15	10.29
Ilex opaca	7.14	0.07	0.13	10.04
Pinus taeda	3.57	0.04	0.42	8.85
Magnolia grandiflora	3.57	0.04	0.14	5.87
Symplocos tinctoria	3.57	0.04	0.07	5.03
Vaccinium elliottii	3.57	0.04	0.05	4.89
Quercus hemisphaerica	3.57	0.04	0.04	4.80
Carya texana	1.79	0.02	0.07	2.93
Ostrya virginiana	1.79	0.02	0.04	2.64
Rhododendron canescens	1.79	0.02	0.04	2.58
Ilex coriacea	1.79	0.02	0.03	2.45
Cornus florida	1.79	0.02	0.02	2.35
Morella caroliniensis	1.79	0.02	0.02	2.35
Total	**146.43**	**1.91**	**9.17**	**300.00**

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BLYXA AUBERTII (HYDROCHARITACEAE) NEW TO MISSISSIPPI, U.S.A.

Daniel M. McNair
Department of Biological Sciences
University of Southern Mississippi
Hattiesburg, Mississippi 39406, U.S.A.
danielmcnair@gmail.com

Mac H. Alford
Department of Biological Sciences
University of Southern Mississippi
Hattiesburg, Mississippi 39406, U.S.A.
mac.alford@usm.edu

ABSTRACT

Blyxa aubertii Rich. (Hydrocharitaceae) is reported as new to the flora of Mississippi. New and historical records, along with negative survey results from nearby states, are mapped at the county level. Voucher specimens are cited, and photographs of *B. aubertii* are provided.

RESUMEN

Se amplía el área de distribución de *Blyxa aubertii* Rich. (Hydrocharitaceae) al estado de Mississippi. Se realiza el mapa de distribución de la especie por condado basándose en nuevos registros, datos históricos y en resultados obtenidos del inventario de presencia/ausencia de especies no detectadas en los censos efectuados en estados aledaños. Se listan los ejemplares revisados en este estudio y se presentan fotografías de *B. aubertii*.

Blyxa aubertii Rich., a native of tropical and subtropical regions in Asia, Australia, and Africa (Wang et al. 2010), was first reported for North America, in Louisiana, over 40 years ago (Thieret et al. 1969). No new occurrences outside Louisiana have been reported since that time or listed in relevant treatments or databases (Godfrey & Wooten 1979; Cook & Lüönd 1983; Thomas & Allen 1993; Haynes 2000; McCook & Kartesz 2000; Haynes & Holm-Nielsen 2001; Diggs et al. 2006; Weakley 2012; Kartesz 2013; USDA, NRCS 2013). Thus, our collections of *Blyxa aubertii* represent a new record for Mississippi, augmenting several other recent records for the state (Majure 2007, 2008; Majure & Bryson 2008; Nesom 2010; Whitson 2010; Pruski 2011; Alford 2012; Urbatsch 2013). Since we found *B. aubertii* in four counties in south Mississippi and it was already known to occur in an equal number of parishes in south Louisiana, we predicted it might have also expanded its range to include parts of Texas and Alabama. While this prediction may still prove true, especially with more extensive surveys, we did not find *B. aubertii* or records of its occurrence in these states (Fig. 1).

Voucher specimens: **U.S.A. MISSISSIPPI. Forrest Co.:** Paul B. Johnson State Park, SE end of Geiger Lake, 31.137253°, -89.235334°, 9 Nov 2013, *McNair 1652* (USMS). **Lamar Co.:** Big Bay Lake, 31.201119°, -89.567456°, 8 Nov 2012, *Alford 4378* (BRIT, LSU, USMS). **Stone Co.:** Flint Creek Water Park, NE edge of lake, near the end of Day Use Road, 30.895945°, -89.124452°, 9 Nov 2013, *McNair 1651* (USMS). **Wayne Co.:** Maynor Creek Water Park, N of Reservoir Road, 31.65752°, -88.719192°, 8 Nov 2013, *McNair 1650* (MISS, MMNS, USMS).

We observed *Blyxa aubertii* only in anthropogenically disturbed habitats, specifically, in artificial lakes, submerged and rooted in nutrient poor substrates; we did not observe it in any naturally formed bodies of water such as oxbow lakes or rivers. Furthermore, the four lakes in which *B. aubertii* was found were all constructed between 1943 and 1974. The oldest of these, Geiger Lake, was finished in 1943 and surveyed for vascular plants in 1965–1966 (Carter & Jones 1968), so it is likely that *B. aubertii* established in Mississippi sometime after 1966.

Like a number of other aquatic monocots, *Blyxa aubertii* has septate leaves and roots, and in vegetative form it might be mistaken for its closest relative in the U.S., *Vallisneria americana*. The leaves of *B. aubertii* have somewhat noticeable midribs (Fig. 2 A, B) and acuminate apices, while the leaves of *V. americana* lack prominent midribs and have rounded apices. Also, *B. aubertii* has bisexual flowers (Fig. 2 C) and ridged seeds (Fig. 2 D), while *V. americana* has unisexual flowers and smooth seeds. In general, individuals of *Blyxa aubertii* are smaller with shorter and narrower leaves than *Vallisneria*. *Blyxa aubertii* may also be confused with *Eriocaulon aquaticum* and *Lachnocaulon anceps*. Common associates include *Nymphaea odorata* and *Juncus repens*. We

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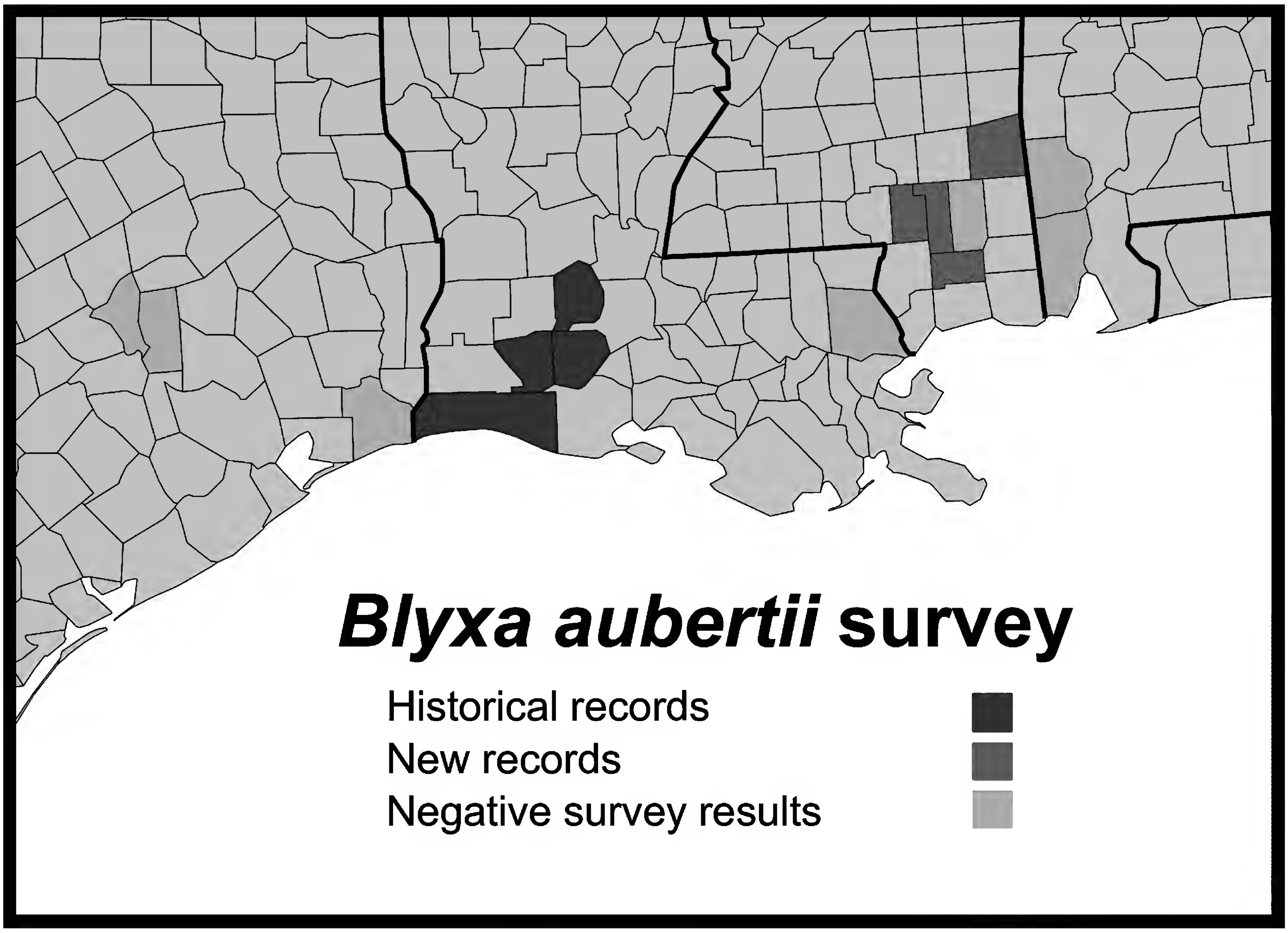

Fig. 1. Distribution of *Blyxa aubertii* in the United States.

observed that many of the plants were in bloom from August to December, the same phenology observed for *B. aubertii* in Japanese rice paddies (Jiang & Kadono 2001).

While *Blyxa aubertii* apparently continues to naturalize and increase its range in the U.S., we do not consider it a serious threat to native plants, at least not to those found in intact habitats, since *B. aubertii* seems confined to disturbed areas of artificial lakes. Still, we believe more investigation will be needed to elucidate this issue, especially if the species is found inhabiting natural bodies of water.

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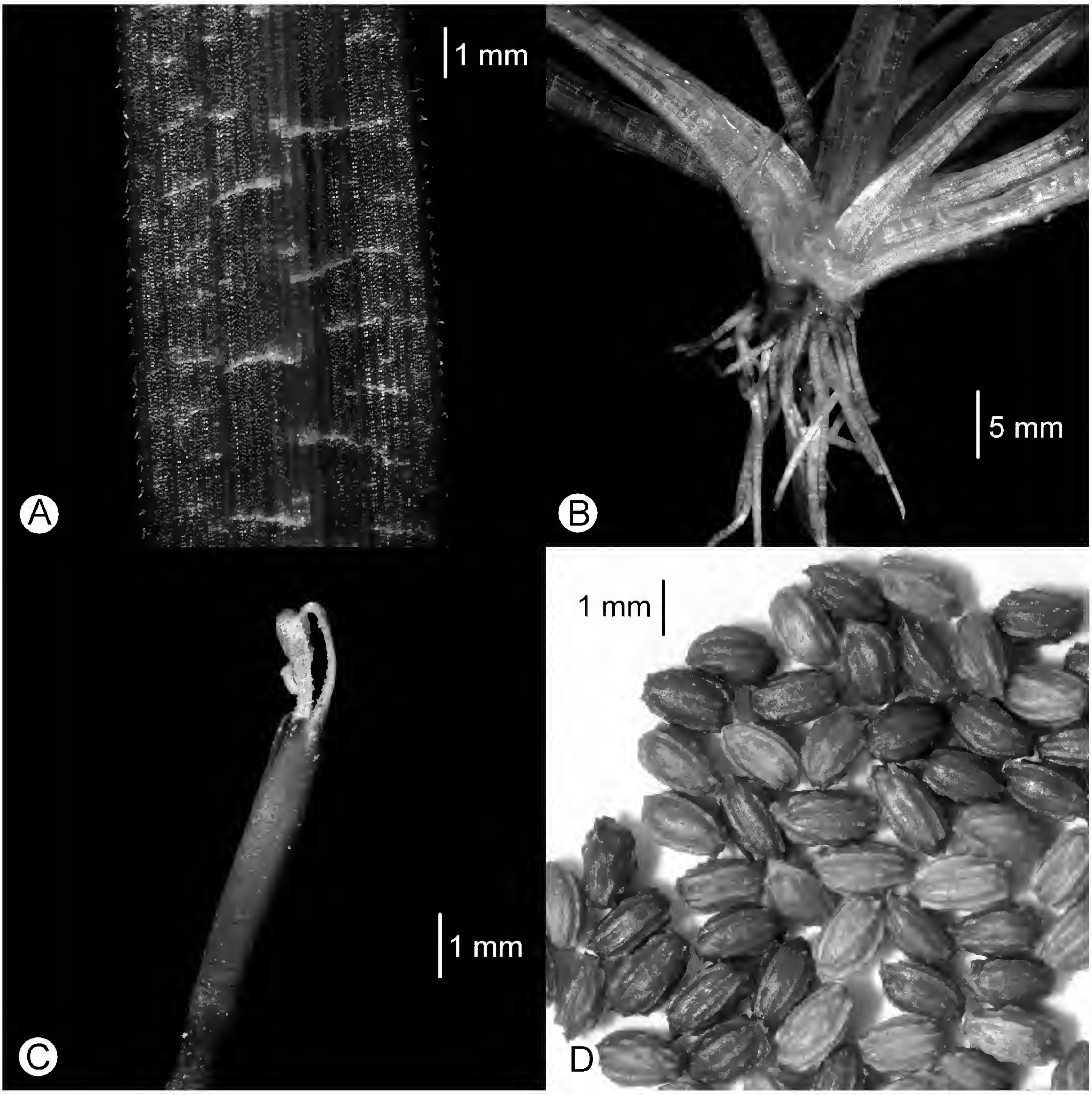

Fig. 2. *Blyxa aubertii*. **A.** Detail of leaf. **B.** Rosette of leaves and roots. **C.** Flower. **D.** Seeds. (A–C, *McNair 1650,* D, *Alford 4378*).

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FLORISTIC STUDIES IN NORTH CENTRAL NEW MEXICO, U.S.A. THE SANGRE DE CRISTO MOUNTAINS

Jill Larson
1072 Hightower Road
Wheatland, Wyoming 82201, U.S.A.
thousandthjill@hotmail.com

Brian Reif
214 South Church Street
Silverton, Oregon 97381, U.S.A.
brianreif_2000@yahoo.com

B.E. Nelson
Rocky Mountain Herbarium
Department of Botany, Dept. 3165
University of Wyoming
1000 E. University Ave.
Laramie, Wyoming 82071, U.S.A.
bnelsonn@uwyo.edu

Ronald L. Hartman
Rocky Mountain Herbarium
Department of Botany, Dept. 3165
University of Wyoming
1000 E. University Ave.
Laramie, Wyoming 82071, U.S.A.
rhartman@uwyo.edu

ABSTRACT

This represents the second of two papers covering the floristic diversity of North Central New Mexico. It reports on results from the Sangre de Cristo Mountains, as well as adjacent lands administered by the State of New Mexico, the Bureau of Land Management, the Picuris and Taos Indian Reservations, and some other private lands. The first paper covered the Jemez and Tusas ranges on the west side of the Rio Grande. For the sake of continuity, the two papers are treated as self-contained companion works. The goal is to enumerate results of the most intensive floristic inventory ever conducted in New Mexico. Here we report on 15,298 numbered collections of vascular plants from an area covering over 1.3 million acres (526,000 ha) (the sum of the entire area covering more than 3.7 million acres (1.5 million ha) is 35,857 new collections). A total of 1226 unique taxa, including 144 infraspecies and 8 hybrids, are documented from 98 families. Of these, 129 are exotics (12 are designated as noxious in New Mexico), 18 are species of conservation concern, 23 represent first reports or their confirmation for New Mexico, and finally 12 are endemic to New Mexico. Based on verified material from the University of New Mexico herbarium, 121 additional unique taxa are included in the Annotated Checklist; thus the grand total is 1347.

RESUMEN

Este es el segundo de los artículos que cubren la diversidad florística del centro norte de Nuevo México. Se señalan los resultados de las montañas Sangre de Cristo, así como tierras adyacentes administradas por el estado de Nuevo México, La Oficina de Gestión del Territorio, las Reservas Indias de Picuris y Taos, y algunos otros territorios privados. El primer artículo cubrió las cordilleras de Jemez y Tusas en el lado oeste de Rio Grande. Por el bien de la continuidad, los dos artículos se tratan como compañeros. Su objetivo es enumerar resultados del inventario florístico más exhaustivo llevado a cabo en Nuevo México. Se citan aquí 15,298 colecciones numeradas de plantas vasculares de un área de más de 1.3 millones de acres (526,000 ha) (la suma total del área cubre más de 3.7 millones de acres (1.5 millón de ha) con 35,857 nuevas colecciones). Se documentan un total de 1226 taxa únicos, incluyendo 144 táxones infraespecíficos y 8 híbridos, de 98 familias. De ellos, 129 son exóticos (12 se designan como nocivos en Nuevo México), 18 son especies con rango de conservación, 23 representan nuevas citas o su confirmación para Nuevo México, y finalmente 12 son endémicas de Nuevo México. Basados en material verificado del herbario de la Universidad de Nuevo México, se incluyen 121 taxa únicos adicionales en el Catálogo anotado; llegando a un total de 1347.

INTRODUCTION

We report on botanical inventories in the eastern portions of the Carson National Forest (CNF) and the Santa Fe National Forest (SFNF) by Jill Larson (2008) and Brian Reif (2006), respectively. Included are surrounding public lands administered by the State of New Mexico as well as the Bureau of Land Management, the Picuris and Taos Pueblo Indian Reservations, and some other private lands (Fig. 1). As these segments of the two forests are defined as the portions occurring east of the Rio Grande, it is restricted to the Sangre de Cristo Mountains.

This is the second paper on federal and adjoining lands in north central New Mexico. The first focused on the Jemez and Tusas Mountains and included the Valles Caldera National Preserve and Bandelier National

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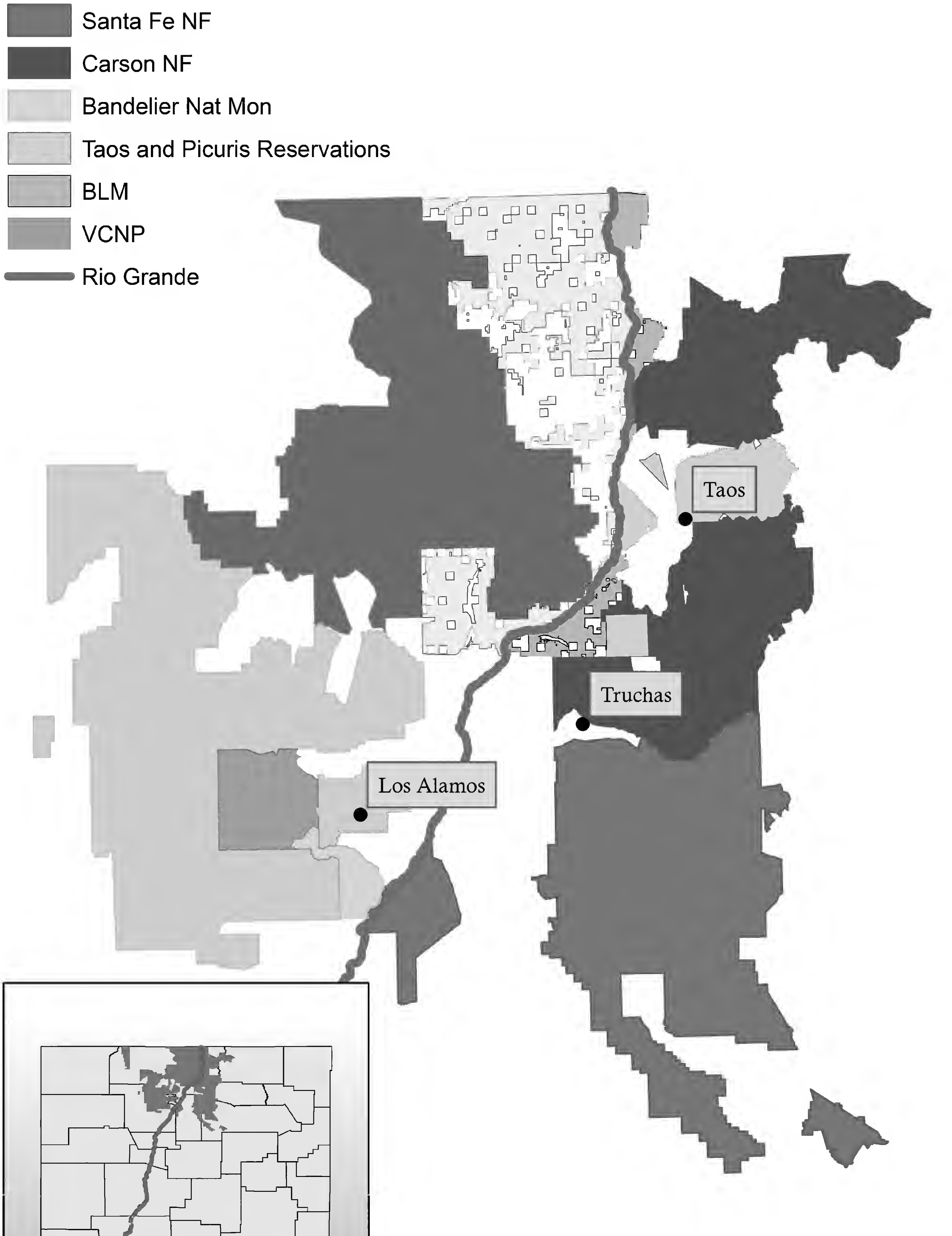

Fig. 1. Location of entire study area in north central New Mexico. This paper covers floristic research conducted to the east of the Rio Grande. Lands to the west of the river (in more muted colors) are treated in the companion paper (Reif et al. 2009). The location of selected towns and villages are indicated and federal agency and tribal lands are delineated (see legend, upper left corner of plate).

Monument (Reif et al. 2009). For the sake of continuity, *the two papers are treated as self-contained companion works.*

The geographic area covered in this paper is over 1.3 million acres (526,000 ha) (the area inventoried as a whole in the two thesis projects was over 3.7 million acres (1.5 million ha). Included are western Colfax, western San Miguel, western Mora, southeastern Rio Arriba, northeastern Santa Fe, and eastern Taos counties. The area ranged from just below 5500 feet (1686 m) in Anton Chico, (the extreme southeastern portion of the area) to 13,161ft (4000 m) on Wheeler Peak, the highest point in New Mexico.

These botanical inventories are part of the larger effort by the Rocky Mountain Herbarium (RM) to map in relatively fine detail the geographic distribution of species based on vouchered specimens and to produce a flora of the greater Rocky Mountain region (Hartman 1992; Hartman et al. 2009; Hartman & Nelson 2008). To this end, 61 major floristics inventories (49 as master's degree projects) have been conducted during the past 35 years in Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming. Over 680,000 new collections have been obtained by graduate students, staff, and research associates of RM. These specimens form the core of the RM Plant Specimen Data Base (830,000 specimen records, 90,000 specimen images, and 4000 field photos) (Hartman et al. 2009).

Topography.—A majority of the area is within the Southern Rocky Mountain Region (Fenneman 1931). To the north, in Colorado, this region is divided by the headwaters of the Rio Grande, thus forming the treeless San Luis Valley. Here the mountains to the west are the San Juans, those to the east, the Sangre de Cristos. The eastern division extends to the south from Colorado into New Mexico as a continuous range to the east of the Rio Grande River. The southern terminous of the Sangre de Cristo Mountains, near Santa Fe, dissolves into a land of mesas and plains. The surficial geology is largely metamorphic and volcanic, but areas covered by sedimentary formations are also present. On the west side of the Rio Grande, the San Juans extend southeast from Colorado and are known locally as the Tusas Mountains separated to the south from the Jemez Mountains and the Sierra Nacimiento by the Rio Chama.

The Taos Plateau is a broad basin and the southern extension of the San Luis Valley of Colorado in the northern portion of the valley of the Rio Grande. It is peppered with volcanic cones some of which rise 3000 ft (914 m) or more above the surrounding desert grass-shrublands. To the south, the Rio Grande Rift is the portion constricted by the mountains and formed by the Embudo Fault (Muehlberger 1978; Muehlberger & Muehlberger 1982).

Climate.—The climate of north central New Mexico is arid in the lowlands, becoming moister as one ascends in elevation. Precipitation is significantly affected by the North American monsoon. The monsoon results in a seasonal pattern of precipitation with a primary maximum during July, August, and September. Strong diurnal cloud cover and precipitation accompany this season. This corresponds with the peak convective heating during the day leading to frequent afternoon thunderstorms (Sheppard et al. 1999). The mountains exert strong orographic effects on precipitation in direct relationship to elevation, while temperature is inversely related. New Mexico receives 30 to 40 percent of its annual precipitation during the summer months.

Winter tends to be drier, with a secondary maximum of precipitation occurring November through March (Sheppard et al. 1999). Winter precipitation is hydrologically important as winter snowpack recharges surface and ground water (Redmond 2003).

On the west side of the Sangres, from north to south, the annual precipitation is about 13 in (33 cm) at Cerro (elevation 7592 ft; 2314 m), 12 in (30 cm) at Taos (6952 ft; 2219 m), 10 in (25 cm) at Española (5589 ft; 1703 m), 14 in (36 cm) at Santa Fe (6989 ft; 2130 m), and 16 in (41 cm) at Pecos (6923 ft; 2110 m). On the east side of the project area, from north to south, the annual precipitation is about 21 in (53 cm) at Red River (8650 ft; 2636 m), 15 in (38 cm) at Eagle Nest (8095 ft; 2467 m), 24 in (61 cm) at Gascon (8045 ft; 2452 m), and about 16 in (41 cm) at Las Vegas (6430 ft; 1960 m) (Western Regional Climate Center 2008). There is no long-term climate data for higher elevations in the mountains.

Drought during a portion of this study had an impact on collecting. Dry conditions were particularly severe in 2002 and 2003 and again in 2006 until the monsoons developed in late July and early August.

Geology and geomorphology.—The current landscape of the Southern Rocky Mountain Region is mainly a product of the Laramide Orogeny (late Cretaceous into the Tertiary (Eocene epoch), 70 to 55 million years ago (mya) that produced the Sangre de Cristos and (to the west of the Rio Grande) the Nacimientos. This uplifting of the Precambrian core caused a warping of the overlying sedimentary strata (anticline). Subsequent volcanism, erosion, infill, and subsidence are recurring themes throughout the region. Furthermore, many older rock types of igneous origins have been uplifted and exposed as a result of the complex geological history. Now, many summits of the Sangre de Cristo consist of Precambrian rocks (to 1.78 billion years old).

The Taos Plateau is the youngest geologic area. It is a broad, relatively flat surface formed by basaltic lava flows. These flows issued from hundreds of volcanic vents during the Pliocene (Lipman 1978; Chronic 1987). The larger shield volcanoes are still present on the Plateau and include Ute Mountain, to the east of the Rio Grande and San Antonio Mountain, to the west. Rocks from some vents date back 2.2–1.8 mya.

The Rio Grande Rift proper is a major break in the earth's crust where large slivers (grabens) between two faults subsided around 30 mya. The rift extends from Colorado south into northern Mexico and is estimated to have been nearly 5 miles in depth (Chronic 1987). Prior to the Pliocene volcanism, the Rift filled with erosive deposits from the surrounding mountains. Around Taos it is still actively subsiding relative to the Sangre de Cristo Mountains (Muehlberger & Muehlberger 1982).

The Rio Grande became a through-flowing river during the Pliocene, having overcome containment in a succession of closed basins within the Rift (Chronic 1987). On the Taos Plateau, it is now confined to a narrow, deeply cut canyon called the Rio Grande Gorge. The gorge is up to 800 ft in depth. The east side of the gorge is marked by alluvium from the Sangre de Cristo Mountains (NMBGMR 2003).

The geology of the Sangre de Cristo Mountains is complex. All of the higher landforms were glaciated repeatedly during the Pleistocene epoch (Cronic 1987). The glaciers shaped more than 60 cirques in the southern Sangre de Cristo Mountains, although many are now below treeline (Miller 1963).

The northern portion is an intricate patchwork of volcanic and metamorphic rocks known as the Taos Range. This range includes the highest and most rugged peaks in the Sangre de Cristo Mountains in New Mexico. Wheeler Peak, the highest point in New Mexico at 13161 ft, is here located. The range is composed of exposed Precambrian granitic rocks with remnants of intrusive silicic rocks and basaltic andesites of Tertiary age (NMBGMR 2003). Faulting is common and adds to the geologic complexity (Shilling 1956). Volcanic activity that shaped the Taos Range is evidenced by the ancient Questa caldera and the Latir volcanic field, which were active during the Oligocene (25 mya; Meyer 1990). A molybdenum (moly) mine now occupies the Questa caldera. Along the east-west trending fault just northeast of Taos, the geology changes to sedimentary formations. This surface is an artifact of Pennsylvanian "skin," leaving the older Precambrian core covered. These sedimentary strata cover a vast area to the south.

The Picuris Mountains are Precambrian quartzite and schist that together with Cerro Azul, on the west side of the Rio Grande, form a constriction. At this point the Rio Grande Rift takes a decided shift to the west (NMBGMR 2003). Here a major fault has brought the Precambrian rocks upward in line with the Pennsylvanian strata in the mountains to the east (Bauer & Ralser 1995). Like the Tusas Mountains to the west of the Rio Grande, the Picuris Mountains experienced volcanism during the middle-Tertiary resulting in thick deposits of Picuris Tuff (Miller 1963).

At the south end, the Sangres contains thick sedimentary deposits from the Pennsylvanian Period (310–280 mya). These deposits may be up to 2700 ft in thickness north of Pecos and extend more than 20 miles (38 km) to the north (Sutherland & Montgomery 1975). This forms a tongue of sedimentary strata flanked by precambrian rock (Chronic 1987). Approximately 26 miles to the north of Pecos in the Truchas Mountains is Truchas Peak at an elevation of 13102 ft (3993 m).

METHODS

Field work on the Carson and Santa Fe National Forests was conducted during the summers of 2002 through 2006, whereas work on the portion to the west of the Rio Grande was begun a year earlier (Valles Caldera National Preserve). Also on the west side of the river, Brian Jacobs conducted an inventory of Bandelier National Monument from 1986 through 1988 (herbarium now housed at University of New Mexico). These studies combined represent the most extensive and exhaustive floristic surveys ever conducted in New Mexico.

Botanists have been roaming the country sides throughout the world for centuries, documenting the riches of floristic diversity. In keeping with the tradition of field botanists, collecting sites were selected and searched based on the researcher's judgment. Thus, the "meander search" strategy was employed (Goff et al. 1982; Hartman 1992; Ristau 1998; Hartman & Nelson 2008). As sites were selected subjectively, the result was the exploration of a much greater diversity of plant communities, soil types, geologic substrates, and topography leading to the documentation of a substantially greater diversity of taxa.

A total of 845 waypoints (each a geographic coordinate determined using a GPS unit) are represented in this paper (for the two thesis projects as a whole, the total was 1542; Fig. 2). Each waypoint represents a general location for collecting plant specimens, usually within one-half mile (either as a radius from a point or a trail segment defined by two successive points; notes on community types were recorded). Details concerning collections as followed in all RM studies are found in Hartman (1992) and Hartman & Nelson (2008).

This paper is based on 15,298 collections from the Sangre de Cristo Mountains and vicinity (total number of collections obtained for the two thesis projects and the Bandelier National Monument was 35,857 collections). This document does not include the northeastern portion of the Sangres in New Mexico. Here, the contiguous Vermejo Park Ranch was surveyed by Legler (2010) who obtained 7503 specimens (912 mi^2; 236,206 ha). A portion of the adjoining Cimarron Range, Philmont National Scout Ranch, was inventoried in 1968 where 1200 collections were taken (210 mi^2; 54,389 ha) (Hartman et al. 2009). A complete set of vouchers from CNF and SFNF as well as the adjoining areas are housed at RM. All authors have made major contributions to the collection, identification, and verification of specimens, as well as the writing of this paper.

RESULTS AND DISCUSSION

The following sections will emphasize the results of research in the Sangre de Cristo Mountains and vicinity with some discussions on various topics. Past discussion referred to the Carson and Santa Fe National Forests to the west of the Rio Grande (Reif et al. 2009), thus this companion paper completes coverage of these forests.

VEGETATION TYPES

New Mexico's vegetation has been divided and described in a number of studies at various spatial scales. The most relevant to this inventory is Dick-Peddie (1993, see Table 12.2). Vegetation types reported here are based on the application and condensation of the above-mentioned classification as confirmed or modified by our field observations. We report 16 vegetation types with five broad physiognomic and zonal categories. These may foster an understanding of the amplitude, common associates, and environmental requirements of the taxa documented by these floristic inventories.

Alpine

Alpine fellfield and meadow.—Alpine vegetation occurs in the Sangre de Cristo Mountains above upper treeline. This varies considerably, but generally occurs between 11,100 and 12,000 ft (3380–3650 m) in elevation. The lower boundary is in contact with Krummholz or dwarfed conifers. Included in this broad category are fellfield cushion plant communities, talus slopes, moist to wet meadows, islands of dwarf shrub, alpine lakes, and small stream drainages. As expected, the species composition of New Mexico's alpine vegetation bears greatest affinity to the main Rocky Mountain Cordillera, implicating a north-south migration as the source of many of its species (Billings 1988; Pase 1994). Consequently, alpine vegetation is regarded as a unit. It is also acknowledged, however, that site conditions greatly affect species composition, and a significant and unrelated component of the flora may be derived from lower elevation. Here is found the most southern alpine area, Lake Peak just northeast of Santa Fe, in the Rocky Mountain Cordilleran.

At least 31 taxa were found exclusive to this vegetation type. These include *Artemisia pattersonii, A. scopulorum, Carex rupestris, Castilleja haydenii, Cymopterus alpinus, Delphinium alpestre, Elymus scribneri, Eritrichium nanum, Paronychia pulvinata, Primula angustifolia, Synthyris alpina, Tonestus pygmaeus,* and *Trifolium na-*

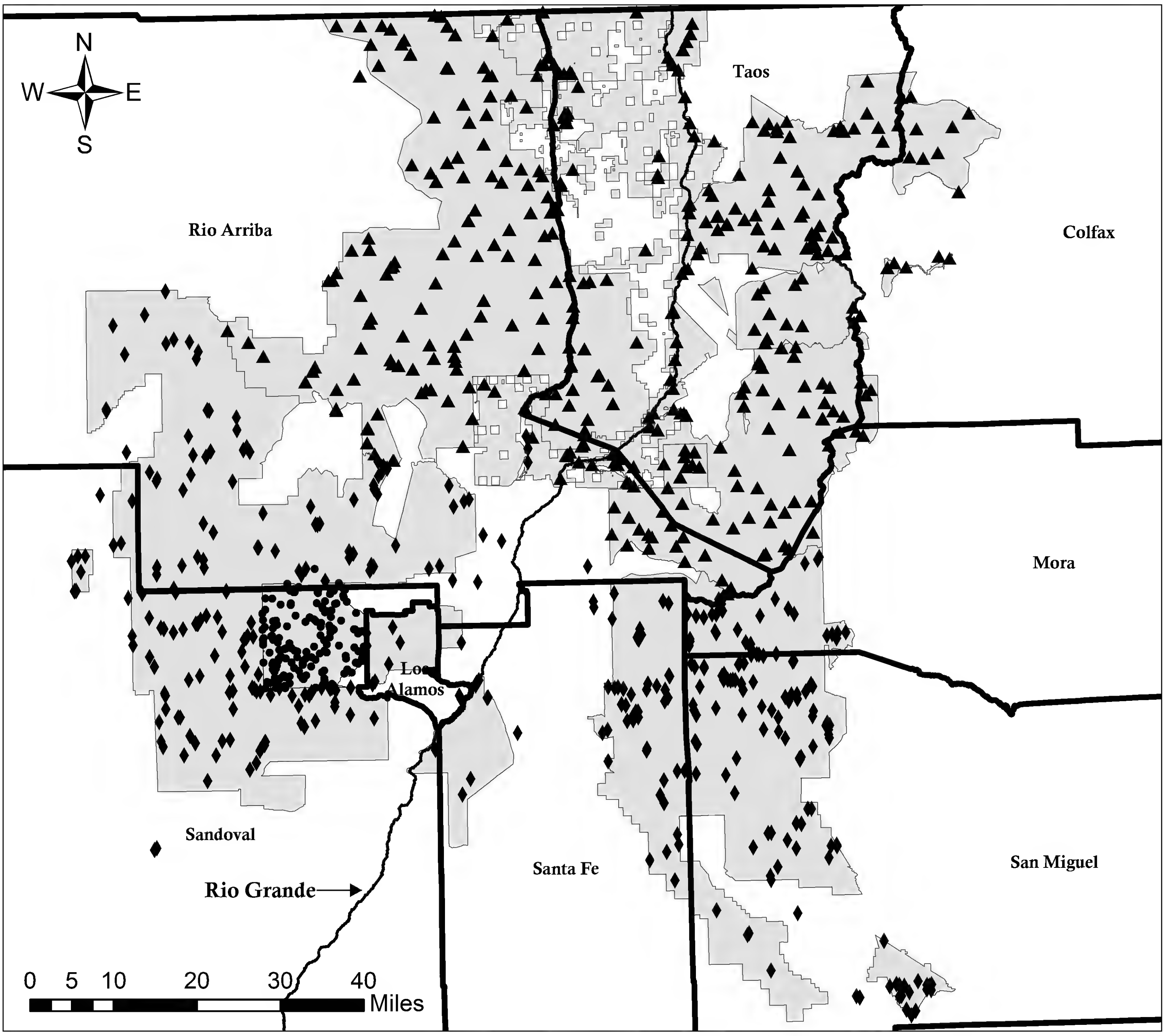

Fig. 2. Map of north central New Mexico counties included in the entire study along with 1542 plant collecting waypoints. Triangles are collecting waypoints associated with the Carson NF portion of the project, diamonds with the Santa Fe NF, and dots with the Valles Caldera NP. The current paper covers floristic research east of the Rio Grande (shown as the thinner black line), while the companion paper (Reif et al. 2009) covers lands west of the river (see Fig. 1).

num. These taxa demonstrate varying distribution patterns regionally. Some are common throughout the Rocky Mountains, while others are restricted to the southern region. This applies to *Castilleja haydenii* and one of the species of conservation concern, *Delphinium alpestre,* both known only from north central New Mexico and adjacent Colorado.

Forests and Woodlands

Bristlecone pine woodland.—These woodlands, fairly limited in distribution, consist of widely spaced, short-conical individuals of *Pinus aristata* occurring above 10,000 ft (3050 m) on dry, rocky, exposed slopes and ridges in surrounding subalpine spruce-fir forests (Peet 1988; Pase & Brown 1994a). Principal associates of this "scree forest" are *Ribes montigenum* and *Saxifraga bronchialis* (Alexander & Ronco 1987). Bristlecone pine woodland also occurs on deep soils bordering meadows and in association with *Festuca thurberi* (Alexander & Ronco 1987). Understory species associated with both subalpine forest and alpine include *Castelleja miniata*, *Eremogone fendleri*, *Festuca idahoensis*, *Helianthella parryi*, *Juniperus communis*, *Luzula spicata*, *Pedicularis racemosa* var. *alba, Phleum alpinum*, *Trifolium attenuatum*.

Spruce-fir forest.—These forests occur in subalpine habitats above 9500 ft (2890 m) or on cooler and more moist slopes at somewhat lower elevations. *Picea engelmannii* and *Abies arizonica* are codominants, although *Picea pungens* may occur as seral on moist sites (Moir 1993; Pase & Brown 1994a). In the upper 1000 ft (304 m) *Picea engelmannii* typically is the sole tree. Scattered stands of *Populus tremuloides* may be present in disturbed areas. Conifers of lower elevations, such as *Abies concolor*, *Pinus flexilis*, and *Pseudotsuga menziesii* may be present in low numbers. Associated shrubs and subshrubs include the abundant and often "impenetrable" *Juniperus communis*, as well as *Lonicera involucrata*, *Dasiphora fruticosa*, *Ribes wolfii*, *Rubus parviflorus*, *Salix scouleriana*, *Sambucus racemosa*, and *Vaccinium myrtillus*. Associated graminoid species are not well represented but may include *Bromus ciliatus*, *Deschampsia cespitosa*, and *Trisetum montanum*. Frequently encountered forbs are *Actaea rubra*, *Castilleja sulphurea*, *Cymopterus lemmonii*, *Erigeron eximius*, *E. coulteri*, *Goodyera oblongifolia*, *Ligusticum porteri*, *Packera sanguisorboides*, *Pedicularis racemosa*, *Penstemon whippleanus*, *Pyrola minor*, *Solidago simplex*, and *Viola canadensis*.

Mixed conifer forest.—Mixed conifer forest occurs throughout the upper montane, roughly between 8000 and 10,000 ft (2440–3050 m). *Pseudotsuga menziesii* and *Abies concolor* are the most widespread and important conifers. *Picea pungens* is restricted to locations subject to cold-air drainage including lower slopes and drainages while *Pinus ponderosa* and *Pinus strobiformis* are found in xeric sites at lower elevations (DeVelice et al. 1986 Moir 1993). The mixed conifer forest is a mix of conifers thus reflecting the heterogeneous landscape.

Common understory shrubs and subshrubs are *Acer glabrum*, *Arctostaphylos uva-ursi*, *Berberis repens*, *Holodiscus dumosa*, *Jamesia americana*, *Juniperus communis*, *J. scopulorum*, *Paxistima myrsinites*, and *Physocarpus monogynus*. Forbs are represented by *Allium cernuum*, *Aquilegia elegantula*, *Artemisia franserioides*, *Castilleja miniata*, *Cymopterus lemmonii*, *Erigeron subtrinervis*, *Fragaria vesca*, *Helianthella parryi*, *Hymenoxys hoopesii*, *Lathyrus leucanthus*, *Lithospermum multiflorum*, *Packera fendleri*, *Potentilla gracilis*, *Solidago simplex*, *Thalictrum fendleri, and Thermopsis rhombifolia, while frequent graminoids include Agrostis scabra*, *Bromus porteri*, *B. richardsonii*, *Carex geophila*, *C. occidentalis*, *C. siccata*, *Elymus trachycaulus*, *Muhlenbergia montana*, and *Oryzopsis asperifolia*.

Fire has created a natural mosaic within this vegetation type, with burns ranging from patchy, low intensity to stand replacing fires (Moir 1993; USDA, Forest Service 1997).

Ponderosa pine forest.—In the Sangre de Cristo Mountains, warmer and dryer conditions from 6700–9000 ft (2040–2740 m) support this forest type, often forming homogenous stands. At its upper limits, *Pinus ponderosa* and mixed conifer forests intergrade, while at its lower limit it merges into piñon-juniper woodland. Where trees are large and scattered the forests may be open and park-like with predominately grasses and forbs. This is especially true along the western side as well as in the southeastern portions of the range. Disturbance patterns in ponderosa pine forest include frequent, low intensity understory fires (DeVelice et al. 1986; Moir 1993; USDA, Forest Service 1997).

Representative subshrubs and shrubs include *Berberis repens*, *Ceanothus fendleri*, *Cercocarpus montanus*, *Fallugia paradoxa*, *Juniperus communis*, *Quercus gambelii*, *Rhus trilobata*, *Ribes cereum*, *R. inerme*, *R. leptanthus*, *Rosa acicularis*, *R. woodsii*, and *Symphoricarpos rotundifolius*. Forbs are represented by *Achillea millefolium*, *Antennaria parvifolia*, *Cymopterus lemmonii*, *Erigeron flagellaris*, *Heterotheca villosa*, *Lithospermum multiflorum*, *Lupinus argenteus*, *Penstemon barbatus*, and *Vicia americana*, while common graminoids include *Blepharoneuron tricholepis*, *Carex inops* ssp. *heliophila*, *Elymus elymoides var. brevifolius*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, and *Poa fendleriana*.

Piñon-juniper woodland.—*Pinus edulis* and *Juniperus monosperma* are dominant in the foothills largely on the western and southeastern side of the Sangre de Cristo Mountains where it forms a discontinuous transitional belt (6000–8500 ft; 1830–2590 m). It is characteristic of escarpments such as Glorieta Mesa where coarse, rocky soil and enhanced infiltration produces moister site conditions (Dick-Pettie 1993). Piñon-juniper woodlands represent the lowest elevation forest type. Piñon forms closed woodlands at the upper elevational ranges, whereas juniper occurs in savanna-like communities at the lower elevational range and interface with grasslands. *Juniperus scopulorum* commonly occurs with piñon at higher elevations in mesic settings and has recently encroached into ponderosa pine understory due to absence of fire disturbance (USDA, Forest Service 1997). Understory conditions are dynamic and vary with canopy cover, soil conditions, and land use and fire history (West 1999).

Shrub cover is variable and includes *Quercus gambelii* and *Q. undulata*, but also *Artemisia tridentata, Cercocarpus montanus, Gutierrezia sarothrae, Fallugia paradoxa, Ribes cereum,* and *Rhus trilobata.* Frequently encountered forbs are *Castilleja integra, Chaetopappa ericoides, Chamaesyce fendleri, Cryptantha cinerea, Eriogonum jamesii, Gaillardia pinnatifida, Hymenoxys richardsonii, Lappula occidentalis, Oenothera suffrutescens, Sphaeralcea coccinea, Tetraneuris argentea, and several succulents including Cylindropuntia imbricata, Opuntia phaeacantha, O. polyacantha,* and *Yucca* spp. Common graminoids are *Achnatherum hymenoides, Aristida purpurea, Bouteloua curtipendula, B. gracilis, Carex geophila, Elymus elymoides* var. *brevifolius, Hesperostipa comata, Hilaria jamesii, Koeleria cristata, Muhlenbergia torreyi, Piptatherum micranthum*, and *Poa fendleriana.*

Historic impacts in woodlands are extensive and include fuel harvest and grazing (Moir 1993). Bark beetle (*Ips confusus*) outbreaks associated with drought stress have resulted in high levels of piñon mortality (Santos & Whitham 2010).

Shrublands

Montane Shrubland.—These shrublands are found throughout the Sangre de Cristo Mountains. They are distributed in a patchy manner in ponderosa pine forests and piñon-juniper woodlands. Areas of montane shrubland are often too limited in extent for mapping because they are produced by site-specific factors: disturbance, substrate, and patterns of moisture. Comparably drier and more rocky sites are typical of montane shrubland, although some associates such as *Prunus virginiana* and *Ptelea trifoliata* are found in areas of increased moisture such as small catchments (Dick-Peddie 1993).

Included in this classification of montane shrubland are thick stands of *Quercus gambelii.* This species occurs on soils that are poorly developed and xeric (Brown 1994), and have also been regarded as seral association indicative of past disturbance. Also included here is the "climax" shrubland of Dick-Peddie (1993) or *Cercocarpus montanus* in association with *Amelanchier alnifolia*, *Philadelphus microphyllus*, *Quercus undulata*, and *Rhus trilobata.* Other shrubs include *Ceanothus fendleri*, *Holodiscus dumosus*, *Jamesia americana*, *Juniperus communis*, *Physocarpus monogynus*, *Ribes cereum*, *R. inerme*, *Rubus parviflorus*, *Sambucus racemosa*, and *Symphoricarpos rotundifolius.* Grass and forb species are those of surrounding montane forests and woodlands.

Desert shrubland.—There are two subtypes that fit this descriptor. The first is found along the Pecos River and in a large area of the Taos Plateau, but less so on the east side of the Rio Grande. This subtype is characterized by the absence of *Artemisia tridentata* and the presence of number of other shrubs. Included are *Atriplex canescens*, *Chrysothamnus greenei*, *Ericameria nauseosa*, and *Gutierrezia sarothrae.* Grass cover is often sparse but may include *Achnatherum hymenoides, Aristida purpurea*, *Bouteloua gracilis*, *Elymus smithii*, and *Muhlenbergia torreyi.* Forbs are also scanty, yet represented by *Castilleja integra*, *Chaetopappa ericoides*, *Eriogonum jamesii*, *Hedeoma drummondii*, *Lappula occidentalis*, and *Thelesperma megapotamicum.*

The second subtype is dominated by *Artemisia tridentata* var. *tridentata.* It most often occurs in glades within piñon-juniper woodlands. *Atriplex canescens*, *Cylindropuntia imbricata*, *Ericameria nauseosa*, and *Rhus trilobata* are common woody associates. Grasses include *Agropyron cristatum*, *Bromus tectorum*, *Elymus elymoides* var. *brevifolius, Hilaria jamesii,* and *Muhlenbergia richardsonis.* Common forbs are *Chaetopappa ericoides*, *Echinocereus coccineus*, *Lappula occidentalis*, *Opuntia polyacantha*, and *Plantago patagonica.*

Grasslands

Montane meadow and grassland.—This vegetation type occurs from about 8500 ft (2590 m) to the highest summits. Transitions between forest and grassland vegetation are often abrupt at the upper elevations where grasslands may represent a climax condition, or are typically gradual at lower elevations where trees can encroach under heavy grazing or have been excluded by past fire (Peedie 1993). Common forbs include *Achillea millifolium*, *Agoseris aurantiaca*, *Allium cernuum*, *Campanula rotundifolia*, *Castilleja miniata*, *Frasera speciosa*, *Hymenoxys hoopesii*, *Linum lewisii*, *Mirabilis melanotricha*, and *Silene scouleri.* Graminoids vary with moisture and, to a lesser degree, elevation. Moist sites frequently include *Carex microptera*, *C. nova*, *Deschampsia cespi-*

tosa, Phleum pratense, and *Poa pratensis.* Drier meadows are characterized by *Bromus porteri, Festuca arizonica, Koeleria macrantha, and Blepharoneuron tricholepis.*

Plains-desert grassland.—This vegetation type is ecotonal to piñon-juniper woodlands, juniper woodlands, or juniper savannas. Desert grassland occurs primarily along the Rio Grande Rift often up slope to the piñon-juniper woodland. It has a significant shrub and forb cover. Characteristic grasses are *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *B. curtipendula*, *Elymus smithii*, *Hesperostipa comata*, and *Hilaria jamesii*, while frequently encountered forbs are *Antennaria microphylla*, *A. rosea*, *Castilleja integra*, *Cryptantha* spp., *Glandularia bipinnatifida*, *Grindelia squarrosa, Oenothera coronopifolia*, *O. suffrutescens*, *Opuntia polyacantha*, *O. phaecantha*, *Ratibida tagetes*, *Sphaeralcea coccinea*, *Teucrium lacinata*, and *Zinnia grandiflora*.

Wetlands

Montane Riparian.—Margins of perennial and intermittent streams support unique species assemblages. Montane riparian vegetation is found in moist areas within spruce-fir and mixed conifer forests. As with montane meadows, the species composition follows an elevational gradient (Dick-Peddie 1993). A rich diversity of herbaceous and woody vegetation is present. Obligate and facultative riparian species of trees and shrubs can be arranged along a descending gradient: *Picea pungens*, *Salix amydaloides*, *S. bebbiana*, *S. irrota*, *Alnus incana*, *Acer glabrum*, *Cornus sericea*, *Populus angustifoliia*, and *Acer negundo.* Additional facultative riparian trees and shrubs include *Populus tremuloides* and *Prunus virginiana.* Among the rich diversity of forbs are *Aconitum columbianum*, *Caltha leptosepala*, *Cardamine cordifolia*, *Dodecatheon pulchellum*, *Equisetum arvense*, *Geum macrophyllum*, *Heracleum maximum*, *Hypericum scouleri*, *Mertensia franciscana*, *Mimulus guttatus*, *Oxypolis fendleri*, *Pedicularis groenlandica*, *Saxifraga odontoloma*, *Sedum rhodanthum*, *Veronica americana*, and species of *Epilobium*, *Potamogeton*, *Ranunculus*, and *Salix.* Graminoids are represented by *Alopecurus aequalis, Deschampsia cespitosa*, *Glyceria grandis*, *G. striata*, *Juncus arcticus*, *Torreyochloa pallida*, and species of *Agrostis*, *Carex*, and *Eleocharis.*

Floodplain-arroyo riparian.—This type of vegetation occurs at lower elevations on floodplains along the Rio Grande and the lowest elevations of the Sangres. Many species that thrive here are well adapted to disturbance and dry conditions with periodic flooding. The most common dominant is *Populus deltoides*, with understory shrubs *Baccharis salicina*, *Ericameria nauseosa*, *Fallugia paradoxa*, *Forestiera pubescens*, *Rhus trilobata*, and *Salix exigua.* The exotics *Elaeagnus angustifolia* and *Tamarix chinensis* have proliferated and may persist in a subclimax state (Dick-Peddie 1993; Minckley & Brown 1994). Arroyo riparian is common to desert shrubland and may grade into montane riparian.

Marsh-lacustrine.—The marsh-lacustrine riparian habitat is found around ponds and springs,in otherwise arid habitats such as piñon-juniper woodland or desert grassland where the water table remains sufficiently high or in various montane vegetation types. Along the shoreline, *Limosella aquatica*, *Potentilla anserina*, *P. norvegia*, *Ranunculus cymbalaria*, *Rorippa* spp., and *Rumex crispus* may be encountered. Emergents include *Scirpus microcarpus*, *Sparganium emersum*, *Typha latifolia* and species of *Carex*, *Eleocharis*, *Juncus*, and *Schoenoplectus.* Floating and submersed taxa include *Callitriche palustris*, *Potamogeton* spp., *Lemna minor, Elodea canadensis*, and *Ranunculus aquatilis.*

Disturbed

Aspen seral forest.—*Populus tremuloides*, an important seral species and post fire increaser, is widely distributed in the Rocky Mountains (Peet 1988). Pure stands of this shade-intolerant species arise through root sprouting following disturbances (Pase & Brown 1994b). Scattered individuals are also found in late-succession or near climax stages in forest types and lower subalpine spruce-fir forests (Moir 1993). However, like many successional communities, aspen forms a distinct assemblage that may persist for long periods of time. Aspen are found in the various coniferous forest types throughout the Sangre de Cristo Mountains.

Forbs include *Campanula rotundifolia, Castilleja miniata, Chamerion angustifolia, Geranium richardsonii, Ligusticum porteri, Pseudostellaria jamesiana,* and *Thalictrum fendleri,* while frequently encountered grasses include *Bromus carinatus, B. richardsonii, Festuca arizonica, Poa fendleriana,* and *P. pratensis.*

Burn Areas.—Natural and anthropogenic fires have been frequent in most of the vegetation types mentioned above. This is true for most of the Sangre de Cristo Mountains. In many areas, the vegetation is in various states of succession. While fire is important ecologically, natural succession is often compromised by exotics. Several major burns have occurred in the Sangres.

Roadside-agricultural.—Here, native vegetation may be largely replaced by exotic and agricultural species. Noxious weeds collected along roads include *Aegilops cylindrica*, *Cirsium vulgare*, *Convolvulus arvensis*, *Lepidium latifolium*, *Linaria dalmaticum*, and *Ulmus pumila*. Weedy or agricultural plants include *Avena sativa*, *Helianthus annuus*, *Salsola tragus*, *Sisymbrium altissimum*, *Tragopogon dubius*, and species of *Ambrosia*, *Bromus*, *Chamaesyce*, *Chenopodium*, *Elymus*, *Lappula*, *Lepidium*, *Medicago*, *Melilotus*, *Plantago*, *Polygonum*, and *Trifolium*. Roadsides often act as corridors for exotics and thus warrant monitoring.

NOXIOUS WEEDS

Invasive plant species that are particularly damaging or prolific are regulated as noxious weeds (USDA, NRCS 2013). A specific goal of our floristic inventories was to document noxious weeds for the purpose of assisting in monitoring and control efforts. Of the 35 taxa listed in New Mexico, 13 were encountered at 91 sites. They are *Acroptilon repens*, *Aegilops cylindrica, Carduus nutans*, *Centaurea stoebe* ssp. *micranthos*, *Cirsium arvense*, *C. vulgare*, *Convolvulus arvensis*, *Elaeagnus angustifolia*, *Lepidium latifolium*, *Linaria dalmatica, L. vulgaris, Tamarix chinensis*, and *Ulmus pumila*. The first of these noxious weeds is based on a specimen at University of New Mexico. Noxious weeds and other exotics are indicated in the Annotated Checklist by a ● or an *, respectively.

TAXA OF CONSERVATION CONCERN

Another primary goal of the inventories was to document the occurrence of rare and endemic taxa. A total of 18 species of conservation concern were documented from 83 sites in the Sangre de Cristo Mountains and vicinity. These species of conservation concern are listed by Natural Heritage New Mexico (2012) and the New Mexico Rare Plant Technical Committee (2012) as such. The list is arranged alphabetically and each is followed by family name, county of occurrence, and collector and associated voucher number(s). They are indicated by a ♦ in the Annotated Checklist.

Astragalus cyaneus (Fabaceae) Taos: *Hartman 80544b*
Astragalus iodopetalus (Fabaceae) Taos: *Larson 4946, 5711, 7140*
Astragalus puniceus var. *gertrudis* (Fabaceae) Taos: *Hartman 80541; Larson 5293*
Calochortus gunnisonii var. *perpulcher* (Liliacaeae) Mora, San Miguel: *Reif 3026, 7232, 7299, 7614*
Cornus canadensis (Cornaceae) Taos: *Larson 2799, 8035*
Cypripedium parviflorum (Orchidaceae) San Miguel: *Reif 6219*
Delphinium alpestre (Ranunculaceae) Taos: *Larson 2945, 3004, 3393, 8991*
Delphinium sapellonis (Ranunculaceae) Mora, San Miguel, Taos: *Nelson 65919, 66309, 69383; Reif 3011, 3773, 4038, 7323, 7641, 8682, 8779, 8934, 10286*
Hackelia hirsuta (Boraginaceae) Colfax, Mora, San Miguel, Taos: *Larson 2303, 3093, 8186, 10626; Nelson 69141, 69442; Reif 3157*
Herrickia horrida (Asteraceae) Colfax: *Larson 10028*
Iliamna grandiflora (Malvaceae) Taos: *Larson 5404, 5470, 5848*
Parnassia fimbriata (Parnassiaceae) Taos: *Larson 3972, 4070, 9775, 9877*
Podistera eastwoodiae (Apiaceae) Taos: *Larson 1579, 1784a, 1842, 2937, 2982, 3015, 4022, 7989, 8080, 9009, 9966, 10310; Reif 8102, 10214*
Salix arizonica (Salicaceae) Mora: *Reif 10294*
Saxifraga cernua (Saxifragaceae) Santa Fe: *Reif 10294*
Selaginella weatherbiana (Selaginellaceae) Rio Arriba, San Miguel, Taos: *Hartman 76708, Larson 2509, 10291, Reif 3111, 3876, 6107, 7441, 8089*
Synthyris alpina (Plantaginaceae) Taos: *Hartman 81340, Larson 720, 1589, 1769, 2991, 8153*
Trifolium brandegeei (Fabaceae) Taos: *Hartman 81284, Larson 1582, 3978, 4061, 4214, 7212b, 7664, 7687, 8127*

SUMMARY OF TAXA

The first number represents results based on our fieldwork. Parenthetical numbers following most of the former are those verified from UNM. The two adjacent numbers below "Exotic taxa" represent the percent of exotics when compared to total unique taxa.

A total of 1226 unique taxa, including 144 infraspecies and 8 hybrids, are documented from 98 families. Of these, 129 are exotics (12 are designated as noxious in New Mexico), 18 are species of conservation concern, 23 represent first reports or their confirmation for New Mexico, and finally 12 are endemic to New Mexico. Based on verified material from the University of New Mexico herbarium, 121 additional unique taxa are included in the Annotated Checklist; thus the grand total is 1347.

List by taxonomic category		List by special category	
Families	98 (103)	Exotic taxa	129 (148)
Genera	475 (514)	Percent exotic taxa	10.5 (11)
Species	1147 (1263)	NM Noxious weeds	12 (13)
Hybrids	8	Taxa conservation concern	18
Infraspecies	144 (149)	NM Endemic taxa	12 (13)
		State records	23
Unique taxa	1226 (1347)		

List of unique taxa by major plant group	
Fern Allies	11 (21)
Ferns	18 (18)
Gymnosperms	13
Angiosperms	1184 (1295)
Total	1226 (1347)

CONCLUSIONS

This paper represents the second of two contributions that cover the floristic diversity of north central New Mexico (for the portion west of the Rio Grande, see Reif et al. 2009). The area here covered encompasses the Sangre de Cristo Range, as well as adjacent lands administered by the State of New Mexico, the Bureau of Land Management, the Picuris and Taos Indian Reservations, and some other private lands. We report on results of 15,298 numbered collections of vascular plants (total for the two publications covering more than 3.7 million acres is 35,857 numbered new collections). A total of 1226 (1347) unique taxa, 144 (149) including infraspecies as well as 8 hybrids, are documented from 98 (103) families. With the addition of 121 taxa (totals within verified from RM and UNM), the total for unique taxa rise to 1347. Of these, 129 (148) are exotic taxa of which 12 (13) are designated as noxious in New Mexico, 18 are species of conservation concern, 23 represent first reports or their confirmation for New Mexico, and 12 (13) are endemic to the state.

THE ANNOTATED CHECKLIST

The checklist is divided into major plant groups (ferns and fern allies, gymnosperms, and angiosperms) each with alphabetical listing by family and species. Nomenclature follows Allred (2012). In some cases (71) it follows that of an antiquated checklist compiled by the staff of the RM. In order to provide an easy "cross walk" between the companion floristic treatments, that name is maintained between the two and the name used in Allred 2012 is placed in square brackets [ ] below the alternate name. The original sources used in identification were relevant state and regional treatments and monographs with comparison to authenticated materal, where possible, in the RM.

Following is a guide to format and abbreviations associated with individual taxa in the checklist. Except for records based on specimens at RM, the citation of the vouchers are omitted. This is justified as collection data are available online (Hartman et al. 2009; Symbiota 2013). In the case of Botrychium, all specimens were collected by Ben Legler on his own.

Taxon Authority (project on the Carson NF or the Santa Fe NF) [3, 9 or 6,-]; COUNTY; elevational range in ft; **GEOLOGIC AREA;** habitat type.

[*Taxon* Authority, name accepted by Allred]

One other attribute includes specimens seen only at the University of New Mexico, [**UNM**-R. Sivinski 3910]

County abbreviations:

A	S**A**n Miguel
C	**C**olfax
M	**M**ora
R	**R**io Arriba
S	**S**anta Fe
T	**T**aos

Geologic area:

G	Rio **G**rande Rift
L	Great P**L**ains
P	Taos **P**lateau
S	**S**angre de Cristo Mountains

Habitat type:

af	Aspen seral forest
am	Alpine fellfield and meadow
br	Burns
bw	Bristlecone pine woodland
ds	Desert shrubland
fr	Floodplain-arroyo riparian
mc	Mixed conifer forest
ml	Marsh-lacustrine wetland
mm	Montane meadow and grassland
mr	Montane riparian
ms	Montane shrubland
pg	Plains-desert grassland
pj	Piñon-juniper woodland
pp	Ponderosa pine forest
ra	Roadside-agricultural
sf	Spruce-fir forest

Symbols by category preceding *Taxon*:

*	Exotic species to New Mexico
●	Noxious weed in New Mexico
♦	Species of conservation concern
+	Endemic to New Mexico
!	State record for New Mexico
×	Hybrid

FERNS AND FERN ALLIES

Aspleniaceae

Asplenium resiliens Kunze **[1,-]** A; 5500′; **S;** fr.

Asplenium trichomanes L. **[1,-]** A; 8900–9500′; **S;** mc.

Dennstaedtiaceae

Pteridium aquilinum (L.) Kuhn var. *pubescens* Underw. **[15,4]** A, C, M, S, T; 7720–10500′; **S;** af, mc, mm, mr, pp, sf.

Dryopteridaceae

Athyrium filix-femina (L.) Roth ex Mert. var. *californicum* Butters **[4,3]** A, S, T; 8300–10500′; **S;** mr.

Cystopteris fragilis (L.) Bernh. **[12,18]** A, M, R, S, T; 7740–12700′; **S;** am, bw, mc, mm, mr, sf.

Cystopteris reevesiana Lellinger **[24,24]** A, C, M, S, T; 7620–12000′; **S;** bw, mc, mr, sf.

Dryopteris filix-mas (L.) Schott **[7,3]** A, C, M, T; 7650–10500′; **S;** mc, mr, pp.

Gymnocarpium dryopteris (L.) Newman **[-,1]** T; 8450–9600′; **S;** mr.

Woodsia neomexicana Windham **[2,2]** R, S, T; 6840–11200′; **P, S;** bw, fr, pp.

Woodsia oregana D.C. Eaton var. *cathcartiana* (B.L. Rob.) Morton **[1,4]** A, C, T; 7400–12450′; **P, S;** am, ds, mc.

Woodsia plummerae Lemmon **[-,1]** T; 7400–7550′; **P;** pj.

Equisetaceae

Equisetum arvense L. **[15,24]** A, C, M, R, S, T; 5781–9700′; **G, P, S;** fr, ml, mm, mr, ra, sf.

× *Equisetum* ×*ferrissii* Clute **[1,2]** S, T; 7760–9400′; **S;** mm, mr.

Equisetum hyemale L. var. *affine* (Engelm.) A.A. Eaton **[8,9]** A, C, M, S, T; 7350–10500′; **S;** mc, mm, mr.

Equisetum laevigatum A. Braun **[7,18]** A, C, M, R, S, T; 5781–9700′; **G, L, P, S;** fr, mc, ml, mm, mr, ra, sf.

× *Equisetum* ×*nelsonii* (A.A. Eaton) J.H. Schaffn. **[-,1]** T; 5781′; **G;** fr.

Lycopodiaceae

Huperzia lucidula (Michx.) Trevis. **[UNM**-C. Dixon A-289**]** S; **S.**

Lycopodium annotinum L. **[UNM**-N. Osborn 1079**]** T; **S.**

Ophioglossaceae

Botrychium echo W.H. Wagner **[UNM**-B. Legler 11545**]** T; **S.**

Botrychium hesperium (Maxon & R.T. Clausen) Wagner & Lellinger **[RM, UNM**-B. Legler 11553**]** T; **S.**

Botrychium lanceolatum (Gmel.) Ångstr. **[RM**-B. Legler 11567**]** C; **S.**

Botrychium lineare W.H. Wagner **[RM, UNM**- B. Legler 11556**]** T; **S.**

Botrychium "neolunaria" in ed. **[RM, UNM**-B. Legler 11584A**]** S; **S.**

Botrychium minganense Vict. **[RM, UNM**-B. Legler 11609**]** T; **S.**

Botrychium pinnatum H.St. John **[RM, UNM**-B. Legler 11582**]** S; **S.**

Botrychium tunux Stevensvold & Farrar **[RM, UNM**-B. Legler 11555**]** T; **S.**

Pteridaceae

Argyrochosma fendleri (Kunze) Windham **[1,5]** R, S, T; 5800–7550′; **G, P, S;** ds, fr.

Cheilanthes eatonii Baker **[4,2]** A, C, T; 5560–8450′; **S;** fr, pj, pp.

Cheilanthes feei T. Moore **[2,-]** A; 5650–7150′; **S;** mr, pj.

Cheilanthes fendleri Hook. **[2,1]** A, S, T; 7600–8640′; **S;** mc, ms, pp.

Cryptogramma acrostichoides R. Br. **[2,6]** M, R, T; 9600–12000′; **S;** am, bw, mc, mm, sf.

Notholaena standleyi Maxon **[2,-]** A; 5560–5840′; **S;** pj.

Pellaea atropurpurea (L.) Link **[1,-]** A; 5500′; **S;** pj.

Selaginellaceae

Selaginella densa Rydb. var. *densa* **[1,16]** A, T; 7050–12700′; **P, S;** am, ds, mc, mm.

Selaginella mutica D.C. Eaton ex Underw. var. *limitanea* Weatherby **[-,1]** T, 7600–8450′; **S;** pp.

Selaginella mutica D.C. Eaton ex Underw. var. *mutica* **[1,-]** S; 6540′; **S;** fr.

Selaginella peruviana (Milde) Hieronymus **[1,-]** A; 5630′; **S;** fr.

Selaginella underwoodii Hieronymus **[2,-]** A, M; 7900–9760′; **S;** mc, sf.

♦ *Selaginella weatherbiana* R. Tryon **[6,2]** A, R, S, T; 7750–13024′; **S;** am, mc.

GYMNOSPERMS

Cupressaceae

Juniperus communis L. var. *depressa* Pursh **[34,43]** A, C, M, R, S, T; 7620–12430′; **P, S;** af, bw, mc, mm, ms, mr, pp, sf.

Juniperus monosperma (Engelm.) Sarg. **[15,18]** A, R, S, T; 5560–8720′; **G, L, P, S;** ds, fr, mr, ms, pj.

Juniperus scopulorum Sarg. **[14,44]** A, C, M, R, S, T; 6050–10500′; **G, P, S;** ds, fr, mc, ml, mm, ms, mr, pj, pp, ra.

Pinaceae

Abies arizonica Merriam **[15,29]** A, C, M, R, S, T; 8500–12400′; **S;** mc, mm, mr, sf.

Abies concolor (Gord. & Glend.) Hildebr. **[32,34]** A, C, M, R, S, T; 7600–10500′; **P, S;** af, mc, mm, mr, pj, pp.

Picea engelmannii Parry ex Engelm. var. *engelmannii* **[20,24]** A, C, M, R, S, T; 7720–12300′; **S;** am, af, bw, mc, mm, mr, sf.

Picea pungens Engelm. **[22,23]** A, C, M, R, S, T; 6840–12000′; **S;** mc, mm, ms, mr, sf.

Pinus aristata Engelm. **[8,21]** A, C, M, S, T; 9375–13000′; **S;** am, bw, mc, mm, mr, sf.

Pinus edulis Engelm. **[28,29]** A, C, M, R, S, T; 5560–10000′; **G, P, S;** br, ds, fr, mc, mm, ms, pj, pp, ra.

Pinus flexilis E. James **[13,10]** A, M, S, T; 7740–11209′; **P, S;** mc, mr, ms, sf.

Pinus ponderosa Douglas ex P. Lawson & C. Lawson var. *scopulorum* Engelm. **[28,29]** A, C, M, R, S, T; 5500–9920′; **P, S;** af, br, fr, mc, mm, ms, mr, pj, pp, ra.

[*Pinus scopulorum* (Engelm.) Lemmon]

Pinus strobiformis Engelm. **[8,5]** A, C, M, S, T; 7720–10150′; **S;** mc, mm, mr.

Pseudotsuga menziesii (Mirb.) Franco var. *glauca* (Beissn.) Franco **[32,38]** A, C, M, R, S, T; 6600–11150′; **P, S;** af, br, mc, mm, ms, mr, pj, pp.

ANGIOSPERMS

Aceraceae [as Sapindaceae]

Acer glabrum Torr. var. *glabrum* **[29,41]** A, C, M, R, S, T; 7320–11300′; **S;** br, mc, mm, ms, mr, ra, sf.

[*Acer glabrum* Torr. var. *neomexicanum* (Greene) Kearn. & Peeb.]

Acer negundo L. var. *interius* (Britton) Sarg. **[5,6]** A, S, T; 5781–8000′; **L, P, S;** fr, mr, pj, ra.

Adoxaceae

Adoxa moschatellina L. **[UNM**-R. Sivinski 3910] S; **S.**

Sambucus caerulea Raf. var. *neomexicana* (Woot.) Rehder **[UNM**-C. Dixon A-285] S; **S.**

Sambucus racemosa L. var. *melanocarpa* (A. Gray) McMinn **[3,-]** M, S; 9840–12000′; **S;** mm, mr.

Sambucus racemosa L. var. *microbotrys* (Rydb.) Kearn. & Peeb. **[18,21]** A, C, M, R, S, T; 7840–11500′; **S;** br, mc, mm, mr, sf.

Agavaceae [includes Nolinaceae]

Nolina greenei S. Watson **[3,-]** A;5700–5800′; **L;** pj.

Yucca angustissima Engelm. ex Trelease var. *angustissima* **[3,-]** A, R; 5730–6620′; **G, L, S;** ds, pj.

Yucca baccata Torr. var. *baccata* **[9,6]** A, R, S, T; 6036–9450′; **G, P, S;** ds, fr, mc, pj.

Yucca baileyi Wooton & Standl. var. *baileyi* **[3,-]** A, S; 6200–7460′; **L, S;** pg, pj.

\+ *Yucca intermedia* McKelvey **[-,4]** R, T; 6050–8150′; **G, P, S;** br, fr, pj, pp.

[*Y. baileyi* Wooton & Standl. var. *intermedia* (McKelvey) Reveal; see Sivinski 2008]

Yucca neomexicana Wooton & Standl. **[2,-]** A, S; 5700–6540′; **G, L;** pj.

Alismaceae

Sagittaria cuneata E. Sheld. **[UNM**-E. Castetter 4792] T; **S.**

Alliaceae [traditionally in Liliaceae]

Allium cernuum Roth **[37,35]** A, C, M, R, S, T; 7000–11700′; **P, S;** af, br, bw, fr, mc, mm, ms, mr, pj, pp, ra, sf.

Allium geyeri S. Watson var. *geyeri* **[10,7]** A, M, S, T; 8100–12700′; **S;** am, bw, mc, mm, ms, mr, pp, sf.

Allium geyeri S. Watson var. *tenerum* M.E. Jones **[1,7]** M, T; 9250–11100′; **S;** mm, mr.

Allium macropetalum Rydb. **[1,-]** A; 6200′; **L**; pg, pj.

Amaranthaceae

Amaranthus albus L. **[1,1]** A, T; 5610–7450′; **L, S;** fr, ra.

* *Amaranthus blitoides* S. Watson **[UNM**-H. Mackay 6T-55] T; **S.**

Amaranthus powellii S. Watson **[3,4]** A, C, M, S, T; 7300–9400′; **S;** fr, mm, mr, ra.

* *Amaranthus retroflexus* L. **[3,-]** A, S; 6840–8000′; **S;** mm, mr.

Guilleminea densa (Humb. & Bonpl. ex Willd.) Moq. var. *aggregata* Uline & Bray **[2,-]** A;5630–5800′; **L;** fr, pj.

Anacardiaceae

Rhus glabra L. **[1,-]** A; 7900′; **S;** mr, ms.

Rhus trilobata Nutt. var. *trilobata* **[10,18]** A, C, M, R, S, T; 5600–8450′; **G, L, P, S;** ds, fr, ms, mr, pj, ra.

Toxicodendron rydbergii (Small ex Rydb.) Greene **[6,2]** A, R, S, T; 5800–8300′; **G, L, P, S;** fr, mc, ml, mm, mr.

Apiaceae

Angelica grayi (J.M. Coult. & Rose) J.M. Coult. & Rose **[5,5]** A, M, R, S, T; 9800–13024′; **S;** am, mm, sf.

* *Carum carvi* L. **[-,1]** T; 8350–9400′; **S;** mc.

Cicuta maculata L. var. *angustifolia* Hook. **[2,1]** A, T; 5800–8000′; **L, P, S;** fr, mr.

Conioselinum scopulorum (A. Gray) J.M. Coult. & Rose **[20,14]** A, C, M, R, S, T; 7000–11500′; **S;** br, mc, mr, sf.

* *Conium maculatum* L. **[1,-]** A; 5800′; **L;** fr.

Cymopterus alpinus A. Gray **[2,2]** A, T; 10000–12584′; **S;** am.

Cymopterus bakeri (J.M. Coult. & Rose) M.E. Jones **[2,8]** M, S, T; 11500–13000′; **S;** am.

Cymopterus constancei R.L. Hartm. **[-,6]** T; 6600–7500′; **P, S;** ds, fr, pj.

Cymopterus glomeratus (Nutt.) DC. var. *fendleri* (A. Gray) R.L. Hartm. **[1,-]** A; 6200′; **L;** pg, pj.

Cymopterus longilobus (Rydb.) W.A. Weber **[-,3]** R, T; 11600–13024′; **S;** am, sf.

[*Cymopterus hendersonii* (J.M. Coult. & Rose) Cronquist, misapplied]

Cymopterus lemmonii (J.M. Coult. & Rose) Dorn **[43,69]** A, C, M, R, S, T; 7550–12960′; **S;** af, am, bw, br, mc, mm, ms, mr, pp, sf.

! *Cymopterus spellenbergii* R.L. Hartm. & J.E. Larson **[-,6]** R, T; 6200–8763′; **G, P, S;** fr, pj, pp.

Harbouria trachypleura (S. Watson) J.M. Coult. & Rose **[4,-]** A, S; 7000–8000′; **S;** pj, pp.

Heracleum maximum W. Bartram **[29,24]** A, C, M, R, S, T; 7720–11650′; **S;** af, mc, ml, mm, mr, ra, sf.

Ligusticum porteri J.M. Coult. & Rose **[18,17]** A, M, S, T; 8350–11940′; **S;** af, mc, mm, mr, sf.

Osmorhiza depauperata Phil. **[21,33]** A, C, M, R, S, T; 7620–11800′; **S;** af, mc, mm, mr, sf.
Oxypolis fendleri (A. Gray) A. Heller **[35,38]** A, C, M, R, S, T; 7620–12000′; **S;** af, mc, mm, mr, sf.
* *Pastinaca sativa* L. **[-,1]** T; 7240′; **S;** ra.
♦ *Podistera eastwoodiae* (J.M. Coult. & Rose) Mathias & Const. **[2,12]** M, R, S, T; 10500–13024′; **S;** am, mm, mr, sf.
Sanicula marilandica L. **[1,-]** S; 8600–8840′; **S;** mc.

Apocynaceae

Apocynum androsaemifolium L. **[9,6]** A, C, S, T; 7720–9700′; **S;** af, mc, mm, mr.
Apocynum cannabinum L. **[3,4]** R, S, T; 5781–7600′; **G, P, S;** fr, ml, mr, ra.
× *Apocynum* ×*floribundum* Greene **[4,1]** A, S, T; 7720–8400′; **S;** mm, mr.
[*Apocynum medium* Greene var. *floribundum* (Greene) Woodson]

Araliaceae

Aralia racemosa L. ssp. *bicrenata* (Wooton & Standl.) S.L. Welsh & N.D. Atwood **[5,2]** A, S, T; 7640–10500′; **S;** mc, mm, mr.

Asclepiadaceae

Asclepias asperula (Decne.) Woodson var. *asperula* **[4,1]** A, C, S; 6540–8600′; **G, S;** br, fr, pj.
Asclepias engelmanniana Woodson **[1,-]** A; 5570–5600′; **L;** fr.
Asclepias involucrata Engelm. ex Torr. **[3,-]** A; 5700–6200′; **L;** pg, pj, ra.
Asclepias latifolia (Torr.) Raf. **[2,-]** A; 5650–5840′; **L;** pg, pj.
Asclepias macrostis Torr. **[2,-]** A; 5650–5800′; **L;** pg, pj.
Asclepias oenotheroides Chamisso & Schlectendal **[1,-]** A; 5700–5800′; **L;** pg, pj.
Asclepias pumila (A. Gray) Vail **[UNM**-Nellessen 70] A; **S.**
Asclepias speciosa Torr. **[1,2]** A, T; 5800–10200′; **L, S;** fr, mr, ra.
Asclepias subverticillata (A. Gray) Vail **[7,2]** A, M, S, T; 5500–7760′; **L, S;** fr, mm, ra.
Asclepias tuberosa L. ssp. *interior* Woodson **[2,-]** A; 7720–7900′; **S;** mm, ms.
Asclepias viridiflora Raf. **[2,-]** A; 5700–7000′; **L, S;** pg, pj, pp.
Funastrum crispum (Benth.) Schlecht. **[1,-]** A; 5700–5800′; **L;** pg, pj.
Matelea producta (Torr.) Woodson **[2,-]** A; 5700–5840′; **L;** pg, pj.

Asparagaceae [traditionally in Liliaceae]

* *Asparagus officinalis* L. **[2,3]** R, S, T; 6050–7860′; **P, S;** br, ml, mm, ra.

Asteraceae

Achillea millefolium L. **[55,55]** A, C, M, R, S, T; 6540–13024′; **G, S;** am, af, br, mc, mm, mr, pp, ra, sf.
*● *Acroptilon repens* (L.) DC. **[UNM**-C.R. Hutchins 6455] T; **S.**
Ageratina herbacea (A. Gray) R.M. King & H. Rob. **[1,-]** A; 7900′; **S;** mc, mm.
Agoseris aurantiaca (Hook.) Greene var. *aurantiaca* **[3,10]** M, R, S, T; 8300–13024′; **S;** am mc, sf.
Agoseris aurantiaca (Hook.) Greene var. *purpurea* (A. Gray) Cronquist **[17,16]** A, M, S, T; 8200–12200′; **S;** am, af, bw, br, mc, mm, mr, sf.
Agoseris glauca (Pursh) Raf. var. *glauca* **[-,8]** M, R, T; 7050–12450′; **S;** am, br, mm, mr, sf.
Agoseris parviflora (Nutt.) Greene **[-,4]** T; 9500–12960′; **S;** am, mm, mr.
Amauriopsis dissecta (A. Gray) Rydb. **[19,11]** A, C, M, R, S, T; 6840–10200′; **S;** br, fr, mc, mr, pp, ra.
Ambrosia artemisiifolia L. **[2,-]** A, S; 5610–7000′; **L, S;** fr, mm, ra.
Ambrosia confertifolia DC. **[UNM**-R. Fleetwood *s.n.,* 3 Sept 1949] A; **S.**
Ambrosia psilostachya DC. **[8,-]** A, M, S; 5500–8575′; **L, S;** fr, mm, mr, ra.
Ambrosia tomentosa Nutt. **[3,3]** A, C, M, T; 7200–9700′; **S;** ml, mm, ra.
Ambrosia trifida L. var. *trifida* **[-,1]** T; 7240′; **S;** ra.
Anaphalis margaritacea (L.) Benth. & Hook. **[4,4]** A, M, R, T; 7750–11900′; **S;** mc, mm, mr, sf.
Antennaria marginata Greene **[6,15]** A, C, M, R, S, T; 7620–10500′; **S;** af, br, mc, mm, mr, pp, sf.
Antennaria media Greene **[4,7]** C, M, S, T; 7400–12850′; **S;** am, mm, sf.
Antennaria microphylla Rydb. **[1,36]** C, M, R, S, T; 7050–13024′; **S;** am, af, br, mc, mm, mr, pj, pp, ra, sf.
Antennaria parvifolia Nutt. **[5,18]** C, M, R, S, T; 6600–11115′; **G, P, S;** fr, mc, mm, mr, pj, pp.
Antennaria rosea Greene **[2,26]** A, M, S, T; 7740–12960′; **S;** am, br, mc, mm, mr, sf.
[*Antennaria rosea* subspecies]
Antennaria rosulata Rydb. **[-,1]** T; 9850–10000′; **S;** mm.
* *Arctium minus* (Hill) Bernh. **[-,3]** M, T; 7200–9400′; **S;** pj, ra.
Arnica cordifolia Hook. **[-,23]** R, T; 8300–11500′; **S;** br, mc, mm, mr, sf.
Arnica latifolia Bong. **[UNM**-R. Jackson 2206] T; **S.**
! *Artemisia borealis* Pall. ssp. *borealis* **[-,1]** T; 11500–12850′; **S;** am.
Artemisia campestris L. var. *pacifica* (Nutt.) M. Peck **[-,2]** C, T; 8500–9500′; **S;** pp, ra.
Artemisia carruthii A.W. Wood ex Carruth **[8,22]** A, M, R, S, T; 6980–10500′; **P, S;** br, mm, mr, ms, pj, ra.
Artemisia dracunculus L. **[2,2]** A, C, T; 7000–8700′; **S;** br, mm, mr.
Artemisia franserioides Greene **[12,8]** A, C, M, R, T; 7840–11500′; **S;** af, mc, mm, mr, sf.
Artemisia frigida Willd. **[2,5]** A, C, M, T; 6750–9750′; **S;** mm, pj, ra.
Artemisia ludoviciana Nutt. var. *ludoviciana* **[8,2]** A, M, R, S, T; 8200–12200′; **S;** mc, mm, ms, pp.
Artemisia ludoviciana Nutt. var. *mexicana* (Willd. ex Spreng.) A. Gray **[2,7]** A, M, R, T; 7600–10300′; **S;** af, br, mc, mm, pj, pp, ra.
Artemisia pattersonii A. Gray **[-,1]** T; 11500–12050′; **S;** am.
Artemisia scopulorum A. Gray **[-,8]** R, T; 11300–13161′; **S;** am.
Artemisia tridentata Nutt. var. *tridentata* **[-,16]** R, T; 6050–10100′; **G, P, S;** br, fr, pj, ra.
Artemisia tridentata Nutt. var. *wyomingensis* (Beetle & A. Young) S.L. Welsh **[-,4]** R, T; 5800–7650′; **G, S;** ds, fr, pj.
Baccharis pteronioides DC. **[1,-]** A; 5800′; **L;** fr.
Baccharis salicina Torr. & A. Gray **[-,2]** R, T; 5781–6540′; **G;** ds, fr, ra.
Baccharis wrightii A. Gray **[1,-]** S; 7320–7370′; **S;** pj.
Berlandiera lyrata Benth. **[6,-]** A; 5650–6200′; **L;** pg, pj.
Bidens cernua L. **[-,1]** C; 8194′; **S;** ml.
Bidens pilosa L. **[1,-]** A; 5500′; **L;** fr.
Bidens tenuisecta A. Gray **[3,1]** A, M; 7700–9320′; **S;** mm, ra.
Brickellia brachyphylla A. Gray **[1,-]** A; 7000′; **S;** pp.
Brickellia eupatorioides (L.) Shinners var. *chlorolepis* (Wooton & Standl.) B.L. Turner **[2,1]** M, T; 7100–8800′; **S;** mm, pp, ra.
Brickellia grandiflora (Hook.) Nutt. **[10,13]** A, C, M, R, S, T; 7650–12200′; **S;** am, mc, mm, ms, mr, pp, ra, sf.
Brickellia rusbyi A. Gray **[UNM**-J. McGrath 737] A; **S.**
Brickelliastrum fendleri (A. Gray) King & H.E. Rob. **[10,5]** A, R, S, T; 6840–10100′; **P, S;** fr, mc, mm, mr, pp.
*● *Carduus nutans* L. **[5,6]** A, C, M, T; 7000–9200′; **S;** mc, ml, mm, pj, ra.
*● *Centaurea stoebe* L. ssp. *micranthos* (S.G. Gmelin ex Gugler) Hayek **[1,-]** A; 5500′; **L;** fr, pj.
Chaetopappa ericoides (Torr.) G.L. Nesom **[15,17]** A, R, S, T; 5600–8200′; **G, L, P, S;** br, ds, pg, pj, ra.
Chrysothamnus depressus Nutt. **[-,1]** R; 8150′; **S;** br.
Chrysothamnus greenei (A. Gray) Greene **[-,4]** T; 7400–8555′; **P;** ds, fr.
* *Cichorium intybus* L. **[2,1]** M, S, T; 6840–7700′; **S;** mm, ra.
*● *Cirsium arvense* (L.) Scop. **[-,12]** C, T; 7350–10500′; **S;** br, ml, mc, mm, mr, ra.
[*Cirsium arvense* varieties]
Cirsium eatonii (A. Gray) B.L. Rob. var. *eriocephalum* (A. Gray) Keil **[3,5]** M, S, T; 10990–12850′; **S;** am, mm.

Cirsium neomexicanum A. Gray **[2,6]** R, S, T; 6540–8900′; **G, S;** br, fr, mc, pj, pp, ra.

Cirsium ochrocentrum A. Gray var. *ochrocentrum* **[2,-]** A, S; 5760–7000′; **L, S;** mm, pg, pj.

Cirsium parryi (A. Gray) Petrak **[27,31]** A, C, M, S, T; 7400–11500′; **S;** mc, mm, mr, ra, sf.

Cirsium scariosum Nutt. var. *coloradense* (Rydb.) Keil **[-,1]** T; 8175′; **S;** ml, mm.

Cirsium undulatum (Nutt.) Spreng **[12,7]** A, C, M, S, T; 5570–9700′; **L, S;** br, fr, mc, mm, ms, pg, pj, pp, ra, sf.

*● *Cirsium vulgare* (Savi) Ten. **[4,3]** A, C, M, S, T; 6840–9320′; **S;** fr, ml, mm, ra.

* *Conyza canadensis* (L.) Cronquist **[7,4]** A, C, S, T; 5500–8575′; **L, P, S;** br, fr, ml, mm, ra.

Coreopsis lanceolata L. **[1,-]** A; 7720′; **S;** pp.

Coreopsis tinctoria Nutt. **[1,-]** A; 7200–7240′; **S;** ra.

Cosmos parviflorus (Jacq.) Pers. **[2,1]** A, M, S; 7380–9320′; **S;** mm, ra.

Crepis runcinata (E. James) Torr. & A. Gray var. *runcinata* **[UNM**-J. Williams 7**]** T; **S.**

!* *Crepis tectorum* L. **[-,1]** C; 8194′; **S;** ml.

Cyclachaena xanthifolia (Nutt.) Fresen. **[1,1]** A, T; 7350–8000′; **S;** ra.

Dieteria bigelovii (A. Gray) Morgan & R.L. Hartm. var. *bigelovii* **[2,8]** A, C, M, R, T; 6120–9700′; **S;** br, fr, mm, ms, pj, ra.

Dieteria canescens (Pursh) Nutt. var. *ambigua* (B.L. Turner) Morgan & R.L. Hartm. **[1,-]** A; 5800′; **L;** fr.

Dieteria canescens (Pursh) Nutt. var. *aristata* (Eastw.) Morgan & R.L. Hartm. **[-,2]** R, T; 5781–7750′; **G, S;** ra.

Dieteria canescens (Pursh) Nutt. var. *glabra* (A. Gray) Morgan & R.L. Hartm. **[-,1]** C; 7650–8600′; **S;** br.

* *Dyssodia papposa* (Vent.) C.L. Hitchc. **[1,2]** M, T; 7200–7700′; **S;** mm, pj, ra.

Engelmannia peristenia (Raf.) Goodman & Lawson **[2,-]** A; 5570–5800′; **L;** fr.

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird var. *bigelovii* (A. Gray) G.L. Nesom & G.I. Baird **[UNM**-E. Wooton *s.n.*, 24 Aug 1910**]** S; **S.**

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird var. *graveolens* (Nutt.) Reveal & Schuyler **[-,1]** T; 7100′; **S;** ra.

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird var. *hololeuca* (A. Gray) G.L. Nesom & G.I. Baird **[-,1]** T; 7700–8555′; **P;** pj.

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird var. *latisquamea* (A. Gray) G.L. Nesom & G.I. Baird **[UNM**-H. Bobisud 37**]** S; **S.**

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird var. *oreophila* (A. Nelson) G.L. Nesom & G.I. Baird **[-,6]** C, T; 7240–9400′; **S;** br, fr, ml, mm.

Ericameria parryi (A. Gray) G.L. Nesom & G.I. Baird var. *affinis* (A. Nelson) G.L. Nesom & G.I. Baird **[UNM**-A. Cully CU-1**]** T; **G.**

Erigeron canus A. Gray **[1,-]** S; 7300–7400′; **S;** pj.

! *Erigeron compositus* Pursh **[-,1]** T; 11600–12450′; **S;** am.

Erigeron concinnus (Hook. & Arn.) Torr. & A. Gray var. *concinnus* **[-,1]** T; 6950′; **P;** pj.

Erigeron coulteri Porter **[12,26]** A, M, R, S, T; 8200–12000′; **S;** mm, mr, sf.

Erigeron divergens Torr. & A. Gray **[21,32]** A, C, R, S, T; 5730–9400′; **G, L, P, S;** br, mc, mm, mr, ms, pg, pj, pp, ra.

Erigeron elatior (A. Gray) Greene **[1,-]** M; 9920–9960′; **S;** af, mm.

Erigeron eximius Greene **[15,16]** A, C, M, R, S, T; 7840–11800′; **S;** am, af, mc, mm, mr, sf.

Erigeron flagellaris A. Gray **[29,53]** A, C, M, R, S, T; 7050–11129′; **G, P, S;** af, bw, br, ds, fr, mc, mm, ms, mr, pj, pp, ra, sf.

Erigeron formosissimus Greene var. *formosissimus* **[5,10]** A, M, R, T; 7850–12000′; **S;** bw, mc, mm, mr, sf.

Erigeron formosissimus Greene var. *viscidus* (Rydb.) Cronquist **[11,23]** A, C, M, R, S, T; 7000–11750′; **S;** mc, mm, ms, mr, pp, ra, sf.

Erigeron glabellus Nutt. **[-,1]** T; 7050′; **S;** mr.

Erigeron glacialis (Nutt.) A. Nelson var. *glacialis* **[4,6]** A, M, R, T; 9700–12000′; **S;** mm, mr, sf.

Erigeron grandiflorus Hook. **[1,9]** A, R, T; 9800–13024′; **S;** am, mm, sf.

Erigeron leiomerus A. Gray **[UNM**-T. Lowrey 2082**]** C; **S.**

Erigeron melanocephalus (A. Nelson) A. Nelson **[2,9]** M, R, S, T; 9800–13024′; **S;** am, mm, sf.

! *Erigeron nivalis* Nutt. **[-,1]** T; 9600–10900′; **S;** sf.

Erigeron pinnatisectus (A. Gray) A. Nelson **[-,5]** R, T; 11600–13024′; **S;** am.

Erigeron pulcherrimus A. Heller **[-,4]** C, R, T; 5781–8050′; **G, S;** ds, fr, mr, pp.

Erigeron speciosus (Lindl.) DC. **[6,1]** A, M, R, S; 7700–11300′; **S;** mc, mm, ms, sf.

+ *Erigeron subglaber* Cronquist **[2,-]** A, M; 11310–11750′; **S;** mm.

Erigeron subtrinervis Rydb. ex Porter & Britton **[13,35]** A, C, M, S, T; 7200–12960′; **P, S;** am, af, bw, br, ds, fr, mc, mm, ms, mr, pj, pp, ra.

Erigeron tracyi Greene **[10,11]** A, R, S, T; 5700–10500′; **G, L, P, S;** br, fr, mm, pg, pj, pp, ra.

Erigeron vetensis Rydb. **[-,22]** C, R, T; 7200–12960′; **S;** am, bw, mc, mm, mr, pj, pp, sf.

Erigeron vreelandii Greene **[6,-]** A, S; 7720–9860′; **S;** af, mc, ms, pp.

Gaillardia aristata Pursh **[-,3]** C, T; 8500–11000′; **S;** mr, ra.

Gaillardia pinnatifida Torr. **[4,1]** A, T; 5570–6500′; **L, P;** pg, pj.

Gaillardia pulchella Foug. **[3,2]** A, T; 5500–10500′; **L, S;** fr, pj, ra.

Gnaphalium exilifolium A. Nelson **[-,1]** C; 8194′; **S;** ml.

Grindelia squarrosa (Pursh) Dunal **[11,10]** A, C, M, R, S, T; 5500–9320′; **L, P, S;** fr, mc, ml, mm, ms, pj, pp, ra.

Gutierrezia sarothrae (Pursh) Britton & Rusby **[5,7]** A, C, M, R, S, T; 5560–8555′; **L, P, S;** br, mm, ms, pg, pj, pp, ra.

Helenium autumnale L. var. *montanum* (Nutt.) Fernald **[UNM**-R. Wallace 92EM023-F2**]** M; **S.**

Helianthella parryi A. Gray **[8,30]** A, C, M, R, T; 7650–12700′; **S;** am, af, bw, mc, mm, ms, mr, pp, ra, sf.

Helianthella quinquenervis (Hook.) A. Gray **[3,4]** M, S, T; 8450–12050′; **S;** af, mc, mm, mr, sf.

Helianthus annuus L. **[3,6]** A, M, T; 5500–10500′; **L, S;** fr, mm, pj, ra.

Helianthus nuttallii Torr. & A. Gray **[UNM**-R. Wallace 92RW002-F3**]** T; **G.**

Helianthus pauciflorus Nutt. var. *subrhomboideus* (Rydb.) Cronquist **[2,2]** A, M, R; 7000–9320′; **S;** br, pp, ra.

Helianthus petiolaris Nutt. var. *petiolaris* **[1,-]** A; 7000′; **S;** ms, pp.

Heliomeris multiflora Nutt. var. *multiflora* **[15,11]** A, M, R, S, T; 7000–11200′; **S;** af, br, mc, mm, pp, ra, sf.

Heliomeris multiflora Nutt. var. *nevadensis* (A. Nelson) W.F. Yates **[2,1]** R, S; 7000–8400′; **S;** br, mm, pp.

Heliopsis helianthoides (L.) Sweet var. *scabra* (Dunal) Fernald **[7,2]** A, C, M, T; 7720–9400′; **S;** af, mc, pj, ra.

♦ *Herrickia horrida* Wooton & Standl. **[-,1]** C; 7800–8400′; **S;** mc.

Heterotheca villosa (Pursh) Shinners var. *minor* (Hook.) Semple **[14,21]** A, C, M, R, S, T; 5800–10500′; **G, P, S;** br, ds, fr, mc, mm, mr, ms, pj, pp, ra.

Heterotheca villosa (Pursh) Shinners var. *nana* (A. Gray) Semple **[11,15]** A, C, M, R, S, T; 6200–9750′; **G, P, S;** ds, fr, mc, mm, mr, pj, pp, ra.

Heterotheca villosa (Pursh) Shinners var. *villosa* **[10,12]** A, C, M, R, S, T; 5500–9880′; **G, L, S;** br, ds, mc, mm, pj, ra.

Hieracium fendleri Sch. Bip. **[4,8]** A, C, M, R, S, T; 7850–11209′; **S;** mc, mm, mr, pp, sf.

Hieracium pringlei A. Gray **[1,-]** A; 8000′; **S;** mc, mm.

Hieracium triste Willd. ex Spreng. **[2,9]** M, R, S, T; 8450–12060′; **S;** bw, mc, mm, mr, sf.

Hymenopappus filifolius Hook. var. *cinereus* (Rydb.) I.M. Johnst. **[8,12]** A, R, S, T; 5781–7950′; **G, P, S;** ds, pj.

Hymenopappus filifolius Hook. var. *pauciflorus* (I.M. Johnst.) B.L. Turner **[-,1]** R; 6380′; **G;** fr.

Hymenopappus flavescens A. Gray var. *canotomentosus* A. Gray **[2,-]** A; 5570–5800′; **L;** fr, pj.

Hymenopappus flavescens A. Gray var. *flavescens* A. Gray **[1,-]** A; 6200′; **L;** pg, pj.

Hymenopappus newberryi (A. Gray) I.M. Johnst. **[20,9]** A, C, M, T; 7720–10700′; **S;** af, mc, mm, mr, ra.

Hymenopappus tenuifolius Pursh **[6,-]** A; 5700–7500′; **L, S;** ds, pg, pj.

Hymenoxys brandegeei (Porter ex A. Gray) Parker **[5,11]** M, R, S, T; 9800–13161′; **S;** am, mm, mr, sf.

Hymenoxys hoopesii (A. Gray) Bierner **[20,21]** A, C, M, S, T; 7850–11800′; **S;** mc, mm, mr, sf.

Hymenoxys richardsonii (Hook.) Cockerell var. *floribunda* (A. Gray) Parker **[12,20]** A, R, S, T; 5800–10500′; **G, P, S;** ds, fr, mc, mm, mr, pj, pp, ra.

Krigia biflora (Walter) S.F. Blake **[1,-]** A; 8400–8850′; **S;** mc, mm.

! *Lactuca biennis* (Moench) Fernald **[3,-]** A, S; 7760–8600′; **S;** mm, mr.

Lactuca canadensis L. **[1,2]** S, T; 7400–10500′; **S;** mm, mr.

Lactuca graminifolia Michx. var. *arizonica* McVaugh **[2,-]** A; 7720–8000′; **S;** mc, mm.

Lactuca pulchella (Pursh) DC. **[-,2]** T; 7550–9800′; **S;** ml, mm.

* *Lactuca serriola* L. **[5,16]** A, C, M, S, T; 5500–10100′; **L, S;** br, fr, mm, mr, pg, pj, ra.

Laënnecia schiedeana (Less.) G.L. Nesom **[1,-]** M; 8040–8700′; **S;** mc, ra.

Leibnitzia lyrata (Sch.Bip.) G.L. Nesom **[UNM**-R. Sivinski 5763] A; **S.**

* *Leucanthemum vulgare* Lam. **[4,9]** A, C, R, T; 7350–10500′; **S;** fr, ml, mm, mr, ra. **[2,1]** A, R; 7000–8200′; **S;** ms, pp.

Liatris punctata Hook. var. *punctata* **[2,1]** A, R; 7000–8200′; **S;** ms, pp.

Lygodesmia juncea (Pursh) D. Don ex Hook. **[2,-]** A; 7200–7500′; **S;** ds, pj.

Machaeranthera tanacetifolia (Kunth) Nees **[1,-]** A; 5610′; **L;** fr.

* *Matricaria discoidea* DC. **[-,1]** T; 7200′; **S;** mr.

Melampodium leucanthum Torr. & A. Gray **[8,-]** A; 5630–6750′; **L, S;** fr, pg, pj.

Oreochrysum parryi (A. Gray) Rydb. **[20,24]** A, C, M, R, S, T; 7700–12450′; **S;** am, af, mc, mm, mr, ms, pp, ra, sf.

Packera dimorphophylla (Greene) W.A. Weber & Á. Löve var. *dimorphophylla* **[-,4]** T; 9700–11500′; **S;** mr.

Packera fendleri (A. Gray) W.A. Weber & Á. Löve **[33,35]** A, C, M, R, S, T; 5781–11500′; **S;** af, bw, br, mc, mm, mr, ms, pj, pp, ra, sf.

Packera hartiana (A. Heller) W.A. Weber & Á. Löve **[UNM**-H. Mackay 6T-207] T; **S.**

Packera multilobata (Torr. & A. Gray ex A. Gray) Weber & Á. Löve **[1,4]** C, M, R, T; 7250–10500′; **S;** br, mm, pj, pp.

Packera neomexicana (A. Gray) W.A. Weber & Á. Löve var. *mutabilis* (Greene) W.A. Weber & Á. Löve **[3,12]** A, C, R, S, T; 7150–10500′; **G, S;** mc, mr, pj, pp.

Packera pseudaurea (Rydb.) W.A. Weber & Á. Löve var. *flavula* (Greene) D. Trock & T.M. Barkley **[-, 1]** T; 10500–11000′; **S;** mm.

+ *Packera sanguisorboides* (Rydb.) W.A. Weber & Á. Löve **[23,23]** A, C, M, R, S, T; 7840–11940′; **S;** af, mc, mm, mr, sf.

Packera streptanthifolia (Greene) W.A. Weber & Á. Löve **[1,16]** R, S, T; 6600–12450′; **P, S;** am, af, br, mc, mm, mr, sf.

Packera thurberi (A. Gray) B.L. Turner **[UNM**-H. Dixon V-24] T; **S.**

Pericome caudata A. Gray **[-,1]** T; 7400–7493′; **R;** fr.

Petradoria pumila (Nutt.) Greene var. *pumila* **[-,8]** R, T; 7200–8763′; **P, S;** br, pj.

Picradeniopsis oppositifolia (Nutt.) Rydb. **[UNM**-R. Sivinski 4542] C; **S.**

Plectocephalus americanus (Nutt.) D. Don **[1,-]** A; 5650–5740′; **L;** pg, pj.

Pseudognaphalium macounii (Greene) Kartesz **[5,-]** A, M, S; 8200–10850′; **S;** mc, mm, ms.

Pseudognaphalium stramineum (Kunth) W.A. Weber **[2,-]** A, S; 7000–8000′; **S;** mc, mm, mr.

Psilostrophe tagetina (Nutt.) Greene **[6,-]** A; 5570–5840′; **L;** fr, pg, pj.

Pyrrhopappus pauciflorus (D. Don) DC. **[2,-]** A, R; 5500–6620′; **G, L;** ds, fr.

Pyrrocoma crocea (A. Gray) Greene var. *crocea* **[4,4]** A, M, R, T; 8700–11300′; **S;** mm

Ratibida columnifera (Nutt.) Wooton & Standl. **[11,6]** A, C, M, T; 5570–10300′; **L, S;** mm, pg, pj, pp, ra.

[*Ratidiba columnifera* formas]

Ratibida tagetes (E. James) Barnhart **[3,-]** A; 5570–7240′; **L, S;** fr, pj.

Rudbeckia hirta L. var. *pulcherrima* Farw. **[22,12]** A, C, M, S, T; 6500–11500′; **P, S;** fr, mm, mr, ra.

Rudbeckia laciniata L. var. *ampla* (A. Nelson) Cronquist **[32,10]** A, C, M, S, T; 7700–10850′; **G, S;** mc, mm, mr.

! *Rudbeckia laciniata* L. var. *laciniata* **[2,-]** A, S; 7000–7750′; **S;** mm, mr.

Sanvitalia abertii A. Gray **[UNM**-R. Sivinski 2574] S; **S.**

Schkuhria multiflora Hook. & Arn. **[UNM**-R. Sivinski 1820] T; **S.**

* *Scorzonera laciniata* L. **[5,8]** A, R, S, T; 5800–8200′; **G, L, P, S;** br, fr, ml, pg, pj, ra.

Senecio amplectens A. Gray var. *amplectens* **[4,10]** M, R, S, T; 9600–13024′; **S;** am, bw, mm, mr, sf.

Senecio amplectens A. Gray var. *holmii* (Greene) Harrington **[2,3]** M, R, S, T; 10990–13024′; **S;** am, sf.

Senecio atratus Greene **[2,18]** M, R, S, T; 7850–11850′; **S;** bw, mc, mm, mr, ra, sf.

Senecio bigelovii A. Gray var. *hallii* A. Gray **[15,14]** A, M, R, S, T; 7750–12000′; **S;** mc, mm, mr, sf.

Senecio crassulus A. Gray **[2,4]** M, R, S, T; 8400–13024′; **S;** am, mm, pp, sf.

Senecio eremophilus Richardson var. *kingii* (Rydb.) Greenm. **[13,15]** A, C, M, R, S, T; 7400–11500′; **S;** mc, mm, mr, sf.

Senecio flaccidus Less. var. *flaccidus* **[8,3]** A, R, T; 5610–8300′; **G, L, P, S;** fr, pg, pj, ra.

Senecio fremontii Torr. & A. Gray var. *blitoides* (Greene) Cronquist **[3,2]** M, R, S, T; 11500–13024′; **S;** am, mm.

Senecio spartioides Torr. & A. Gray **[-,1]** T; 7240′; **S;** ra.

Senecio taraxacoides (A. Gray) Greene **[-,7]** T; 11300–13161′; **S;** am.

Senecio triangularis Hook. **[6,25]** M, R, S, T; 7850–12000′; **S;** mm, mr, sf.

Senecio wootonii Greene **[3,8]** A, C, R, S, T; 7910–11209′; **S;** mc, mr, sf.

Solidago altissima L. ssp. *gilvocanescens* (Rydb.) Semple **[1,4]** A, T; 6980–10093′; **P, S;** br, mc, mm, pj, pp.

Solidago gigantea Aiton **[2,-]** A; 7750–8000′; **S;** mr, ra.

Solidago missouriensis Nutt. var. *fasciculata* Holz. **[1,1]** A, T; 7520–11200′; **S;** pp, sf.

Solidago missouriensis Nutt. var. *missouriensis* **[1,4]** A, C, T; 7650–10300′; **S;** br, mc, mm, sf.

Solidago mollis Bartl. **[2,1]** A, S, T; 7000–8260′; **S;** pp, ra.

Solidago nemoralis Aiton var. *decemflora* (DC.) Fernald **[5,4]** A, R, S, T; 7950–8880′; **S;** br, mc, mm, ms, pp.

Solidago simplex Kunth var. *simplex* **[28,34]** A, C, M, R, S, T; 7840–13024′; **S;** am, af, bw, mc, mm, mr, pp, ra, sf.

Solidago speciosa Nutt. var. *pallida* Porter **[1,-]** A; 7750′; **S;** mm.

Solidago velutina DC. ssp. *sparsiflora* (A. Gray) Semple **[4,1]** A, C, M, S; 7440–9760′; **S;** mc, ra.

Solidago wrightii A. Gray var. *adenophora* S.F. Blake **[9,-]** A, M, S; 7840–9760′; **S;** mc, mm, mr, pp, ra.

* *Sonchus asper* (L.) Hill **[2,1]** A, R, T; 5800–7660′; **G, L, S;** ds, fr, ml.

Stephanomeria pauciflora (Torr.) A. Nelson **[3,-]** A; 5700–5840′; **L;** pg, pj.

Symphyotrichum ascendens (Lindl.) G.L. Nesom **[2,3]** M, T; 8080–9500′; **S;** mc, mr, ra.

Symphyotrichum eatonii (A. Gray) G.L. Nesom **[UNM**-R. Wallace 92RW002-F5] T; **S.**

Symphyotrichum falcatum (Lindl.) G.L. Nesom var. *commutatum* (Torr. & A. Gray) G.L. Nesom **[-,1]** R; 8150′; **S;** br.

Symphyotrichum foliaceum (Lindl. ex DC.) G.L. Nesom var. *canbyi* (A. Gray) G.L. Nesom **[-,3]** M, T; 7400–10700′; **S;** mm, mr.

Symphyotrichum foliaceum (Lindl. ex DC.) G.L. Nesom var. *parryi* (D.C. Eaton) G.L. Nesom **[-,2]** T; 7850–10500′; **S;** mr.

Symphyotrichum laeve (L.) Á. Löve & D. Löve var. *geyeri* (A. Gray) G.L. Nesom **[12,2]** A, M, R, S; 7700–9320′; **S;** af, mc, mm, mr, ms, pp, ra.

Symphyotrichum lanceolatum (Willd.) Nesom var. *hesperium* (A. Gray) G.L. Nesom **[3,-]** A, S; 7400–8260′; **S;** mm, ra.

Symphyotrichum porteri (A. Gray) G.L. Nesom **[2,-]** A; 7000′; **S;** mm, pp.

Taraxacum ceratophorum (Ledeb.) DC. **[-,1]** T; 10500–11000′; **S;** mm.

* *Taraxacum erythrospermum* Andrz. ex Besser **[1,9]** C, R, S, T; 7700–10100′; **S;** br, mm, ms, mr, pj, pp.

* *Taraxacum officinale* Weber ex F. H. Wigg. **[15,50]** A, C, M, R, S, T; 7050–12000′; **G, S;** br, fr, mc, ml, mm, ms, mr, pj, pp, ra, sf.

Tetradymia canescens DC. **[-,3]** C, T; 7200–8500′; **S;** br, pj.

Tetraneuris acaulis (Pursh) Greene var. *acaulis* **[1,2]** S, T; 7250–7950′; **S;** pj, pp.

Tetraneuris acaulis (Pursh) Greene var. *arizonica* (Greene) Parker **[4,-]** A; 5700–6200′; **L, S;** pg, pj.

Tetraneuris acaulis (Pursh) Greene var. *caespitosa* A. Nelson **[1,4]** A, T; 7380–12600′; **S;** am, mm, pj.

Tetraneuris argentea (A. Gray) Greene **[11,26]** A, R, S, T; 6050–8700′; **G, P, S;** br, fr, pj, pp.

Tetraneuris scaposa (DC.) Greene var. *scaposa* **[UNM**-F. Broeke Co-75] A; **L.**

Thelesperma filifolium (Hook.) A. Gray var. *intermedium* (Rydb.) Shinners **[3,-]** S; 7000–7350′; **S;** mm, pj, ra.

Thelesperma megapotamicum (Spreng.) Kuntze **[16,2]** A, R, S, T; 5570–7950′; **G, L, S;** ds, fr, ml, mm, pg, pj, pp.

Tonestus pygmaeus (Torr. & A. Gray) A. Nelson **[2,9]** R, S, T; 11990–13024′; **S;** am, mm.

Townsendia eximia A. Gray **[21,18]** A, M, R, S, T; 7000–10800′; **S;** br, mc, mm, ms, pj, pp, ra.

Townsendia exscapa (Richardson) Porter **[2,8]** A, C, S, T; 5625–8555′; **L, P, S;** ds, fr, pg, pj, pp.

Townsendia fendleri A. Gray **[1,-]** S; 6540′; **G;** pj.

Townsendia leptotes (A. Gray) Osterh. **[-,3]** T; 7250–8763′; **P, S;** pj, pp.

* *Tragopogon dubius* Scop. **[27,37]** A, C, M, R, S, T; 5750–10500′; **G, L, P, S;** af, br, ds, mc, ml, mm, mr, pj, pp, ra, sf.

* *Tragopogon porrifolius* L. **[2,-]** A; 7840–8325′; **S;** mm, ra.

* *Tragopogon pratensis* L. **[11,4]** A, M, R, S, T; 7000–10660′; **S;** mc, mm, mr, ra.

!* *Tripleurospermum inodorum* (L.) Schultz-Bip. **[-,1]** T; 8175′; **S;** ml.

Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray **[3,1]** A, S, T; 5500–7450′; **L, S;** fr, mm, ra.

[*Verbesina encelioides* var. *exauriculata* B.L. Rob. & Greenm.]

Xanthisma gracile (Nutt.) Morgan & R.L. Hartm. **[1, -]** S; 7000′; **S;** mm, mr.

Xanthisma grindelioides (Nutt.) Morgan & R.L. Hartm. **[1,-]** S; 6540′; **S;** pj.

Xanthisma spinulosum (Pursh) Morgan & R.L. Hartm. var. *glaberrimum* (Rydb.) Morgan & R.L. Hartm. **[-,1] G;** 6540′; R; fr.

Xanthisma spinulosum (Pursh) Morgan & R.L. Hartm. var. *spinulosum* **[16,11]** A, R, S, T; 5610–7600′; **G, L, P, S;** ds, fr, pg, pj, ra.

* *Xanthium spinosum* L **[1,-] A;** 5610′; **L;** fr.

Xanthium strumarium L. var. *canadense* (Mill.) Torr. & A. Gray **[1,-]** A; 5500′; **L;** fr.

Zinnia grandiflora Nutt. **[7,-]** A; 5610–6200′; **L, S;** pg, pj.

Berberidaceae

Berberis fendleri A. Gray **[14,7]** A, M, S, T; 7000–9400′; **P, S;** mc, mm, mr, pj, pp.

Berberis fremontii Torr. **[3,-]** A; 5500–6150′; **L, S;** fr, pj.

Berberis repens Lindl. **[7,27]** C, R, S, T; 7350–10100′; **S;** af, br, mc, mm, mr, pj, pp.

* *Berberis vulgaris* L. **[UNM**-J. Carter 935] T; **G.**

Betulaceae

Alnus incana (L.) Moench var. *occidentalis* (Dippel) C.L. Hitchc. **[34,32]** A, C, M, R, S, T; 6040–10500′; **S;** mr, ra.

[*Alnus incana* ssp. *tenuifolia* (Nutt.) Breitung]

Alnus oblongifolia Torr. **[1,-]** S; 7000′; **S;** mr.

Betula occidentalis Hook. **[-,6]** R, T; 6500–9400′; **P, S;** mc, mr.

Boraginaceae

Cryptantha cinerea (Greene) Cronquist var. *cinerea* **[9,3]** A, S, T; 5700–7976′; **L, S;** fr, mm, mr, pg, pj, ra.

Cryptantha crassisepala (Torr. & A. Gray) Greene var. *elachantha* I.M. Johnst. **[-,2]** R, T; 5781–6380′; **G;** fr, ra.

Cryptantha fulvocanescens (S. Watson) Payson var. *fulvocanescens* **[-,4]** R; 6036–6540′; **G, P;** ds, fr, pj.

Cryptantha minima Rydb. **[5,-]** A; 5700–7500′; **L, S;** ds, pg, pj.

* *Cynoglossum officinale* L. **[1,19]** C, M, T; 6055–10500′; **S;** fr, mc, ml, mm, mr, ra.

Eritrichum nanum (Vill.) Schrad. ex Gaudin var. *elongatum* (Rydb.) Cronquist **[-,4]** T; 11500–13009′; **S;** am.

Hackelia besseyi (Rydb.) J.L. Gentry **[2,-]** A, S; 7800–9200′; **S;** pp, mc.

Hackelia floribunda (Lehm.) I.M. Johnst. **[3,9]** A, C, M, T; 7650–10500′; **S;** mc, ml, mm, mr, ra.

+♦ *Hackelia hirsuta* (Wooton & Standl.) I.M. Johnst. **[1,6]** A, C, M, T; 7650–11000′; **S;** mc, mm, ra.

Lappula occidentalis (S. Watson) Greene var. *cupulata* (A. Gray) L.C. Higgins **[3,1]** A, S, T; 6380–7420′; **S;** mm, pj.

Lappula occidentalis (S. Watson) Greene var. *occidentalis* **[10,40]** A, C, R, S, T; 5781–9750′; **G, P, S;** br, ds, fr, mc, ml, mm, mr, pj, pp, ra.

* *Lappula squarrosa* (Retz.) Dumort. **[-,1]** T; 8175′; **S;** ml.

Lithospermum incisum Lehm. **[7,12]** A, C, R, S, T; 5750–8830′; **G, L, P, S;** ds, fr, mc, pg, pj, pp, ra.

Lithospermum macromeria J. Cohen **[3,-]** A; 7720–8600′; **S;** mm, pp, ra.

Lithospermum multiflorum Torr. ex A. Gray **[13,14]** A, C, S, T; 7000–11500′; **S;** br, mc, mm, mr, pj, pp, ra.

Mertensia alpina (Torr.) G. Don **[UNM**-H. Mackay 5T-318] T; **S.**

Mertensia ciliata (E. James ex Torr.) G. Don **[-,7]** T; 9300–13161′; **S;** am, bw, mr, sf.

Mertensia franciscana A. Heller **[31,40]** A, M, R, S, T; 7350–12850′; **S;** bw, mc, mm, mr, pj, sf.

Mertensia lanceolata (Pursh) DC. **[2,18]** A, C, R, S, T; 7350–12850′; **S;** am, br, mc, mm, mr, ra.

[*Mertensia lanceolata* varieties]

* *Symphytum officinale* L. **[UNM**-R. Sivinski 3125] S; **S.**

Brassicaceae

* *Alyssum alyssoides* (L.) L. **[-,1]** R; 8900–9100′; **S;** ra.

* *Alyssum desertorum* Stapf **[-,1]** T; 7200′; **S;** ra.

* *Alyssum simplex* Rudolphi **[-,15]** C, R, T; 5800–10000′; **G, P, S;** br, ds, fr, ml, mm, mr, pj, pp, ra.

Arabis pycnocarpa M. Hopkins var. *pycnocarpa* **[-,1]** T; 7840–8500′; **S;** mm.

[*Arabis hirsuta* (L.) Scop. var. *pycnocarpa* (M. Hopkins) Rollins]

Barbarea orthoceras Ledeb. **[1,1]** A, T; 6053–7800′; **P, S;** mr, ra.

* *Barbarea vulgaris* R. Br. **[2,3]** A, C, R, S, T; 5800–8000′; **L, S;** fr, mr.
× *Boechera ×divaricarpa* (A. Nelson) Á. Löve & D. Löve **[-,11]** C, R, T; 7150–10500′; **G, S;** br, mc, mm, mr, pj, pp, ra
[A hybrid between *Boechera stricta* and another taxon]
Boechera fendleri (S. Watson) W.A. Weber **[-,19]** C, R, T; 6600–10500′; **G, P, S;** br, mc, mm, mr, pj, pp.
Boechera lignifera (A. Nelson) W.A. Weber **[-,2]** T; 7380–8350′; **S;** pj.
[error: *B. gracilenta* (Greene) Windham & Al-Shehbaz]
Boechera pallidifolia (Rollins) W.A. Weber **[-,6]** T; 7100–8350′; **S;** pj, pp.
Boechera spatifolia (Rydb.) Windham & Al-Shehbaz **[2,-]** A, S; 7150–8410′; **S;** mm, mc.
Boechera stricta (Graham) Al-Shehbaz **[4,22]** A, C, M, S, T; 8400–12850′; **S;** am, mc, ml, mm, ms, mr, ra, sf.
* *Camelina microcarpa* Andrz. ex DC. **[4,9]** C, R, S, T; 7100–8550′; **S;** ds, mc, ml, mm, mc, mr, pj, pp, ra.
* *Capsella bursa-pastoris* (L.) Medik. **[9,14]** A, M, R, S, T; 7550–10600′; **S;** br, mc, mm, mr, pp, ra.
Cardamine cordifolia A. Gray var. *cordifolia* **[12,21]** A, C, M, R, S, T; 7900–12000′; **S;** mc, mm, mr, sf.
* *Chorispora tenella* (Pall.) DC. **[-,1]** R; 6540′; **G;** ra.
* *Conringia orientalis* (L.) Dumort. **[UNM**-E. Castetter *s.n.*, 6 Jul 1935**]** C; **S.**
Descurainia californica (A. Gray) O.E. Schulz **[-,4]** C, T; 7800–10500′; **S;** br, mm, mr.
Descurainia incana (Bernh. ex Fisch. & C.A. Mey.) Dorn var. *incisa* (Engelm.) Kartez & Gandhi **[4,9]** A, C, M, S, T; 7215–10500′; **S;** br, mc, mm, mr, pj, pp.
[*Descurainia longepedicellata* (Fourn.) O. E. Schult]
Descurainia incana (Bernh. ex Fisch. & C.A. Mey.) Dorn var. *macrosperma* (O.E. Schulz) Dorn **[3,-]** A, M; 8700–10700′; **S;** mm, mr.
[*Descurainia incana*]
Descurainia incana (Bernh. ex Fisch. & C.A. Mey.) Dorn var. *viscosa* (Rydb.) Dorn **[13,9]** A, M, R, S, T; 6200–10700′; **P, S;** ds, fr, mc, mm, pj, ra.
[Not included in taxon count; *Descurainia longepedicellata* (Fourn.) O. E. Schult]
Descurainia obtusa (Greene) O.E. Schultz ssp. *obtusa* **[1,-]** S; 6540′; **G;** mr.
Descurainia pinnata (Walter) Britton var. *filipes* (A. Gray) M. Peck **[-,1]** R; 8100′; **S;** pj.
[Not included in taxon count; *Descurainia longepedicellata* (Fourn.) O. E. Schult]
Descurainia pinnata (Walter) Britton var. *osmiarum* (Cockerell) Shinners **[2,1]** A; T; 6200–7500′; **L, S;** ds, pg, pj.
[Not included in taxon count; *Descurainia longepedicellata* (Fourn.) O. E. Schult]
* *Descurainia sophia* (L.) Webb ex Prantl **[5,16]** A, C, R, S, T; 5781–9100′; **G, L, P, S;** br, ds, fr, mc, ml, mm, mr, pj, pp, ra.
Draba aurea Vahl ex Hornem. **[-,14]** R, T; 8350–13024′; **S;** am, mc, mr, sf.
Draba cana Rydb. **[-,1]** T; 11500–12700′; **S;** am.
Draba cuneifolia Nutt. ex Torr. & A. Gray var. *cuneifolia* **[-,1]** R; 7650′; **S;** pj.
Draba helleriana Greene var. *blumeri* C.L. Hitchc. **[-,1]** T; 8500–10500′; **S;** mc.
Draba helleriana Greene var. *helleriana* **[26,34]** A, M, R, S, T; 7750–13009′; **S;** am, bw, mc, mm, mr, pj, sf.
Draba helleriana Greene var. *patens* (Heller) O. E. Schulz **[6,-]** A, M; 9000–10660′; **S;** mc, mm, ms.
! *Draba nemorosa* L. var. *nemorosa* **[-,1]** T; 7350–7450′; **P;** ds.
Draba reptans (Lam.) Fernald **[-,2]** R, T; 7050–7740′; **G, S;** fr, pj.
Draba spectabilis Greene **[1,1]** S, T; 10150–11900′; **S;** mr.
Draba streptocarpa A. Gray **[2,16]** A, C, T; 8300–13009′; **S;** am mc, mm, mr, sf.
Erysimum capitatum (Douglas ex Hook.) Greene var. *capitatum* **[2,5]** A, M, S, T; 6400–12584′; **S;** am, bw, mc, mm, pj, sf.
Erysimum capitatum (Douglas ex Hook.) Greene var. *elatum* (Nutt.) Torr. **[31,35]** A, M, R, S, T; 6100–13000′; **G, P, S;** am, br, ds, fr, mc, ml, mm, mr, ms, pj, pp, ra.
[*Erysimum capitatum* (Douglas ex Hook.) Greene var. *purshii* (Durand) Rollins]
Erysimum inconspicuum (S. Watson) MacMill. **[2,1]** A, M, T; 8680–12183′; **S;** am, mc, mr.
Hesperidanthus linearifolius (A. Gray) Rydb. **[6,9]** A, R, S, T; 5500–8540′; **L, P, S;** br, ds, fr, pg, pj, pp, ra.
Lepidium alyssoides A. Gray var. *alyssoides* **[-,2]** T; 7100–8175′; **S;** ml, ra.
* *Lepidium campestre* (L.) R. Br. **[-,1]** T; 7100–7800′; **S;** ra.
Lepidium densiflorum Schrad. var. *densiflorum* **[4,3]** A, C, S, T; 5750–8000′; **L, P, S;** ds, ml, pj, ra.
! *Lepidium densiflorum* Schrad. var. *macrocarpum* G.A. Mulligan **[-,2]** T; 6100–6500′; **P;** pj.
Lepidium densiflorum Schrad. var. *ramosum* (A. Nelson) Thell. **[1,-]** S; 6540′; **G;** fr.
Lepidium lasiocarpum Nutt. var. *wrightii* (A. Gray) C.L. Hitchc. **[-,1]** T; 5781′; **G;** fr, ra.
*● *Lepidium latifolium* L. **[-,3]** T; 5781–8550′; **G, P, S;** fr, ra.
* *Lepidium perfoliatum* L. **[-,1]** T; 6053′; **P;** ra.
Lepidium ramosissimum A. Nelson var. *bourgeauanum* (Thell.) Rollins **[1,1]** S, T; 7000–9750′; **S;** mm, mr, ra, sf.
Lepidium virginicum L. var. *medium* (Greene) C.L. Hitchc. **[-,3]** R, T; 6053–9400′; **P, S;** fr, pp, ra.
[*Lepidium virginicum* var. *menziesii* (DC.) Thell.]
Lepidium virginicum var. *pubescens* (Greene) Thell. **[3,4]** A, S, T; 6500–9400′; **P, S;** mc, mr, pp, sf.
[*Lepidium virginicum* L. var. *menziesii* (DC.) Thell.]
* *Nasturtium officinale* R. Br. **[-,1]** T; 6600–6800′; **P;** fr.
Noccaea fendleri (A. Gray) Holub ssp. *glauca* (A. Nelson) Al-Shebaz & M. Koch **[8,27]** A, M, R, S, T; 7250–11950′; **S;** bw, br, mc, mm, mr, pj, pp, sf.
Pennellia longifolia (Benth.) Rollins **[3,-]** A; 8000–8575′; **S;** mc, ms.
Pennellia micranthra (A. Gray) Nieuwl. **[1,4]** A, C, R, T; 5840–10500′; **L, S;** mc, pg, pj, pp.
Physaria calcicola (Rollins) O'Kane & Al-Shehbaz **[2,-]** S; 7100–7350′; **S;** pj.
Physaria fendleri (A. Gray) O'Kane & Al-Shehbaz **[1,-]** A; 5700–5800′; **L;** pg, pj.
Physaria floribunda Rydb. var. *floribunda* **[-,6]** T; 7250–8550′; **S;** br, pj.
Physaria montana (A. Gray) Greene **[2,9]** R, S, T; 7050–8000′; **G, P, S;** ds, fr, pj.
Physaria rectipes (Wooton & Standl.) O'Kane & Al-Shehbaz **[1,10]** R, S, T; 6050–8500′; **G, P, S;** ds, pj.
Physaria valida (Greene) O'Kane & Al-Shehbaz **[1,-]** S; 7000–7200′; **S;**
Rorippa palustris (L.) Besser var. *fernaldiana* (Butters & Abbe) Stuckey **[-,1]** T; 7240′; **S;** ra.
[*Rorippa palustris* var. *palustris*]
Rorippa sinuata (Nutt.) Hitchc. **[UNM**-R. Ivey *s.n.*, 1 Sept 1992**]** T; **S.**
Rorippa sphaerocarpa (A. Gray) Britton **[3,-]** A, M; 8375–9600′; **S;** mc, mm.
* *Rorippa sylvestris* (L.) Besser **[1,-]** A; 5500′; **L;** fr.
* *Sisymbrium altissimum* L. **[8,17]** A, C, R, S, T; 5781–9600′; **G, P, S;** br, ds, fr, ml, mm, mr, pj, pp, ra.
* *Sisymbrium loeselii* L. **[-,2]** T; 7100–7240′; **S;** ra.
Streptanthella longirostris (S. Watson) Rydb. **[-,1]** T; 5781′; **G;** ds, fr.
Streptanthus cordatus Nutt. var. *cordatus* **[-,2]** T; 7600–8900′; **S;** pj, pp.
\+ *Thelypodiopsis vaseyi* (S. Watson ex B.L. Rob.) Rollins **[7,3]** A, M, T; 7900–10660′; **S;** af, mc, mm, ra.
Thelypodium wrightii A. Gray ssp. *wrightii* **[-,1]** T; 7600–8300′; **S;** pj.

* *Thlaspi arvense* L. **[-,4]** R, T; 5781–9500'; **G, P, S;** fr, mc, mr, ra.

Turritis glabra L. **[9,2]** A, C, S; 8230–9320'; **S;** mm, mr, ra.

Cactaceae

Coryphantha vivipara (Nutt.) Britton & Rose **[-,3]** T; 7600–8450'; **S;** pj, pp.

Cylindropuntia imbricata (Haw.) Knuth var. *imbricata* **[9,9]** A, R, S, T; 5585–8300'; **G, L, P, S;** ds, fr, pg, pj.

Echinocereus coccineus Engelm. **[5,9]** A, C, R, S, T; 5625–8900'; **G, L, P, S;** ds, mm, mc, pg, pj, pp.

Echinocereus triglochidiatus Engelm. **[2,10]** A, R, T; 5781–8450'; **G, L, P, S;** ds, fr, pj, pp, ra.

Echinocereus viridiflorus Engelm. **[-,15]** C, R, T; 6200–8277'; **G, P, S;** ds, fr, pj, pp.

Opuntia engelmannii Salm-Dyck ex Engelm. var. *engelmannii* **[1,-]** A; 5700–5800'; **L;** pj.

Opunita macrorhiza Engelm. **[UNM**-E. Castetter 1250] T; **S.**

Opuntia phaeacantha Engelm. **[9,9]** A, C, R, S, T; 5730–8300'; **G, L, P, S;** ds, mm, pg, pj, pp.

Opuntia polyacantha Haw. var. *polyacantha* **[5,28]** A, C, R, S, T; 5730–8900'; **G, L, P, S;** ds, fr, mc, mm, pg, pj, pp, ra.

Pediocactus simpsonii (Engelm.) Britton & Rose **[UNM**-W. Sedlacek 3769] T; **S.**

Campanulaceae

Campanula parryi A. Gray var. *parryi* **[2,11]** A, C, R, T; 7400–10400'; **S;** mc, mm, mr, ra.

Campanula rotundifolia L. **[49,51]** A, C, M, R, S, T; 7000–13024'; **S;** am, bw, br, mc, mm, ms, mr, pj, pp, ra, sf.

Campanula uniflora L. **[UNM**-H. Mackay 9T-1] T; **S.**

Lobelia cardinalis L. **[UNM**-F. Bartlette *s.n.*, Aug 1905] A; **S.**

Cannabaceae

Cannabis sativa L. var. *sativa* **[1,-]** M; 7700'; **S;** mr.

Celtis occidentalis L. **[1,-]** A; 5500'; **L;** fr, pj.

Celtis reticulata Torr. **[1,-]** A; 5700–5800'; **L;** fr, pj.

Humulus lupulus L. var. *neomexicanus* A. Nelson & Cockerell **[4,1]** A, S, T; 7580–8400'; **S;** mm, mr.

Caprifoliaceae (includes Valerianaceae)

Linnaea borealis L. var. *longiflora* Torr. **[2,4]** M, S, T; 8410–10800'; **S;** mc, mr, sf.

Lonicera involucrata (Richardson) Banks ex Spreng. **[18,20]** A, M, R, S, T; 7840–11950'; **S;** mc, mm, mr, sf.

Symphoricarpos rotundifolius A. Gray **[33,24]** A, M, R, S, T; 7250–10500'; **S;** br, mc, mm, mr, pj, pp.

Valeriana acutiloba Rydb. var. *acutiloba* **[2,9]** M, R, T; 7550–11850'; **S;** br, mc, mm, pp, sf.

Valeriana arizonica A. Gray **[2,-]** A, S; 7740–8180'; **S;** mr.

Valeriana edulis Nutt. ex Torr. & A. Gray **[17,16]** A, C, M, S, T; 7050–12850'; **S;** bw, br, mc, mm, mr, ra, sf.

Caryophyllaceae

Arenaria lanuginosa (Michx.) Rohrb. var. *saxosa* (A. Gray) Zarucchi, R.L. Hartm., & Rabeler **[15,23]** A, C, M, S, T; 7840–12000'; **S;** af, bw, mc, mm, mr, ms, ra, sf.

[*Spergulastrum lanuginosum* Michx. ssp. *saxosum* (A. Gray) W.A. Weber]

Cerastium arvense L. var. *strictum* (Gaudin) Koch **[-, 20]** C, T; 7620–13009'; **S;** am, mm, mr, sf.

Cerastium brachypodum (Engelm. ex A. Gray) B.L. Rob. **[3,-]** A, M; 8600–9340'; **S;** mc, mm, mr.

* *Cerastium fontanum* Baumg. ssp. *vulgare* (Hartm.) Greuter & Burdet **[17,2]** A, M, S, T; 7000–10880'; **S;** af, mc, mm, mr, ra.

* *Dianthus armeria* L. **[-,1]** R; 7600–7750'; **S;** pj.

Eremogone eastwoodiae (Rydb.) Ikonn. var. *adenophora* (Kearney & Peebles) R.L. Hartm. & Rabeler **[-,3]** R; 6050–6500'; **G, P;** fr, pj.

Eremogone eastwoodiae (Rydb.) Ikonn. var. *eastwoodiae* **[2,1]** R, S; 6540–7050'; **G;** ds, fr, pj.

Eremogone fendleri (A. Gray) Ikonn. **[22,27]** A, C, M, R, S, T; 7000–13024'; **P, S;** am, bw, fr, mc, mm, mr, pp, sf.

Minuartia obtusiloba (Rydb.) House **[7,20]** A, M, R, S, T; 9800–13024'; **S;** am, mm.

Minuartia rubella (Wahlenb.) Hiern **[-,4]** T; 10500–12700'; **S;** am, mm.

Moehringia lateriflora (L.) Fenzl **[-,1]** T; 9475'; **S;** mr.

Moehringia macrophylla (Hook.) Fenzl **[1,7]** S, T; 7620–10500'; **S;** br, mc, mr.

Paronychia jamesii Torr. & A. Gray **[2,-]** A; 5730–7500'; **L, S;** pg, pj.

Paronychia pulvinata A. Gray **[-,3]** T; 10200–12500'; **S;** am.

Pseudostellaria jamesiana (Torr.) W.A. Weber & R.L. Hartm. **[-,14]** R, T; 7550–11800'; **S;** br, mc, mm, mr, pp, sf.

Sagina saginoides (L.) H. Karst. **[-,1]** T; 10700'; **S;** mr.

* *Saponaria officinalis* L. **[2,-]** A, S; 7400–8000'; **S;** mm, mr.

Silene acaulis (L.) Jacq. var. *subacaulescens* (F.N. Wms.) Fern. & St John **[1,7]** S, T; 9800–12850'; **S;** am.

Silene antirrhina L. **[-,1]** T; 7600–8450'; **S;** pp.

Silene drummondii Hook. var. *drummondii* **[8,16]** A, M, R, S, T; 7840–12000'; **S;** mc, mm, mr, pp, sf.

! *Silene drummondii* Hook. var. *striata* (Rydb.) Bocq. **[-,4]** C, M, T; 8300–10986'; **S;** mc, mm, mr, sf.

! *Silene hitchguirei* Bocq. **[-,1]** T; 11500–12850'; **S;** am.

Silene latifolia Poiret ssp. *alba* (Miller) Greuter & Burdet **[6,-]** A; 7800–9750'; **S;** mc, mm, mr, ra.

* *Silene noctiflora* L. **[1,-]** M; 7700'; **S;** mm, ra.

Silene scouleri Hook. var. *pringlei* (S. Watson) C.L. Hitchc. & Maguire ex Kartesz & Gandhi **[12,9]** A, C, M, S, T; 8160–11500'; **S;** mc, mm, mr, sf.

Stellaria longifolia Muhl. ex Willd. **[1,4]** M, T; 7050–11333'; **S;** mm, mr.

Stellaria longipes Goldie var. *longipes* **[4,16]** A, M, S, T; 7850–12700'; **S;** am, mc, mm, mr, pp, sf.

Stellaria umbellata Turcz. ex Karel. & Kir. **[1,7]** S, T; 9700–12700'; **S;** am, mc, mm, mr, sf.

* *Vaccaria hispanica* (Mill.) Rauschert **[UNM**-F. Bartlette *s.n.*, Jul 1904] A; **S.**

Celastraceae

Paxistima myrsinites (Pursh) Raf. **[14,31]** A, C, M, R, S, T; 7350–12000'; **P, S;** br, mc, mm, mr, pp, ra, sf.

Chenopodiaceae

Atriplex canescens (Pursh) Nutt. var. *canescens* **[4,8]** A, R, S, T; 5800–7550'; **G, P, S;** ds, fr, pj, ra.

* *Bassia hyssopifolia* (Pall.) Kuntze **[-,2]** T; 8550–9675'; **G, P, S;** br, mc, mr.

Chenopodium atrovirens Rydb. **[4,8]** A, M, T; 7750–11500'; **S;** mm, mr, ra, sf.

Chenopodium berlandieri Moq. var. *zschackei* (Murr) Murr ex Asch. **[8,2]** A, C, M, S; 7400–9200'; **S;** mc, ml, mm, ra.

Chenopodium fremontii S. Watson **[5,6]** A, M, T; 7350–10500'; **S;** br, fr, mc, mm, pj, ra.

* *Chenopodium glaucum* L. var. *glaucum* **[-,1]** C; 8194'; **S;** ml.

Chenopodium glaucum L. var. *salinum* (Standl.) B. Boivin **[UNM**-E. Castetter 3951] C; **S.**

Chenopodium incanum (S. Watson) A. Heller var. *incanum* **[5,1]** A, T; 5610–7240'; **L, S;** fr, ds, mm, pg, pj, ra.

Chenopodium leptophyllum (Moq.) Nutt. ex S. Watson **[UNM**-K. Goodrow 558] A; **S.**

* *Chenopodium overi* Aellen **[7,4]** A, M, S, T; 8160–9800'; **S;** mc, mm, ra.

[*Chenopodium capitatum* (L.) Ambrosi var. *parvicapitatum* S.L. Welsh]

Chenopodium pallescens Standl. **[1,-]** A; 7000′; **S;** pp.

Chenopodium pratericola Rydb. **[-,2]** C, T; 7650–9700′; **S;** pj, mm. [*Chenopodium desiccatum* A. Nelson var. *leptophylloides* (Murr) Wahl]

Chenopodium watsonii A. Nelson **[1,-]** A; 5600–5650′; **L;** pg.

* *Dysphania botrys* (L.) Mosyakin & Clemants **[UNM**-E. Kelley 247**]** S; **S.**

Dysphania graveolens (Willd.) Mosyakin & Clemants **[4,6]** A, C, R, S, T; 7400–9400′; **S;** br, mm, mr, pp, ra.

* *Kochia scoparia* (L.) Schrad. **[3,2]** A, C, S, T; 5730–8750′; R, S, T; mr, pg, pj, ra.

Krascheninnikovia lanata (Pursh) Meeuse & Smit **[3,3]** A, T; 5730–8555′; **L, P, S;** ds, fr, pg, pj.

Monolepis nuttalliana (Schult.) Greene **[-,3]** T; 9200–11800′; **S;** am, mr, sf.

* *Salsola collina* Pall. **[UNM**-E. Kelley 304**]** S; **S.**

* *Salsola tragus* L. **[-,3]** C, T; 7240–9400′; **S;** ml, pj, ra.

Cleomaceae [Capparaceae]

Cleome serrulata Pursh **[UNM**-H. Dixon V-97**]** T; **S.** [*Peritoma serrulata* (Pursh) A. DC.]

Polanisia dodecandra (L.) DC. var. *trachysperma* (Torr. & A. Gray) H.H. Iltis **[2,-]** A; 5500–5610′; **L;** fr, pj.

Commelinaceae

Commelina dianthifolia Delile **[5,1]** A, C, S; 7000–8260′; **S;** ms, pp.

Commelina erecta L. var. *angustifolia* (Michx.) Fernald. **[2,-]** A; 5500–5840′; **L;** ds, fr, pj.

Tradescantia occidentalis (Britton) Smyth var. *occidentalis* **[4,-]** A; 5500–6200′; **L;** fr, pg, pj.

Convallariaceae [traditionally in Liliaceae]

Maianthemum racemosum (L.) Link var. *amplexicaule* (Nutt.) Dorn **[14,15]** A, C, M, S, T; 7840–10850′; **S;** mc, mm, mr, sf.

Maianthemum stellatum (L.) Link **[8,13]** A, C, M, S, T; 7620–11650′; **S;** mc, mm, mr, sf.

Polygonatum biflorum (Walter) Elliott **[1,-]** M; 9760–10600′; **S;** mr.

Convolvulaceae

*● *Convolvulus arvensis* L. **[10,5]** A, M, R, S, T; 5800–9320′; **G, L, S;** fr, ml, mm, pg, pj, ra.

Convolvulus equitans Benth. **[1,-]** A; 5650–5740′; **L;** pg, pj.

Evolvulus nuttallianus Roemer & Schult. **[2,-]** A; 5700–5840′; **L;** pg, pj, ra.

Evolvulus sericeus Swartz var. *sericeus* **[2,-]** A; 5700–5840′; **L;** pg, pj, ra.

Ipomoea cristulata H. Hall **[1,-]** S; 6840–6880′; **S;** pj.

Ipomoea leptophylla Torr. **[1,-]** A; 5570–5600′; **L;** fr.

Cornaceae

♦ *Cornus canadensis* L. **[-,2]** T; 9700–11500′; **S;** mc, mm, mr, sf.

Cornus sericea L. var. *sericea* **[11,12]** A, C, S, T; 7400–9400′; **S;** mc, mr.

Crassulaceae

Sedum cockerellii Britton **[14,3]** A, C, M, S, T; 7750–9400′; **S;** mc, mr, ms.

Sedum integrifolium (Raf.) A. Nelson ssp. *integrifolium* **[10,19]** A, C, M, R, S, T; 7840–13009′; **S;** am, mc, mm, mr, sf.

Sedum lanceolatum Torr. ssp. *lanceolatum* **[-,18]** R, T; 7600–12400′; **S;** am, bw, mc, mm, mr, ra, sf.

Sedum rhodanthum A. Gray **[3,4]** M, R, T; 9900–12050′; **S;** am, mm, mr, sf.

Sedum wrightii A. Gray **[UNM**-N.D. Atwood 21328**]** S; **S.**

Cucurbitaceae

Cucurbita foetidissima Kunth **[4,-]** A; 5570–7240′; **L, S;** fr, pj, ra.

Echinocystis lobata (Michx.) Torr. & A. Gray **[UNM**-R. Jackson 2341**]** T; **G.**

Cyperaceae

Carex albonigra Mack. **[1,5]** M, T; 10500–12850′; **S;** am, mm.

Carex aquatilis Wahlenb. var. *aquatilis* **[-,10]** M, T; 9700–11200′; **S;** mm, mr, sf.

Carex aurea Nutt. **[1,5]** A, T; 8300–10500′; **S;** mm, mr.

Carex bella L.H. Bailey **[5,19]** A, M, R, S, T; 8300–11650; **S;** bw, mm, mr, sf.

Carex brevior (Dewey) Mack. ex. Lunell **[1,-]** A; 7200–7240′; **S;** ml.

Carex canescens L. var. *canescens* **[2,3]** M, S, T; 8410–12000′; **S;** mm, mr, sf.

Carex capillaris L. **[-,1]** T; 9700–11500′; **S;** mr.

Carex chalciolepis T. Holm **[-,8]** T; 10990–13009′; **S;** am, mm.

! *Carex deweyana* Schwein. var. *deweyana* **[1,3]** S, T; 7620–9300′; **S;** mr, pp.

Carex disperma Dewey **[1,3]** M, R, T; 8400–10180′; **S;** mr.

Carex douglasii Boott **[-,5]** R, T; 7050–8500′; **G, P, S;** ds, fr, mm, mr, pp.

Carex duriuscula C.A. Mey. **[-,4]** C, T; 7200–9700′; **S;** mm, mr, pj, pp.

Carex ebenea Rydb. **[6,12]** A, M, R, S, T; 9375–13024′; **S;** am, bw, mm, mr, sf.

Carex elynoides Holm **[-,8]** T; 11500–13161′; **S;** am.

Carex emoryi Dewey **[-,3]** R, T; 5781–10000′; **G, S;** fr, ra.

Carex geophila Mack. **[-,30]** C, R, T; 6100–11200′; **G, P, S;** bw, ds, fr, mc, ms, mr, pj, pp.

! *Carex gynocrates* Wormsk. ex Drejer **[-,1]** T; 9700–11500′; **S;** mr.

Carex illota L.H. Bailey **[-,2]** R, T; 11750–12960′; **S;** mr, sf.

Carex inops L.H. Bailey ssp. *heliophila* (Mack.) Crins. **[2,17]** A, C, R, S, T; 7050–9600′; **G, S;** af, br, mc, mm, ms, mr, pj, pp, ra.

Carex interior L.H. Bailey **[1,1]** M, T; 9900–12050′; **S;** mm, mr.

! *Carex lenticularis* Michx. var. *lipocarpa* (Holm) L.A. Standl. **[2,-]** S; 7580–8410′; **S;** mr.

Carex micropoda C.A. Meyer **[UNM**-C. Keller 2218**]** T; **S.** [*Carex pyrenaica* Wahlenb.]

Carex microptera Mack. **[19,31]** A, C, M, R, S, T; 7580–12960′; **S;** am, bw, mc, mm, mr, ms, sf.

Carex nebrascensis Dewey **[2,15]** C, M, S, T; 6500–11200′; **G, P, S;** ml, mm, mr.

Carex nova L.H. Bailey var. *nova* **[-,16]** M, T; 9200–12960′; **S;** am, mc, mm, mr, sf.

Carex occidentalis L.H. Bailey **[14,28]** A, C, M, R, S, T; 5750–10000′; **G, L, P, S;** bw, br, ds, fr, mc, mm, mr, ms, pp, ra, sf.

Carex oreocharis Holm **[-,1]** C; 10000–10600′; **S;** mm, sf.

Carex pellita Muhl. ex Willd. **[2,3]** A, C, T; 6600–8400′; **P, S;** fr, mr.

Carex petasata Dewey **[-,2]** T; 9375–12000′; **S;** bw, mr.

Carex phaeocephala Piper **[-,1]** T; 12000–12625′; **S;** am.

Carex pityophila Mack. **[-,9]** C, T; 7775–12000; **S;** am, mc, pp sf. [*Carex geophila* Mack.]

Carex praegracilis Boott **[-,4]** R, T; 6500–10700′; **P, S;** fr, ml, mr.

! *Carex rosea* Schkuhr ex Willd. **[2,-]** A; 7800–8325′; **S;** mc, mr.

Carex rossii Boott **[-,17]** R, T; 6036–11000′; **P, S;** br, mc, mr, pp, sf.

Carex rupestris Bellardi ex All. var. *drummondiana* (Dewey) L.H. Bailey **[-,4]** T; 10500–13000′; **S;** am.

Carex siccata Dewey **[2,16]** A, C, M, R, T; 8300–12960′; **S;** am, mc, mm, mr, sf. [*Carex foenea* Willd. var. *foenea*]

Carex stevenii (T. Holm) Kalela **[3,8]** M, S, T; 7620–11500′; **S;** mm, mr.

Carex stipata Muhl. ex Willd. var. *stipata* **[6,2]** A, T; 7850–10500′; **S;** mm, mr.

Carex subfusca Boott **[2,-]** S; 8260–8940′; **S;** mr.

Carex tahoensis Smiley **[UNM**-R. Gierisch 3146**]** R; **S.**

Carex utriculata Boott **[2,12]** A, C, T; 7050–11209′; **S;** ml, mm, mr, sf.

Carex vallicola Dewey **[-,1]** T; 7550′; **S;** br.

Carex vulpinoidea Michx. **[1,-]** A; 7740–7880′; **S;** mr.

Carex wootonii Mack. **[2,-]** A; 8900–9500′; **S;** mc, mr.

Cyperus esculentus L. var. *leptostachyus* Boeck. **[1,-]** A; 5500′; **L;** fr.

Cyperus fendlerianus Boeck. **[17,2]** A, C, M, S; 5800–9080′; **L, S;** mc, mm, mr, pj, pp, ra.
Cyperus retroflexus Buckley var. *pumilus* (Britton) R. Carter & S.D. Jones **[1,-]** A; 5500′; **L;** fr.
Cyperus schweinitzii Torr. **[1,-]** A; 5630′; **L;** fr.
Eleocharis bella (Piper) Svenson **[1,-]** A; 7200–7240′; **S;** ml.
Eleocharis engelmannii Steud. **[1,-]** A; 7200–7240′; **S;** ml.
Eleocharis erythropoda Steud. **[UNM**- E. Castetter 3390] C; **S.**
Eleocharis palustris (L.) Roem. & Schult. **[1,12]** C, M, R, T; 5781–10000′; **G, P, S;** fr, ml, mm, mr, ra.
Eleocharis quinqueflora (F.X. Hartm.) O. Schwarz **[-,5]** C, T; 8500–10500′; **S;** mm, mr.
Eleocharis rostellata (Torr.) Torr. **[-,1]** R; 6450′; **G;** fr.
Eriophorum angustifolium Honck. ssp. *angustifolium* **[-,3]** T; 10700–12050′; **S;** mr.
Kobresia myosuroides (Villars) Fiori & Paoli **[-,2]** T; 11990–12050′; **S;** am.
Schoenoplectus acutus (Muhl. ex Bigelow) Á. Löve & D. Löve var. *occidentalis* (S. Watson) S.G. Sm. **[-,2]** T; 7550–9300′; **S;** ml, mr.
Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller **[-,2]** T; 6500–7660′; **P, S;** fr, ml.
Schoenoplectus pungens (Vahl) Palla var. *longispicatus* (Britton) S.G. Sm. **[2,1]** M, R; 6380–7700′; **G, S;** fr, ml, mr.

Elaeagnaceae

*● *Elaeagnus angustifolia* L. **[5,3]** A, R, S, T; 5500–7400′; **G, L, P, S;** fr, ml, ra.
Shepherdia canadensis (L.) Nutt. **[16,14]** A, C, M, R, S, T; 7620–10200′; **S;** mc, mm, mr, pp.

Ericaceae

Arctostaphylos pungens Kunth **[UNM**-K. Weissenborn 37] S; **S.**
Arctostaphylos uva-ursi (L.) Spreng. **[18,13]** A, C, M, R, S, T; 7720–11209′; **P, S;** mc, mm, mr, pp, sf.
Chimaphila umbellata (L.) W.P.C. Barton var. *occidentalis* (Rydb.) S.F. Blake **[5,1]** A, S, T; 8385–10440′; **S;** mc, sf.
[*Chimaphila umbellata* (L.) Nutt. var. *acuta* (Rydb.) S.F. Blake]
Gaultheria humifusa (Graham) Rydb.**[UNM**-H. Mackey 6T-169] T, **S.**
Moneses uniflora (L.) A. Gray var. *uniflora* **[1,16]** M, R, S, T; 7850–11500′; **S;** mm, sf.
Monotropa hypopithys L. **[2,1]** C, M, S; 8880–9040′; **S;** mc.
Orthilia secunda (L.) House **[11,20]** A, M, R, S, T; 7850–12115′; **S;** mc, mm, sf.
Pterospora andromedea Nutt. **[9,3]** A, C, S, T; 7580–10500′; **S;** mc.
Pyrola asarifolia Michx. var. *asarifolia* **[1,3]** C, S, T; 8960–10440′; **S;** mc, sf.
Pyrola chlorantha Sw. **[1,6]** S, T; 8350–11150′; **S;** mc, mr, sf.
Pyrola elliptica Nutt. **[1,-]** S; 8200–8320′; **S;** mr.
Pyrola minor L. **[4,4]** A, M, S, T; 8410–11500′; **S;** mc, mm, mr, sf.
Pyrola picta Sm. **[1,-]** A; 8400–8900′; **S;** mc.
Vaccinium myrtillus L. var. *oreophilum* (Rydb.) Dorn **[11,5]** A, M, R, S, T; 8450–13024′; **S;** mc, sf.
Vaccinium scoparium Leiberg ex Coville **[-,15]** C, T; 9400–12850′; **S;** am, mc, mr, sf.

Euphorbiaceae

Chamaesyce fendleri (Torr. & A. Gray) Small var. *chaetocalyx* (Boiss.) Shinners **[2,-]** S; 6540–7100′; **G, S;** pj, ra.
Chamaesyce fendleri (Torr. & A. Gray) Small var. *fendleri* **[7,17]** A, R, S, T; 5700–7950′; **G, L, P, S;** ds, fr, pg, pj, ra.
Chamaesyce glyptosperma (Engelm.) Small **[2,1]** A, S, T; 5760–7100′; **L, S;** pg, pj, ra.
Chamaesyce serpyllifolia (Pers.) Small **[4,7]** A, C, M, R, S, T; 5610–9400′; **L, S;** br, fr, mr, pj, pp, ra.
Chamaesyce strictospora (Engelm.) Small **[UNM**-E. Castetter 7078] T, **G.**
Croton texensis (Klotzsch) Müll.Arg. **[5,-]** A, S; 5500–6880′; **L, S;** fr, pg, pj, ra.
Euphorbia brachycera Engelm. **[UNM**-R. Sivinski 2221] A; **S.**
Euphorbia davidii Subils **[2,-]** S; 6840–7420′; **S;** ra.
Tragia nepetifolia Cav. **[2,-]** A; 5800–6750′; **L, S;** pg, pj.
Tragia ramosa Torr. **[1,-]** A; 5700–5800′; **L;** fr, pj.

Fabaceae

Amorpha canescens Pursh **[3,2]** A, C; 7000–8600′; **S;** ms, pp.
Astragalus agrestis Douglas ex G. Don **[-,1]** C; 8400–8500′; **S;** pp.
Astragalus allochrous A. Gray var. *playanus* (M.E. Jones) Isley **[-,2]** T; 6600–8555′; **P;** ds, fr, pj.
Astragalus alpinus L. **[-,6]** T; 8700–11000′; **S;** mr, sf.
Astragalus crassicarpus Nutt. var. *cavus* Barneby **[1,-]** A; 6120–6180′; **S;** pj.
+♦ *Astragalus cyaneus* A. Gray **[-,1]** T; 7215′; **S;** pj.
Astragalus drummondii Douglas ex Hook. **[-,8]** R, T; 6600–9400′; **P, S;** fr, mc, pj, pp, ra.
Astragalus flexuosus (Hook.) Douglas ex G. Don var. *flexuosus* **[1,2]** A, T; 7500–9500′; **S;** mm, mr, sf.
Astragalus gracilis Nutt. **[1,-]** A; 6200′; **L;** pg, pj.
Astragalus hallii A. Gray var. *hallii* **[-,3]** C, M, T; 8175–9320′; **S;** ml, mr, ra.
Astragalus humistratus A. Gray var. *humistratus* **[-,2]** C, T; 7650–9750′; **S;** mm.
♦ *Astragalus iodopetalus* (Rydb.) Barneby **[-,3]** T; 7100–7660′; **S;** pj.
Astragalus kentrophyta A. Gray var. *tegetarius* (S. Watson) Dorn **[UNM**-E. Castetter 10533] T; **S.**
Astragalus laxmannii Jacq. var. *robustior* (Hook.) S.L.Welsh & Barneby **[-,1]** T; 9150′; **S;** mm.
Astragalus lentiginosus Douglas ex Hook. var. *albiflorus* (A. Gray) Schoener **[-,4]** R, T; 6036–6700′; **P;** fr, pj, ra.
Astragalus lonchocarpus Torr. **[3,10]** R, S, T; 5800–7660′; **G, P, S;** ds, fr, ml, pj.
Astragalus lotiflorus Hook. **[-,1]** T; 5781′; **G;** fr, ra.
Astragalus missouriensis Nutt. var. *missouriensis* **[2,6]** A, R, S, T; 5750–8100′; **G, L, P, S;** ds, fr, pg, pj, pp, ra.
Astragalus multiflorus (Pursh) A. Gray **[-,7]** R, T; 6380–7950′; **G, S;** fr, pj, ra.
[*Astragalus tenellus* Pursh]
Astragalus praelongus E. Sheld. var. *praelongus* **[1,1]** A, R; 6350–6500′; **P, S;** pj.
+♦ *Astragalus puniceus* Osterh. var. *gertrudis* (Greene) Barneby **[-,2]** T; 7215–8000′; **S;** pj.
Astragalus puniceus Osterh. var. *puniceus* **[-,3]** R, T; 6976–7215′; **G, P, S;** ds, pj.
Astragalus racemosus Pursh var. *racemosus* **[UNM**-K. Epperson *s.n.*, 16 May 2004] T; **S.**
Astragalus robbinsii (Oakes) A. Gray var. *minor* (Hook.) Barneby **[-,1]** T; 9900–10500′; **S;** sf.
Astragalus scopulorum Porter **[1,2]** A, R, T; 7150–12200′; **S;** bw, mc, mr.
Calliandra humilis Benth. var. *humilis* **[3,-]** A; 5800–8200′; **L, S;** ms, pg, pj, pp.
Dalea candida Michx. ex Willd. var. *oligophylla* (Torr.) Shinners **[3,-]** A; 5570–7000′; **L, S;** pg, pj, pp.
Dalea formosa Torr. **[2,1]** A, R; 5800–6350′; **G, L, S;** ds, pj.
Dalea jamesii (Torr.) Torr. & A. Gray **[2,1]** A, R; 5750–6500′; **L, P;** pg, pj.
Dalea purpurea Vent. var. *purpurea* **[3,-]** A; 7000–7520′; **S;** ms, pp.
Dalea tenuifolia (A. Gray) Shinners **[2,-]** A; 5700–5800′; **L;** pg, pj.
Desmanthus cooleyi (Eaton) Trel. **[UNM**-R. Sivinski 2414] S; **S**
Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald **[UNM**-C.R. Hutchins 9946] S; **S.**
Glycyrrhiza lepidota Nutt. ex Pursh **[1,1]** S, T; 5781–6540′; **G;** fr, ra.

Hedysarum boreale Nutt. var. *boreale* **[UNM**-C.R. Hutchins 5859] C; **G.**

Hoffmannseggia drepanocarpa A. Gray **[1,-]** A; 5760′; **L;** pg, pj.

Lathyrus arizonicus Britton **[UNM**-C.R. Hutchins 6340] S; **S.**

Lathyrus eucosmus Butters & H. St.John **[1,3]** S, T; 7200–7500′; **S;** fr, mr, ra.

Lathyrus graminfolius T.G. White **[UNM**-D. Atwood 21434] A; **S.**

* *Lathyrus latifolius* L. **[UNM**-C.R. Hutchins 8305] S; **S.**

Lathyrus leucanthus Rydb. **[4,17]** A, R, S, T; 7620–11500′; **S;** bw, mc, mm, mr, pj, pp, ra, sf.

Lupinus argenteus Pursh var. *argenteus* **[-,14]** R, T; 6850–10500′; **G, P, S;** br, mc, mr, pj, ra.

Lupinus argenteus Pursh var. *argophyllus* (A. Gray) S. Watson **[9,10]** A, R, S, T; 6380–8150′; **G, S;** br, fr, ml, mm, mr, pj, ra.
[*Lupinus caudatus* Kellogg var. *argophyllus* (A. Gray) S.L. Welsh]

Lupinus argenteus Pursh var. *fulvomaculatus* (Payson) Barneby **[1,1]** S, T; 8260–10500′; **S;** mc, mm.

Lupinus argenteus Pursh var. *palmeri* (S. Watson) Barneby **[UNM**-A. Foster 78] T; **S.**

Lupinus argenteus Pursh var. *rubricaulis* (Greene) S.L. Welsh **[-,1]** T; 8350–9400′; **S;** mc.

Lupinus brevicaulis S. Watson **[-,1]** T; 7598′; **S;** pj.

Lupinus kingii S. Watson **[1,1]** A, T; 7200–8763′; **P, S;** pj, pp.

* *Medicago lupulina* L. **[24,22]** A, C, M, R, S, T; 5800–10660′; **L, P, S;** fr, mc, ml, mm, mr, pj, pp, ra.

* *Medicago sativa* L. **[14,12]** A, M, R, S, T; 5781–10500′; **G, L, S;** ds, fr, ml, mm, mr, pp, ra.

* *Melilotus albus* Medik. **[8,8]** A, C, M, R, S, T; 6560–10500′; **G, S;** ds, fr, mc, mm, mr, pj, ra.

* *Melilotus officinalis* (L.) Pall. **[19,34]** A, C, M, R, S, T; 5781–10500′; **G, L, P, S;** br, ds, fr, mc, ml, mm, ms, mr, pg, pj, pp, ra.

Oxytropis deflexa (Pall.) DC. var. *sericea* Torr. & A. Gray **[-,6]** C, T; 8175–11000′; **S;** ml, mm, mr, sf.

Oxytropis lambertii Pursh var. *bigelovii* A. Gray **[2,6]** A, C, R, T; 6560–11200′; **G, S;** ds, mc, mm, ms, pj, pp, ra.

Oxytropis sericea Nutt. var. *sericea* **[2,7]** C, M, S, T; 6600–10093′; **P, S;** ds, fr, mc, pj, pp.

Oxytropis splendens Douglas ex Hook. **[1,2]** M, T; 8700–10080′; **S;** mm.

Pomaria jamesii (Torr. & A. Gray) Walp. **[1,-]** A; 5500′; **L;** fr.

Prosopis glandulosa Torr. var. *torreyana* (L. Benson) M.C. Johnston **[1,-]** A; 5800′; **L;** fr, pj.

Psoralidium lanceolatum (Pursh) Rydb. **[-,1]** T; 5781′; **G;** fr, ra.

Psoralidium tenuiflorum (Pursh) Rydb. **[6,-]** A; 5570–7240′; **L, S;** mm, pg, pj, pp.

Robinia neomexicana A. Gray var. *neomexicana* **[2,-]** A, M; 7700–8000′; **S;** mm, ms.

Senna bauhinioides (A. Gray) Irwin & Barneby **[2,-]** A; 5760–5840′; **L;** pg, pj.

Thermopsis rhombifolia (Nutt. ex Pursh) Nutt. ex Richardson var. *divaricarpa* (A. Nelson) Isely **[1,-]** M; 10600–10800′; **S;** mm.

Thermopsis rhombifolia (Nutt. ex Pursh) Nutt. ex Richardson var. *montana* (Nutt.) Isley **[15,23]** A, C, M, R, S, T; 7200–10440′; **S;** mc, mm, mr, pj, pp, ra, sf.

Trifolium attenuatum Greene **[4,21]** M, S, T; 9300–12960′; **S;** am, bw, mc, mm, mr.

♦ *Trifolium brandegeei* S. Watson **[-,9]** T; 9300–12700′; **S;** am, mr, sf.

Trifolium gymnocarpon Nutt. **[-,1]** T; 6600–6800′; **P;** ds, fr.

* *Trifolium hybridum* L. **[1,3]** A, C, T; 8050–9700′; **S;** mr.

Trifolium longipes Nutt. var. *reflexum* A. Nelson **[-,4]** T; 9200–11209′; **S;** mm, mr, sf.

Trifolium longipes Nutt. var. *rusbyi* (Greene) H.D. Harr. **[UNM**-W. Moir 18] T; **S.**

Trifolium nanum Torr. **[-,3]** T; 10500–13000′; **S;** am.

Trifolium parryi A. Gray **[-,1]** T; 12400–12700′; **S;** am.

* *Trifolium pratense* L. **[35,13]** A, C, M, S, T; 6540–10700′; **G, S;** mc, ml, mm, mr, ra.

* *Trifolium repens* L. **[25,33]** A, C, M, R, S, T; 5781–11300′; **G, S;** fr, mc, ml, mm, mr, pp, ra.

Trifolium wormskjoldii Lehm. var. *arizonicum* (Greene) Barneby **[-,4]** T; 7550–9700′; **S;** mc, ml, mr.

Trifolium wormskjoldii Lehm. var. *wormskjoldii* **[-,3]** T; 7050–11000′; **S;** mm, mr.

Vicia americana Muhl. ex Willd. **[21,26]** A, C, M, R, S, T; 7200–11700′; **S;** br, bw, mc, mm, mr, ra, sf.

Vicia ludoviciana Nutt. ex Torr. & A. Gray var. *ludoviciana* **[1,-]** A; 6200′; **L;** pg, pj.

Vicia pulchella Kunth **[9,-]** A, M; 7720–9760′; **S;** af, mc, mm, ms, pp, ra.

* *Vicia villosa* Roth ssp. *varia* (Host) Corb. **[UNM**-C.R. Hutchins 8347] T; **G.**

Fagaceae

Quercus gambelii Nutt. **[43,55]** A, C, M, R, S, T; 6200–10500′; **G, P, S;** af, br, ds, fr, mc, mm, ms, mr, pj, pp, ra.

Quercus grisea Liebm. **[11,3]** A, R, T; 5640–8000′; **L, S;** pj, pp, ra.

Quercus turbinella Greene **[1,-]** A; 5730′; **L;** pg, pj.

× *Quercus* ×*undulata* Torr. **[6,4]** A, C, S, T; 5725–8900′; **L, S;** br, ms, pj, pp.

Fumariaceae

Corydalis aurea Willd. var. *aurea* **[4,14]** A, C, M, S, T; 7550–10600′; **S;** br, mc, mm, mr, ra, sf.

Corydalis aurea Willd. var. *occidentalis* Engelm. ex A. Gray **[-,7]** R, T; 6600–10100′; **P, S;** br, ds, mc, pp.

Gentianaceae

Frasera speciosa Douglas ex Griseb. **[13,10]** A, C, M, S, T; 7900–12000′; **S;** af, bw, mc, mm, sf.

Gentiana algida Pall. **[1,3]** M, R, T; 11990–13024′; **S;** am.

! *Gentiana aquatica* L. **[-,2]** T; 9600–10900′; **S;** mm, mr.

Gentiana bigelovii A. Gray **[3,-] A**, M; 9160–10000′; **S;** af, mc, mm.
[*Gentiana affinis* Griseb.]

Gentiana parryi Engelm. **[10,8]** A, M, R, T; 9320–12000′; **S;** af, am, br, mm, sf.

Gentianella amarella (L.) Börner var. *acuta* (Michx.) Herder **[2,16]** A, M, R, T; 7840–12000′; **S;** am, mc, mm, mr, sf.

Gentianella amarella (L.) Börner var. *heterosepala* (Engelm.) Dorn **[1,-]** A; 8400–8850′; **S;** mm, mr.

Gentianopsis thermalis (Kuntze) H.H. Iltis **[3,1]** M, T; 10200–12500′; **S;** mm, mr, sf.

Swertia perennis L. **[6,3]** A, M, S, T; 9320–11333′; **S;** mm, mr.

Geraniaceae

* *Erodium cicutarium* (L.) L'Her. ex Aiton **[12,10]** A, C, M, R, S, T; 5800–9320′; **L, S;** br, fr, ml, mm, pj, pp, ra.

Geranium caespitosum E. James **[44,24]** A, C, M, R, S, T; 6540–10500′; **G, S;** af, fr, mc, ml, mm, mr, ms, pj, pp, ra.

Geranium richardsonii Fisch. & Trautv. **[45,55]** A, C, M, R, S, T; 7000–11920′; **S;** af, mc, mm, mr, pp, sf.

Grossulariaceae

Ribes aureum Pursh var. *aureum* **[1,2]** A, T; 5781–8230′; **G, S;** fr, mr, ra.

Ribes cereum Douglas **[19,30]** A, C, M, R, S, T; 6500–10500′; **G, P, S;** ds, fr, mc, ml, mm, ms, mr, pj, pp, ra, sf.

Ribes inerme Rydb. var. *inerme* **[14,7]** A, C, R, S, T; 7600–11290′; **S;** mm, mr, ra.

Ribes leptanthum A. Gray **[3,4]** M, S, T; 6540–11940′; **G, S;** am, mr.

Ribes montigenum McClat. **[13,20]** A, C, M, R, S, T; 7580–12500′; **S;** am, mc, mm, mr, sf.

Ribes wolfii Rothrock **[16,17]** A, C, M, R, S, T; 8300–12300′; **S;** mc, mm, mr, sf.

Haloragaceae

Myriophyllum sibiricum Komarov **[-,3]** M, T; 9900–10800′; **S;** mr.

Heliotropaceae

Heliotropium curassavicum L. var. *obovatum* DC. **[-,1]** C; 8500′; **S;** ml.

Hydrangeaceae

Fendlera rupicola A. Gray var. *falcata* (Thornber) Rehder **[-,1]** T; 5781′; **G;** fr, ra.

Fendlera rupicola A. Gray var. *rupicola* **[-,1]** T; 7250–8000′; **S;** pj.

Fendlera rupicola A. Gray var. *wrightii* A. Gray **[-,2]** R, T; 6200–6700′; **S;** pj.

Jamesia americana Torr. & A. Gray var. *americana* **[36,12]** A, C, M, S, T; 7350–11650′; **P, S;** af, mc, mm, mr, ms, sf.

Philadelphus microphyllus A. Gray var. *microphyllus* **[-,1]** T; 8300–9300′; **S;** mr.

Hydrocharitaceae

Elodea canadensis Michx. **[1,1]** A, T; 7800–8175′; **S;** ml, mr.

Hydrophyllaceae

Hydrophyllum fendleri (A. Gray) A. Heller var. *fendleri* **[21,11]** A, M, R, S, T; 7620–12850′; **S;** af, bw, mc, mm, mr, sf.

Nama dichotomum (Ruiz & Pavon) Choisy **[-,1]** R; 8200′; **S;** pp.

Phacelia alba Rydb. **[1,1]** A, T; 7900–9750′; **S;** mc.

Phacelia bakeri (Brand) J.F. Macbr. **[-,2]** T; 11120–12960′; **S;** am, mr.

Phacelia heterophylla Pursh var. *heterophylla* **[25,14]** A, M, R, S, T; 7600–11650′; **S;** af, mc, mm, mr, ra, sf.

Phacelia integrifolia Torr. var. *integrifolia* **[1,3]** R, S, T; 6100–7950′; **G, S;** fr, pj, ra.

Phacelia sericea (Graham) A. Gray **[UNM**-H. Bobisud 126] T; **S.**

Hypericaceae

Hypericum scouleri Hook. **[2,1]** T; 7720–9675′; **S;** mr.

Iridaceae

Iris missouriensis Nutt. **[19,18]** A, C, M, R, S, T; 7050–11300′; **S;** af, mc, ml, mm, mr, ra, sf.

Sisyrinchium demissum Greene **[1,2]** C, R, T; 6500–7660′; **G, S;** ml.

Sisyrinchium montanum Greene var. *montanum* **[2,1]** A, T; 8400–11000′; **S;** mm, mr.

Juncaceae

Juncus arcticus Willd. var. *balticus* (Willd.) Trautv. **[10,32]** A, C, M, R, S, T; 5781–12000′; **G, P, S;** fr, mc, ml, mm, mr, ra, sf.

Juncus arcticus Willd. var. *mexicanus* (Willd. ex Roem. & Schult.) Balslev **[3,-]** S; 6840–8760′; **S;** mr.

Juncus bufonius L. **[-,1]** C; 8960–9040′; **S;** ra.

Juncus castaneus Sm. **[UNM**-J. McGrath 423] C; **S.**

Juncus confusus Cov. **[-,1]** T; 8100′; **S;** mr.

Juncus drummondii E. Mey. **[6,10]** A, M, R, S, T; 9800–12960′; **S;** am, mr, sf.

Juncus dudleyi Wiegand **[4,1]** A, M, T; 7700–10500′; **S;** mc, mm, mr.

Juncus ensifolius Wikstr. var. *montanus* (Engelm.) C.L. Hitchc. **[17,19]** A, C, M, R, S, T; 6840–12000′; **S;** mc, mm, mr, sf.

Juncus hallii Engelm. **[1,-]** M; 11940′; **S;** am.

Juncus interior Wiegand **[4,3]** A, C, M, T; 5750–8625′; **G, L, S;** fr, ml, ra.

Juncus longistylis Torr. **[2,8]** C, M, R, T; 6380–11209′; **G, S;** fr, ml, mm, mr, ra, sf.

Juncus mertensianus Bong. **[2,-]** M; 10800–12000′; **S;** ml, mm.

Juncus torreyi Coville **[UNM**-R. Sivinski et al. 2434] A; **S.**

Luzula parviflora (Ehrh.) Desv. **[17,28]** A, M, R, S, T; 7620–12960′; **S;** am, mc, ml, mr, sf.

Luzula spicata (L.) DC. **[3,13]** M, R, S, T; 9800–13024′; **S;** am, bw, mm, mr.

Juncaginaceae

Triglochin palustris L. **[UNM**-R. Worthington 32634] T; **S.**

Lamiaceae

Dracocephalum parviflorum Nutt. **[21,11]** A, C, M, R, S, T; 7200–9400′; **S;** af, br, mc, ml, mm, mr, ra.

Hedeoma drummondii Benth. **[1,4]** A, T; 6980–7550′; **P, S;** ds, fr, pj, pp, ra.

* *Marrubium vulgare* L. **[7,4]** A, C, M, S, T; 5800–7840′; **L, P, S;** ds, ml, pj, ra.

Mentha arvensis L. **[4,6]** A, C, M, T; 7240–9700′; **S;** mm, mr, ra.

Monarda fistulosa L. var. *menthifolia* (Graham) Fernald **[7,8]** A, S, T; 7400–11115′; **S;** mc, mm, mr, pp.

Monarda pectinata Nutt. **[2,-]** A; 7000–7500′; **S;** pj, pp.

* *Nepeta cataria* L. **[UNM**-R. Sivinski & B. Simpson 2391] S; **S.**

Prunella vulgaris L. var. *lanceolata* (W.P.C. Barton) Fernald **[21,15]** A, C, M, S, T; 7550–11209′; **S;** mc, ml, mm, mr, ra, sf.

Salvia reflexa Hornem. **[1,1]** M, T; 7350–7700′; **S;** fr, mr, ra.

Satureja vulgaris (L.) Fritsch **[5,1]** A, S, T; 7600–8900′; **S;** mc, mm, mr, ra.

Stachys pilosa Nutt. var. *pilosa* **[-,2]** C, T; 8500–9800′; **S;** mm, mr.

Teucrium laciniatum Torr. **[5,-]** A; 5650–6200′; **L;** pg, pj, ra.

Lemnaceae

Lemna minor L. **[1,1]** A, T; 7550–7880′; **S;** ml, mr.

Liliaceae (see also Alliaceae, Asparagaceae, Convallariaceae, Melanthiaceae)

Calochortus gunnisonii S. Watson var. *gunnisonii* **[-,5]** T; 8350–11000′; **P, S;** mc, mm, mr.

+♦ *Calochortus gunnisonii* S. Watson var. *perpulcher* Cockerell **[4,-]** A, M; 9840–10700′; **S;** mm, mr, sf.

Calochortus nuttallii Torr. & A. Gray **[-,1]** R; 6050–6350′; **G;** ds.

Lilium philadelphicum L. **[2,-] A**; 8325–8900′; **S;** mc, mr.

Lloydia serotina (L.) Rchb. var. *serotina* **[-,3]** T; 11200–12500′; **S;** am, mr.

Streptopus amplexifolius (L.) DC. **[9,14]** A, M, R, S, T; 7840–11960′; **S;** mc, mm, mr, sf.

Linaceae

Linum australe A. Heller var. *australe* **[3,3]** A, S, T; 7000–9400′; **S;** mr, pj, ra.

Linum lewisii Pursh var. *lewisii* **[9,7]** A, C, M, T; 5730–10660′; **L, S;** fr, mc, mm, mr, pg, pj, ra.

Linum pratense (Norton) Small **[2,-]** A; 5650–5800′; **L;** pg, pj.

Linum puberulum (Engelm.) A. Heller **[3,-]** A; 5650–6750′; **L, S;** pg, pj.

Loasaceae

Mentzelia laciniata (Rydb.) J. Darl. **[1,1]** A, T; 5650–7100′; **L, S;** pg, mr, ra.

Mentzelia multiflora (Nutt.) A. Gray var. *multiflora* **[9,5]** A, R, S, T; 5500–8300′; **G, L, P, S;** ds, fr, pj, ra.

Mentzelia nuda (Pursh) Torr. & A. Gray var. *stricta* (Osterh.) Harrington **[-,2]** M; 9160–9320′; **S;** ra.

Mentzelia rusbyi Wooton **[1,-]** M; 7700′; **S;** ms, mr.

Malvaceae

♦ *Iliamna grandiflora* (Rydb.) Wiggins **[-,3]** T; 7550–10100′; **S;** br.

* *Malva neglecta* Wallr. **[4,1]** A, M, T; 7200–9360′; **S;** mr, ra.

* *Malva parviflora* L. **[UNM**-W. Adair *s.n.*, 21 Sep 1907] T; **G.**

Sidalcea candida A. Gray var. *candida* **[26,17]** A, C, M, S, T; 7400–10800′; **S;** mm, mr.

Sidalcea neomexicana A. Gray var. *neomexicana* **[-,2]** T; 7050–9400′; **S;** ml, mr.

Sphaeralcea angustifolia (Cav.) G. Don **[2,-]** A; 5650–7440′; **L, S;** ra.

Sphaeralcea coccinea (Nutt.) Rydb. var. *coccinea* **[11,7]** A, S, T; 5600–8100′; **G, L, S;** br, ds, fr, pg, pj, ra.

Sphaeralcea fendleri A. Gray var. *fendleri* **[3,3]** A, C, M, S, T; 7000–7800′; **S;** mr, pj, ra.

Sphaeralcea incana Torr. ex A. Gray var. *cuneata* Kearney **[5,-]** A, S; 5610–7900′; **L, S;** fr, mr, ra.
Sphaeralcea incana Torr. ex A. Gray var. *incana* **[1,-]** S; 6840–6880′; **S;** fr, ra.

Melanthiaceae [traditionally in Liliaceae]
Veratrum californicum T. Durand var. *californicum* **[9,15]** A, C, M, R, S, T; 8300–12100′; **S;** mc, mm, mr, sf.
Zigadenus elegans Pursh **[27,29]** A, C, M, S, T; 7050–13161′; **S;** af, am, bw, mc, mm, mr, sf.
[*Anticlea elegans* (Pursh) Rydb.]

Myrsinaceae
Lysimachia ciliata L. **[UNM**-J. McGrath 730] A; **S.**

Nyctaginaceae
Mirabilis albida (Walter) Heimerl **[-,3]** M, T; 8300–10300′; **S;** mc, ra.
Mirabilis linearis (Pursh) Heimerl var. *decipiens* (Standl.) S.L. Welsh **[1,6]** R, S, T; 7350–8320′; **S;** br, mr, pj, ra.
Mirabilis linearis (Pursh) Heimerl var. *linearis* **[9,2] A**, R, S, T; 5600–8575′; **G, L, P, S;** ds, fr, mr, pj, pp, ra.
Mirabilis melanotricha (Standl.) Spellenb. **[14,-]** A, M, S; 7600–9760′; **S;** af, mc, mm, mr, ra.
Mirabilis multiflora (Torr.) A. Gray var. *multiflora* **[2,1]** A, T; 5650–8000′; **L, S;** fr, pg, pj.
Mirabilis oxybaphoides (A. Gray) A. Gray **[UNM**-E. Castetter 4034] T; **G.**

Oleaceae
Forestiera pubescens Nutt. **[-,3]** R, T; 5781–6540′; **G, P;** ds, fr, ra.
Menodora scabra A. Gray **[4,3]** A, R, S, T; 5570–7950′; **L, S;** fr, pg, pj.
!* *Syringa vulgaris* L. **[2,-]** M, S; 7320–7700′; **S;** mr.

Onagraceae
Chamerion angustifolium (L.) Holub var. *canescens* (A.W. Wood) N. Holmgren & P. Holmgren **[19,21]** A, C, M, R, S, T; 7750–13024′; **S;** af, am, br, mc, mm, mr, sf.
[*Chamerion angustifolium* ssp. *circumvagum* (Mosquin) Hoch]
Epilobium anagallidifolium Lam. **[2,7]** A, S, T; 9400–11900′; **S;** mc, mm, mr.
[*Epilobium alpinum* L.]
Epilobium ciliatum Raf. var. *ciliatum* **[20,11]** A, C, M, S, T; 6840–11209′; **S;** ml, mm, mr, ra, sf.
Epilobium ciliatum Raf. var. *glandulosum* (Lehm.) Dorn **[1,5]** C, S, T; 7800–11500′; **S;** mc, mr.
Epilobium halleanum Haussk. **[7,7]** A, M, R, S, T; 7840–11940′; **S;** ml, mr, sf.
Epilobium hornemannii Rchb. var. *hornemannii* **[2,6]** M, T; 8790–12000′; **S;** ml, mr, sf.
Epilobium lactiflorum Haussk. **[1,-]** S; 8900′; **S;** mc, mr.
Epilobium saximontanum Haussk. **[4,7]** A, M, S, T; 8350–10986′; **S;** af, mc, mm, mr, sf.
Gayophytum diffusum Torr. & A. Gray var. *strictipes* (Hook.) Dorn **[-,2]** C, T; 9090–10600′; **P, S;** mc, mm.
Gayophytum ramosissimum Torr. & A. Gray **[-,1]** T; 9200–9750′; **S;** mc.
Oenothera albicaulis Pursh **[4,1]** A, S, T; 5570–7460′; **L, P, S;** ds, fr, pg, pj.
* *Oenothera biennis* L. **[5,2]** A, C, T; 8000–8900′; **S;** mr, ra.
Oenothera cespitosa Nutt. var. *macroglottis* (Rydb.) Cronquist **[-,13]** M, R, T; 6036–9320′; **G, P S;** ds, fr, mr, pj, ra.
Oenothera cespitosa Nutt. var. *marginata* (Nutt. ex Hook. & Arn.) Munz **[2,1]** R, S, T; 6540–8550′; **G, S;** fr, pj.
Oenothera coronopifolia Torr. & A. Gray **[5,7]** A, C, S, T; 7200–9750′; **P, S;** ds, fr, ml, mm, mr, pj, pp, ra.
Oenothera curtifolia W.L. Wagner & Hoch **[-,1]** T; 7240′; **S;** ra.
Oenothera elata Kunth var. *hirsutissima* (A. Gray ex S. Watson) Cronquist **[11,2]** A, S, T; 7000–8840′; **S;** pp, mc, mr, ra.
Oenothera flava (A. Nelson) Garrett **[-,1]** T; 9950–11000′; **S;** mr.
Oenothera hartwegii (Benth.) ssp. *fendleri* (A. Gray) W.L. Wagner & Hoch. **[5,-]** A; 5800–7500′; **L, S;** pg, pj, ra.
Oenothera laciniata Hill **[3,-]** A; 5700–8840′; **L, S;** fr, mr, ra
Oenothera pallida Lindl. var. *latifolia* Rydb. **[-,1]** T; 7350–7450′; S; fr, ra
Oenothera pallida Lindl. var. *runcinata* (Engelm.) Cronquist **[1,-]** A; 5840′; **L;** pg, pj.
Oenothera serrulata Nutt. **[1,-]** A; 6200′; **L;** pg, pj.
Oenothera suffrutescens (Seringe) W.L. Wagner & Hoch **[17,6]** A, R, S, T; 5650–7660′; **G, L, S;** fr, pg, pj, ml, ra.
Oenothera villosa Thunb. var. *strigosa* (Rydb.) Dorn **[5,-] A**, S; 7200–8400′; **S;** mr, pp, ra

Orchidaceae
Calypso bulbosa (L.) Oakes var. *americana* (R. Br.) Luer **[-,4]** C, T; 8555–10600′; **S;** mc.
Coeloglossum viride (L.) Hartm. var. *virescens* (Muhl. ex Willd.) Luer **[1,-]** S; 9860–10320′; **S;** ml, mr.
Corallorhiza maculata (Raf.) Raf. var. *maculata* **[-,8]** M, T; 7850–10700′; **S;** mc, sf.
Corallorhiza maculata (Raf.) Raf. var. *occidentalis* (Lindl.) Ames **[12,9]** A, M, S, T; 7900–10500′; **S;** af, mc, mm, mr, sf.
Corallorhiza striata Lindl. var. *striata* **[2,-]** A, S; 7640–9190′; **S;** mr.
Corallorhiza striata Lindl. var. *vreelandii* (Rydb.) L.O. Williams **[-,2]** T; 7620–8900′; **S;** mr.
Corallorhiza trifida Chatelain **[UNM**-R. Jackson 2203] T; **S.**
Corallorhiza wisteriana Conrad **[-,3]** R, T; 8000–8800′; **S;** mc, mr, pp.
♦ *Cypripedium parviflorum* Salisb. var. *pubescens* (Willd.) O.W. Knight **[1,-] A**; 8630–9190′; **S;** mr.
* *Epipactis helleborine* L. **[1,-]** S; 7400–7760′; **S;** mr.
Goodyera oblongifolia Raf. **[11,17]** A, C, M, R, S, T; 7800–11500′; **S;** af, mc, mr, pp, sf.
Goodyera repens (L.) R. Br. ex W.T. Aiton **[2,2]** A, C, S, T; 8450–9600′; **S;** mc, sf.
Listera cordata (L.) R. Br. var. *nephrophylla* (Rydb.) Hultén **[2,7]** M, R, S, T; 9150–11940′; **S;** mr, sf.
Malaxis soulei L.O. Williams **[1,-]** A; 8400–8850′; **S;** mc.
Platanthera aquilonis Sheviak **[-,3]** T; 9250–11000′; **S;** mc, mr, sf.
Platanthera huronensis (Nutt.) Lindl. **[1,13]** C, M, S, T; 8300–12000′; **S;** mc, mr, sf.
Platanthera purpurascens (Rydb.) Sheviak & W.F. Jenn. **[15,10]** A, M, S, T; 7620–12500′; **S;** mc, ml, mr, sf.
Platanthera sparsiflora (S. Watson) Schltr. **[2,-]** A; 8325–10180′; **S;** mc, mr.
Spiranthes romanzoffiana Cham. **[UNM**-H. Mackay 6T-171] T; **S.**

Orobanchaceae (previously Scrophulariaceae)
Castilleja haydenii (A. Gray) Cockerell **[1,9]** M, T; 11500–12850′; **S;** am.
Castilleja integra A. Gray **[19,23]** A, C, R, S, T; 5630–10200′; **G, L, P, S;** br, ds, fr, mc, ml, mm, mr, pg, pj, pp, ra.
Castilleja linariifolia Benth. **[8,3]** A, M, S, T; 7100–9160′; **P, S;** mc, mr, ms, ra.
Castilleja lineata Greene **[-,3]** T; 7350–10500′; **S;** mm, mr, ra.
Castilleja miniata Douglas ex Hook. var. *miniata* **[24,45]** A, C, M, R, S, T; 7850–12430′; **S;** af, bw, mc, mm, mr, pp, sf.
Castilleja exilis A. Nelson **[1,-]** R; 6500–6620′; **G;** ml.
[*Castilleja minor* (A. Gray) A. Gray var. *exilis* (A. Nelson) J.M. Egger]
Castilleja occidentalis Torr. **[2,14]** M, R, S, T; 9800–13024′; **S;** am, bw, mm, mr, sf.
Castilleja rhexifolia Rydb. **[UNM**-M. Olsen 204] S; **S.**
Castilleja sulphurea Rydb. **[10,9]** A, M, T; 8325–12000′; **S;** mc, ml, mm, mr.
Conopholis alpina Liebm. var. *mexicana* (A. Gray ex S. Watson) Haynes **[5,-]** A, M, S; 5700–9350′; **L, S;** fr, mr, pj, pp.
Cordylanthus wrightii A. Gray ssp. *wrightii* **[-,1]** R; 7600–7750′; **S;** ra.

Orobanche fasciculata Nutt. **[1,5]** C, M, T; 6600–9000′; **P, S;** ds, fr, mc, pj, pp, ra.

Orobanche ludoviciana Nutt. var. *multiflora* (Nutt.) Beck **[2,1]** A, T; 5610–7450′; **L, S;** fr, pj, ra.

Orthocarpus luteus Nutt. **[3,10]** A, C, M, R, T; 8350–11000′; **P, S;** af, mc, mm, mr, ms, pp.

Orthocarpus purpureoalbus A. Gray ex S. Watson **[-,1]** T; 7200–7500′; **S;** pj.

Pedicularis bracteosa Benth. var. *paysoniana* (Pennell) Cronquist **[-,1]** T; 10150–11900′; **S;** mr.

Pedicularis canadensis L. var. *fluviatilis* (A. Heller) Macbr. **[7,11]** A, C, M, S, T; 7620–10200′; **S;** af, mc, mm, mr.

Pedicularis centranthera A. Gray **[-,14]** R, T; 6232–8900′; **G, S;** fr, pj, pp.

Pedicularis groenlandica Retz. **[9,16]** A, M, S, T; 9300–12960′; **S;** am, ml, mm, mr, sf.

Pedicularis parryi A. Gray **[6,7]** A, M, S, T; 11310–12850′; **S;** am, mm, mr, sf.

Pedicularis procera A. Gray **[22,14]** A, M, S, T; 7840–12115′; **S;** af, mc, mm, mr, ra, sf.

Pedicularis racemosa Douglas ex Benth. var. *alba* (Pennell) Cronquist **[10,20]** A, M, R, S, T; 9300–12000′; **S;** am, bw, mc, mr, sf.

Pedicularis racemosa Douglas ex Benth. var. *racemosa* **[-,1]** T; 10150–11900′; **S;** mr.

Oxalidaceae

Oxalis corniculata L. var. *wrightii* (A. Gray) B.L. Turner **[4,-]** A, S; 7000–8300′; **S;** mr, ra.

Oxalis metcalfei Knuth **[6,2]** A, C, M, T; 7840–10500′; **S;** mm, mr.

Papaveraceae

Argemone hispida A. Gray **[-,2]** T; 7400–8100′; **S;** br, pj.

Parnassiaceae (previously Saxifragaceae)

♦ *Parnassia fimbriata* König **[-,4]** T; 8450–11500′; **S;** mr.

Parnassia palustris L. var. *montanensis* (Fernald & Rydb. ex Rydb.) C.L. Hitchc. **[UNM**-J. McGrath 420] C; **S.**

Plantaginaceae (includes Callitrichaceae, Scrophulariaceae, in part)

Callitriche heterophylla Pursh var. *heterophylla* **[UNM**-R. Sivinski 5611] C; **S.**

Callitriche palustris L. **[UNM**-J. McGrath 936] R; **S.**

*● *Linaria dalmatica* (L.) Mill. var. *dalmatica* **[1,-]** S; 7380–7420′; **S;** pj, ra.

*●+ *Linaria vulgaris* Mill. **[-,3]** T; 7050–10900′; **S;** mm, mr.

Mimulus glabratus Kunth var. *jamesii* (Torr. & A. Gray ex Benth.) A. Gray **[-,2]** T; 8350–9400′; **S;** mc, mr.

Mimulus guttatus DC. **[22,24]** A, M, S, T; 7850–11800′; **S;** ml, mr, sf.

Mimulus rubellus A. Gray **[-,1]** T; 7600–8450′; **S;** fr, pp.

Mimulus tilingii Regel **[4,-]** A, M, S; 8200–12000′; **S;** am, ml, mr.

Penstemon barbatus (Cav.) Roth var. *torreyi* (Benth.) A. Gray **[33,25]** A, C, M, R, S, T; 5500–10500′; **G, L, P, S;** af, br, fr, mc, mm, mr, ms, pj, pp, ra.

* *Penstemon cobaea* Nutt. **[UNM**-C.R.. Hutchins 11490] T; **G.**

Penstemon crandallii A. Nelson var. *glabrescens* (Pennell) G.T. Nisbet & R.C. Jacks. **[-,17]** R, T; 7350–9400′; **G, S;** br, fr, mc, pj, pp, ra.

\+ *Penstemon crandallii* A. Nelson var. *taosensis* (Keck) G.T. Nisbet & R.C. Jacks. **[-,3]** T; 7440–8900′; **P, S;** pj, pp.

Penstemon fendleri Torr. & A. Gray **[1,-]** A; 6200′; **L;** pg, pj.

! *Penstemon glaber* Pursh var. *alpinus* (Torr.) A. Gray **[-,1]** T; 10000–12200′; **S;** bw, mm.

Penstemon griffinii A. Nelson **[2,-]** S; 7300–8000′; **S;** pj.

\+ *Penstemon inflatus* Crosswhite **[1,6]** S, T; 7550–10500′; **S;** br, mc, mr, pj, pp.

Penstemon jamesii Benth. **[10,-]** A, S; 5600–7460′; **L, S;** pg, pj, ra.

Penstemon linarioides A. Gray ssp. *coloradoensis* (A. Nelson) D.D. Keck **[1,-]** S; 8300′; **S;** mr.

Penstemon palmeri A. Gray **[UNM**-J. McGrath 602] T; **G.**

Penstemon rydbergii A. Nelson var. *rydbergii* **[-,2]** T; 9850–10000′; **S;** mm.

Penstemon secundiflorus Benth. **[3,6]** A, R, S, T; 6380–9400′; **G, P, S;** fr, mc, mr, pj.

Penstemon strictus Benth. **[-,7]** T; 8350–10000′; **S;** mc, mm, mr.

Penstemon unilateralis Rydb. **[-,2]** C, T; 7350–7450′; **S;** br, fr, ra [*Penstemon virgatus* ssp. *asa-grayi* Crosswhite]

Penstemon virgatus A. Gray **[3,3]** A, R, S, T; 6540–8175′; **G, S;** fr, pj, pp, ra.

Penstemon whippleanus A. Gray **[9,24]** A, M, R, S, T; 8650–13024′; **S;** am, bw, mc, mm, mr, sf.

Plantago argyraea Morris **[-,1]** R; 8200′; **S;** pp.

* *Plantago lanceolata* L. **[8,5]** A, C, M, R, S, T; 5500–9100′; **L, P, S;** fr, mm, mr, ra.

* *Plantago major* L. **[22,10]** A, C, M, R, S, T; 5500–10700′; **L, S;** af, fr, mc, ml, mm, mr, ra.

Plantago patagonica Jacq. **[6,4]** A, R, S, T; 5700–8175′; **G, L, P, S;** ds, fr, ml, pg, pj, ra.

Plantago tweedyi A. Gray **[2,-]** M, S; 11600–11850′; **S;** am.

♦ *Synthyris alpina* A. Gray **[-,6]** T; 11500–13161′; **S;** am.

Synthyris plantaginea (E. James) Benth. **[8,10]** A, C, M, S, T; 7000–13009′; **S;** am, br, mc, mm, mr, pp.

Veronica americana Schwein. ex Benth. **[9,7]** A, S, T; 7850–11209′; **S;** ml, mr, sf.

* *Veronica anagallis-aquatica* L. **[2,2]** S, T; 5781–7050′; **G, S;** fr, ml, mr.

Veronica peregrina L. var. *xalapensis* (Kunth.) St. John & F.W. Warren **[5,2]** A, S, T; 5781–10440′; **G, S;** fr, mr, ra.

* *Veronica serpyllifolia* L. var. *humifusa* (Dickson) Vahl **[7,8]** A, M, S, T; 7775–12000′; **S;** af, mc, mr, sf.

Veronica wormskjoldii Roem. & Schult. **[3,16]** A, M, S, T; 9150–12960′; **S;** am, mm, mr, sf.

Poaceae

Achnatherum hymenoides (Roem. & Schult.) Barkworth **[5,26]** A, R, S, T; 5781–8900′; **G, L, P, S;** br, ds, fr, pg, pj, pp, ra.

Achnatherum lettermanii (Vasey) Barkworth **[-,11]** R, T; 7600–10887′; **S;** mc, mm, mr, ra, sf.

Achnatherum lobatum (Swallen) Barkworth **[-,1]** T; 7600–8300′; **S;** pj.

! *Achnatherum nelsonii* (Scribn.) Barkworth var. *nelsonii* **[-,5]** A, T; 7550–10150′; **S;** br, mc, mm, mr.

Achnatherum perplexum Hoge & Barkworth **[1,-]** A; 7720; **S;** sf.

Achnatherum robustum (Vasey) Barkworth **[15,11]** A, C, M, S, T; 7000–10300′; **P, S;** fr, mc, ml, mm, mr, pj, pp, ra.

Achnatherum scribneri (Vasey) Barkworth **[2,1]** A, T; 7400–8000′; **P, S;** ds, mc, ra.

*● *Aegilops cylindrica* Host **[3,3]** A, S, T; 5781–7230′; **G, L, P, S;** fr, pj, ra.

* *Agropyron cristatum* (L.) Gaertn. var. *cristatum* **[1,8]** A, R, T; 5781–9400′; **G, S;** br, ds, fr, ml, mr, pj, ra. [*Agropyron cristatum*]

* *Agropyron cristatum* (L.) Gaertn. var. *desertorum* (Fisch. ex Link) Dorn **[3,6]** A, R, S, T; 6540–8760′; **G, P, S;** ds, fr, ms, pj, ra. [*Agropyron cristatum*]

Agrostis exarata Trin. var. *minor* Hook. **[9,2]** A, M, S, T; 7000–11000′; **S;** mm, mr, sf.

* *Agrostis gigantea* Roth **[19,7]** A, C, M, S, T; 6840–10300′; **S;** af, mc, ml, mm, mr, ra.

Agrostis idahoensis Nash **[UNM**-H. Mackay 6T-136] T; **S.**

Agrostis scabra Willd. **[28,37]** A, C, M, R, S, T; 7000–13024′; **S;** br, bw, mc, mm, mr, ms, pp, sf.

* *Agrostis stolonifera* L. **[5,5]** A, C, M, R, S, T; 6500–10700′; **G, S;** mc, ml, mm, mr, ra.

Agrostis variabilis Rydb. **[1,-]** A; 11240–11340′; **S;** mm, ra.

Alopecurus aequalis Sobol. var. *aequalis* **[2,2]** A, T; 7050–11209′; **S;** ml, mr, sf.

* *Alopecurus pratensis* L. **[-,1]** T; 7050′; **S;** mr.

Andropogon gerardii Vitman ssp. *hallii* (Hack.) Wipff **[1,-]** A; 7000′; **S;** ms, pp.

Aristida adscensionis L. **[1,-]** A; 5630′; **L;** fr.

Aristida divaricata Humb. & Bonpl. ex Willd. **[UNM**-K. Weissenborn 14] A; **S.**

Aristida havardii Vasey **[1,-]** A; 5760′; **L;** pg.

Aristida purpurea Nutt. var. *fendleriana* (Steud.) Vasey **[2,10]** A, R, T; 6120–8350′; **P, S;** ds, fr, mr, pj, pp.

Aristida purpurea Nutt. var. *longiseta* (Steud.) Vasey **[11,12]** A, R, S, T; 5650–7598′; **G, L, P, S;** ds, fr, pg, pj, ra.

Aristida purpurea Nutt. var. *nealleyi* (Vasey) Allred **[2,-]** A; 5600–5800′; **L;** pj.

Aristida purpurea Nutt. var. *wrightii* (Nash) Allred **[1,-]** A; 5800′; **L;** pj, ra.

* *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl **[UNM**-H. Mackay 5T-119**] T;** S.

* *Avena fatua* L. **[1,-]** A; 5800′; **L;** fr, ra.

* *Avena sativa* L. **[1,-]** A; 5800′; **L;** fr, ra.

Beckmannia syzigachne (Steud.) Fernald ssp. *baicalensis* (N.I. Kusnezow) T. Koyana & Kawano **[UNM**-N. & P. Holmgren 7245] T; **S.**

Blepharoneuron tricholepis (Torr.) Nash **[18,20]** A, C, M, R, S, T; 7750–12700′; **S;** af, am, br, mc, mm, ms, mr, pj, pp, sf.

* *Bothriochloa ischaemum* (L.) Keng var. *ischaemum* **[1,-]** A; 5500′; **L;** fr, pj.

Bothriochloa laguroides (DC.) Herter ssp. *torreyana* (Steud.) Allred & Gould **[4,-]** A; 5610–5760′; **L;** fr, pg, pj.

Bouteloua curtipendula (Michx.) Torr. var. *caespitosa* Gould & Kapadia **[3,2]** A, S, T; 5700–7550′; **L, P, S;** fr, pj, ra.

Bouteloua curtipendula (Michx.) Torr. var. *curtipendula* **[7,7]** A, R, S, T; 5500–8763′; **L, P, S;** br, ds, fr, ms, pg, pj, pp, ra.

Bouteloua dactyloides (Nutt.) J.T. Columbus **[-,1]** T; 7240′; **S;** ra.
[*Buchloë dactyloides* (Nutt.) Engelm.]

Bouteloua gracilis (Willd. ex Kunth) Lag.ex Griffiths **[13,18]** A, C, M, R, S, T; 5800–10115′; **L, P, S;** br, ds, fr, mc, mm, mr, ms, pg, pj, pp, ra.

Bouteloua hirsuta Lag. **[4,-]** A; 5700–7000′; **L, S;** pg, pj, pp.

Bouteloua simplex Lag. **[-,2]** T; 7200–8500′; **S;** mr, pj.

Bromus carinatus Hook. & Arn. **[10,3]** A, M, S, T; 6200–11500′; **L, S;** mc, mm, mr, ra.

* *Bromus catharticus* Vahl **[3,1]** A, T; 5500–8450′; **L, S;** fr, mr, ra.

Bromus ciliatus L. **[33,10]** A, M, R, S, T; 7380–12050′; **S;** af, br, mc, mm, mr, pp, sf.

* *Bromus inermis* Leyss. **[29,39]** A, C, M, R, S, T; 5800–11500′; **G, L, P, S;** af, br, fr, mc, ml, mm, mr, ms, pj, pp, ra, sf.

* *Bromus japonicus* Thunb. ex Murray **[11,9]** A, C, R, S, T; 5700–9750′; **G, L, P, S;** br, fr, mc, ml, mm, pj, pp, ra.

Bromus lanatipes (Shear) Rydb. **[2,8]** A, M, T; 5650–10700′; **L, P, S;** fr, mc, mm, mr, ms, pj, pp, ra.

Bromus porteri (J.M. Coult.) Nash **[5,14]** A, M, S, T; 8160–10700′; **S;** bw, mc, mm, mr.
[*Bromus anomalus* Rupr. ex E. Fourn.]

Bromus richardsonii Link **[-,26]** C, M, T; 7400–12960′; **S;** af, mc, mm, ms, mr, ra, sf.
[*Bromus ciliatus* L.]

* *Bromus tectorum* L. **[9,41]** A, C, M, R, S, T; 5800–9750′; **G, L, P, S;** br, ds, fr, mc, ml, mm, ms, mr, pj, pp, ra, sf.

Calamagrostis canadensis (Michx.) P. Beauv. var. *canadensis* **[10,18]** A, C, M, R, S, T; 7850–11940′; **S;** am, mc, mm, mr, sf.

Calamagrostis purpurascens R. Br. var. *purpurascens* **[-,6]** T; 11800–12850′; **S;** am, sf.

Calamagrostis stricta (Timm) Koeler ssp. *inexpansa* (A. Gray) C.W. Greene **[-,1]** T; 8700–9700′; **S;** mm.

Catabrosa aquatica (L.) P. Beauv. var. *aquatica* **[UNM**-J. McGrath 434] C; **S.**

Cenchrus longispinus (Hack.) Fernald **[2,-]** A; 5500–5610′; **L;** fr, ra.

Chloris verticillata Nutt. **[2,-]** A; 5500–5800′; **L;** fr, ra.

* *Chloris virgata* Sw. **[1,-]** A; 8900–9500′; **S;** mc.

Cinna latifolia (Trev. ex Goepp.) Griseb. **[4,2]** A, C, S, T; 7850–10500′; **S;** mr.

* *Dactylis glomerata* L. **[30,37]** A, C, M, R, S, T; 5800–10900′; **G, L, P, S;** fr, mc, ml, mm, mr, pj, pp, ra, sf.

Danthonia intermedia Vasey **[5,12]** A, M, R, T; 9270–12548′; **S;** am, mm, mr, sf.

Danthonia parryi Scribn. **[14,19]** A, C, M, R, S, T; 7650–12000′; **S;** am, br, bw, mc, mm, pp, ra.

Danthonia spicata (L.) P. Beauv. ex Roem. & Schult. **[9,3]** A, C, R, S, T; 7720–9600′; **S;** mc, mr, pp, ra.

Deschampsia cespitosa (L.) P. Beauv. var. *cespitosa* **[15,41]** A, M, R, S, T; 7050–13024′; **S;** am, bw, mc, ml, mm, mr, sf.

Dichanthelium oligosanthes (Schult.) Gould var. *scribnerianum* (Nash) Gould **[1,-]** A; 7720′; **S;** pp.

Distichlis spicata (L.) Greene var. *stricta* (Torr.) Scribn. **[-,2]** C, T; 5781–8500′; **G, S;** fr, ml, ra.

* *Echinochloa crus-galli* (L.) P. Beauv. **[2,-]** A; 5500–5610′; **L;** fr, ra.

* *Echinochloa muricata* (P. Beauv.) Fernald var. *microstachya* Wiegand **[1,-]** S; 7380–7420′; **S;** fr, ra.

Elymus bakeri (E.E. Nelson) Á. Löve **[4,5]** A, M, R, T; 10350–13024′; **S;** am, mm, mr, ra, sf.

Elymus canadensis L. var. *canadensis* **[5,3]** A, C, M, S, T; 5500–9320′; **L, S;** fr, mr, pj, pp, ra.

* *Elymus elongatus* (Host) Runem. var. *elongatus* **[1,-]** M; 8040–8700′; **S;** mc, ra.

Elymus elymoides (Raf.) Swezey var. *brevifolius* (J.G. Sm.) Dorn **[39,68]** A, C, M, R, S, T; 5730–10850′; **G, L, P, S;** br, ds, fr, mc, ml, mm, mr, pg, pj, pp, ra, sf.
[*Elymus longifolius* (Smith) Gould]

Elymus glaucus Buckley var. *glaucus* **[7,8]** A, C, M, S, T; 7840–10500′; **S;** af, mc, mm, mr.
[*Elymus hispidus* ssp. *barbulatus* (Schur) Melderis]

* *Elymus hispidus* (Opiz) Melderis var. *hispidus* **[7,7]** A, C, M, R, S, T; 7500–10580′; **S;** br, mc, mr, ra.

* *Elymus hispidus* (Opiz) Melderis var. *ruthenicus* (Griseb.) Dorn **[1,4]** M, R, T; 7240–8880′; **S;** mc, pp, ra.

* *Elymus junceus* Fisch. **[4,-] A**, S; 7000–7460′; **S;** pj, ra.
[*Psathyrostachys juncea* (Fisch.) Nevski]

× *Elymus* ×*pseudorepens* (Scribn. & J.G. Sm.) Barkworth & Dewey **[6,-]** A, M, S; 7900–12100′; **S;** mc, mm, ra.

* *Elymus repens* (L.) Gould **[2,-]** A; 7900–8000′; **S;** mc, mr, ra.

Elymus scribneri (Vasey) M.E. Jones **[3,9]** M, S, T; 10990–12900′; **S;** am.

Elymus smithii (Rydb.) Gould **[11,13]** A, C, M, R, S, T; 5570–9675′; **G, L, P, S;** br, ds, fr, mc, mm, mr, ms, pj, pp, ra

Elymus trachycaulus (Link) Gould ex Shinners ssp. *subsecundus* (Link) Á. Löve & D. Löve **[-,4]** M, T; 8000–10700′; **S;** af, mc, mm, ms.

Elymus trachycaulus (Link) Gould ex Shinners ssp. *trachycaulus* **[24,18]** A, C, M, S, T; 6500–11700′; **P, S;** fr, mc, mm, mr, pj, pp, ra.

Elymus trachycaulus (Link) Gould ex Shinners ssp. *violaceus* (Hornem.) Á. Löve & D. Löve **[5,15]** A, M, T; 8300–12850′; **S;** am, mc, mm, mr, ra, sf.

Eragrostis curtipedicellata Buckley **[1,-]** A; 5560–5840′; **L;** pj.

* *Eragrostis curvula* (Schrad.) Nees var. *curvula* **[4,-]** A; 5570–7840′; **L, S;** fr, pj, ra.

Eragrostis intermedia Hitchc. **[2,-]** A; 5700–5840′; **L;** fr, pj.

Erioneuron pilosum (Buckley) Nash **[2,-]** A; 6120–6750′; **S;** fr, pj.

Festuca arizonica Vasey **[5,10]** A, C, M, T; 7650–10700′; **S;** af, br, mc, mm, pp, ra.

* *Festuca arundinacea* Schreb. **[5,6]** A, C, M, R, S, T; 5781–9100′; **G, P, S;** fr, mm, mr, ra.

Festuca brachyphylla Schult. ex Schult. & Schult. f. ssp. *coloradensis* Fred. **[-,13]** C, T; 7850–12960′; **S;** am, mr, pp.

Festuca calligera (Piper) Rydb. **[-,1]** T; 10360–10440′; **S;** ra.

Festuca earlei Rydb. **[-,5]** R, T; 9800–12050′; **S;** mm, mr, sf.

Festuca idahoensis Elmer **[3,10]** A, T; 7215–11000′; **S;** bw, mm, mr, pj, pp, ra.

Festuca minutiflora Rydb. **[4,-]** A, M, S; 11240–12430′; **S;** am, mm.

* *Festuca pratensis* Huds. **[5,2]** A, S, T; 5800–9360′; **L, S;** fr, mr, ra.

Festuca rubra L. ssp. *rubra* **[-,3]** M, T; 9900–10800′; **S;** sf.

Festuca saximontana Rydb. var. *saximontana* **[1,11]** A, M, R, T; 8160–13024′; **S;** am, mc, mm, sf.

Festuca sororia Piper **[1,2]** A, T; 7850–12115′; **S;** mc, mr, sf.

Festuca thurberi Vasey **[9,22]** A, M, T; 8450–12960′; **S;** am, bw, mc, mm, mr, sf.

* *Festuca trachyphylla* (Hack.) Krajina **[-,2]** C, T; 7650–9700′; **S;** mc, mm.

Glyceria elata (Nash ex Rydb.) M.E. Jones **[-,1]** C; 8500–8750′; **S;** mr.

Glyceria grandis S. Watson **[1,2]** M, T; 8300–9300′; **S;** mr.

Glyceria striata (Lam.) Hitchc. **[18,16]** A, C, M, S, T; 7810–10500′; **S;** af, mc, ml, mr, sf.

Helictotrichon hookeri (Scribn.) Henrard **[-,1]** T; 9250–9500′; **S;** mm.

Hesperostipa comata (Trin. & Rupr.) Barkworth var. *comata* **[3,12]** R, S, T; 5781–9400′; **G, P, S;** br, ds, fr, mc, mm, mr, pj, pp, ra.

Hesperostipa comata (Trin & Rupr.) Barkworth var. *intermedia* (Scribn. & Tweedy) Dorn **[-,2]** T; 7850–9750′; **S;** mm, pp.

Hesperostipa neomexicana (Thurb. ex J.M. Coult.) Barkworth **[4,-]** A; 5700–6750′; **L, S;** fr, pg, pj.

Hierochloë odorata (L.) P. Beauv. **[-,1]** C; 8000–8104′; **S;** mm.

Hilaria jamesii (Torr.) Benth. **[12,7]** A, R, S, T; 5600–8000′; **G, L, P, S;** br, ds, fr, pg, pj.
[*Pleuraphis jamesii* Torr.]

Hopia obtusa (Kuntz) Zuloaga & Morrone **[2,-]** A; 5570–5840′; **L;** fr, pg.

Hordeum brachyantherum Nevski **[-,2]** T; 9250–10500′; **S;** mr.

Hordeum jubatum L. ssp. *intermedium* Bowden **[2,7]** A, C, R, T; 6380–10500′; **G, S;** fr, mc, ml, mr, pp, ra.

Hordeum jubatum L. ssp. *jubatum* **[2,7]** A, C, M, S, T; 5800–10500′; **L, S;** br, fr, mc, ml, mr, ra.

* *Hordeum murinum* L. ssp. *glaucum* (Steud.) Tzvelev **[1,2]** A, T; 5781–7200′; **G, L, S;** fr, ml, mr, ra.

Hordeum pusillum Nutt. **[1,-]** A; 6200′; **L;** pg, ra.

Koeleria macrantha (Ledeb.) Schult. **[35,57]** A, C, M, R, S, T; 5700–12960′; **G, L, P, S;** af, br, fr, mc, mm, mr, pj, pp, ra, sf.

* *Lolium perenne* L. var. *aristatum* Willd. **[3,1]** A, C, S; 7650–10800′; **S;** br, mr, ml, ra.

* *Lolium perenne* L. var. *perenne* **[2,2]** A, T; 8350–11340′; **S;** mc, mm, mr, ra.

Lycurus setosus (Nutt.) C. Reeder **[6,-]** A, S; 5700–7000′; **L, S;** ds, pg, pj, pp.

Melica porteri Scribn. var. *porteri* **[17,7]** A, C, M, S, T; 7760–12115′; **S;** mc, mr, sf.

Muhlenbergia arenicola Buckley **[2,-]** A; 5650–5840′; **L;** pg, pj.

Muhlenbergia asperifolia (Nees & Meyen ex Trin.) Parodi **[2,-]** A, R; 5610–6620′; **G, L;** fr.

Muhlenbergia filiformis (Thurb. ex S. Watson) Rydb. **[UNM**-A. Fleck *s.n.*, 19 Sep 1964**] T;** S.

Muhlenbergia minutissima (Steud.) Swallen **[-,1]** T; 8160–9400′; **S;** ra.

Muhlenbergia montana (Nutt.) Hitchc. **[11,13]** A, C, M, R, S, T; 7560–11500′; **P, S;** af, bw, mc, mm, mr, ms, pj, pp, ra.

Muhlenbergia pauciflora Buckley **[2,-]** A, S; 5650–8320′; **L, S;** ds, pj.

Muhlenbergia racemosa (Michx.) Britton, Sterns, & Poggenb. **[1,-]** A; 7750′; **S;** mr, ra.

Muhlenbergia repens (J. Presl) Hitchc. **[UNM**-R. Sivinski 2627**]** A; **S.**

Muhlenbergia richardsonis (Trin.) Rydb. **[-,1]** T; 9200–9500′; **S;** mm.

Muhlenbergia torreyi (Kunth) Hitchc. ex Bush **[4,1]** A, T; 5700–7500′; **L, S;** ds, pg, pj.

Muhlenbergia wrightii Vasey ex J.M. Coult. **[6,4]** A, C, M, T; 7200–9360′; **P, S;** ds, fr, mr, ms, pj, ra.

Munroa squarrosa (Nutt.) Torr. **[1,4]** A, T; 5610–7550′; **L, P, S;** ds, fr, pj, ra.

Nassella viridula (Trin.) Barkworth **[-,2]** T; 6500–7450′; **P, S;** fr, ra.

Oryzopsis asperifolia Michx. **[4,13]** A, C, M, R, S, T; 7550–10200′; **S;** br, mc, mr, pp, sf.

Panicum bulbosum Kunth **[5,1]** A, C, M; 5650–8200′; **L, S;** pg, mr, ms, pp.

Panicum capillare L. var. *brevifolium* (Rydb.) Shear **[1,1]** S, T; 6840–7500′; **S;** fr, pj, ra.

Phalaris arundinacea L. var. *arundinacea* **[1,3]** A, T; 5781–8400′; **G, S;** fr, ml, mr, ra.

Phleum alpinum L. var. *alpinum* **[10,29]** A, M, R, S, T; 8450–13024′; **S;** am, bw, mc, mm, mr, sf.

* *Phleum pratense* L. var. *pratense* **[34,27]** A, C, M, S, T; 7000–11750′; **S;** af, mc, ml, mm, mr, pp, ra.

Phragmites australis (Cav.) Trin. ex Steud. ssp. *berlandieri* (E. Fourn.) Saltonstall & Hauber **[1,-]** A; 7900′; **S;** ml.

Piptatherum micranthum (Trin. & Rupr.) Barkworth **[7,20]** A, R, S, T; 5650–9500′; **G, L, P, S;** br, ds, fr, mc, pj, pp.

Piptochaetium pringlei (Beal) Parodi **[3,-]** A; 8000–8500′; **S;** mr, ms, pp.

Poa alpina L. **[1,2]** S, T; 9800–12625′; **S;** am, sf.

* *Poa annua* L. **[8,1]** A, M, S, T; 8600–11340′; **S;** mr, ra.

Poa arctica R. Br. var. *aperta* (Scribn. & Merr.) Soreng **[-,2]** R, T; 11120–13024′; **S;** am, mr.

Poa arctica R. Br. var. *grayana* (Vasey) Á. Löve, D. Löve, & B.M. Kapoor **[-,3]** T; 10500–12700′; **S;** am, sf.

Poa bigelovii Vasey & Scribn. **[1,-]** A; 6200′; **L;** pg.

* *Poa compressa* L. **[17,11]** A, C, M, R, S, T; 7240–10700′; **S;** af, mc, ml, mm, mr, ms, pp, ra.

Poa fendleriana (Steud.) Vasey **[2,51]** A, C, R, S, T; 6100–12850′; **G, P, S;** am, br, bw, ds, fr, mc, mm, mr, pj, pp, ra, sf.
[*Poa fendleriana* subspecies]

Poa glauca Vahl var. *glauca* **[-,3]** T; 10603–12050′; **S;** am, sf.

Poa glauca Vahl var. *rupicola* (Nash ex Rydb.) B. Boivin **[2,10]** S, T; 11120–12960′; **S;** am, mr.

Poa interior Rydb. **[-,13]** M, T; 8500–12850′; **S;** am, bw, mc, mm, mr, sf.

Poa leptocoma Trin. **[3,9]** M, R, T; 9400–11940′; **S;** mc, mr, sf.

Poa occidentalis Vasey **[3,1]** A, M, T; 9340–11300′; **S;** af, mc, mm, sf.

Poa palustris L. **[1,6]** A, C, T; 8000–9300′; **S;** mc, ml, mr.

* *Poa pratensis* L. **[32,65]** A, C, M, R, S, T; 5781–12200′; **G, P, S;** am, af, bw, br, fr, mc, ml, mm, ms, mr, pj, pp, ra, sf.
[*Poa pratensis* subspecies]

Poa reflexa Vasey & Scribn. ex Vasey **[-,3]** T; 9700–12000′; **S;** sf.

Poa secunda J. Presl **[-,2]** T; 8500–10000′; **S;** mc, mr.
[*Poa secunda* subspecies]

* *Polypogon monspeliensis* (L.) Desf. **[2,-]** A, R; 5500–6620′; **G, L;** fr, ml.

Puccinellia nuttalliana (Schult.) Hitchc. **[-,1]** T; 8175′; **S;** ml.

Schedonnardus paniculatus (Nutt.) Trel. **[3,-]** A, S; 5730–7240′; **L, S;** pg, pj, ra.

Schizachne purpurascens (Torr.) Swallen **[2,1]** A, T; 8700–9700′; **S;** mm, mr.

Schizachyrium scoparium (Michx.) Nash var. *scoparium* **[3,10]** A, C, R, T; 5650–8500′; **L, P, S;** br, fr, mc, ms, pj, pp, ra.

* *Secale cereale* L. **[1,1]** R, S; 6232–8540′; **G, S;** br, fr, pj.

Setaria leucopila (Scribn. & Merr.) K. Schum. **[1,-]** A; 5500′; **L;** fr.

* *Setaria viridis* (L.) P. Beauv. **[-,1]** M; 9160–9320′; **S;** ra.

Sorghastrum nutans (L.) Nash **[UNM**-D. Kennemore 2222] A; **L.**
* *Sorghum halepense* (L.) Pers. **[1,-]** A; 5500′; **L;** fr.
Sphenopholis obtusata (Michx.) Scribn. var *obtusata* **[1,-]** R; 6500–6620′; **G;** ml.
Sporobolus airoides (Torr.) Torr. **[-,2]** T; 7100–7240′; **S;** mr, ra
Sporobolus cryptandrus (Torr.) A. Gray **[5,7]** A, C, R, S, T; 5570–9400′; **L, S;** br, ds, fr, pj, pp, ra.
Torreyochloa pallida (Torr.) G.L. Church var. *pauciflora* (J. Presl) J.I. Davis **[1,-]** S; 8940′; **S;** mr.
Trisetum montanum Vasey **[21,13]** A, C, M, S, T; 7840–11800′; **S;** af, mc, mm, mr, sf.
Trisetum spicatum (L.) K. Richt. **[9,29]** A, M, R, S, T; 8450–13024′; **S;** am, mc, mm, mr, sf.
Vulpia octoflora (Walter) Rydb. **[2,6]** A, R, S, T; 6050–7598′; **G, L, P, S;** fr, pg, pj, ra.
[*Vulpia octoflora* varieties]

Polemoniaceae
Aliciella pinnatifida (Nutt. ex A. Gray) J.M. Porter **[1,-]** S; 8200–8320′; **S;** mr.
Collomia linearis Nutt. **[-,4]** T; 8700–11500′; **S;** mc, mm.
Eriastrum diffusum (A. Gray) H. Mason **[-,2]** R, T; 6036–7450′; **P;** ds, fr, pj.
Gilia ophthalmoides Brand **[-,4]** R, T; 7050–8450′; **G, S;** fr, pj, pp.
Gilia sinuata Douglas ex Benth. **[-,1]** T; 8400–8900′; **S;** mc.
Ipomopsis aggregata (Pursh) V.E. Grant ssp. *candida* (Rydb.) V.E. Grant & A.D. Grant **[-,4]** C, T; 8500–10300′; **S;** mm, ra.
Ipomopsis aggregata (Pursh) V.E. Grant ssp. *collina* (Greene) Wilken & Allard **[2,2]** M, T; 7700–11200′; **S;** mc, mm, sf.
Ipomopsis aggregata (Pursh) V.E. Grant ssp. *formosissima* (Greene) Wherry **[37,26]** A, C, M, R, S, T; 5800–11209′; **L, P, S;** af, br, fr, mc, mm, mr, ms, pj, pp, ra, sf.
Ipomopsis laxiflora (J.M. Coult.) V.E. Grant **[4,1]** A, R; 5610–6500′; **L, P;** ds, fr, pg, pj.
Ipomopsis longiflora (Torr.) V.E. Grant ssp. *neomexicana* Wilken **[1,-]** A; 5500′; **L;** pj.
Ipomopsis multiflora (Nutt.) V.E. Grant **[-,2]** R, T; 7350–9700′; **S;** pj, ra.
Linanthus pungens (Torr.) J.M. Porter & L.A. Johnson **[-,2]** T; 6900–7450′; **P, S;** ds, mc, pp.
Microsteris gracilis (Hook.) Greene **[-,3]** R, T; 7050–8100′; **G, S;** fr, pj.
Phlox condensata (A. Gray) E. Nelson **[3,-]** S; 12160–12500′; **S;** am.
Phlox longifolia Nutt. ssp. *longifolia* **[1,10]** R, S, T; 6976–8100′; **G, P, S;** br, fr, pj, ra.
Phlox nana Nutt. **[15,-]** A, S; 5700–8000′; **L, S;** pg, pj, pp, ra.
Phlox pulvinata (Wherry) Cronquist **[-,3]** T; 11500–13161′; **S;** am.
Polemonium brandegei (A. Gray) Greene **[UNM**-E. Castetter & H. Dittmer 9827] T; **S.**
Polemonium foliosissimum A. Gray **[10,3]** A, M, T; 8000–10800′; **S;** ml, mm, mr.
! *Polemonium occidentale* Greene var. *occidentale* **[-,1]** T; 9475′; **S;** mm, mr.
Polemonium pulcherrimum Hook. var. *delicatum* (Rydb.) Cronquist **[1,12]** A, T; 9800–11960′; **S;** bw, mc, mr, sf.
Polemonium viscosum Nutt. **[1,4]** S, T; 11500–13000′; **S;** am.

Polygalaceae
Polygala alba Nutt. var. *alba* **[2,-]** A; 5700–5800′; **L;** pg, pj.

Polygonaceae
Bistorta bistortoides (Pursh) Small **[7,16]** A, M, R, S, T; 9300–13024′; **S;** am, mm, mr, sf.
Bistorta vivipara (L.) S.F. Gray **[2,9]** A, M, T; 8300–13009′; **S;** am, ml, mr, sf.
Eriogonum alatum Torr. var. *alatum* **[12,6]** A, M, R, S, T; 5800–9640′; **G, L, P, S;** br, fr, mc, mm, ms, pj, pp, ra.
Eriogonum annuum Nutt. **[1,-]** A; 5570–5600′; **L;** fr.
Eriogonum jamesii Benth. var. *jamesii* **[16,25]** A, C, M, R, S, T; 5600–11200′; **L, P, S;** br, ds, fr, mm, mr, pj, pp, ra.
Eriogonum lachnogynum Torr. ex Benth. var. *lachnogynum* **[1,-]** A; 5730′; **L;** ds, pj.
Eriogonum microthecum Nutt. var. *simpsonii* (Benth.) Reveal **[-,3]** R, T; 7200–7500′; **S;** fr, pj, ra.
Eriogonum racemosum Nutt. **[3,13]** A, R, S, T; 7000–9400′; **P, S;** br, mc, mr, pj, pp, ra.
Eriogonum tenellum Torr. **[5,-]** A; 5570–6200′; **L;** fr, pg, pj.
* *Fallopia baldschuanica* (Regel) Holub **[UNM**- C.R. Hutchins 5887] R; **G.**
* *Fallopia convolvulus* L. **[UNM**-R. Sivinski 2427] A; **S.**
Oxyria digyna (L.) Hill **[-,3]** T; 11150–12700′; **S;** am, bw, sf.
* *Persicaria lapathifolia* (L.) A. Gray **[2,2]** A, C, T; 5500–8194′; **L, S;** fr, ml, ra.
* *Persicaria maculosa* A. Gray **[2,-]** S; 6840–7000′; **S;** fr, ra.
* *Polygonum aviculare* L. **[8,8]** A, M, R, S, T; 6540–10887′; **G, S;** ds, fr, ml, mm, mr, ra.
Polygonum douglasii Greene **[2,8]** A, M, R, T; 7200–12050′; **S;** af, mc, mm, mr, ra, sf.
Polygonum ramosissimum Michx. var. *ramosissimum* **[-,2]** T; 8700–9700′; **S;** mc.
Polygonum sawatchense Small **[-,3]** R, T; 7200–8550′; **P, S;** pj, pp, ra.
* *Rumex acetosella* L. **[21,10]** A, M, S, T; 7000–11700′; **S;** af, mc, mm, mr, ra.
Rumex altissimus A.W. Wood **[1,-]** A; 5700–5800′; **L;** fr, ra.
* *Rumex crispus* L. ssp. *crispus* **[23,5]** A, C, M, S, T; 6540–9680′; **G, S;** mc, ml, mr, ra.
Rumex densiflorus Osterh. **[-,3]** C, T; 8500–10986′; **S;** mc, mr.
Rumex fueginus Phil. **[-,1]** C; 8194′; **S;** ml.
[*Rumex maritimus* L.]
Rumex mexicanus Meisn. **[UNM**-E. Castetter 3879] T; **G.**
Rumex occidentalis S. Watson **[-,9]** M, R, T; 7240–11500′; **S;** ml, mr, ra.
* *Rumex patientia* L. **[3,-]** A, S; 5800–7580′; **L, S;** fr, mr, ra.
* *Rumex pulcher* L. **[-,1]** T; 7350–7450′; **S;** ra.
Rumex triangulivalvis (Danser) Rech. f. **[2,2]** A, T; 7200–10660′; **S;** ml, mr, ra.

Portulacaceae
Claytonia megarhiza (A. Gray) Parry ex S. Watson **[-,2]** T; 11500–13000′; **S;** am.
Lewisia nevadensis (A. Gray) B.L. Rob. **[UNM**-R. Sivinski 3921] S; **S.**
Montia chamissoi (Ledeb. ex Spreng.) Greene **[-,2]** T; 9150–10500′; **S;** mr.
Phemeranthus brevicaulis (S. Watson) Kiger **[UNM**-R. Sivinski 4556] A; **S.**
Phemeranthus parviflorus (Nutt) Kiger **[1,-]** A; 7900′; **S;** ml, ms.
* *Portulaca oleracea* L. **[2,2]** A, S, T; 5700–9400′; **L, S;** fr, ml, pj, pp, ra.
[*Portulaca oleracea* subspecies]

Potamogetonaceae (includes Zannichelliaceae)
Potamogeton diversifolius Raf. **[1,-]** A; 7200–7240′; **S;** ml.
Potamogeton foliosus Raf. var. *foliosus* **[UNM**-J. McGrath 444] C; **S.**
Potamogeton gramineus L. **[UNM**-J. McGrath 442] C; **S.**
Potamogeton natans L. **[-,1]** T; 9375–10625′; **S;** mr.
Potamogeton nodosus Poir. **[1,-]** A; 7200–7240′; **S;** ml.
Potamogeton pusillus L. var. *pusillus* **[UNM**-R. Sivinski & B. Simpson 2301] A; **S.**
Zannichellia palustris L. **[UNM**-J. McGrath 437] C; **S.**

Primulaceae
Androsace chamaejasme Wulfen. var. *arctica* Kunth **[-,6]** T; 10500–13000′; **S;** am, mm.
[*Androsace chamaejasme* Wulfen ssp. *lehmanniana* (Spreng.) Hultén]

Androsace occidentalis Pursh **[-,1]** R; 7150′; **S;** pj, ra.
Androsace septentrionalis L. **[18,62]** A, C, M, R, S, T; 6200–12960′; **G, P, S;** am, br, ds, mc, mm, ms, mr, pj, pp, sf.
Dodecatheon pulchellum (Raf.) Merr. var. *pulchellum* **[13,13]** A, M, R, S, T; 7740–11500′; **S;** mc, ml, mm, mr, sf.
[*Primula pauciflora* (Greene) Mast & Reveal]
Primula angustifolia Torr. **[-,4]** T; 11500–13009′; **S;** am.
Primula parryi A. Gray **[2,4]** M, S, T; 9800–12430′; **S;** am, mr, sf.
Primula rusbyi Greene [**UNM**-E. Castetter 3301-A] A; **S.**

Ranunculaceae

Aconitum columbianum Nutt. var. *columbianum* **[31,27]** A, C, M, S, T; 7400–12960′; **S;** mm, mr, sf.
Actaea rubra (Aiton) Willd. var. *arguta* (Nutt.) Lawson **[26,15]** A,C, M, R, S, T; 7775–11115′; **S;** af, mc, mm, mr.
[*Actaea rubra* ssp. *arguta* (Nutt.) Hultén]
Anemone canadensis L. **[-,3]** T; 8350–9400′; **S;** mc, mm, mr.
Anemone cylindrica A. Gray **[1,-]** A; 7720′; **S;** pp.
Anemone multifida Poir. **[-,4]** T; 9250–10500′; **S;** mc, mm, mr.
Aquilegia coerulea E. James var. *coerulea* **[12,18]** A, M, S, T; 7720–12960′; **S;** af, am, bw, mc, ml, mr, sf.
Aquilegia elegantula Greene **[8,20]** A, C, R, S, T; 7550–11500′; **S;** br, mc, mr, pp, sf.
Caltha leptosepala DC. **[9,15]** A, M, S, T; 9300–12960′; **S;** am, ml, mm, mr.
Clematis columbiana (Nutt.) Torr. & A. Gray var. *columbiana* **[24,23]** A, C, M, R, S, T; 7250–10600′; **P, S;** am, br, ds, mc, mr, pp.
Clematis hirsutissima Pursh var. *scottii* (Porter) E.O. Erickson **[-,1]** T; 7350–7500′; **P;** ds.
Clematis ligusticifolia Nutt. **[3,4]** A, S, T; 5570–8400′; **L, P, S;** fr, mr, ra.
♦ *Delphinium alpestre* Rydb. **[-,4]** T; 11120–12960′; **S;** am.
Delphinium barbeyi (Huth) Huth **[3,10]** M ,S, T; 8450–12000′; **S;** mc, mr, sf.
Delphinium nuttallianum Pritz var. *nuttallianum* **[-,3]** R, T; 7600–8900′; **S;** pj, pp.
Delphinium ramosum Rydb. **[-,4]** C, T; 7840–11500′; **S;** mc, mr, sf.
Delphiunium robustum Rydb. [**UNM**-M. Schiebout 8846] M; **S.**
+♦ *Delphinium sapellonis* Cockerell **[9,3]** A, M, T; 7840–10800′; **S;** af, mc, mm, mr, sf.
Delphinium wootonii Rydb. **[3,-]** A, S; 5700–7200′; **L, S;** pg, pj, ra.
Pulsatilla patens (L.) Mill. ssp. *multifida* (Pritz.) Zamels **[-,5]** C, T; 7350–10600′; **P, S;** ds, mm, pp.
Ranunculus abortivus L. [**UNM**-R. Fletcher 6252] T; **S.**
Ranunculus aquatilis L. var. *diffusus* With. **[-,5]** C, T; 8000–9500′; **S;** ml, mr, pp.
Ranunculus cardiophyllus Hook. [**UNM**-J. Williams 53] T; **S.**
Ranunculus cymbalaria Pursh **[-,2]** C, T; 8175–8194′; **S;** ml.
Ranunculus gmeliniii DC. [**UNM**-E. Castetter 4465] C; **S.**
Ranunculus inamoenus Greene var. *inamoenus* **[4,9]** A, R, S, T; 8400–11500′; **S;** bw, mc, mm, mr, sf.
Ranunculus macauleyi A. Gray **[2,8]** S, T; 10500–13000′; **S;** am, mr, sf.
Ranunculus macounii Britton **[6,-]** A, M, S; 7740–8940′; **S;** mc, mr.
Ranunculus pensylvanicus L. f. **[1,-]** S; 8250–8540′; **S;** mr, ra.
Ranunculus ranunculinus (Nutt.) Rydb. **[2,1]** A, C; 7900–8575′; **S;** mc, pp, ra.
!* *Ranunculus repens* L. **[1,-]** A; 8000′; **S;** mr, ra.
Ranunculus scleratus L. var. *multifidus* Nutt. [**UNM**-E. Castetter 4473] C; **S.**
* *Ranunculus testiculatus* Crantz **[-,1]** T; 7350–7450′; **P;** ds.
Ranunculus uncinatus D. Don ex G. Don **[-,3]** T; 7775–8150′; **S;** ml, mr.
[*Ranunculus uncinatus* var. *earlei* (Greene) L.D. Benson]
Thalictrum alpinum L. **[-,2]** T; 11500–13009′; **S;** am.
Thalictrum fendleri Engelm. ex A. Gray **[25,20]** A, C, M, R, S, T; 7400–12050′; **S;** br, bw, mc, mm, mr, ra.
Thalictrum revolutum DC. [**UNM**-J. McGrath 729] A; **S.**
Trautvetteria caroliniensis (Walter) Vail **[5,4]** A, M, R, S, T; 8450–11900′; **S;** ml, mr, sf.

Rhamnaceae

Ceanothus fendleri A. Gray **[13,6]** A, C, M, S, T; 7650–10500′; **S;** br, mc, ms, pp.

Rosaceae

Agrimonia gryposepala Wallr. **[2,-]** A; 7900–8230′; **S;** mc, mr.
Agrimonia striata Michx. **[11,2]** A, C, S, T; 7580–10500′; **S;** mr.
* *Alchemilla vulgaris* L. [**UNM**-R. Fletcher 8429] T; **S.**
Amelanchier alnifolia (Nutt.) Nutt. ex Roem. var. *alnifolia* **[12,7]** A, M, R, S, T; 7620–10500′; **S;** mc, mr, sf.
Amelanchier utahensis Koehne **[-,2]** T; 7250–9600′; S; br, pj.
Cercocarpus montanus Raf. var. *montanus* **[25,40]** A, C, M, R, S, T; 5650–11500′; **G, L, P, S;** br, ds, fr, mc, mm, mr, ms, pj, pp, ra.
Crataegus macracantha Lodd. ex Loud. var. *occidentalis* (Britton) Eggleston **[2,-]** A, S; 7760–8400′; **S;** mr, ms.
Dasiphora fruticosa (L.) Rydb. **[23,29]** A, C, M, R, S, T; 8310–13024′; **S;** af, am, fr, mc, ml, mm, ms, mr, ra, sf.
Fallugia paradoxa (D. Don) Endl. ex Torr. **[8,18]** A, R, S, T; 5570–8900′; **G, L, P, S;** br, ds, fr, mc, pj, pp, ra.
Fragaria vesca L. **[16,18]** A, C, M, R, S, T; 7350–11900′; **S;** am, br, mc, mr, pp, sf.
Fragaria virginiana Mill.**[7,33]** A, C, R, S, T; 8000–11650′; **S;** bw, br, mc, mm, mr, sf.
Geum aleppicum Jacq. **[13,4]** A, M, S, T; 7760–10800′; **S;** af, mc, mm, mr.
Geum macrophyllum Willd. var. *perincisum* (Rydb.) Raup **[13,13]** A, M, R, S, T; 7050–11209′; **S;** mc, mr, sf.
Geum rivale L. **[-,2]** T; 8450–10500′; **S;** mr.
Geum rossii (R. Br.) Ser. var. *turbinatum* (Rydb.) C.L. Hitchc. **[5,17]** A, M, R, T; 9800–13161′; **S;** am, mm, mr.
Geum triflorum Pursh var. *ciliatum* (Pursh) Fass. **[-,2]** T; 9850–10500′; **S;** mm, mr.
Holodiscus dumosus (Nutt. ex Hook.) A. Heller **[14,17]** A, C, M, R, S, T; 7560–11200′; **P, S;** af, mc, mr, ms, pp, ra, sf.
* *Malus pumila* Mill. **[6,2]** A, S, T; 6840–8450′; **S;** mr, ra.
Physocarpus monogynus (Torr.) J.M. Coult. **[21,3]** A, M, S, T; 7720–10200′; **S;** af, mc, mr, ra.
Potentilla ambigens Greene **[1,-]** S; 7600′; **S;** mr.
Potentilla anserina L. **[1,11]** A, C, M, R, T; 5500–11000′; **G, L, P, S;** fr, ml, mm, mr, ra.
Potentilla concinna Richardson var. *bicrenata* (Rydb.) S.L.Welsh & B.C. Johnst. **[-,1]** T; 7700–8555′; **P;** mc.
[*Potentilla bicrenata* Rydb.]
Potentilla concinna Richardson var. *concinna* **[2,8]** A, C, M, R, T; 8380–13000′; **S;** am, mc, mm, pp, sf.
Potentilla crinita A. Gray var. *crinita* **[2,-]** S; 7380–8550′; **S;** mr, ra.
Potentilla diversifolia Lehm. var. *diversifolia* **[1,13]** M, R, T; 7850–12960′; **S;** am, af, ml, mr, sf.
! *Potentilla fissa* Nutt. **[1,-]** A; 10000–10212′; **S;** mc.
Potentilla gracilis Douglas ex Hook. var. *glabrata* (Lehm.) C.L. Hitchc. **[1,1]** S, T; 9950–12430′; **S;** am, mr.
Potentilla gracilis Douglas ex Hook. var. *pulcherrima* (Lehm.) Fernald **[25,24]** A, C, M, R, S, T; 7840–12584′; **S;** af, am, bw, br, mc, mm, mr, ra, sf.
Potentilla hippiana Lehm. var. *hippiana* **[29,28]** A, C, M, R, S, T; 7000–11800′; **S;** af, am, br, mc, mm, mr, ms, pp, ra, sf.
× *Potentilla hippiana* Lehm. ×*P. gracilis* Douglas ex Hook. var. *pulcherrima* (Lehm.) Fernald **[1,1]** A, T; 8160–11300′; **S;** mr, sf.
Potentilla norvegica L. ssp. *monspeliensis* (L.) Asch. & Graebn. **[3,6]** A, C, T; 5781–10440′; **G, S;** fr, mc, ml, mr, ra.
[*Potentilla norvegica*]
Potentilla pensylvanica L. var. *pensylvanica* **[8,13]** A, C, M, T; 6900–10700′; **P, S;** br, ds, mc, mm, mr, ra.

Potentilla plattensis Nutt. [**UNM**-J. Williams 31] T; **S.**

* *Potentilla recta* L. [**UNM**-J. McGrath 728] A; **S.**

Potentilla subviscosa Greene **[-,1]** C; 8400–8500′; **S;** pp.

Potentilla thurberi A. Gray var. *atrorubens* (Rydb.) Kearney & Peebles **[4,-]** A; 7720–8575′; **S;** mr, pp, ra.

Potentilla thurberi A. Gray var. *thurberi* **[1,-]** S; 7760′; **S;** mr.

* *Prunus americana* Marshall **[-,2]** R, T; 6540–7300′; **G, S;** ds, fr, ra.

Prunus virginiana L. var. *melanocarpa* (A. Nelson) Sarg. **[29,14]** A, M, S, T; 5800–9675′; **L, P, S;** br, fr, mc, mm, mr, ra, sf.

Rosa acicularis Lindl. var. *sayana* Erlanson **[23,19]** A, C, M, S, T; 5800–11500′; **G, S;** af, br, mc, mr, pp, ra, sf.

Rosa arkansana Porter var. *arkansana* **[15,4]** A, M, S, T; 7000–10200′; **S;** af, mc, ml, mm, mr, ra.

Rosa nutkana C. Presl **[5,12]** A, M, R, S, T; 7775–12000′; **S;** mc, mr, pp, sf.

[*Rosa nutkana* ssp. *melina* (Greene) W.H. Lewis & Ertter]

Rosa woodsii Lindl. var. *ultramontana* (S. Watson) Jeps. **[4,9]** A, M, T; 5800–10000′; **L, S;** br, fr, mc, mm, mr.

Rubus idaeus L. var. *aculeatissimus* Regel & Tiling **[37,20]** A, C, M, R, S, T; 7600–11940′; **S;** af, am, mc, mr, ra, sf.

[*Rubus idaeus* var. *strigosus* (Michx.) Maxim.]

Rubus deliciosus Torr. var. *neomexicanus* (A. Gray) Kearney [**UNM**-M. Schiebout 3706] A; **S.**

Rubus parviflorus Nutt. var. *parviflorus* **[28,18]** A, C, M, S, T; 7600–10880′; **S;** af, mc, mr, sf.

* *Sanguisorba minor* (Scopoli) ssp. *muricata* (Spach) Nordborg [**UNM**-*C.R. Hutchins 9683*] A; **S.**

Sibbaldia procumbens L. **[4,11]** A, M, R, S, T; 9600–13024′; **S;** am, mm, mr.

Sorbus dumosa Greene **[1,-]** M; 9760–10600′; **S;** mr.

Sorbus scopulina Greene var. *scopulina* **[-,5]** R, T; 7900–11500′; **S;** mr.

Rubiaceae

* *Galium aparine* L. var. *echinospermum* (Wallr.) Farw. **[-,5]** T; 7600–10500′; **S;** mc, mr, ra.

[*Gallium aparine*]

Galium boreale L. **[23,37]** A, C, M, S, T; 7440–11150′; **S;** af, br, mc, ml, mm, mr, pj, ra, sf.

Galium fendleri A. Gray **[7,-]** A, S; 7900–8900′; **S;** mc.

Galium mexicanum Kunth var. *asperrimum* (A. Gray) Higgins & S.L. Welsh **[23,2]** A, C, M, S, T; 7600–10500′; **S;** af, mc, mm, mr, sf.

Galium trifidum L. var. *subbiflorum* Wiegand **[1,1]** S, T; 8410–11050′; **S;** mr, sf.

Galium triflorum Michx. **[13,6]** A, M, S, T; 7620–11115′; **S;** mc, mm, mr, sf.

Houstonia acerosa (A. Gray) A. Gray ex Benth. & Hook. var. *polypremoides* (A. Gray) Terrell **[1,-]** A; 5700–5800′; **L;** pg, pj.

Houstonia rubra Cav. **[3,-]** A; 5650–5840′; **L;** pg, pj.

Stenaria nigricans (Lam.) Terrell var. *nigricans* [**UNM**-C.R. Hutchins 9948] S; **S.**

[*Hedyotis nigricans* (Lam.) Fosberg var. *nigricans*]

Rutaceae

Ptelea trifoliata L. **[5,7]** S, T; 5800–8000′; **G, P, S;** ds, fr, mr, pj, ra.

[*Ptelea trifolata* infrataxa]

Salicaceae

× *Populus* ×*acuminata* Rydb. **[2,2]** R, S, T; 6380–7950′; **G, S;** fr, mr.

Populus angustifolia E. James **[13,26]** A, C, M, R, S, T; 6380–9400′; **G, P, S;** fr, mm, mr, ra.

Populus deltoides W. Bartram ex Marshall var. *wislizenii* (S. Watson) Dorn **[4,6]** A, R, S, T; 5610–7100′; **G, L, P, S;** fr, pj, ra.

Populus tremuloides Michx. **[41,44]** A, C, M, R, S, T; 7000–12300′; **S;** af, br, mc, mm, mr, pj, pp, sf.

Salix arctica Pall. var. *petraea* (Andersson) Bebb **[-,7]** R, T; 11990–13161′; **S;** am.

♦ *Salix arizonica* Dorn **[1,-]** M; 10500′; **S;** mr.

Salix bebbiana Sarg. **[14,7]** A, M, R, S, T; 7750–10500′; **S;** mc, mr, ra, sf.

Salix brachycarpa Nutt. var. *brachycarpa* **[1,6]** M, T; 9800–11960′; **S;** am, mr.

Salix drummondiana Barratt ex Hook. **[11,7]** A, M, R, S, T; 8000–10850′; **S;** mr, sf.

Salix eriocephala Michx. var. *ligulifolia* (C.R. Ball) Dorn **[8,4]** A, M, R, S, T; 6450–8990′; **G, S;** fr, mc, ms, mr, pp.

Salix exigua Nutt. var. *exigua* **[11,22]** A, C, M, R, S, T; 5781–9300′; **G, L, P, S;** fr, ml, mr, pj, pp, ra.

* *Salix fragilis* L. **[1,-]** A; 5500′; **L;** fr.

Salix glauca L. var. *villosa* (D. Don ex Hook.) Andersson **[-,1]** T; 11529–11793′; **S;** am.

Salix gooddingii C.R. Ball **[1,1]** A, R; 5800–6540′; **G, L;** ds, fr, ra.

Salix irrorata Andersson **[11,7]** A, C, M, R, S, T; 6540–9100′; **G, S;** fr, mr, ms, pj.

Salix lasiandra Benth. var. *caudata* (Nutt.) Sudw. **[-,2]** R, T; 6380–7600′; **G, S;** fr, mr.

[*Salix lucida* Muhl. ssp. *caudata* (Nutt.) Murray]

Salix lasiandra Benth. var. *lasiandra* **[5,1]** A, S, T; 7850–10500′; **S;** mc, mr.

[*Salix lucida* Muhl. ssp. *lasiandra* (Benth.) Murray]

Salix monticola Bebb **[5,3]** A, M, T; 7200–10180′; **S;** ml, mm, mr.

Salix planifolia Pursh var. *planifolia* **[4,3]** M ,S, T; 9200–12000′; **S;** am, mc, ml, mm, mr.

Salix reticulata L. var. *nana* Andersson **[2,2]** S, T; 11500–12430′; **S;** am.

[*Salix reticulata* ssp. *nivalis* (Hook.) Á. Löve, D. Löve, & B.M. Kapoor]

Salix scouleriana Barratt ex Hook. **[8,8]** A, M, S, T; 8000–10700′; **S;** br, mc, mr, sf.

Salix wolfii Bebb var. *wolfii* [**UNM**-D. Atwood 21490] A; **S.**

Santalaceae (Viscaceae)

Arceuthobium divaricatum Engelm. **[1,4]** R, S, T; 7000–8300′; **S;** pj.

Arceuthobium douglasii Engelm. **[1,4]** S, T; 7600–10093′; **P, S;** mc, pj.

Arceuthobium vaginatum (Willd.) J. Presl var. *cryptopodium* (Engelm.) Cronquist **[-,7]** C, R, T; 7600–8900′; **S;** br, pp.

Comandra umbellata (L.) Nutt. var. *pallida* (DC.) M.E. Jones **[-,7]** C, T; 7550–9675; **S;** mc, pj, pp, ra.

Phoradendron juniperinum Engelm. ex A. Gray var. *juniperinum* **[3,9]** R, S, T; 6500–9400′; **G, S;** pj, pp.

Saururaceae

Anemopsis californica Hook. & Arn. [**UNM**- R.C. Sivinski 2471] A; **S.**

Saxifragaceae

Boykinia jamesii (Torr.) Engler **[1,-]** A; 10100–10200′; **S;** mc.

[*Telesonix jamesii* (Torr.) Raf.]

Heuchera parvifolia Nutt. ex Torr. & A. Gray **[10,33]** A, M, R, S, T; 7050–13024′; **G, P, S;** am, br, ds, mc, mm, mr, pj, pp, sf.

\+ *Heuchera wootonii* Rydb. [**UNM**-E. Castetter & H. Dittmer 9825] T; **S.**

Mitella stauropetala Piper var. *stenopetala* (Piper) Rosend. **[-,1]** T; 10000–10850′; **S;** mr.

Saxifraga bronchialis L. var. *austromontana* (Wiegand) Piper ex G.N. Jones **[20,23]** A, C, M, R, S, T; 7750–13024′; **S;** am, mc, mm, mr, ra, sf.

♦ *Saxifraga cernua* L. **[1,-]** S; 11900–11940′; **S;** am.

Saxifraga chrysantha A. Gray **[-,1]** T; 12144–13009′; **S;** am.

Saxifraga debilis Engelm. ex A. Gray [**UNM**-H. Mackay 9T-3] T; **S.**

Saxifraga flagellaris Willd. ex Sternb. var. *crandallii* (Gand.) Dorn **[-,3]** T; 11500–13009′; **S;** am.

Saxifraga hirculus L. var. *hirculus* [**UNM**-T. Lowrey 2099] C; **S.**

Saxifraga odontoloma Piper **[6,18]** A, M, R, S, T; 8410–11960′; **S;** mc, mm, mr, sf.

[*Micranthes odontoloma* (Piper) A.A. Heller]
Saxifraga rhomboidea Greene **[2,8]** A, C, S, T; 9900–13009′; **S;** am, mc, ml, mr.
[*Micranthes rhomboidea* (Greene) Small]

Scrophulariaceae (see also Orobanchaceae, Plantaginaceae)
Scrophularia lanceolata Pursh **[-,1]** T; 7850–10500′; **S;** mc, mr.
\+ *Scrophularia montana* Wooton **[2,1]** A, M, T; 8450–10660′; **S;** mm.
* *Verbascum thapsus* L. **[19,15]** A, C, M, R, S, T; 5570–10500′; **L, S;** af, br, fr, mc, ml, mr, pj, pp, ra.

Solanaceae
Chamaesaracha coronopus (Dunal) A. Gray **[5,-]** A; 5700–6200′; **L, S;** fr, pg, pj.
Chamaesaracha coniodes (Moric.) Britton **[3,-]** A; 5570–5800′; **L;** fr, pg, pj.
Datura wrightii Regel **[1,-]** A; 5500′; **L;** fr.
Lycium pallidum Miers **[1,-]** A; 5800–5840′; **L;** pj.
Nicotiana trigonophylla Dunal **[1,-]** A; 5600–5800′; **L;** pj.
Physalis hederifolia A. Gray var. *comata* (Rydb.) Waterf. **[1,-]** A; 5700–5800′; **L;** fr, ra.
Physalis hederifolia A. Gray var. *fendleri* (A. Gray) Cronquist **[3,3]** A, R, S, T; 6232–8000′; **G, S;** fr, pg, pj, ra.
Physalis longifolia Nutt. var. *longifolia* **[1,-]** A; 6980′; **S;** pp.
Physalis subulata Rydb. var. *neomexicana* (Rydb.) Waterf. ex Kartesz & Gandhi **[3,1]** A, S, T; 6840–7840′; **S;** fr, mr, ra.
[*Physalis foetens* Poir. var. *neomexicana* (Rydb.) Waterf. ex Kartesz & Gandhi]
Solanum elaeagnifolium Cav. **[11,-]** A; 5570–7000′; **L, S;** fr, mr, pg, pj, ra.
Solanum jamesii Torr. **[UNM**-Bamberg 60] A; **S.**
Solanum nigrum L. **[UNM**-H. Mackay 6T-58] T; **S.**
Solanum rostratum Dunal **[2,-]** A; 5500–5610′; **L;** fr.

Sparganiaceae
Sparganium emersum Rehmann **[-,1]** T; 9375–9675′; **S;** ml, mr.

Tamaricaceae
*● *Tamarix chinensis* Lour. **[2,8]** A, R, T; 5500–8175′; **G, L, P, S;** fr, ml, ra.

Typhaceae
Typha latifolia L. **[1,4]** R, T; 6380–7660′; **G, S;** fr, ml, mr, ra.

Ulmaceae
*● *Ulmus pumila* L. **[13,11]** A, R, S, T; 5800–8700′; **G, L, P, S;** fr, mr, pj, pp, ra.

Urticaceae
* *Urtica dioica* L. var. *procera* (Muhl. ex Willd.) Wedd. **[18,22]** A, C, M, R, S, T; 7400–11500′; **S;** mc, ml, mm, mr, ra, sf.
[*Urtica dioica* ssp. *gracilis* (Aiton) Selander]

Verbenaceae
Glandularia bipinnatifida (Nutt.) Nutt. var. *bipinnatifida* **[16,-]** A, S; 5600–7500′; **L, S;** mr, pg, pj.
Phyla cuneifolia (Torr.) Greene **[1,-]** A; 5500′; **L;** fr.
Verbena bracteata Lag. & Rodr. **[8,4]** A, C, S, T; 5500–9070′; **L, S;** br, fr, mc, mr, pj, pp, ra.
Verbena macdougalii A. Heller **[23,8]** A, C, M, S, T; 6840–10500′; **S;** af, fr, mc, ml, mr, pj, pp, ra.

Violaceae
Viola adunca J.E. Sm. **[1,11]** R, S, T; 8000–12850′; **S;** am, mc, mr, sf.
Viola canadensis L. **[19,29]** A, C, M, R, S, T; 7320–12000′; **S;** af, br, mc, mr, ra, sf.
Viola nephrophylla Greene **[1,2]** A, R, T; 7740–8700′; **S;** mr.

Vitaceae
Parthenocissus vitacea (Knerr) Hitchc. **[7,5]** A, R, S, T; 5610–7493′; **G, L, P, S;** fr, mr, pj, pp, ra.
Vitis arizonica Engelm. **[3,1]** A, T; 5610–6540′; **G, L;** fr, ra.

Zygophyllaceae
* *Tribulus terrestris* L. **[3,-]** A, S; 5610–7000′; **L, S;** fr, mr, ra.

ERRATUM

In the prior article (Reif et al. 2009), we incorrectly reported 3 collections of *Asclepias macrosperma*. These specimens are *A. macrotis*. A corrected checklist entry for this taxon appears below:

Asclepias macrotis Torr. **[1,-,4,3]** D,L,R; 5300–6900′; **G, P, U;** ds, fr, pj.

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BOOK NOTICE

James Solomon, Tatyana Shulkina, and George Schatz, eds. 2014. **Red List of the Endemic Plants of the Caucasus: Armenia, Azerbaijan, Georgia, Iran, Russia, and Turkey.** (ISBN-13: 978-0915279821, hbk). *Monographs in Systematic Botany from the Missouri Botanical Garden*, Volume 125 (ISSN: 0161-1542). Missouri Botanical Garden Press, P.O. Box 299, St. Louis, Missouri 63166-0299, U.S.A. (**Orders:** www.mbg-press.org). Price not given, 768 pp., illustrated.

From the publisher: Red List of the Endemic Plants of the Caucasus: Armenia, Azerbaijan, Georgia, Iran, Russia, and Turkey provides the first floristic and conservation analysis of the plants of the Caucasus region, with assessments for over 60% of the endemic taxa, including top priorities for conservation action. This book was made possible by an unprecedented collaboration between botanists from all six regions covered within.

LOW GENETIC DIVERSITY AND POOR DISPERSAL, BUT NOT CONSERVATION STATUS RANK, ARE LINKED TO CLIMATE CHANGE VULNERABILITY

Cynthia M. Morton

Section of Botany
Carnegie Museum of Natural History
4400 Forbes Avenue
Pittsburgh, Pennsylvania 15213, U.S.A.

Matthew D. Schlesinger

Chief Zoologist
New York Natural Heritage Program
625 Broadway, 5th Floor
Albany, New York 12233, U.S.A.

ABSTRACT

Climate change vulnerability assessments for Pennsylvania were completed for 35 plant species using the Climate Change Vulnerability Index (CCVI v2.0) developed by NatureServe. The CCVI allows the user to examine the exposure and sensitivity of a species to a series of risk factors associated with climate change. This study, as well as studies from West Virginia (Byers & Norris 2011) and New York (Schlesinger et al. 2011), indicates that among the top five risk factors, based upon both floral and fauna assessments, appeared to be related to a lack of dispersal and movement mechanisms along with low genetic diversity. All of the above studies found that conservation status rankings and vulnerability to climate change were not directly related to one another. In light of these findings conservation protocols need to be reexamined to direct resources where they will be most effective in furthering the conservation of plant species.

RESUMEN

Se completaron evaluaciones de vulnerabilidad por el cambio climático en Pennsylvania para 35 especies vegetales usando el Climate Change Vulnerability Index (CCVI v2.0) desarrollado por NatureServe. El CCVI permite al usuario examinar la exposición y sensibilidad de una especie a una serie de factores de riesgo asociados con el cambio climático. Este estudio, así como estudios de West Virginia (Byers & Norris 2011) y Nueva York (Schlesinger et al. 2011), indica que entre los cinco mayores factores de riesgo, basados en evaluaciones de flora y fauna, parecieron estar relacionados con una falta de mecanismos de dispersión y movimiento junto con una diversidad genética baja. Todos los estudios encontraron que las graduaciones de estatus de conservación y vulnerabilidad al cambio climático no estaban relacionadas directamente una con otra. A la luz de estos hallazgos los protocolos de conservación necesitan ser reexaminados para dirigir los recursos allí done son más efectivos el fomento de la conservación de especies vegetales.

INTRODUCTION

Global climate change (e.g., increasing temperatures, increased carbon dioxide levels, and altered patterns of precipitation) may alter the distribution of plant species and natural plant communities and may decrease habitat value for wildlife over broad segments of North America. A number of studies have shown that as climates warm, many species will suffer a decline in population and reduced range sizes while others will experience an increase in populations and range sizes. The relative vulnerability of species or habitats to climate change can be used to set goals, determine management priorities, and direct resources where they will be most effective in furthering the conservation of plant species biodiversity (Glick et al. 2011).

Climate change is only one of many stresses, or pressures from the external environment that plant species and their habitats are currently experiencing. The management strategies traditionally used to address conventional threats to biodiversity will likely be similar to those needed for threats induced by climate change. The list of plant taxa which are currently deemed most at risk will change as climate change alters species distribution and population viability, and re-emphasized strategies may become more important as habitats change.

One planning tool that is increasingly employed for conservation and management decisions is the vulnerability assessment. These assessments typically are models in which the inputs are characteristics of the species or ecosystems and the output is a rating of relative vulnerability. This type of risk assessment has historically been used in wildlife management and conservation programs but only recently has been available for addressing the threat of climate change (Boyce 1992; Ruggiero et al. 1994; Faith & Walker 1996). Vulnerabil-

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ity assessment can be especially useful to highlight new conservation targets and can be a useful way for states to address climate change in their state-wide conservation plans or to coordinate broad-scale policy efforts that span multiple agencies or political boundaries.

Several states such as New York (Schlesinger et al. 2011), Pennsylvania (Furedi et al. 2011), West Virginia, Nevada, Illinois, and Florida (https://connect.natureserve.org /science/climate-change/ccvi) have implemented NatureServe's Climate Change Vulnerability Index (CCVI; Young et al. 2010). One of the chief strengths of the CCVI is that it is designed to be used in conjunction with NatureServe's conservation status ranks (S-ranks; Master et al. 2009), which are an existing global standard for assessing conservation status based on rarity, trends, and threats. Another important strength lies in its explicit incorporation of scientific uncertainty into the assessment: assessors are free to pick a range of values for each factor, and this uncertainty is quantified in a Confidence score. Thus the CCVI considers how susceptible a species or a system is to climate change, while directly acknowledging inherent uncertainties in future conditions and species responses. Species in the northeast US are predicted to be exposed to increased temperatures and decreased moisture availability (ClimAid www.nyserda.ny.gov/climaid). However, each individual species is expected to vary in its sensitivity to these direct climate change impacts. Thus inherent species characteristics, such as dispersal ability, dependence upon or restriction to specific habitats, interspecific interactions, and genetic variation, will factor into the species' vulnerability to climate change.

NatureServe and various member programs, including the Pennsylvania Natural Heritage Program have assigned conservation status ranks to each species. These ranks provide an estimate of extinction risk for the plant species. The conservation status ranks, documented at the statewide geographic scale, are based on a one to five scale, ranging from critically imperiled (S1) to demonstrably secure (S5). The CCVI was designed to be used in conjunction with S-ranks; integrating climate change vulnerability assessments into existing lists of at-risk species can be considered a more holistic approach to conservation concerns. This study objective was to examine 35 plants of S1 and S2 ranking to see if there was a relationship between conservation status ranks and the CCVI index and then use a regression analysis to find the consistent risk factors across all taxonomic groups examined.

METHODS

Development of a priority assessment list

Rhoads and Klein (1993) reported 3318 taxa of vascular plants for Pennsylvania, which included 2076 native and 1242 introduced species. It was therefore necessary to develop a more refined list of priority species for the climate change vulnerability assessment. Previous reports conducted by Byers and Norris (2011), Furedi et al. (2011), and Schlesinger et al. (2011) used existing lists of species of conservation concern. Understanding the need for future monitoring of imperiled plant species in danger of extirpation due to climate change, we selected plant species with a NatureServe conservation status ranking of S1 (Critically Imperiled) and S2 (Imperiled) that occur or have been known to occur near one central site in the state. We did not consider habitat preferences, life forms, tolerance of disturbance, or species distribution patterns within the state of Pennsylvania. Following the criteria of imperiled conservation status and proximity to one central site, our set of plant taxa could be efficiently monitored in the future for range expansion, range contraction, extinction or maintenance, possibly due to climate change. The funding for this project limited our scope to 35 species.

Plant taxa of S1 and S2 ranking that have been known to occur within a 10-mile radius of Bedford, Pennsylvania, based upon herbarium label data of specimens from the Carnegie Museum of Natural History, were chosen for assessment. The city of Bedford is located in Bedford County in the south-central portion of the state within the Appalachian Mountain section of the Ridge and Valley Physiographic Province. A series of ridges, namely, Buffalo, Evitts, Tussey, and Polish Mountains and Warrior Ridge, run the length of this 10-mile radius from southwest to northeast. The Raystown Branch of the Juniata River flows through the circle west to east and its tributaries generally run in a northeasterly and southeasterly direction. Elevations in the 10-mile radius range from 2000 to 2500 feet along the ridges to 900 to 1200 feet along the valley floors. At a larger scale, these physical features of ridgelines and stream valleys are prominent and extensive features that provide continuous habitat over many miles. Variations in aspect, slope, and elevation of the ridge and valley province combine to create different habitats and microenvironments (Wagner 1998).

This 10-mile radius was also selected so that efficient monitoring program within a small geographic area could be implemented at a future date. Changes in distribution of species and plant communities potentially due to climate change may be most evident in populations of species occurring at various elevations and in a variety of habitats from ridgetop to steep slope and to wetland and floodplain areas along streams. For many imperiled species with relatively few populations overall, or occurring at the edge of their range, climate change may lead either to their extirpation or expansion in Pennsylvania.

Thirty-five plant species met the above criteria of conservation status and location. The list includes 17 perennial herbs, 1 biennial, and 2 annual herbs, 2 perennial vines, 5 shrubs, 1 subshrub, and 7 graminoids (full list of taxa at https://connect.natureserve.org sites/default/files/documents/Pennsylvania-Plant-CCVI-2012.pdf). Seven species are typically found in wetlands and eight species are typically deemed calciphiles with the remaining taxa occurring in mixed habitats. Two are known to be parasites and at least five are known to depend upon a mycorrhizal relationship. The NatureServe Climate Change Vulnerability Index (CCVI) Release 2.0 was applied to each of the 35 plant species.

Examination of species vulnerability to climate change

We scored each of the criteria (described below) using information from peer-reviewed published papers and reputable websites. Some criteria were more easily scored than others simply because of available information and previous research. Accurate information on effective pollinators is nonexistent, or untested, for many of the plant species, and dispersal mechanisms are more often hypothesized than experimentally proven. Fortunately the index is designed so that the accumulated knowledge of the plant species or genera allows for choosing a range of values.

Vulnerability to climate change was assessed by considering the two main components of vulnerability as defined by Williams et al. (2008): the exposure of a species to climate change within a defined area combined with the sensitivity of a species to climate change. Vulnerability assessment involves describing the severity and scope of the exposure that species experience, and combining this with species' sensitivity and capacity to adapt to climate change. NatureServe's newly developed Climate Change Vulnerability Index (Young et al. 2010) provides a means of dividing species into groupings of relative risk to climate change and of identifying key factors causing species to be vulnerable. Used with standard conservation status assessments such as the NatureServe G- and S-rank system, the Index can help land managers evaluate the likely effectiveness of alternative strategies to promote adaptation of species to climate change as well as select key species to monitor. It is designed to complement, and not duplicate, information contained in the NatureServe conservation status ranks (Master et al. 2009), and may be used to update conservation status ranks to include the additional stressor of climate change. Using regionally specific climate models, the index examines how the changed climate will impact a species using factors known to be associated with vulnerability to climate change, including species-specific factors as well as external stressors imposed by human actions. Downscaled climate data representing an ensemble of 16 global circulation models were downloaded from Climate Wizard (Girvetz et al. 2009) and displayed in a GIS format. Climate data were available on a 4-km grid for historical data, and a 12-km grid for predicted future data. The overlap of changing climate with each species' range was used to calculate direct exposure.

The factors considered in evaluating species response might be divided into general categories including direct exposure, indirect exposure, sensitivity, documented response, and modeled response. Detailed information including the scientific references used to develop each factor and the limitations of the methodology are given in Young et al. (2010).

Brief definitions of the factors are given below and scored NatureServe's Climate Change Vulnerability Index Table (https://connect.natureserve.org/science/climate-change/ccvi).

A—Direct Exposure

Temperature change is the predicted change in annual temperature by 2050, calculated over the range of the species in Pennsylvania (ClimateWizard).

Moisture change is the predicted net change in moisture based on the Hamon AET:PET moisture Metric by 2050, calculated over the range of the species in Pennsylvania (Kartesz 2011; WCRP, Maurer et al. 2007; ClimateWizard) (Figs. 1 & 2).

B—Indirect Exposure

B1: Exposure to Sea Level Rise

Weiss et al (2011) predict that only a very small portion of Pennsylvania will be subject to a sea level rise of 0.5 to 1 meter; accordingly, less than 10% of the range of plant species eligible for this study could be subject to sea level rise.

B2: Distribution relative to Barriers

Given the topography and geographical context of the state, most plant species in Pennsylvania will not be subject to natural or anthropogenic barriers such as high mountain ranges, large expanses of water, or intensive agricultural or urban development.

B3: Predicted impact of land-use changes resulting from human responses to climate change

Forestland in Pennsylvania totals 58% of land cover and is the dominant land class at 166 million acres. This proportion remained stable from 1989 to 2004; the state's forest loss (primarily due to residential and industrial development) was offset by conversion of agricultural land to forest through natural succession (Pennsylvania's Forest 2004). Nowak & Walton (2005) predicted that if growth trends of the 1990s continued through 2050, urban development could subsume an additional 15 million acres. Even if this loss cannot be offset by agricultural land conversion, forestland should still be a primary land class. Forest fragmentation and smaller patch sizes are prevalent in the southeast and west, but, in the north-central region, forest patches are large and contain more interior forest habitat (Pennsylvania's Forest 2004).

Twenty-nine percent of the forest land is owned by the state and federal US Forest Service. Government agencies are likely, as part of their management plans, to manage the forests for mitigation-related carbon storage and carbon sequestration. The majority of forest-land, 71%, is privately owned (Pennsylvania's Forest 2004).

C—Sensitivity

C-1: Dispersal—The ability of a species to shift locations in response to climate change (Vittoz & Engler 2007). For seed dispersal distances we used a typology based on dispersal modes and plant traits.

C-2: Predicted sensitivity to temperature and moisture changes: Species requiring specific precipitation and temperature regimes may be less likely to find similar areas as climates.

C-2-a: Predicted sensitivity to changes in temperatures.

C-2-b: Predicted sensitivity to changes in precipitation, hydrology, or moisture regime.

C-2-c: Dependence on a specific disturbance regime likely to be impacted by climate change. Species dependent on habitats such as prairies, or are maintained by regular disturbances such as fire or flooding are vulnerable to climate change.

C-2-d: Dependence on ice, ice-edge, or snow-cover habitats. This factor is of minor significance depending on a species' range in PA.

C-3: Physical Habitat Specificity. Species requiring specific soils (limestone outcrops) or physical features such as caves, cliffs or sand dunes may become vulnerable to climate change.

C-4: Reliance on Interspecific Interactions. Species with tight relationships with other species may be threatened by climate change.

C-4-a: Dependence on other species to generate habitat

C-4-c: Pollinator versatility

C-4-d: Dependence on other species for propagule dispersal

C-4-e: Forms part of an interspecific interaction not covered above

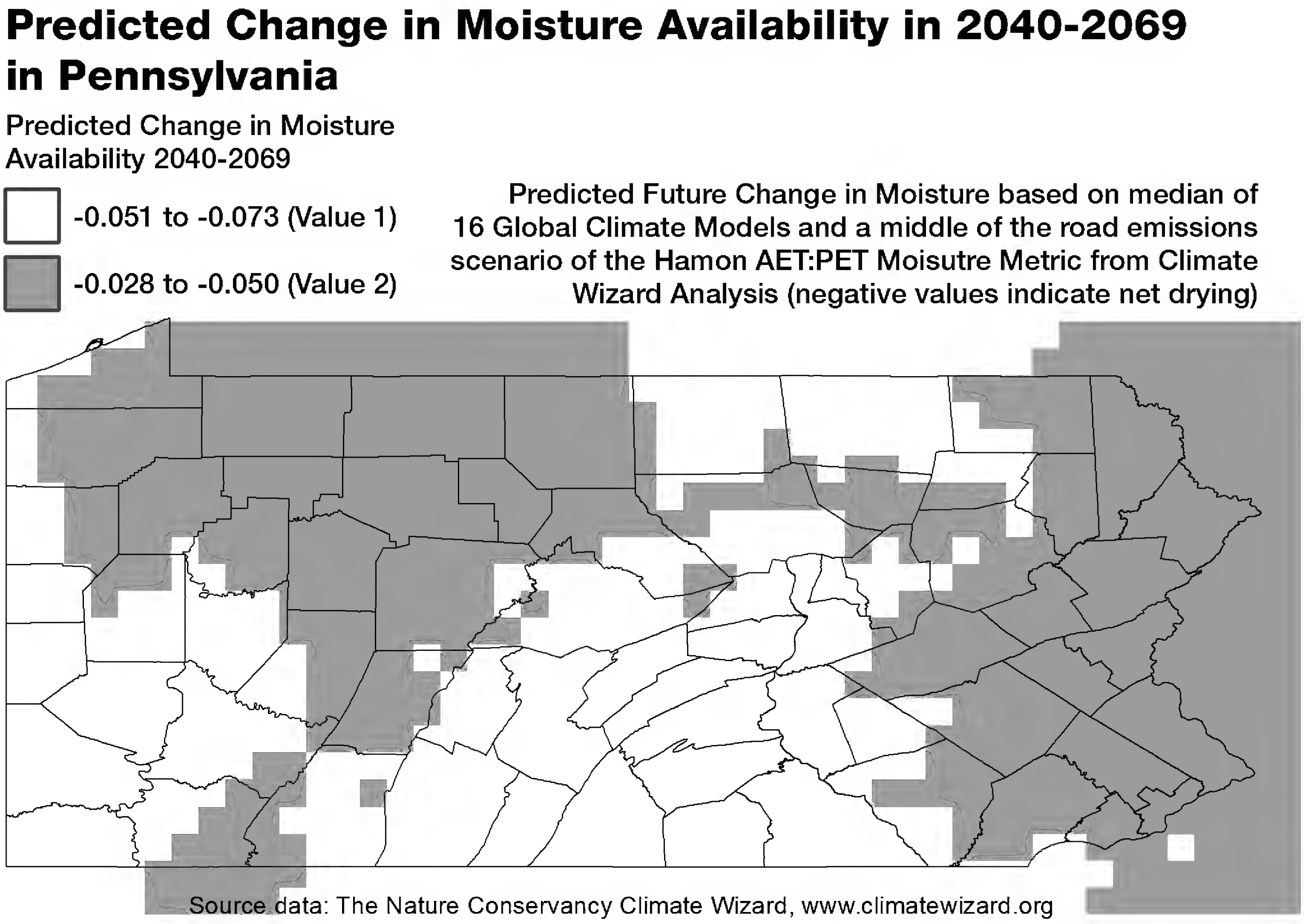

Fig. 1. Predicted future change in Pennsylvania moisture availability. Based on median of 16 global climate models and a middle-of-the-road emissions scenario of the Hamon AET:PET moisture metric from Climate Wizard Analysis. Negative values indicate net drying.]

C-5: Genetic Factors—A species' ability to evolve adaptations to environmental conditions brought about by climate change is largely dependent on its existing genetic variation.

We used the internal transcribed spacer (ITS) gene because it contained the most data at this generic level. The ITS region of nuclear ribosomal DNA (nrDNA) has proven to be a valuable resource for plant systematics as a useful source of characters for phylogenetic studies in many angiosperm families (Baldwin et al. 1995). We scored the number of parsimony informative characters, a common measure of genetic variation. If the number of parsimony informative characters was under 150 then we coded the factor as increasing vulnerability to climate change; between 151–250 was coded as somewhat increasing vulnerability; between 251–350 we coded as neutral and over 351 was coded as somewhat decreasing vulnerability.

C-6: Phenological response to changing seasonal temperature and precipitation regimes. Recent research suggests that some phylogenetic groups are declining due to lack of response to changing annual temperature dynamics (e.g., earlier spring, longer growing season), including some temperate zone plants that are not moving their flowering times.

D—Documented or Modeled Response to Climate Change

D-1: Documented responses to recent climate change: The results of published research may be available that document changes within species that can be definitively linked to climate change.

D-2: Modeled future change in range or population size: The change in area of the predicted future range relative to the current range is a useful indicator of vulnerability to climate change.

D-3: Overlap of modeled future range with current range: The results of future distribution models can be compared to current range maps to address potential overlap.

D-4: Occurrences of protected areas in modeled future distribution: The results of future distribution

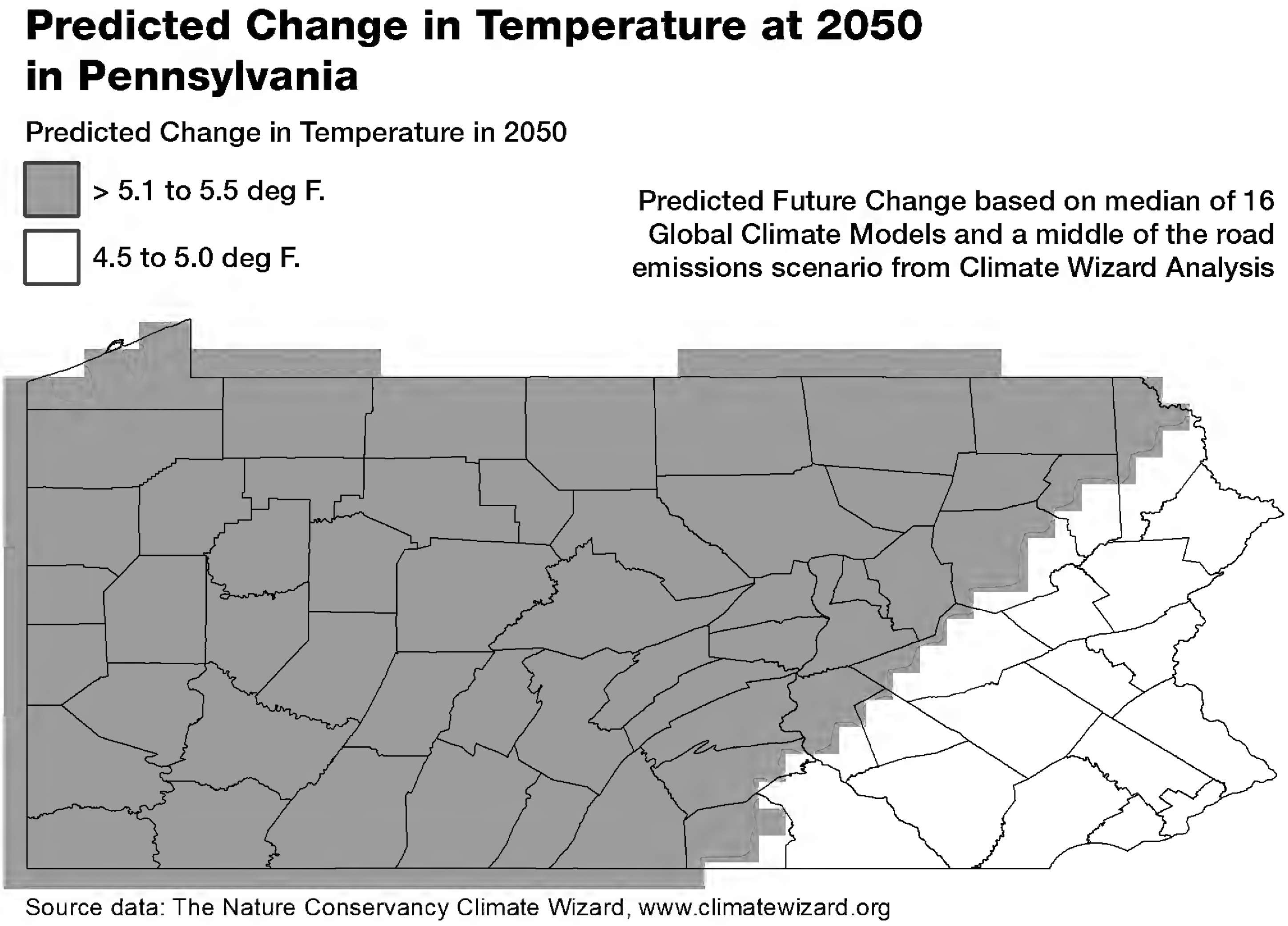

Fig. 2. Predicted future temperature change in Pennsylvania. Based on median of 16 global climate models and a middle-of-the-road emissions scenario from Climate Wizard Analysis.]

models can be compared to present protected areas to see if future ranges may fall entirely outside of protected areas and therefore compromise their long-term viability.

Compile and analyze results: Climate Change Vulnerability Index results were compiled and analyzed in order to (a) highlight those species most (and least) vulnerable to climate change, (b) identify and rank causative factors, and (c) identify geographic areas or habitat types at high risk.

Regression analysis

To determine the factors most important in assessing vulnerability, we followed the methodology used by Schlesinger et al. (2011). We built classification trees using the Random Forests (Breiman 2001; Liaw & Wiener 2002) package in R (R Development Core Team 2011), a technique from the field of machine learning. The Random Forests routine is to build thousands of classification and regression trees using bootstrap samples of the data set and predictors. We limited our predictor variables to the exposure and sensitivity variables influencing vulnerability (i.e., omitting documented and modeled responses) and imputed (estimated) values recorded as "Unknown," as the routine does not accept missing data.

RESULTS AND DISCUSSION

Documented responses to climate change are incorporated into NatureServes Climate Change Vulnerability Index Table. The output is one of five categories of vulnerability and one indicating lack of evidence. Definitions, and the abbreviations that are used throughout this document, follow Young et al. (2010) and are presented in Table 1.

Plant species assessed and factors affecting vulnerability

The 35 plants included in this assessment ranged from highly vulnerable to not vulnerable to climate change.

Table 1. Five Vulnerability Index scores and eight individual Risk Factor scores.

Vulnerability Index	
EV (Extremely Vulnerable)	Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050; HV Highly Vulnerable Abundance and/or range extent within geographical area assessed likely to to decrease significantly by 2050.
MV (Moderately Vulnerable)	Abundance and/or range extent within geographical area assessed likely to decrease by 2050.
PS (Not Vulnerable/Presumed Stable)	Available evidence does not suggest that abundance and/or range extent within geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.
IL (Not Vulnerable/Increase Likely)	Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.
Risk Factor:	
GI	Greatly Increase Vulnerability
Inc	Increase Vulnerability
SI	Somewhat Increase Vulnerability
N	Neutral
SD	Somewhat Decrease Vulnerability
D	Decrease Vulnerability
N/A	Not Applicable
U	Unknown

Vulnerability to climate change was due to a combination of multiple risk factors. Influential risk factors appear to be limited dispersal capabilities, decreased genetic variation, and dependence on a specific hydrological or moisture regime. Plants assessed as stable were often habitat generalists and less dependent upon a wetland habitat, were able to disperse longer distances, and were genetically more diverse. For example, *Astragalus canadensis*, a plant somewhat dependent upon marshy ground or moist prairie, rarely disperses more than 10 meters when its exploding fruit ejects its seeds (Gleason & Cronquist 1991). ITS phylogenetic inference revealed a low number of parsimony information characters and thus low genetic variation. Its vulnerability index score was Moderately Vulnerable. On the other hand, *Amelanchier sanguinea*, a shrub found in an assortment of habitats throughout its range, produces sweet and juicy fruits highly palatable to birds (Gleason & Cronquist 1991 and PNHP Factsheet). ITS phylogenetic inference revealed a higher number of parsimony information characters and thus higher genetic variation. Its vulnerability index score was Not Vulnerable.

Fourteen of the 35 (40%) species assessed were determined to be vulnerable (HV or MV) to climate change. None of the species were rated as “Extremely Vulnerable” and only two as “Highly Vulnerable.” Twenty species (57%) were rated as “Presumed Stable” and only one as “Increase Likely.” Both of the “Highly Vulnerable” species are poor dispersers.

All 35 species assessed were ranked S1, S1S2, or S2. The vulnerability statuses were distributed throughout these conservation status ranks. Fifteen of the 35 species examined were S1 ranked (imperiled species), 8 of these taxa were presumed stable. S1 species did not appear to be more vulnerable to climate change than did the S2 species (Fig. 3).

A review of global conservations ranks found only four taxa were at some risk to global extinction. These were ranked G2 (globally imperiled – at high risk of extinction due to very restricted range, few populations, etc.) or G3 (vulnerable – at moderate risk of extinction due to restricted range, relatively few populations, etc.). Their vulnerability status was Presumed Stable. The remaining 31 species were ranked G4 (apparently secure) or G5 (secure), and the vulnerability statuses included Increase Likely, Presumed Stable, Moderately and Highly Vulnerable (Fig. 4).

An important result of this assessment is that we cannot predict the climate change vulnerability of a species based on its current Conservation Status Rank (G=global or S=state rank). Rare species may not always be vulnerable to climate change and common species are not necessarily resilient. Each species will behave and respond according to its unique life history characteristics, habitat requirements, and distribution. The impli-

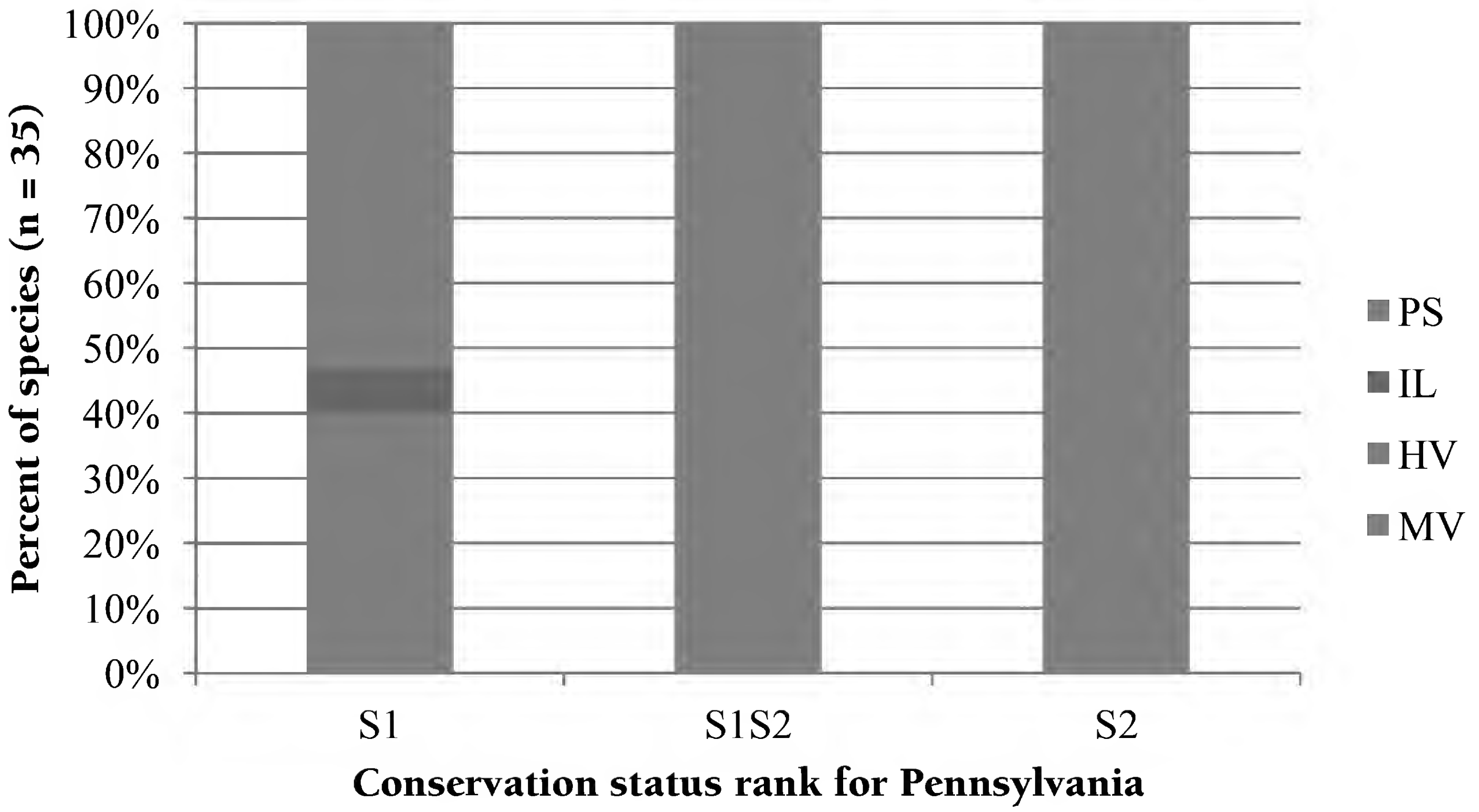

Fig. 3. Percent of species within state conservation status ranks in each vulnerability category (S1 n=15, S1S2 n=3 and S2 n=17). **PS**= Presumed Stable; **IL**= Increase Likely; **HV**= Highly Vulnerable; **MV**= Moderately Vulnerable. Adapted from Byers and Norris (2011) and Schlesinger et al. (2011).

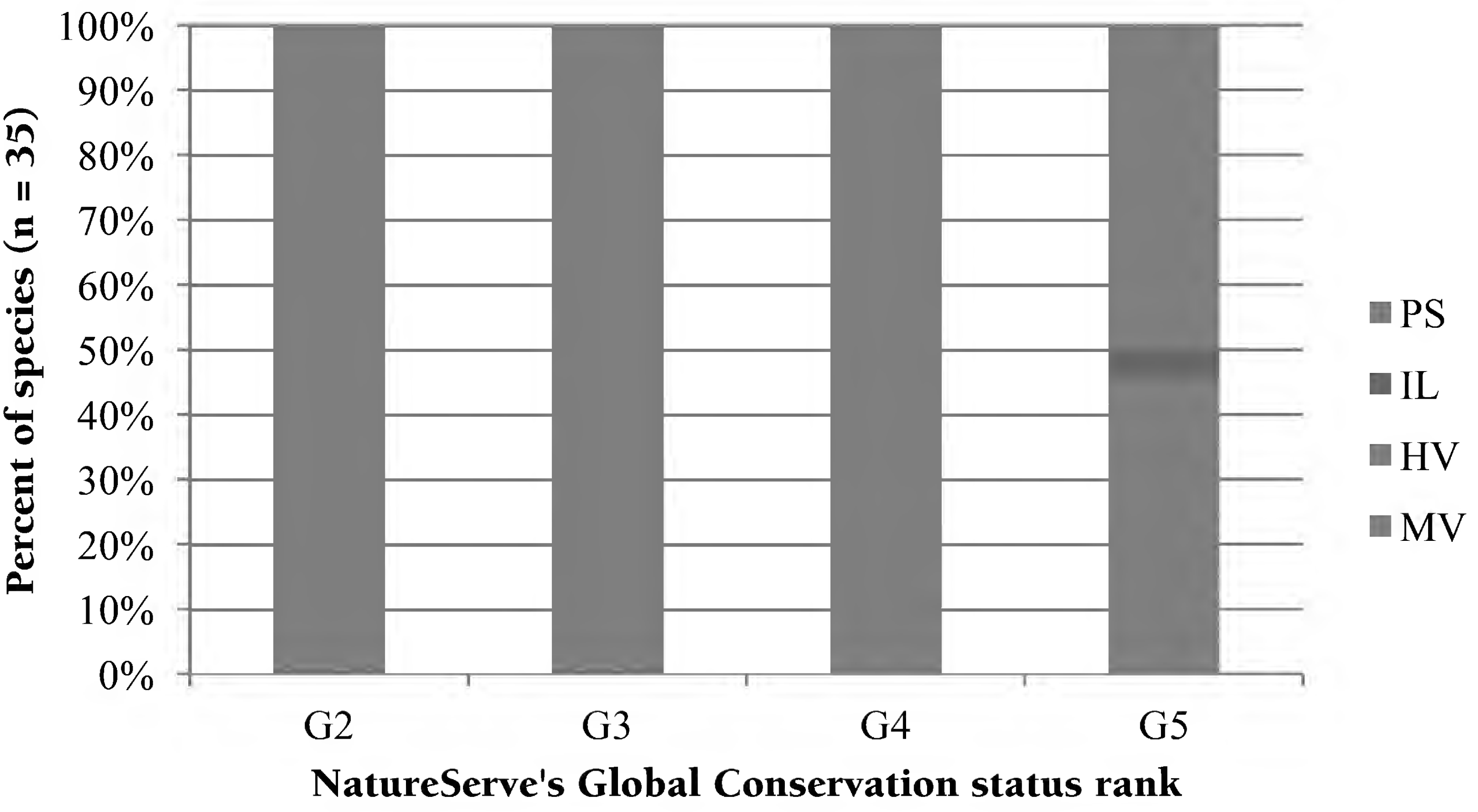

Fig. 4. Percent of species within global conservation status ranks in each vulnerability category (G2 n=2; G3 n=2; G4 n=25; and G5 n=6). **PS**= Presumed Stable; **IL**= Increase Likely; **HV**= Highly Vulnerable; **MV**= Moderately Vulnerable. Adapted from Byers and Norris (2011) and Schlesinger et al. (2011).

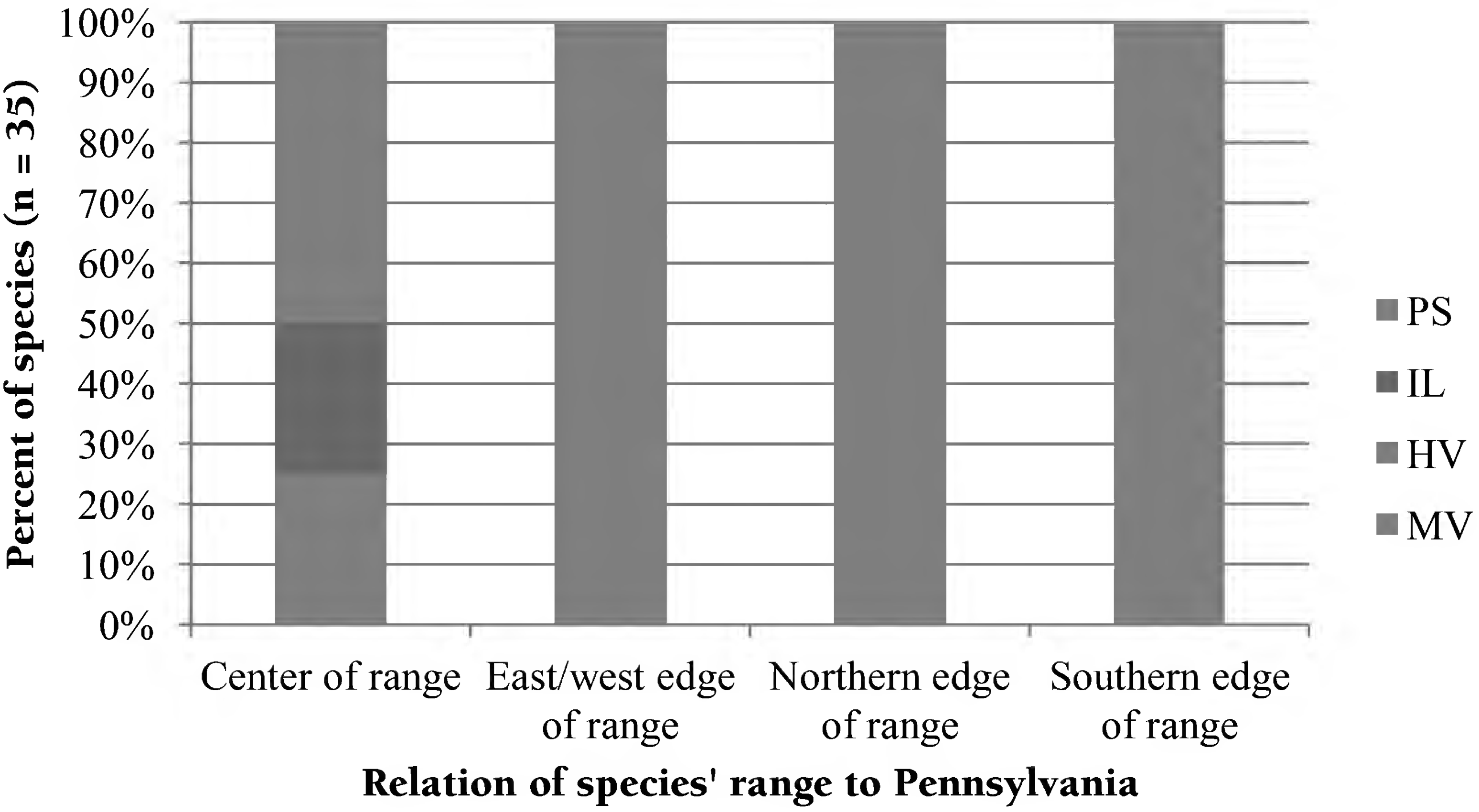

Fig. 5. Percent of species in each vulnerability category categorized according to the position of their range relative to Pennsylvania (Center n=4; East/West n=18; North n=11; and Southern n=2). PS= Presumed Stable; IL= Increase Likely; HV= Highly Vulnerable; MV= Moderately Vulnerable. Adapted from Byers and Norris (2011) and Schlesinger et al. (2011).

cations of this are important to rare plant conservation and management strategies, since climate change may necessitate the reassessment of conservation status. We need to examine and re-align our ranking process to best conserve species and habitats with the resources available.

Both species at the southern edge of their range were assessed as Moderately Vulnerable, and therefore possibly disappearing from the state (Fig. 5), whereas the Center of the range, East/West edge of the range and Northern edge of the range contained 50% or greater of the Presumed Stable (PS) taxa and were assessed as not highly vulnerable to climate change.

Dispersal scores ranged from somewhat decrease vulnerability to greatly increase vulnerability (Fig. 6) and did have an influence. Twelve of the 25 species were scored as GI, Inc, and SI indicating dispersal limitations and were assessed as Highly Vulnerable (HV) or Moderately Vulnerable (MV). The taxa with overall neutral and somewhat decreased vulnerable scores consisted of mostly Presumed Stable (PS) taxa (7 of the 10 species) indicating no dispersal or movement influence. These results also agree with the first Pennsylvania study (Furedi et al. 2011), West Virginia (Byers & Norris 2011) and New York (Schlesinger et al. 2011) climate change vulnerability assessment reports. These reports indicated that the top risk factors, based upon both floral and fauna assessments, appeared to be related to dispersal and movement mechanisms. Plants that lack the specialized structures for dispersal by wind, or lack attractive coloration for animal dispersal, have limited potential for long-distance dispersal.

Measured genetic variation scores were an influence (Fig. 7). Nine of the seventeen species in the Inc and SI categories indicated low genetic diversity, assessed as Highly Vulnerable (HV) or Moderately Vulnerable (MV). Taxa with the overall neutral and somewhat decreased vulnerable scores consisted of mostly Presumed Stable (PS) taxa (11 out of 16 species) and were assessed as not vulnerable to climate change. This study used the number of parsimony informative characters of the ITS gene as an indicator of genetic diversity. ITS (internal transcribed spacer) region was selected because it is typically used at the species level. Although additional assessment needs to be done using this technique, it was in agreement with other factors used in this study and

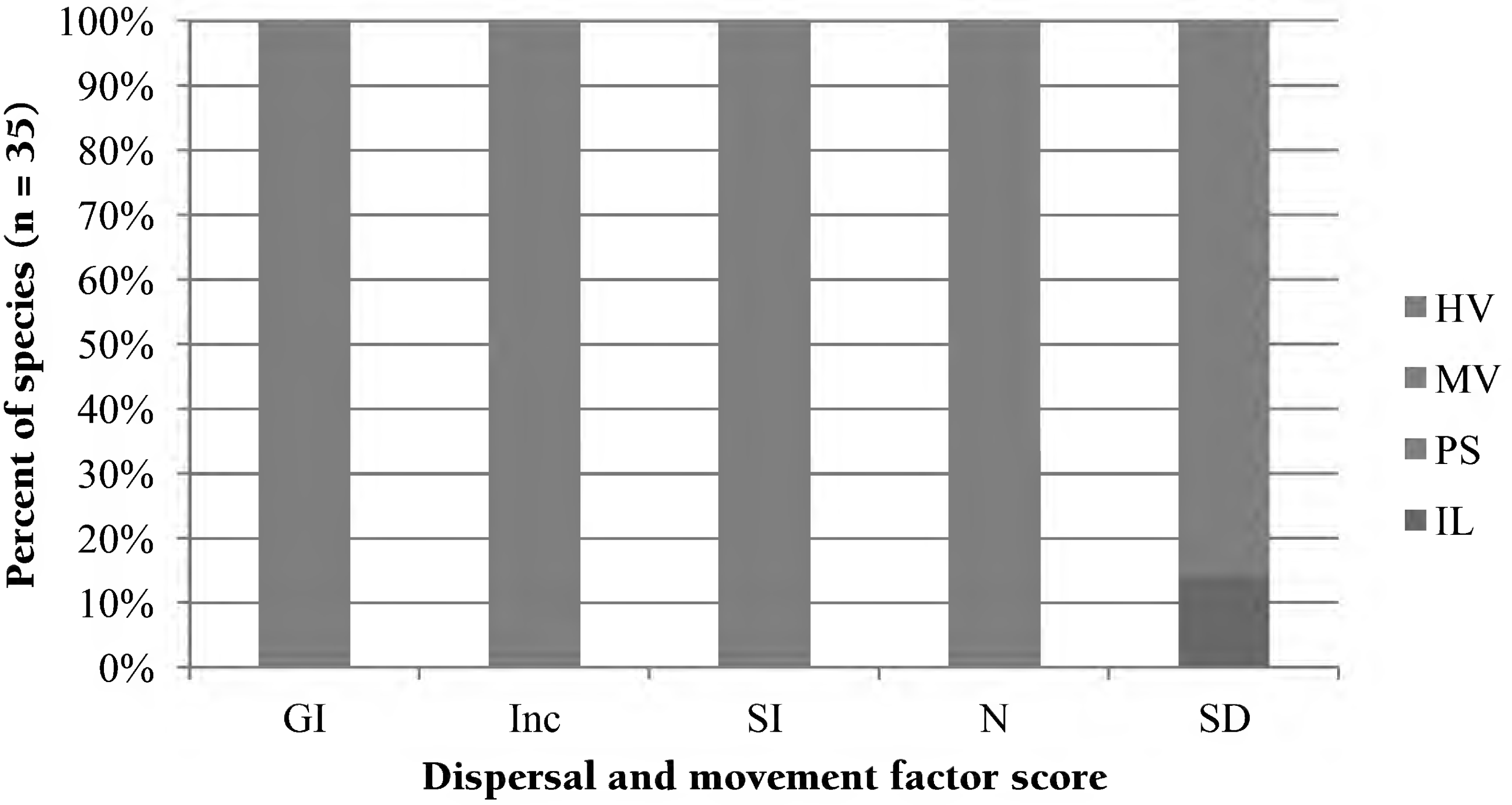

Fig. 6. Percent of species in each vulnerability category categorized according to the dispersal and movement factor relative to Pennsylvania (GI=Greatly Increase Vulnerability n=4; Inc=Increase Vulnerability, n=16; SI=Somewhat Increase Vulnerability, n=5; N=Neutral, n= 3; and SD=Somewhat Decrease Vulnerability, n=7). **PS**= Presumed Stable; **IL**= Increase Likely; **HV**= Highly Vulnerable; **MV**= Moderately Vulnerable. Adapted from Byers and Norris (2011) and Schlesinger et al. (2011).

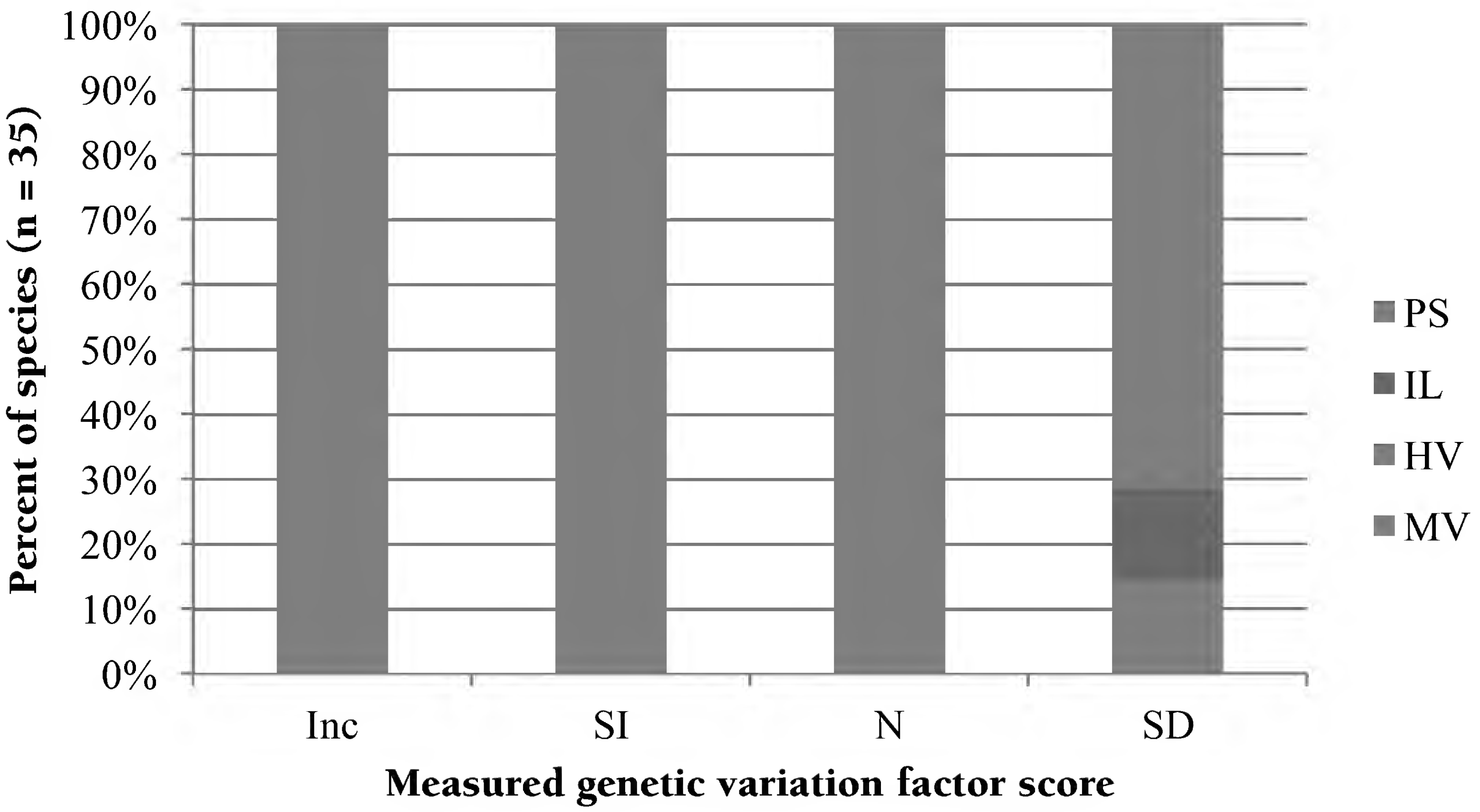

Fig. 7. Percent of species in each vulnerability category categorized according to the measured genetic variation factor relative to Pennsylvania (Inc=Increase, n=10; SI=Somewhat Increase Vulnerability, n=7; N=Neutral, n= 9; SD=Somewhat Decease Vulnerability, n=7; and U=Unknown, n=2). **PS**= Presumed Stable; **IL**= Increase Likely; **HV**= Highly Vulnerable; **MV**= Moderately Vulnerable. Adapted from Byers and Norris (2011) and Schlesinger et al. (2011).

with the results from West Virginia and New York. The previous Pennsylvania study did not contain enough genetic data to be significant. As stated, these results also agree with the West Virginia (Byers & Norris 2011) and the New York (Schlesinger et al. 2011) state climate change vulnerability assessment reports. Both of these reports indicated that genetic factors predisposing species to potential climate change effects were easily the most important factor. Species with reduced genetic variation are less likely to be able to respond to environmental change (e.g., Aitken et al. 2008). In addition, plants with poor dispersal strategies will eventually be genetically bottlenecked and therefore have low genetic diversity (http://www.nature.com/scitable/definition/population-bottleneck-300).

Regression scores

The most important factors, as indicated by the R^2 values, driving a species' vulnerability status were as follows:

1. Dispersal and movement;
2. Predicted sensitivity to changes in precipitation, hydrology, or moisture regime;
3. Predicted sensitivity to changes in temperature;
4. Physiological hydrological niche (a dependence on a narrow precipitation/hydrologic regime), and
5. Genetic factors.

These top five factors are probably representative of the most consistent risk factors across all plant taxonomic groups in the state.

The random forest regression analysis supports the visual assessments of the graphs. Dispersal limitations, the ability of a species to shift locations in response to climate change, were one of the most important factors in our assessment. The next most important factors were temperature and moisture. Those species requiring moist microhabitats will experience stress if these habitats dry up. Finally genetic variation, which affects a species' ability to adapt to environmental conditions, was among the top five factors (Fig. 8).

Comparisons to other states

Three states in the Northeast—Pennsylvania, New York and West Virginia—have recently completed CCVI analyses, but only Pennsylvania and West Virginia included plants. Our study contained 2 out of 35 taxa as highly vulnerable whereas the first Pennsylvania analysis contained 24 out of 40 taxa as extremely (EV) to highly vulnerable (HV) and West Virginia contained 7 out of 33 plant taxa as (EV or HV). The proportion of species assessed as vulnerable depends greatly on the species selected for analysis, as conducting the analysis on all species is not possible given constraints of funding, time and available information. Other studies aimed to select species they thought might prove vulnerable to climate change based on habitat; however, we selected taxa based on their current Conservation Status State Rank (imperiled or endangered species).

Our results agreed with those of West Virginia while there was no overlap between our study and the first Pennsylvania analysis. Our study and the West Virginia study assessed 2 species in common. The final index values either matched exactly (*Pycnanthemeum torreyi*) or were off by one step (*Paxistima canbyi,* Presumed Stable versus Moderately Vulnerable). These differences in index values might result from true differences in vulnerability among states or differences in interpretation of data; a full analysis of these differences is beyond the scope of this study.

Management and monitoring recommendation

A complete discussion of management, monitoring and restoration of habitat connectivity is past the capacity of this paper. However, we can provide some recommendations that are applicable here based on our results.

The fact that the species assessed as Highly Vulnerable in our analyses are associated with the identification of barriers to dispersal as an important component of our vulnerability and regression scores. Maintaining and restoring habitat connectivity is crucial for many ecological processes, including dispersal, gene flow, and movement in response to climate change (Mawdsley et al. 2009; Heller & Zavaleta 2009; Byers & Norris 2011; McRae et al. 2012). This is especially true for vulnerable species restricted to certain habitats. Another valuable outcome of this procedure is it allows biologists to ascertain which life history traits of a particular species in-

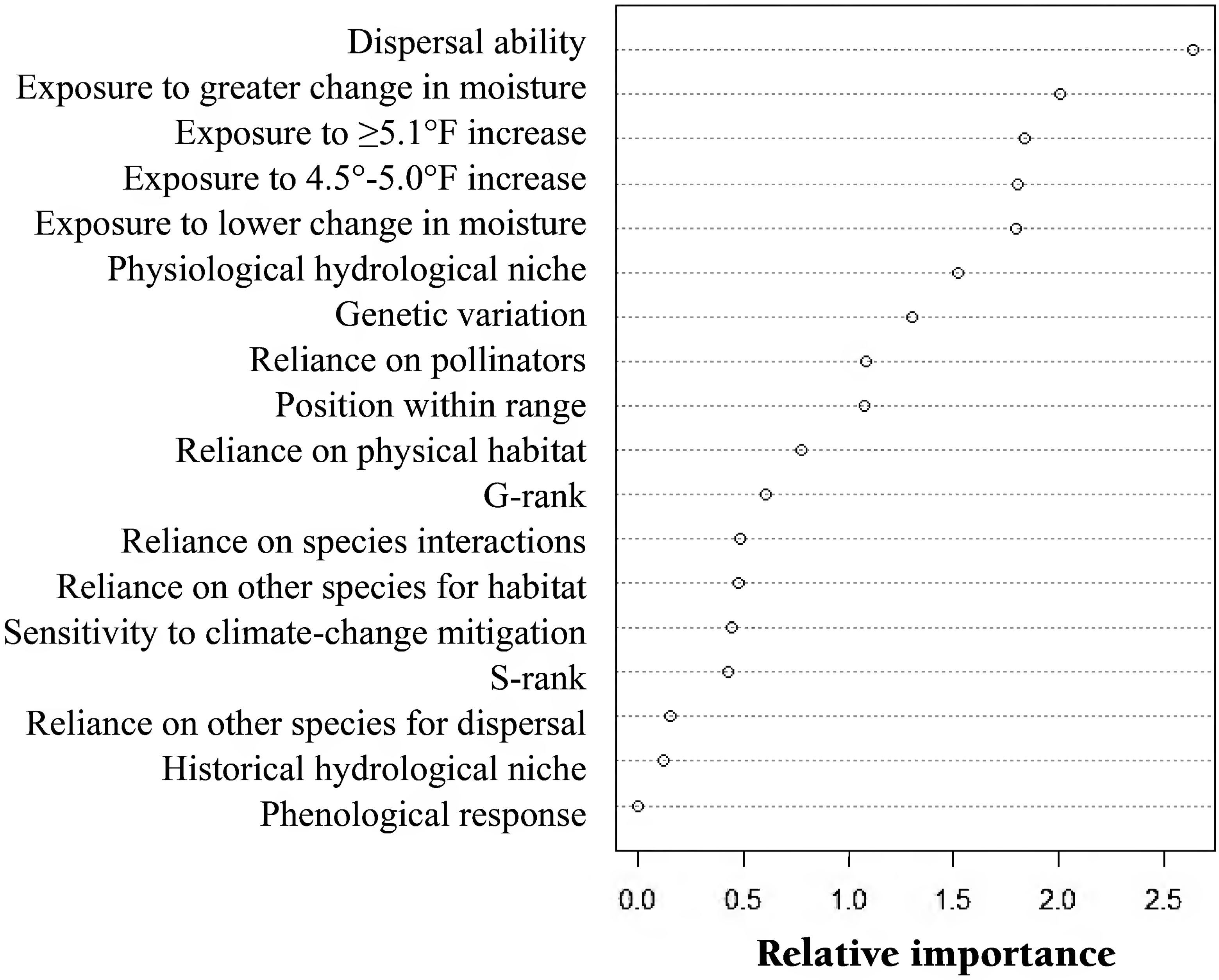

Fig. 8. Variable importance (decrease in node impurity according to the Gini index) from the random forest analysis of Climate Change Vulnerability Index scores of 35 Pennsylvania plants.

dicate propensity of that species to be vulnerable to climate change and further highlights other factors that might pose more immediate threats to certain imperiled species (such as dispersal limitations and low genetic diversity). Species with good dispersal mechanisms can redistribute themselves, but the key to successful movement and migration is the presence of contiguous habitats that species are able to colonize or move across. Protecting large blocks of unfragmented habitats and using linkages and corridors to enhance connectivity will facilitate this colonization or movement, but this is only one solution. Developing methods to identify barriers whose removal would significantly improve connectivity, such as least-cost and simulation modeling, can be cost effective and broaden alternatives available to connectivity conservation. This network of intact habitats should represent a full range of ecosystems to sustain biodiversity and genetic diversity. Key ecological processes such as pollination, seed dispersal, nutrient cycling, and natural disturbance cycles will be maintained under this environment.

Long-term monitoring using multiple taxa and habitats will help 1) test hypotheses about vulnerability; 2) detect changes in species; 3) test hypotheses about consistent risk factors; 4) identify barriers to improve connectivity; and 5) help examine alternative methods for least-cost simulation modeling to maintain connectivity. Currently, these data are not readily available and it is imperative for governmental and non-governmental organization to have these data to make the most informed conservation and management decisions. The success in combating these environment changes will only be achievable through an unprecedented level of collaboration and cooperation between wildlife managers, other organizations, scientists, and the public. Building science-driven strategies that maximize the use of scarce resources will be necessary so legislative support and policy changes can be implemented. In order to facilitate long-term monitoring of multiple taxa we have used herbarium data to designate a 10-mile radius in Bedford County including most of the plants we analyzed in this study. Additional sites could be established using the same techniques (i.e. a small number of species within a defined radius), so a manageable monitoring program could be funded in the future allowing for improved collaboration and cooperation between organizations which reduce the cost of research yet obtain a wealth of information so good conservation decisions are made.

Proposed taxa for more detailed monitoring programs

Broad-scale, long-term monitoring of taxa will help test hypotheses about vulnerability, which are essentially what the CCVI provides. Monitoring can detect unanticipated changes in populations, can identify particular stressors, and can reveal range shifts and changes in phenology. Long-term monitoring has already revealed shifts that have been vital in demonstrating responses to climate change (Parmesan et al. 1999; Hitch & Leberg 2007; Zuckerberg et al. 2010). There is a pressing need to establish a solid baseline of data that will allow us to detect these changes in Pennsylvania and make the most informed conservation and management decisions. As new factors affect wildlife and habitats, such as changes in phenology and the effects on pollinators and the increase in invasive species, managers will need to monitor these changes and incorporate them into new action strategies.

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THE VASCULAR FLORA OF FORT SUMTER AND FORT MOULTRIE, SOUTH CAROLINA, U.S.A.

Richard Stalter, Brent A. Berger[1]
Department of Biological Sciences
St. John's University
Jamaica, New York 11439, U.S.A.
[1]*corr. author: brent.a.berger@gmail.com*

Eric E. Lamont
The New York Botanical Garden
2900 Southern Blvd.
Bronx, New York 10458, U.S.A.

John Nelson
Department of Biological Sciences
University of South Carolina
Columbia, South Carolina 29208, U.S.A.

ABSTRACT

The vascular flora of Fort Moultrie and Fort Sumter, Charleston County, South Carolina, were sampled in 1990, one growing season after Hurricane Hugo, and during the 2008–10 growing seasons. The flora at Fort Moultrie consisted of 303 taxa, while 77 taxa were identified at Fort Sumter. The Asteraceae and Poaceae were the largest families in the flora at both sites. *Cyperus* (9 taxa at Fort Moultrie, 3 taxa at Fort Sumter) was the largest genus in the flora. The annotated checklist includes the locality and habitat in which each species occurs, the years the taxa were observed, frequency of occurrence, and pertinent synonyms.

RESUMEN

Se muestreó la flora vascular de Fort Moultrie y Fort Sumter, Charleston County, South Carolina, en 1990, una estación después del huracán Hugo, y durante las estaciones de 2008–10. La flora de Fort Moultrie consistió en 303 taxa, mientras que se identificaron 77 taxa en Fort Sumter. Las Asteraceae y Poaceae fueron las mayores familias de la flora en ambos lugares. *Cyperus* (9 taxa en Fort Moultrie, 3 taxa en Fort Sumter) fue el género más grande de la flora. El catálogo anotado incluye la localidad y el hábitat de cada especie, los años en que los taxa se observaron, la frecuencia de ocurrencia, y los sinónimos pertinentes.

INTRODUCTION

Fort Sumter National Monument in Charleston County, South Carolina, is comprised of Fort Sumter National Monument (32.75N 79.87W), an island in Charleston Harbor, and Fort Moultrie (32.76N 79.86W) on the southern rim of Sullivan's Island north of the harbor (Fig. 1). Two vegetation studies of the sites have occurred in the last twenty-five years. Stalter and Lamont (1993) sampled the vascular plant species of Fort Moultrie and Fort Sumter at six-week intervals during the growing season after Hurricane Hugo from March–October 1990. The combined flora of both sites (ca. 27 ha at Fort Moultrie and ca. 1 ha at Fort Sumter) in 1990 consisted of 63 families, 161 genera and 287 species; 69 species occurred at Fort Sumter, while 218 species occurred at Fort Moultrie. Subsequently, Schmidt (2004) produced an unvouchered, unpubished list of 265 vascular plant species at Fort Moultrie. One-hundred fifty-four of the taxa (58%) reported by Schmidt were also found by Stalter and Lamont (1993), while 52 taxa (19%) were not.

METHODS

Four plant communities were documented at Fort Moultrie and Fort Sumter (Stalter & Lamont 1993). Three occur at both sites (salt marsh, dune and ruderal), while one is exclusive to Fort Moultrie (maritime woodland). The maritime woodland community was not included in the present study as it was destroyed in Hurricane Hugo. Remnants of the flora in this community appeared in the earlier paper by Stalter and Lamont (1993).

The vascular plant species at Fort Moultrie and Fort Sumter were sampled at six-week intervals from April–October 2008–2010. The data was analyzed with previously published data from March-October 1990 (Stalter & Lamont 1993), as well as unpublished data from Schmidt (2004), to better characterize the complete flora at the two sites. The most intensive collecting was during the 1990 growing season, one year after Hurricane Hugo. Objectives for each trip included the collection of voucher material and accumulation of information on habitat preference and abundance for ach species. One complete set of vouchers was deposited at the A. C. Moore Herbarium at the University of South Carolina (USCH). Duplicate vouchers were retained in James

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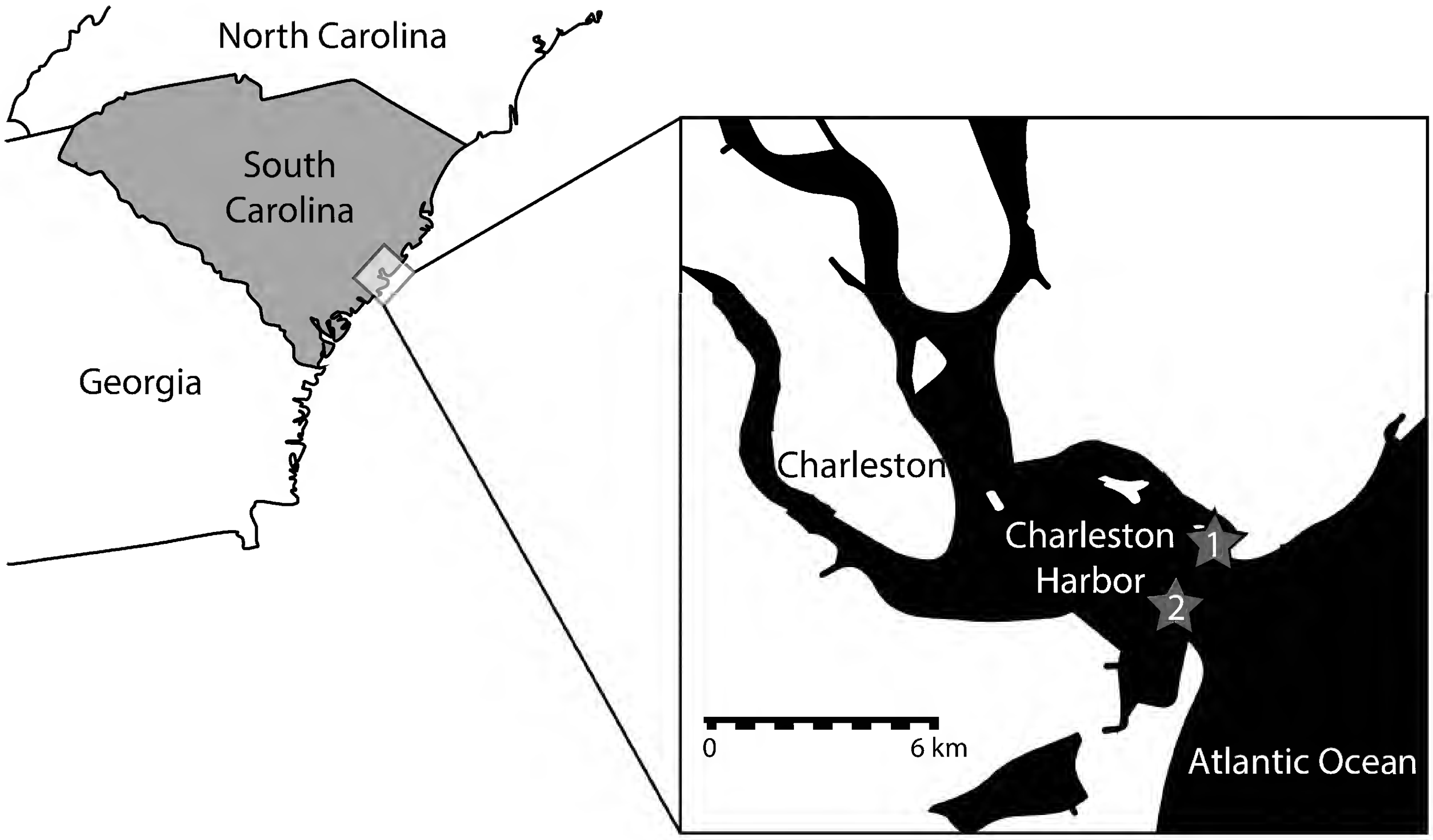

Fig. 1. General map of South Carolina and the Charleston Harbor Area. The locations of Fort Moultrie (1) and Fort Sumter (2) are designated by gray stars.

Montgomery's (ferns) private herbarium while and Gordon Tucker's (Cyperaceae) material is housed at Eastern Illinois University Herbarium (EIU). Accession numbers for taxa collected in the 2008–2010 study and taxa reported exclusively by Schmidt (2004) but not by us are included in the appendix. Because many of Schmidt's exclusive taxa from 2004 are not accessioned, we designate these taxa as "sight record."

The species checklist at both forts contains an inventory of the vascular plant species that reproduce spontaneously and persist for one growing season, including native species, naturalized and adventive weeds, and escapes from cultivation. Plant species collected or identified exclusively by Schmidt (2004) are annotated as such in the checklist. All non-native species are designated using an asterisk (*). Native and non-native status follows that of Gleason and Cronquist (1991) and Wunderlin (1998). The checklist is divided into four categories: Polypodiophyta, Pinophyta, Magnoliophyta: Magnoliopsida, and Magnoliophyta: Liliopsida. Radford et al. (1968) was used as the initial guide for identification, but the names of all taxa were verified using the working draft from 30 November 2012 of the *Flora of the Southern and Mid-Atlantic States* (Weakley 2012). If taxonomy or synonymy was in question, the Integrated Taxonomic Information System (ITIS) and the International Plant Names Index (IPNI) were used for verification. Annotated names reflect currently accepted nomenclature from these sources.

RESULTS

Four plant communities as described by Stalter and Lamont (1993) occur at Fort Moultrie: 1) a large salt marsh community dominated by *Spartina alterniflora* Loisel; 2) a dune community dominated by graminoids and forbs; 3) a ruderal community consisting of lawns, fields, roadsides and thickets; and 4) a maritime woodland. All but the maritime woodland occur at Fort Sumter where a large ruderal, salt marsh and small dune community are present. The ruderal community at both forts supports the greatest number of taxa.

Salt Marsh Community.—The salt marsh community is best developed at Fort Moultrie near the dock. Common species there and at Fort Sumter include *Spartina alterniflora*, *S. patens* (Ait.) Muhl., *Salicornia depressa* Stanl., *Sesuvium portulacastrum* (L.) L., *Borrichia frutescens* (L.) DC. and *Sporobolus virginicus* (L.) Kunth. The distribution of these taxa along an elevation (tidal) and salinity gradient has been well documented previously (Stalter 1973; Baden et al. 1973; Stalter and Lamont, 1993). *Spartina alterniflora*, the most flood tolerant species, occupies the greatest area of salt marsh at both sites.

Dune Community.—*Uniola paniculata* L. is the dominant species of the primary dune system at Fort Moultrie. At both Fort Moultrie and Fort Sumter, the state rare *Oenothera drummondii* Hook. thrives and is especially conspicuous when in flower. Additional members of the dune community are *Spartina patens* (Ait.) Muhl., *Cakile edentula* (Bigelow) Hook., *Salsola kali* L., *Yucca aloifolia* L., *Strophostyles helvola* (L.) Ell., *Croton punctatus* Jacq., *Euphorbia polygonifolia* L., *Xanthium strumarium* L. and *Cenchrus tribuloides* L. The dune community is poorly developed at Fort Sumter, occupying a small area of land outside the western portion of the fort. At Fort Moultrie an additional species, *Ipomoea imperati* (Vahl) Griseb., thrives on and in front of the primary dune.

Ruderal Community.—The ruderal community was the largest assemblage at Fort Sumter, composed primarily by lawn inside and outside of the park. The lawn was trimmed several times a month from March–November, making it difficult for annuals to become established. Common species included *Stenotaphrum secundatum* (Walter) Kuntze, *Hydrocotyle umbellata* L., *Medicago arabica* (L.) Huds., *Sisyrinchium rosulatum* Bickn., *Sonchus asper* (L.) Hill., *Oenothera humifusa* Nutt. and *O. laciniata* Hill. *Arenaria serpyllifolia* L. grows in brick crevices within both forts along with *Centella asiatica* (L.) Urb., *Polycarpon tetraphyllum* (L.) L., *Pteris vittata* L. and *Sagina decumbens* (Ell.) Torrey & A. Gray. The weedy border of the visitor center at Fort Moultrie harbors *Vicia sativa* ssp. *nigra* (L.) Ehrh., *V. hirsuta* (L.) Gray, *Medicago arabica* (L.) Huds., *M. lupulina* L., *Hieracium gronovii* L., and *Sonchus asper* (L.) Hill. A small population of *Salvia lyrata* L. thrives on the southern border of Fort Moultrie's Visitor Center. Additional taxa around Fort Moultrie include *Sporobolus indicus* (L.) Br., *Lantana camara* L., *Bromus catharticus* Vahl, *Oenothera speciosa* Nutt., *O. fruticosa* L., and *O. drummondii* Hook. *Oenothera speciosa* Nutt. was abundant in the unmowed fields at Fort Moultrie in 1990, but was rare in the often-mowed fields at the fort in 2008–2010. A Florida species, *Asparagus densiflorus* (Kunth) Jessop., was observed in a thicket bordering the road on the southeastern side of the fort in 2009 and had spread to additional sections of the park by 2011. The species has been previously reported in Beaufort County, South Carolina (Damrel 2009, pers. comm.). *Ranunculus muricatus* L. was common at Fort Moultrie in the northern portion of the lawn, but not observed in 1990. One additional southern taxa observed by us for the first time at Fort Moultrie was *Tillandsia recurvata* (L.) L.

Maritime Woodland.—The maritime woodland community occurring exclusively at Fort Moultrie is comprised of *Quercus virginiana* Mill., *Sideroxylon tenax* L., *Celtis laevigata* Willd., *Prunus caroliniana* (Mill.) Ait. and *Juglans cinerea* L. Additional woody species are *Prunus angustifolia* Marshall, *Zanthoxylum clava-herculus* L., *Campsis radicans* (L.) Seem, *Ilex vomitoria* Ait., *Ligustrum sinense* Lour., and *Wisteria sinensis* (Sims) DC. Herbaceous plants along the woodland edges include *Canna* × *generalis* L.H. Bailey, *Verbena brasiliensis* Vell., *Paspalum floridanum* Michx., *Coreopsis basalis* (A. Dietr.) S.F. Blake, *Chaerophyllum tainturieri* Hook., and *Sorghum halepense* (L.) Pers.

The vascular flora at Fort Moultrie consists of 303 taxa in 72 families representing 198 genera (see Table 1). The Asteraceae (51 taxa) and Poaceae (40 taxa) were the largest families in the flora comprising 30% of the taxa sampled. The third largest family was the Cyperaceae with 16 taxa. *Cyperus*, with 9 taxa, was the largest genus in the flora. An annotated list of taxa at Fort Moultrie is provided below, while a summary of the flora is listed in Table 1.

Seventy-five taxa at Moultrie observed by us in 1990 were not reobserved in 2008–2010, including 16 monocots and 59 dicots. Eleven new monocots and 10 new dicots were collected at Fort Moultrie for the first time. Of the 303 taxa observed in our twenty-year study, 96 taxa (32%) either colonized or were extirpated at the site.

The vascular flora at Fort Sumter consisted of 77 taxa in 24 families representing 63 genera (see Table 2). The Poaceae (17 taxa) and Asteraceae (15 taxa) were the largest families comprising 42% of the flora. *Cyperus*, with 3 taxa, was the largest genus in the flora. No other genus had more than two taxa. Taxa at Fort Sumter are listed below in the annotated list, while a summary is provided in Table 2. We observed six new taxa at Fort

Table 1. A summary of the vascular flora of Fort Moultrie, South Carolina.

	Ferns	Gymnosperms	Dicots	Monocots	Total
Family	2	2	54	14	72
Genus	2	3	145	48	198
Native species	1	3	159	59	223 (73.6%)
Non-native species	1	0	63	17	80 (26.4%)
Total species	2	3	222	76	303

Table 2. A summary of the vascular flora of Fort Sumter, South Carolina.

	Ferns	Gymnosperms	Dicots	Monocots	Total
Family	2	0	18	4	24
Genus	2	0	44	18	64
Native species	1	0	36	14	51 (65.4%)
Non-native species	1	0	17	9	27 (34.6%)
Total species	2	0	53	23	78

Sumter during the 2008–2010 collecting season, including three new species of *Cyperus*. During the twenty-year study, 17 taxa (27%) were identified as colonists or were extirpated. Non-native taxa composed 34.6% of the flora occurring on land within Fort Sumter. The combined vascular flora at Fort Moultrie and Fort Sumter one year after Hurrcane Hugo (1990) consisted of 63 families, 161 genera, and 287 species. Fort Moultrie, the larger of the two sites, supported 218 vascular plant species including one spore plant, three gymnosperms, 185 dicots and 44 monocots. Sixteen fewer taxa were collected at Fort Moultrie during the three-year collecting period from 2008–2010. Sixty-nine species occurred at Fort Sumter in 1990, while 66 species were observed during the collecting period from 2008–2010.

DISCUSSION

Four more monocots were found at Fort Moultrie during the 1990 collecting period than in the three-year collecting period from 2008–2010. The higher number of monocots, immediately after Hurricane Hugo, was most likely due to the lack of mowing, allowing more successional forbs and grasses to thrive.

Two tropical/subtropical species have been identified at Fort Moultrie—*Tillandsia recurvata* and *Asparagus densiflorus*. *Tillandsia recurvata* was observed at the Visitor Center growing on live oak (*Quercus virginiana* Mill.) near the NPS dock. This tree was planted by the NPS and probably originated as landscape material from Florida although no documentation is available. Alan Weakley and Dixie Damrel (pers. comm. 2009) have reported *T. recurvata* as introduced in coastal South Carolina in Beaufort, Jasper, Georgetown, and Charleston counties, brought to South Carolina on nursery stock shipped from Florida, and Carter et al. (2009) report from it similarly in Georgia.

Asparagus densiflorus has also been reported in Beaufort Co., South Carolina, by Daniel C. Payne (Damrel, pers. comm.). Material was collected by Payne at 100 Laurens St., Beaufort, South Carolina, on 6 January 2005, the Shell Convience Store, Lady's Island Shopping Center, Hwy 21, Lady's Island, South Carolina, on 6 January 2006, and as an epiphyte at the entrance to Hampton Plantation Bluffton, South Carolina, 23 December 2006. Although Wunderlin (1998) reported that *A. densiflorus* is common in central Florida and rare northward, the species can survive the cold temperatures of coastal South Carolina winters, as demonstrated in 2008–2009 when temperatures dropped lower than -6°C.

In summary, the number of taxa at both Fort Moultrie and Fort Sumter decreased from 1990 to 2008–2010. Fort Moultrie lost 75 of its original taxa while gaining 21 new colonists. Eleven taxa present at Fort Sumter in 1990 were not observed in the present study; 6 new taxa were observed including three species of *Cyperus*. Schmidt (2004) reported several taxa at Fort Moultrie that were not observed by us during the 1990 and

2008–2010 collecting periods. Since taxa invade and become extirpated at a site from year to year the differences in taxa numbers was expected. Disturbance from Hurrricane Hugo, during September 1989, may have created new open habitats for taxa to colonize, and the absence of mowing the large field between the dunes and Fort Moultire may account for the higher number of taxa identified during the 1990 collecting season.

ANNOTATED CHECKLIST OF SPECIES

The vascular plant taxa have been arranged according to the following categories: vascular cryptograms, gymnosperms, dicots, and monocots. Within each category, families and lower taxa are arranged alphabetically. Asterisks (*) are used to designate non-native taxa. Nomenclature at lower taxonomic levels follows the working draft from 30 November 2012 of the Flora of the Southern and Mid-Atlantic States (Weakley 2012). When taxonomy or synonymy was questioned, ITIS and IPNI were used for verification.

FORT MOULTRIE

POLYPODIOPHYTA

Polypodiaceae

Pleopeltis polypodioides ssp. *michauxiana* (Weath.) E.G. Andrews & Windham [=*Polypodium polypodioides* (L.) Watt var. *michauxianum* Weatherby]. Ruderal—masonry walls: rare. Stalter, 29 Mar 1990.

Pteridaceae

**Pteris vittata* L. Ruderal—masonry walls: infreq. Stalter 19479, 2008/10.

PINOPHYTA

Cupressaceae

Juniperus virginiana var. *silicicola* (Small) E Murray. [=*J. silicicola* (Small) Bailey]. Dunes—coastal foredunes and swales: infreq. Stalter, 29 Mar 1990. Stalter 19529, 2008/10.

Taxodium distichum (L.) Rich. Maritime Woodland—ephemeral ponds: rare. Stalter, 27 Aug 1990. Stalter 19771, 2008/10.

Pinaceae

Pinus taeda L. Maritime Woodland: infreq. Stalter, 29 Mar 1990. Stalter 19530, 2008/10.

MAGNOLIOPHYTA MAGNOLIOPSIDA (DICOTS)

Aizoaceae

Sesuvium portulacastrum (L.) L. Salt Marsh: freq. Stalter, 27 Aug 1990. freq. Stalter 19772, 2008/10.

Amaranthaceae (including Chenopodiaceae)

**Alternanthera philoxeroides* (Mart.) Griseb. Ruderal—roadside ditches and moist waste areas: rare. Stalter 19803, 2008/10.

Amaranthus cannabinus (L.) Sauer. Salt Marsh: infreq. Stalter, 27 Aug 1990.

Atriplex mucronata Raf. [=*A. arenaria* Nutt.]. Dunes: infreq. Stalter, 26 Oct 1990. Stalter 19805, 2008/10.

Atriplex prostrata Boucher ex DC. [=*A. hastata* L.]. Salt Marsh and Dunes: freq. Stalter, 27 Aug 1990. Stalter 19804/20254, 2008/10.

**Chenopodium album* L. Ruderal—roadsides and waste places: freq. Stalter 19806, 2008/10.

**Dysphania ambrosioides* (L.) Mosyakin & Clemants. [=*Chenopodium ambrosioides* L.]. Ruderal—swales, fields and disturbed sands: freq. Stalter, 27 Aug 1990. Stalter 19573, 2008/10.

Iresine rhizomatosa Standl. Salt Marsh—edges of tidal marshes: infreq. Stalter, 26 Oct 1990.

Salicornia virginica L. Salt Marsh: freq. Stalter 19534, 2008/10.

Salicornia maritima Wolff & Jefferies (synonymy incomplete). Salt Marsh: infreq. Stalter 19807, 2008/10.

Salsola kali L. Dunes—upper beach: freq. Stalter, 26 Oct 1990. Stalter 19937, 2008/10.

Suaeda linearis (Ell.) Moq. Salt Marsh: freq. Stalter, 26 Oct 1990.

Anacardiaceae

Rhus copallinum L. Maritime Woodland—open, dry, waste places and swales: freq. Stalter, 27 Aug 1990. Stalter 19532, 2008/10.

Toxicodendron radicans var. *radicans* (L.) Kuntze [=*Rhus radicans* L.]. Maritime Woodland—shrublands, disturbed sands; freq. 1990, 2008/10. No specimens collected.

Apiaceae

Centella asiatica (L.) Urb. [=*C. erecta* (L. f.) Fernald.]. Ruderal—moist fields and other open moist, sandy places: freq. Stalter, 26 Oct 1990.

Chaerophyllum tainturieri Hook. Ruderal—fields and waste places: infreq. to locally freq. Stalter, 29 Mar 1990.

**Daucus carota* L. Ruderal—roadsides and waste places: infreq to locally freq. Stalter, 27 Aug 1990.

Ptilimnium capillaceum (Michx.) Raf. Ruderal—apparently salt tolerant: infreq to locally freq. Stalter, 29 Mar 1990. Stalter 19938, 2008/10.

Aquifoliaceae

Ilex opaca Ait. Maritime Woodland: infreq. Stalter, 27 Aug 1990. Stalter 19574, 2008/10.

Ilex vomitoria Ait. Ruderal and Maritime Woodland—swales, thickets, and fields: freq. Stalter, 29 Mar 1990. Stalter 19575, 2008/10.

Araliaceae

Hydrocotyle bonariensis Lam. Dunes—moist, open swales: infreq. Stalter, 29 Mar 1990. Stalter 20280, 2008/10.

Hydrocotyle umbellata L. Dunes—moist, open swales: infreq. Stalter, 29 Mar 1990.

Hydrocotyle verticillata Thunb. Sight record. Schmidt 2004.

Asteraceae

**Achillea millefolium* L. Ruderal: freq. Stalter, 14 Jun 1990.

Ambrosia artemisiifolia L. Ruderal: freq. Stalter, 29 Mar 1990. Stalter 19480, 008/10.

**Artemisia vulgaris* L. Ruderal—disturbed site adjacent to the Visitor's Center: rare. Stalter, 14 Jun 1990.

Baccharis halimifolia L. Salt Marsh: freq. Stalter, 29 Mar 1990. Stalter 19481, 2008/10.

Bidens bipinnata L. Ruderal: infreq. Stalter 20055, 2008/10.

Borrichia frutescens (L.) DC. Salt Marsh: freq. Stalter, 27 Aug 1990, Stalter 20056, 2008/10.

Carphephorus sp. Sight record. Schmidt 2004.

Cirsium nutallii DC. Ruderal—fields: infreq. Stalter, 27 Aug 1990.

Conoclinium coelestinum (L.) DC. [=*Eupatorium coelestinum* L.]. Ruderal—fields: infreq. Stalter, 26 Oct 1990.

**Conyza bonariensis* (L.) Cronq. [=*Erigeron bonariensis* L.]. Ruderal—disturbed fields: freq. Stalter, 14 Jun 1990. Stalter 20057, 2008/10.

Conyza canadensis (L.) Cronq. var. *pusilla* (Nutt.) Cronq. [=*Erigeron canadensis* L. var. *pusillus* (Nutt.) Boivin, *non* Ahles]. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19484, 2008/10.

**Coreopsis basalis* (A. Dietr.) Blake. Ruderal—disturbed fields: rare. Stalter, 14 Jun 1990.

Elephantopus nudatus A. Gray. Maritime Woodland: rare. Stalter, 27 Aug 1990.

Elephantopus tomentosus L Sight record. Schmidt 2004.

Erechtites hieracifolius (L.) Raf. ex DC. Ruderal—disturbed fields and waste places: infreq. Stalter, 14 Jun 1990. Stalter 20058, 2008/10.

Erigeron philadelphicus L var. *philadelphicus*. Ruderal—fields: infreq. Stalter, 29 Mar 1990; 26 Oct 1990.

Erigeron quercifolius Lam. Ruderal—fields, roadsides, and waste places: freq. Stalter, 29 Mar 1990. Stalter 19486, 2008/10.

Erigeron strigosus Muhl. ex Willd. Ruderal—fields and waste places: freq. Stalter, 29 Mar 1990; 14 Jun 1990.

Eupatorium capillifolium (Lam.) Small. Ruderal—fields and swales: freq. Stalter, 26 Oct 1990. Stalter 20059, 2008/10.

Euthamia graminifolia (L.) Nutt. [=*Solidago microcephala* (Greene) Bush]. Ruderal—fields and swales: freq. Stalter, 26 Oct 1990. Stalter 20062, 2008/10.

Gaillardia pulchella Foug. Ruderal—sandy waste places and swales: freq. Stalter, 14 Jun 1990; 26 Oct 1990. Stalter 20063, 2008/10.

Gamochaeta argyrinea G.L. Nesom. GA Acc#237534. Schmidt 2004.

**Gamochaeta calviceps* (Fernald) Cabrera [=*G. falcata* (Lam.) Cabrera]. Sight record, Schmidt 2004.

Gamochaeta pensylvanica (Willd.) Cabrera. GA Acc# 237530, GA Acc#237475. Schmidt 2004.

Gamochaeta purpurea (L.) Cabrera. [=*Gnaphalium purpureum* L. var. *purpureum*]. Ruderal—fields lawns, roadsides, and waste places: freq. Stalter 19487, 1990. Stalter 20061, 2008/10.

Heterotheca subaxillaris (Lam.) Britton & Rusby. Ruderal—disturbed sands and waste places: freq. Stalter, 26 Oct 1990. Stalter 19488, 2008/10.

Hieracium gronovii L. Ruderal—lawns and fields: infreq. Stalter 19489, 2008/10.

**Hypochaeris chillensis* (Kunth) Britton. Ruderal—sandy waste places: rare. Stalter, 29 Mar 1990.

**Hypochaeris glabra* L. Ruderal—lawns, fields, and waste places: infreq. Stalter, 29 Mar 1990. Stalter 19490, 2008/10.

Iva frutescens L. Salt Marsh: freq. Stalter, 29 Mar 1990. Stalter 19491, 2008/10.

Lactuca canadensis L. Dunes—along seashore: infreq. Stalter, 14 Jun 1990. Stalter 19492, 2008/10.

Pluchea camphorata (L.) DC. Ruderal—moist soil and ephemeral ponds: freq. Stalter 20281 2008/10.

Pluchea carolinensis (Jacq.) G. Don. Schmidt 2004. According to Wunderlin (l998) this taxon occupies the southern portion of the Florida penninsula.

Pluchea odorata var. *odorata* (L.) Cass. Ruderal—roadside ditch and moist (fresh to brackish) places: infreq to locally freq. Stalter, 27 Aug 1990. Stalter 20253, 2008/10.

Pseudognaphalium obtusifolium (L.) Hillard & Burtt. Ruderal—fields and swales: freq. Stalter, 29 Mar 1990.

Pyrrhopappus carolinianus (Walter) DC. Ruderal—fields and waste places: infreq. Stalter, 29 Mar 1990. Stalter 19493, 2008/10.

**Senecio vulgaris* L. Ruderal—lawns and waste places: infreq. Stalter, 14 Jun 1990. Stalter 19494, 2008/10.

Solidago odora Ait. Ruderal—thickets: infreq. Stalter, 26 Oct 1990.

Solidago rugosa var. *aspera* (Ait.) Fernald. Ruderal—fields: infreq. Stalter, 26 Oct 1990. Stalter 20062, 2008/10.

Solidago mexicana L. Dunes—upper beach and swales: freq. Stalter, 26 Oct 1990. Stalter 20064, 2008/10.

Solidago stricta Ait. Ruderal—roadside ditch: rare. Stalter, 26 Oct 1990.

**Sonchus asper* (L.) Hill. Ruderal—disturbed sands and waste places: infreq. Stalter, 29 Mar 1990.

**Sonchus oleraceus* L. Ruderal—disturbed sands: rare. Stalter, 14 Jun 1990. Stalter 19495, 2008/10.

Symphyotrichum dumosum (L.) Nesom var. *dumosum* [=*Aster dumosus* L.]. Ruderal—fields: infreq. Stalter, 26 Oct 1990.

Symphyotrichum pilosum (Gray) Nesom var. *pringlei* [=*Aster pilosus* var. *demotus* Blake]. Ruderal—moist roadsides: infreq. Stalter, 26 Oct 1990.

Symphyotrichum subulatum (Michx.) Nesom [=*Aster subulatus* var. *subulatus* Michx.]. Ruderal—roadside ditches: infreq. to locally freq. Stalter, 26 Oct 1990.

Symphyotrichum tenuifolium (L.) Nesom [=*Aster tenuifolius* L.]. Salt Marsh: infreq. to locally freq. Stalter, 26 Oct 1990. Stalter 20065, 2008/10.

* *Taraxacum erythrospermum* Andrz. ex Besser. [=*Taraxacum laevigatum* (Willd.) DC.]. Ruderal—lawns: rare. Stalter, 29 Mar 1990.

**Taraxacum officinale* Weber ex Wigg. Ruderal—lawns and disturbed sites: freq. Stalter 29 Mar 1990. Stalter 19496, 2008/10.

Xanthium strumarium L. [=*X. echinatum* Murray]. Dunes: infreq. Stalter 20066, 2008/10.

**Youngia japonica* (L.) DC. [=*Crepis japonica* (L.) Benth.]. Ruderal—disturbed sites: rare. Stalter, 14 Jun 1990.

Bignoniaceae

Bignonia capreolata L. [=*Anisostichus capreolata* (L.) Bureau]. Ruderal—thickets: rare. Stalter, 14 Jun 1990.

Campsis radicans (L.) Seem. ex Bureau. Ruderal—edge of field on trees: rare. Stalter, 14 Jun 1990. Stalter 19535, 2008/10.

Boraginaceae

**Buglossoides arvensis* (L.) I.M. Johnst ssp. *arvensis*. Ruderal—roadsides and sandy fields: infreq. Stalter, 14 Jun 1990.

Brassicaceae

Cakile edentula (Bigelow) Hook. Dunes—upper beach: freq. Stalter, 29 Mar 1990. Stalter 19596, 2008/10.

**Cardamine hirsuta* L. Ruderal—disturbed sands and roadsides: infreq. Stalter, 29 Mar 1990. Stalter 19537, 2008/10.

Caradamine pensylvanica Muhl. ex Willd. Ruderal—moist fields and lawns: infreq. Stalter, 29 Mar 1990.

Descurainia pinnata (Walter) Britton. Ruderal—sandy fields and waste places: freq. Stalter, 29 Mar 1990. Stalter 19575, 2008/10.

**Lepidium didymum* L. Ruderal—fields, roadsides, and disturbed habitats: freq. Stalter, 29 Mar 1990.

Lepidium virginicum L. ssp. *virginicum*. Ruderal—disturbed sands, fields, roadsides, and waste places: freq. Stalter, 29 Mar 1990. Stalter 19577, 2008/10.

Cactaceae

Opuntia ficus-indica (L.) P. Mill. Dunes—swales: rare. Stalter 19538, 2008/10.

Opuntia humifusa (Raf.) Raf. Dunes—swales and sandy waste places: infreq, but locally abundant. Stalter, 27 Aug 1990. Stalter 19539, 2008/10.

Opuntia pusilla (Haw.) Nutt. Dunes—swales: rare. Stalter, 27 Aug 1990. Stalter 19540, 2008/10.

Campanulaceae

Triodanis perfoliata (L.) Nieuwl. Ruderal—disturbed sands and waste places: infreq. Stalter, 29 Mar 1990. Stalter 19576, 2008/10.

Cannabaceae

Celtis laevigata Willd. Maritime Woodland—salt marsh border at Visitor's center: infreq. Stalter, 14 Jun 1990. Stalter 19497, 2008/10.

Caprifoliaceae

**Lonicera japonica* Thunb. Ruderal—disturbed sands and fields: freq. Stalter, 29 Mar 1990. Stalter 19498, 2008/10.

Caryophyllaceae

**Arenaria serpyllifolia* L. Ruderal—disturbed sands and pavement cracks: rare. Stalter, 29 Mar 1990. Stalter 19499, 2008/10.

**Cerastium fontanum* Baumg. var. *vulgare* (Hartman) Greuter & Burdet. Sight record. Schmidt 2004.

**Cerastium glomeratum* Thuill. Ruderal—lawns and disturbed sites: freq. Stalter, 29 Mar 1990.

**Polycarpon tetraphyllum* (L.) L. ssp. *tetraphyllum*. Ruderal—lawns and disturbed sites: rare. Stalter, 29 Mar 1990.

**Stellaria media* (L.) Vill. Ruderal—lawns, fields, and waste places: freq. Stalter, 29 Mar 1990. Stalter 19500, 2008/10.

Cistaceae

Lechea mucronata Raf. GA Acc# 237706. Schmidt 2004.

Convolvulaceae

Dichondra carolinensis Michx. Ruderal—lawn: rare, only one population seen adjacent to casemate wall. Stalter, 14 Jun 1990. Stalter 19939, 2008/10.

Ipomoea carnea ssp. *fistulosa* (Mart. ex Choisy) D. Austin. Schmidt 2004.

Ipomoea imperati (Vahl) Griseb. [=*I. stolonifera* (Cirillo) J.F. Gmelin]. Dunes—upper beach: infreq. Stalter, 27 Aug 1990. Stalter 20282, 2008/10.

Ipomoea lacunosa L. Dunes and Ruderal—waste places: freq. Stalter, 26 Oct 1990. Stalter 19940, 2008/10.

Ipomoea *pandurata* (L.) G. Mey. Ruderal—fields: infreq. Stalter, 26 Oct 1990.

Ipomoea sagittata Poir. Salt Marsh—upper fringe: freq. Stalter, 14 Jun 1990. Stalter 19941, 2008/10.

Cucurbitaceae

**Citrullus lanatus* (Thunb.) Matsum. & Nakai ssp. *lanatus*. Dunes—upper beach: rare. Stalter, 26 Oct 1990.

Melothria pendula L. Ruderal—swales and fields: infreq. Stalter, 27 Aug 1990. Stalter 19942, 2008/10.

Ebenaceae

Diospyros virginiana L. Ruderal—successonal fields: rare. Stalter, 14 Jun 1990.

Elaeagnaceae

**Elaeagnus pungens* Thunb. Ruderal—roadside: rare. Stalter, 29 Mar 1990. Stalter 19541, 2008/10.

Euphorbiaceae

Acalypha gracilens A. Gray. Ruderal—disturbed sands: infreq. to locally freq.. Stalter 19943, 2008/10.

Croton glandulosus L. var. *septentrionalis* Müll. Arg. Ruderal—swales and disturbed sands: freq. Stalter, 14 Jun 1990; 26 Oct 1990. Stalter 20254, 2008/10.

Croton willdenowii Webster. Schmidt 2004.

Croton punctatus Jacq. Dunes: infreq. Stalter, 26 Oct 1990. Stalter 19542, 2008/10.

Euphorbia heterophylla L. Ruderal—disturbed site near fort: rare. Stalter, 26 Oct 1990. Stalter 20255, 2008/10.

Euphorbia maculata L. [=*Chamaesyce maculata* (L.) Small]. Ruderal—lawns, roadsides, disturbed places and waste places: freq. Stalter, 14 Jun 1990. Stalter 19543, 2008/10.

Euphorbia nutans Lag. & Segura [=*Chamaesyce nutans* (Lag.) Small]. Schmidt 2004.

Euphorbia polygonifolia L. [=*Chamaesyce polygonifolia* (L.) Small]. Dunes—upper beaches, foredunes and swales: freq. Stalter, 14 Jun 1990. Stalter 19544, 2008/10.

Fabaceae

**Aeschynomene indica* L. Ruderal—wet roadside ditch: rare. Stalter, 27 Aug 1990.

Centrosema virginianum (L.) Benth. Ruderal—fields and disturbed sites: freq. Stalter, 27 Aug 1990.

Chamaecrista fasciculata (Michx.) Greene var. *fasciculata* [=*Cassia fasciculata* Michx.]. Ruderal—roadsides and disturbed sands: freq. Stalter, 29 Mar 1990. Stalter 20256, 2008/10.

Chamaecrista nictitans (L.) Moench var. *nictitans* [=*Cassia nictitans* L.]. Ruderal—roadsides and disturbed sands: freq. Stalter, 29 Mar 1990.

Clitoria mariana L. var. *mariana*. Ruderal—roadside: rare. Stalter, 27 Aug 1990. Stalter 20257, 2008/10.

Crotalaria spectabilis Roth. Ruderal—fields and disturbed sites: infreq. Stalter, 27 Aug 1990.

Desmodium incanum DC. Sight record. Schmidt 2004.

Galactia volubilis (L.) Britton var. *volubilis*. Ruderal—fields and swales: freq. Stalter, 27 Aug 1990. Stalter 20258, 2008/10.

**Medicago arabica* (L.) Huds. Ruderal—fields and disturbed soil: freq. Stalter 19501, 2008/10.

**Medicago lupulina* L. Ruderal—disturbed sands and roadsides: infreq. Stalter, 29 Mar 1990. Stalter 19502, 2008/10.

**Medicago polymorpha* L. Ruderal—lawns, fields, and waste places: infreq. Stalter 19545, 2008/10.

**Melilotus albus* Medik. Ruderal—roadsides and waste places: freq. Stalter, 29 Mar 1990. Stalter 19503, 2008/10.

**Melilotus officinalis* (L.) Pallas. Ruderal—roadsides: infreq. Stalter, 29 Mar 1990.

Senna obtusifolia (L.) Irwin & Barneby. GA Acc#237795. Schmidt 2004.

Sesbania punicea (Cav.) Benth. Dunes: freq. Stalter, 27 Aug 1990. Stalter 20259, 2008/10.

Sesbania vesicaria (Jacq.) Ell. Ruderal—side of path to beach: rare. Stalter 20260, 2008/10.

Strophostyles helvola (L.) Ell. Dunes—swales and disturbed sands: infreq. Stalter, 26 Aug 1990. Stalter 19504, 2008/10.

**Trifolium dubium* Sibth. Ruderal—lawns and roadsides: freq. Stalter, 14 Jun 1990.

**Trifolium repens* L. Ruderal—lawns: infreq. Stalter, 14 Jun 1990. Stalter 19505, 2008/10.

**Vicia hirsuta* (L.) Gray. Ruderal—fields: rare. Stalter, 29 Mar 1990.

Vicia sativa L. ssp. *nigra* (L.) Ehrh. Ruderal—swales and disturbed sands: infreq. Stalter, 29 Mar 1990; visitor center: freq. Stalter 19506, 2008/10.

**Wisteria sinensis* (Sims) DC. Ruderal—border of dune and moist roadside ditch: rare. Stalter, 14 Jun 1990. Stalter 19579, 2008/10.

Fagaceae

Quercus chapmanii Sarg. GA Acc#237568. Schmidt 2004.

Quercus geminata Small. GA Acc#237817. Schmidt 2004.

Quercus laurifolia Michx. Maritime Woodland—thickets: infreq. Stalter, 29 Mar 1990, Stalter 19546, 2008/10.

Quercus nigra L. Maritime Woodland: rare Stalter, 27 Aug 1990.

Quercus virginiana Mill. Maritime Woodland—fields and scattered stations: infreq but widespread. Stalter, 29 Mar 1990. Stalter 19547, 2008/10.

Gentianaceae

Sabatia stellaris Pursh. Salt Marsh: rare. Stalter, 14 Jun 1990; Dunes: infreq. Stalter, 14 Jun 1990. Stalter 19808, 2008/10.

Geraniaceae

Geranium carolinianum L. Ruderal—fields and disturbed sands: freq. Stalter, 29 Mar 1990. Stalter 19548, 2008/10.

Hypericaceae

Hypericum gentianoides (L.) Britton, Sterns & Poggenb. Ruderal—swales and disturbed sands: locally freq. Stalter, 14 Jun 1990.

Hypericum hypericoides (L.) Crantz. Ruderal—swales: rare. Stalter, 27 Aug 1990. Stalter 19809, 2008/10.

Juglandaceae

**Carya illinoinensis* (Wangenh.) Koch. Maritime Woodland—near fort, persistent after cultivation: rare. Stalter, 26 Oct 1990.

Juglans cinerea L. Maritime Woodland: rare. Stalter 19507, 2008/10.

Lamiaceae

Callicarpa americana L. Ruderal—fields and swales: infreq. Stalter, 26 Oct 1990. Stalter 19578, 2008/10.

**Lamium amplexicaule* L. var. *amplexicaule*. Ruderal—lawns, fields, waste places: freq. Stalter, 29 Mar 1990. Stalter 19508, 2008/10.

Salvia lyrata L. Ruderal—only along hedgerow near visitor's center: rare. Stalter, 14 Jun 1990. Stalter 19509, 2008/10.

**Stachys floridana* Shuttlw. ex Benth. Previously identified by Schmidt (2004) as *Salvia floridana*. Ruderal—field borders: freq. Stalter 19810, 2008/10.

Stachys hyssopifolia Michx. Ruderal—field: rare. Stalter, 14 Jun 1990.

Teucrium canadense L. Maritime Woodland—edge of thickets: infreq. Stalter, 26 Oct 1990. Stalter 20269, 2008/10.

**Vitex agnus-castus* L. Ruderal—persistant after cultivation near fort: rare. Stalter, 14 Jun 1990.

Lauraceae

Persea borbonia (L.) Spreng. Maritime Woodland—old stable dunes at maritime forests: rare. Stalter, 29 Mar 1990. Stalter 19510, 2008/10.

Malvaceae

Hibiscus moscheutos L. Dunes—ephemeral ponds: infreq. Stalter 19811, 2008/10.

Kosteletzkya pentacarpos (L.) Ledeb. Dunes—ephemoral ponds: infreq. Stalter 19812, 2008/10.

Sida rhombifolia L. var. *rhombifolia*. Ruderal—field: rare. Stalter, 26 Oct 1990. Stalter 19813, 2008/10.

Meliaceae

**Melia azedarach* L. Ruderal—fields and roadsides; persistent after cultivation: infreq. Stalter, 29 Mar 1990. Stalter 19549, 2008/10.

Molluginaceae

**Mollugo verticillata* L. Ruderal—roadsides and waste places: freq. Stalter, 14 Jun 1990. Stalter 19774, 2008/10.

Moraceae

**Morus alba* L. Ruderal and Maritime Woodland—fields: rare. Stalter, 29 Mar 1990. Stalter 19550, 2008/10.

Morus rubra L. Maritime Woodland—thickets: rare. Stalter, 14 Jun 1990. Stalter 19551, 2008/10.

Myricaceae

Morella cerifera (L.) Small. Ruderal and Maritime Woodland—swales and edges of fields: infreq. Stalter, 29 Mar 1990. Stalter 19580, 2008/10.

Nyctaginaceae

Boerhavia erecta L. Ruderal—sands: infreq. Stalter 19944, 2008/10.

Oleaceae

**Ligustrum japonicum* Thunb. Ruderal and Maritime Woodland—escaped from cultivation near old battery: rare. Stalter, 29 Mar 1990, Stalter 19581/19814, 2008/10.

**Ligustrum sinense* Lour. Ruderal and Maritime Woodland—escaped from cultivation near old battery: infreq. Stalter, 29 Mar 1990. Stalter 19552, 2008/10.

Onagraceae

Ludwigia maritima R.M. Harper. Ruderal—moist roadside ditch: infreq. Stalter, 29 Mar 1990. Stalter 19815, 2008/10.

Oenothera biennis L. Dunes: rare. Stalter, 27 Aug 1990. Stalter 19816/19945, 2008/10.

Oenothera drummondii Hook. ssp. *drummondii*. Dunes: freq. but rare in the Carolinas (Radford et al. 1968). Stalter, 29 Mar 1990. Stalter 19817, 2008/10.

Oenothera fruticosa L. Sight record. Schmidt 2004.

Oenothera humifusa Nutt. Dunes: infreq. Stalter, 27 Aug 1990.

Oenothera laciniata Hill. Ruderal—disturbed sands and fields: freq. Stalter, 29 Mar 1990. Stalter 19818, 2008/10.

**Oenothera speciosa* Nutt. Ruderal—fields: infreq. to locally freq. Stalter, 29 Mar 1990. Stalter 19775, 2008/10.

Oxalidaceae

Oxalis articulata Savigny [=*O. rubra* A. St.-Hil.]. Ruderal—fields: freq. Stalter, 29 Mar 1990. Stalter 19512, 2008/10.

Oxalis dillenii Jacq. Ruderal—disturbed sands and waste places: infreq. Stalter, 29 Mar 1990. Stalter 19511, 2008/10.

Phytolaccaceae

Phytolacca americana L. Ruderal—swales and disturbed fields: infreq. Stalter, 29 Mar 1990. Stalter 19513, 2008/10.

Pittosporaceae

**Pittosporum tobira* (Thunb.) Ait. Ruderal—persistent after cultivation. Stalter 19581, 2008/10.

Plantaginaceae

Nuttallanthus canadensis (L.) D.A. Sutton [=*Linaria canadensis* (L.) Dum. Cors.]. Ruderal—swales, disturbed sands, and waste places: freq. Stalter, 29 Mar 1990. Stalter 19553, 2008/10.

**Plantago aristata* Michx. Ruderal—sandy waste places, roadsides, fields, and lawns: freq. Stalter, 29 Mar 1990; 14 Jun 1990.

**Plantago lanceolata* L. Ruderal—disturbed fields and lawns: freq. Stalter, 29 Mar 1990. Stalter 19554, 2008/10.

Plantago major L. Ruderal—disturbed fields and lawns: rare. Stalter, 14 Jun 1990. Stalter 19555, 2008/10.

Plantago virginica L. Ruderal—lawns: rare. Stalter, 29 Mar 1990. Stalter 19556, 2008/10.

**Veronica arvensis* L. Ruderal—lawns and waste places: freq. Stalter, 29 Mar 1990. Stalter 19557, 2008/10.

Veronica peregrina L. Ruderal—moist fields: infreq. Stalter, 29 Mar 1990. Stalter 19558, 2008/10.

Polemoniaceae

**Phlox drummondii* Hook. Ruderal and Dunes—swales and disturbed sands: infreq. Stalter, 14 Jun 1990. Stalter 19777, 2008/10.

Polygonaceae

**Persicaria maculosa* S.F. Gray [=*Polygonum persicaria* L.]. Ruderal—disturbed moist fields: infreq. Stalter, 14 Jun 1990.

Persicaria punctata (Ell.) Small [=*Polygonum punctatum* Ell.]. Ruderal—fields: infreq. Stalter, 14 Jun 1990. Stalter 19776, 2008/10.

Persicaria virginiana (L.) Gaertn. [=*Polygonum virginianum* L.]. Ruderal—moist roadside ditch: rare. Stalter, 27 Aug 1990.

Rumex conglomeratus Murray. Ruderal—seen only at one moist field: rare. Stalter, 27 Aug 1990.

**Rumex crispus* L. ssp. *crispus*. Ruderal—waste places and fields: infreq. Stalter, 29 Mar 1990. Stalter 19582, 2008/10.

Rumex hastatulus Baldwin. Ruderal—disturbed sands and fields: infreq. Stalter, 29 Mar 1990. Stalter 19583, 2008/10.

Rumex verticillatus L. Ruderal—moist roadside ditch: rare. Stalter, 27 Aug 1990.

Portulacaceae

**Portulaca oleracea* L. Ruderal—disturbed sands, seen only at Visitor's Center: rare. Stalter, 14 Jun 1990. Stalter 19584, 2008/10.

**Portulaca pilosa* L. Ruderal—dry sandy fields: rare. Stalter, 14 Jun 1990. Stalter 19585, 2008/10.

Rananculaceae

Ranunculus muricatus L. Ruderal—fields: freq. Stalter 19559, 2008/10.

Rosaceae

Prunus angustifolia Marshall. Dunes: rare. Stalter, 14 Jun 1990. Stalter 19515, 2008/10.

Prunus caroliniana (Mill.) Ait. Maritime Woodland—edge of swales: infreq. Stalter, 29 Mar 1990. Stalter 19516, 2008/10.

Prunus serotina Ehrh. var. *serotina*. Maritime Woodland—swales and fields: infreq. Stalter, 29 Mar 1990. Stalter 19517, 2008/10.

Rubus pensilvanicus Poir. [=*R. argutus* Link]. Ruderal and Dunes—swales and disturbed sands: infreq. Stalter, 29 Mar 1990.

Rubus trivialis Michx. Ruderal and Dunes—swales and fields: freq. Stalter, 29 Mar 1990. Stalter 19819, 2008/10.

Rubiaceae

Diodia teres Walter. Ruderal—swales and disturbed sands: freq. Stalter, 14 Jun 1990; 26 Oct 1990. Stalter 19820, 2008/10.

Diodia virginiana L. Ruderal—moist roadside ditch and moist field: infreq. Stalter, 14 Jun 1990. Stalter 19821, 2008/10.

Galium tinctorium (L.) Scopoli var. *tinctorium*. Ruderal—moist field: rare. Stalter, 27 Aug 1990.

Oldenlandia uniflora L. Ruderal—fields: rare. Stalter, 14 Jun 1990.

**Richardia scabra* L. Ruderal—waste places: rare. Stalter, 27 Aug 1990.

Rutaceae

Zanthoxylum clava-herculis L. Dunes—swales: infreq. Stalter, 29 Mar 1990. Stalter 19513, 2008/10.

Salicaceae

**Populus alba* L. Ruderal—waste places: infreq. Stalter, 29 Mar 1990. Stalter 19514, 2008/10.

Populus heterophylla L. Ruderal—moist field: rare. Stalter, 29 Mar 1990.

Sapotaceae

Sideroxylon lycioides L. [*Bumelia lycioides* (L.) Pers.]. Maritime Woodland—swales: rare. Stalter, 29 Mar 1990. Stalter 19560, 2008/10.

Sideroxylon tenax L. [=*Bumelia tenax* (L.) Willd.]. Maritime Woodland—thickets and woodland: infreq. Stalter, 27 Aug 1990. Stalter 19561, 2008/10.

Solanaceae

Physalis walteri Nutt. [=*P. viscosa* ssp. *maritima* (M. A. Curtis) Waterf.]. Dunes—swales and dunes: infreq. Stalter, 14 Jun 1990. Stalter 19823, 2008/10.

Solanum americanum Mill. [=*S. nigrum* var. *virginicum* L.]. Ruderal—disturbed sands near margin of salt marsh: rare. Stalter, 29 Mar 1990. Stalter 19822, 2008/10.

Solanum carolinense L. Ruderal—swales and disturbed sands: infreq. Stalter, 14 Jun 1990.

Solanum rostratum Dunal. Ruderal—disturbed fields: infreq. Stalter, 27 Aug 1990.

Tamaricaceae

**Tamarix gallica* L. Salt Marsh—seen only at border between salt marsh and uplands: rare. Stalter, 29 Mar 1990. Stalter 20283, 2008/10.

Tetrachondraceae (previously in Buddlejaceae)

Polypremum procumbens L. Ruderal—dry sandy soil: freq. Stalter, 14 Jun 1990. Stalter 19518, 2008/10.

Verbenaceae

**Lantana camara* L. Ruderal—escaped from cultivation at field near fort: rare. Stalter, 29 Mar 1990. Stalter 19519, 2008/10.

Phyla nodiflora (L.) Greene. Ruderal—moist disturbed sands: infreq. to locally freq. Stalter, 14 Jun 1990. Stalter 19946, 2008/10.

**Verbena bonariensis* L. Ruderal—edge of fields: freq. Stalter, 14 Jun 1990. Stalter 19947, 2008/10.

**Verbena brasiliensis* Vell. Ruderal—fields: infreq. Stalter, 14 Jun 1990. Stalter 19948, 2008/10.

Vitaceae

Ampelopsis arborea (L.) Koehne. Ruderal—swales: infreq. Stalter, 29 Mar 1990. Stalter 19562, 2008/10.

Parthenocissus quinquefolia (L.) Planch. Maritime Woodland—swales, thicket: infreq. Stalter, 29 Mar 1990. Stalter 19563, 2008/10.

Vitis aestivalis Michx. Maritime Woodland: infreq. Stalter, 29 Mar 1990. Stalter 19564, 2008/10.

LILIOPSIDA (MONOCOTS)

Agavaceae

**Yucca aloifolia* L. Dunes—swales: infreq. Stalter, 29 Mar 1990. Stalter 19825, 2008/10.

Yucca filamentosa L. Dunes—protected dunes and dry sands: infreq. Stalter, 29 Mar 1990. Stalter 19826, 2008/10.

Amaryllidaceae

**Nothoscordum bivalve* (L.) Britton. Ruderal—fields: rare. Stalter, 29 Mar 1990.

Zephyranthes atamasco (L.) Herb. Ruderal—lawn in front of fort: infreq. Stalter, 14 Jun 1990. Stalter 19520, 2008/10.

Arecaceae

Sabal palmetto (Walter) Lodd. ex Schult.& Schult. Maritime Woodland—swales: infreq. Stalter, 29 Mar 1990. Stalter 19586, 2008/10.

Asparagaceae

**Asparagus aethiopicus* L. [=*A. densiflorus* (Kunth) Jessop]. Ruderal—roadsides: rare. Stalter 19587, 2008/10.

**Asparagus officinalis* L. Ruderal—roadsides and waste places: infreq. Stalter, 14 Jun 1990; 26 Oct 1990. Stalter 19588, 2008/10.

Bromeliaceae

Tillandsia recurvata (L.) L. Maritime Woodland—epiphyte on *Q. virginiana*: rare. Stalter 19521, 2008/10.

Tillandsia usneoides (L.) L. Maritime Woodland—epiphyte on *Q. virginiana*: infreq. Stalter, 29 Mar 1990.

Cannaceae

**Canna × generalis* L.H. Bailey (pro. sp.) [=*C. glauca × indica*]. Ruderal—persistent after cultivation near fort; entrance to path to beach: locally abundant. Stalter, 14 Jun 1990. Stalter 19827, 2008/10.

Commelinaceae

**Commelina communis* L. Ruderal—roadside ditch: locally abundant. Stalter 19949, 2008/10.

Tradescantia ohiensis Raf. Ruderal—swales and fields: infreq. Stalter, 29 Mar 1990. Stalter 19589, 2008/10.

Cyperaceae

Bolboschoenus robustus (Pursh) Soják. [=*Scirpus robustus* Pursh]. Salt Marsh: rare. Stalter, 14 Jun 1990.

Carex longii Mack. Ruderal—field edges: rare. Stalter, 14 Jun 1990. Stalter 19950, 2008/10.

Cyperus croceus Vahl. [=*C. globulosus* Aubl.]. Ruderal—sandy fields: rare. Stalter, 26 Oct 1990.

Cyperus echinatus (L.) Wood. [=*Cyperus ovularis* (Michx.) Torr.]. Ruderal—fields: rare. 26 Oct 1990.

Cyperus esculentus L. var. *leptostachyus* Boeck. Salt Marsh—swales: infreq to locally freq. Stalter, 26 Oct 1990. Stalter 19829, 2008/10.

Cyperus filicinus Vahl. Ruderal—moist soil: infreq. Stalter 19830, 2008/10.

Cyperus odoratus L. Ruderal—moist soil: infreq. Stalter 19831, 2008/10.

Cyperus pseudovegetus Steud. Ruderal—ditch bordering road: infreq. Stalter 19834, 2008/10.

Cyperus retrorsus Chapm. Ruderal—moist soil: infreq. Stalter, 26 Oct 1990. Stalter 19832, 2008/10.

Cyperus strigosus L. Ruderal—moist soil: infreq. Stalter, 27 Aug 1990. Stalter 19833, 2008/10.

Cyperus surinamensis Rottb. Sight record. Schmidt 2004.

Eleocharis elliptica Kunth. Ruderal—moist depressions: infreq. Stalter 19951, 2008/10.

Eleocharis flavescens (Poir.) Urban. Ruderal—moist edge of roadside ditch: rare. Stalter, 29 Mar 1990; 14 Jun 1990.

Fimbristylis castanea (Michx.) Vahl. Dunes—interdunal depressions; infreq. Stalter 19835, 2008/10.

Fimbristylis puberula (Michx.) Vahl. var. *puberula* [=*F. spadicea* (L.) Vahl.]. Salt Marsh—transition zone between salt marsh and uplands: infreq. Stalter, 26 Oct 1990. Stalter 19836, 2008/10.

Kyllinga brevifolia Rottb. [=*Cyperus brevifolius* (Rottb.) Endl. ex Hassk.]. Schmidt 2004.

Juncaceae

Juncus roemerianus Scheele. Salt Marsh—brackish upper of tidal marshes: infreq. to locally freq. Stalter, 14 Jun 1990. Stalter 19522, 2008/10.

Iridaceae

Sisyrinchium rosulatum Bickn. Ruderal—lawns: freq. Stalter 19523, 2008/10.

Liliaceae

**Allium vineale* L. Ruderal—lawns and fields. Stalter, 29 Mar 1990. Stalter 19524, 2008/10.

**Ornithogalum umbellatum* L. Ruderal—lawns and waste places: infreq. Stalter, 29 Mar 1990. Stalter 19525, 2008/10.

Poaceae

Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. Ruderal—moist sands and old dunes: infreq. Stalter, 26 Oct 1990. Stalter 19837, 2008/10.

Andropogon gyrans Ashe [=*Andropogon elliotii* Chapm.]. Ruderal—swales: infreq. 26 Oct 1990. Schmidt 2004.

Andropogon ternarius Michx. var. *ternarius*. Ruderal—fields and old dunes: infreq. Stalter, 26 Oct 1990.

Andropogon virginicus L. var. virginicus. Ruderal—swales, fields and roadsides: freq. Stalter, 26 Oct 1990. Stalter 19838, 2008/10.

**Arundo donax* L. Ruderal—border of visitor center parking lot: rare. Stalter 19839, 2008/10.

Briza minor L. Ruderal—disturbed sands: infreq. Stalter, 29 Mar 1990. Stalter 19565, 2008/10.

**Bromus catharticus* Vahl. var. *catharticus* [=*B. wildenowii* Kunth.]. Ruderal—roadsides: rare. Stalter, 29 Mar 1990.

Cenchrus longispinus (Hack.) Fernald. Ruderal—sandy fields and waste places: infreq. Stalter, 26 Oct 1990. Stalter 19778, 2008/10.

Cenchrus tribuloides L. Dunes—swales: freq. Stalter, 26 Oct 1990. Stalter 19779, 2008/10.

Chasmanthium laxum (L.) Yates [=*Uniola laxa* (L.) Britton, Sterns & Poggenb.]. Ruderal—moist, sandy fields: infreq. Stalter, 29 Mar 1990.

**Cynodon dactylon* (L.) Pers. Ruderal—lawns, fields, roadsides and disturbed sites: freq. Stalter, 14 Jun 1990. Stalter 19566, 2008/10.

Dichanthelium acuminatum (Sw.) Gould & Clark var. *acuminatum* [=*Panicum lanuginosum* Ell.]. Ruderal—fields: freq. Stalter, 14 Jun 1990.

Dichanthelium commutatum (Schult.) Gould var. *commutatum*. [=*Panicum commutatum* Schult.]. Sight record. Schmidt 2004.

Dichanthelium scabriusculum (Ell.) Gould & C.A. Clark. Schmidt 2004.

**Digitaria sanguinalis* (L.) Scop. Ruderal—roadsides, lawns and disturbed sites: freq. Stalter, 26 Otober 1990. Stalter 19780, 2008/10.

Digitaria violascens Link. Ruderal—sandy roadside: rare. Stalter, 26 Oct 1990.

Distichlis spicata (L.) Greene. Salt Marsh: freq. Stalter, 26 Oct 1990. Stalter 19781, 2008/10.

**Eleusine indica* (L.) Gaertn. Ruderal—roadsides and disturbed sites: infreq. Stalter, 29 Mar 1990; 14 Jun 1990. Stalter 19782, 2008/10.

Elymus virginicus L. var. *halophilus* (Bickn.) Wieg. Salt Marsh—upland borders of brackish water and salt marshes: infreq. Stalter, 29 Mar 1990; 14 Jun 1990. Stalter 19840, 2008/10.

Eustachys petraea (Sw.) Desv. [=*Chloris petraea* Sw.]. Ruderal—swales: rare. Stalter, 26 Oct 1990.

**Lolium perenne* L. var. *aristatum*. Ruderal—fields and lawns: infreq. Stalter, 14 Jun 1990. Stalter 19783, 2008/10.

Muhlenbergia capillaris (Lam.) Trin. Dunes: infreq. Stalter 19841, 2008/10.

Muhlenbergia expansa (Poir.) Trinius [=*M. capillaris* var. t*richopodes* (Ell.) Vasey]. Sight record. Schmidt 2004.

Panicum amarum Ell. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19842, 2008/10.

Panicum dichotomiflorum Michx. Ruderal—moist roadside depressions and borders of marshes: infreq. Stalter, 26 Oct 1990.

**Paspalum dilatatum* Poir. ssp. *dilatatum*. Ruderal—roadsides and waste places: freq. Stalter, 14 Jun 1990; 26 Oct 1990. Stalter 19845, 2008/10.

Paspalum floridanum Michx. Ruderal—fields: infreq. Stalter 19843, 2008/10.

Paspalum notatum Flügge. Ruderal—lawns, fields, and waste places: freq. Stalter, 26 Oct 1990. Stalter 19844, 2008/10.

**Poa annua* L. Ruderal—lawns, roadsides and disturbed sands: freq. Stalter, 29 Mar 1990. Stalter 19526, 2008/10.

Setaria corrugata (Ell.) Schult. Ruderal—fields: freq. Stalter, 27 Aug 1990.

Sorghum halepense (L.) Pers. Ruderal—disturbed sites, ditches: freq. Stalter, 26 Oct 1990. Stalter 19846, 2008/10.

Spartina alterniflora Loisel. Salt Marsh: freq. Stalter, 26 Oct 1990. Stalter 19848, 2008/10.

Spartina patens (Ait.) Muhl. Dunes: infreq. Stalter, 29 Mar 1990; 26 Oct 1990. Stalter 19847, 2008/10.

Sphenopholis nitida (Biehler) Scribn. Sight record. Schmidt 2004.

**Sporobolus indicus* (L.) R. Brown. [=*S. poiretii* (Roem. & Schult.) Hitchc.]. Ruderal—lawns and fields: freq. Stalter, 27 Aug 1990. Stalter 19955, 2008/10.

Sporobolus virginicus (L.) Kunth. Salt Marsh: infreq. to locally freq. Stalter, 14 Jun 1990. Stalter 19849, 2008/10.

Stenotaphrum secundatum (Walter) Kuntze. Ruderal—moist field: infreq. Stalter, 26 Oct 1990.

Triplasis purpurea (Walter) Chapm. var. *purpurea*. Dunes—interdunal swales and dry sandflats: freq. Stalter, 26 Oct 1990. Stalter 19850, 2008/10.

Uniola paniculata L. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19851, 2008/10.

Vulpia octoflora (Walter) Rydb. var. *octoflora* [=*Festuca octoflora* Walter]. Ruderal—lawns and disturbed sands: infreq. Stalter, 14 Jun 1990. Stalter 19956, 2008/10.

Smilacaceae

Smilax auriculata Walter. Dunes: rare. Stalter, 26 Oct 1990. Stalter 19527, 2008/10.

Smilax bona-nox L. Maritime Woodland—successional shrublands and swales: freq. Stalter, 26 Oct 1990. Stalter 19528, 2008/10.

Smilax laurifolia L. Maritime Woodland—thickets: rare. Stalter, 29 Mar 1990.

Typhaceae

Typha latifolia L. Ruderal—wet roadside ditch: rare. Stalter, 26 Oct 1990; ephemeral wet depressions: infreq. Stalter 19784, 2008/10.

FORT SUMTER

POLYPODIOPHYTA

Polypodiaceae

Pleopeltis polypodioides ssp. *michauxiana* (Weath.) E.G. Andrews & Windham [=*Polypodium polypodioides* (L.) Watt var. *michauxianum* Weatherby]. Ruderal—masonry walls: rare. Stalter, 14 Jun 1990.

Pteridaceae

**Pteris vittata* L. Ruderal—masonry walls: infreq. Stalter 19567, 2008/10.

MAGNOLIOPHYTA MAGNOLIOPSIDA (DICOTS)

Aizoaceae

Sesuvium portulacastrum (L.) L. Salt Marsh: freq. Stalter, 14 Jun 1990. Stalter 19568, 2008/10.

Amaranthaceae

Atriplex mucronata Raf. [=*A. arenaria* Nutt.]. Dunes—upper beach and dunes: infreq. Stalter, 14 Jun 1990. Stalter 19786, 2008/10.

**Dysphania ambrosioides* (L.) Mosyakin & Clemants. [=*Chenopodium ambrosioides* L.]. Dunes—upper beach: freq. Stalter, 14 Jun 1990. Stalter 19801, 2008/10.

Salicornia virginica L. Salt Marsh: freq. Stalter 19590, 2008/10.

Salsola kali L. Dunes—upper beach: freq. Stalter, 14 Jun 1990. Stalter 19785, 2008/10.

Suaeda linearis (Ell.) Moq. Salt Marsh: freq. Stalter, 14 Jun 1990.

Asteraceae

**Achillea millefolium* L. Ruderal—disturbed sand outside fort: freq. Stalter, 29 Mar 1990.

Baccharis halimifolia L. Salt Marsh—border: rare. Stalter, 14 Jun 1990; 26 Oct. Stalter 19591, 2008/10.

Borrichia frutescens (L.) DC. Salt Marsh: freq. Stalter, 14 Jun 1990. Stalter 19592, 2008/10.

**Conyza bonariensis* (L.) Cronq. [=*Erigeron bonariensis* L.]. Ruderal—disturbed soil outside fort: freq. Stalter, 14 Jun 1990. Stalter 19800, 2008/10.

Conyza canadensis (L.) Cronq. var. *pusilla* (Nutt.) Cronq. [=*Erigeron canadensis* L. var. *pusillus* (Nutt.) Boivin, *non* Ahles]. Ruderal—disturbed soil ourside fort: freq. Stalter, 14 Jun 1990. Stalter 20157, 2008/10.

Erigeron quercifolius Lam. Ruderal—lawn: freq. Stalter, 29 Mar 1990. Stalter 20158, 2008/10.

Euthamia graminifolia (L.) Nutt. [=*Solidago microcephala* (Greene) Bush]. Dunes: rare. Stalter, 26 Oct 1990. Stalter 19853, 2008/10.

Gamochaeta pensylvanica (Willd.) Cabrera [=Gnaphalium *purpureum* var. *spathulatum* (Lam.) Ahles]. Ruderal—lawn: rare. Stalter, 14 Jun 1990.

Gamochaeta purpurea (L.) Cabrera. [=*Gnaphalium purpureum* L. var. *purpureum*]. Ruderal—lawn: freq. Stalter, 29 Mar 1990; 14 Jun 1990. Stalter 19854, 2008/10.

Heterotheca subaxillaris (Lam.) Britton & Rusby. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19855, 2008/10.

Iva imbricata Walter. Dunes: infreq. Stalter, 26 Oct 1990. Stalter 20159, 2008/10.

Solidago mexicana L. [=*S. sempervirens* ssp. *mexicana* (L.) Semple]. Dunes—upper beach and dune: freq. Stalter, 26 Oct 1990. Stalter 20160, 2008/10.

**Sonchus asper* (L.) Hill. Ruderal—disturbed soil and lawn: infreq. Stalter, 29 Mar 1990.

**Sonchus oleraceus* L. Ruderal—disturbed soil: rare. Stalter, 29 Mar 1990. Stalter 19594, 2008/10.

**Taraxacum officinale* Weber ex Wigg. Ruderal—lawns and disturbed sites: freq. Stalter, 29 Mar 1990. Stalter 19595, 2008/10.

Brassicaceae

Cakile edentula (Bigelow) Hook. Dunes—upper beach: freq. Stalter, 29 Mar 1990. Stalter 19857, 2008/10.

Descurainia pinnata (Walter) Britton. Ruderal—disturbed soil: freq. Stalter, 29 Mar 1990. Stalter 19799, 2008/10.

Lepidium virginicum L. ssp. *virginicum*. Ruderal—disturbed soil: freq. Stalter, 14 Jun 1990. Stalter 19798, 2008/10.

Caryophyllaceae

**Polycarpon tetraphyllum* (L.) L. Ruderal—lawns and disturbed sites: rare. Stalter, 14 Jun 1990.

Sagina decumbens (Ell.) Torrey & A. Gray. Ruderal—pavement cracks and waste places: infreq. Stalter, 29 Mar 1990.

**Stellaria media* (L.) Vill. Ruderal—lawn and disturbed soil: freq. Stalter, 29 Mar 1990. Stalter 19599, 2008/10.

Convolvulaceae

Dichondra carolinensis Michx. Ruderal—lawn: rare, only one population seen adjacent to casemate wall. Stalter, 26 Oct 1990. Stalter 19858, 2008/10.

Ipomoea lacunosa L. Dunes: freq. Stalter, 14 Jun 1990. Stalter 19860, 2008/10.

Euphorbiaceae

Croton glandulosus var. *septentrionalis* (L.) Müll. Arg. Ruderal—disturbed soil: freq. Stalter, 26 Oct 1990. Stalter 20284, 2008/10.

Croton punctatus Jacq. Dunes: infreq. Stalter, 26 Oct 1990. Stalter 19859, 2008/10.

Euphorbia maculata L. [=*Chamaesyce maculata* (L.) Small]. Ruderal—lawns, and disturbed sites: freq. Stalter, 14 Jun 1990; 26 Oct. Stalter 202161, 2008/10.

Euphorbia polygonifolia L. [=*Chamaesyce polygonifolia* (L.) Small]. Dunes—upper beach: freq. Stalter, 14 Jun 1990. Stalter 20162, 2008/10.

Fabaceae

**Medicago arabica* (L.) Huds. Ruderal—disturbed soil: freq. Stalter 19596, 2008/10.

**Medicago polymorpha* L. Ruderal—lawns: infreq. Stalter 19597, 2008/10.

Melilotus albus Medik. Ruderal—disburbed soil: infreq. Stalter, 14 Jun 1990. Stalter 19598, 2008/10.

Melilotus officinalis (L.) Pallas. Dunes: infreq. Stalter, 29 Mar 1990; 14 Jun 1990.

Strophostyles helvola (L.) Ell. Dunes: infreq. Stalter, 26 Oct 1990.

Vicia sativa L. ssp. *nigra* (L.) Ehrh. Ruderal—disturbed soil: infreq. Stalter, 29 Mar 1990. Stalter 19797, 2008/10.

Geraniaceae

Geranium carolinianum L. Ruderal—lawn and disturbed soil: infreq. Stalter, 29 Mar 1990. Stalter 21163, 2008/10.

Lamiaceae

Lamium amplexicaule L. var. *amplexicaule*. Ruderal—lawns and disturbed soil: freq. Stalter, 29 Mar 1990. Stalter 19600, 2008/10.

Malvaceae

Modiola caroliniana (L.) G. Don. Ruderal—seen only at border between lawn and fort: rare. Stalter, 29 Mar 1990. Stalter 20164, 2008/10.

Onagraceae

Oenothera drummondii Hook. ssp. *drummondii*. Dunes: freq. but rare in the Carolinas (Radford et al. 1968). Stalter, 29 Mar 1990. Stalter 20165, 2008/10.

Oenothera laciniata Hill. Dunes: freq. Stalter, 29 Mar 1990. Stalter 20168, 2008/10.

Oxalidaceae

Oxalis dillenii Jacq. Ruderal—disturbed soil: infreq. Stalter, 29 Mar 1990. Stalter 20167, 2008/10.

Phytolaccaeae

Phytolacca americana L. Ruderal—disturbed soil and dune: infreq. Stalter, 14 Jun 1990. Stalter 19601, 2008/10.

Plantaginaceae

Nuttallanthus canadensis (L.) D.A. Sutton [=*Linaria canadensis* (L.) Dum. Cors.]. Ruderal—disturbed soil and dune: freq. Stalter, 29 Mar 1990. Stalter 20285, 2008/10.

Plantago lanceolata L. Ruderal—disturbed soil and lawn: freq. Stalter, 29 Mar 1990. Stalter 20286, 2008/10.

Veronica arvensis L. Ruderal—lawns and disturbed soil: freq. Stalter, 29 Mar 1990. Stalter 19602, 2008/10.

Veronica peregrina L. Ruderal—disturbed soil: infreq. Stalter, 29 Mar 1990. Stalter 19603, 2008/10.

Polygonaceae

Rumex crispus L. ssp. *crispus*. Ruderal—disturbed soil: rare. Stalter, 29 Mar 1990. Stalter 19795, 2008/10.

Portulacaceae

Portulaca pilosa L. Ruderal—lawns and disturbed soil: infreq. Stalter, 14 Jun 1990. Stalter 20169, 2008/10.

Rubiaceae

Diodia teres Walter. Ruderal—disturbed sands: freq. Stalter, 14 Jun 1990. Stalter 20287, 2008/10.

LILIOPSIDA (MONOCOTS)

Agavaceae

Yucca aloifolia L. Dunes: infreq. Stalter, 29 Mar 1990. Stalter 19566, 2008/10.

Cyperaceae

Cyperus compressus L. Dunes: rare. Stalter 20270, 2008/10.

Cyperus croceus Vahl. [=*C. globulosus* Aubl.]. Dunes: rare. Stalter 20271, 2008/10.

Cyperus grayi Torr. Dunes: rare. Stalter 20272, 2008/10.

Iridaceae

Sisyrinchium rosulatum Bickn. Ruderal—lawn: infreq. Stalter 19570, 2008/10.

Poaceae

Bromus catharticus Vahl. var. *cartharticus* [=*B. wildenowii* Kunth.]. Ruderal—disturbed soil: rare. Stalter, 29 Mar 1990.

Cenchrus longispinus (Hack.) Fernald. Dunes: infreq. Stalter, 14 Jun 1990. Stalter 20273, 2008/10.

Cenchrus tribuloides L. Dunes: freq. Stalter, 14 Jun 1990. Stalter 20274, 2008/10.

Cynodon dactylon (L.) Pers. Ruderal—lawn: freq. Stalter, 29 Mar 1990; 14 Jun 1990. Stalter 19791, 2008/10.

Digitaria sanguinalis (L.) Scop. Ruderal—lawn and disturbed soil: freq. Stalter, 14 Jun 1990. Stalter 19792, 2008/10.

Eleusine indica (L.) Gaertn. Ruderal—lawn and disturbed soil: infreq. Stalter, 29 Mar 1990. Stalter 20275, 2008/10.

Eustachys petraea (Sw.) Desv. [=*Chloris petraea* Sw.]. Ruderal—lawn and disturbed soil: rare. Stalter, 29 Mar 1990.

Lolium perenne L. var. *aristatum*. Ruderal—lawn: infreq. Stalter, 14 Jun 1990. Stalter 19793, 2008/10.

Panicum amarum Ell. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19794, 2008/10.

Paspalum dilatatum Poir. ssp. *dilatatum*. Ruderal—disturbed soil outside fort: freq. Stalter, 14 Jun 1990. Stalter 20277, 2008/10.

Paspalum notatum Flügge. Ruderal—disturbed soil outside fort: freq. Stalter, 14 Jun 1990. Stalter 20278, 2008/10.

Poa annua L. Ruderal—lawn: freq. Stalter, 29 Mar 1990. Stalter 19572, 2008/10.

Spartina alterniflora Loisel. Salt Marsh: freq. Stalter, 26 Oct 1990. Stalter 19789, 2008/10.

Spartina patens (Ait.) Muhl. Dunes: freq. Stalter, 14 Jun 1990. Stalter 19790, 2008/10.

Sporobolus junceus (P. Beauv.) Kunth. [=*S. poiretii* (Roem. & Schult.) Hitchc.]. Ruderal—lawns and disturbed soil: freq. Stalter, 26 Oct 1990. Stalter 20279, 2008/10.

Triplasis purpurea (Walter) Chapm. var. *purpurea*. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19788, 2008/10.

Uniola paniculata L. Dunes: freq. Stalter, 26 Oct 1990. Stalter 19787, 2008/10.

Vulpia octoflora (Walter) Rydb. var. *octoflora* [=*Festuca octoflora* Walter]. Ruderal—lawn and disturbed soil: infreq. Stalter, 14 Jun 1990. Stalter 20276, 2008/10.

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BOOK NOTICE

Dennis Wm. Stevenson, Roy Osborne, and Alberto Sidney Taylor Blake, eds. 2012. **Proceedings of Cycad 2008: The 8th International Congress on Cycad Biology, 13–15 January 2008, Panama City, Panama.** (ISBN-13: 978-0893275150, hbk). *Memoirs of the New York Botanical Garden*, Volume 106. The New York Botanical Garden Press, 2900 Southern Boulevard, Bronx, New York 10458-5126, U.S.A. (**Orders:** http://nybgpress.org, 1-718-817-8721, nybgpress@nybg.org). $95.00, 554 pp., b&w and color figures, scientific name index, subject index, 7" × 10".

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EXPANDED DISTRIBUTION OF *GRATIOLA QUARTERMANIAE* (PLANTAGINACEAE) IN TEXAS, U.S.A.

Kimberly Norton Taylor and Robert J. O'Kennon

Botanical Research Institute of Texas
1700 University Drive
Fort Worth, Texas 76107, U.S.A.
ktaylor@brit.org, okennon@brit.org

ABSTRACT

Forty-nine new populations of *Gratiola quartermaniae* are reported from seven new counties in north central Texas. All populations were found on seasonally wet Walnut Limestone glades and are the first to be found in the Texas Grand Prairie and Limestone Cut Plain. These collections indicate that the species and its calcareous glade habitat are much more abundant in Texas than previously thought.

RESUMEN

Se citan cuarenta y nueve poblaciones nuevas de *Gratiola quartermaniae* de siete condados nuevos en el centro norte de Texas. Todas las poblaciones se encontraron en los claros estacionalmente húmedos de Walnut Limestone y son las primeras que se encuentran en la Grand Prairie de Texas y Limestone Cut Plain. Estas colecciones indican que la especie y su hábitat calcáreo son mucho más abundantes en Texas de lo que se creía previamente.

Gratiola quartermaniae D. Estes (Plantaginaceae) was first described from Eastern North America by Estes and Small in 2007. The species typically grows in thin, seasonally saturated soil over exposed limestone or dolomite bedrock (Estes & Small 2007; Taylor & Estes 2012). This habitat is typically found associated with limestone glades, barrens, prairies, and alvars. Estes and Small (2007) note that the species is most common in the limestone cedar glades of central Tennessee and northern Alabama, though it also occurs in primarily calcareous habitats in northeastern Illinois, central Texas, and southeastern Ontario. Similar disjunction patterns are seen in several other calciphilous species which grow in association with *G. quartermaniae* including *Clinopodium arkansanum* (Nutt.) House, *Grindelia lanceolata* Nutt, *Heliotropium tenellum* (Nutt.) Torr., *Isoëtes butleri* Engelm., *Juncus filipendulus* Buckl., and *Minuartia patula* (Michx.) Mattf.

Gratiola quartermaniae is known from five collections in Texas (Fig. 1) including one each in Bell (*Wolff 2317*, SMU) and Llano (*Whitehouse 18477*, SMU, UC, US) counties, and three in Williamson County (*Bodin s.n.*, PH, MIN; *Turner & Turner 122*, BRIT, MO, TENN, TEX; *Turner & Turner 119*, BRIT, GH, MO, TENN, TEX). While the label data do not indicate the exact location of each site, the Williamson and Bell county specimens appear to occur in calcareous habitats, which is typical for the taxon. The Llano County site appears to be an exception, apparently occurring on granite.

In 2007, O'Kennon discovered a population of what he later determined to be *Gratiola quartermaniae* from a calcareous Walnut Limestone glade seep in Wise County, Texas (*O'Kennon 20515B*, BRIT). This represents the first documented population for *G. quartermaniae* in north central Texas, a disjunction of approximately 230 km to the north of the populations in central Texas. Despite the large disjunction, the occurrence of *G. quartermaniae* in the Grand Prairie is not surprising. The predominately Cretaceous limestone substrate that comprises the Edwards Plateau extends northward through the Limestone Cut Plain (Lampasas) and Grand Prairie (Griffith et al. 2004). With these large extensions of similar, and in some cases identical, substrate it is not surprising that we find calciphilous species with distributions extending farther to the north than previously thought (Swadek & Burgess 2012; Taylor et. al 2012; Taylor & O'Kennon 2012).

In the spring of 2012, the authors conducted extensive surveys of limestone prairies, barrens, and glades in the Grand Prairie and northern Limestone Cut Plain of north central Texas. Areas where limestone outcrops form "glades" reminiscent of the cedar glades found in the Central Basin of Tennessee were searched for *G.*

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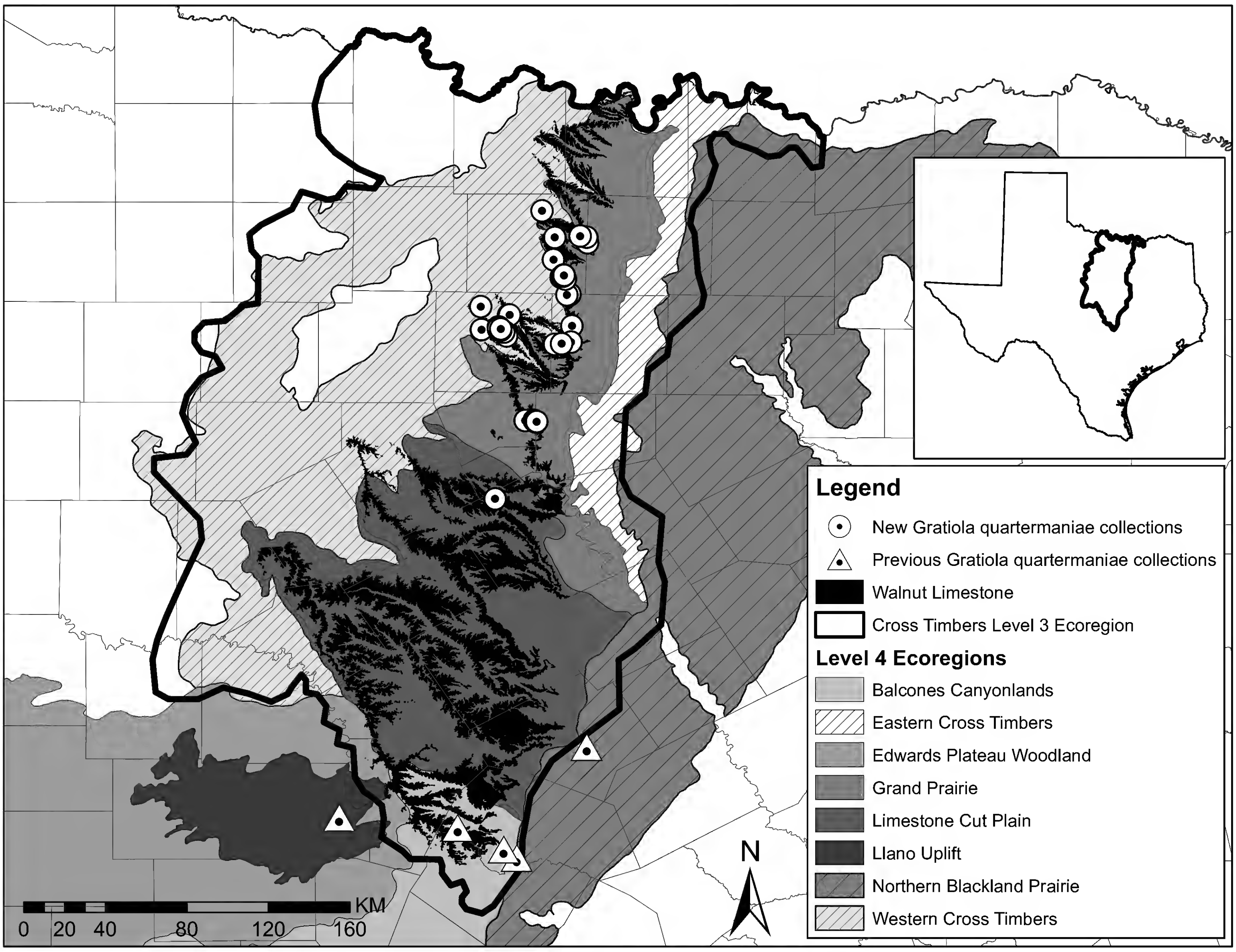

Fig. 1. Documented collection sites of *Gratiola quartermaniae* in Texas. Forty-nine previously unknown sites were documented in 2012 from Walnut Limestone glade seeps on the western edge of the Grand Prairie and the northern Limestone Cut Plain (McGowen et al. 1987; McGowen et al. 1991; Griffith et al. 2004).

quartermaniae. Satellite imagery and geologic maps were used to identify other possible locations for exploration. During this search, 49 new locales were identified for *G. quartermaniae.* These collections represent 7 new county records, including Bosque, Denton, Hood, Johnson, Parker, Tarrant, and Wise counties (Fig. 1). At least one voucher specimen from each county was collected and deposited at BRIT. Specific collection information for each specimen is available online at atrium.brit.org.

All sites in north central Texas are underlain by Walnut Limestone substrate. This Cretaceous, fossiliferous, erosion resistant limestone forms glades when exposed. In the Grand Prairie these glades form at lower topographic positions as the overlying substrate erodes (Fig. 2). In the Limestone Cut Plain, Walnut Limestone glades are found encircling the Edwards or Comanche Peak Limestone mesas that characterize the region (Hill 1901). Seepage from the interbedded limestone and marl layers upslope will often form shallow pools or streams over exposed Walnut bedrock at the base of the slopes (Swadek & Burgess 2012).

Gratiola quartermaniae was found in very shallow soil directly over limestone bedrock on the edges and on small soil islands in limestone bedrock creeks and seeps, or in deeper, mucky limestone soil in disturbed sites including highly grazed cattle ponds (Fig. 3). *Gratiola quartermaniae* is most abundant in areas with little competing vegetation or in areas with high levels of disturbance.

The majority of the sites were found on relatively undisturbed, seasonally saturated seeps and streambeds with little to no soil accumulation and large amounts of exposed limestone bedrock (Fig. 3). The remaining sites were found in deeper soils over Walnut Limestone but were highly disturbed. Most deeper soil sites were

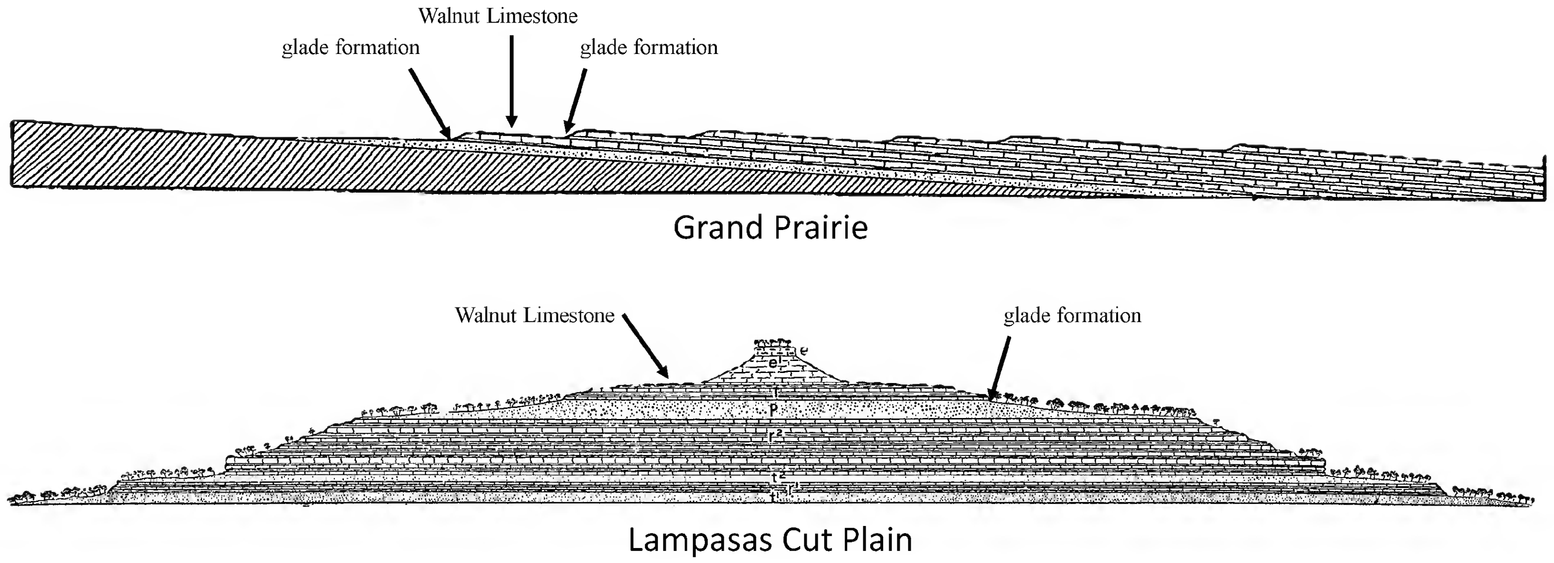

Fig. 2. Diagrammatic section of Grand Prairie (top) and Limestone (Lampasas) Cut Plain (bottom), showing position of Walnut Limestone outcrops across the landscape. In the Grand Prairie Walnut Limestone glades form when Walnut Limestone bedrock is exposed. In the Lampasas Cut Plain glades are found near the base of the many mesas throughout the region. Diagrams modified from Figures 3 and 5 by Hill (1901).

heavily grazed by livestock and were highly trampled. We believe this high level of disturbance eliminates competitors allowing *G. quartermaniae* to persist in the deeper soils. Most populations were small and isolated with fewer than 50 plants, though a few sites had well over 500 plants. Associated species include *Eleocharis occulta* S.G. Sm., *Hypoxis hirsuta* (L.) Coville, *Spiranthes magnicamporum* Sheviak, *Isoëtes butleri* Engelm., *Nothoscordum bivalve* (L.) Britton, *Allium canadense* L. var. *fraseri* Ownbey, *Juncus filipendulus* Buckl., *Fuirena simplex* Vahl var. *simplex*, and *Leucospora multifida* (Michx.) Nutt.

Plants flower from late March through May, and set seed from April through early June. The plant dries and disappears completely by early summer. This phenology closely matches the hydrological regime of the limestone glades where the species is found. Saturated conditions in the spring give rise to near drought-like conditions in the summer and fall as temperatures rise and rainfall decreases. *Gratiola quartermaniae* appears to be specifically adapted to complete its life cycle within this narrow hydrological window.

Gratiola quartermaniae is much more widespread in Texas than previously thought. This oversight can be attributed to the short lifecycle of the species and the lack of thorough botanical exploration in the limestone prairies of north central Texas. Until recently, the limestone glade habitat, which is prolific on the western edge of the Grand Prairie, remained relatively unexplored botanically. This is evident by the recent discovery or range expansion of several species characteristic of glades in the region, including *Isoëtes butleri* (Taylor et. al 2012), *Phemeranthus calcaricus* (Engelm.) Kiger (Swadek 2012), and *Dalea reverchonii* (S. Wats.) Shinners (Taylor & O'Kennon 2012). Additional exploration of the Grand Prairie and Limestone Cut Plain regions of Texas would likely reveal the presence of additional glade taxa and more locations for *G. quartermaniae*. In particular, the Walnut Limestone formation is quite extensive in the Limestone Cut Plain and warrants further exploration.

Representative Voucher Specimens.—**U.S.A. TEXAS. Bosque Co.:** Co Rd 2650 ca. 0.7 mi SE of Co Rd 2660, ca. 3.5 air mi NW of Walnut Springs. 32.087772N, -97.795782W, elev 297 m, abundant along ephemeral glade stream, 27 Apr 2012, *Norton & O'Kennon 1673* (BRIT). **Denton Co.:** N County Line Rd ca. 0.25 mi S of Hwy 380, ca. 70 m E, Walnut Limestone seep glade, 33.242092N, -97.38987W, elev 226 m, 21 Apr 2012, *O'Kennon 24963* (BRIT). **Hood Co.:** Running Deer Ct ca. 0.8 mi N Cleburne Hwy, Walnut Limestone glade, 32.433357N, -97.621662W, elev 229 m, 27 Apr 2012, *Norton & O'Kennon 1676* (BRIT). **Johnson Co.:** Running Deer Ct at Cleburne Hwy, Walnut Limestone glade, 32.427675N, -97.615694W, elev 240 m, 27 Apr 2012, *Norton & O'Kennon 1675* (BRIT). **Parker Co.:** Old Agnes Rd ca. 0.1 mi N of Louis Scherer Rd on E side of rd, 32.846977N, -97.778998W, elev 355 m, growing in thin soil over Walnut Limestone bedrock, seasonally wet, abundant, 10 Apr 2012, *Norton & O'Kennon 1525* (BRIT). **Tarrant Co.:** White Settlement, Verna Trail N ca. 0.2 mi N of Stubbs Trail, 32.77301N, -97.5015W, elev 216 m, growing in ephemeral swale over Walnut Limestone, 13 Apr 2012, *Norton & O'Kennon 1548* (BRIT). **Wise Co.:** Hwy 114 ca. 0.6 mi W of hwy 81 at Rhome. N side of rd, 33.060325N, -97.488865W, elev 247 m, seasonally wet seepage area below pond damn, thin soil over Walnut Limestone bedrock, growing with *Isoëtes butleri, Fuirena simplex*, and *Leucospora multifida,* 13 May 2007, *O'Kennon 20515B* (BRIT); 8 May 2012, *Norton & O'Kennon 1689* (BRIT).

Fig. 3. **Ephemeral limestone seep with exposed Walnut Limestone bedrock, Denton Co. (*O'Kennon 24971*, BRIT) (top); *Gratiola quartermaniae* growing in shallow soil overtop exposed bedrock, Wise Co. (*Norton & O'Kennon 1539*, BRIT) (left); close up of *G. quartermaniae,* Parker Co. (*Norton & O'Kennon 1511*, BRIT) (right).**

ACKNOWLEDGMENTS

We thank Austin Sewell from the Lyndon B. Johnson National Grasslands for his assistance in locating sites and Dwayne Estes for his assistance in verifying species identification. We thank Dwayne Estes, Allan Nelson, and Rebecca Swadek for their helpful reviews of the manuscript. We also thank all the landowners who granted us permission to collect on their property.

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ANNOUNCEMENT

LANDON E. McKINNEY
(1949–2014)

Source of information: www.schoedinger.com

Landon E. McKinney, age 65, passed away on Thursday, June 5th, 2014 at the Wade Park Veteran's Medical Center in Cleveland. He was born May 17, 1949 in Nashville, Tennessee, to the late Lawrence Vern and Constance Joy McKinney.

A proud Vietnam Veteran of the United States Navy, Mr. McKinney was a Marine Navy Corpsman. He is survived by his loving wife of 31 years, Lela McKinney; children Adam McKinney, Amanda (Troy) Chitwood, and Eric (Amy) McKinney; grandchildren Landon, Lucas, Erica, Katelyn, and Whitney; many extended family members, special friends, and colleagues.

Landon was a friend and colleague and published violet (*Viola*) articles in *Sida* and *Journal of Botanical Research Institute of Texas*. Landon published his monograph of the acaulescent blue violets in *Sida, Botanical Miscellany* (see reference below).—*Barney Lipscomb*

McKinney, L.E. 1992. A Taxonomic Revision of the Acaulescent Blue Violets (Viola) of North America. Sida, Bot. Misc. 66 pp., 28 b/w figs., photographs, maps.

We plan to have a more complete tribute to Landon in a forthcoming issue.

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THE VASCULAR FLORA OF GALVESTON ISLAND STATE PARK, GALVESTON COUNTY, TEXAS, U.S.A.

David J. Rosen and Shiron K. Lawrence

Department of Biology
Lee College
Baytown, Texas 77522-0818, U.S.A.
drosen@lee.edu

Andrew Sipocz

Natural Resources, State Parks
Texas Parks and Wildlife Department
14200 Garrett Road
Houston, Texas 77044, U.S.A.
andrew.sipocz@tpwd.texas.gov

ABSTRACT

Galveston Island State Park is located near the center of Galveston Island in Galveston County, Texas, U.S.A. The 789.1 ha park lies within the Western Gulf Coastal Plain ecoregion. A floristic survey was conducted from July 2011 through November 2013, and vouchered specimens at TEX collected in the early 70s by R.J. Fleetwood verified, with the goal of assembling an annotated checklist of vascular plants. This resulted in a checklist of 317 species of vascular plants representing 68 families and 221 genera. The largest families were Poaceae (65 spp.), Asteraceae (36 spp.), Fabaceae (25 spp.), Cyperaceae (24 spp.), and Amaranthaceae (11 spp.). Non-native species account for 16.4% of the total flora. Seven species in six different families are of conservation interest in that they are endemic to the ecoregion. Lists of species characteristic of readily recognizable habitat types are provided.

RESUMEN

El Galveston Island State Park está localizado cerca del centro de la isla Galveston en el condado de Galveston, Texas, U.S.A. Es parque de 789.1 ha está en la ecoregión de Western Gulf Coastal Plain. Se realizó un estudio floristico de julio de 2011 a noviembre de 2013, y se verificaron especimenes testigo en TEX collectados a principios de los 70 por R.J. Fleetwood, con el objetivo de realizar un catálogo anotado de plantas vasculares. Así se obtuvo una catálogo de 317 especies de plantas vasculares que representan 68 familias y 221 géneros. Las familias más numerosas fueron Poaceae (65 spp.), Asteraceae (36 spp.), Fabaceae (25 spp.), Cyperaceae (24 spp.), y Amaranthaceae (11 spp.). Las especies no nativas fueron el 16.4% de la flora total. Siete especies de seis diferentes familias son de interés para la conservación ya que son endémicas de la ecoregión. Lists of species characteristic of readily recognizable habitat types are provided.

INTRODUCTION

Galveston Island State Park is located near the center of Galveston Island, one of a series of barrier islands and bay/lagoon systems separating most of the Texas mainland from the Gulf of Mexico (Fig. 1). The Texas coast comprises most of the area designated by Griffith et al. (2004) as the Western Gulf Coastal Plain ecoregion. The 789.1 ha (1,950 acre) park straddles the Island from the Gulf to West Galveston Bay and is roughly square in overall dimensions (Fig. 2). Galveston Island's formation is recent, beginning as a submerged offshore bar no more than 4,500 to 5,000 years ago that accumulated until about 1900 when it reached its maximum width (Garner 1997). The bayside region consists of salt marsh fringing a series of peninsulas and intervening lagoons perpendicular to the Island's long axis (Fig. 2). A series of dune ridges and swales parallel the Island's long axis from its center to the beach (Fig. 2). These formed as the Island accreted seaward and became too wide and high for significant wash-over events. The ridges and swales support prairie and freshwater wetlands respectively. All of these features are well represented in the park.

Galveston Island has been narrowing through erosion and apparent sea level rise since approximately 1900. This is due to several factors including the construction of jetties at the mouth of Galveston Bay which block the longshore drift and sand supply to the island's beaches, subsidence of the Island from subsurface fluid withdrawal, and eustatic sea level rise (Raven et al. 2009). Since the park's establishment in 1972, its beach has moved inland approximately 74.1 m (243 feet; Sipocz 2010). The active dune system has been completely displaced since the park's establishment and now overlies what had previously been wetlands or developed facilities (Sipocz 2010).

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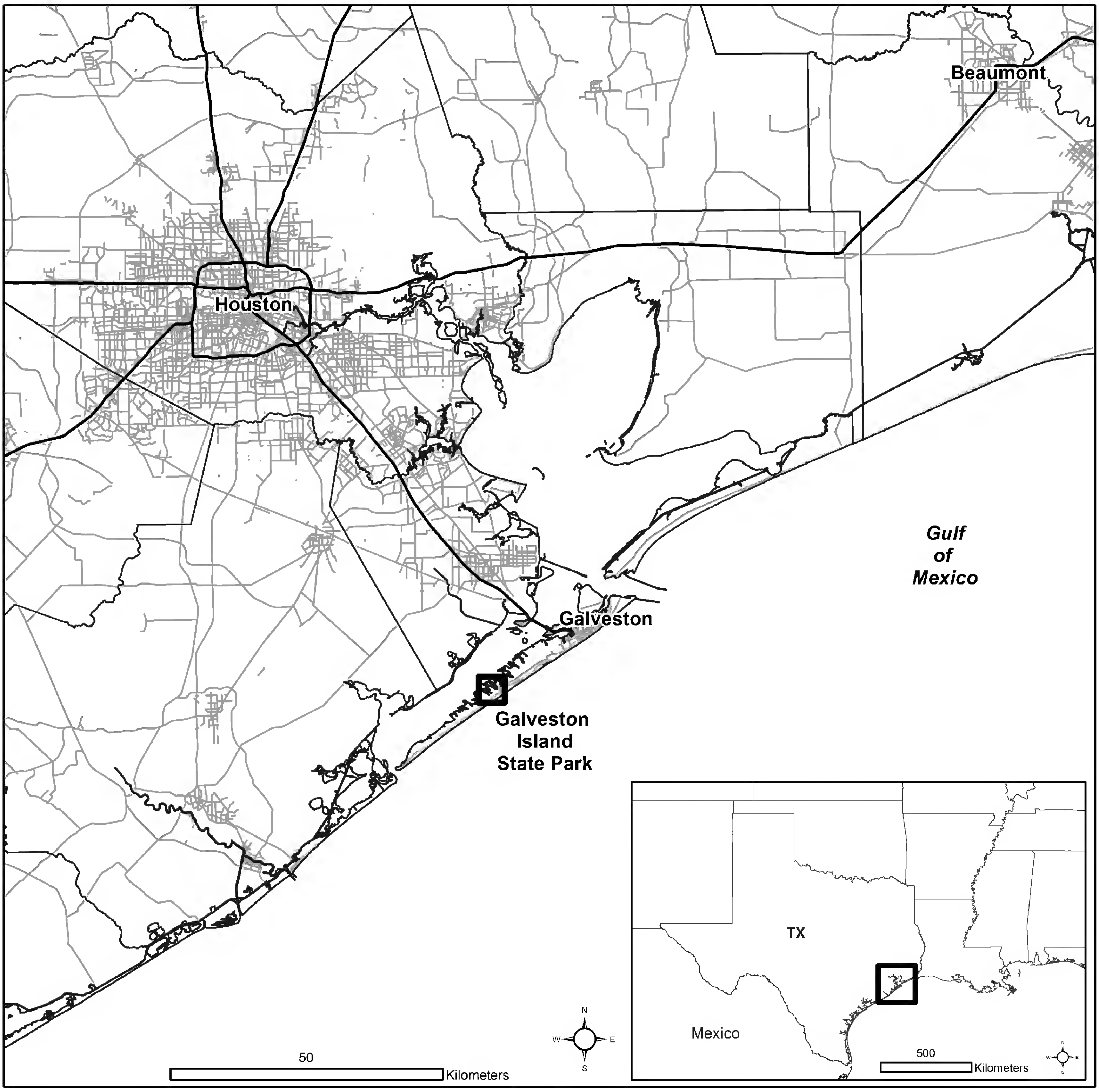

Fig. 1. General location of Galveston Island State Park, Galveston County, Texas.

Climate

Galveston Island occurs within a humid, warm-temperate to marginally subtropical region receiving an average of 129 cm (51 in) of rainfall annually (Britton & Morton 1989; National Weather Service 2013). The average temperature for Galveston Island is 21.8°C (71.2°F), with August being the warmest month (29°C, 85°F) and January the coldest (12.9°C, 55.2°F; National Weather Service 2013). The cooling effect of sea-breezes from the Gulf of Mexico moderates summer temperatures (Crenwelge et al. 1988). The predominant wind direction is southeast, but varies by season. The light southerly winds predominate in spring through early fall, while cold fronts with strong northerly winds that push water out of the bay punctuate the winter. Tropical storms and hurricanes are frequent on the Texas coast, striking with a frequency of 0.67 storms per year (Hollingsworth 1998).

Soils and Vegetation

Four different soil series occur at Galveston Island State Park, and all are derived from the inland deposition of

Fig. 2. True-color aerial photograph of Galveston Island State Park (outlined in green), Galveston County, Texas.

beach sands (Fig. 3; Crenwelge et al. 1988). The Karankawa Mucky Loam Series is a bayside salt marsh soil formed on over-wash-deposited sands with a high amount of partially decayed organic matter resulting from plant growth coupled with anaerobic soil conditions (Crenwelge et al. 1988).

Prominent dune ridges in the interior of the park consist of Galveston Loamy Fine Sand and Galveston Fine Sand Series soils (Fig. 3). These are wind accumulated, mildly alkaline, somewhat excessively drained soils that are very rapidly permeable with fine sand in the upper 183 cm (72 in) to 356 cm (140 in) and support prairie vegetation (Crenwelge et al. 1988). Upland prairie on Texas' barrier islands is regionally referred to as "strand prairie" (Hollingsworth 1998). We are uncertain as to the origin of this seemingly colloquial name, but it is clear that Hollingsworth (1998) used it to refer to *Schizachyrium littorale* (Nash) E.P. Bicknell- *Paspalum monostachyum* dominated grasslands of Texas' barrier islands and Coastal Sand Plain (Diamond et al. 1987). This community is considered an ally of coastal prairie marked by tolerance of occasional tidal over-wash, and probably more importantly, the salt spray typical of the spring through fall months which produces measur-

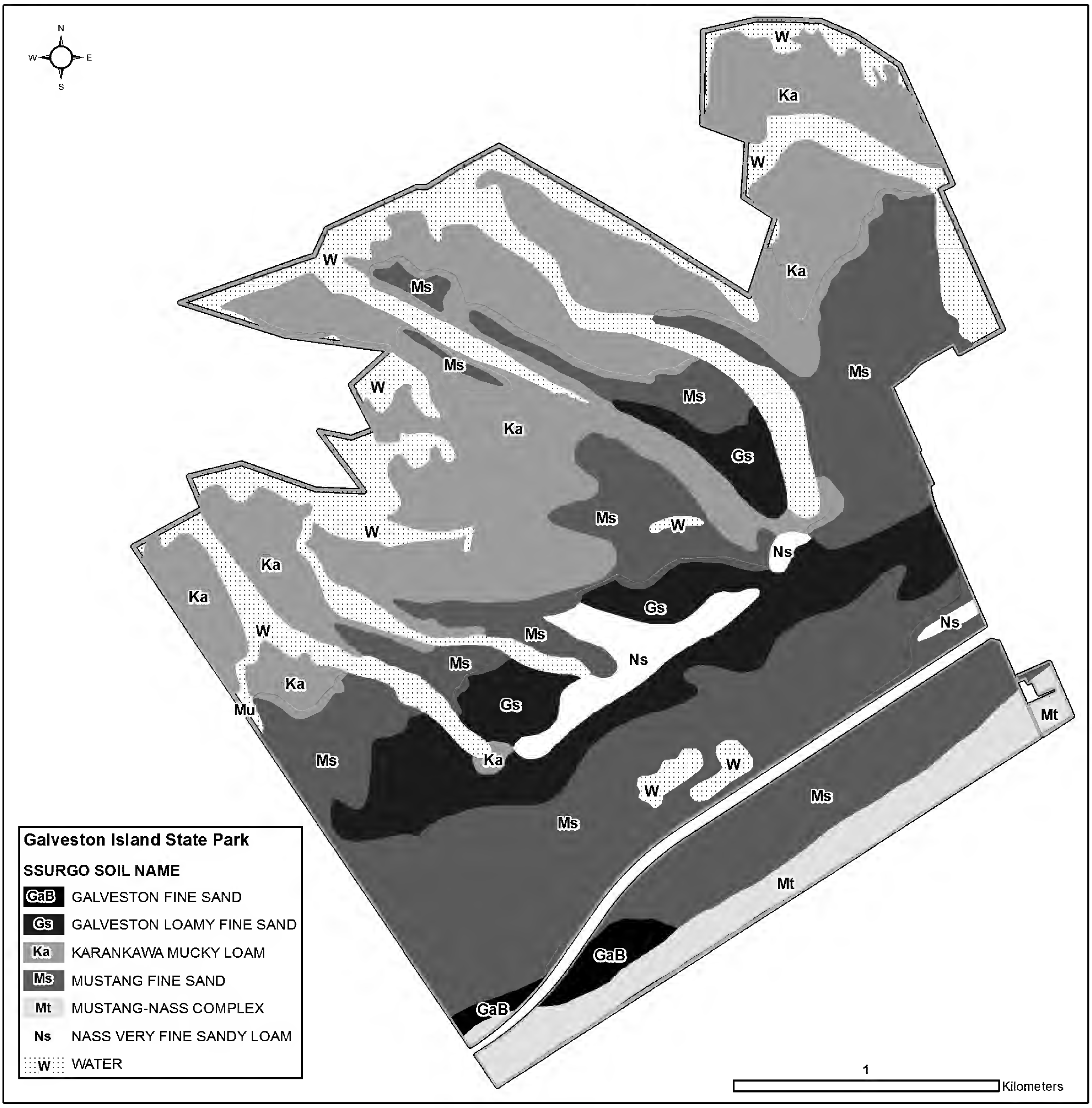

Fig. 3. Map of major soil series of Galveston Island State Park, Galveston County, Texas.

able soil salinity throughout the park and accumulates on plant surfaces during dry periods. The Galveston Loamy Fine Sand Series is uniquely underlain by a shell layer and portions of it support live oak (*Quercus virginiana*) woodlands known colloquially as "live oak mottes." Just east of the park, a live oak motte on this soil type contains an extensive Native American burial ground which was described by early Spanish explorers indicating that the presence of trees on the Island predates European settlement (Ricklis et al. 1994). The Galveston Fine Sand Series also supports strand prairie but is treeless, not underlain by shell fragments, and lies closer to the beach.

The majority of the terrestrial park lands consist of the Mustang Fine Sand Series. This strongly alkaline, somewhat poorly drained, very slowly permeable soil occurs on flats or slightly convex or concave surfaces and although it includes dune ridges and swales, they are poorly developed (Crenwelge et al. 1988). These soils are a mixture of wind and washover deposits of slightly coarser sands. The water table is close to and occasionally at the surface of these soils; normally 25.4 cm (10 in) to 76.2 cm (30 in) in depth (Crenwelge et al. 1988). Vegetation composition within the Mustang Soil region changes considerably with surface slope and configuration. The water table elevation follows surface topography and so lies at different elevations throughout the Park (Lambert 1998). Topographical changes control depth to the water table and affect soil alkalinity, drainage, and permeability. Therefore, even very slight topographical and slope changes result in markedly different plant communities. Concave surfaces contain what Texas' Natural Heritage Program (1993) termed a "Gulf Cordgrass Series" grassland dominated by *Spartina spartinae* and *S. patens*, while convex surfaces support strand prairie.

Nass Very Fine Sandy Loam Series soils are neutral to moderately alkaline soils in non-tidal swales and occur as inclusions in each of the three prairie soil types. The water table extends to or above the soil surface in most years and a permanent water table lies within 15.2 cm (6 in) to 70 cm (24 in) of the surface (Crenwelge et al. 1988). They are the remainder of lagoons formed as the Island accreted seaward and offshore bars accumulated sand, rising to form new dune ridges parallel to the beach. The older swales have been broken by overwash deposition and wind erosion into strings of circular, freshwater ponds up to 1.8 m (6 ft) in depth. These are often surmounted by crescent-shaped dunes along leeward sides that may contain small live oak mottes.

Resource Management

Resource management at the park strives to conserve and restore its pre-European settlement landscape, and terrestrial and aquatic plant and wildlife communities. Prior to becoming a State Park in 1972 the site had been intensively grazed by fenced cattle, greatly reducing the dominance of tall grasses such as little bluestem (*Schizachyrium scoparium*) that are typical of strand prairie (Keith 2005). In addition, much of the park had been invaded by non-native plants including Chinese tallow-tree (*Triadica sebifera*) and Japanese honeysuckle (*Lonicera japonica*). Mowing, mechanical chipping, herbicide, and prescribed fire have been used to almost eliminate these species and slowly increase those described as dominants in strand prairie.

Prescribed and wildfires have been documented in the park since 1976 (Creacy 2007). Between 1976 and 2006, when a more rigorous prescribed fire program was implemented, 11 fires burned a total of 985.8 ha (2,436 acres), mostly within the 356.1 ha (880 acres) containing strand prairie and gulf cordgrass plant communities though the results were poorly documented. Since 2006 prescribed fires applied to the prairies have been better documented including the use of permanent vegetation plots for effects monitoring. The entire prairie area of the park has been burned at least once during the 2007 to present time period.

Present resource management includes the continued use of prescribed fire to burn the prairies on an approximate 3 to 7 year rotation as well as spot treatment of non-native, invasive plant species including Guinea grass (*Megathyrsus maximus*), Chinese tallow-tree, Vasey grass (*Paspalum urvillei*), black locust (*Robinia pseudoacacia*), cabbage palm (*Sabal palmetto*), and Mexican fan palm (*Washingtonia robusta*). Mechanical treatments are no longer used as it is thought to spread invasive species into the prairies, and they have been made unnecessary by the more rigorous use of prescribed fires.

Other management activities include the propagation and planting of species that are uncommon or absent from the park's prairies, but are common to strand prairie on an unfenced reference site on the adjacent barrier island just south of Galveston. Indeed, a focus on the restoration of the park's prairies revealed the need for an intensive baseline inventory of vascular plant species that occurred there. Raymond J. Fleetwood, a U.S. Fish & Wildlife Service biologist who worked on the Texas coast beginning in the 1960s, performed what was probably the first and only effort to survey the vascular plants at Galveston Island State Park, compiling a list comprising 108 species distributed in 96 genera and 39 families (Fleetwood 1973). Fleetwood also vouchered a modest exsiccatae of 63 specimens at the University of Texas at Austin Plant Resources Center Herbarium (TEX). Interest in restoring the park's prairie flora and continuing the work that Fleetwood began four decades ago has culminated in the study reported here.

METHODS

Twenty collecting trips were made to the park from July 2011 through November 2013, and in all months except December–February. A complete set of voucher specimens is housed at TEX. Plant identifications were

TABLE 1. Taxonomic summary of vascular plants of Galveston Island State Park, Galveston County, Texas.

	Families	Genera	Species		
			Native	Non-native	Total
Monocots	14	67	94	23	117
Eudicots	54	154	171	29	200
Totals	**68**	**221**	**265**	**52**	**317**

primarily made using the appropriate volumes of *Flora of North America* (1993+), Correll and Johnston (1970), and Gould (1975). When practical, infraspecific names were determined. Classification and author names follow Tropicos (2013). Nativity and any special conservation status of each species were determined by review of *Flora of North America* (1993+) and Correll and Johnston (1970). We follow Nesom (2000) in defining non-native species as those originating from a different continent or less commonly in this flora cultivated from outside the geographic extent of the Western Gulf Coastal Plain ecoregion (Griffith et al. 2004).

RESULTS & DISCUSSION

A combination of field work from July 2011 through November 2013 and review of Fleetwood's specimens housed at TEX yielded 317 species of vascular plants representing 68 families and 221 genera (Table 1). The families containing the largest number of species (native and non-native combined) are Poaceae (65 spp.), Asteraceae (36 spp.), Fabaceae (25 spp.), Cyperaceae (24 spp.), and Amaranthaceae (11 spp.). Large genera include *Cyperus* with nine native and one non-native species, and *Juncus* with eight native species. Non-native species account for 16.4% of the total flora. Poaceae included the most non-native species (16). Two families, Arecaceae and Tamaricaceae, are represented by only non-native species. The two Arecaceae species are not known to be invasive in Texas (Nesom 2009), but have begun rapidly reproducing on Galveston Island, likely because of warmer winters (Britton & Morton 1989; National Weather Service 2013), and are a new threat to the prairie habitats. Seven species in six different families are of conservation interest in that they are endemic to the ecoregion.

Plant Communities

No effort was made to quantitatively describe plant communities that occur in the park. However, due to the influence of soil types, wind, wave, tidal action, and sometimes sharp elevation gradients across the landscape, several habitat types are readily identified in the field simply because the resulting species composition is so consistent (Fig. 4, Table 2). We believe we provide nearly complete lists of characteristic species for some habitats (beach, dunes, salt marsh), or at least a list of dominant species (prairie, woodlands). The sea-grass beds in the park are dominated by a two species, *Halodule wrightii* and *Ruppia maritima*. Although a decline and eventual disappearance of sea-grass by the early 1980s was reported for West Galveston Bay (Pulich & White 1991), sea-grass beds are now frequent along the lagoon and bay-shores in Galveston Island State Park (Fig. 4F). To what degree this is the result of past efforts to reintroduce plants, natural recruitment, or both is not known. The park's prairies have the highest species richness (153 spp.) and include five of the seven endemic species we collected (Fig. 4D, Table 2, Appendix). The park's woodlands occur as small stands of trees along natural berms and ridges (e.g., Fig. 4G).

Endemics and Species of Conservation Interest

Seven endemic species were documented during field work. *Digitaria arenicola,* a rhizomatous perennial restricted to prairies in the park, is endemic to deep coastal sands of Texas and is mapped by Wipff and Hatch (1994) as seeing its northern-most records from Galveston County. *Digitaria texana* is another sandy-prairie species known only from the Texas' coast and Rio Grande plains (Correll & Johnston 1970). *Gomphrena nealleyi* seems to be of restricted distribution, known from sandy or clayey soils in coastal Texas and the Rio Grande plains and adjacent southwest Texas and Mexico (Correll & Johnston 1970). *Herbertia lahue*, *Tradescantia*

Fig. 4. Representative photos of general habitat types at Galveston Island State Park, Galveston County, Texas. **A.** Beach. **B.** Dunes (seaward aspect). **C.** Dunes (leeward aspect). **D.** Strand prairie. **E.** Salt marsh. **F.** Seagrass bed. **G.** Woodland. **H.** Wetland.

TABLE 2. Characteristic native species (listed in alphabetical order) of select habitats of Galveston Island State Park, Galveston County, Texas.

Beach
Amaranthus greggii
Cakile constricta
Cakile geniculata
Eustoma exaltatum
Fimbristylis castanea
Rayjacksonia phyllocephala var. *phyllocephala*
Sesuvium portulacastrum
Sporobolus virginicus
Tidestromia lanuginosa subsp. *lanuginosa*

Dunes (both seaward & leeward)
Ipomoea imperati
Ipomoea pes-caprae subsp. *brasiliensis*
Panicum amarum
Uniola paniculata
Aphanostephus skirrhobasis
Helianthus praecox
Croton punctatus
Rubus trivialis
Spartina patens
Heterotheca subaxillaris
Baptisia bracteata var. *leucophaea*
Oenothera drummondii
Vigna luteola

Salt marsh
Agalinis maritima
Batis maritima
Cuscuta indecora var. *indecora*
Iva angustifolia
Iva frutescens
Limonium carolinianum
Lycium carolinianum
Salicornia bigelovii
Sarcocornia utahensis
Monanthochloe littoralis
Spartina alterniflora
Spartina spartinae
Spergularia salina
Strophostyles helvola

Strand Prairie
Agalinis fasciculata
Ambrosia psilostachya
Baptisia bracteata var. *leucophaea*
Croton capitatus var. *lindheimeri*
Croton glandulosus var. *lindheimeri*
Dichanthelium scoparium
Digitaria cognata subsp. *cognata*
Eupatorium serotinum
Euthamia leptocephala
Fimbristylis caroliniana
Fimbristylis castanea
Heterotheca subaxillaris
Mimosa strigillosa
Monarda punctata
Muhlenbergia capillaries
Oenothera drummondii
Panicum virgatum
Paspalum monostachyum
Paspalum plicatulum var. *plicatulum*
Paspalum setaceum var. *stramineum*
Physalis cinerascens var. *spathulifolia*
Schizachyrium scoparium var. *scoparium*
Setaria pumila
Spartina patens
Spartina spartinae
Strophostyles leiosperma

Woodlands
Baccharis halimifolia
Campsis radicans
Celtis laevigata
Erythrina herbacea
Ilex vomitoria
Indigofera suffruticosa
Melothria pendula
Paspalum monostachyum
Quercus nigra
Quercus virginiana
Sideroxylon lanuginosum subsp. *oblongifolium*
Smilax bona-nox
Vitis mustangensis
Zanthoxylum clava-herculis

subacaulis, and *Zephyranthes traubii* are also prairie species endemic to the either primarily the Western Gulf Coastal Plain (in the case of *H. lahue*) or Texas (Correll & Johnston 1970). In the 1970s, Raymond J. Fleetwood discovered a population of "corkwood" he identified as *Leitneria floridana* in forested wetlands in nearby Brazoria County. Recognizing the plants were regionally unique and concerned with the conservation of the population, in 1972, he introduced plants to several suitable sites in the park's prairies (Fleetwood 1973; David Riskind, personal communication). Since then, the donor-site (Bird Pond) has been permanently protected through acquisition by the U.S. Fish & Wildlife Service, and the plants there have been recently described as a new species, *Leitneria pilosa* subsp. *pilosa*, known only from forested wetlands and prairies of the upper Texas Gulf Coast (Schrader & Graves 2011).

A native plant known to have been extirpated from the park has been successfully re-introduced. Sea-oats

(*Uniola paniculata*) from native populations on nearby Follet's Island were established in dunes in the park in 2010. Future efforts to restore the park's strand prairies will continue and include the use of fire as well as local cultivation and reintroduction of species absent, but expected in this community type. Interestingly, *Schizachyrium littorale* does not occur in the park as mapped by Diamond et al. (1987), but rather is replaced by *S. scoparium* var. *scoparium*. The need for protection and floristic inventory of a remnant strand prairie on nearby Follet's Island has also come to light during this study, and steps are being taken to bring this about.

Plant introductions during restoration should first be carefully evaluated. Probably in an effort to improve habitat for migratory songbirds, in about 1990, the non-native black locust (*Robinia pseudoacacia*) was purposefully planted in the park's woodlands or in stands to create new-woodlands. This species has since become invasive and required control.

APPENDIX

ANNOTATED CHECKLIST OF VASCULAR PLANTS AT GALVESTON ISLAND STATE PARK

Families are arranged alphabetically, beginning with monocots and followed by eudicots. Genera, species, and infraspecific names are arranged alphabetically under families. Some species names are preceded by special symbols to indicate nativity and conservation interest as follows: (1) non-native species are indicated by an asterisk (*) based on review of Correll and Johnston (1970); (2) endemic species are indicated by a superscript dagger (†) based on review of *Flora of North America* (1993+) and Correll and Johnston (1970). Following each name is an abbreviation from Palmer et al. (1995) representing one of the following subjective estimates of the relative abundance of that species in the particular habitat(s) where it was collected: **r** = rare (very difficult to find and limited to one or very few locations or uncommon habitats); **i** = infrequent (difficult to find with few individuals or colonies but found in several locations); **o** = occasional (widely scattered but not difficult to find); **f** = frequent (easily seen or found in one or more common habitats but not dominant in any common habitat); and **a** = abundant (dominant or co-dominant in one or more common habitats; terms in quotes are those of Fleetwood). Following the relative abundance, the habitat(s) where that species is typically found is indicated by the following general categories (terms in quotes are those of Fleetwood): **beach** = from the wave swash zone to the base of the dunes; **dunes** (both seaward and leeward) = vegetation stabilized wind deposited mounds and ridges that parallel the beach; **prairie** = grasslands throughout the park; **woodlands** = thickets of woody species; **wetlands** = all non-tidal freshwater wetlands including seasonally flooded ponds and swales; **salt marsh** = wetlands with rare to daily tidal flooding dominated by halophytic vascular plants; **sea-grass beds** = stands of rooted aquatic vascular plants that occur in shallow waters of the bay and lagoons; **disturbed** = dirt roads, roadside ditches, fence-lines, campgrounds, and vicinity of man-made structures. Collections are the first authors with the exceptions of two without number (*s.n.*) by the third author and those of Fleetwood (RJF) or William R. Carr (WRC).

MONOCOTS

Alismataceae
Sagittaria longiloba Engelm. ex J.G. Sm., **r**, wetland, 5592

Amaryllidaceae
Allium canadense L. var. *mobilense* (Regel) Ownbey, **i**, prairie, 5997
Nothoscordum bivalve (L.) Britton, **o**, disturbed, 5959
†*Zephyranthes traubii* (W. Hayw.) Moldenke, **o**, prairie, 6109

Arecaceae
Sabal palmetto* (Walter) Lodd. ex Schult. & Schult. f., **o, prairie, 6113
Washingtonia robusta* H. Wendl., **o, disturbed, woodland 6137

Asparagaceae
Yucca flaccida Haw., **r**, prairie, 6140

Commelinaceae
Commelina erecta L. var. *angustifolia* (Michx.) Fernald, **r**, prairie, 5488
Tradescantia occidentalis (Britton) Smyth, **o**, disturbed, 5976
Tradescantia ohiensis Raf., **o**, prairie, 5553
†*Tradescantia subacaulis* Bush, **i**, prairie, 5938

Cymodoceaceae
Halodule wrightii Asch., **a**, seagrass beds, 6119

Cyperaceae
Carex longii Mack. **o**, wetland, 5982
Cyperus acuminatus Torr. & Hook., **r**, prairie, 6148
Cyperus croceus Vahl, **r**, prairie, 5760
Cyperus esculentus* L., **r, prairie, 5489
Cyperus odoratus L. var. *odoratus*, **r**, wetland, 5910
Cyperus polystachyos Rottb., **o**, prairie, wetland, 5576
Cyperus pseudovegetus Steud., **o**, wetland, 5759
Cyperus retrorsus Chapm., **o**, prairie, 5254
Cyperus strigosus L., "disturbed", RJF 10,912
Cyperus surinamensis Rottb., **o**, disturbed, 6094
Cyperus virens Michx. var. *virens*, **f**, wetland, 5756
Eleocharis albida Torr., **o**, prairie, wetland, 5993

Eleocharis ambigens Fernald, **r**, wetland, 6133
Eleocharis montevidensis Kunth, **o**, prairie, wetland, 5599
Eleocharis palustris (L.) Roem. & Schult., **o**, wetland, 5594
Fimbristylis caroliniana (Lam.) Fernald, **o**, prairie, 5494
Fimbristylis castanea (Michx.) Vahl, **f**, beach, prairie, 5300
Isolepis carinata* Hook. & Arn. ex Torr., **r, prairie, 5558
Isolepis cernua* (Vahl) Roem. & Schult., **o, prairie, 5602
Kyllinga brevifolia* Rottb., **o, disturbed, 6066
Rhynchospora colorata (L.) H. Pfeiff., **o**, prairie, 6075
Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller, **o**, wetland, 5590
Schoenoplectus californicus (C.A. Mey.) Soják, **a**, wetland, 6013
Schoenoplectus pungens (Vahl) Palla, **f**, prairie, wetland, 5995

Iridaceae

†*Herbertia lahue* (Molina) Goldblatt, **l**, prairie, 5989
Sisyrinchium biforme E.P. Bicknell, **r**, prairie, 5581
Sisyrinchium exile* E.P. Bicknell, **r, prairie, 5578
Sisyrinchium langloisii Greene, **o**, prairie, 5941

Juncaceae

Juncus acuminatus Michx., **o**, prairie, 5981
Juncus brachycarpus Engelm., **o**, prairie, 6016
Juncus dichotomus Elliott, **o**, prairie, 5992
Juncus marginatus Rostk., **o**, prairie, 5567
Juncus megacephalus M.A. Curtis, **o**, wetland, 5755
Juncus roemerianus Scheele, **f**, wetland, 5572
Juncus validus Coville var. *fascinatus* M.C. Johnst., **o**, wetland, 5754
Juncus validus Coville var. *validus*, **o**, wetland, 5762

Lemnaceae

Lemna minuta Kunth, **a**, wetland, 6014

Poaceae

Agrostis hyemalis (Walter) Britton, Sterns & Poggenb., **o**, prairie, 5988
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb., **r**, wetland, 5916
Andropogon virginicus L., **o**, prairie, 5498
Aristida purpurascens Poir., **i**, prairie, s.n.
Arundo donax* L., **f, wetland, 6139
Axonopus fissifolius (Raddi) Kuhlm., "abundant, grassland", RJF 10,507
Bothriochloa ischaemum* (L.) Keng, **o, disturbed, 6136
Briza minor* L., **f, disturbed, 5974
Cenchrus spinifex Cav., **i**, disturbed, 6070
Cynodon dactylon* (L.) Pers., **o, disturbed, 5969
**Dactyloctenium aegyptium* (L.) Willd., "occasional, disturbed", RJF 10,542
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark, **o**, prairie, 6015
Dichanthelium laxiflorum (Lam.) Gould, **o**, prairie, 5568
Dichanthelium scoparium (Lam.) Gould, **o**, prairie, 5274
Dichanthelium sphaerocarpon (Elliott) Gould "occasional, dunes, wetlands", RJF 10,813
†*Digitaria arenicola* (Swallen) Beetle, **i**, prairie, 6086
Digitaria ciliaris* (Retz.) Koeler var. *ciliaris*, **o, prairie, 5285
Digitaria cognata (Schult.) Pilg. subsp. *cognata*, **o**, prairie, 5487
†*Digitaria texana* Hitchc., **r**, prairie, 6151
Echinochloa walteri (Pursh) A. Heller, **o**, wetland, 5593
Elymus virginicus L., **i**, prairie, 6040
Eragrostis elliottii S. Watson, **o**, prairie, 5497
Eragrostis secundiflora J. Presl, **r**, prairie, 5919
Eragrostis silveana Swallen, **r**, prairie, 6152
Eustachys petraea (Sw.) Desv., **o**, prairie, 5996
Hordeum pusillum Nutt., **f**, disturbed, 5967
Leptochloa fusca (L.) Kunth subsp. *uninervia* (J. Presl) N.W. Snow, **r**, wetland, 5266
Leptochloa nealleyi Vasey, **f**, wetland, 5289
Limnodea arkansana (Nutt.) L.H. Dewey, **i**, woodland, 6003
**Lolium arundinaceum* (Schreb.) Darbysh., "infrequent, grassland", RJF 10,513
Lolium perenne* L., **o, disturbed, 6029
Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs, **r, prairie, 5485
Monanthochloe littoralis Engelm., **a**, salt marsh, 5957
Muhlenbergia capillaris (Lam.) Trin., **o**, prairie, 5491
Panicum amarum Elliott, **f**, dunes, 6145
Panicum dichotomiflorum Michx., **f**, wetland, 6150
Panicum repens* L., **o, beach, 6091
Panicum virgatum L., **o**, prairie, 5298
Parapholis incurva* (L.) C.E. Hubb., **o, saltmarsh, 5964
Paspalidium geminatum* (Forssk.) Stapf var. *geminatum*, **f, wetland, 6131
Paspalum monostachyum Vasey, **o**, prairie, woodlands, 5495
Paspalum plicatulum Michx. var. *plicatulum*, "common", prairie, RJF 10,541
Paspalum setaceum Michx. var. *stramineum* (Nash) D.J. Banks, **o**, prairie, 5492
Paspalum urvillei* Steud., **o, prairie, 6078
Paspalum vaginatum Sw., **a**, wetland, 5265
Phalaris angusta Nees ex Trin., **i**, prairie, 5944
Phalaris caroliniana Walter, **o**, prairie, 5561
Phragmites australis (Cav.) Trin. ex Steud., **f**, wetland, 6146
Poa annua* L., **o, prairie, disturbed, 5937
Polypogon monspeliensis* (L.) Desf., **f, saltmarsh, 5963
Sacciolepis striata (L.) Nash, **o**, wetland, 5915
Schizachyrium scoparium (Michx.) Nash var. *scoparium*, **f**, prairie, 5490
Setaria magna Griseb., **f**, wetland, 5301
Setaria parviflora (Poir.) Kerguélen, **o**, prairie, 5598
Setaria pumila (Poir.) Roem. & Schult., **f**, prairie, 5261
Sorghum halepense* (L.) Pers., **o, disturbed, 6116
Spartina alterniflora Loisel., **a**, saltmarsh, 6123
Spartina patens (Aiton) Muhl., **a**, dunes, prairie, 5257
Spartina spartinae (Trin.) Merr. ex Hitchc., **f**, prairie, saltmarsh, 5589
Sphenopholis obtusata (Michx.) Scribn., **o**, prairie, 5559
Sporobolus virginicus (L.) Kunth, **o**, wetland, beach, 5911
Tridens strictus (Nutt.) Nash, **i**, prairie, s.n.
Tripsacum dactyloides (L.) L., **r**, prairie, 6041
Uniola paniculata L., **r**, dunes, 6144
Vulpia octoflora (Walter) Rydb. var. *octoflora*, **o**, prairie, 5575

Ruppiaceae

Ruppia maritima L., **o**, seagrass beds, wetland, 5971

Smilacaceae

Smilax bona-nox L., **o**, woodland, 6127

Typhaceae

Typha latifolia L., **r**, wetland, 5299

EUDICOTS

Adoxaceae

Sambucus nigra L. subsp. *canadensis* (L.) Bolli, **i**, prairie, 6042

Aizoaceae

Sesuvium maritimum (Walter) Britton, Sterns & Poggenb., **f**, wetland, 5268
Sesuvium portulacastrum (L.) L., **f**, beach, 5934

Amaranthaceae

Alternanthera philoxeroides* (Mart.) Griseb., **f, wetland, 5927
Amaranthus greggii S. Watson, **f**, beach, 6087

*?*Amaranthus spinosus* L., “disturbed”, RJF 10,530
Chenopodium album* L., **r, prairie, 5311
Dysphania ambrosioides* (L.) Mosyakin & Clemants, **f, prairie, 5409
†*Gomphrena nealleyi* J.M. Coult. & Fisher, **o**, prairie, 6110
Gomphrena serrata L., **i**, prairie, 6024
Salicornia bigelovii Torr., **a**, salt marsh, 6114
Sarcocornia utahensis (Tidestr.) A.J. Scott, **a**, salt marsh, 6064
Suaeda linearis (Elliott) Moq., **r**, wetland, 5303
Tidestromia lanuginosa (Nutt.) Standl. subsp. *lanuginosa*, **o**, beach, 6103

Apiaceae

Ammoselinum butleri (Engelm. ex S. Watson) J.M. Coult. & Rose, **o**, prairie, 5951
Chaerophyllum tainturieri Hook. var. *tainturieri*, **o**, disturbed, prairie, 5940
Cyclospermum leptophyllum (Pers.) Sprague, **o**, prairie, 5603
Limnosciadium pinnatum (DC.) Mathias & Constance, **o**, prairie, 5586
Limnosciadium pumilum (Engelm. & A. Gray) Mathias & Constance, **f**, prairie, 5962

Apocynaceae

Cynanchum angustifolium Pers., **o**, wetland, 5295

Aquifoliaceae

Ilex vomitoria Aiton, **i**, woodland, 6028

Araliaceae

Hydrocotyle bonariensis Lam., **o**, wetland, 5752

Asteraceae

Ambrosia psilostachya DC., **o**, prairie, 6134
Ambrosia trifida L. var. *texana* Scheele, **o**, woodland, 6134
Aphanostephus skirrhobasis (DC.) Trel. ex Coville & Branner, **o**, dunes, 5929
Baccharis halimifolia L., **f**, woodland, 6128
Borrichia frutescens (L.) DC., **o**, wetland, 5307
Cirsium horridulum Michx. var. *horridulum*, **o**, prairie, 5998
Conoclinium coelestinum (L.) DC., **r**, wetland, 5292
Conyza canadensis (L.) Cronquist, **o**, prairie, 5408
Coreopsis basalis (A. Dietr.) S.F. Blake, **o**, prairie, 6022
Coreopsis tinctoria Nutt., **r**, prairie, 5749
Eclipta prostrata (L.) L., **r**, wetland, 5286
Erigeron procumbens (Houst. ex Mill.) G.L. Nesom, **i**, prairie, 5746
Eupatorium capillifolium (Lam.) Small ex Porter & Britton, **o**, prairie, 6130
Eupatorium serotinum Michx., **f**, prairie, 5407
Euthamia gymnospermoides Greene, “common, grassland”, WRC 10,187
Euthamia leptocephala (Torr. & A. Gray) Greene ex Porter & Britton, **a**, prairie, 5499
Gaillardia pulchella Foug., **o**, prairie, 5277
Helenium amarum (Raf.) H. Rock, **r**, prairie, 5417
Helianthus petiolaris Nutt. subsp. *petiolaris*, **o**, prairie, 5255
Helianthus praecox Engelm. & A. Gray, **f**, dunes, 6076
Heterotheca subaxillaris (Lam.) Britton & Rusby, **o**, dunes, prairie, 5753
Hypochaeris microcephala* (Sch. Bip.) Cabrera var. *albiflora* (Kuntze) Cabrera, **i, disturbed, 6020
Iva angustifolia Nutt. ex DC., **o**, saltmarsh, 6124
Iva frutescens L., **f**, saltmarsh, 5269
Krigia wrightii (A. Gray) K.L. Chambers ex K.J. Kim, **r**, disturbed, 5958
Mikania scandens (L.) Willd., **o**, wetland, 5291
Pluchea odorata (L.) Cassini var. *odorata*, **o**, wetland, 5259
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt, **o**, prairie, 5555
Pyrrhopappus carolinianus (Walter) DC., **r**, prairie, 5748
Rayjacksonia phyllocephala (DC.) R.L. Hartm. & M.A. Lane var. *phyllocephala*, **a**, beach, 5932
Rudbeckia hirta L., **o**, prairie, 5552
Solidago sempervirens L., **o**, prairie, 5420
Soliva sessilis Ruiz & Pav., **f**, disturbed, 6025
Sonchus asper* (L.) Hill, **i, prairie, 6023
Sonchus oleraceus* L., **i, disturbed, 5961
Symphyotrichum subulatum (Michx.) G.L. Nesom, **o**, prairie, 5914

Bataceae

Batis maritima L., **a**, saltmarsh, 5305

Bignoniaceae

Campsis radicans (L.) Bureau, **o**, woodland, 6072

Boraginaceae

Heliotropium curassavicum L. var. *curassavicum*, **f**, wetland, 5288
Nama jamaicensis L., “disturbed”, RJF 10,905

Brassicaceae

Cakile constricta Rodman, **f**, beach, 6031
Cakile geniculata (B.L. Rob.) Millsp., **f**, beach, 6032
Lepidium virginicum L. var. *virginicum*, **o**, prairie, 5587

Cactaceae

Opuntia humifusa (Raf.) Raf. var. *humifusa*, **o**, prairie, woodland, 6096

Campanulaceae

Triodanis biflora (Ruiz & Pav.) Greene, **o**, prairie, 5556

Cannabaceae

Celtis laevigata Willd., **o**, woodland, 6007

Caprifoliaceae

Lonicera japonica* Thunb, **o, woodland, 5985
Valerianella woodsiana (Torr. & A. Gray) Walp., RJF 10,908

Caryophyllaceae

Cerastium glomeratum Thuill., **o**, prairie, 5936
**Polycarpon tetraphyllum* (L.) L., “disturbed”, RJF 10,922
**Silene gallica* L., “disturbed”, RJF 10,888
Spergularia salina J. Presl & C. Presl, **o**, saltmarsh, 5965
Stellaria media (L.) Vill., **o**, prairie, 5953

Celastraceae

Lepuropetalon spathulatum Muhl. ex Elliott, **o**, prairie, 5573

Cistaceae

Helianthemum rosmarinifolium Pursh, **o**, prairie, 6125
Lechea mucronata Raf., **r**, prairie, 5912

Convolvulaceae

Calystegia sepium (L.) R. Br. subsp. *limnophila* (Greene) Brummitt, **o**, disturbed, 6034
Cuscuta indecora Choisy var. *indecora*, **o**, saltmarsh (on *Iva frutescens*), 6118
Dichondra carolinensis Michx., **o**, prairie, 5973
Ipomoea cordatotriloba Dennst. var. *cordatotriloba*, **i**, prairie, 6112
Ipomoea imperati (Vahl) Griseb., **f**, dunes, 6033
Ipomoea pes-caprae (L.) R. Br. subsp. *brasiliensis* (L.) Ooststr., **f**, dunes, 6090
Ipomoea sagittata Poir., **f**, wetland, 5302

Cucurbitaceae

Ibervillea lindheimeri (A. Gray) Greene, “occasional, disturbed”, RJF 10,539
Melothria pendula L., **o**, woodland, 6147

Euphorbiaceae

Chamaesyce maculata* (L.) Small, **o, prairie, 5284
Chamaesyce nutans* (Lag.) Small, **o, disturbed, 6143

Croton capitatus Michx. var. lindheimeri (Engelm. & A. Gray) Müll. Arg., **o**, prairie, 5922
Croton glandulosus L. var. *lindheimeri* Müll. Arg., **f**, prairie, 5256
Croton punctatus Jacq., **f**, dunes, 6077
Triadica sebifera* (L.) Small, **o, woodland, 6126

Fabaceae
Acacia farnesiana (L.) Willd., **o**, prairie, 5983
Aeschynomene indica* L., **r, wetland, 5414
Astragalus leptocarpus Torr. & A. Gray, **i**, prairie, 5949
Baptisia bracteata Muhl. ex Elliott var. *leucophaea* (Nutt.) Kartesz & Gandhi, **f**, dunes, prairie, 5580
Centrosema virginianum (L.) Benth., **r**, prairie, 5418
Chamaecrista fasciculata (Michx.) Greene, **o**, prairie, 5406
Erythrina herbacea L., **f**, woodland, 5984
Glottidium vesicarium* (Jacq.) R.M. Harper, **r, prairie, 5496
Indigofera miniata Ortega, **i**, prairie, 6035
Indigofera suffruticosa Mill., **o**, woodland, 6129
Leucaena leucocephala* (Lam.) de Wit, **o, woodland, 6121
Medicago polymorpha* L., **o, disturbed, 5977
Melilotus indicus* (L.) All., **r, prairie, 5994
Mimosa strigillosa Torr. & A. Gray, **o**, prairie, 5278
Pediomelum rhombifolium (Torr. & A. Gray) Rydb., "infrequent, disturbed", RJF 10,535
Rhynchosia americana (Mill.) Metz, **o**, prairie, 6071
Robinia pseudoacacia* L., **i, woodland, 6074
Sesbania drummondii (Rydb.) Cory, **o**, wetland, 5294
Strophostyles helvola (L.) Elliott, **f**, prairie, slatmarsh, 6117
Strophostyles leiosperma (Torr. & A. Gray) Piper, **f**, prairie, 5262
Tephrosia onobrychoides Nutt., **r**, prairie, 5744
Trifolium carolinianum Michx., **i**, disturbed, 5991
Vicia ludoviciana Nutt. ex Torr. & A. Gray, **o**, disturbed, 5972
Vicia minutiflora D. Dietr., **o**, prairie, 5948
Vigna luteola (Jacq.) Benth., **f**, wetland, dunes, 5283

Fagaceae
Quercus nigra L., **i**, woodland, 6011
Quercus virginiana Mill., **f**, woodland, 6008

Gentianaceae
Centaurium pulchellum* (Sw.) Druce, **r, disturbed, 5966
Eustoma exaltatum (L.) Salisb. ex G. Don, **r**, beach, prairie, 5419
Sabatia campestris Nutt., **r**, prairie, 5579

Geraniaceae
Geranium carolinianum L., **f**, prairie, 5952
Geranium texanum (Trel.) A. Heller, **o**, prairie, 5577

Hypericaceae
Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray, **o**, prairie, 5921

Lamiaceae
Monarda punctata L., **o**, prairie, 5583
Scutellaria parvula Michx., **o**, woodland, 6073
Teucrium canadense L., **f**, prairie, 5272

Linaceae
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald, **o**, prairie, 5750

Malvaceae
Callirhoe involucrata (Torr. & A. Gray) A. Gray var. *lineariloba* (Torr. & A. Gray) A. Gray, "disturbed", RJF 10,926
Hibiscus laevis All., **i**, wetland, 6095
Kosteletskya virginica C. Presl, **f**, wetland, 5263
Sida ciliaris L., **o**, prairie, 6079
Sida rhombifolia L., **o**, disturbed, 6005

Melastomataceae
Rhexia mariana L. var. *mariana*, **o**, prairie, 5745

Myricaceae
Morella cerifera (L.) Small, **i**, prairie, woodlands, 6012

Onagraceae
Gaura filiformis Small, **f**, prairie, 5271
Gaura parviflora Douglas ex Lehm., **i**, prairie, 6027
Ludwigia glandulosa Walter, **o**, wetland, 6081
Ludwigia grandiflora* (Michx.) Greuter & Burdet subsp. *hexapetala* (Hook. & Arn.) G.L. Nesom & Kartesz, **o, wetland, 6082
Ludwigia linearis Walter, **o**, wetland, 5758
Ludwigia repens J.R. Forst., **o**, wetland, 6065
Oenothera drummondii Hook., **f**, dunes, prairie, 5751
Oenothera laciniata Hill, **o**, prairie, 5970
Oenothera speciosa Nutt., **f**, prairie, 5956

Orobanchaceae
Agalinis fasciculata (Elliott) Raf., **f**, prairie, 5276
Agalinis heterophylla (Nutt.) Small, **i**, prairie, 6141
Agalinis maritima (Raf.) Raf., **o**, salt marsh, 6069
Buchnera americana L., **r**, prairie, 6111

Oxalidaceae
Oxalis corniculata* L., **o, prairie, 5943
Oxalis violacea L., **r**, disturbed, 5918

Phytolaccaceae
Phytolacca americana L., **o**, prairie, 5282

Plantaginaceae
Bacopa monnieri (L.) Wettst., **f**, wetland, 5267
Callitriche peploides Nutt., **r**, wetland, 5597
Callitriche terrestris Raf., **o**, wetland, 5596
Nuttallanthus texanus (Scheele) D.A. Sutton, **o**, prairie, 5584
Plantago hookeriana Fisch. & C.A. Mey., "disturbed", RJF 10,904
Plantago virginica L., **f**, disturbed, 5968

Plumbaginaceae
Limonium carolinianum (Walter) Britton, **o**, saltmarsh, 5913

Polygalaceae
Polygala verticillata L., **o**, prairie, 5588

Polygonaceae
Persicaria hydropiperoides (Michx.) Small, "common, wetland", RJF 10,527
Persicaria punctata (Elliott) Small, **f**, wetland, 5591
Rumex crispus L., **o**, wetland, 5978
Rumex hastatulus Baldwin, **o**, prairie, 5582
Rumex verticillatus L., **i**, wetland, 5945

Polypremaceae
Polypremum procumbens L., **r**, prairie, 5920

Portulacaceae
Portulaca oleracea* L., **o, disturbed, 6068
Portulaca pilosa L., **o**, disturbed, 6108

Primulaceae
Anagallis arvensis L., **o**, prairie, 5605
Anagallis minima (L.) E.H.L. Krause, **r**, prairie, 5557
Samolus ebracteatus Kunth, **o**, prairie, 6000

Ranunculaceae
Ranunculus muricatus L., **o**, disturbed, 5980
Ranunculus pusillus Poir., **f**, wetland, 5595

Rosaceae
Rubus trivialis Michx., **f**, dunes, 5924

Rubiaceae
Diodia teres Walter, **o**, prairie, 5923
Diodia virginiana L., **o**, wetland, 5296
Galium aparine L., **o**, disturbed, prairie, 5955
Galium tinctorium L., **f**, wetland, 5597
Galium uniflorum Michx., "common, wetlands", RJF 10,510
Oldenlandia uniflora L., **r**, prairie, 5747

Rutaceae
Zanthoxylum clava-herculis L., **f**, woodland, 5987

Salicaceae
Salix nigra Marshall, **i**, wetland, 6083

Sapotaceae
Sideroxylon lanuginosum Michx. subsp. *oblongifolium* (Nutt.) T.D. Penn., **o**, woodland, 6122

Simaroubaceae
†*Leitneria pilosa* J.A. Schrad. & W.R. Graves subsp. *pilosa*, **i**, wetland, 6138

Solanaceae
Lycium carolinianum Walter, **a**, salt marsh, 6149
Physalis angulata L. var. *angulata*, **r**, wetland, 5297
Physalis cinerascens (Dunal) Hitchc. var. *spathulifolia* (Torr.) J.R. Sullivan, **o**, prairie, 6085
Physalis pubescens L. var. *pubescens*, **o**, wetland, 5306
Solanum ptychanthum Dunal, **r**, prairie, 5304

Tamaricaceae
Tamarix ramosissima* Ledeb., **f, wetland, 5933

Urticaceae
Urtica chamaedryoides Pursh, "wetlands", RJF 10,818

Verbenaceae
Lantana camara* L., **o, prairie, 5281
Phyla lanceolata (Michx.) Greene, **f**, wetland, 5975
Phyla nodiflora (L.) Greene, "common", RJF 10,532
Verbena halei Small, **o**, prairie, 5942
Verbena brasiliensis* Vell., **o, disturbed, 6010

Vitaceae
Ampelopsis arborea (L.) Koehne, **r**, prairie, 5412
Cissus incisa Des Moul., **o**, wetland, 5413
Vitis mustangensis Buckley, **o**, woodland, 5986

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AN ANNOTATED FLORA OF REED PLATEAU AND ADJACENT AREAS, BREWSTER COUNTY, TEXAS, U.S.A.

Wendy Weckesser

102 Miguel Angel Court
Del Rio, Texas 78840, U.S.A.
wendyweck13@gmail.com

Martin Terry

Sul Ross State University
Box C-64
Alpine, Texas 79832, U.S.A.

ABSTRACT

Reed Plateau is a geographic feature in south Brewster County, Texas (U.S.A.) that exhibits a floral array characteristic of the northern Chihuahuan Desert region. Held as private property by many landowners, Reed Plateau and areas adjacent to it have never been the focus of a botanical study. A survey of Reed Plateau and adjacent areas was conducted from August 2004 through November 2007, with a total of 1065 specimens collected. The flora consists of 262 taxa, including 1 subspecies and 15 varieties, in 188 genera and 63 families. The best-represented families are the Asteraceae (33 species), Poaceae (23 species), Fabaceae (18 species), Cactaceae (17 species), and Euphorbiaceae (13 species). One federally listed threatened species, *Echinomastus mariposensis*, was identified within the study area. The only known U.S. populations of *Genistidium dumosum* occur on Reed Plateau. The occurrence of *Stemodia coahuilensis* represents a new county record, and a new *Hibiscus* hybrid was described. Two Big Bend and three Trans-Pecos endemics were documented. Four non-native species were collected, three of which are considered noxious or invasive. The vegetation associations found in the Reed Plateau study area strongly reflect the predominantly limestone substrate of the Terlingua-Solitario structural block. Diverse geographic factors within the relatively small study area support floral diversity patterns which are compared to studies from nearby Big Bend National Park and Big Bend Ranch State Park, as well as the Southwestern United States and the Chihuahuan Desert region.

RESUMEN

Reed Plateau es un elemento geográfico en el sur del condado Brewster, Texas, que exhibe una colección floral característica del norte del Desierto Chihuahuense. Compuesto de terrenos privados de muchos propietarios, Reed Plateau y sus alrededores nunca han sido el sujeto de un estudio botánico. Una investigación fue conducida entre agosto 2004 y noviembre 2007, con 1065 especímenes recogidos. La flora consiste en 262 especies, con una subespecie y 18 variedades, de 188 géneros y 63 familias. Las familias mejor representadas fueron las Asteraceae (33 especies), Poaceae (23 especies), Fabaceae (18 especies), Cactaceae (17 especies) y Euphorbiaceae (13 especies). Una especie amenazada en la lista federal, *Echinomastus mariposensis*, fue identificada dentro de la zona del estudio. Las únicas poblaciones de *Genistidium dumosum* conocidas en los E.U. ocurren en Reed Plateau. La ocurrencia de *Stemodia coahuilensis* representa una especie nueva para el condado de Brewster, y un híbrido nuevo de *Hibiscus* fue descrito. Dos especies endémicas de Big Bend y tres del Trans-Pecos fueron documentadas. Cuatro especies no nativas fueron recogidas, tres de ellas consideradas nocivas o invasivas. Las asociaciones vegetales encontradas en Reed Plateau reflejan fuertemente el sustrato predominantemente calizo del bloque estructural Terlingua-Solitario. Factores geográficos diversos dentro del área relativamente pequeña del estudio apoyan patrones de diversidad floral, los cuales se comparan con los patrones de diversidad encontrados en estudios que se han hecho en sitios cercanos, como el parque nacional de Big Bend y el parque estatal de Big Bend Ranch, y además con estudios del Suroeste de los E.U. y la región del Desierto Chihuahuense.

INTRODUCTION

Reed Plateau is a geographic feature located near Terlingua in southern Brewster County, Texas. Two protected areas flank Reed Plateau, Big Bend National Park (BBNP) to the east and Big Bend Ranch State Park (BBRSP) to the west (Fig. 1). While much floristic work has been done in the protected areas (Butterwick & Lamb 1976; Butterwick & Strong 1976a, 1976b, 1976c; Powell 1985; Worthington 1995; Louie 1996; Bartel 2002; Henklein 2003), Reed Plateau is held as private property in its entirety and has never been the focus of a botanical survey. The compilation of an annotated flora for Reed Plateau and adjacent areas (RP) was the primary objective of this study. In conjunction with the flora, we have described the vegetation associations in the study area. The species list generated by the current effort has been compared with the floras resulting from similar studies in the nearby protected areas (Hardy 1997; Fenstermacher 2008), as well as a Chihuahuan Desert (CD) flora (Henrickson & Johnston 2004) and a Southwest United States (SW) flora (McLaughlin 1986). The annotated RP list can be used as baseline information for future studies, as the level of human activity on and near RP changes.

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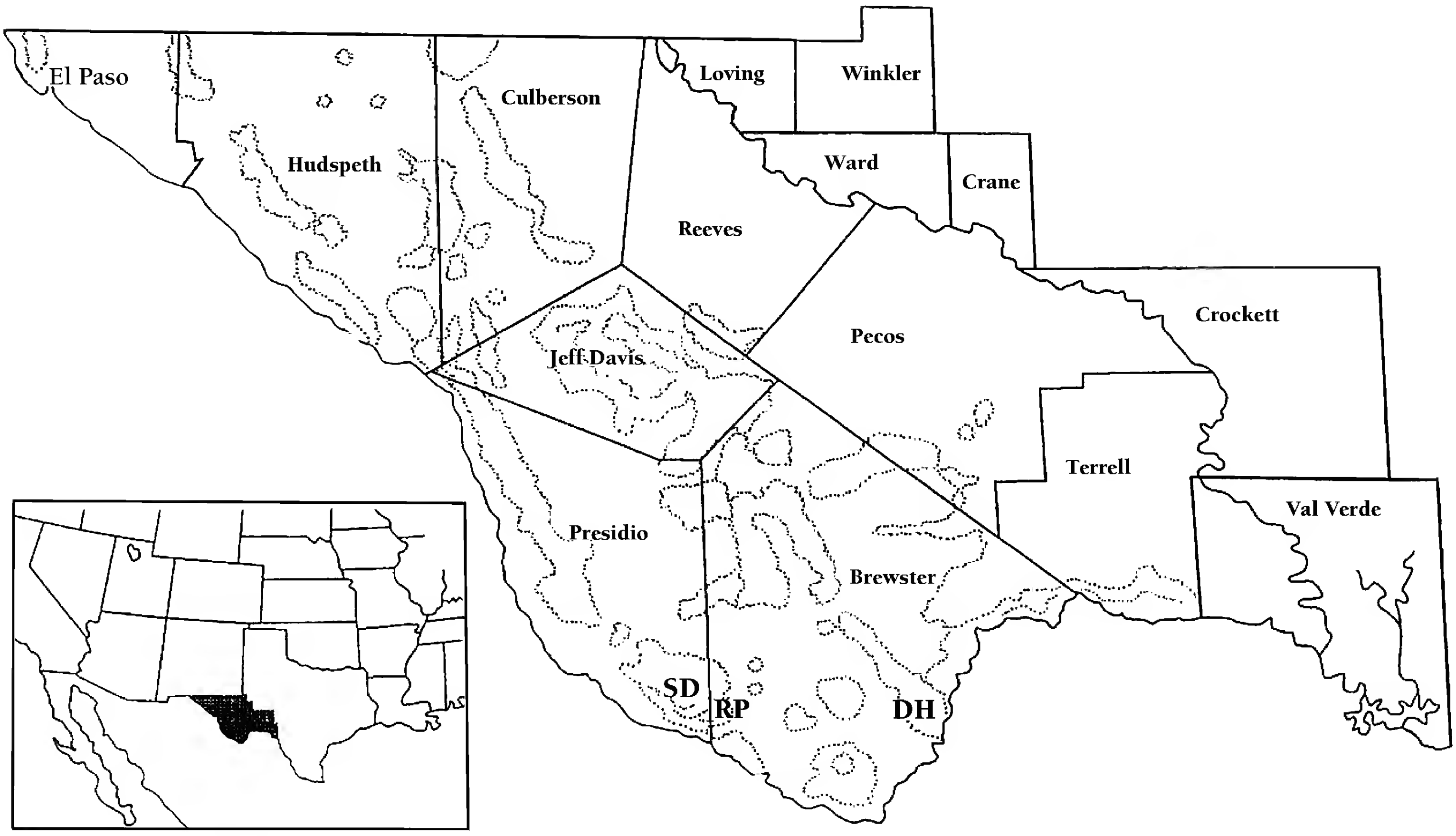

Fig. 1. Map of Trans-Pecos Texas with locations of Reed Plateau study area (RP), Solitario Dome (SD), and Dead Horse Mountains (DH) noted (courtesy of Sul Ross State University Department of Biology, with modifications.)

Site description

Physical features of the Terlingua-Solitario structural block (Erdlac 1990) define the study area: the Terlingua uplift, the Terlingua monocline and the Long Draw drainage. The portion of the Terlingua uplift that lies to the south of Highway 170 with a general east-west orientation is identified on United States Geologic Survey (USGS) topographic and geologic maps (USGS 1971a, 1971b; Barnes 1979) as Reed Plateau. North of Highway 170, the uplift continues uninterrupted in a more northwesterly direction to the point where Long Draw, from its origins in the vicinity of Black Mesa, cuts through the cliffs. The Terlingua uplift is seen as steep to near-perpendicular cliff faces cut by narrow drainages and canyons. The plateau rises 70–100 m (230–340 ft) in elevation above the surrounding desert floor, with a maximum elevation of 1012 m (3380 ft). Long Draw, a broad creek bed that is normally dry but sporadically flooded, follows the base of the cliff formed by the uplift until it cuts through the cliff once again to head in a southerly direction. The Terlingua monocline falls away to the south and west, with wide slopes and cliff faces that are less steep than those of the north side. The southern slopes and cliffs are cut by wide drainages and canyons or abruptly drop off with steep limestone outcrops.

The study area is approximately 3,237 ha (8,000 ac; 31 km^2; 12.5 sq mi). Long Draw forms the northern and eastern limits. The Terlingua monocline loosely delineates the southern and western boundaries of the study area; investigational forays into the lower elevations extended only to where there seemed to be no further variation in vegetation.

The east-west section of RP is 7.2 km (4.5 mi) from the eastern intersection of Long Draw and the Terlingua uplift to the Terlingua Sinkhole. Approximately 3.2 km (2 mi) to the northwest beyond the Terlingua sinkhole, Long Draw again cuts through the plateau, forming the northern boundary of RP. The study area is approximately 1.6 km (1 mi) wide, measuring from Long Draw to the elevations of the Terlingua monocline where no further variations in vegetation were observed.

RP experiences hot summers and cool winters. Temperatures range from 43°C (110°F) in midsummer to below freezing in winter. Average rainfall in the area varies from 16 to 28 cm (6 to 11 in), depending on elevation. Most precipitation occurs in late summer, as scattered afternoon downpours. There is a strong relation between the occurrence of high summer temperatures and the onset of the rainy season in late summer

(Schmidt 1986). Winter precipitation occurs infrequently, with intermittent snowfall more common in the higher elevations (pers. obs.; Arbingast et al. 1973; Morafka 1977; Schmidt 1979, 1986). During the course of the study, precipitation was above average for late summer 2004 and midsummer 2005 (unpublished data, BBNP and BBRSP).

The geology of RP is largely Cretaceous limestone. Across the Terlingua uplift, Lower to Upper Cretaceous formations are present (Erdlac 1990). The uplift is comprised of Buda limestone, Del Rio clay, and Santa Elena limestone (Barnes 1979). This stratigraphy is also found in BBNP (Maxwell et al. 1967) and in the Solitario of BBRSP (McCormick et al. 1996). Alluvium, colluvium, and surface caliche of Old Quaternary deposits are found in the drainages of and at the base of the Terlingua monocline (Barnes 1979). At the base of the Santa Elena limestone cliffs, the surface strata in Long Draw are identified as Young Quaternary deposits (Barnes 1979). An outcrop of the Pen Formation is located within the study area in Long Draw drainage near the Rainbow Mine, just west of the Terlingua Ghost Town.

Current classification of soils from the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) shows that the most common soil type on the uplands of Reed Plateau is the Blackgap-Rock outcrop complex. In Long Draw, the soils are identified as the Riverwash-Pantera complex. The Geefour silty clays complex is associated with the Del Rio and the Pen Formations, and is also found at the eastern end of the study area and in scattered pockets north of Hwy 170 (Web Soil Survey 2013).

Vegetation Associations

The vegetation associations of the Chihuahuan Desert region (CD) described by Henrickson and Johnston (1986) provide the basis for the description of the vegetation associations of RP. Communities are broadly categorized as desert scrub, woodland, grassland, and chaparral, with multiple subcategories and variations that reflect the complexity and diversity of CD vegetation patterns found on RP.

Cultural History

Substantial evidence of human habitation in the Terlingua area dates to the late Archaic Period, from approximately 1000 BC to AD 900 (Hudson 1976; Ing et al. 1996). In the Prehistoric Period (900 AD–1530 AD), evidence of permanent habitation and agriculture appears, especially in the area of the confluence of the Rio Grande and the Río Conchos (Ing et al. 1996). In the Historic Period (1530 AD to present), the sedentary peoples of the rivers and deserts came in contact with Spanish explorers; the Mescalero Apache, in their seasonal migration, moved through the area; and, later, Comanche groups supplanted the Apaches. The Comanche moved continually through the area until their complete subjugation by United States forces in the late 1880s (Ragsdale 1976).

The first geologic survey was conducted in the area in the 1880s. From that time until the 1920s ranching was the dominant way of life in the region. With little water and, reportedly, not much grass, Terlingua was the last area to be impacted by ranching.

An awareness of cinnabar in the area was longstanding, and in 1884 the first mercury mining claim was put into operation (Ragsdale 1976). The Colquitt Tigner Mine, still identified by name on the Amarilla Mountain topographic map (USGS 1971a), was in a drainage immediately to the west of the northern extent of the study area. The Waldrop Mine is within the study area of this project. The furnaces to process the cinnabar were fired with cottonwood and mesquite, gathered from the Rio Grande corridor, and probably Long Draw, to the point of being completely depleted by the 1930s (Ragsdale 1976).

The mercury was carted overland to Marfa. Two-track roads from Villa de la Mina, within the study area, and Lone Star Mine, to the west of RP, still exist that eventually reach Marfa (Ragsdale 1976). These old roads provided access to some of the more remote sections of the study area.

When the demand for mercury declined in the 1940s, the area population plummeted, and Terlingua became a ghost town (Ragsdale 1976). One activity that continued through the 1950s and into the 1970s was candelilla wax processing (B. Pittman, pers. comm.). *Euphorbia antisyphilitica* was harvested and processed for its wax, used in cosmetics. At least three processing sites were within RP. Another extractive activity from the 1970s that continues today is the removal of cacti and other succulents for commercial purposes (Harrington 1980).

In the late 1970s, the population of the area slowly began to increase. BBNP had been established in the 1940s, and it was a draw for outdoor adventurers. River-tour companies started providing guided trips on the Rio Grande. Current land division dates to that time, with home construction the predominant use of the land. The pace of development had been slow until approximately 10 years ago, when the rate of land sales and new home construction increased, compared to the previous twenty years.

MATERIALS AND METHODS

Herbaria search

Herbaria at Angelo State University (SAT), the Botanical Research Institute of Texas (BRIT), Texas A&M University (TAES and TAMU), and University of Texas Austin (TEX-LL) were contacted via email with requests for electronic searches. A manual search was conducted at the A. Michael Powell Herbarium at Sul Ross State University (SRSC). In addition, the Flora of Texas Consortium website was used for an online search of electronic databases (Texasflora.org 2003).

Field collections

Permission for access to the privately held lands of RP was documented with written statements from landowners. Variation in geology and terrain guided field efforts, in an attempt to find as much diversity within the study area as possible. USGS maps of the Amarilla Mountain, Texas (1971a), and Terlingua, Texas (1971b), quadrangles were references for elevation and topography. Access to portions of the study area was possible by vehicle along old two-track mining roads, but much of the study area is accessible only on foot. A modified meander-search method, based on Goff et al. (1982), was employed to collect enough specimens to reflect the diversity of plant life on RP. Specimens were collected from August 2004 through November 2007, with 127 days in the field. Collection effort, over 500 hours, was greatest in spring and early fall, especially after rains.

Principal sources for identification and nomenclature were Correll and Johnston (1970), Powell (1994, 1998), and Powell and Weedin (2004), as well as online sources (ITIS 2007; Tropicos.org 2014; USDA-PLANTS 2014). Access to Powell's key (in prep.) to Trans-Pecos non-woody plants was especially helpful. Billie L. Turner and A. Michael Powell verified specimen identifications. Taxonomy follows Evert and Eichhorn (2013) at the phyla level. Additional sources for identification and nomenclature were Jones et al. (2003), Turner et al. (2003), and Yarborough and Powell (2002). Warnock (1970, 1974, 1977) proved useful for visual identifications. Current nomenclature and authors were found on two online sources (Tropicos.org 2014; efloras.org 2014). Author abbreviations follow Brummitt and Powell (1992). A representative collection of each taxon is housed at SRSC, with selected duplicates sent to BRIT and TEX-LL.

RESULTS AND DISCUSSION

During the three-year study period, 1065 specimens were collected. The flora consists of 262 taxa, including 1 subspecies and 15 varieties, in 188 genera and 63 families. Phylum Anthophyta, with 254 species, forms 97% of the floral array. The families best represented in the flora are the Asteraceae (33 species), Poaceae (23 spp.), Fabaceae (18 spp.), Cactaceae (17 spp.), and Euphorbiaceae (13 spp.). These five families comprise 40% of the flora. Other well-represented families include the Boraginaceae, Solanaceae, Malvaceae, Nyctaginaceae, Verbenaceae, Brassicaceae, Pteridaceae, and Onagraceae, which together constitute 19% of the flora. Thirty-eight species are the sole representatives of their families on RP. Five species endemic to the Big Bend area or the Trans-Pecos region (*Kallstroemia perennans*, *Lycium puberulum* var. *berberioides*, *Lycium texanum*, *Chamaesyce perennans*, *Thelypodium texanum*) were documented. Four species with conservation status (*Genistidium dumosum*, *Oenothera boquillensis*, *Lycium texanum*, *Echinomastus mariposensis*) and four non-native species (*Cynodon dactylon*, *Salsola tragus*, *Tamarix chinensis*, *Pennisetum ciliare*) were identified. Further distributional data for RP, along with taxonomic distributions of the Dead Horse Mountains (DH) and Solitario Dome (SD) floras, are presented in Table 1.

Herbaria search

The amount of material from the study area previously disseminated to herbaria in Texas seems to be sparse,

Table 1. Taxonomic composition of three Big Bend floras [RP = Reed Plateau study area; DH = Dead Horse Mountains (Fenstermacher 2008); SD = Solitario Dome (Hardy 1997)].

	RP		DH		SD	
Taxa	Families	Species	Families	Species	Families	Species
Lycopodiophyta	1	1	1	3	1	4
Monilophyta	1	6	2	20	1	16
Gnetophyta	1	1	1	3	1	2
Coniferophyta	0	0	2	4	1	2
Monocotyledones	4	29	10	107	10	74
Dicotyledones	56	225	75	525	72	434
Totals	63	262	91	662	86	532

which may be expected since RP has never been the sole focus of a floristic survey. In addition, limited availability of herbaria information in electronic format meant that online searches would be far from exhaustive. The electronic search of the TAMU database resulted in a list of over 6,000 records from Brewster County, with no feasible means of narrowing the search parameters. No further examination of that database was performed. No results from search requests were returned from BRIT or TAES since their collections were not completely accessioned electronically or not available via the Internet. The probability of locating other collections from RP and the Terlingua area in herbaria such as BRIT and TAES will increase when their collections are fully accessible in an electronic format. No information was available from the herbarium at Angelo State University (SAT).

The search of the University of Texas at Austin (TEX-LL) database resulted in a list of over 500 collections from the Terlingua area, including RP. A manual search of SRSC resulted in a number of collections from RP, some of which were duplicated in the TEX-LL list. Eleven collections of species not encountered during the current study are stored at SRSC and TEX-LL. These are included in the annotated species list for RP.

Taxonomic breakdown

A comparison of the RP flora with the DH (Fenstermacher 2008) and the SD (Hardy 1997) floras (Table 1) shows expected similarities in species diversity and taxonomic composition, with minor variations that can be explained by the differences in scope of study and geographic variability. The SD study area encompassed igneous as well as limestone substrates and canyon environments more developed than those seen in RP. The DH, with the inclusion of the Rio Grande corridor, presents a much greater range of elevation and habitat variation than either RP or SD. In addition to the riparian habitat included in DH, both DH and SD contain springs and seeps. There is no permanent aquatic habitat in RP.

The Gnetophyta are represented in the three study areas by the genus *Ephedra* (Ephedraceae). While several species were found on DH and SD, only *E. aspera* was found on RP. The relative homogeneity of the habitats on RP may account for *Ephedra* being represented by a single species. Of the Coniferophyta, species from two families were documented on the DH and the SD, but no conifers were documented from RP in this study.

While all species of the Monilophyta of RP are also found on both DH and SD, there are additional species from this group in DH and SD that do not occur in RP. The taxonomic breakdown of the RP flora shows a lower percentage of ferns and fern allies, as well as a lower proportion of the monocots, with a concomitant slightly higher proportional representation of the eudicots, when compared to the other Big Bend floras (Table 1). Additional representation among the ferns and monocots on SD and DH, with their springs and riparian habitats, is especially notable at the family level. The monocot families Amaryllidaceae, Orchidaceae, Commelinaceae, Juncaceae, and Typhaceae are represented on both SD and DH. The absence of these families from RP may explain the seemingly anomalous dominance of the eudicots on RP. One possible explanation for this is the lack of mesic habitats on RP. There are species from these families present in the SD and DH that require moister habitats than are found on RP. The ferns and fern allies show this same trend. Another contributing factor to the lower percentage of monocots could be the under-representation of the family Poaceae in the RP flora.

Table 2. Taxonomic breakdown of families and species of local and regional [SW = Southwest U.S. (McLaughlin 1986); CD = Chihuahuan Desert region (Henrickson pers. comm.); DH = Dead Horse Mountains (Fenstermacher 2008); SD = Solitario Dome (Hardy 1997); RP = Reed Plateau study area].

Taxonomic Group	RP	%	DH	%	SD	%	CD	%	SW	%
Families										
Ferns and fern allies	2	3.2	3	3.3	2	2.3	11	7.3	9	7.0
Gymnosperms	1	1.6	3	3.3	2	2.3	4	2.7	3	2.4
Monocots	5	6.3	10	11.0	10	11.6	21	14.0	10	7.9
Eudicots	55	88.9	75	82.4	75	83.7	114	76.0	105	82.7
Species										
Ferns and fern allies	7	2.7	23	3.5	20	3.8	94	2.9	120	2.2
Gymnosperms	1	0.4	7	1.1	4	0.8	35	1.1	36	0.7
Monocots	29	11.1	107	16.2	74	13.9	515	15.9	723	13.2
Eudicots	225	85.9	525	79.3	734	81.6	2588	80.0	4579	83.9

In a regional context (Table 2), trends emerge in the broad scope of their relationships to each other and to floras of the SW (McLaughlin 1986) and the CD (Henrickson & Johnston 2004). The taxonomic distribution of the DH, easternmost of the three Big Bend study areas, shows influences from the Great Plains and the Chihuahuan Desert. The SD flora aligns more closely with the SW flora. RP, closer geographically to the SD than to the DH, but in between the two, presents influences from both regions. The gymnosperms are poorly represented on RP when compared to regional as well as local floras. The representation of gymnosperms for DH is the same as that for the CD, and the SD shows similar proportions to those of the SW.

In contrast to the lack of gymnosperms on RP, ferns and fern allies are represented in the RP flora at a level commensurate with their representation in the CD. Both DH and SD show greater percentages of ferns and fern allies in their floras, more than either regional flora as well.

The percentage of monocots in the CD flora is higher than that of the SW flora. The greater number of graminoid species, as a reflection of the influence of the grasslands to the east of the CD, has been proposed as the point of departure (Fenstermacher 2008). As with the local comparisons of monocots and eudicots, RP does not support the level of diversity of monocot families seen in the SW or CD, given its relatively small area, the limited range of habitat variability, and the lack of permanent water.

Life forms

The most common life forms found on RP are, in order of decreasing abundance, perennial herbs, shrubs, subshrubs, and annual herbs. Vines, trees, and semi-succulents make up less than 4% each of the flora. The life form categories used in the Big Bend studies and the SW are not identical, but regrouping some of the data allows for an indirect comparison (Weckesser 2008). No summary of life forms from the CD is available. Perennial herbs are the dominant life forms for the three Big Bend study areas, as well as in the SW flora. Annual herbs constitute the next most dominant form on DH, SD, and the SW. In contrast, the shrubs are more abundant than annual herbs in RP. With its dry, rocky ridges and gullies, RP supports more shrub species throughout the year than annual herbs in season.

Six species in RP are categorized as trees. Two species (*Acacia roemeriana* and *Prosopis glandulosa*) that can grow to tree form in appropriate conditions are most commonly found as shrubs on RP. *Quercus vaseyana* is usually found as a major shrub component of the chaparral association, but on RP it occurs, unexpectedly, as a glade of trees in a steep-sided, narrow canyon. All of the tree species encountered on RP are also found on DH and SD.

Floral diversity

The most abundant families, i.e., those represented by the greatest proportion of species in each flora, are the Asteraceae, Poaceae, Fabaceae, Cactaceae, and Euphorbiaceae. The Asteraceae are most numerous in each study area. But on DH, the Asteraceae and Poaceae are of nearly equal abundance, reflecting the influence of the proximity to the Great Plains (Fenstermacher 2008). The Fabaceae comprise the third most abundant family in both DH and RP floras. The Tamaulipan thornscrub vegetation zone, to the east and south of the Big Bend region, apparently influences the make-up of the flora of the DH in this regard (Fenstermacher 2008), and this influence may extend to RP. The Poaceae constitute the second most abundant family in each of the three floras, but on RP the family makes up a smaller portion of the flora than seen in DH or SD. This may be a result of the greater range of elevation in the DH and a wider range of habitat on SD, or it may be due to under-representation of grasses in the RP collections.

In the context of the Big Bend region, the family representations in the floras of RP and SD seem to have more in common with each other than with DH, and this fits with the proximity of RP to SD and their common geologic past. The variations in habitat within these two study areas are not as extreme as those in the DH, with range in elevation, perhaps, being the most significant physical difference.

In contrast, fifty-one species from the RP flora were not documented on SD, which is to say that nearly 20% of the RP flora is distinct from the SD flora. Thirty species, over 10% of the RP flora, were not found in the DH. Nine species from RP were not found on either SD or DH. Four of these species are endemic to the immediate vicinity of RP. Three of these species are associated with gypsiferous soils. Of these species unique to RP, 11 not on SD are known or suspected gypsophiles. Eight known or suspected gypsophiles are documented on RP that are not found on DH.

When looking at the taxonomic make-up of the three Big Bend floras in the context of the CD and SW floras (Table 2) it is clear that the DH, at the species level, shows a stronger affinity for the CD flora than for the SW flora. The SD shows a slightly greater affinity for the floral assemblage of the SW than for that of the CD. RP also shows a slightly greater affinity for the SW flora, even as its dominant shrub component reflects the influence of the Tamaulipan thornscrub vegetation zone.

Noteworthy Collections, Rare Taxa, Non-natives

Many species of concern have been identified in the protected areas of BBNP and BBRSP. For example, *Echinocereus chisoensis* var. *chisoensis* is endemic to one locale within BBNP and is federally listed as a threatened species (Louie 1996). *Echinomastus mariposensis*, found in both parks, is listed as threatened, according to both state and federal criteria. *Quercus hinckleyi* is known from only two areas in the United States: Shafter, Texas, and the Solitario Dome in BBRSP (Hardy 1997; Powell 1998). In contrast, plant life on the greater expanses of private land is less well understood, due to limited access and scarce funding for research on private lands. However, as a result of change in land ownership, work on private land to the west of Terlingua has uncovered a species not previously described (Turner & Nesom 2003). This brings to light the importance of work by trained botanists on private property. For example, communication among local botanists about the presence of *Stemodia coahuilensis* on RP enabled recognition of the species when it was subsequently recognized in BBNP. In other regions of the country, similar work is being done to compare the floras of adjacent protected and private lands (Chester 2003). Expanding field effort on private lands with owners increasingly aware of conservation issues will only increase our understanding of the botanical resources of the Chihuahuan Desert.

Stemodia coahuilensis is a new record for Brewster County. It had been considered a strictly Mexican species, but work in recent years has resulted in collections in Presidio and Jeff Davis counties (*Worthington 25254* SRSC, *Turner 24-492B* SRSC). The existence of a fourth Texas *S. coahuilensis* population has been strongly suggested by a photograph taken by Roy Morey in the Ernst Tinaja area on the east side of BBNP (Fig. 2).

A new naturally occurring hybrid between *Hibiscus coulteri* and *H. denudatus* has been described and named *H.* × *sabei* (Weckesser 2011). It has been documented in four sites in the Big Bend area. In habit it resembles *H. coulteri* (Fig. 3), but all specimens consistently differ from both parent species in flower color and several vegetative characters (Fig. 4).

The endemic flora of gypseous deposits in the Chihuahuan Desert is one of the largest but least studied restricted floras in North America (Moore & Jansen 2007). The Pen formation, described as gypsiferous (Maxwell et al. 1967), is exposed within the study area along a stretch of the Long Draw drainage. It supports populations of several gypsophilous taxa: *Anulocaulis leiosolenus* var. *lasianthus*, *A. eriosolenus*, *Acleisanthes parvifolius*, *Tiquilia gossypina*, and *T. hispidissima*. *Xylorhiza wrightii*, common on the clay flats of the Pen Formation

Fig. 2. ***Stemodia coahuilensis*, near Ernst Tinaja, Big Bend National Park, Texas (photograph by Roy Morey).**

and on other known gypsiferous sites in the Big Bend area, is a suspected gypsophile (M. Powell, pers. comm.). The ubiquitous nature of gypsum in clay soils of RP is demonstrated by the distribution of gypsophiles on soils not otherwise identified as gypsiferous. Known gypsophiles were found in the Long Draw drainage, on the Del Rio clay, and on other clayey soils. These include *Mentzelia mexicana*, *Psathyrotopsis scaposa*, and *Haploesthes greggii* var. *texana*.

Over 50% of the species included in the proceedings of the Texas Plant Conservation Conference (Clary et al. 2002) are found in Trans-Pecos Texas. Several species from the current work are endemic to the Trans-Pecos or to the Big Bend Region and are of special conservation concern.

Genistidium dumosum (Fig. 5) is a monotypic genus, endemic to the Chihuahuan Desert (Correll & Johnston 1970). *Genistidium dumosum* has been documented on only three sites in the U.S., all located on RP (Poole 1992), and five populations have been recorded in Mexico (Clary et al. 2002). It is ranked G1S1 by NatureServe (2013) and it is under review for threatened or endangered status by the USFWS (2009). Attempts to relocate the RP populations have had mixed results. Three previously documented populations were not relocated. A population reported to have approximately 100 plants (M. Powell, pers. comm.) was not located. However, in the search for that population, a population of 12 plants was located.

Kallstroemia perennans is an endemic of the Trans-Pecos, its range limited to the western Edwards Plateau near Langtry, Texas, southwest Brewster County, and adjacent areas of Presidio County (Fig. 6). It is ranked G1S1 by NatureServe (2013) due to its limited distribution.

Chamaesyce perennans (Fig. 7) is a Big Bend endemic, restricted to the Terlingua-Lajitas area and adjacent Chihuahua, Mexico. It is ranked G3S3 (NatureServe 2013) due to its limited distribution.

Lycium puberulum var. *berberidoides* (Fig. 8) and *Lycium texanum* (Fig. 9) are endemic to Trans-Pecos Texas. *Lycium texanum* is considered a species of concern and is ranked G2S2 (NatureServe 2013).

Fig. 3. ***Hibiscus* × *sabei* in flower, Highway 170 at Pepper's Hill. Reed Plateau study area, Brewster County, Texas.**

Thelypodium texanum (Fig. 10) is endemic to the Big Bend region. Given its restricted distribution, it is considered vulnerable and ranked G3S3 by NatureServe (2013).

Oenothera boquillensis (Fig. 11) is ranked as G3S2 (NatureServe 2013). Its range is limited to Brewster and Presidio counties in Texas and the Mexican states of Chihuahua, Coahuila and Nuevo Leon. *Oenothera boquillensis* was also found in the Dead Horse Mountains of BBNP (Fenstermacher 2008), and though Hardy (1997) did not find it in the SD, she noted that it was previously observed or collected there.

Echinomastus mariposensis (Fig. 12) was listed as a threatened species under the federal Endangered Species Act in 1979 and was listed in Texas in 1983 (NatureServe 2013). Its range is limited to Cretaceous limestone in the Big Bend area and in Coahuila, Mexico; it is common and locally abundant in the Terlingua area.

The non-native species of RP were initially encountered on or near roadways, homes, or construction sites. Since the study period, the spread of invasive exotics such as *Salsola tragus* and *Pennisetum ciliare* is increasing dramatically, with highway and canyons serving as vectors from roadways and human habitation into desert terrain.

Salsola tragus is common along the dirt road at the east end of RP that leads onto the plateau. It is abundant along the shoulders of Highway 170 and at the construction site near Villa de la Mina. *Salsola tragus* is spreading along the drainages and dirt roads throughout RP and the drainages that cut across the highway.

Pennisetum ciliare was observed on the south slopes of the east end of RP and in Coultrin's Canyon, a large canyon that drains to the south of RP. It is common and abundant in the channels and gullies of Long Draw, having spread from Hwy 170 after construction in 2003. Dense stands of *P. ciliare* have spread to the north past

Fig. 4. *Hibiscus × sabei* buds and leaves. Highway 170 at Pepper's Hill, Reed Plateau study area, Brewster County, Texas. Note length of bracts in relation to length of sepals and color of petals in bud (photograph by Betty Alex).

Fig. 5. ***Genistidium dumosum*, in recently discovered population on Reed Plateau study area, Brewster County, Texas.**

Villa de la Mina, following the 2-track road and spreading into the drainages that cross the road. This hardy non-native grass, difficult to manage once established, has a high degree of reproductive vigor, a wide range of adaptability, and few pests and predators (NatureServe 2013).

Tamarix chinensis is common in the Big Bend region. *Tamarix chinensis* is established but not yet a dominant species in Long Draw. It has also appeared in the right-of-way of Highway 170 since the road construction in 2003.

Sorghum halepense is established in thick stands where roads cross low, wide gullies or drainages in the Terlingua area. Though not collected, it was found in a construction site on RP.

Cynodon dactylon is a competitive, invasive weed (NatureServe 2013). Once established, it is difficult to remove. It does not spread, though, beyond a water supply, so it remains restricted to irrigated, landscaped home sites, or over septic systems.

Vegetation Associations

The topographic variation of RP—hills, ridges, drainages, arroyos, canyons, flats, gradual and steep slopes, and cliffs—sets the stage for vegetation associations typical of the Chihuahuan Desert. In Henrickson and Johnston's scheme (1986) topography plays a significant role in defining some of the associations (e.g., sandy arroyo, canyon, or dune associations), and Butterwick and Lamb (1976) and Butterwick and Strong (1976a, 1976b, 1976c) based their vegetation associations on type of terrain in BBRSP. Fenstermacher (2008), also referring to Henrickson and Johnston (1986), added elevation to the criteria used to describe the vegetation associations of the DH. But in these works the mosaic patterns of the assemblages of plants is stressed; trends and patterns

Fig. 6. ***Kallstroemia perennans*****, endemic to Trans-Pecos Texas. Reed Plateau study area, Brewster County, Texas.**

exist and associations form with predictability, especially in topographically distinct areas, but there are not always clear demarcations between adjacent associations.

The vegetation of RP closely follows the association descriptions outlined by Henrickson and Johnston (1986), with some variations and modifications. The Mixed Desert Scrub association is widespread, intergrading with *Larrea* Scrub, Lechuguilla Scrub, Gypsophilous Scrub, Sandy Arroyo Scrub, and Canyon Scrub associations.

The *Yucca* Woodland or *Dasylirion* Scrub association of Henrickson and Johnston (1986) refers to extensive areas dominated, at least visually, by *Yucca* spp. or *Dasylirion* spp. with a mixed grass-shrub understory. No extensive area of RP is truly dominated by *Yucca* spp. or *Dasylirion* spp., but on some of the slopes and higher ridges of RP there are stands of numerous *Y. torreyi* (Fig. 13) or *D. leiophyllum* (Fig. 14).

With changes in surface features and elevation, the grasses, especially *Bouteloua ramosa*, can dominate a slope or a ridge top, forming a Grama Grassland association (Fig. 15). *Bouteloua ramosa* is by far the most plentiful grass on RP. The presence of this association demonstrates that a Grama Grassland association need not be restricted to coarse, sandy soils of volcanic origin, as stated by Hendrickson and Johnston (1986).

Chaparral and Oak Woodland associations are not to be expected in low, desert terrain, yet elements of these higher-elevation associations are combined here in one intriguing site, the previously mentioned canyon that drains to the north into Long Draw (Fig. 16). Amidst the expected vegetation of the Canyon Scrub association (Henrickson & Johnston 1986) there is one anomalous addition: a stand of *Quercus vaseyana* trees, with a dense *Q. vaseyana* shrub understory. A species normally associated with shrub-dominated Montane Chaparral, *Q. vaseyana* reaches the height of 3–4 m (10–12 ft) in this canyon. The presence of *Q. vaseyana* as

Fig. 7. ***Chamaesyce perennans*****, endemic to Big Bend region, Texas. Reed Plateau study area, Brewster County, Texas (photograph by Betty Alex).**

woodland trees as well as chaparral shrubs speaks to the unique conditions in that canyon, especially deep and narrow with sheer rock walls, unlike other canyons on RP. While it could be a relictual population, this seems unlikely given its proximity to Villa de la Mina and the wood-fired mercury processing furnace in operation during the first half of the last century (Ragsdale 1976). The stand may represent new growth in the last 70 years.

A similar situation was encountered in SD (Hardy 1997), where elements of higher elevation and mesic associations were encountered at lower elevations in protected canyons. In several small canyons, *Quercus grisea*, also identified with the Chaparral association, approaches the tree form expected in the Oak Woodland association, along with *Juniperus pinchotii* of the Pinyon-Juniper association.

An especially diverse blend of associations occurs along portions of Long Draw, where the main course of the dry stream bed butts against the base of the cliffs of the Terlingua monocline. The monocline is a generally north-facing escarpment, irregularly cut by numerous canyons, drainages, and pour-offs. The water channeled over the cliffs and the north exposure creates a community comprised of elements of the Sandy Arroyo and Canyon Scrub associations (Henrickson & Johnston 1986). At the base of the cliffs, fairly steep scree slopes of Santa Elena limestone breakdown, strewn with boulders, have become overgrown with large shrubs and several tree species. There is a dense understory of smaller shrubs, subshrubs, and perennial herbs in the resulting soils, high in organic matter, and a number of annuals present after summer rains. Several species normally associated with the more mesic habitats in canyons or at higher elevations are intermixed with species expected in the dry arroyos of Mixed Desert Scrub and Sandy Arroyo associations. This particular assemblage is another example of the overlap and intergradation of the vegetation associations of the CD.

Fig. 8. ***Lycium puberulum*** **var.** ***berberidoides*****, endemic to Trans-Pecos Texas. Reed Plateau study area, Brewster County, Texas.**

An additional association not described by Henrickson and Johnston merits consideration. In several locations in the Big Bend area, including RP, stands of *Fouquieria splendens* (ocotillo) are so dense as to create the appearance of a forest. In the *F. splendens* associations of RP, the understory varies, from sparse vegetation of widely scattered shrubs to dense vegetation with shrubs and grasses from the desert scrub associations, *Larrea tridentata* often appearing as a co-dominant. A recent vegetation survey in BIBE has generated descriptions of vegetation associations, including a series of associations with *F. splendens* as a nominal component (Lea 2014). The Ocotillo-Creosotebush-Lechuguilla Desert Scrub association describes the most common association on RP, with a significant variation. As with the Grama Grassland association of Henrickson and Johnston (1986), the occurrence of the Ocotillo-Creosotebush-Lechuguilla Desert Scrub association on RP demonstrates that this association is not restricted to non-calcareous substrates, as described for BIBE. Further description and delineation of the Desert Scrub vegetation association continuum on RP is warranted.

ANNOTATED CHECKLIST OF THE SPECIES OF REED PLATEAU AND ADJACENT AREAS

The annotated species list for RP is arranged phylogenetically following Evert and Eichhorn (2013), with Phylum Anthophyta divided into Monocotyledones and Eudicotyledones. Family, genus, species, and lower rankings are listed alphabetically. All collections of the first author cited in the list, designated *WW*, are housed at SRSC. Taxa previously collected on RP, as documented by voucher specimens in SRSC and TEX-LL, are included in the list with collector and herbarium information. Taxa observed but not collected during the current study are included in the list and noted as such.

Fig. 9. ***Lycium texanum*****, endemic to Trans-Pecos Texas. Reed Plateau study area, Brewster County, Texas.**

The information for each species includes scientific name and authorship, common name, nativity, special status, abundance, habitat, and the author's collection number of a representative specimen. Where applicable, notations for status for invasive, threatened, or endangered species are also included. Significant additional information is included at the end of the description. Native species are noted with N; non-native species with I (TexasInvasives.org 2008). Species endemic to Trans-Pecos Texas (E-TP) or to the Big Bend Region (E-B) are noted (Correll & Johnston 1970; Clary et al. 2002; TAM-BWG 2007). Species ranked for conservation purposes, with state or federal protection status, are also noted (USDA-PLANTS 2014; NatureServe 2013).

Habitat terms are general descriptions of common habitat for a given species. Habitat descriptors used in the species list are: alluvium – sand and/or gravel with organic debris in arroyos, drainages or canyon bottoms; arroyo – dry wash or stream bed, seasonally flooded; drainage – cut in side of slope, with varying width and steepness; canyon – vertical-sided cut through limestone; clay flat – flat to gentle slope of clay substrate; cliffs – sheer-faced limestone, as seen in the Terlingua uplift or in canyons; disturbed site – current home site or historically disturbed areas; ridges – top of slopes, knife-edge summits, or saddles between higher hills; roadside – along dirt roads or on shoulders of paved highway; rock outcrop – exposed rock surface or blocks; slope – relatively smooth terrain tilted with varying aspect and degrees of steepness; ubiquitous – occurs in most or all habitats throughout study area.

A scheme to describe abundance was derived from Palmer et al. (1995). Determination of abundance was based on field observations during the course of the study. The terms used here are: rare (R); uncommon (U); occasional (O); common (C); and abundant (A).

Fig. 10. ***Thelypodium texanum* (white flowers), endemic to the Big Bend Region, Texas, with *Nama havardii* (pink flowers), along Highway 170. Reed Plateau study area, Brewster County, Texas.**

LYCOPODIOPHYTA

Selaginellaceae

Selaginella lepidophylla (Hook. & Grev.) Spring, Resurrection fern, N, A, slopes, canyons, ridges, open rocky areas, *WW 184*

MONILOPHYTA

Pteridaceae

Argyrochosma microphylla (Mett. ex Kuhn) Windham, Littleleaf cloakfern, N, U, sheltered rock outcrops, *WW 79A*

Astrolepis cochisensis (Goodd.) D.M. Benham & Windham, Cochise scaly cloakfern, N, U, sheltered rock outcrops, *WW 78*

Astrolepis integerrima (Hook.) D.M. Benham & Windham, Wholeleaf cloakfern, N, U, sheltered rock outcrops, *WW 77*

Cheilanthes alabamensis (Buckley) Kunze, Alabama lipfern, N, sinkhole, *Barbee & Powell 4*, SRSC

Cheilanthes horridula Maxon, Rough lipfern, N, U, sheltered rock outcrops, *WW 675*

Fig. 11. *Oenothera boquillensis*, found in Long Draw at base of cliffs, Reed Plateau study area, Brewster County, Texas.

Cheilanthes villosa Davenp. ex Maxon, Villous lipfern, N, U, sheltered rock outcrops, *WW 679*

GNETOPHYTA

Ephedraceae

Ephedra aspera Engelm. ex S. Watson, Rough jointfir, N, C, ubiquitous, *WW 369*

ANTHOPHYTA, Monocotyledones

Agavaceae

Agave lechuguilla Torr., Lechuguilla, N, A, ubiquitous, *WW 1004*

Bromeliaceae

Hechtia texensis S. Watson, Texas false agave, N, C, limestone outcrops, slopes, *WW 433*

Cyperaceae

Eleocharis montevidensis Kunth, Sand spikerush, N, R, drainage, one population was found after significant rain at the edge of a water-filled earthen tank, *WW 1008*

Liliaceae

Allium kunthii G. Don, Kunth onion, N, U, north-facing gravelly slopes, *WW 34*

Dasylirion leiophyllum Engelm. ex Trel., Sotol, N, O, slopes, drainages, *WW 804A*

Yucca torreyi Shafer, Torrey yucca, N, O, slopes, drainages, *WW 276*

Poaceae

Aristida purpurea var. *longiseta* (Steud.) Vasey, Red three-awn, N, O, gravelly slopes, *WW 750*

Aristida purpurea var. *purpurea* Nutt., Purple three-awn, N, O, slopes, ridges, *WW 761*

Aristida purpurea var. *nealleyi* (Vasey) Allred, Blue three-awn, N, O, slopes, ridges, *WW 606*

Bothriochloa barbinodis (Lag.) Herter, Cane bluestem, N, *D.S. Correll & M.C. Johnston 24466* TEX-LL

Bothriochloa laguroides (DC.) Herter var. *torreyana* (Steud.) M. Marchi & Longhi-Wagner, Silver bluestem, N, U, drainage, disturbed site, *WW 575*

Bouteloua barbata Lag., Six-week grama, N, U, drainage, disturbed site, *WW 571*

Bouteloua curtipendula (Michx.) Torr., Side-oats grama, N, O, gravelly drainage, clay, *WW 731*

Bouteloua ramosa Scribn. ex Vasey, Chino grama, N, A, ubiquitous, *WW 601*

Bouteloua trifida Thurb., Red grama, N, O, gravelly slopes, *WW 605*

Cathestecum erectum Vasey & Hack., False grama, N, slopes, alluvium, *Hughes 337* SRSC

Fig. 12. ***Echinomastus mariposensis*** **in flower with** ***Bahia absinthifolia*** **var.** ***dealbata*****, near Villa de la Mina. Reed Plateau study area, Brewster County, Texas.**

Cynodon dactylon (L.) Pers., Bermuda grass, I, U, disturbed sites, *WW 568*

Dasyochloa pulchella (Kunth) Willd. ex Rydberg, Fluff grass, N, A, ubiquitous, *WW 565A*

Digitaria californica (Benth.) Henrard, California cottontop, N, clay flats with gravel, *Powell 5362* SRSC

Digitaria cognata (Schult.) Pilg., Fall witchgrass, N, O, gravelly drainage, *WW 825*

Enneapogon desvauxii P. Beauv., Feather pappusgrass, N, O, slopes, drainages, *WW 820*

Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult., Tanglehead, N, C, ridges, slopes, drainages, *WW 789*

Muhlenbergia porteri Scribn. ex Beal, Bush muhly, N, U, drainages, canyon slopes, *WW 1046*

Panicum hallii Vasey, Hall panicgrass, N, U, gravelly slopes, *WW 1003*

Pappophorum vaginatum Buckley, Whiplash pappusgrass, N, O, disturbed clay flats, drainages, *WW 573*

Pennisetum ciliare (L.) Link, Buffelgrass, I, C, roadside, disturbed sites, drainages, spreading into canyons and drainages since 2003 road construction, *WW 574*

Pleuraphis mutica Buckley, Tobosa grass, N, O, disturbed slopes, limestone and clay, *WW 1009*

Poa bigelovii Vasey & Scribn., Bigelow bluegrass, N, O, canyons, drainages, *WW 163*

Setaria macrostachya Kunth, Streambed bristlegrass, N, O, canyon, drainages, clay flats, *WW1015*

Sporobolus pyramidatus (Lam.) Hitch., Madagascar dropseed, N, O, disturbed sites, clay flats, *Weckesser 572*

Tridens muticus (Torr.) Nash, Slim tridens, N, O, canyon bottom, drainages, *Weckesser 947A*

ANTHOPHYTA, Eudicotyledones

Acanthaceae

Carlowrightia arizonica A. Gray, Arizona carlowrightia, N, U, steep slopes, *WW 415*

Ruellia parryi A. Gray, Parry wild petunia, N, C, slopes, drainages, canyon, *WW366*

Stenandrium barbatum Torr. & A. Gray, Shaggy stenandrium, N, O, restricted to rock outcrops, *WW 237*

Amaranthaceae

Iresine leptoclada (Hook. f.) Henrickson & S.D. Sundb., Texas shrub, N, base of cliffs, *D.S.Correll 30709* TEX-LL

Tidestromia carnosa (Steyerm.) I.M. Johnst., Fleshy tidestromia, N, U, gravelly slopes, *WW 755*

Tidestromia lanuginosa var. *lanuginosa* (Nutt.) Standl., Wooly tidestromia, N, C, gravelly slopes, *WW 59*

Tidestromia suffruticosa (Torr.) Standl., Shrubby honeysweet, N, C, gravelly slopes, alluvium, *WW 85*

Anacardiaceae

Rhus microphylla Engelm., Littleleaf sumac, N, O, canyons, drainages, alluvium, *WW 471*

Fig. 13. ***Yucca torreyi*****, Reed Plateau study area, Brewster County, Texas.**

Rhus virens Lindh. ex A. Gray, Evergreen sumac, N, U, steep sided canyons, *WW 553*

Apocynaceae

Amsonia longiflora Torr., Tubular slimpod, N, U, clay flats, drainages, canyons, *WW 199*

Mandevilla macrosiphon (Torr.) Pichon, Rocktrumpet, N, C, slopes, drainages, alluvium, *WW 585*

Aristolochiaceae

Aristolochia coryi I.M. Johnst., Dutchman's pipe, N, R, drainage, one population found at the edge of a water filled earthen tank after significant rain, *WW 903*

Asclepiadaceae

Asclepias asperula (Decne.) Woodson, Antelope-horns milkweed, N, U, slopes, drainages, *WW 375*

Asclepias oenotheroides, Schltdl. & Cham., Zizotes milkweed, N, U, gravelly ridges, *WW 805*

Funastrum crispum (Benth.) Schltr., Wavyleaf twinevine, N, R, gravelly slope, *WW 486*

Funastrum torreyi (A. Gray) Schltr., Soft twinevine, N, R, canyons, *WW 907*

Matelea parvifolia (Torr.) Woodson, Spearleaf milkvine, N, R, rock crevices, *WW 395*

Asteraceae

Artemisia ludoviciana Nutt., White sagebrush, N, U, alluvium, *WW 1049*

Bahia absinthifolia var. *dealbata* (A. Gray) A. Gray, Dealbata bahia, N, C, slopes, drainages, ridges, *WW 213*

Chaetopappa bellioides (A. Gray) Shinners, Manyflower leastdaisy, N, O, slopes, drainages, *WW 465*

Cirsium turneri Warnock, Turner thistle, N, U, restricted to cliff faces of canyons, *WW 930*

Conoclinium dissectum A. Gray, Palm-leaf mistflower, N, R, canyon, *WW 816*

Dyssodia acerosa DC., Prickleleaf dogweed, N, C, slopes, ridges, *WW 831*

Dyssodia pentachaeta (DC.) B.L. Rob., Prickly dogweed, N, A, slopes, ridges, alluvium, drainages, *WW 60*

Erigeron bigelovii A. Gray, Bigelow fleabane, N, slopes, ridges, along cliffs, *Worthington 968* TEX-LL

Erigeron tracyi Greene, Running fleabane, N, C, slopes, ridges, drainages, *WW 664*

Gymnosperma glutinosum (Spreng.) Less., Tatalencho, N, C, ubiquitous, *WW 76*

Haploesthes greggii var. *texana* (J.M. Coult.) I.M. Johnst., False broomweed, N, O, clay flats, alluvium, slopes, drainages, *WW 58*

Helenium microcephalum var. *ooclinium* (A. Gray) Bierner, Sneezeweed, N, R, drainage, one population found at the edge of a water filled earthen tank after significant rain, *WW 905*

Fig. 14. ***Dasylirion leiophyllum*, Reed Plateau study area, Brewster County, TX.**

Heterotheca fulcrata (Greene) Shinners, Rocky goldaster, N, U, north-facing canyon, *WW 929*

Jefea brevifolia (A. Gray) Strother, Shorthorn zexmenia, N, O, canyon sediment, *WW 657*

Melampodium leucanthum Torr. & A. Gray, Blackfoot daisy, N, O, drainages, canyons, slopes, *WW 536*

Parthenium confertum A. Gray, Lyreleaf parthenium, N, O, alluvium, gravelly slopes, *WW 9*

Parthenium incanum Kunth, Mariola, N, C, ubiquitous, *WW 592*

Perityle parryi A. Gray, Heartleaf rockdaisy, N, U, restricted to cliff face, *WW 1053*

Perityle vaseyi J.M. Coult., Margined perityle, N, U, restricted to gypseous clay, *WW 847*

Porophyllum scoparium A. Gray, Shrubby Poreleaf, N, O, gravelly slope, canyon, *WW 393*

Psathyrotopsis scaposa (A. Gray) H. Rob., Naked brittlestem, N, U, restricted to gypseous clay, *WW 193*

Psilostrophe tagetina (Nutt.) Greene, Wooly paperflower, N, A, ubiquitous, *WW 141*

Stephanomeria pauciflora (Torr.) A. Nelson, Brownplume wirelettuce, N, U, drainage, alluvium, *WW 71*

Thelesperma longipes A. Gray, Longstalk greenthread, N, O, slopes, drainages, *WW 90*

Thelesperma megapotamicum (Spreng.) Kuntze var. *megapotamicum*, Rayless greenthread, N, C, slopes, drainages, canyon bottom, *WW 890*

Trixis californica Kellogg, American trixis, N, O, drainages, canyons, *WW 73*

Viguiera dentata (Cav.) Spreng., Sunflower goldeneye, N, U, alluvium, *WW 1050*

Viguiera stenoloba S.F. Blake, Skeletonleaf goldeneye, N, A, ubiquitous, *WW 22*

Xanthisma spinulosum var. *chihuahuanum* (B.L. Turner & R.L. Hartm.) D.R. Morgan & R.L. Hartm., Lacy tansyaster, N, O, disturbed sites, clay flats, *WW 212*

Xanthium strumarium L., Cocklebur, N, R, alluvium, *WW 95*

Xylorhiza wrightii (A. Gray) Greene, Gyp daisy, N, U, restricted to gypseous clays; *WW 377*

Xylothamia triantha (S.F. Blake) G.L. Nesom, Trans-Pecos desert goldenrod, N, R, clay flats with limestone gravel, *WW 578*

Zinnia acerosa (DC.) A. Gray, Spinyleaf zinnia, N, C, slopes, ridges, drainages, canyons, *WW 456*

Berberidaceae

Mahonia trifoliolata Moric., Agerita, N, R, canyons, deep drainages, *WW 283*

Bignoniaceae

Chilopsis linearis (Cav.) Sweet, Desert willow, N, U, alluvium, *WW 1035*

Tecoma stans (L.) Juss. ex Kunth, Trumpetflower, N, O, slopes, drainages, canyons, *WW 19*

Fig. 15. South-facing slope dominated by *Bouteloua ramosa*. Reed Plateau study area, Brewster County, Texas.

Boraginaceae

Cryptantha coryi I.M. Johnst., Cory cryptantha, N, R, north-facing slopes, gravel and clay, *WW 206*

Cryptantha mexicana (Brandegee) I.M. Johnst., Mexican cryptantha, N, O, ubiquitous, *WW 385*

Heliotropium powelliorum B.L. Turner, Powell heliotrope, N, C, slopes, drainages, arroyos, *WW 513*

Lappula redowskii (Hornem.) Greene, Flatspine stickseed, N, U, alluvium, *WW 164*

Omphalodes aliena A. Gray ex Hemsl., Mexican navelwort, N, U, rocky slopes, canyons, *WW 114*

Tiquilia canescens (A. DC.) A.T. Richardson, Woody crinklemat, N, A, ubiquitous, *WW 582*

Tiquilia gossypina (Wooton & Stand.) A.T. Richardson, Texas crinklemat, N, U, clay and gravel, slopes, ridges, *WW 569*

Tiquilia greggii (Torr. & A. Gray) A.T. Richardson, Plumed tiquilia, N, C, slopes, arroyos, *WW 493*

Tiquilia hispidissima (Torr. & A. Gray) A.T. Richardson, Rough coldenia, N, O, slopes, ridges, clay flats, drainages, *WW 734*

Tiquilia mexicana (S. Watson) A.T. Richardson, Mexican crinklemat, N, C, ubiquitous, *WW 406*

Brassicaceae

Descurainia pinnata (Walter) Britton, Tansymustard, N, R, alluvium, *WW 151*

Draba cuneifolia Nutt. ex Torr. & A. Gray, Whitlow-wort, N, R, alluvium, *WW 115*

Nerisyrenia camporum (A. Gray) Greene, Bicolor mustard, N, A, ubiquitous, *WW 175*

Physaria fendleri (A. Gray) O'Kane & Al-Shehbaz, Fendler bladderpod, N, C, slopes, drainages, alluvium, *WW 109*

Streptanthus carinatus C. Wright ex A. Gray, Lyreleaf twistflower, N, U, north-facing rocky slopes, alluvium, *WW 166*

Thelypodium texanum (Cory) Rollins, Texas thelypody, N, C, E-BB, slopes, canyon bottoms, alluvium, clay flats, *WW 120*

Cactaceae

Ariocarpus fissuratus (Englem.) K. Schum., Living rock cactus, N, C, slopes, drainages, *WW 80*

Coryphantha echinus (Engelm.) Britton & Rose, Sea-urchin cactus, N, O, slopes, ridges, *WW s.n.*, photographic record only

Coryphantha sneedii var. *albicolumnaria* (Hester) A.D. Zimmerman, Silverlace cactus, N, U, G2G3S2S3, slopes, ridges north end of RP, *WW s.n.*, photographic record only

Echinocactus horizonthalonius Lem., Eagle claw cactus, N, C, slopes, ridges, arroyos, *Weckesser s.n.*, photographic record only

Echinocereus dasyacanthus Engelm., Rainbow cactus, N, C, slopes, ridges, arroyos, *WW 475*

Echincereus enneacanthus Engelm., Strawberry cactus, N, O, slopes, drainages, *WW 997*

Fig. 16. Tree form of *Quercus vaseyana* in steep-sided limestone canyon. Reed Plateau study area, Brewster County, Texas.

Echinocereus stramineus (Engelm.) F. Seitz, Strawberry pitaya, N, A, slopes, ridges, drainages, arroyos, *WW s.n.*, photographic record only

Echinomastus mariposensis Hester, Mariposa cactus, N, U, G2S2, LT/T, slopes, ridges, drainages, *WW 996*

Epithelantha bokei L.D. Benson, Boke's button cactus, N, U, gravel-covered flat to gently sloping rock outcrops, *WW 564A*

Ferocactus hamatacanthus (Muehlenpf.) Britton & Rose, Giant fishhook cactus, N, U, slopes, ridges, arroyos, canyons, *WW s.n.*, photographic record only

Glandulicactus uncinatus var. *wrightii* (Engelm.) Backeb., Eagleclaw cactus, N, U, slopes, ridges, *WW s.n.*, photographic record only

Mammillaria lasiacantha Engelm., Golfball cactus, N, U, slopes, ridges, *WW 565*

Mammillaria pottsii Scheer ex Salm-Dyck, Rattail mammillaria, N, C, slopes, ridges, clay flats, drainages, *WW 563*

Opuntia aggeria Ralston & Hilsenb., Dog cholla, N, C, ubiquitous, *WW 476*

Opuntia camanchica Engelm. & J.M. Bigelow, Comanche pricklypear, N, A, drainages, arroyos, slopes, ridges, *WW 923*

Opuntia engelmannii Salm-Dyck ex Engelm., Engelmann pricklypear, N, O, slopes, drainages, arroyos, *WW 1058*

Opuntia leptocaulis DC., Christmas cactus, N, O, drainages, slopes, arroyos, *WW 848A*

Opuntia rufida Engelm., Blind pricklypear, N, C, drainages, slopes, arroyos, canyons, *WW 995*

Celastraceae

Mortonia scabrella A. Gray, Tickbush, N, O, clay flats, drainages, *WW 497*

Chenopodiaceae

Atriplex canescens (Pursh.) Nutt., Four-wing saltbush, N, O, alluvium, drainages, *WW 643*

Salsola tragus L., Tumbleweed, I, C, roadsides, arroyos, drainages, spreading into canyons and drainages following road construction in 2003, *WW 848*

Convolvulaceae

Bonamia repens (I.M. Johnst.) D.F. Austin & Staples, Creeping lady's nightcap, N, O, rock outcrops, rocky slopes, *WW 804*

Convolvulus equitans Benth., Texas bindweed, N, O, disturbed sites, clay and gravel, *WW 950*

Evolvulus alsinoides (L.) L., Ojo de vibora, N, A, slopes, drainages, canyons, *WW 988*

Ipomoea costellata Torr., Crestrib morning glory, N, R, sediments of canyon bottom, *WW 648*

Cucurbitaceae

Ibervillea tenuisecta (A. Gray) Small, Slimlobe globeberry, N, O, arroyos, alluvium, drainages, *WW 609*

Ebenaceae

Diospyros texana Scheele, Texas persimmon, N, O, deep drainages, arroyos, canyons, *WW 669*

Euphorbiaceae

Bernardia obovata I.M. Johnst., Myrtlecroton, N, O, ridges, gravelly slopes, *Weckesser 688*

Chamaesyce albomarginata (Torr. & A. Gray) Small, Whitemargin sandmat, N, gravelly slope, disturbed site, *Bennack 108B* SRSC

Chamaesyce perennans Shinners, Perennial sandmat, N, C, E-BB, ubiquitous, *WW 738*

Chamaesyce serrula (Engelm.) Wooton & Standl., Sawtooth sandmat, N, gravelly slope, disturbed site, *Bennack 108A* SRSC

Chamaesyce stictospora (Engelm.) Small, Slimseed spurge, N, U, arroyo, *WW 632*

Croton fruticulosus Engelm. ex Torr., Bush croton, N, U, canyons, steep drainages, *WW 660*

Croton pottsii (Klotzsch.) Müll. Arg., Leatherweed Croton, N, A, ubiquitous, *WW 964*

Argythamnia neomexicana Müll. Arg., New Mexico wild mercury, N, O, drainages, canyons, *WW 904*

Euphorbia antisyphilitica Zucc., Candelilla, N, A, ubiquitous, *WW 966*

Euphorbia exstipulata Engelm., Squareseed spurge, N, base of cliff, arroyo, *Bennack 112* SRSC

Jatropha dioica var. *graminea* McVaugh, Leatherstem, N, A, ubiquitous, *WW 985*

Phyllanthus polygonoides Nutt. ex Spreng., Knotweed leafflower, N, C, drainages, arroyos, canyons, *WW 104*

Tragia amblyondonta (Müll. Arg.) Pax & K. Hoffm., Dogtooth noseburn, N, U, shaded arroyo, *WW 1048*

Tragia ramosa Torr., Branched noseburn, N, O, drainages, arroyos, canyons, *WW 49*

Fabaceae

Acacia greggii A. Gray, Catclaw acacia, N, C, slopes, drainages, ridges, *WW 458*

Acacia neovernicosa Isely, Varnished acacia, N, C, slopes, drainages, ridges clay flats, *WW 43*

Acacia roemeriana Scheele, Roemer acacia, N, O, ubiquitous, *WW 891*

Acacia schottii Torr., Schott acacia, N, U, slopes, *WW 1010*

Calliandra iselyi B.L. Turner, False mesquite, N, O, ubiquitous, *WW 584*

Dalea formosa Torr., Feather dalea, N, O, ubiquitous, *WW 309*

Dalea neomexicana (A. Gray) Cory, New Mexico dalea, N, O, slopes, ridges, *WW 398*

Dalea pogonathera A. Gray, Bearded dalea, N, U, canyon, *WW 328*

Dalea wrightii A. Gray, Wright dalea, N, C, ubiquitous, *WW 15*

Desmanthus glandulosus (B.L. Turner) Luckow, Bundleflower, N, slopes, drainages, canyon, *WW 663*

Genistidium dumosum I.M. Johnst., Johnston bushpea, N, R, G1S1, rocky slopes, only known populations in U.S.A., *WW 946*

Mimosa emoryana Benth., Emory mimosa, N, O, drainages, canyons, *WW 436*

Mimosa texana (Gray) Small, Catclaw mimosa, N, O, slopes, canyons, disturbed sites, *WW 429*

Pomaria melanosticta S. Schauer, Parry holdback, N, O, slopes, drainages, canyons, *WW 5*

Prosopis glandulosa Torr., Mesquite, N, C, ubiquitous, *WW 856*

Senna lindheimeriana (Scheele) H.S. Irwin & Barneby, Lindheimer senna, N, C, ubiquitous, *WW 524*

Senna pilosior (B.L. Rob. ex J.F. Macbr.) H.S. Irwin & Barneby, Trans-Pecos senna, N, O, drainages, arroyos, slopes, *WW 590*

Vicia ludoviciana Nutt. ex Torr.& A. Gray, Deer pea vetch, N, U, arroyos, *WW 162*

Fagaceae

Quercus vaseyana Buckley, Sandpaper oak, N, R, restricted to one narrow, steep-sided canyon, *WW 517*

Fouquieriaceae

Fouquieria splendens Engelm., Ocotillo, N, C, slopes, ridges, drainages, *WW 405*

Gentianaceae

Zeltnera arizonica (A. Gray) A. Heller, Arizona centaury, N, R, shaded slope, one population found after significant rain, *WW 357*

Hydrophyllaceae

Nama havardii A. Gray, Havard nama, N, C, ubiquitous, *WW 220*

Nama hispida A. Gray, Rough nama, N, U, alluvium, canyon bottom, *WW 179*

Phacelia congesta Hook., Bluecurls, N, U, shaded alluvium, canyons, *WW 165*

Krameriaceae

Krameria erecta Willd. ex Schult., Range ratany, N, C, slopes, ridges, arroyos, canyons, *WW 403*

Krameria grayi Rose & Painter, White ratany, N, C, slopes, ridges, arroyos, canyons, *WW 69*

Lamiaceae

Hedeoma drummondii Benth., Drummond pennyroyal, N, R, alluvium, found once on gravel bar in dry wash, *WW 865*

Hedeoma nana (Torr.) Briq., Dwarf false pennyroyal, N, U, slopes, drainages, ridges, canyons, *WW 129*

Linaceae

Linum berlandieri Hook., Berlandier flax, N, C, ubiquitous, *WW 110*

Linum rupestre (A. Gray) Engelm. ex A. Gray, Rock flax, N, U, canyons, *WW 714*

Loasaceae

Cevallia sinuata Lag., Stinging cevallia, N, O, slopes, drainages, disturbed areas, *WW 914*

Eucnide bartonoides Zucc., Yellow rocknettle, N, R, restricted to rock walls of steep drainages and canyons, *WW 447*

Mentzelia mexicana H.J. Thomps. & Zavort., Mexican blazingstar, N, O, slopes, drainages, ridges, arroyos, *WW 839*

Mentzelia pachyrhiza I.M. Johnst., Coahuila blazingstar, N, R, slope, *WW 1044*

Loganiaceae

Buddleja marrubiifolia Benth., Butterfly bush, N, C, arroyos, drainages, canyons, *WW 670*

Malpighiaceae

Janusia gracilis A. Gray, Helicopter bush, N, U, canyons, steep drainages, *WW 958*

Malvaceae

Abutilon crispum (L.) Medik., Netvein mallow, N, slopes, drainages, *Powell 3185* SRSC

Abuliton fruticosum Guill. & Perr., Pelotazo, N, C, slopes, drainages, canyons, *WW 490*

Abutilon malacum S. Watson, Yellow indian mallow, N, U, disturbed site, *WW 1041*

Abutilon wrightii A. Gray, Wright abutilon, N, U, cliff face in steep canyon, *WW 327*

Hibiscus coulteri Harv. ex A. Gray, Desert rosemallow, N, O, slopes, ridges, *WW 61*

Hibiscus × sabei Weckesser, Ken's rosemallow, N, R, roadside, *WW 645*

Hibiscus denudatus Benth., Paleface rosemallow, N, O, slopes, flats, drainages, *WW 97*

Sida abutifolia Mill., Spreading sida, N, O, slopes, drainages, rock outcrops, *WW 12*

Sida longipes A. Gray, Stockflower fanpetals, N, O, slopes, drainages, clay flats, *WW 216A*

Nyctaginaceae

Acleisanthes angustifolia (Torr.) R.A. Levin, Narrowleaf moonpod, N, O, slopes, drainages, ridges, clay flats, *WW 721*

Acleisanthes longiflora A. Gray, Angel trumpets, N, O, drainages, canyons, *WW 770*

Acleisanthes parvifolia (Torr.) R.A. Levin, Small leaf moonpod, N, U, restricted to gypseous clay, *WW 36*

Allionia incarnata L., Trailing four-o'clock, N, A, ubiquitous, *WW 639*

Anulocaulis eriosolenus (A. Gray) Standl., Big Bend ringstem, N, R, restricted to gypseous clay, *WW 1045*

Anulocaulis leiosolenus var. *lasianthus* I.M. Johnst., Ringstem, N, U, restricted to gypseous clay flats, *WW 1042*

Cyphomeris gypsophiloides (M. Martens & Galeotti) Standl., Birdfruit, N, R, cliff base, *WW 1055*

Mirabilis texensis (J.M. Coult.) B.L. Turner, Texas mirabilis, N, R, cliff base, *WW 1056*

Oleaceae

Forestiera angustifolia Torr., Desert olive, N, C, ubiquitous, *WW 318*

Menodora longiflora Engelm. ex A. Gray, Twinpod, N, U, arroyo, *WW 102*

Menodora scabra A. Gray, Rough menodora, N, O, ubiquitous, *WW 35*

Onagraceae

Oenothera boquillensis (P.H. Raven & D.P. Greg.) W.L. Wagner & Hoch, Boquillas gaura, N, R, G2S2, arroyo margin, *WW 1054*

Oenothera brachycarpa A. Gray, Shortpod evening primrose, N, slopes, drainages, clay flats, disturbed areas, *WW 723*

Oenothera hartwegii Benth., Hartweg sundrops, N, U, arroyos, *WW 1032*

Oenothera kunthiana (Spach) Munz, Kunth sundrops, N, shaded slope, drainage, *Hughes s.n.*, SRSC

Oenothera rosea L'Her. ex Aiton, Rose sundrops, N, U, drainages, slopes, disturbed areas, *WW 256*

Oenothera triloba Nutt., Stemless evening primrose, N, U, slopes, clay, *WW 226*

Orobanchaceae

Castilleja rigida Eastw., Broadbract paintbrush, N, O, slopes, drainages, canyons, *WW 778*

Orobanche multicaulis Brandegee, Spiked broomrape, N, R, alluvium, drainage, middle of a gravelly wash, *WW 462*

Phytolaccaceae

Rivina humilis L., Pigeonberry, N, R, one plant at cliff base, *WW 1047*

Plantaginaceae

Penstemon baccharifolius Hook., Baccharis-leaf penstemon, N, R, restricted to crevices in canyon walls and bottoms, *WW 899*

Plantago helleri Small, Heller plantain, N, U, shaded alluvium, slopes, *WW 299*

Stemodia coahuilensis (Henrickson) B.L. Turner, Coahuila twintip, N, R, canyon bottom, alluvium, new Brewster County record, *WW 690*

Polemoniaceae

Gilia rigidula subsp. *acerosa* A. Gray, Blue gilia, N, O, ridges and slopes of Santa Elena limestone, *WW 136*

Gilia purpusii subsp. *stewartii* (I.M. Johst.) J.M. Porter, Stewart gilia, N, C, ubiquitous, *WW 81*

Polygalaceae

Hebecarpa barbeyana (Chodat) J.R. Abbott, Narrowleaf milkwort, N, C, arroyos, drainages, canyons, *WW 26*

Hebecarpa macradenia (A. Gray) Abbott, Glandleaf milkwort, N, C, rock outcrops, *WW 491*

Rhinotropis lindheimeri var. *parvifolia* (Wheelock) R.R. Abbott, Shrubby milkwort, N, R, gravelly clay flats, *WW 881*

Polygala scoparioides Chodat, Broom milkwort, N, C, arroyos, drainages, canyons, slopes, *WW 724*

Portulacaceae

Portulaca pilosa L., Kiss me quick, N, O, ridges, slopes, flats with gravel surface, *WW 961*

Ranunculaceae

Clematis drummondii Torr. & A. Gray, Virgin's bower, N, C, drainages, arroyos, canyons, *WW 94*

Resedaceae

Oligomeris linifolia (Vahl) Macbride, Desert spike, N, C, drainages, arroyos, canyons, *WW 911*

Rhamnaceae

Condalia ericoides (A. Gray) M.C. Johnst., Javelinabush, N, O, ubiquitous; *WW 473*

Condalia warnockii M.C. Johnst., Warnock condalia, N, *Powell 3633* SRSC

Ziziphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray, Lotebush, N, O, ubiquitous, *WW 894*

Rosaceae

Fallugia paradoxa (D. Don) Endl. ex Torr., Apache plume, N, O, arroyos, drainages, canyons, *WW 105A*

Amelanchier denticulata (Kunth) K. Koch, Serviceberry, N, R, drainage, northern-most extent of Long Draw, *WW 279*

Purshia ericifolia (Torr. ex A. Gray) Henrickson, Heath cliffrose, N, R, cliff faces of canyons and steep drainages, *WW 949*

Rubiaceae

Galium proliferum A. Gray, Limestone bedstraw, N, U, slopes, drainages, *WW 263*

Hedyotis nigricans (Lam.) Fosberg, Prairie Bluet, N, O, drainages, slopes, canyons, especially in rock crevices, *WW 43*

Rutaceae

Thamnosma texanum (A. Gray) Torr., Dutchman's britches, N, C, ubiquitous, *WW 140*

Sapindaceae

Ungnadia speciosa Endl., Mexican buckeye, N, R, arroyos and canyons, *WW 319*

Scrophulariaceae

Leucophyllum minus A. Gray, Big Bend silverleaf, N, C, slopes, drainages, arroyos, *WW 960*

Maurandella antirrhiniflora Humb. & Bonpl. ex Willd., Snapdragon vine, N, O, shaded arroyo, base of cliff, *WW 530*

Solanaceae

Chamaesaracha pallida Averett, False nightshade , N, O, slopes, ridges, *WW 238*

Chamaesaracha coniodes Britton, Hairy false nightshade, N, O, slopes, ridges, clay flats, *WW 413*

Lycium berlandieri Dunal, Berlandier wolfberry, N, O, ridges, clay flats, *WW 753*

Lycium puberulum var. berberidoides (Correll) F. Chiang, Downy wolfberry, N, O, E-TP, slopes, clay flats, *WW 392*

Lycium texanum Correll, Texas wolfberry, N, R, G2S2, E-TP, slope, *WW 1029*

Nicotiana obtusifolia M. Martens & Galeotti, Desert tobacco, N, O, ubiquitous, *WW 74*

Physalis hederifolia A. Gray, Heartleaf groundcherry, N, O, drainages, canyons, disturbed sites, *WW 210*

Physalis lobata (Torr.) Raf., Purple groundcherry, N, O, clay flats, arroyos, disturbed areas, *WW 62*

Solanum elaeagnifolium Cav., Silverleaf nightshade, N, O, clay flats, disturbed sites, *WW 381*

Sterculiaceae

Ayenia microphylla A. Gray, Dense ayenia, N, C, ubiquitous, *WW 539*

Tamaricaceae

Tamarix chinensis Lour., Saltcedar, I, U, arroyos, roadsides, *WW 906*

Ulmaceae

Celtis iguanaea (Jacq.) Sarg., Spiny hackberry, N, U, canyon, drainages, *WW 526*

Urticaceae

Parietaria pensylvanica Muhl. ex Willd., Pennsylvania pellitory, N, R, shaded base of cliff, *WW 160*

Verbenaceae

Aloysia gratissima (Gillies & Hook.) Tronc., Beebrush, N, O, arroyos, drainages, *WW 620*

Aloysia wrightii A. Heller, Oreganillo, N, U, rocky slopes, drainages, *WW 703*

Bouchea linifolia A. Gray ex Torr., Groovestem bouchea, N, O, drainages, canyons, *WW 51*

Glandularia bipinnatifida (Nutt.) Nutt. var. *ciliata* (Benth.) Turner, Dakota mock vervain, N, R, drainage, northern-most extent of Long Draw, *WW 280*

Glandularia quadrangulata (A. Heller) Umber, Beaked verbena, N, R, drainage, *WW 146*

Lantana achyranthifolia Desf., Veinyleaf lantana, N, O, drainages, arroyos, canyons, *WW 656*

Tetraclea coulteri A. Gray, Stinkweed, N, O, gravelly slopes, *WW 389*

Vitaceae

Cissus incisa Des Moul., Ivy treebine, N, R, arroyo, *WW 641*

Zygophyllaceae

Guaiacum angustifolium Engelm., Guayacan, N, C, ubiquitous, *WW 868*

Kallstroemia perennans B.L. Turner, Turner's desert poppy, N, R, E-TP clay flats or Del Rio clay outcrops, *WW 33*

Larrea tridentata (Sessé & Moc. ex DC.) Coville, Creosotebush, N, A, ubiquitous, *WW 855*

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By allowing access to their property, the landowners on and near Reed Plateau demonstrated their interest in understanding and protecting the community in which they live. This study never would have taken place without their involvement. Many friends, including one particular dog, accompanied us in the field. The first author wishes to thank J.C. Zech for steadfast support and assistance during the course of the study. Special thanks go to A.M. Powell for his untiring efforts in maintaining the herbarium at Sul Ross State University and assistance with plant identification. Dr. Powell's accumulated botanical knowledge of the Trans-Pecos region is an invaluable resource that he shared without reservation. Billie L. Turner verified the plant collections and offered unwavering encouragement for further studies. Without the gracious hospitality of Dr. and Mrs. M. Terry much of WW's time on campus would have been impossible. Much of the authors' discussions took place over cups of hot tea in the kitchen. NRCS personnel in the Alpine, Texas office provided an introduction to the Soil Survey website. Jackie Poole offered insight and discussion on *Genistidium dumosum*. Sul Ross State University's Mary Moll Jennings Memorial and Read Memorial Scholarships and the Coors CLASE Scholarship partially funded this work.

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Applications for the 2014 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and letter of recommendation sent by the major professor. Please send letters of application to: Dr. Donna M.E. Ware, P.O. Box 8795, Herbarium, Biology Department, The College of William and Mary, Williamsburg, Virginia 23185-8795, U.S.A. 1-757-221-2799; Email: ddmware@wm.edu. Applications may be sent to: Barney Lipscomb, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A. 1-817-332-7432; Email: barney@brit.org. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying. The Systematics Symposium dates for 2014 are 10–11 October 2014 (dates tentative and subject to change).

The Delzie Demaree Travel Award was established in 1988 honoring **Delzie Demaree** who attended 35 out of a possible 36 symposia before he died in 1987. Delzie Demaree was a frontier botanist, explorer, discoverer, and teacher. His teaching career as a botanist began in Arkansas at Hendrix College in 1922. He also taught botany at the University of Arkansas, Navajo Indian School, Yale School of Forestry, Arkansas A&M, and Arkansas State University at Jonesboro where he retired as professor emeritus in 1953. One of the things he enjoyed most as a botanist was assisting students with their field botany research.

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ADDENDUM TO THE VASCULAR FLORA OF NASH PRAIRIE, TEXAS, U.S.A.

David J. Rosen

Department of Biology
Lee College
Baytown, Texas 77522-0818, U.S.A.
drosen@lee.edu

ABSTRACT

Nash Prairie is a 120 ha remnant of Texas upper coastal prairie with a previously reported native vascular plant flora of 289 species. Miscellaneous collections made over the past seven years are reported here, increasing the known native flora to 301 species.

RESUMEN

Nash Prairie es un resto de 120 ha de la pradera costera superior de Texas con una flora vascular nativa previa de 289 especies. Se citan aquí diversas colecciones realizadas en los últimos siete años, que incrementan la flora nativa conocida a 301 especies.

Nash Prairie, a 120 ha (296.5 acre) remnant of Texas upper coastal prairie in Brazoria County, remains, in my estimation, the largest and best example of this rare plant community throughout its historic range (Rosen 2007). Since publishing a checklist of vascular plants for this site that included 289 native species, two important events have occurred: 1) the tract (along with Mowotony Prairie; Rosen 2010) has been purchased by the Nature Conservancy of Texas, ensuring its conservation in perpetuity, and 2) additional collections made from 2007 through 2013 have revealed the following native species not previously reported from the site.

APOCYNACEAE

Asclepias viridiflora Raf.

Voucher specimen: infrequent and widespread in uplands of the prairie, 9 Aug 2011, *D.J. Rosen 5403 with W.R. Carr* (TEX).

CLUSIACEAE

Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray

Voucher specimen: rare in uplands near the north hayfield road, 27 Oct 2007, *D.J. Rosen 4644* (TEX).

LAMIACEAE

Monarda citriodora Cerv. ex Lag.

Voucher specimen: rare in uplands near the north hayfield road, 20 May 2010, *D.J. Rosen 5013* (TEX).

Salvia azurea Michx. ex Vahl var. **grandiflora** Benth. Throughout the upper coastal prairie, I've only observed this species in high quality remnants.

Voucher specimen: rare and seemingly represented by a few individuals restricted to a single pimple mound in the southwest quadrant of the prairie, 24 Jul 2010, *D.J. Rosen 5036* (TEX).

ONAGRACEAE

Oenothera lindheimeri (Engelm. & A. Gray) W.L. Wagner & Hoch. A coastal prairie endemic based on my observations and the distribution indicated by Correll and Johnston (1970).

Voucher specimen: rare and represented by a few individuals in a single location at the south-central boundary of the prairie, 9 Aug 2011, *D.J. Rosen 5404 with W.R. Carr* (TEX).

PHYTOLACCACEAE

Phytolacca americana L.

Voucher specimen: locally frequent in a pond recently disturbed by removal of Chinese tallow tree, 18 Oct 2013, *D.J. Rosen 6157* (TEX).

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POACEAE

Andropogon virginicus L. var. **virginicus**
Voucher specimen: occasional in low-lying places in the southeast quadrant of the prairie, 18 Oct 2013, *D.J. Rosen 6156* (MO, TEX).

Aristida longespica Poir. var. **longespica**
Voucher specimen: rare on pimple mounds near the center of the prairie, 6 Oct 2012, *D.J. Rosen 5902* (TEX).

Aristida oligantha Michx.
Voucher specimen: rare along the north hayfield road, 27 Oct, 2007, *D.J. Rosen 4643* (TEX).

Panicum hallii Vasey subsp. **filipes** (Scribn.) Freckmann & Lelong
Voucher specimen: rare along the north hayfield road,18 Oct 2013, *D.J. Rosen 6158* (TEX).

Schedonnardus paniculatus (Nutt.) Branner & Coville. A widespread monotypic prairie and plains species of North America (Snow 2003).
Voucher specimen: rare along the south hayfield road, 1 Jul 2007, *D.J. Rosen 4290* (BRIT, TEX).

PORTULACACEAE

Portulaca umbraticola Kunth subsp. **lanceolata** J.F. Matthews & Ketron. This southwestern species is described as occurring in disturbed sites and granitic and sandstone outcrops (Matthews 2003); and, in Texas, it is restricted to prairies, mesquite thickets, and saltmarshes (Correll & Johnston 1970).
Voucher specimen: occasional on the north hayfield road, 18 Oct 2013, *D.J. Rosen 6159* (TEX).

The addition of the 12 species reported here increases the known native vascular flora of the Nash Prairie to 301 species. Five new native species increases the already rich grass flora to 64. New families (Phytolaccaceae and Portulacaceae) and genera (*Monarda*, *Phytolacca*, *Schedonnardus*, and *Portulaca*) also increase the numbers previously reported to 65 and 201 respectively. This report is also offered to emphasize that a floristician's work is never done. As suggested by Prater et al. (2004a), our understanding of biodiversity and the soundness of our conservation decisions are advanced by continued plant collecting. Even in well explored states and ecoregions, continued plant collecting should be encouraged and supported (Prather et al. 2004b).

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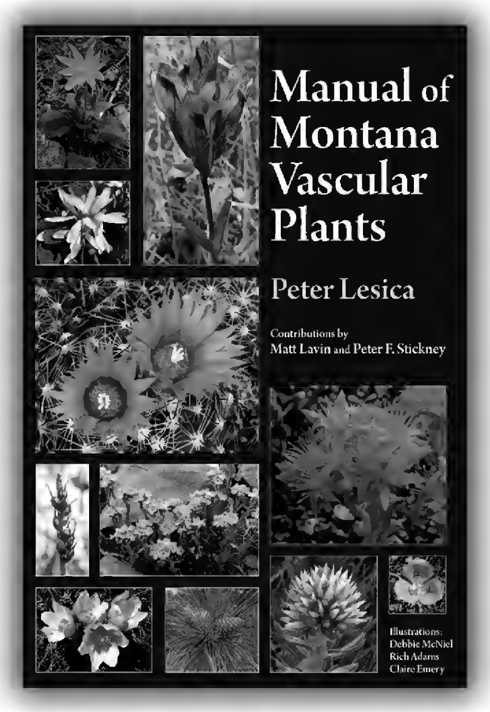


Manual of Montana Vascular Plants

August 2013

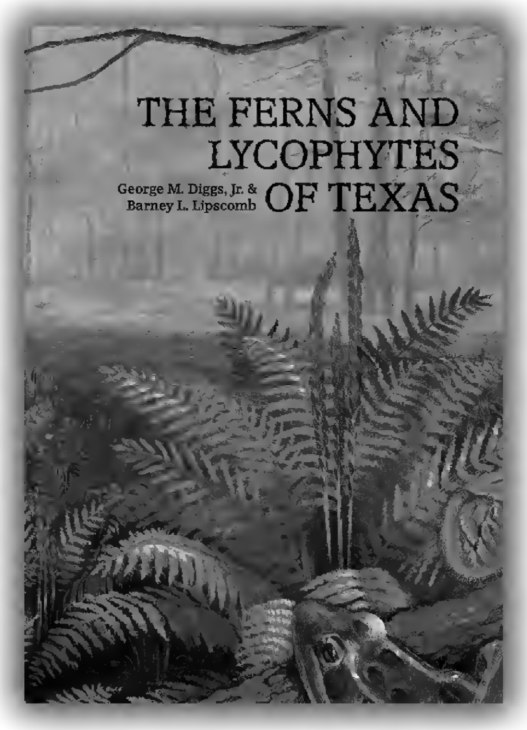
Second printing with corrections and errata, 28 May 2014

Montana is the fourth largest state in the United States. It includes portions of the Northern Great Plains and the Rocky Mountains. The vegetation of Montana is diverse, due primarily to the size of the state and its great topographic relief which provide strong variation in environmental factors. Montana has a relatively large flora for a northern continental region due to being at the intersection of the Cordilleran, Great Plains and Boreal floristic provinces. This book is a comprehensive field guide to the more than 2,500 species of Montana's vascular plants. It contains descriptions as well as habitat and distribution information based on specimens housed at the states two major herbaria. Portraits or illustrations of diagnostic structures are provided for nearly one-third of the species.

Lesica, P., with contributions by M. Lavin and P.F. Stickney. Illustrations by Debbie McNiel, Rich Adams, Claire Emery. 2012 (2nd printing with corrections/errata). ***Manual of Montana Vascular Plants.*** (ISBN-13: 978-1-889878-39-3, pbk.). Botanical Research Institute of Texas Press, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A. (**Orders:** shop.brit.org, orders@brit.org, 817-332-4441 ext. 264, fax 817-332-4112). $55.00, 6.5"×9.5" (pbk), 780 pp., 2000 + maps + 128 plates. $6.00 shipping ($3.00 each additional copy), outside the U.S.A. contact orders@brit.org, Texas residents add 8.25% ($5.03) to subtotal including postage for each book.

The Ferns and Lycophytes of Texas

February 2014



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The journal is published twice yearly in a multiple topic format and provides information to scientists, professionals, and the general public for research, education, and cultural enhancement. All articles are indexed and abstracted in print and/or electronic form by the following: AGRICOLA Database (National Agricultural Library); Applied Botany Abstracts; Biosciences Information Service of Biological Sciences (BIOSIS); Current Awareness in Biological Sciences (CABS); ISI Thomson; The Kew Record of Taxonomic Literature; Natural Products Alert (NAPRALERT); Scopus® database, SCImago Journal and Country Rank (Elsevier B.V.); and Referativnyi Zhurnal (Abstracts Journal of the Institute of Scientific Information of the Republic of Russia).

Lloyd H. Shinners, whose herbarium and library were the basis of the Southern Methodist University (SMU) legacy that became BRIT in 1987, founded the journal in 1962. **William F. Mahler** succeeded Shinners as SMU herbarium director in 1971 and inherited both ownership and editorship of the journal. Since 1993, it has been published by the Botanical Research Institute of Texas.

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