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*Cryptantha geohringii*

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## Phytologia

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**JUNIPERUS OF CANADA AND THE UNITED STATES:  
TAXONOMY, KEY AND DISTRIBUTION**

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**ABSTRACT**

The taxonomy of *Juniperus* of Canada and the United States is reviewed and keys to the taxa are presented as well as distribution maps. *Phytologia* 90(3): 255-314 (December, 2008).

**KEY WORDS:** *Juniperus*, Cupressaceae, taxonomy, keys, distribution, Canada, United States.

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The genus *Juniperus* consists of approximately 70 species and 27 varieties (Adams, 2008). All the taxa grow in the northern hemisphere, except *J. procera* Hochst. ex Endl. which grows along the rift mountains in east Africa, thence into the southern hemisphere (Adams, Demeke and Abulfatih 1993), and some of the Mediterranean *Juniperus* species such as *J. oxycedrus* L., *J. phoenicea* L., and *J. thurifera* L. that grow in the mountains of the northernmost part of Africa (Morocco, Algeria).

*Juniperus* of Canada and the United States was treated in the Flora of North America (Adams, 1993) and more recently in the monograph of *Juniperus* (Adams, 2008). This paper is presented to update recent changes in nomenclature that have resulted from new information obtained from DNA sequencing.

***Juniperus*** Linnaeus, Sp. pl. 1038. 1753. – Juniper, Cedar (the classical Latin name).

Perennial, evergreens, dioecious (or sometimes monoecious), prostrate to tall shrubs or trees; crowns strict (in young *J. virginiana*) to rounded or flat-topped (*J. virginiana* var. *silicicola*); branches variously oriented but not planar; bark reddish brown to gray, fibrous and exfoliating in strips, or rarely exfoliating in rectangular plates (*J.*



*deppeana*). Twigs variously oriented, not flattened (not planar). Roots fibrous, often exposed along cracks in rocks. Leaves persisting 3-5 years, of four types: (1) subulate (acicular or awn-shaped); (2) decurrent-blade deciduous (with an abscission layer between the blade and sheath, sections *Caryocedrus* Endlicher and *Oxycedrus* Spach); (3) whip-leaves, (decurrent without an abscission layer between the blade and sheath, section *Sabina* Spach); and (4) scale leaves (section *Sabina* Spach). Whip-leaves are found on juvenile foliage and/or at the tips of rapidly growing shoots (but occasionally an entire mature tree will have only whip-leaves, and one species, endemic to Cuba, *J. saxicola*, has only whip-leaves). Scale leaves closely appressed, decussate or ternate, often both decussate and ternate on the same branch. Foliage from light to dark green, or often blue or silver-glaucous, turning reddish, to purple in some species in the winter. Leaf margins entire to denticulate (at 20–40 X). Stomatal bands on the adaxial surface of the leaves range from none (apparent) to one or two. All leaves have a single gland but it may not be visible, the glands vary from elongate to hemispherical (*J. ashei*), several species have ruptured glands that exude a white crystalline deposit. Seed cones maturing in 1 or 2 years, persisting for several months to a year after maturity depending on bird predation pressure. Seed cones axillary or terminal, sessile to short peduncled. Pollen cones oblong, 3-5 mm, light tan to brown. Seed cones globose and “berry-like”; 3-20 mm in dia., scales all fused, fleshy to fibrous to obscurely woody, indehiscent, blue-black, blue, rose, copper-red, brown, brownish-blue, purplish-brown, usually with a blue or glaucous hue. Seeds wingless, 1-13 per cone, light tan to brown, with two hilum scars covering from  $\frac{1}{4}$  to  $\frac{3}{4}$  of the seed. Cotyledons several to numerous.

The genus is the source of numerous cultivars that are widely used for landscaping around the world. Mutants or “sports” are very common and are likely due to single gene mutations. Rare mutations affecting the plant habit and foliage are present in all species. Many of the “sports” have been given formal names or else incorrectly ascribed to hybridization or introgression. Due to the widespread exaggerations of the degree of hybridization, this topic is discussed after each treatment. Gymnocarpy (bare seeds protruding from the cone) is occasionally found in most junipers, particularly in the SW United States. This condition is due to insect larvae (see Zanoni, 1978).

Finally, it should be noted that due to the aforementioned morphological mutations, aberrant specimens may be almost impossible to identify without chemical or molecular data.

At present, 16 species, 8 varieties, and 2 formas of *Juniperus* in Canada and the United States are recognized.

Key to *Juniperus* of Canada and the United States

1. Leaves all acicular (subulate, jointed at the base) and spreading; seed cones sessile, axillary; decumbent or rarely upright shrubs (in the western hemisphere).....***J. communis***
1. Leaves decurrent (not jointed at the base), both whip- and scale-like; seed cones terminal; trees or decumbent to upright shrubs.
  2. Whip- and scale-leaf margins entire (20 X) or with irregular teeth (40 X) and then with scale leaves with acuminate to mucronate tips and tan-brown to brownish purple seed cones.
    3. Whip- and scale-leaf margins with irregular teeth (40 X), scale leaves acuminate; seed cones (4-) 6-10 (-13) seeded, and tan-brown to brownish-purple; branches pendulous.....***J. flaccida***
    3. Whip- and scale-leaf margins smooth (entire) (40 X), scale leaves obtuse to acute to apiculate; seed cones 1-2(3) seeded, blue-black to brownish-blue when mature; branches not drooping (but ultimate branchlets are often flaccid).
  4. Prostrate to decumbent shrub; scale-leaves apiculate; both whip- and scale-leaves growing along the branchlets; peduncles generally curved.....***J. horizontalis***
  4. Tree with 1(2-3) stems and rounded, flattened, pyramidal, or strict crowns; scale-leaves obtuse to acute; whip-leaves growing only at branchlet tips (on mature trees); peduncles generally straight.
5. Scale leaves not overlapping, or, if so, not by more than 1/5 the length, obtuse to acute; seed cones globose to reniform.....5a.
  - 5a. Twigs (3-5 mm dia.) with smooth bark, twigs (6-15 mm dia.) with bark exfoliating in plates, reddish-copper beneath; seed cones maturing in 2 yrs, most seed cones normal, rarely with exserted seeds.....***J. scopulorum***

- 5a. Twigs (3-5 mm dia.) with persistent dead whip-leaves, twigs (6-15 mm dia.) reddish-brown beneath; seed cones maturing in 1 yr. (14-16 mos.), often the seed cones with exserted (naked) seeds; Pacific northwest near the seaside in Georgia Straits and Puget Sound.....***J. maritima***
5. Scale leaves overlapping (more than 1/4 length) acute; twigs (3-5 mm dia.) with persistent dead whip-leaves, twigs (6-15 mm dia.) with bark not exfoliating in plates, or, if so, brownish beneath; seed cones maturing in 1 yr.....***J. virginiana***
2. Whip- and scale-leaf margins denticulate (20 X).
6. Seed cones with (3-) 4 - 5 (-6) seed, fibrous to obscurely woody, trunk bark exfoliating in square or quadrangular plates (except. in *f. sperryi* with bark that exfoliates in strips).....***J. deppeana***
6. Seed cones 1 - 2 (-3) seeded, fleshy to fibrous (when mature and fresh)
7. Scale leaves with a raised hemispherical gland, whip-leaves with raised hemispherical gland (var. *ashei*) or oval, raised gland (var. *ovata*), dark brownish-green on dark grayish-green mature leaf; angle of branching of ultimate twig 25-40 degrees, bark on branches with patches of white fungus.....***J. ashei***
7. Scale leaves without a raised hemispherical gland
8. Mature seed cones orange, reddish-orange, red, bronze, or reddish-brown, appearing pink or rose-color if covered with bloom.
9. Mature seed cones orange to red, with light bloom appearing pink or rose-colored; whip-leaf ventral side white-glaucous, glands on whip leaves visible, raised, elongated and divided (often 3 glands); often single stemmed shrub-trees with stocky, clumpy foliage.....9a.
- 9a. Shorter whip-leaf glands, half or less as long as the associated sheath.....***J. arizonica***
- 9a. Longer whip-leaf glands, more that half as long as the associated sheath.....***J. coahuilensis***



- 9. Mature seed cones copper to reddish-brown, with no bloom; whip leaf ventral side not white-glaucous, glands on whip-leaves visible, raised, oval, not divided; shrubs with elongated terminal whips ..... ***J. pinchotii***
- 8. Mature seed cone dark blue, dark bluish-black to bluish-brown, with a light to heavy coat of bloom appearing light blue.
- 10. Glands on scale leaves visible (conspicuous) and ruptured.
- 11. Seed cones 7-10 mm long; maturing in 2 yrs., 2(3) seeded; bark on twigs (5-10 mm diam.) reddish and exfoliating in scales or flakes; single stemmed tree to 20 (-30)m, dioecious or monoecious..... 11a.
- 11a. Trunk bark red-brown; seeds cones avg. 7.7 mm (5-9); approx. 95% of the plants dioecious, leaf glands usually not ruptured, if ruptured with clear to light yellow exudate..... ***J. grandis***
- 11a. Trunk bark brown; seeds cones avg. 8.5 mm (7-10); approx. 50% of the plants dioecious, leaf glands ruptured with yellow exudate turning dark brown to black..... ***J. occidentalis***
- 11. Seed cones 6-10 mm long, maturing in 1 yr., 1 (-2) seeded, bark on trigs brown to ash, not exfoliating in scales or flakes, shrubs to small trees, mostly dioecious.
- 12. Seed cones with a fibrous to woody pericarp, (7-) 9-10 (-13) mm. diam., bluish-brown under glaucous, 1 (-2) seeded; dioecious (1.9% monoecious), branchlets approx. as wide as scale-leaf length; scale leaves closely appressed and generally flattened, branchlets terete..... ***J. californica***
- 12. Seed cones with a soft, juicy pericarp, 6-8 mm diam., reddish-blue to brownish-blue, globose to ovoid, scale-leaf glands barely visible not conspicuous, few (less than 1/5) of the whip-leaf glands with a white crystalline exudate (visible without a lens), ultimate twigs 1.3-1.5 mm wide..... ***J. monosperma***
- 10. Glands on scale leaves not conspicuous (embedded in the leaf, therefore not visible), plants monoecious, ultimate twigs 1.3-1.5 mm wide, seed cones bluish brown, very glaucous, 8-9 mm diam., 1-seeded ..... ***J. osteosperma***

*Juniperus arizonica* R. P. Adams Phytologia 88(3): 306 (2006), Arizona juniper. Type: United States, Arizona, Yavapai, Co.: 72 km south of Flagstaff, 1160 m., R. P. Adams 2132, BAYLU

*Juniperus coahuilensis* (M. Martinez) Gaussen ex R.P. Adams var. *arizonica* R.P. Adams, Biochem. Syst. Ecol. 22 (7): 708 (1994).

*J. erythrocarpa* Cory (in part: New Mexico, Arizona)

*J. pinchotii* var. *erythrocarpa* (Cory) J. Silba

**Dioecious.** **Trees** large shrub to small tree, 3-8 m, often with a single stem to 1 m, when shrubs branched at the base, with flattened-globular or irregular crowns. **Trunk bark** brown, thin, exfoliating in long ragged strips. **Branches** ascending to erect in shrubs, but spreading in trees. Branch bark scaly, ashy-gray. Stumps sprouting after burning or cutting. **Leaves** decurrent (whip) and scale. Whip- and scale-leaf margins denticulate (20 X), white glaucous on adaxial leaf surface. At least  $\frac{1}{4}$  or more of the whip-leaf glands with a white crystalline exudate.

**Seed cones** rose to pinkish but yellow-orange, orange or dark red beneath the white-blue glaucous, soft and juicy, globose to ovate, 6-7 mm, 1(-2) seeded, the hilum scar pale brown, approx.  $\frac{1}{2}$  as long as seed. **Seeds** 4-5 mm long. **Pollen shed** late fall to early winter.



*Juniperus arizonica* leaves and seed cone.

**Habitat** *Bouteloua* grasslands and adjacent rocky slopes; 980-1600 (-2200) m. **Uses** fence posts. Sprouts from cut stumps and is thus a pest in grasslands. **Dist.:** Arizona, South of the Mogollon Rim; and in southwestern New Mexico and northeastern Sonora, Mexico (Fig. 1). **Status:** abundant and weedy in areas. **Taxonomy:** Adams et al. (2006) recently reviewed the taxonomy and on the basis of combined nrDNA, trn-C-trn sequences data, plus RAPDs and terpenoids concluded that *J. coahuilensis* var. *arizonica* merited recognition as *J. arizonica*.

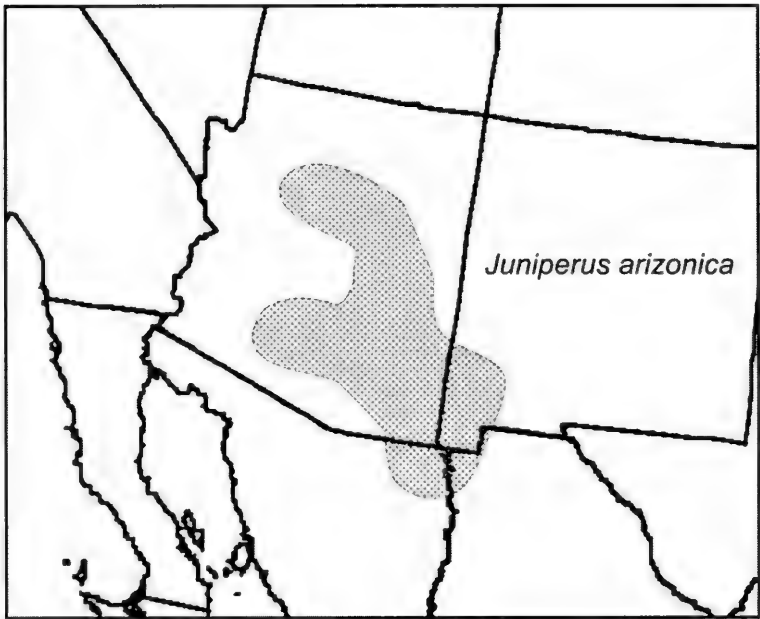


Figure 1. Distribution of *J. arizonica*.

***Juniperus ashei* Buch.**Key to *J. ashei* varieties:

1. Whip-leaf glands hemispherical, scale-leaf glands hemispherical; female cones (8) 9 (10) mm in diameter; seeds 16-27 mm<sup>2</sup>, 1 (avg. 1.01, rarely 2,) per cone. ***J. ashei* var. *ashei***
1. Whip leaf glands oval to elliptical; scale-leaf glands hemispherical, female cones (5) 6 (8) mm in diameter; seeds 13-16 mm<sup>2</sup>, 2 (avg. 1.7), per cone.....***J. ashei* var. *ovata***

***Juniperus ashei*** J. Buchholz. Bot. Gaz. (Crawfordsville) 90(3):329 (1930). Mountain cedar, rock cedar, post cedar, Mexican Junipers, Ashe juniper. Lectotype: NCU!

*Cupressus sabinoides* Kunth in Humboldt et al., Nov. Gen. Sp. Pl. 2: 3 (1817)

*J. sabinoides* (Kunth) Nees, Linnaea 19: 706 (1847), *non* Griseb. (1846)

*J. sabinoides* Sarg., Silva N. Amer. 10: 91 (1896), *non* Griseb. (1846)

*J. sabinoides* (H.B.K.) sensu Sargent *non* Nees

*J. occidentalis* Hook. var. *texana* Vasey, (Cat. Forest Trees U.S. 37) Rep. U.S. Dept. Agric. 1875: 185 (1876)

*J. occidentalis* Hook. var. *conjugens* Engelm., Trans. St. Louis Acad. Sci. 3: 590 (1878)

*J. tetragona* Moench var. *oligosperma* Engelm., Trans. St. Louis Acad. Sci. 3: 590 (1878)

*Sabina sabinoides* Small, Fl. S.E. United States: 33 (1903)

*J. mexicana* Sprengel in part, see Zanoni, 1978

**Diocious.** **Trees** with broad, bushy rounded or irregularly open crown, to 15 m, with a single trunk branching at 1-3 m or occasionally branching at the base. **Trunk bark** exfoliating in thin brown strips. **Branches** brown but usually with a grey-white fungus. **Leaves** both whip- and scale-like. Whip-leaves with a raised, hemispherical glands (not prominent on scale leaves). Whip- and scale-leaf margins denticulate (20 X). **Seed cones** ovoid to subglobose, maturing in one year, dark blue and glaucous, 6-9 mm in diam., 1(2-3) seeded. **Seeds** 4-6 mm long. **Chromosome number** 2n = 22 (Irving, 1980). **Pollen**

**shed** Dec. -Feb. **Habitat** Limestone glades and bluffs, 150-600 m. **Uses** source of Texas cedar wood oil (Adams, 1987), fence posts. **Dist.:** Ark., Okla., Tex.; N. Mexico. **Maps:** Adams, 2004 (amended Little, 1971, 21-E, W). **Status:** abundant on limestone in central/ west Texas, range is expanding, regarded as a weed in Texas. **Taxonomy:** see Adams (2007).

The type for *J. ashei* Buch. consisted of one male and three female specimens (Hall, 1954). To resolve this problem, Hall (1954) selected a female specimen (acc. number 22520, dated Sept. 16, 1923, UNC) and designated it as the lectotype. All of the material cited by Buchholz (1930) was collected on limestone bluffs, above the White River, near Sylamore, Arkansas. It is clear in Buchholz (1930) that his illustration is of *J. ashei* var. *ashei* with the hemispherical glands on the whip-leaves.

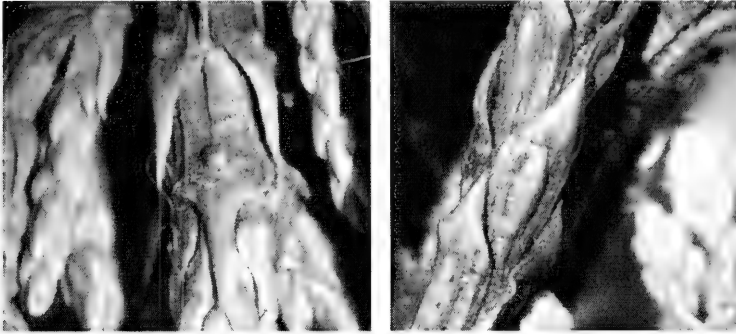
*Juniperus ashei* var. *ovata* R. P. Adams, Phytologia 89(1): 17 (2007), TYPE: U. S. A., Texas, Crockett Co., 5 km w. Ozona, 6 Dec. 1994, R. P. Adams 7463 (HOLOTYPE: BAYLU, PARATYPES: R. P. Adams 7664, 7465, 7466, 7467 (BAYLU).

This variety is similar to var. *ashei*, but instead of having hemispherical glands, the glands are oval to elongated on the whip-leaves. The var. *ovata* also has smaller cones, and more seeds per cone than var. *ashei*.

Other specimens examined: MEXICO, Coahuila, Adams 1066-1076. U.S.A., Texas, Crockett Co., Ozona, Adams 7424-42 (BAYLU), Coryell Co., TX, Adams 7463-82 (BAYLU).

The whip-leaf glands are illustrated in figure 2. Notice hemispherical glands on var. *ashei* (below) and the raised, oval to elongated glands on var. *ovata* (below). It should be noted that a few nearly hemispherical glands are present on whip-leaves of var. *ovata*. This is informative, as these characters can be used to distinguish var. *ovata* from var. *ashei*, yet exclude other nearby juniper species such as *J. monosperma*, *J. pinchotii* and *J. coahuilensis*. The distribution of the two varieties is shown in fig. 3. The area of possible sympatry in west

Texas and around New Braunfels is not well known and additional field collections are needed to define better their distributions in these areas.



1 mm *J. ashei* var. *ashei*      1 mm *J. ashei* var. *ovata*

Figure 2. Comparison of whip-leaf glands for *J. ashei* var. *ashei* and var. *ovata*.

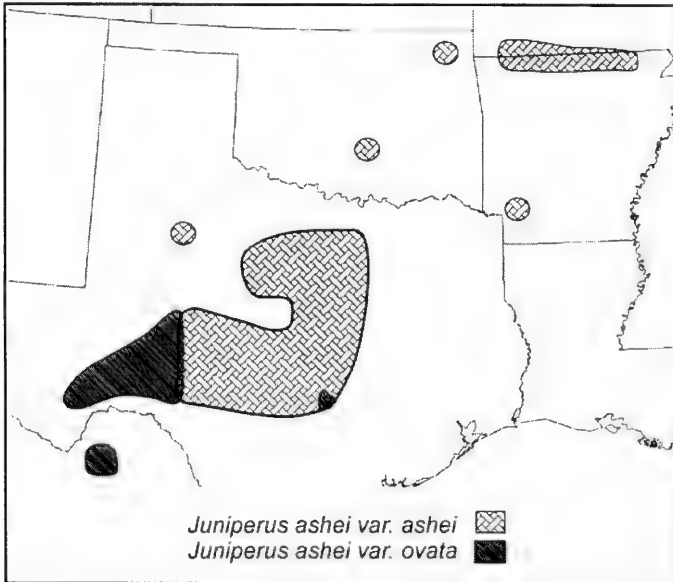


Figure 3. Distribution of *J. ashei* var. *ashei* and var. *ovata*.

***Juniperus californica*** Carriere, Rev. Hort. Ser. 4, 3: 352 (1854).  
California juniper. Holotype: P!

*J. pyriformis* Lindley A. Murray bis ex Lindl., Gard. Chron.  
1855:420 (1855)

*Sabina californica* (Carriere) Antoine, Cupress.-Gatt.: 52 (1857)

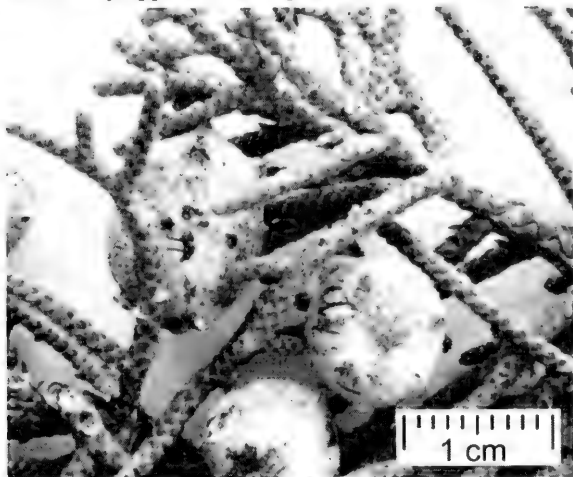
*J. cedrosiana* Kellogg, Hesperian 4:3 (1860)

*J. cerrosianus* Kellogg, Proc. Calif. Acad. Sci. 2:37 (1863)

*J. californica* Carriere f. *lutheyana* J. T. Howell & Twisselm., Four  
Seasons 2(4): 16 (1968)

*J. occidentalis* sensu Parl. non W. J. Hooker

**Dioecious (rarely monoecious, 1.9%). Shrubs** multi- (seldom one)  
stemmed shrub-tree, 2-8 m, with round crown. **Trunk bark** on twigs  
(5-10 mm diam.) brown or gray, not exfoliating in scales or flakes.  
**Branches**, ultimate branchlets approx. as wide as scale-leaf length;  
scale leaves closely appressed and generally flattened, branchlets terete.



*Juniperus californica* leaves and seed cones.

**Leaves** both whip and scale. Leaf glands conspicuous. Whip- and  
scale-leaf margins denticulate (20 X). **Seed cones** bluish-brown, white  
glaucous, reddish-brown beneath glaucous, (7-) 9-10 (-13) mm.  
Maturing in 1 yr. **Seeds** 1(2-3) per cone (avg. 1.3), 5-7 mm long.

**Pollen shed** Jan. - March. **Habitat** Dry, rocky slopes and flats; 750-1600 m. **Uses** none known, possibly fence posts. **Dist.:** AZ, CA, NV; Baja California, Mexico (Fig. 4). **Status:** common and expanding its range.

Two chemical (volatile leaf oils) races were described by Vasek and Scora (1967) and reconfirmed by Adams, von Rudloff and Hogge (1983). These two chemo-types were not found using the volatile wood oils (Adams, 1987). To date, no morphological character appears to be correlated with the chemical races. It is noteworthy that analyses of the leaf volatile oils of all the other 40 taxa of *Juniperus* in the western hemisphere has failed to reveal any other species with chemical races.

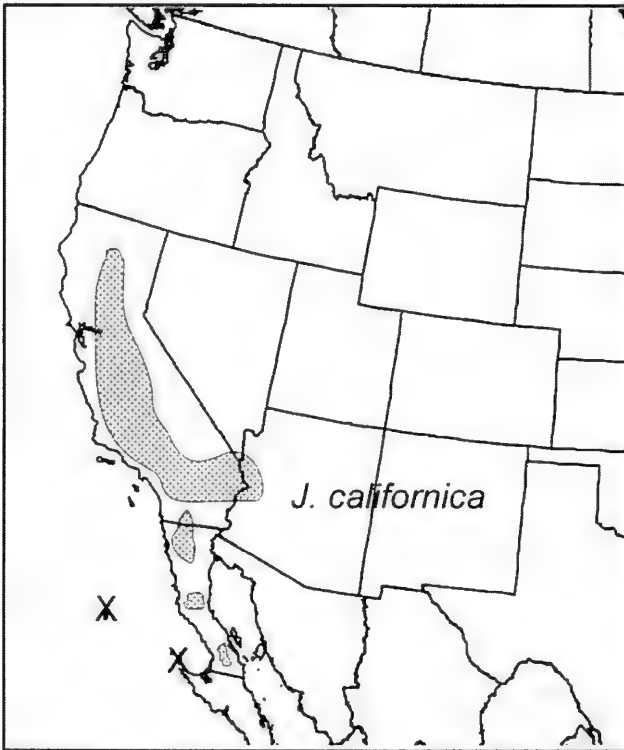


Figure 4. Distribution of *J. californica*. Xs denote outlying populations.



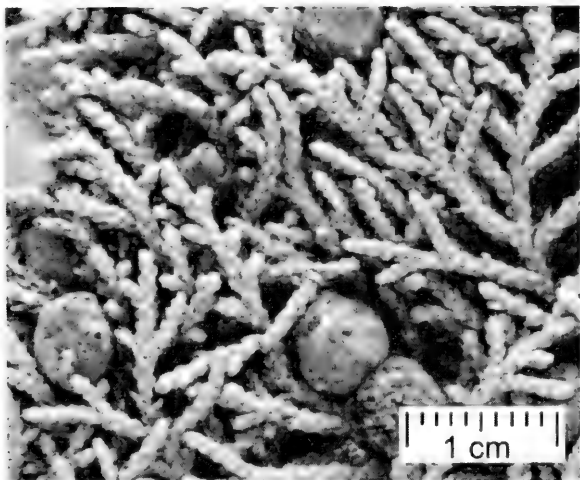
*Juniperus coahuilensis* (Martinez) Gausсен ex R. P. Adams  
Phytologia 74: 450 (1993). Rose fruited juniper. Type: A!

*J. erythrocarpa* Cory. Rhodora 38:186 (1936)

*J. erythrocarpa* var. *coahuilensis* Martinez

*J. pinchotii* var. *erythrocarpa* (Cory) J. Silba

**Dioecious.** Trees large shrub to small tree, 3-8 m, often with a single stem to 1 m, when shrubs, branched at the base, with flattened-globular or irregular crowns. **Trunk bark** brown, thin, exfoliating in long ragged strips. **Branches** ascending to erect in shrubs, spreading in trees. Branch bark scaly, ashy-gray. Stumps sprouting after burning or cutting. **Leaves** both whip and scale. Whip- and scale-leaf margins denticulate (20 X), white-glaucous on adaxial leaf surface. At least  $\frac{1}{4}$  or more of the whip-leaf glands with a white crystalline exudate. **Seed cones** rose to pinkish but yellow-orange, orange or dark red beneath the white-blue glaucous layer, soft and juicy, globose to ovate, 6-7 mm,



*Juniperus coahuilensis* leaves and seed cones.

1(-2) seeded, the hilum scar pale brown, approx.  $\frac{1}{2}$  as long as seed. **Seeds** 4-5 mm long. **Pollen shed** late fall - early winter. **Habitat** *Bouteloua* grasslands and adjacent rocky slopes. **Uses** fence posts. Sprouts from cut stumps and is thus a pest in grasslands. **Dist.:** 980-

1600 (-2200) m, trans-Pecos Texas, common in northern Mexico around the margins of the Chihuahuan Desert (Fig. 5). **Status:** abundant and increasing. Hybridization between *J. coahuilensis* and *J. monosperma* appears likely in Arizona (see *J. monosperma* above). Hybridization between *J. coahuilensis* and *J. pinchotii* occurs in the Big Bend Natl. Park, Brewster Co., Tex. (Adams and Kistler, 1991) and possibly near Saltillo, Mexico. Previous reports of hybridization with *J. ashei* (Hall et al., 1961) have been negated.

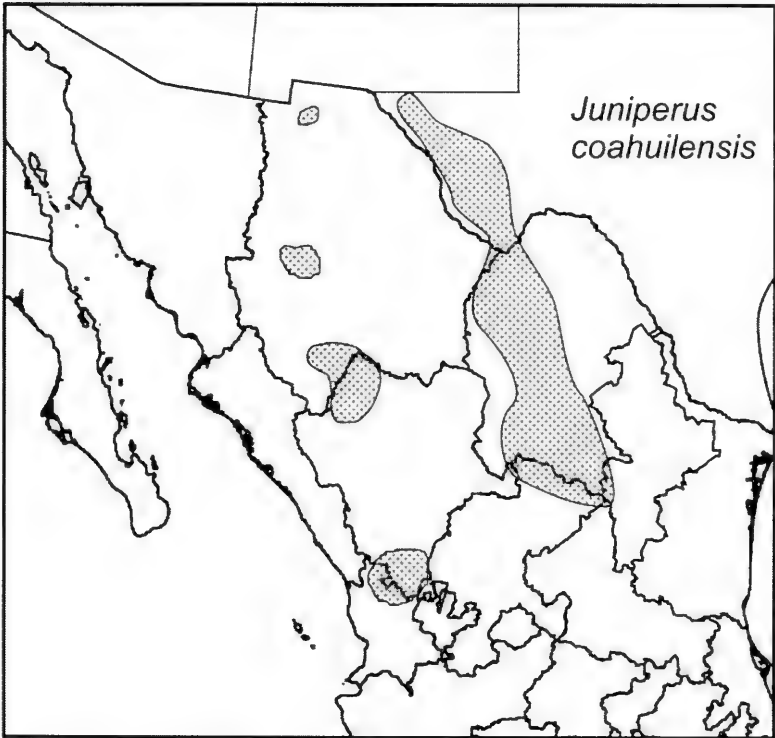


Figure 5. Distribution of *J. coahuilensis*.

**Juniperus communis** L., common juniper.

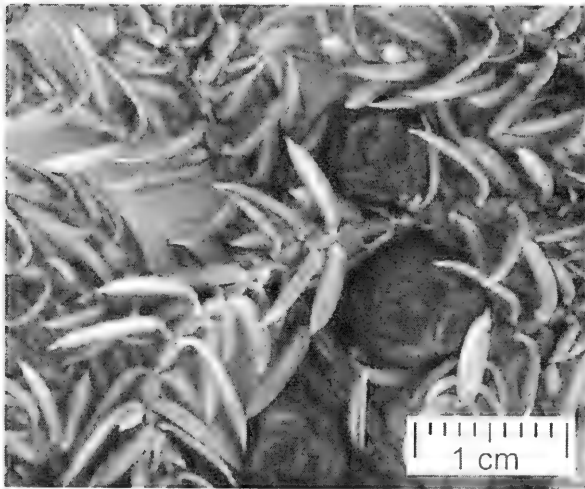
The taxonomy of *J. communis* in North America has recently been reviewed and revised based on morphology, RAPDs and nrDNA SNPs (Adams, 2008) and five varieties were recognized.

Key to *J. communis* varieties in North America:

- 1. Glaucons stomatal band twice (or more) as wide as each green leaf margin, spreading; mat-like shrub (or occasionally upright); leaves upright, sometimes almost imbricate, closely set, curved, 5 - 10 (12) mm long.....3.
- 1. Glaucons stomatal band about as wide to 1.5 x as wide as each green leaf margin; prostrate or low shrub with ascending branchlet tips (or occasionally a spreading shrub), leaves upturned, rarely spreading, linear to curved, 10-20+ mm long.....2.
  - 2. Seed cones 6 – 9 mm diam., smaller than leaf length, North America.....var. **depressa**
  - 2. Seed cones 10 – 13 mm diam., larger than leaf length, known only from southeastern Canada.....var. **megistocarpa**
- 3. Mature seed cones 8-9 mm diam., greater than leaf length, Endemic to Queen Charlotte Islands, grows in sphagnum bogs .....var. **charlottensis**
- 3. Coastal range of w. Canada and U. S., grows on serpentine, lava and other rock substrates, mature seed cones about a long as leaves.....4
- 4. Mature seed cones, elongated-subglobose stomatal band 3 to 4 times as wide as each green leaf margin.....var. **jackii**
- 4. Mature seed cones globose, stomatal band 2 times as wide as each green leaf margin.....var. **saxatilis**

*Juniperus communis* var. *charlottensis* R. P. Adams, Phytologia 90(2): 187 (2008). Queen Charlotte Island juniper. Type: Canada, Queen Charlotte Island, 9 km s of Masset, on hwy 16, in muskeg bog, 53° 55.511'N, 132° 06.471'W, 61m, 8-July-2007, R. P. Adams 10306 (holotype BAYLU!).

**Dioecious.** Low shrubs with upturned branchlets. **Trunk bark** brown, exfoliating in wide strips or plates. **Branches** spreading and upturned. **Leaves** acicular, imbricate to open, curved, boat shaped, tips apiculate to mucronate, 5 - 7 mm x 1.6 mm. Glaucous stomatal band twice as wide as each green leaf margin. **Seed cones** 8-9 mm, larger than leaf length, dark blue when mature (2-3yrs). **Seeds** 1(2) per cone. **Pollen shed** spring. **Habitat** sphagnum bogs. **Uses** none known. **Dist.:** endemic to Queen Charlotte Island, Canada (Fig. 6). **Status:** At present, the habitat (sphagnum bogs) seems conserved, so it does not appear to be threatened nor endangered.



*Juniperus communis* var. *charlottensis* leaves and seed cones.

*Juniperus communis* var. *depressa* Pursh, Fl. Amer. Sept. 2: 646 (1814). Depressed juniper. Type: not located, (Coll. F. T. Pursh?), said to be from New York, and particularly in the province of Maine.

*J. canadensis* Lodd. ex Burgsd., Anleit. Sich. Erfzieh. Holzart. 2:124 (1787)

*J. depressa* Raf. ex M'Murtrie, Florula Louisvill, 219 (1819)

*J. depressa* (Pursh) Raf., Med. Fl. 2:13 (1830)

*J. communis* L. var. *canadensis* (Lodd. ex Burgsd.) Loudon, Arbor. Frut. Brit. 4:249 (1838)

*J. intermedia* Schur. Verh. Mitth. Siebenburg. Vereins Naturwiss. Hermannstadt 2:169 (1851)

*Sabina multiova* Goodwyn, Amer. Botanist 37(4): 152 (1931)

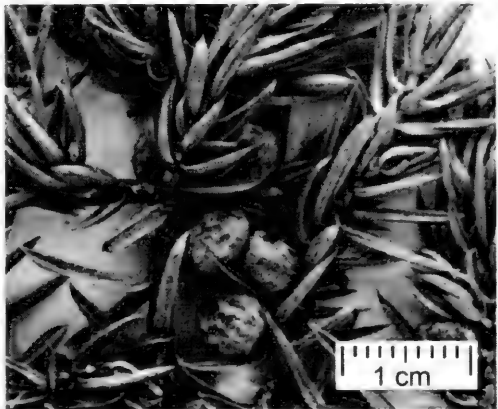
*J. communis* L. subsp. *depressa* (Pursh) Franco in Bol. Soc. Broteriana Ser. 2, 36:117 (1962)

*J. communis* subsp. *depressa* (Pursh) E. Murray

**Dioecious. Prostrate or low shrubs** with ascending branchlet tips (or occasionally a spreading shrub to 3 m). **Trunk bark** brown, exfoliating in wide strips or plates. **Branches** erect to ascending. **Leaves** acicular, upturned, rarely spreading, linear, acuminate, tips acute to mucronate, to 15.0 x 1.6 mm. Glaucous stomatal band approx. as wide as each green leaf margin. **Seed cones** 6-9 mm, smaller than leaf length, dark blue when mature (2-3yrs).

**Chromosome number**  $2n=22$  (Hall, Mukherjee and Crowley, 1979). **Seeds** 3 per cone.

**Pollen shed** spring. **Habitat** Rocky soil, rocky slopes and summits, sea level to 2800 m due to latitudinal range. **Uses** none known. **Dist.:** common in mountains in United States and Canada (Fig. 6).



*Juniperus communis* var. *depressa* leaves and seed cones.

**Status:** common and expanding into disturbed areas. Not threatened.

*Juniperus communis* var. *jackii* Rehder, Mitt. Deutsch. Dendrol. Ges. 1907 (16): 70 (1907) Type locality: Siskiyou Mtns., on the road from Waldo, Oregon to Crescent City, CA, 3000 ft., 25 Aug., 1904, J. G. Jack and Alfred Rehder. Named after J. G. Jack.

**Dioecious.** Prostrate shrubs to small shrubs. **Trunk bark** brown, exfoliating in wide strips or plates. **Branches** spreading. **Leaves** acicular, curved, tips apiculate to mucronate, 5 - 7 mm x 1.6 mm. Glaucous stomatal band 3 - 4 times as wide as each green leaf margin. **Seed cones** 6-7 mm, elongated-subglobose, dark blue when mature (2-3yrs). **Seeds** 1(2) per cone. **Pollen shed** spring. **Habitat** Serpentine rock and lava talus slopes. **Uses** none known. **Dist.:** Serpentine rock in nw CA, and lava talus slopes in Cascade Mtns., OR (Fig. 6).

**Status:** At present, the habitat (serpentine and lava talus slopes) seems conserved, so it does not appear to be threatened nor endangered.

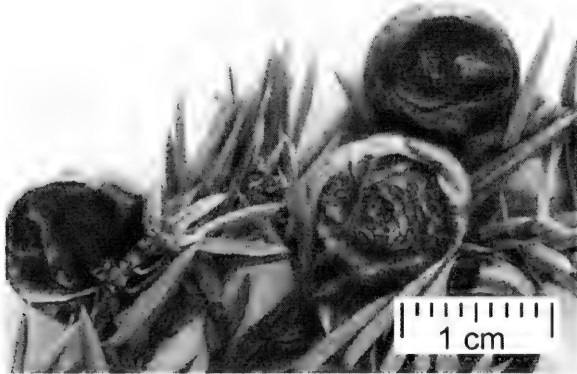


The type locality is on serpentine, but var. *jackii* *Juniperus communis* var. *jackii* leaves and seed cones. also grows on high elevation lava (Mt. Hood, OR). *Juniperus communis* having short, curved leaves with a stomatal band about twice as wide as the green leaf margin, is found from n California to Alaska. Recent analysis of nrDNA SNPs (Adams, 2008) shows that the Siskiyou Mtns. and Mt. Hood populations are somewhat different from the other populations. In addition, the Queen Charlotte Islands plants that grow in a sphagnum bog show considerable differentiation.

*Juniperus communis* var. *megistocarpa* Fernald & H. St. John, Proc. Bos. Soc. Nat. Hist. 36: 58 (1921). Large fruited common juniper. Type: Canada, Quebec, Madeleine Islands, Alright Island, Narrows, *M. L. Fernald* (with *B. H. Long*) 6729 (holotype GH!).

**Dioecious. Prostrate shrubs. Trunk bark** cinnamon, exfoliating in wide strips or plates. **Branches** mostly prostrate on the ground. **Leaves** acicular, boat-shaped, curved, 7 – 10 mm, stomatal band 1.5 x as wide as green leaf margins. **Seed cones** very glaucous, purple-blue, mature in 2 yrs., 9-13 mm, larger than leaf length, dark blue when mature (2-3yrs). **Seeds** 1 – 3 per cone. **Pollen shed** spring? **Habitat** sand dunes, serpentine and limestone barrens; 0-500 m. **Uses** none known. **Dist.:** Newfoundland, N.S.: Sable Isl., Que.: Magdalene Isl. (Fig. 7). **Status:** this is a very restricted taxon and can easily become threatened.

This is the most distinct variety of *J. communis*, especially in its seed cones, habitat, and DNA fingerprints, yet it appears to be of only recent (Pleistocene) origin (Adams et al., 2003).



*Juniperus communis* var. *megistocarpa* leaves and seed cones.

***Juniperus communis* var. *saxatilis*** Pall., Fl. Ross. 1 (2): 12 (1789).  
Rocky juniper Type: none, Lectotype K, Illustration in Pallas, Fl. Rossica 1(2): 12, t. 54 (1789), designated by Farjon (2005).

- J. sibirica* Burgsd., Anleit. Sich. Erzieh. Holzart. 2:124 (1787)  
*J. nana* Willd., Berl. Baumz.: 159, *nom. nud.* (1796)  
*J. communis* L. var. *montana* Aiton, Hort. Kew 3:413 (1789)  
*J. communis* L. var. *alpina* Suter, Fl. Helvet. 2:292 (1802)  
*J. oblonga* M.-Bleb., Fl. Taur.-Cauc. 2:426 (1808)  
*J. communis* L. var. *nana* (Willd.) Baumg. Enum. Stirp. Transsilv. 2:308 (1816)  
*J. alpina* S. F. Gray, Nat. Air. Brit. Pl. 2: 226 (1821)  
*J. communis* L. var. *oblonga* (M.-Bieb.) Parl. in Candolle, Prodr. 16 (2): 479 (1868), *non* Loudon (1838)  
*J. communis* L. var. *caucasica* Endl., Syn. Conif.: 16 (1847)  
*J. nana* Willd. var. *alpina* (Aiton) Endl., Syn. Conif.: 14 (1847)  
*J. pygmaea* K. Koch, Linnaea 22:302 (1849)  
*J. montana* (Aiton) Lindl. & Gordon, J. Hort. Soc. London 5:200 (1850)  
*J. caesia* Regel. Gartenflora 6:346 (1857), *non* Carriere (1855)  
*J. communis* L. subsp. *alpina* (Suter) Celak., Prodr. Fl. Bohmen: 17 (1867)  
*J. communis* L. subsp. *nana* (Willd.) Syme in Sowerby, Engl. Bot., ed. 3, 8:275, t. 1383 (1868)  
*J. communis* subsp. *alpina* (Smith) Celakovsky (1869)  
*J. sibirica* Burgsd. var. *montana* (Aiton) Beck, Blatt. Verein. Landesk. Niederosterreichs 1890: 78 (1890)  
*J. rebunensis* Kudo & Suzaki, Med. Pl. Hokaido, No. 6, t.6 (1920)  
*J. communis* L. subsp. *oblonga* (M.-Bieb.) Galushko, Mat. Izuchenya Stavrop. Kraya 2-3:165 (1950)  
*J. communis* L. subsp. *saxatilis* (Pall.) E. Murray, Kalmia 12:21 (1982)  
*J. communis* L. subsp. *pygmaea* (K. Koch) Imkhan., Novosti Sost. Vyssh. Rast. 27: 10 (1990)

**Dioecious.** Shrubs procumbent, to 70 cm. **Trunk bark** thin, cinnamon, exfoliating in wide strips. **Branches** procumbent, densely



arranged, 3-angled, thick, ca. 2 mm in diam. **Leaves** acicular, in whorls of 3, ascending, lanceolate or linear, usually subfalcate, 4-10 x 1-2 mm, slightly concave adaxially with a single white stomatal band broader than green marginal bands, keeled abaxially, base jointed, not decurrent. **Seed cones** brownish black when ripe, glaucous, globose or subglobose, 4-7 mm in diam. **Seeds** 1-3 per cone, 3-4 mm, dark blue when mature (2-3yrs). **Pollen shed** late spring. **Habitat** rocky areas. **Uses** seed cones ('berries') used to flavor gin. **Dist.:** nw US, w Canada (Fig. 6), also in the e. hemisphere (Europe and Asia). **Status:** this taxon is widespread so it seems robust.



*Juniperus communis* var. *saxatilis* leaves and seed cones from Redfish Lake, Idaho, USA, cf *Adams 10890*.

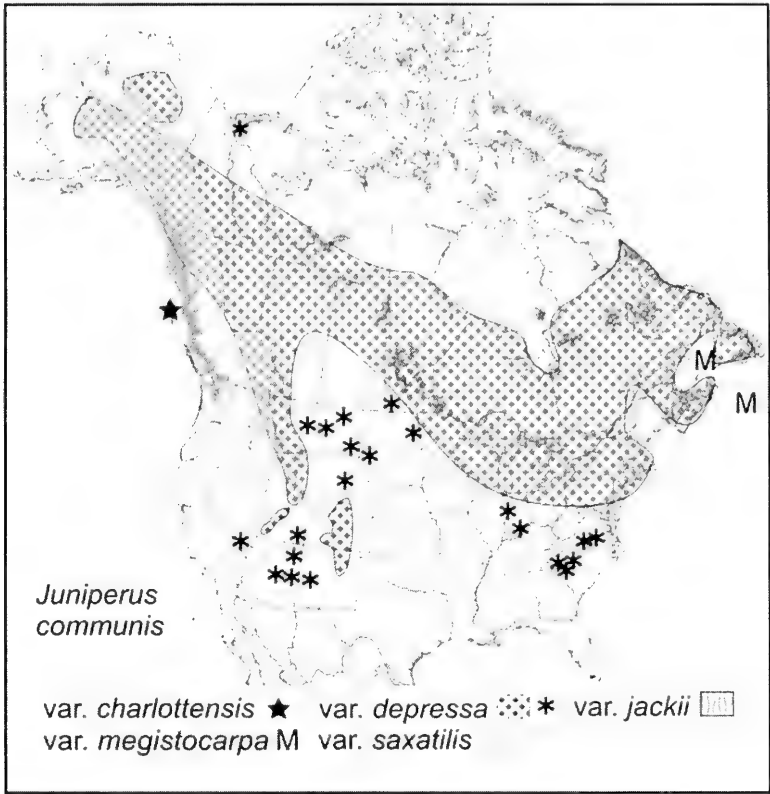


Figure 6. Distribution of *J. communis* in North America.

***Juniperus deppeana* Steudel, alligator bark juniper**

Adams et al. (2007) show (Fig. 7) that there is some differentiation between populations of var. *deppeana* from Arizona and New Mexico and those from the Chisos and Davis Mtns. of Trans-Pecos Texas, but not sufficient to warrant formal recognition.

*Juniperus deppeana* grows in montane areas in the southwestern United States and Mexico (Fig. 8).

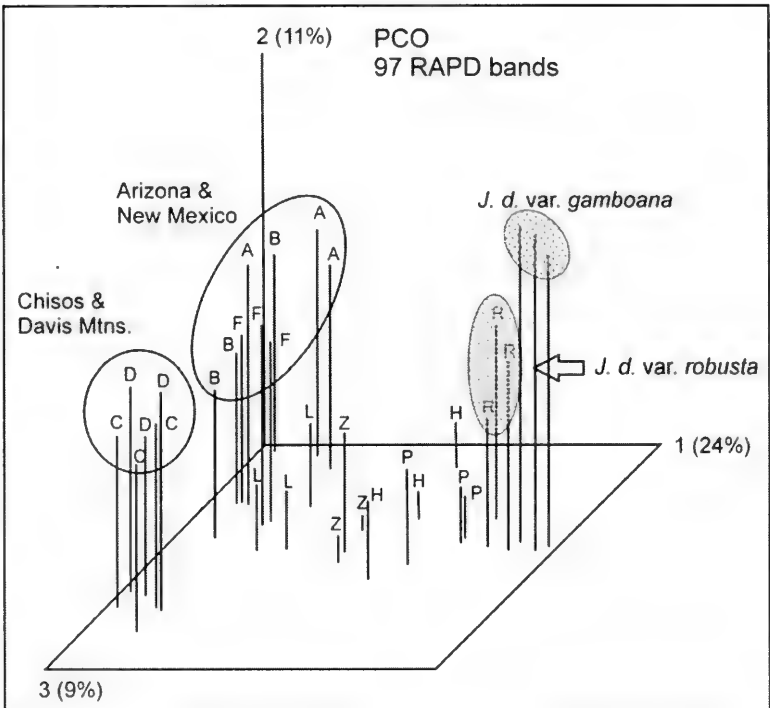


Figure 7. PCO of *J. deppeana* varieties, from Adams et al. (2007). The first principal coordinate separates var. *gamboana* and var. *robusta* from the other *J. deppeana* varieties. Notice some separation between the Arizona - New Mexico and Chisos - Davis Mtns. populations.

Adams, Zanoni and Hogge (1984), using leaf terpenoids examined the varieties of *J. deppeana*. They found that samples from Arizona (BA, SA) to be rather distinct from the other *J. deppeana* varieties. However, additional research using DNA sequencing and fingerprinting (Adams et al., 2007), confirmed that there is only one variety in the southwestern United States (*J. d. var. deppeana*).

### Key to varieties and forms:

1. Stem bark longitudinally furrowed into long, interconnected strips, terminal whip branches often flaccid and somewhat pendulous ..... f. *sperryi*
1. Stem bark in quadrangular plates, terminal whip branches ascending to erect
2. Terminal whips long (15-30 cm) and pendulous, all (or nearly all) leaves on adult plants juvenile (decurent, whip-type).....f. *elongata*
2. Terminal whips short (5-10 cm) and not pendulous, all leaves on adult plants scale-like (except on new growth where whip-leaves occur).....var. *deppeana*

*Juniperus deppeana* Steudel var. *deppeana*, Nom. Bot. ed. 2, 1:835 (1840). Alligator bark juniper, Cedro, cedro chins (Puebla), sabino, Tascate (Chihuahua and Durango), Tascal or Tlaxcal (Hidalgo), Huata, Agoziza (Sonora).. Type: Mexico, Vera Cruz: Llanos de Perote, Schiede in 1828 (Type material unknown or destroyed). Lectotype: MO, designated by Zanoni Adams, Bot. Soc. Mex. 38: 83 (1979).

*J. thurifera* Spach, Ann. Sci. Nat. Bot., ser. 2, 16: 298 (1841), non L. (1753)

*J. mexicana* Schiede ex Schltdl. & Cham., Linnaea 5: 77 (1830), non Spreng. (1826)

*J. foetida* Spach, Hist. Nat. Veg. Phan. 11: 314 (1841)

*Sabina mexicana* (Schltdl. & Cham.) Antoine, Cupress.-Gatt.: 38 (1857)

*J. gigantea* Roezl, Cat. Grain. Conif. Mexic. 8 (1857)

*Sabina gigantea* (Roetzl) Antoine, Cupress.-Gatt.: 36 (1857)

*Juniperus deppeana* Steud. var. *pachyphlaea* (Torr.) Martinez. Anales Inst. Biol. Univ. Nac. Mex. 17(1): 53 (1946). Type: Zuni Mts., NM, USA, Bigelow in 1853, NY!.

*J. pachyphlaea* Torr., US Rep. Expl. Survey Miss. Pacific 4(5):

142 (1857)

*Sabina pachyphlaea* (Torr.) Antoine, Cupress.-Gatt.: 39 (1857)

*S. plochyderma* Antoine, Cupress.-Gatt.: 40 (1857).[*nom nud.*]

**Dioecious.** Trees 10-15 (-30) m, with rounded crown. **Trunk bark** exfoliating in rectangular plates. **Branches** erect, often gray-green or light green, branchlets (1 cm) exfoliating to reveal copper color.

**Leaves** both decurrent (whip) and scale. Decurrent and scale leaf margins denticulate (20 X), whip and scale leaves usually with ruptured glands (clear, yellow or white exudate).

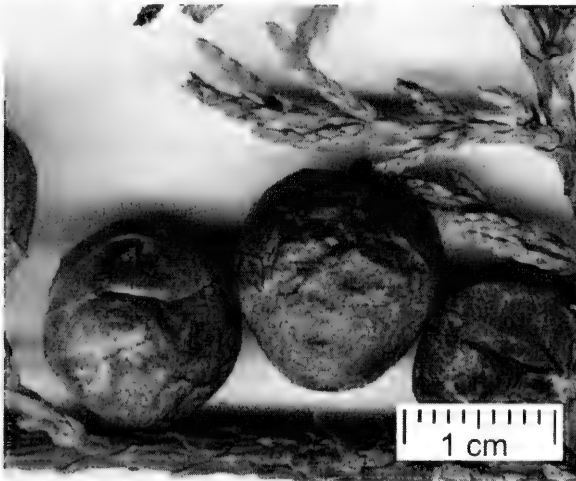
**Seed cones** globose, 8-15 mm across, fibrous to obscurely woody, maturing in the second year, reddish-tan to dark reddish-brown with glaucous bloom. **Seeds** 2-4 per cone, 6-9 mm long. **Pollen shed** late winter - early spring.

**Habitat** rocky soils, slopes and mountains; 2000-2900 m. **Uses** fence posts.

Sprouts from cut stumps and is thus a pest in grasslands. **Dist.:** AZ, NM, TX, northern Mexico (Fig. 8). **Status:** common, not threatened.



checked or 'alligator' bark of *J. deppeana*.



*Juniperus deppeana* leaves and seed cones.

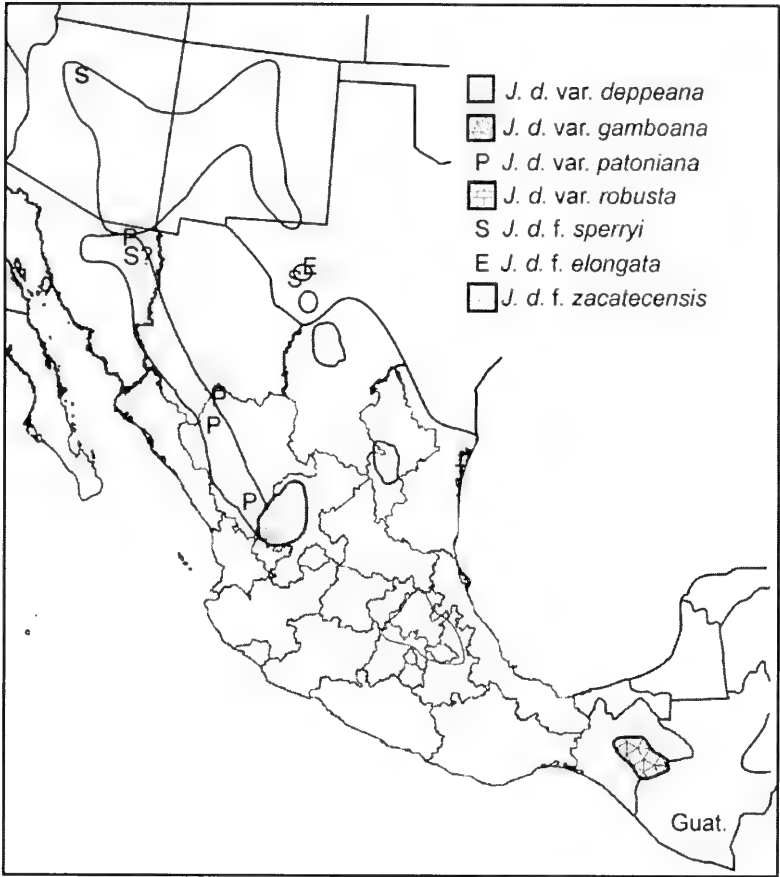


Figure 8. Distribution map of *J. deppeana*. The population of *J. d. var. patoniana* (P) in n. Sonora, Mexico has previously been called *J. d. f. sperryi*, but appears better identified as var. *patoniana*.

*Juniperus deppeana* f. *sperryi* (Correll) R. P. Adams. Brittonia 25:289 (1973). Sperry's juniper. Type: GH: Isotype: US!. United States: Jeff Davis County: Dry Canyon of Davis Mountains, about 8 mi. from Sproul Ranch Headquarters. *Sperry T879*.

*J. deppeana* var. *sperryi* Correll, Wrightia 3:188 (1966)

*J. deppeana* subsp. *sperryi* (Correll) E. Murray, Kalmia 13:8 (1983)

**Dioecious.** **Trees** 10-15 m, with rounded crown. **Trunk bark** stem bark longitudinally furrowed into interconnected strips (Fig. 9). **Branches** terminal whip branches and larger branches somewhat flaccid. **Leaves** both decurrent (whip) and scale. Decurrent and scale-leaf margins denticulate (20 X). **Seed cones** globose, 8-15 mm, fibrous to obscurely woody, maturing in the second year, reddish-tan when immature, then reddish-blue with very light bloom (glaucous) when mature. **Seeds** 5-6 per cone or 1(2) in Sonora (see discussion below), 6-9 mm long. **Pollen shed** spring? **Habitat** rocky soils, slopes and mountains. **Uses** none known. **Dist.:** Davis Mts., Texas, Prescott NF, AZ, n. Sonora, Mexico.



Fig. 9. *J. deppeana* f. *sperryi* bark.

**Status:** Type tree is from the Sproul Ranch, Davis Mts (Fig. 10). Trees with furrowed bark and pendulous foliage are in n. Sonora and have only 1(2) seeds per cone. These are referred to var. *patoniana*, but additional research is needed in this area. David Thornburg (pers. comm.) has recently found *J. deppeana* trees in northern Arizona that have furrowed bark. They do not seem to form a natural population, but occur as scattered individual trees among otherwise normal (quadrangular) barked trees. This suggests that only a few genes may be expressed to give the furrowed bark. Sampling and analyses of such trees is presently being undertaken by the author.



*Juniperus deppeana* f. *sperryi* leaves and seed cones.



Fig. 10. *Juniperus deppeana* f. *sperryi* with the author (1968) at the type tree on the H. E. Sproul Ranch, near Ft. Davis, Texas



*Juniperus deppeana* f. *elongata* R. P. Adams. Phytologia 87(2) 101 (2005). TYPE: Jeff Davis Co., Texas, USA, on Tex 118, 4.2 km west of w. entrance to Lawrence E. Wood Madera Ck. park, 1845 m, Lat. 30° 43.437' N, Long. 104° 08.255' W, 11 March 2005, R. P. Adams 10627 (HOLOTYPE: BAYLU, ISOTYPE: SRSC).

Additional specimen examined: Jeff Davis Co. Texas, USA, Brown Mtn., 2190 m (summit), R. P. Adams 10629 (BAYLU).

**Diocious.** Trees 4-5 m, with rounded crown. **Trunk bark** stem bark exfoliating in rectangular plates. **Branches** terminal whip branches elongated and very flaccid (Fig. 11). **Leaves** both decurrent (whip) and scale. Decurrent and scale-leaf margins denticulate (20 X). **Seed cones** globose, 8-15 mm across, fibrous to obscurely woody, maturing in the second year, reddish-tan when immature, then reddish-blue with very light bloom (glaucous) when mature. **Seeds** 5-6 per cone or 1(2) in Sonora (see discussion below), 6-9 mm long. **Pollen shed** spring? **Habitat** rocky soils, slopes and mountains. **Uses** none known. **Dist.:** Davis Mts., Texas (Fig. 8). **Status:** two trees known. Additional trees are likely to be found.

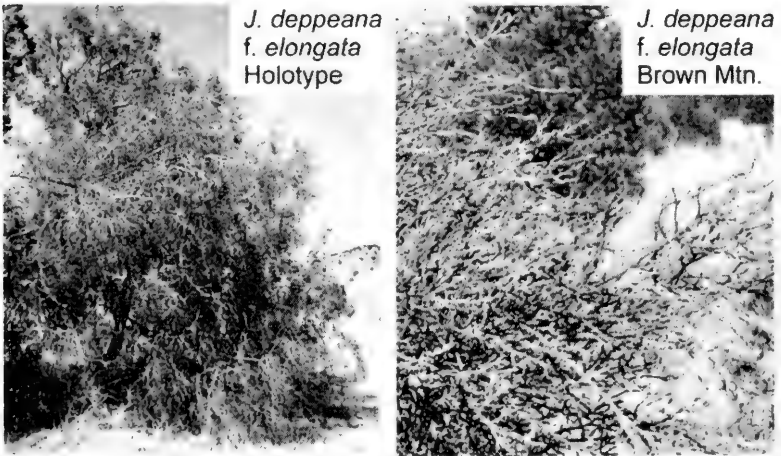


Fig. 11. Habit of *J. deppeana* f. *elongata* showing the long terminal whips and pendulous nature of the foliage.

*Juniperus flaccida* Schltld. Linnaea 12: 495 (1838). Weeping juniper.  
Lectotype MO, 2085919.

*J. gracilis* Endl., Syn. Conif.: 31 (1847)

*J. gigantea* Roehl in part

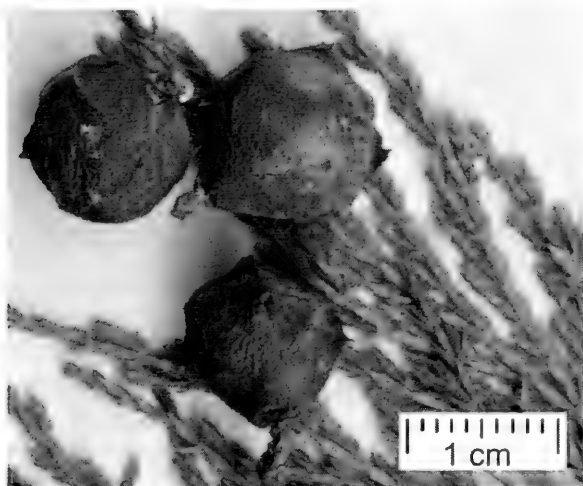
*J. flaccida* var. *gigantea* (Roehl) Gaussen

*J. foetida flaccida* (Schlecht.) Spach

*Sabina flaccida* (Schlecht.) Antoine

*S. flaccida* (Schlecht.) A. A. Heller

**Dioecious.** Trees to 12 m, trunk branching at 1-2 m. **Trunk bark** cinnamon reddish brown or gray reddish brown, exfoliating in broad interlaced fibrous strips. **Branches** spreading and forming a globular crown. Ultimate branchlets drooping, flaccid. **Leaves** both decurrent (whip) and scale. Scale-leaves often appearing somewhat decurrent, 1.5-2 mm, opposite, narrowly ovate, acuminate. Whip- and scale-leaf margins appearing entire at 20 X but with irregular teeth at 40 X. **Seed cones** spherical (4-) 6-10 (-13) seeded, tan-brown to brownish-purple with white glaucous, 9-20 mm in diam., maturing in 2 yr.? **Seeds** 5-6 mm long. **Pollen shed** late winter-early spring. **Habitat** rocky soils and slopes. **Uses** none known. **Dist.:** Mexico, Big Bend Natl. Park., Texas, USA (12). **Status:** widespread in Mexico and reproducing.



*Juniperus flaccida* leaves and seed cones.

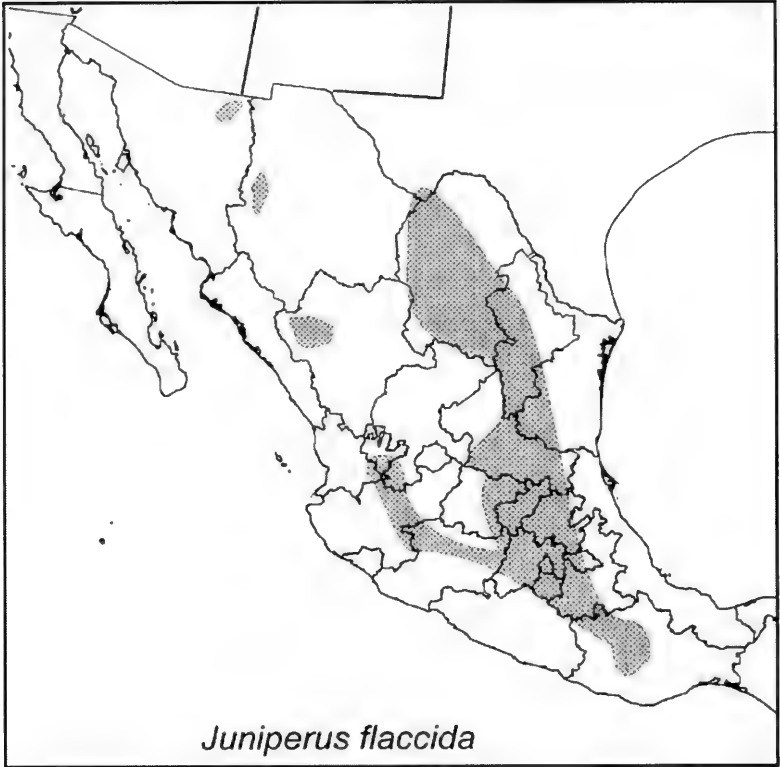


Figure 12. Distribution of *J. flaccida*. The only population in the United States is in the Chisos Mtns., Big Bend National Park, Texas.

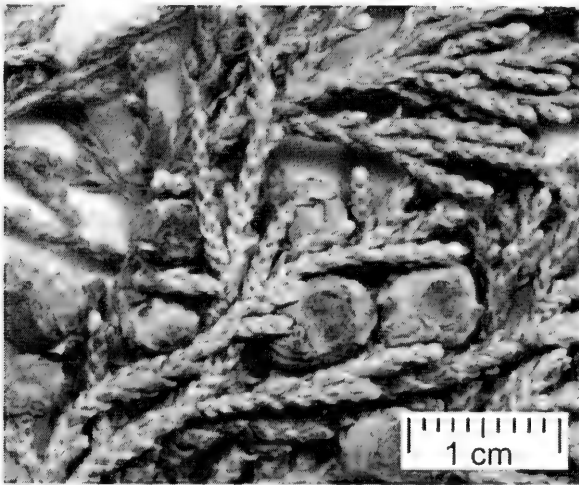
*Juniperus grandis* R. P. Adams. Phytologia 88(3): 306 (2006), Big western juniper, grand juniper. Type: United States, California, San Bernardino Mtns., CA, Vasek 610929 (HOLOTYPE: RSA).

*Juniperus occidentalis* W. J. Hooker subsp. *australis* Vasek, Brittonia 18: 352 (1966),

*Juniperus occidentalis* var. *australis* (Vasek) A. & N. Holmgren., Intermountain Fl. 1: 239 (1972).

**Dioecious**, approx. 5% trees **Monoecious** (Vasek, 1966). **Trees** to 30 m. **Trunk bark** brown. **Branches** erect to pendulous. **Leaves** decurrent (whip) and scale-like, scale and whip-leaves with visible glands. **Seed cones** blue to blue-black, with resinous pulp, maturing in 2 yrs., 5 – 9 mm long (avg. 7.6). **Seeds** 1-2(3) per cone (avg. 1.5). **Pollen shed** spring. **Habitat** Sierra Nevada on dry rocky slopes; 1000-3000 m. Calif. **Uses** fence posts. **Dist.:** Sierra Nevada of California (Fig. 13). **Status:** occurs in protected areas, it is not threatened.

**Taxonomy:** Adams et al. (2006), using both DNA sequence and fingerprinting data, clearly showed that *J. occidentalis* var. *australis* to be more closely related to *J. osteosperma* than *J. occidentalis*. Based on these data, the var. *australis* was recognized as a distinct species, *J. grandis*.



*Juniperus grandis* leaves and seed cones.



Figure 13. Distribution of *J. grandis* (= *J. occidentalis* var. *australis*).

***Juniperus horizontalis*** Moench, Methodus Plantas 699 (1794).

Creeping juniper, prostrate juniper. Type: no longer extant. (Zanoni, 1978).

*J. sabina* Michx., Fl. Bor. Amer. 2: 246 (1803), *non* L. (1753)

*J. prostrata* Pers., Syn. Pl 2(2): 632 (1807)

*J. sabina* Michx. var. *procumbens* Pursh, Fl. Amer. Sept. 2: 647 (1814)

*J. repens* Nuttall, Gen. N. Amer. Pl. 2: 245 (1818)

*J. sabina* Michx. var. *humilis* Hook., Fl. Bor. Amer. 2(10):166 (1838)

*J. hudsonica* Forbes, Pinetum Woburn.: 208 (1839)

*J. virginiana* L. var. *prostrata* (Pers.) Torr., Fl. New York 2: 235 (1843)

*Sabina prostrata* (Pers.) Antoine, Cupress.-Gatt.: 57 (1857)

*J. foetida multicaulis* Spach in part

*J. horizontalis* forma *alpina* (Loud.) Rehder

*J. horizontalis* forma *lobata* O.W. Knight

*J. horizontalis* var. *douglasii* Hort.

*J. horizontalis* var. *variegata* Beissn.

*J. sabina* B. *humilis* Carr. in part

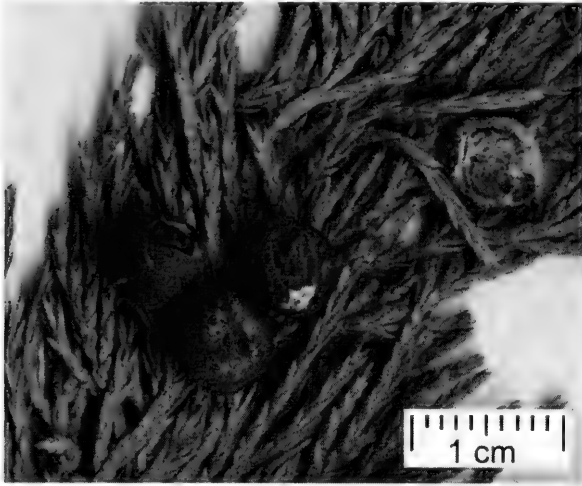
*J. sabina*  $\beta$  *procumbens* Pursh

*S. horizontalis* (Moench) Rydb., Bull. Torrey Bot. Club 39: 100 (1912)

*S. vulgaris* Antoine in part

**Dioecious. Prostrate to decumbent shrub. Trunk bark** brown, exfoliating in plates. **Branches** procumbent, forming large mats often several meters across. **Leaves** decurrent (whip) and scale-like. Foliage green but turning reddish-purple in winter. Leaf margins entire (20 X and 40 X). scale-leaf tips apiculate, mostly overlapping, both whip and scale leaves growing along the branchlets. **Seed cones** 1-2(3) seeded, blue-black to blue-brownish when ripe, borne on generally curved peduncles, mostly maturing in 2 yrs., 5-7 mm. **Seeds** 4-5 mm. **Chromosome number**  $2n=22$  (Hall, Mukherjee and Crowley, 1979). **Pollen shed** spring. **Habitat** sand dunes, sandy and gravelly soils, prairies, slopes and along stream banks; sea level to 1000 m. **Uses** none known. **Dist.:** Canada: all provinces. AK, MT, WY, ND, SD, NB, MN, IA, WS, IL, MI, NY, VT, MA, ME (Fig. 14). **Status:** this taxon is common and reproducing. Not threatened.

*Juniperus horizontalis* hybridizes with both *J. virginiana* and *J. scopulorum* (Adams, 1983; Fassett, 1945a,b; Palma-Otal, et al, 1983). The *J. horizontalis* x *J. scopulorum* hybrid has been named *J. scopulorum* var. *patens* Fassett (= X *J. fassettii* B. Boivin).



*Juniperus horizontalis* leaves and seed cones.

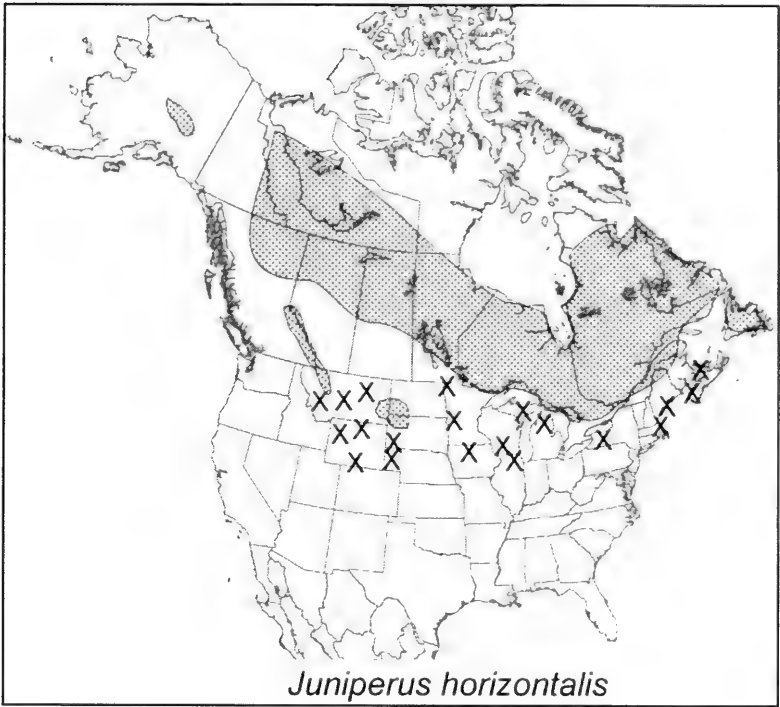


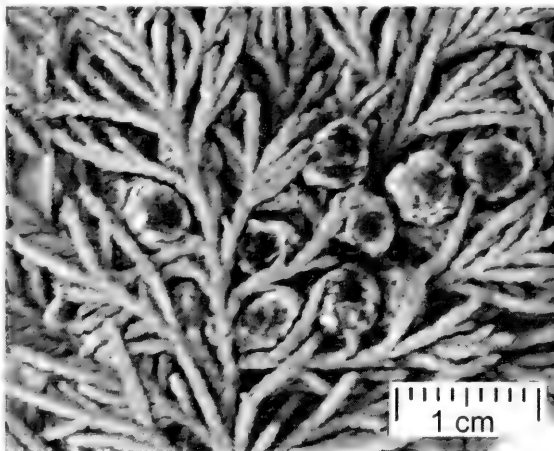
Figure 14. Distribution of *J. horizontalis*. Xs denote outlying populations.



*Juniperus maritima* R. P. Adams Phytologia 89(3): 278 (2007).

Type: Canada, BC, Vancouver Island, Brentwood Bay, Lat 48° 34.794' N; Long 123° 20.211' W, elev. 5 m., 29 May 2006, R. P. Adams 11056 (HOLOTYPE: BAYLU; ISOTYPE: V).

This species is similar to *J. scopulorum* but differs in having seed cones mature in 1 year (14-16 months), seeds are usually exserted from the cone, and the scale-leaf tips are obtuse (see below). It differs from *J. virginiana*



*Juniperus maritima* leaves and seed cones.

in having larger seed cones (6-8 mm) that are often reniform, seeds often exserted from the cone, scale-leaves overlap less than 1/5 the length, and branchlets are smooth and reddish-brown.

Character	<i>J. maritima</i>	<i>J. scopulorum</i>	<i>J. virginiana</i>
seed cones mature	1 yr (14-16 mos.)	2 years	1 year
seed cone diam.	6-8 mm	6-9 mm	3-6(7) mm
seed cone shape	globose to reniform	globose to reniform	ovoid
seeds per cone	(1) 2	(1) 2 (3)	1-2 (3)
exserted seeds	ubiquitous	rare	rare
scale-leaf overlap	< 1/5 length	< 1/5 length	> 1/4 length
scale-leaf tips	obtuse	acute to obtuse	acute
branchlets (6-15mm, diam.)	smooth, reddish-brown	smooth, bright reddish-brown	brown with persistent old leaves

*Junipers maritima* is known only from the Puget Sound and Strait of Georgia areas (Fig. 15). It is usually found in rocky areas, often within meters of the water. However, a population exists on coastal sand dunes near Cranberry Lake, Whidbey Island, WA. No other population has been found on sand, so that site may be atypical.

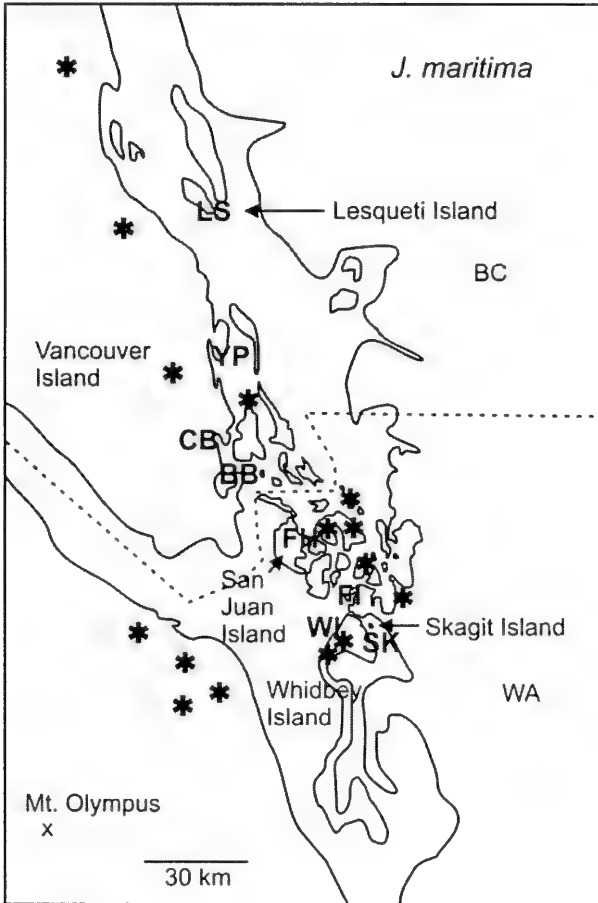


Figure 15. Distribution of *Juniperus maritima* based on Adams field collections (acronyms) and herbarium specimens (stars) from ONP, V, WS, and WTU (from Adams, 2007).

*Juniperus monosperma* (Engelm.) Sargent. Silva N. Amer. 10: 89 (1896). One-seeded juniper, cherry-stone juniper. Type: USA, Colorado, Fremont Co., Canon City, limestone hills, G. Englemann, s. n., Lectotype: MO 3377643 selected by T. Zanoni, Feb. 1992, designated by Farjon (2005).

*J. occidentalis* Hook. var. *monosperma* Engelm., Trans. St. Louis Acad. Sci. 3: 590 (1878)

*J. californica* Carriere var. *monosperma* (Engelm.) Lemmon, Handb. W. Amer. Conebearers, ed. 2: 17 (1892)

*J. occidentalis* Hook. var. *gymnocarpa* Lemmon, Handb. W. Amer.

Cone-bearers, ed. 3: 80 (1895)

*Sabina monosperma* (Engelm.) Rydberg, Bull. Torrey Bot. Club 32: 598 (1905)

*J. occidentalis* Hook. f. *gymnocarpa* (Lemmon) Rehder, J. Arnold Arbor. 7: 239 (1926)

*J. mexicana* Schiede ex Schltld. & Cham. var. *monosperma* (Engelm.) Cory, Rhodora 38: 183 (1936)

*J. gymnocarpa* (Lemmon) Cory, Rhodora 38: 184 (1936)

**Dioecious.** **Shrub** or small tree, 2-7 (-12) m, usually with stems branching near the ground. **Trunk bark** thin, gray to brown, exfoliating in thin strips revealing cinnamon color. **Branches** ascending to erect, with an ashy-white peeling bark. **Leaves** both decurrent (whip) and scale-like. Ultimate branchlets approx. 2/3 as wide as scale leaf length, square or six-sided but not terete. Whip- and scale-leaf margins denticulate (20 X). Scale leaves acute to acuminate. Whip-leaf gland  $\frac{3}{4}$  as long as the leaf, adaxial (inner) leaf surface glaucous. Scale-leaves 1-3 mm, ovate, acute to acuminate, green. Scale-leaf tips free with the abaxial surface raised. Few (less than 1/5) whip-leaf glands ruptured and with a white crystalline exudate (visible without a lens). **Seed cones** 6-8 mm, soft and juicy pulp, globose to ovoid, reddish-blue to brownish-blue, white glaucous, 1(2-3) seeded, the hilum scar approx. 1/3 as long as seed. **Seeds** 4-5 mm long. **Pollen shed** late winter—early spring. **Habitat** common shrub in dry rocky soils and slopes; 1000-2300 m. **Uses** not rot resistant, so not commonly used for fence posts. **Dist.:** Ariz., Colo., N. Mex., Okla., Tex. (Fig. 16). Often reported from Mexico, but these plants should be referred to *J. angosturana* or *J. coahuilensis*. True *J. monosperma* has not been seen

in Mexico by the author. **Status:** This species is the dominant plant on millions of hectares in New Mexico, USA. It is reproducing and is considered a pest (weed) in pastures.

Hybridization between *J. monosperma* and *J. pinchotii* (Hall and Carr, 1968) has been negated using numerous chemical and morphological characters (Adams, 1969; 1975). Hybridization is unlikely in that pollination activity for *J. monosperma* is in late winter - early spring whereas that for *J. pinchotii* is in the fall. Hybridization with *J. coahuilensis*, a sibling species, does appear likely and is currently under investigation. The distribution of *J. monosperma* is shown in figure 16.

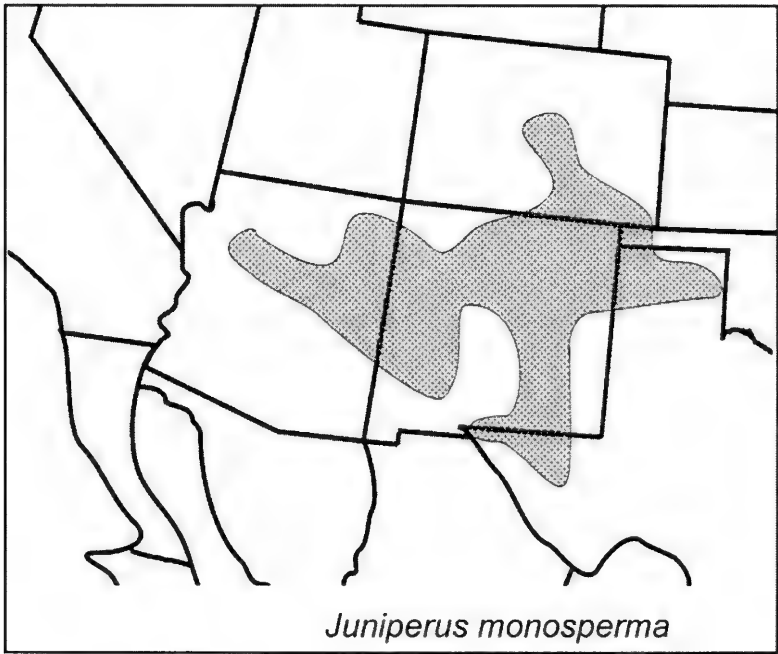
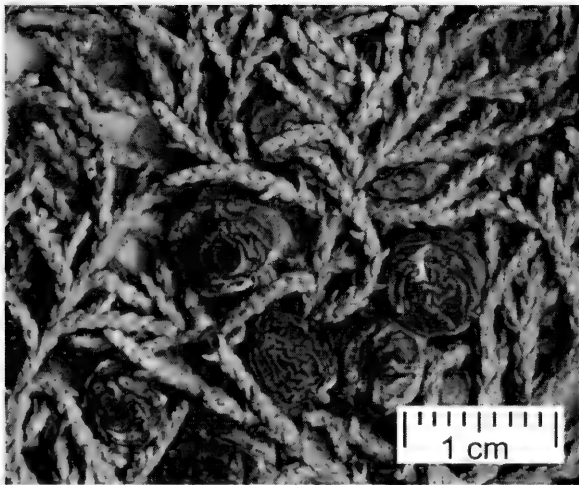


Figure 16. Distribution of *J. monosperma*.

The synonym, *J. occidentalis* Hook. var. *gymnocarpa* Lemmon, came from a term 'gymnocarpa' that seems to have been introduced by Lemmon in 1895. It is common to see the seeds exerted from the seed cones in most *Juniperus* species. This is apparently due to insect damage to the immature cone. See the figure 17 to the left of exerted seeds in *J. saltillensis*.



Fig. 17. Gymnocarpy in *J. saltillensis*



*Juniperus monosperma* leaves and seed cones.

***Juniperus occidentalis*** W. J. Hooker, Fl. Bor. Amer. 2(10): 166 (1838).  
Western juniper, Sierra juniper. Type: K!

*J. andina* Nutt., N. Amer. Sylva 3: 95, t.110 (1849)

*Chamaecyparis boursieri* Decne., Bull. Soc. Bot. France 1: 70  
(1854)

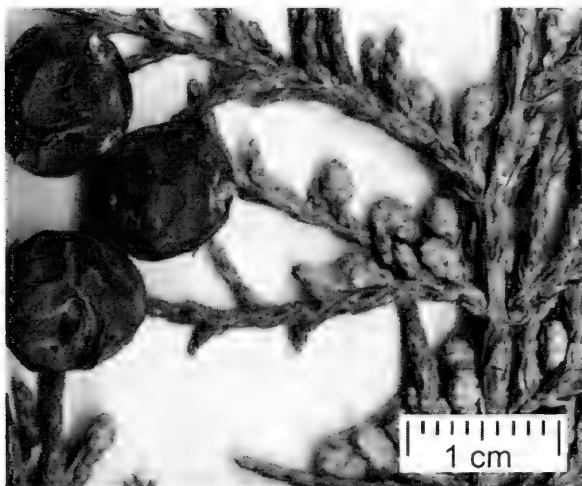
*Sabina occidentalis* (Hook.) Antoine, Cupress.-Gatt.: 64 (1857)

*J. pseudocupressus* Dieck, Neuheit.-Off. Nat.-Arb. Zoschen 1899:  
8 (1899)

*J. californica* var. *siskiyouensis* L.F. Henderson, Rhodora 33: 203  
(1931)

*J. occidentalis* f. *robinsoni* O. V. Matthew

**Monoecious/Dioecious** approx. 50% of the plants monoecious (Vasek, 1966). **Trees** to 20 m. **Trunk bark** red-brown. **Branches** ascending. **Leaves** decurrent (whip) and scale-like, both kinds with visible glands. **Seed cones** blue to blue-black, with resinous pulp, maturing in 2 yrs., 7-10 mm long (avg. 8.3). **Seeds** 1-2(3) per cone (1.6 avg.). **Pollen shed** late spring. **Habitat** dry rocky foothill and mtn. slopes; (near sea level) to 1500-3000 m; Calif., Idaho, Ore., Nev., Wash. **Map:** Vasek, 1966. **Uses** fence posts (but not very rot resistant). **Dist.:** Sierra Nevada of northern California, Oregon and Washington



*Juniperus occidentalis* leaves, pollen and seed cones.

into Nevada (Fig. 18). **Status:** common and reproducing. Considered a pest (weed) on pasture lands in Oregon. Vasek (1966) reported hybridization with *J. osteosperma* in n. w. Nevada. Terry et al. (2000) confirmed hybridization between *J. occidentalis* and *J. osteosperma* using cp and nuclear DNA markers. Adams et al. (2006) recognized *J. occidentalis* var. *australis* as *J. grandis*.

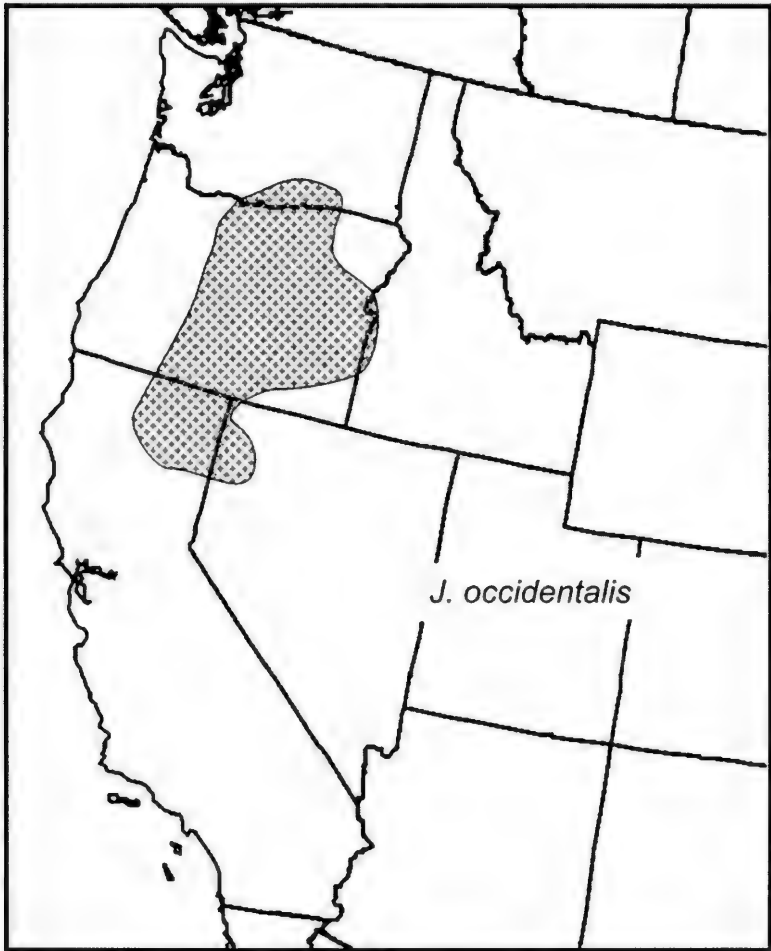


Figure 18. Distribution of *J. occidentalis*.

***Juniperus osteosperma*** (Torrey) Little, Leafl. Western Bot. 5:125 (1948). Utah juniper. Lectotype: NY!

*J. tetragona* Schldl. var. *osteosperma* Torr., Pacif. Railr. Rep. 4(5): 141 (1857)

*Sabina osteosperma* (Torr.) Antoine, Cupress.-Gatt.: 51 (1857)

*J. californica* var. *utahensis* Engelm., Trans. St. Louis Acad. Sci. 3: 588 (1878)

*J. californicus* var. *utahense* Vasey

*J. occidentalis* Hook. var. *utahensis* (Engelm.) Kent, Veitch's Man. Conif.: 289 (1881)

*J. utahensis* (Engelm.) Lemmon, (Cone Bearers Calif.) Calif. State Board Forest. Bienn. Rep. 3: 183 (1890)

*J. knightii* A. Nelson, Bot. Gaz. (Crawfordsville) 25: 198 (1898)

*J. monosperma* (Engelm.) var. *knightii* (A. Nelson) Lemmon, Handb. W. Amer. Cone-bearers, ed. 4: 114 (1900)

*J. utahensis* (Engelm.) Lemmon var. *cosnino* Lemmon, Bull. Sierra Club 4: 123, t. 62 (1902)

*S. knightii* (A. Nelson) Rydberg, Bull. Torrey Bot. Club 32: 598 (1905)

*S. utahensis* (Engelm.) Rydberg, Bull. Torrey Bot. Club 32: 598 (1905)

*J. megalocarpa* Sudw., Forestry & Irrig. 13: 307 (1907)

*S. megalocarpa* (Sudw.) Cockerell, Muhlenbergia 3: 143 (1908)

*J. utahensis* (Engelm.) Lemmon var. *megalocarpa* (Sudw.) Sargent, Bot. Gaz. (Crawfordsville) 67: 208 (1919)

*J. californica* Carriere subsp. *osteosperma* (Torr.) E. Murray, Kalmia 12: 21 (1982)

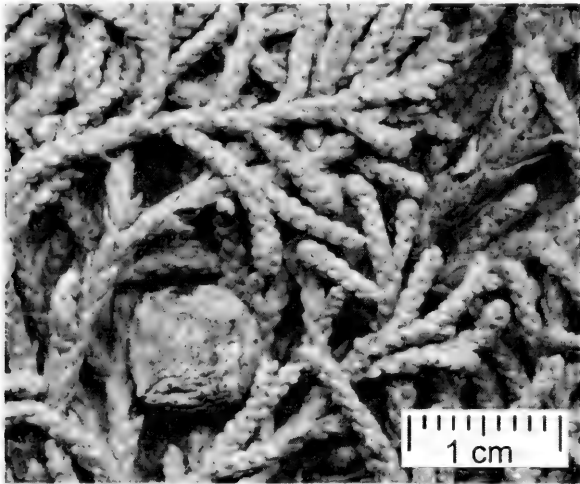
*J. californica* Carr. var. *osteosperma* (Torr.) E. Murray, Kalmia 12: 21 (1982)

**Monoecious or rarely Dioecious (10%).** Shrubs multi- (seldom one) stemmed shrub or tree, 3-6 (-12) m. with round crown. **Trunk bark** exfoliating in thin gray-brown strips. Bark on twigs (5-10 mm diam.) brown or gray, not exfoliating in scales or flakes. **Branches** erect. **Leaves** decurrent (whip) and scale-like, foliage light yellow-green. Whip- and scale-leaf margins denticulate (20 X). Leaf-glands not conspicuous (embedded in the leaf, therefore not visible). **Seed cones** fibrous, bluish-brown, with white glaucous, often almost tan beneath the glaucous, (6-) 8-9(-13) mm. Maturing in 1-2 yrs. **Seeds** 1(2) avg.



1.07 per cone, 4-5 mm long. **Pollen shed** spring. **Habitat** dry, rocky soil and slopes; 1300-2600 m. **Uses** none known, not rot resistant. Trunks of living trees often with rotted heartwood. **Dist.:** Ariz., Calif., Colo., Idaho, Mont., Nev., N. Mex., Utah, Wyo., USA (Fig. 19.). **Status:** abundant in Utah and adjacent states. Considered a weed in ranch lands.

The dominant juniper of Utah. Reported to hybridize with *J. occidentalis* (see *J. occidentalis* above).



*Juniperus osteosperma* leaves and seed cone.

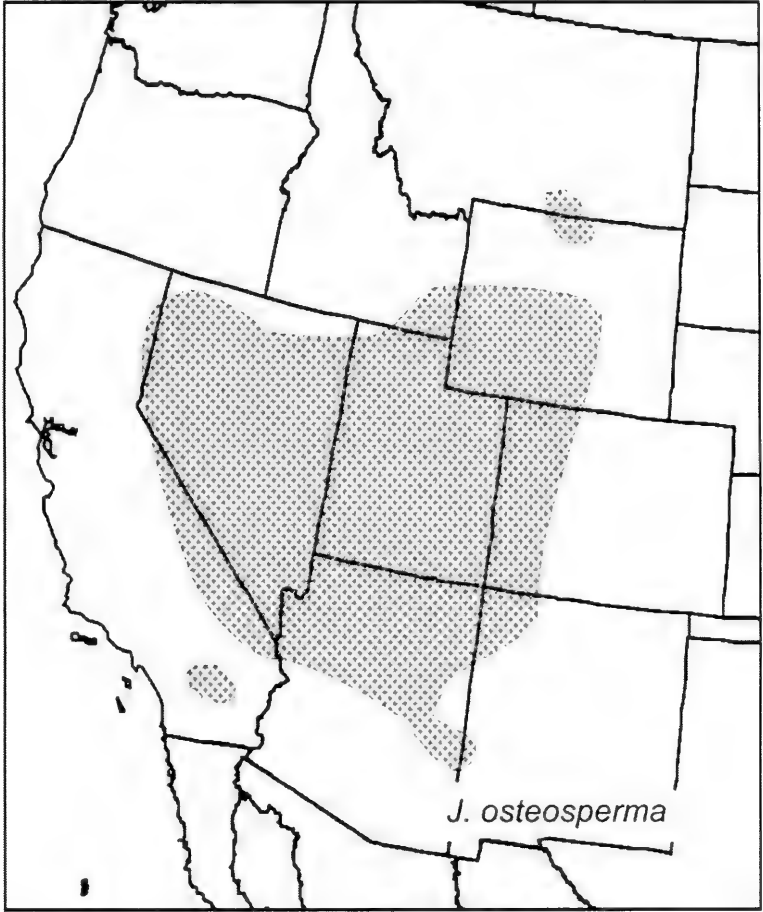


Figure 19. Distribution of *J. osteosperma*.

***Juniperus pinchotii*** Sudworth, Forest. & Irrig. 11: 204 (1905). – Copper berry juniper, Pinchot juniper, red-berry juniper. Type: US!

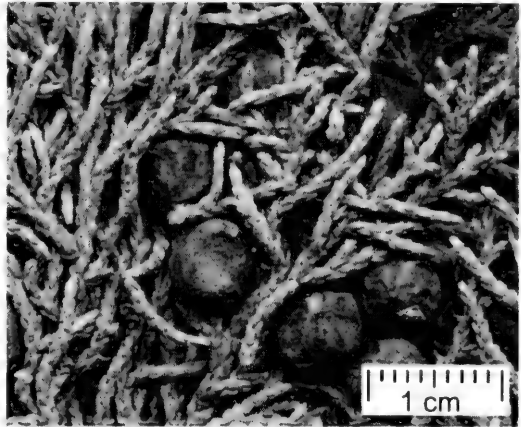
*J. erythrocarpa* Cory, Rhodora 38: 186 (1936)

*J. monosperma* (Engelm.) Sarg. var. *pinchotii* (Sudw.) Melle, Phytologia 4: 29 (1952)

*J. texensis* Melle, Phytologia 4: 26 (1952)

*J. pinchotii* Sudw. var. *erythrocarpa* (Cory) Silba, Phytologia Mem. 7: 35 (1984)

**Dioecious.** Trees, shrub to small shrubby tree, 1-6 m, usually multi-stemmed at the base and forming broad shrubs. **Trunk bark** thin, ashy-gray, exfoliating in long strips. **Branches** stiff, erect or spreading, the bark in long, narrow scales. **Leaves** both decurrent (whip) and scale-like. Whip- and scale-leaf margins denticulate (20 X), leaves yellow-green. Adaxial leaf surface not glaucous. Many glands ruptured and with a white, crystalline (mostly camphor) exudate, both whip- and scale-leaf glands elliptical to elongate. **Seed cones** copper to copper-red, not glaucous, globose to ovoid, 6-8 (-10) mm; soft and juicy, sweet pulp, 1(2) seeded, the hilum scar approx.  $\frac{1}{2}$  as long as the seed. **Seeds** 4-5 mm long. **Pollen shed** fall. **Habitat** 300-1000(-1700) m; gravelly soils on rolling hills and ravines, limestone, gypsum. **Uses** occasionally used as fence posts, but it is not rot resistant. **Dist.:** N. Mex., Okla., Tex. ; northeastern Mexico (Fig. 20).



*Juniperus pinchotii* leaves and seed cones.

**Status:** this species is abundant in its range and is an invasive weed that invades degraded grasslands. It has greatly increased in areas that are not subjected to periodic burning.

The species forms hybrids with *J. coahuilensis* (see above). No hybridization with *J. ashei* has been noted (see above) nor has hybridization with *J. monosperma* (see above) been documented, at least by terpenoid analyses.

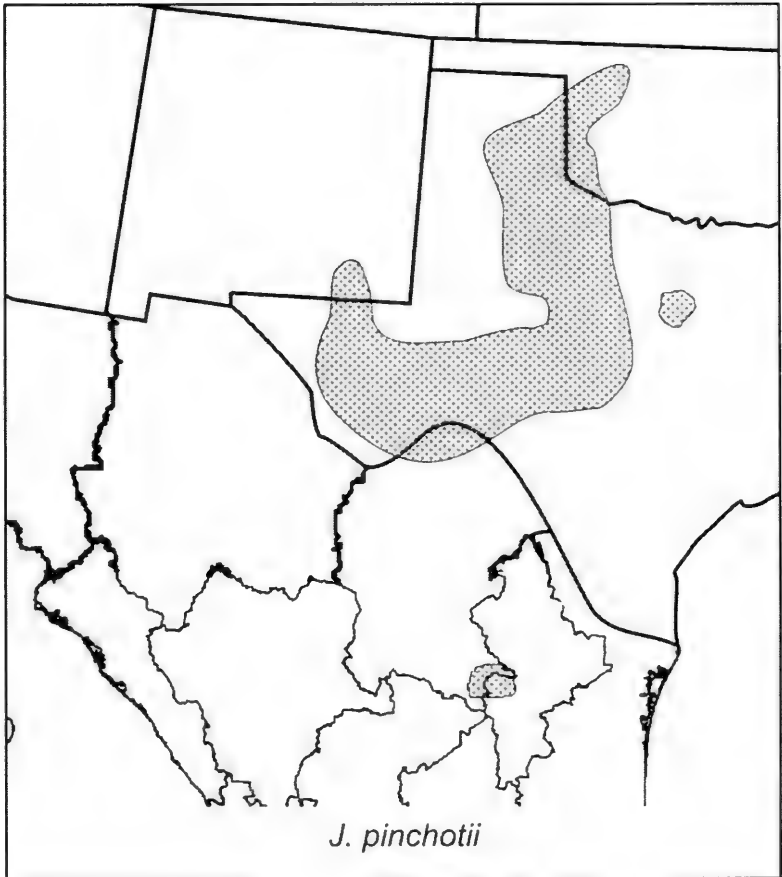


Figure 20. Distribution of *J. pinchotii*.

***Juniperus scopulorum*** Sargent, Gard. & Forest 10: 420, f. 54 (1897).- Rocky mountain juniper. Type: not designated by Sargent; Lectotype: A! Yellowstone Natl. Pk. (designated by Zanoni, 1978).

*J. excelsa* Pursh, Fl. Amer. Sept. 2: 647 (1814), *non* M.-Bieb. (1800)

*J. virginiana* L. var. *montana* Vasey, (Cat. Forest Trees U.S. 30) Rep. U.S. Dept. Agric. 1875: 47 (1876)

*J. occidentalis* Hook. var. *pleiosperma* Engelm., Trans. St. Louis Acad. Sci. 3: 590 (1878)

*J. virginiana* L. var. *scopulorum* (Sarg.) Lemmon, Handb. W. Amer. Cone-Bearers, ed. 4: 114 (1900)

*Sabina scopulorum* (Sarg.) Rydberg, Bull. Torrey Bot. Club 32: 598 (1905)

*J. scopulorum* var. *patens* Fassett, Bull. Torrey Bot. Club 72: 46 (1945) [= *X fassettii* Boivin (*horizontalis* x *scopulorum*) ]

*J. scopulorum* Sarg. var. *columnaris* Fassett, Bull. Torrey Bot. Club 72: 482 (1945)

*J. scopulorum* Sarg. f. *columnaris* (Fassett) Rehder, Bibliogr. Cult. Trees Shrubs: 63 (1949)

*J. fassettii* A. Boivin, Naturaliste Canad. 93: 372 (1966)

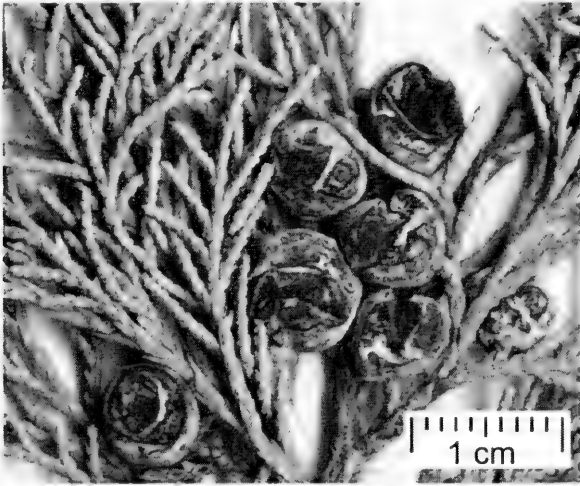
*J. scopulorum* var. *columnaris* Fassett (environmentally induced by gases from burning coal, see Adams, 1982)

*J. virginiana* L. subsp. *scopulorum* (Sarg.) E. Murray, Kalmia 13: 8 (1983)

**Dioecious.** **Trees** single (rarely multi-) stemmed tree to 20 m. pyramidal to occasionally round crowns. Twigs (3-5 mm diam.) with smooth bark, twigs (6-15 mm diam.) with bark exfoliating in plates, reddish-copper beneath. **Trunk bark** brown, exfoliating in thin strips. Foliage light to dark green but often blue and blue-gray due to glaucousness. **Branches** erect to occasionally pendulous at the tips. **Leaves** both decurrent (whip) and scale. Whip-leaves growing only at branchlet tips (on mature trees). Scale-leaves not overlapping, or, if so, then not by more than 1/5 the length, obtuse to acute, margins entire at 20 X (and 40 X). **Seed cones** maturing in 2 yrs., globose to 2-lobed, appearing light blue when with heavy glaucous, but dark blue-black beneath glaucous (when mature). [Note: cones may appear tan beneath the glaucous when immature], 6-9 mm, borne on mostly straight peduncles. **Seeds** (1)2(3) per cone, 4-5 mm long. **Chromosome**

**number**  $2n = 22$  (Hall, Mukherjee and Crowley, 1973). **Pollen shed** March-April. **Habitat** rocky soils, and slopes, eroded hillsides, sea level (Vancouver Isl., Puget Sound), otherwise 1200-2700 m. **Uses** fence posts. **Dist.:** Canada: Alberta, B.C., USA: Ariz., Colo., Idaho, Mont., Neb., N.D., N. Mex., Nev., Ore., S.D., Tex., Utah, Wash., Wyo., N. Mexico (Fig. 21). **Status:** abundant and increasing, considered a weed in rangelands.

*Juniperus scopulorum* hybridizes with its eastern sibling species, *J. virginiana* in the zones of contact in the Missouri R. Basin (Comer, Adams and Van Haverbeke, 1982; Flake, Urbatsch and Turner, 1978; Van Haverbeke, 1968). Relictual hybridization with *J. virginiana* is present in Palo Duro Canyon in the Texas Panhandle (Adams, 1983). The species hybridizes with *J. horizontalis* (see *J. horizontalis*, above).



*Juniperus scopulorum* leaves and seed cones.

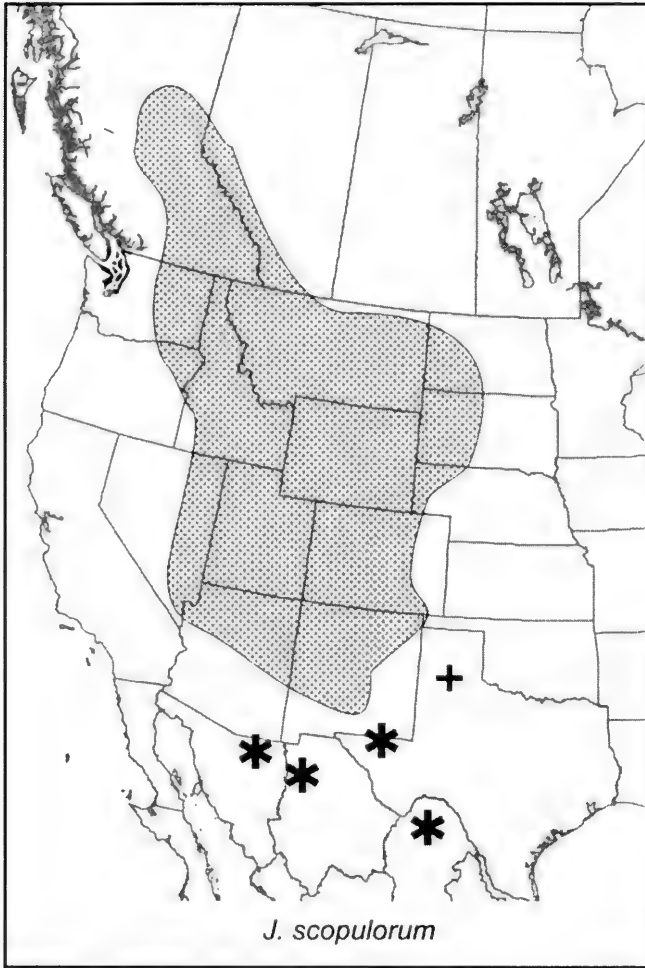


Figure 21. Distribution of *J. scopulorum*. The + symbol in Palo Duro Canyon of the Texas Panhandle denotes that the plants are intermediate between *J. scopulorum* and *J. virginiana* (see Adams, 1983).

***Juniperus virginiana* L., Sp. Pl. 2:1039 (1753).**

In the present treatment, two varieties are recognized. However, var. *virginiana* can be divided into pyramidal (var. *virginiana*) and strict (var. *crebra*) growth habits. Research is currently being conducted to determine if var. *crebra* merits recognition.

**Key to varieties:**

1. Seed cones 4-6 mm; crowns strict, pyramidal to round; bark reddish-brown; scale-leaves acute; pollen cones 3-4 mm; inland and in old fields .....var. ***virginiana***
1. Seed cones 3-4 mm; crowns flattened; bark cinnamon-reddish; scale-leaves bluntly obtuse to acute; pollen cones 4-5 mm; on sand on fore-dunes (coastal).....var. ***silicicola***

***Juniperus virginiana* var. *silicicola*** (Small) E. Murray, Kalmia 13: 8 (1983). Southern red cedar, coastal red cedar. Co-Type: USA, Alabama, Mobile, C. T. Moir, NYBG.

*Sabina silicicola* J. K. Small, N. Y. Bot. Gard. 24: 5 (1923)

*J. barbadensis* C. Mohr non Linnaeus

*J. silicicola* (J. K. Small) L.H. Bailey, Cult. Conif. N Amer. 18 (1933)

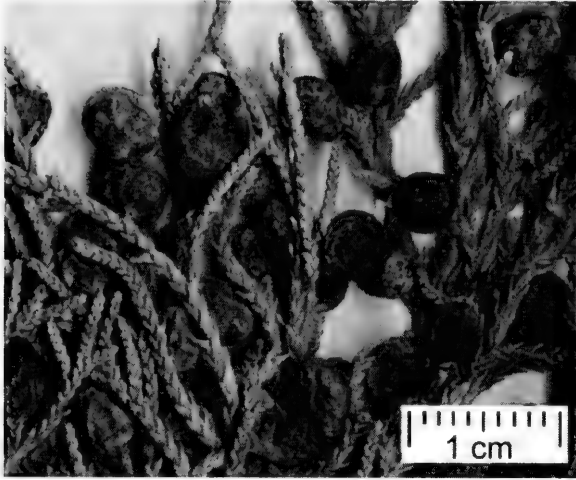
*J. virginiana* L. subsp. *silicicola* (Small) E. Murray, Kalmia 13: 8 (1983)

*J. virginiana* L. var. *silicicola* (Small) J. Silba, Phytologia Mem. 7: 37 (1984)

**Dioecious.** **Trees** small tree to 10 m, with a flattened crown, pyramidal when young and protected or crowded. **Trunk bark** cinnamon-reddish, exfoliating in narrow strips. **Branches** spreading to pendulous, ultimate twigs terete or 4-angled. **Leaves** both decurrent (whip) and scale. Scale-leaves bluntly obtuse to acute. Whip- and scale-leaf margins entire (20 X and 40 X). Pollen cones 4-5 mm. **Seed cones** maturing in 1 year, blue, glaucous, resinous, ovoid 4-5 mm in diam. **Seeds** tan to chestnut brown, 1.5-3 mm long. **Pollen shed** late winter - early spring. **Habitat** coastal fore-dunes, coastal river sand banks, sea level- 15 m. **Uses** none known. **Dist.:** along the coast from N.C., S.C., Ga., to western FL and AL (Fig. 22). **Status:** This southern variety of *J. virginiana* appears to be restricted to coastal fore-dunes and differs little in morphology or leaf terpenoids from the upland *J.*



*virginiana* (Adams, 1986). Both of these taxa are distinct from the Caribbean junipers (*J. barbadensis* var. *lucayana* Britt., Bahamas, Jamaica, Cuba; *J. bermudiana* L., Bermuda), see Adams, Zanoni and Hogge, 1984; Adams, 2008). There appears to be some intergradation of characters between *J. virginiana* and this variety in Georgia (Adams, 1986).



*Juniperus virginiana* var. *silicicola* leaves and seed cones.

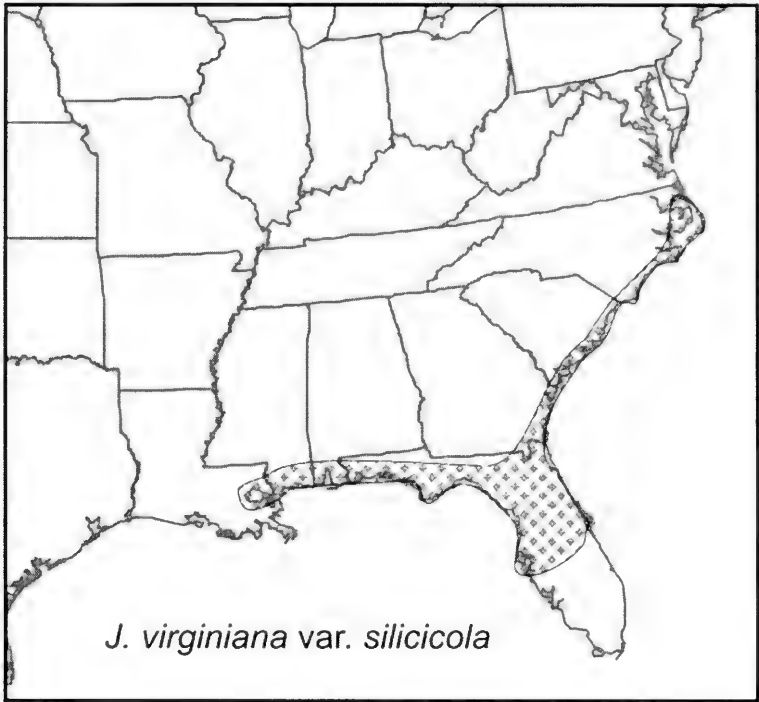


Figure 22. Distribution of *J. virginiana* var. *silicicola*.

- Juniperus virginiana* L. var. *virginiana*, Sp. Pl. 2:1039 (1753). Red cedar, Virginia cedar, eastern red cedar. Type: LINN!
- J. caroliniana* Mill., Gard. Dict., ed. 8: *Juniperus* No. 4 (1768)
- J. arborescens* Moench, Methodus: 699 (1794)
- J. caroliniana* Du Roi, Harbk. Baumz., ed 2, 1: 497 (1795)
- J. hermannii* Spreng., Syst. Veg. 3: 908 (1826)
- J. foetida* Spach var. *virginiana* (L.) Spach, Ann. Sci. Nat. Bot., ser. 2, 16: 298 (1841)
- J. virginiana* L. var. *vulgaris* Endl., Syn. Conif.: 28 (1847)
- Sabina virginiana* (L.) Antoine, Cupress.-Gatt.: 61 (1857)
- J. virginiana* L. var. *crebra* Fernald & Griscom, Rhodora 37: 133, t. 332 (1935)
- J. virginiana* L. var. *ambigens* Fassett; (=X *Ambigens*, *virginiana* x *horizontalis*) Bull. Torrey Bot. Club 72: 380 (1945)
- J. virginiana* L. subsp. *crebra* (Fernald & Griscom) E. Murray, Kalmia 12 :21 (1982)

**Dioecious.** Trees single stemmed to 30 m, pyramidal to strict. **Trunk bark** brown, exfoliating in thin strips. **Branches** foliage erect or occasionally lax, green but turning reddish-brown in the winter, twigs (3-5 mm diam.) with persistent dead scale leaves, bark on twigs (6-15 mm diam.) not exfoliating in plates, if so brownish beneath. **Leaves** both decurrent (whip) and scale. Whip-leaves growing only at branchlet tips (on mature trees), with an elliptical or elongated gland. Scale leaves overlapping (more than ¼ length). Scale-leaf margins entire (20 X and 40 X). **Seed cones** blue-black to blue brownish, maturing in 1 year, borne terminally, 3-6(7) mm in diam., 1-2(3) seeded. **Seeds** tan to brown, 2-4 mm long. **Chromosome number**  $2n = 22$ ,  $3n = 33$  (Hall, Mukherjee and Crowley, 1979). **Pollen shed** March-April. **Habitat** upland or low woods, old fields, glades, fence rows and river swamps, near sea level to 1400 m. **Uses** production of eastern red cedar wood oil, furniture, fence posts, widely cultivated for landscaping. **Dist.:** Canada: Ont., Que.; United States (Fig. 23): all states except: Alaska, Ariz., Calif., Colo., Idaho, Mont., Nev., N. Mex., Ore., Utah, Wash., Wyo. **Status:** Perhaps the most aggressive, weedy juniper in the world. It is spread by birds and invades abandoned fields and roadsides in the eastern United States from the Atlantic ocean to the Edwards Plateau in central Texas and into the central Great Plains.

*Juniperus virginiana* hybridizes with the sibling species, *J. horizontalis* (see *J. horizontalis*, above) and *J. scopulorum* (see *J. scopulorum*, above). Earlier reports of hybridization between *J. ashei* and *J. virginiana* (Hall, 1952) were negated in subsequent studies (Adams, 1977; Flake, von Rudloff and Turner, 1969).

Eastern Red Cedar is an aggressive, weedy species. *Juniperus v. virginiana* (and most junipers) are disseminated by birds and a typical pattern in the USA is the 'fence row junipers' where birds have dropped the seeds while sitting on the fence wire. It also invades disturbed sites as well as old fields. *Juniperus v. virginiana* is the most weedy juniper known in that it can invade tall (0.5 m tall) grass. The control of *Juniperus* is a major problem in the United States. Interestingly, the junipers of the eastern hemisphere are seldom weeds. Of course, much of the juniper habitat in the eastern hemisphere has been grazed by goats for centuries, whereas goat grazing is a relatively modern phenomenon in the western hemisphere and little practiced in the United States.



*Juniperus virginiana* var. *virginiana* leaves and seed cones.

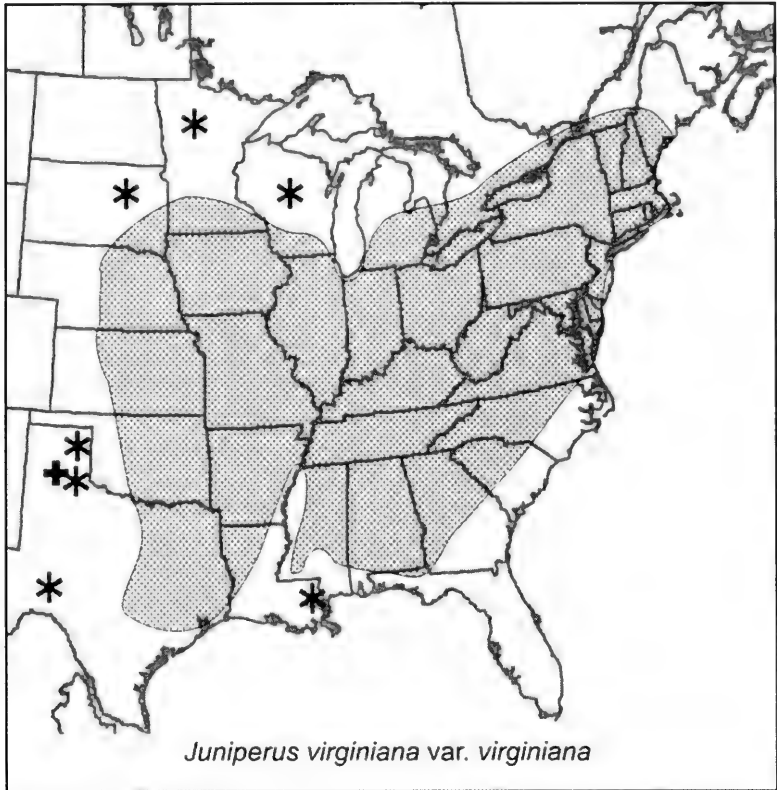


Figure 23. Distribution of *J. virginiana* var. *virginiana*. The + symbol at Palo Duro Canyon, Texas Panhandle denotes plants that are intermediate to *J. scopulorum* (see Adams, 1983).

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## TYPIFICATION OF *SALIX CORDIFOLIA* (SALICACEAE)

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### ABSTRACT

*Salix cordifolia* Pursh was mostly considered a valid species into the 1950's. No type was cited by Pursh nor preserved. In 1965 it was subordinated as a "phase" of *Salix glauca* L. The taxon is here typified and the correct varietal name is proposed. *Phytologia* 90(3): 315-317 (December, 2008).

**KEY WORDS:** *Salix cordifolia*, Salicaceae, typification

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*Salix cordifolia* was described by Frederick Pursh (1814) from a Labrador plant grown in the garden of George Anderson in England. No type was designated. A specimen in the Hooker Herbarium at K reputedly from Anderson's garden was thought to be from this plant, but a comment by Hooker (1838) suggests otherwise. He noted that, "The plant thus named for me by Mr Borrer, who is probably acquainted with the original plant cultivated by Mr Anderson, little deserves the appellation of *cordifolia*, its leaves being more frequently acute than retuse at the base." Pursh described the leaves as "basi cordatis." William Borrer "evidently tried to cultivate ... all the hardy exotic plants he could obtain" (Seaward 2002). This specimen could not be located at K. There is a crude tracing of it at GH and it shows a plant with non-cordate leaves and catkins. The label reads in part, "*S. cordifolia* Pursh" with "Garden: from G. Anderson" beneath, and "Borrer" beneath that. A possible duplicate of this collection is from the Schweinitz Herbarium at PH, but the leaves are narrower and younger than on the K specimen. Since both specimens have catkins, and Pursh did not see catkins, neither can be an original type.

Schneider (1918) gave a detailed discussion of the treatment of this taxon. He considered it a valid species and it was considered as such into the 1950's (Fernald 1950, Ball 1952). Argus (1965) did a

detailed study of this group in North America and subordinated *S. cordifolia* to a "phase" under *S. glauca* L. More recently he used the names *S. glauca* ssp. *callicarpaea* (Trautv.) Böcher or *S. glauca* var. *callicarpaea* (Trautv.) Argus for this taxon (Argus 1997). The former name was used correctly but the latter name was not.

Before providing the correct varietal name, the taxon should be typified. Fernald (1926) cited several collections that matched Pursh's original description. One of these can serve as a neotype.

*Salix cordifolia* Pursh, Fl. Amer. Sept. 611. 1814 [1813].

**Neotype here designated:** Canada, Newfoundland, Ingornachoix Bay, Dry rocky limestone barrens, near sea-level, August 1, 1910, *Fernald & Wiegand 3219* (GH!).

*Salix cordifolia* Pursh var. *macounii* (Rydb.) Schneid., Bot. Gaz. 66: 347. 1918. Established var. *cordifolia* autonym.

*Salix glauca* L. var. **cordifolia** (Pursh) Dorn, **stat. & comb. nov.**

Based on *Salix cordifolia* Pursh, Fl. Amer. Sept. 611. 1814 [1813].

#### ACKNOWLEDGEMENTS

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**KEYS TO THE FLORA OF FLORIDA - 20,  
NYSSA (NYSSACEAE)**

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**ABSTRACT**

*Nyssa* (Nyssaceae) is represented in Florida by four native species: *N. aquatica*, *N. biflora*, *N. ogeche* and *N. sylvatica*. *Nyssa biflora*, in turn, is represented by var. *biflora* and var. *ursina*. Var. *ursina* is endemic to Florida. The reported southern limit of *N. sylvatica* is corrected. The nomenclatural justification is given for use of *Nyssa aquatica* rather than *N. uniflora*. An amplified key is given to the Florida taxa. *Phytologia* 90(3): 318-323 (December, 2008).

**KEY WORDS:** *Nyssa*, Nyssaceae, Florida flora.

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The genus *Nyssa* (Nyssaceae) is more fully represented in Florida than in any other area of North America. The morphology, ecology, and distribution of its few species, as well as their nomenclature, has received thoughtful, scholarly examination (R. H. Eyde, *Rhodora* 61: 209-218. 1959, a delightful discourse on the discovery and naming of the genus; E. West & L. E. Arnold, *Native Trees of Florida*. 1956; R. K. Godfrey & J. W. Wooten, *Aquatic and Wetland Plants*, vol. 2. 1981; R. K. Godfrey, *Trees, Shrubs, and Woody Vines*. 1988; R. E. Burckhalter, *Sida* 15: 323-342. 1992, a well-done revision). Even so, details overlooked or perhaps misunderstood by previous workers merit further comment.

It is useful where matters of taxonomic rank and nomenclature are to be discussed and where common names are stable, to establish a vernacular baseline: *Nyssa aquatica* L. is here called the Water Tupelo, *N. ogeche* Bartr. ex Marsh. the Ogeechee Lime, *N. sylvatica* Marsh. the Black Tupelo or Black Gum, and *N. biflora* Walt. the Swamp Tupelo with its endemic variety, the Dwarf Tupelo or Bear Gum.

The Black Tupelo, *Nyssa sylvatica*, has been treated as a species with one or two varieties (Godfrey, 1988; Wunderlin & Hansen, 2003), or as one of a complex of three distinct species (Clewell, 1985; Burckhalter, 1992). The closely related *N. biflora*, with basally enlarged trunks, is amply distinct when seen in its swamp habitat; but when trees with slender trunks are encountered in poorly drained but seasonally dry flatwoods, they often are identified as *N. sylvatica*. Conversely, trees of *N. sylvatica* on temporarily wet soil are sometimes called *N. biflora*. Confounding this distinction, trees of *N. sylvatica* in northern states occur both on well-drained upland soils and in low White Cedar (*Chamaecyparis thyoides*) swamps, a status never seen in Florida. Habitat thus gains an improper level of importance, overshadowing the obvious differences in leaf shape and flower/fruit numbers. Misidentifications abound.

These misidentifications have led to quite large errors in the range assigned to *Nyssa sylvatica*. E. L. Little (Atlas of United States Trees, map 144-E. 1971), a study largely compiled from herbarium records, extended the range to northern Collier County, in the southwestern peninsula. Burckhalter (1992) and Wunderlin & Hansen (2003), with greater caution, accepted a range to Manatee County, just south of Tampa Bay. In the present report, after years of field observation, no specimen of *N. sylvatica* has been verified south of Alachua County, in the north-central peninsula. All others are *Nyssa biflora*.

Other *Nyssa* in Florida also require range corrections. *Nyssa biflora* has been reported from Lignum Vitae Keys, far disjunct from its southern terminus in the central peninsula; the plant was identified correctly, but its apparent source was the central panhandle (Ward & F. C. Craighead, Sida 14: 287-304. 1990). A disjunct population of *Nyssa ogeche* in Hillsborough County (Burckhalter, 1992: 336) appears to be derived from introduced plants (Wunderlin & Hansen, 2003: 400).

Specific status for both *Nyssa sylvatica* and *N. biflora*, as employed here, is based on: mesic habitat (hydric northward, but not in Florida) vs. hydric; leaves broadly obovate with few irregular teeth

toward tip vs. leaves medium obovate with even margins; petiole and lower midrib usually bearing a few long, spreading hairs vs. petiole glabrous or with short appressed hairs. The character of petiole pubescence is distinctive when present (lost late in season) and seems not to have been noted previously.

Botanists consistently acknowledge the Black Tupelo, *Nyssa sylvatica*, to differ from the Swamp Tupelo, *N. biflora*, though sometimes only at varietal level. But the Dwarf Tupelo, *N. ursina*, has met with diverse views, either dismissed as an environmentally induced variant of *N. biflora* (Godfrey, 1988; Wunderlin & Hansen, 2003), or accepted at full specific rank (Clewell, 1985; Burckhalter, 1992). Godfrey, whose field familiarity with these plants was unequalled, was adamant (pers. comm., Dec 1989) that the stocky shrubs of the Apalachicola delta were fire-induced *N. biflora*. Burckhalter (1992), however, excellently pointed out their differences, agreeing with Small's original specific rank. The similarity of range of the Dwarf Tupelo to an array of wetland panhandle endemics suggests a genetic component. With Solomonian wisdom, Ward (Novon 11: 362. 2001) split the difference, giving it varietal status.

The name *Nyssa aquatica* has received attention from several skilled nomenclaturalists. Observant reviewers of northern floras will have noted that the Water Tupelo is consistently called *N. aquatica* L. in publications originating with, or influenced by, the Gray Herbarium, Harvard, while workers at the New York Botanical Garden since about 1945 have invariably used *N. uniflora* Wengen.

H. W. Rickett (N. Amer. Flora 28B: 313-316. 1945) pointed out, correctly, that a majority of Linnaeus' references under his *Nyssa aquatica* are to the Black Tupelo. Examination of Linnaeus' specimens (LINN microfiche) shows them also to be Black Tupelo, the present *N. sylvatica*. R. H. Eyde (Taxon 13: 129-132. 1964) discussed the "Typification of *Nyssa aquatica* L.," offering interpretations that would support (1) replacement of *N. sylvatica* by *N. aquatica*, (2) rejection of *N. aquatica* as a confused name, or (3) typification of *N. aquatica* by the one Linnaean reference that represents the Water Tupelo.

Interpretation (1) is supported by the evidence but is disruptive of the names of both the Water Tupelo and the Black Tupelo. Interpretation (2) is scarcely tenable since the confusion lies in the writings of early authors, not in Linnaeus' specimens. Interpretation (3), preferred by Eyde (pers. comm., Oct 1989), is contradicted by Linnaeus' specimens which Eyde did not address. Eyde thus came to no useful conclusion.

Neither Rickett (1945) nor Eyde (1964) called attention to a collateral consequence of employing *Nyssa aquatica* for the Black Tupelo. A second domino would also fall; the Water Tupelo, if *N. aquatica* were used elsewhere, would become *N. uniflora*.

In re-examination of this issue, J. L. Reveal (Phytologia 71:468-471. 1991) reviewed the references cited by Linnaeus. He then lectotypified *Nyssa aquatica* (as Eyde had failed to do) by a Clayton spm. (BM) of Water Tupelo that Linnaeus did not mention but perhaps had seen. Almost as an afterthought Reveal observed (as Eyde had not) that prior to 1753 Linnaeus also saw (and annotated as "*aquatica*") a Pehr Kalm spm. (1232.1, LINN) of the Black Tupelo, or *N. sylvatica*. This spm., as part of Linnaeus' own herbarium, clearly is an unequivocal basis for Linnaeus' new species, and it is unfortunate that authors in years past had not recognized its significance. Reveal did not well lay out his nomenclatural justification for designating the Clayton spm.; indeed, he obscured his strategy by providing detailed but unnecessary and distracting literature references. However, assuming his intent was to preserve *N. aquatica* and *N. sylvatica* in their customary usages, his procedure was sound. The Kalm spm. (LINN) is certainly part of the "original material" (I.C.B.N., Art. 9, Note 2) from which a lectotype must be designated. But the Clayton spm. (BM) may also be argued to be part of Linnaeus' "original material" and thus also available for lectotype designation; though very possibly never seen by Linnaeus, it was once owned by Gronovius, whose work (*Flora Virginica*, 1739) had been cited by Linnaeus. Reveal is to be chided for a devious (and perhaps dubious) interpretation of the Code, and to be commended for employing a stratagem that can preserve the familiar scientific names of the Water Tupelo and the Black Tupelo.

NYSSA L.      Tupelos<sup>1</sup>

1. Petioles mostly 3-6 cm. long; leaf blades ovate, acuminate-tipped, with margin entire or few- and shallowly-toothed; pistillate flowers solitary; fruits 1.5-3.0 cm. long, purple at maturity, on 2-3 cm. peduncles. Tree, to 30 m. Floodplain forests, swamps. Panhandle and northwest peninsula (s. to Levy County); infrequent. Spring. [*Nyssa uniflora* Wangenh.]  
 WATER TUPELO. **Nyssa aquatica** L.

1. Petioles less than 2.5 cm. long.
2. Lower leaf surface grayish green, densely soft-pubescent; pistillate flowers solitary; fruits 2.0-3.5 cm. long, bright red (fading to dull orange) at maturity, on 0.5-1.0 cm. peduncles. Tree, to 30 m. River banks, bottomland woodlands. Panhandle and north Florida (s. to Dixie, Alachua counties); infrequent. Spring.  
 OGEECHEE LIME, OGEECHEE TUPELO.

**Nyssa ogeche** Bartr. ex Marsh.

2. Lower leaf surface light green, glabrous to smooth-pubescent; pistillate flowers usually 2 or more; fruits  $\pm$ 1.0 cm. long, blue-black at maturity, on 1-3 cm. peduncles.
3. Leaves 8-15 cm. long, blades broadly obovate, some with a few coarse shallow teeth toward apex, petioles usually with a few long (1.0-1.5 mm.) spreading hairs; fruits borne in clusters of 4-5. Tree, to 20 m. Upland well-drained woodlands. Panhandle and north Florida (s. to Alachua County); infrequent. Spring.  
 BLACK TUPELO, BLACK GUM.

**Nyssa sylvatica** Marsh.

3. Leaves 3-12 cm. long, blades elliptic to narrowly obovate, always entire, petioles glabrous or with short (0.2-0.5 mm.) appressed hairs; fruits borne singly or in pairs. Wetlands. Spring.  
 SWAMP TUPELO. **Nyssa biflora** Walt.



- a. Tree, to 35 m., single-trunked; leaves 5-12 cm. long. Swamps (with trunks much enlarged at base), low pinelands. Panhandle and peninsula, south to Lake Okeechobee (Glades County); common.  
SWAMP TUPELO (typical). var. **biflora**
- a. Shrub, to 5 m., much branched from base; leaves 3-6 cm. long. Marshes, low pinelands. Central coastal panhandle (Bay, Calhoun, Gulf, Liberty, Franklin, Wakulla counties); rare and local. Endemic. [*Nyssa ursina* Small] DWARF TUPELO, BEAR GUM.  
var. **ursina** (Small) D. B. Ward

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<sup>1</sup> This paper is a continuation of a series begun in 1977. The "amplified key" format employed here is designed to present in compact form the basic morphological framework of a conventional dichotomous key, as well as data on habitat, range, and frequency. Amplified keys are being prepared for all genera of the Florida vascular flora; the present series is restricted to genera where a new combination is required or a special situation merits extended discussion.

**“ANABAENA,” “ANABAINA,” AND CODES OF  
NOMENCLATURE: A REVIEW OF THE  
FEASIBILITY OF NAME CORRECTION, AND A POSSIBLE  
DIRECTION FOR THE FUTURE**

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**ABSTRACT**

Spanning the better part of two centuries, two spellings, “*Anabaena*” and “*Anabaina*,” have competed as the name of a well-known genus of filamentous “blue-green algae” (Cyanobacteria). The orthographic form “*Anabaena*” has been generally favored, but “*Anabaina*” has been defended as well. Although “*Anabaina*” was proposed first (Bory, 1822), “*Anabaena*” is indicated (botanical code, conservation) as the spelling employed in the starting-point publication of those Oscillatoriales with heterocysts (Bornet and Flahault, 1886)—an assemblage largely equivalent to the Nostocales, as presently recognized. Since, according to the botanical code, valid publication of a name can date only from the official nomenclatural starting-date of the group to which it belongs, it might be assumed that “*Anabaena*” is the spelling to be selected. However, it can be shown that “*Anabaena*” is in error and, also, is not a conserved spelling. The name should be returned to the original spelling, “*Anabaina*”—maintaining authorship, under present code structure, in accordance with the starting-point document, viz., *Anabaina* Bory ex Bornet & Flahault. If not acceptable under the botanical code, proposed changes of cyanobacterial names (such as *Anabaina*) could be effected if their nomenclature were transferred from the botanical code to the bacteriological code. However, the case of *Anabaina* invokes larger questions of nomenclatural governance of different kingdoms, putative kingdoms, or parts of kingdoms—Bacteria *pro parte* (i.e., Cyanobacteria), Protozoa *pro parte* (e.g., “Myxomycetes”), Oomycetes (and a number of other Stramenopiles), and Fungi—by the botanical code (an instrument obviously intended for naming members of the plant kingdom). In the long-run, problems of nomenclature involving such “code-misplaced

groups” could probably be resolved with greatest equanimity through development of a unified code for naming all organisms. *Phytologia* 90(3): 324-354 (December, 2008).

**KEY WORDS:** *Anabaena*, blue-green algae, Cyanobacteria, heterocysts, *International Code of Botanical Nomenclature*, *International Code of Nomenclature of Bacteria*, Nostocaceae, starting-point document.

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As may be surmised from systematically oriented botany textbooks (e.g., Brown, 1935; Pool, 1940; Smith, 1953; Cronquist, 1961; Raven et al., 1999; Nabors, 2004), *Anabaena* has long been a familiar name for a significant cyanophycean genus—a genus of perhaps 100 species (Van den Hoek et al., 1995; Komárek et al., 2003), although the exact number is uncertain in a group lacking typical sexual reproduction (compare Geitler, 1932; Desikachary, 1959; Drouet, 1978; Anand, 1980; Van den Hoek et al., 1995). *Anabaena*, considered now a member of the Nostocales (Van den Hoek et al., 1995; Graham and Wilcox, 2000), is distinguished from *Nostoc*: by retention of motility of trichomes in the “adult” stage (Kantz and Bold, 1969); by generally less contorted trichomes that do not occur in firm, macroscopic colonies (Prescott, 1962); and, by a sometimes differently patterned relationship of “vegetative cells,” akinetes, and heterocysts (cf. Wilcox et al., 1973; Bold and Wynne, 1985).<sup>1</sup> Also, *Anabaena* is not prone to form the bulbous, hormogonial packets (incipient colonies) characteristic of species of *Nostoc* (cf. Lazaroff, 1973; Komárek et al., 2003). *Anabaenopsis*, a genus similar to *Anabaena*, is distinguished by short filaments, with heterocysts on both ends of the trichome (Smith, 1950). The terminal heterocysts of *Anabaenopsis* arise from a pair of intercalary, incipient heterocysts (formed by asymmetric divisions of two adjacent vegetative cells); the heterocysts separate, leaving one at each end of the trichome (Smith, 1950; Komárek et al., 2003). Heterocysts of *Anabaena*, by contrast, are typically intercalary (Smith, 1950), sometimes specifically positioned along the trichome (Graham

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<sup>1</sup> The term “heterocytes” is preferred to “heterocysts” by some, since these cells are not strictly cysts—D. A. Casamatta, personal communication.

and Wilcox, 2000). The genus *Pseudanabaena* (see Desikachary, 1959; Anagnostidis and Komárek, 1988; Komárek et al., 2003), while resembling *Anabaena* and certain other nostocalean genera, lacks cell differentiation (heterocysts absent); relationships of *Pseudanabaena* to oscillatorialean (non-heterocystous) forms have been elucidated—cf. Graham and Wilcox, 2000, p. 104 (adapted from Wilmotte, 1994); and Casamatta et al. (2005).

*Anabaena* is frequently an important component of blue-green algal blooms in plankton of freshwater ponds and lakes (Round, 1965), especially during hot, dry conditions of late summer. These blooms may significantly affect trophic conditions, and even water toxicity (Paerl, 1988). Specifically, species of *Anabaena* are known to play a role in nitrogen and phosphorus metabolism in such bodies of water (cf. Moss, 1980; Fogg and Thake, 1987; Graham and Wilcox, 2000). Related to occurrence in phytoplankton, *Anabaena* species exhibit phototactic orientation (Barsanti and Gualtieri, 2006)—varying position in upper layers of water with the aid of gas vacuoles (cf. Bold and Wynne, 1985; Lee, 1999). Buoyancy and rate of photosynthesis may be adjusted to varying light quantity (Kromkamp, 1990; Lee, 1999; Graham and Wilcox, 2000). Although high light intensity can result in temporary photo-inhibition in *Anabaena* (Kromkamp, 1990), biosynthesis of superoxide dismutase may be induced—in *Anabaena* and various planktonic cyanophytes (some studied in marine environments)—scavenging photo-produced molecular oxygen, and enhancing light tolerance (Miyake and Asada, 2003).

In spite of the apparently satisfactory taxonomic and ecological knowledge and distinctiveness of *Anabaena*, and several other major cyanophytes, systematic and culture/habitat delimitation of a number of genera (and species) of heterocystous filamentous blue-green alga—i.e., the formal taxonomic framework in which the genus *Anabaena* resides—remains a matter of debate (cf. Geitler, 1932, 1942; Smith, 1950; Tiffany and Britton, 1952; Desikachary, 1959; Prescott, 1962; Bourrelly, 1970; Drouet, 1978; Rippka et al., 1979; Giovannoni et al., 1988; Komárek and Anagnostidis, 1989; Whitton, 2002; Komárek et al., 2003). This is not to say that progress in understanding the phylogeny of heterocystous groupings has not been made (see Rippka et al., 1979; Van den Hoek et al., 1995; Graham and Wilcox,

2000; Gugger and Hoffmann, 2004; Henson et al., 2004). However, the detailed systematics of cyanophyte genera is beyond the scope of the present paper, which focuses primarily on *Anabaena*.

To make a potentially lengthy introduction relatively short, and pertinent to the presentation here, there appears to be little question that *Anabaena* is a well-established name for a distinct, legitimate, large and important genus of the systematically and environmentally significant group, the Cyanophyta (Cyanobacteria or Cyanoprokaryotes). Furthermore, *Anabaena*, unlike some “algal” genera, has received considerable taxonomic attention (e.g., Fritsch, 1949; Anand, 1980; Stulp and Stam, 1985; Hiroki et al., 1998). Thus, there could surely be no real nomenclatural dispute here—at least regarding the propriety of the generic name, *Anabaena*—or, could there? As seen below, there is controversy indeed. As will also become evident, questions concerning *Anabaena* nomenclature call forth the larger issue of how problems involving the naming of entire “code-misplaced” groups, such as the “blue-green algae,” might ultimately be resolved.

### THE SPELLING OF “ANABAENA”: IT SHOULD BE “ANABAINA”

It may be surprising to some that Appendix III of the *International Code of Botanical Nomenclature* (ICBN, McNeill et al., 2006) lists *Anabaena* as a “conserved name.” In other words, it was deemed necessary to “save” the phycological name *Anabaena*—but, from what? Unlike the majority of the 11 conserved blue-green-algal generic names, *Anabaena* is not expressly protected against another algal name (homonymic or not). According to the *Code*, the cyanophycean name *Anabaena* (valid publication date noted as 1886) is conserved, specifically, against an earlier (1824), identically spelled name, *Anabaena* A. Jussieu, applying to an angiosperm genus. This earlier homonym (cf. Article 14.10, ICBN), referring to a Brazilian member of the Euphorbiaceae, is renamed *Romanoa* (cf. Mabberley, 1987). In the 19<sup>th</sup> century, *Trichormus* Allman was used for a time (Ralfs, 1850) as a replacement name for *Anabaena* (blue-green algae), in part because of potential confusion with the euphorbiaceous homonym. But, because of conservation, the seemingly entrenched

cyanophyte generic name, spelled "*Anabaena*," is in any case secure, is it not? Well, in spite of the apparent edict of the ICBN, perhaps not.

A majority of phycological authors seemingly considered "*Anabaena*" an assured name, and spelling, for this familiar genus of blue-green algae (e.g., Fritsch, 1945; Smith, 1950; Tiffany and Britton, 1952; Desikachary, 1959; Round, 1965; Morris, 1967; Chapman, 1968; Prescott, 1968; Bourrelly, 1970; Fogg et al., 1973; Pentecost, 1984; South and Whittick, 1987; Paerl, 1988; Trainor, 1988; Van den Hoek et al., 1995; Lee, 1999). However, Bold and Wynne (1985) and Graham and Wilcox (2000), while adopting the spelling "*Anabaena*," noted that the name is also sometimes spelled "*Anabaina*"—an "i" replacing the "e" in the name. Neither of these latter author-pairs, though, explained why one spelling is preferable to the other. A minority of authors employed "*Anabaina*" as the correct spelling of the name (Drouet, 1978; Humm and Wicks, 1980; Silva et al., 1987, 1996). Humm and Wicks (1980, p. 162), in fact, asserted (without explanation) that the spelling "*Anabaena*" is "an error," and "not available for conservation"—obviously, a rationale for selecting "*Anabaina*." So, who is correct? Is it "*Anabaena*" or "*Anabaina*," and what is the basis for deciding?

According to the botanical code, Bornet and Flahault are the validating authors of the name *Anabaena*, because certain groups of blue-green algae are among those "plants" with a later starting date for nomenclature than Linnaeus (1753). The starting point for filamentous cyanophytes with heterocysts, such as *Anabaena*, is taken as Jan. 1, 1886, a consensus date for publication of the four parts of Bornet and Flahault's "Révision des Nostocacées hétérocystées" (see Article 13, ICBN). Thus, valid publication of *Anabaena* is considered to date only from 1886. Yet, Bory (de Saint-Vincent) originated this generic name more than 60 years earlier in the *Dictionnaire* (1822); Bory, however, spelled the name "*Anabaina*." Consistent with Articles 46.6 and 46.7, the *Code* (Appendix III) cites authorship of *Anabaena* as, Bory ex Bornet & Flahault (1886). The *Code*, however, makes no mention of the initial spelling of the name by Bory, viz. *Anabaina*. Because of the starting point rule (Article 13), citation of authorship of *Anabaena* could simply be Bornet & Flahault (1886). But, since Bornet and

Flahault ascribed the name to Bory, it is appropriate to cite authority of *Anabaena* (regardless of spelling) as Bory ex Bornet & Flahault, 1886.

In reviewing various phylogenetic works, authorship for *Anabaena* and other “algal” genera is often omitted (e.g., Fritsch, 1945; Morris, 1967; Pentecost, 1984; Trainor, 1988; Van den Hoek et al., 1995; Dillard, 1999; Lee, 1999; Graham and Wilcox, 2000; Barsanti and Gualtieri, 2006). When writers bothered to provide name authority, *Anabaena* authorship is typically indicated merely as “Bory” or “Bory 1822” (cf. Smith, 1950; Tiffany and Britton, 1952; Desikachary, 1959; Prescott, 1962, 1968; Cocke, 1967; Bourrelly, 1985; Bold and Wynne, 1985). Drouet (1978) also cited “Bory” as the author of “*Anabaina*,” in this case utilizing Bory’s spelling of the name. Relatively few authors (e.g., Anand, 1980; Whitton, 2002; Komárek et al., 2003) mentioned the authority of Bornet and Flahault (1886), even though, by application of the later starting point rule (Article 13), Bornet and Flahault established validation of the generic name.

Problems of nomenclature of *Anabaena* run deeper still. *Anabaena oscillarioides*, the “type” of *Anabaena* (cf. Geitler, 1942), is traced to Bornet and Flahault (1886), who attributed the name to Bory. Bory did not employ the epithet “*oscillarioides*” in 1822, but apparently did in 1831 (see Drouet, 1978). Bory (1822) used the name *Anabaina pseudo-oscillatoria*. In further complication, Fries (1835) published a different spelling of *oscillarioides*, viz. “*oscillatorioides*.” Drouet (1978) noted the type of “*Anabaina*” as *A. pseudo-oscillatoria*, yet listed *A. pseudo-oscillatoria* as a synonym of *A. oscillarioides*. It would appear, thus, if *A. oscillarioides* were not the name used in the starting point document (Bornet and Flahault, 1886), that *A. pseudo-oscillatoria* would be the legitimate type instead. The nomenclature of *Anabaena* at both genus and species levels is caught into whether or not one accepts a designated starting point (ICBN, Article 13) for nostocalean naming.

To return to the main point—authorship and spelling of the generic name *Anabaena*—the crux of the problem is this: When Bornet and Flahault attributed *Anabaena* to Bory, they did not employ Bory’s spelling, *Anabaina*. The question becomes, should the spelling in the starting point document (Bornet and Flahault, 1886)—allegedly “*Anabaena*,” i.e., as adopted by the botanical code—be retained? Or,

should a change be made to Bory's original spelling, *Anabaina*, since Bory provided a description of the genus (cf. Articles 32 and 41.2), and since he is usually given credit for this name in any case. One might assume that the ICBN is the ultimate arbiter in such matters, and that this genus should continue to be referenced by the more familiar name, "*Anabaena*." However, this indeed may not be the correct answer.

It is plausible to debate both sides of this spelling issue. A minor spelling glitch does not obviate Bornet and Flahault's validation of *Anabaena* or, necessarily, acceptance of their spelling of the name (cf. Article 60.2, ICBN). Furthermore, if one wishes to change a spelling, such as *Anabaena*, there are caveats: Article 60.1 states that "the original spelling of a name or epithet is to be retained, except for the correction of typographical or orthographical errors...." Article 60.3 cautions that "the liberty of correcting a name is to be used with reserve...." In other words, altering the spelling of an established name is not something done casually. A potential change of spelling of *Anabaena*, or any other putatively valid name, hinges ultimately on whether it can be shown that the validating authors made what may be construed as an actual mistake (as interpreted from Articles 60 and 61). In the usual situation, perhaps, one cannot conclusively demonstrate an error, especially since generic names may be composed essentially from any source (Article 20.1). However, in the case of *Anabaena*, inaccuracy can be demonstrated, a conclusion apparently also reached by Humm and Wicks (1980). In fact, there are two embedded mistakes—explained below.

Bornet and Flahault (1886)—who attributed *Anabaena* to Bory (1822)—were assuming no credit for authorship of this genus. In using Bory's generic name, Bornet and Flahault should have used Bory's spelling "*Anabaina*"—but they did not (using *Anabaena*, instead). However, they made no reference to any problem with the name as Bory spelled it. Bory's name, *Anabaina*, is based on two Greek roots: "*ano-*" meaning "upward," and "*baino-*" meaning to "pass" or "go" (Brown, 1956). Graham and Wilcox (2000) offered a reasonable approximation of the meaning of "*anabaina*," as "to rise"—fitting for a planktonic organism. It is certainly a more noble etymological derivation than that of the genus name, *Nostoc*, meaning, loosely, "snot," or else something the equivalent of the part of the anatomy from



which such emanates, i.e., “nostril” (Potts, 1997). In any event, there is no problem with the Greek origin of the two parts of the name *Anabaina*—such (dual Greek origin) is common in botanical nomenclature (Stearn, 1983)—and, the name is appropriately latinized (i.e., the ending and connecting vowel). Bornet and Flahault nonetheless changed the spelling in a limited, but crucially different, way. The first person to alter the spelling, however, was Fries (1835), who indeed used the spelling “*Anabaena*.” But, there is no evidence that Fries’ orthographical variant (cf. Article 61) influenced Bornet and Flahault. And, there is a small but significant difference in Bornet and Flahault’s spelling, versus that of Fries.

Bornet and Flahault not only spelled the name *Anabaena*—erroneously substituting “e” for “i” in Bory’s name (*Anabaina*)—they employed a ligature (second mistake), in which the “a” and “e” are abutted, viz. “æ” (in “*Anabæna*”). It is plausible that Bornet and Flahault used this ligature (æ) to suggest that the two vowels (originally “a” with “i”) be pronounced together—that is, as a single vowel sound (in effect, a transformed, classical Latin diphthong). Whether this was intended to simulate the sound of /e/, /i/, or /a/ is difficult to say with certainty (cf. Brown, 1956; Hendricks, 1962; Stearn, 1983). In any case, utilization of ligature amounts to further orthographic mutation. The *Code* indicates (Article 60.6) that ligatures of “ae” and “oe”—viz. æ, œ—are not permissible. Thus, if Bornet and Flahault’s name, “*Anabæna*,” is adopted, a correction is in order, and there are two possibilities: Usually, as understood from Article 60.6 (ICBN), the ligature would simply be unhinged—“æ” becomes “ae.” However, the situation with *Anabaena* is special, in that Bornet and Flahault (1886) were attempting to base their spelling on a previous, accepted name. Since this previous name (*Anabaina* Bory, 1822) was spelled with a separated “a” and “i”—which Bornet and Flahault were probably trying to unitize (phonetically) with a ligature—it is a more reasonable adjustment just to return *Anabaena* to the original, intended spelling of the name, “*Anabaina*.”

The argument that the spelling of *Anabaena* cannot be changed because it is a *nomen conservandum* in the botanical code (ICBN, 2006) is moot, for two related reasons: In the first place, *Anabaena* (Cyanophyceae) is conserved, in effect, only against

*Anabaena* (Euphorbiaceae), cf. Appendix III—not, specifically, against other generic names (including “algal” names). One cannot cogently argue, in this case, that *Anabaena* is automatically conserved against another particular generic name based on the same type (viz. *Anabaina*) since, as discussed above, *Anabaena* is simply a misspelling of *Anabaina*; in other words, these represent the *same* name (Note 1, Article 14.4). Secondly, whereas *Anabaena* Bornet & Flahault is a *nomen conservandum*, it is not among names that are *orthographia conservanda* (cf. Art. 14.11 and App. III, pp. 158, 172). This latter point is especially telling. If the spelling can be shown to be in error (see above), *Anabaena* (Cyanophyceae) is no more protected from correction than a non-conserved name. The technically correct spelling for this well-known nostocaceous genus should be *Anabaina*, and there is no “legal” reason not to make this change. Whereas the name originated with Bory (1822), the *Code* is nonetheless correct, in that, if one accepts the later starting point rule, authorship should be Bory ex Bornet & Flahault (1886). But even this could become subject to debate, as discussed in the next section.

One point more, before concluding this first section: If it is the case that *Anabaena* is returned to the proper spelling, *Anabaina*, an interesting possibility is raised as a consequence—this being, that conservation against the earlier homonym, *Anabaena* (Euphorbiaceae), may no longer be necessary since, due to the one-letter change of spelling, the cyanophyte name would no longer be (precisely) a later homonym. This could be interpreted as essentially “freeing up” *Anabaena* A. Jussieu (Euphorbiaceae) in nomenclatural competition against the *nomen novum*, *Romanoa*, which has seemingly replaced it. It will, however, be for others to decide if Bory’s original spelling, *Anabaina* (Cyanophyceae), and *Anabaena* Jussieu (Euphorbiaceae) are still to be viewed as homonyms. The ICBN is unclear on such a question. Compare, for example, the somewhat different messages of Article sections 53.1 and 53.3. The botanical code should be clarified as to whether spellings must be identical, or merely very similar, for names to qualify as homonyms.

## IS IT A QUESTION, EVENTUALLY, OF EITHER SWITCHING CODES OR CODE CHANGE?

Nomenclature of Cyanobacteria (= Cyanophyta = blue-green algae)—including “*Anabaena*”—is controlled by the *International Code of Botanical Nomenclature*. “Justification” for this control is found in item 7 of the Preamble of the ICBN (McNeill et al., 2006) which states that the rules and recommendations of this code apply to “all organisms traditionally treated as plants....” Indeed, there is historical precedent, in that the Cyanophyceae (Myxophyceae) were placed in the plant kingdom in older textbooks of botany (e.g., Brown, 1935; Pool, 1940; Smith et al., 1953). Appreciation of blue-green algae as prokaryotic organisms (viz., bacteria) accrued during the 1960s and early 1970s (see review by Stanier, 1977). The various editions of the botanical code since the mid-1970s are outmoded in continuing to recognize Cyanobacteria as “algae”—not because they do not fit within the polyphyletic, ecological form/function grouping, “algae” (cf. Blackwell and Powell, 1995; Graham and Wilcox, 2000), i.e., within an assemblage of primary producers with relatively simple, often similar, thallus structure (cf. Guttman, 1999)—but because of the implication that, as “algae,” they are treated, de facto, as “plants.” Even green algae (among algae, most closely related to plants) are often no longer included in the plant kingdom *sensu stricto* (cf. Graham and Wilcox, 2000), although certain kinds of green algae, i.e., Charophytes, are clearly in the lineage leading to “higher” plants (Embryophytes), cf. Niklas (1997), Graham and Wilcox (2000), Blackwell (2003). In any event, nomenclaturally, the Cyanobacteria (dealt with, operationally, as “plants” by the botanical code) are a “code-misplaced group”—along with other groups such as Oomycetes, Fungi, and slime molds (and certain other protists)—meaning, that improved knowledge of the biology of these organisms indicates that they should no longer be placed in the plant kingdom (see, for example, Purves et al., 1998; Guttman, 1999). Therefore, one would think, their nomenclature should no longer be governed by the botanical code (cf. Blackwell and Powell, 1999). Nonetheless, the ICBN (McNeill et al., 2006) continues to oversee the naming of these organisms, given the concession in Article 45.4 allowing recognition of names validated under a “pertinent non-botanical code....” In regard to this latter point, some (Friedmann and Borowitzka, 1982; Hoffmann, 2005) suggested the possibility of a

converse recognition of names by the bacteriological code, published in accordance with the botanical code.

As might be surmised from the previous section, some might conclude (contrary to the conclusion I reached) that the name "*Anabaena*" cannot be changed (to "*Anabaina*"), since it is conserved in the botanical code, and seemingly further bound in perpetuity by the starting-point document for heterocystous blue-green algae. If the botanical code is viewed as intractable in permitting such a name change, yet the change is desirable, what options are available? At the moment, there are none perhaps; however, there are eventual possibilities (discussed subsequently) by which such name problems could be resolved—perhaps efficacious in achieving lasting solutions. Since this present paper deals specifically with the naming of blue-green algae, I will limit focus mainly to this group. Informed nomenclatural decision-making ultimately requires proper understanding of the biology of the organisms in question. Our biological understanding of blue-green algae has been greatly enhanced in recent decades. Not only are blue-greens, cytologically, bacteria, they comprise a significant group of true bacteria, viz. the Cyanobacteria (cf. Stanier and Cohen-Bazire, 1977; Olsen et al., 1994; Blackwell & Powell, 1995; Snyder and Champness, 2003). They are distinct among Eubacteria by virtue of their chlorophyll-*a*-associated, oxygenic photosynthesis (cf. Margulis and Schwartz, 1988). As is well known currently, from introductory (and even popular) biological literature, the cells of Cyanobacteria are definitively prokaryotic (Sagan and Margulis, 1988; Purves et al., 1998; Byrd & Powledge, 2006; Cain et al., 2007)—as are other bacteria—not eukaryotic as cells of plants and animals (which contain distinct, membrane-bounded organelles). Beyond the fact that cyanophytes are bacteria, the phylogeny of blue-greens and relationships to other prokaryotes are increasingly well understood (cf. Campbell & Reece, 2005). Blue-greens "constitute a phylogenetically coherent grouping within...Eubacteria" (Van den Hoek et al., 1995, p. 39); see also Graham and Wilcox (2000, p. 103), adapted from Olsen et al. (1994); and Ayala (2007, p. 81), adapted from Woese (2000). Furthermore, Cyanobacteria are considered to be included within the gram-negative assemblage of Eubacteria, i.e., the Gracilicutes (cf. Margulis, 1993; Barnes et al., 1998). In short, the general relationships of Cyanobacteria are no longer in doubt.

Knowledge of phylogenetic relationships within Cyanobacteria is also being clarified, particularly among filamentous forms—e.g., Van den Hoek et al. (1995); Graham and Wilcox (2000, p. 104), adapted from Wilmotte (1994); Gugger and Hoffmann (2004); Henson et al. (2004); and Casamatta et al. (2005).

If blue-green algae are not plants, and they are bacteria, why do they remain under the aegis of the botanical code? Logically, some (e.g., Stanier et al., 1978) have argued that nomenclature of blue-green algae (Cyanobacteria) should be transferred from the *International Code of Botanical Nomenclature* (ICBN) to the *International Code of Nomenclature of Bacteria* (ICNB). Stanier (1977, p. 79) based this proposal on the premise that “the largest evolutionary discontinuity among contemporary organisms lies at the cellular level,” distinguishing “eukaryotes and prokaryotes.” According to Stanier et al. (1978), this major distinction, of prokaryotes (including Cyanobacteria) from eukaryotes, should be observed by codes of nomenclature, as it is in biology textbooks. Gibbons and Murray (1978b) suggested formalizing the name, *Cyanobacteriales* Stanier in Gibbons and Murray (1978a), under the bacteriological (i.e., prokaryotic) code. Other workers (e.g., Lewin, 1976, 1979), however, have favored maintaining the status quo—retention of control of blue-green “algal” nomenclature by the botanical code—because of potential nomenclatural confusion, and possible development of dual nomenclatures (undue proliferation of synonymy), if governance of naming of blue-greens is shifted to the bacteriological code. I note, in passing, that some workers have, to an extent, seemed to downplay the over-riding importance of the prokaryote/eukaryote dichotomy (e.g., Woese, 1981; Woese et al., 1990; Olsen et al., 1994; Woese, 2000)—this in relation to the increasing importance assigned to molecular/biochemical differences between Archaea (= Archaeobacteria) and Bacteria (= Eubacteria). I do not underestimate the importance of the three-domains viewpoint (Archaea, Bacteria, Eucarya) espoused by Woese et al. (1990). The concept of three domains is now well-known, and accepted in a number of modern biology textbooks (e.g., Campbell and Reece, 2005; Johnson, 2006). However, this construct does not, in my view, transcend the significance that both “bacterial” groups (Archaea and Bacteria) are structurally prokaryotic—vastly different in cell complexity vs. eukaryotes—and that both are nomenclaturally covered,

without distinction, by the bacteriological code—It would seem foolish to suggest that there should be separate codes for naming Archaeobacteria and Eubacteria, when they can scarcely be told apart, except by biochemical means. In biological terms, Cavalier-Smith (1987) suggested that sequence homology between these two prokaryotic groups may be greater than initially supposed, a statement basically re-enforced by Carroll (2006). Brinkmann and Philippe (1999, p. 817) indicated at least a limited support for “the monophyly of prokaryotes” (i.e., a sister-group relationship of Archaea and Bacteria). See also Margulis and Schwartz (1988) and Blackwell and Powell (1995) for an interpretation differing from Woese et al. (1990).

I return to the main point of this section, the nomenclatural placement of the cyanobacterial grouping of Eubacteria, i.e., the blue-green bacteria. Whitton (2003, p. 25) stated that “the blue-greens are anomalous in that they are currently treated by some authors under the conventions of the International Code of Botanical Nomenclature, while others treat them under the International Code of Bacteriological Nomenclature.” Whereas it is true that in recent times a limited number species of Cyanobacteria have been named under the bacteriological code (mentioned in Oren, 2004)—or the “code of nomenclature of prokaryotes,” as some prefer to call it (cf. Oren and Tindall, 2005)—formal governance of Cyanobacteria (though not other bacteria) remains, stately, with the botanical code (ICBN, 2006, page 2: statement 7 and footnote 2). The overwhelming majority of Cyanobacteria have been validly published using the botanical code, and some cyanobacterial taxa continue to be named under this code, e.g., Řeháková et al. (2007). Names among Cyanobacteria suggesting bacterial affinity—e.g. *Gloeobacter* (Rippka et al., 1974), a form lacking thylakoids—are historically most uncommon (Gibbons and Murray, 1978b). Contributing to this scarcity, no doubt, is the fact that the bacteriological code contains no explicit statement of inclusion of Cyanobacteria—only brief mention in the Preface (Lapage et al., 1992) of consideration given to the matter at the Congress for Microbiology in 1978. Nonetheless, discussions on further integrating the naming of Cyanobacteria into the bacteriological code, or facilitating cyanobacterial nomenclature, jointly, under the botanical and the bacteriological codes, have recently been put forward by cyanobacterial systematists (Oren, 2004; Oren and Tindall, 2005; Hoffmann, 2005).

Hoffmann (2005) outlined recommendations for unifying the nomenclature of Cyanophyta/Cyanobacteria (under the ICBN and the ICNB), including, allowance of greater flexibility of the type method under the bacteriological code. Needed presently, in seeking further resolution, is to inveigle both bacterial and botanical systematists to become more involved (perhaps in consort) with these ideas and suggestions for future code-governance of Cyanobacteria. In part, the point of my present paper (written from the viewpoint of involvement with botanical nomenclature) is to address such concepts. I agree that cyanobacterial nomenclature should be phased more effectively into the bacteriological naming system or, at least, into a system of naming that all systematists (including microbiologists) can possibly agree upon.

Arguments based on presumed nomenclatural disruption (Lewin, 1976, 1979)—should blue-greens be transferred to the bacteriological code—are not compelling. It is not clear that serious nomenclatural problems (e.g., discarding names) would arise pursuant to transfer; it is likely that existing (blue-green algal) names would continue to be used in most cases (see Oren and Tindall, 2005, on this point). Also, dual nomenclatures (should such develop for blue-greens) already exist in biological classification—for certain “ambireginal protists,” e.g., euglenoids and dinoflagellates (cf. Corliss, 1995; Blackwell and Powell, 1999)—without causing substantial difficulty. Concern over possible nomenclatural upset begs the significant question of relationships of major groups of organisms—My opinion on this issue, however, does not constitute endorsement of phylogenetic nomenclature at all systematic levels, i.e., a “*PhyloCode*” (compare, for example, Blackwell, 2002; vs. Cantino, 2000)—Among other problems, it is unlikely that the complete phylogenetic information (i.e., for all known species, of all “categories” of organisms) required to underpin such a “total” system will ever become available. There is, on the other hand, scant reason for codes of nomenclature to ignore basic biological knowledge, resulting in maintenance of improper code placement of entire groups of organisms (case-in-point, the Cyanobacteria). A quote from Sneath (2005) is pertinent in this regard: “Nomenclature is determined by taxonomy, not the reverse.”

In light of unequivocal knowledge of blue-greens (Cyanobacteria) as prokaryotes (Stanier and Cohen-Bazire, 1977;

Gibbons and Murray, 1978a,b; Fox et al., 1980; Krogmann, 1981), it is puzzling that some authors (e.g., Bold & Wynne, 1985; Bold et al., 1987) persisted in recognizing the "Cyanophyta" as "algae"—not because they do not fit within the loose, morpho-ecological construct of "algae" (as previously discussed), but because of the implication that they are somehow more like plants than they are like bacteria. In evidence of their putative algal (i.e., "botanical") nature, Bold and co-authors cited the plant-like, oxygenic (chlorophyll-*a*-utilizing) photosynthesis of "blue-green algae"—albeit minus chlorophyll *b*, unless the Prochlorophyta are included in the cyanophytes (compare, for example, Krogmann, 1981; Bold and Wynne, 1985; Rowan, 1989; Van den Hoek et al., 1995; Lee, 1999; Graham and Wilcox, 2000). However, it should simply be understood, in this regard, that a free-living cyanobacterium was the source of chloroplast origin through an ancient endosymbiosis that eventually diverged into three basal lineages: glaucocystophytes, green, and red lineages (Van den Hoek et al., 1995; Delwiche, 1999; Palmer, 2000; Bhattacharya et al., 2004; Keeling, 2004). Primary plastids, resultant of original endosymbiosis, are generally considered monophyletic (Moreira et al., 2000; Bhattacharya et al., 2004; Keeling, 2004; Reyes-Prieto et al., 2007), although Delwiche (1999) cautioned concerning the certainty of such a conclusion. Regardless, green algae, and ultimately plants, are a product of primary endosymbiosis, cf. Giovannoni et al. (1988), Stackebrandt (1989), Sitte and Eschbach (1992), Olsen et al. (1994), Blackwell and Powell (1995), Van den Hoek et al. (1995), Barnes et al. (1998), Graham and Wilcox (2000), Larkum and Vesk (2003), Snyder and Champness (2003), Blackwell (2004), Keeling (2004)—while euglenoids and chlorarachniophytes are derived (from the green-algal lineage) by separate, secondary endosymbioses (McFadden and Gilson, 1995; Lee, 1999; Keeling, 2004). Whereas present red algae are the result of primary endosymbiosis (Bonen and Doolittle, 1976; Moreira et al., 2000; Keeling, 2004), evolutionary lines believed to be related to the red lineage developed subsequently through a major, secondary endosymbiosis (e.g., cryptomonads and the different chromistan algal groups), and even by tertiary endosymbioses (various dinoflagellates), cf. Whatley and Whatley (1981); Cavalier-Smith (1986); Maier (1992); Blackwell and Powell (1995); Chesnick et al. (1997), Delwiche (1999); Bhattacharya et al. (2004); Keeling (2004); Reyes-Prieto et al. (2007).



Messages from the discussion above, most pertinent to the point of this paper, are: 1) There is no doubt of the ultimate connection of Cyanobacteria to chloroplasts (whether simple or complex) of all “algal” and plant groups. Plastids are cell organelles descended from cyanobacterial endosymbionts which were once free-living microbes (Delwiche, 1999). 2) However, the well-established relationships between plastids and cyanophyte-cells notwithstanding, the differences between, for example, green-algae/plants (Viridiplantae), on one hand, and Cyanobacteria on the other, must still be judged to be enormous. This major distinction represents (in spite of plastid lineage) the “quantum” cellular divide between present-day eukaryotic and prokaryotic organisms (cf. Stanier, 1977; Margulis, 1993). As Barnes et al. (1998, p. 3) noted, “unlike the Eukarya, the Prokarya [including Cyanobacteria] did not evolve by symbiogenesis.” The structural arrangements of both cell and genome are strikingly different in eukaryotes and prokaryotes—lacking compartmentalization (of function) in prokaryotes (cf. Avers, 1976; Alberts et al., 1989; Campbell and Reece, 2005). 3) Regardless of massive biological evidence to the contrary (and a clear understanding that blue-green “algae” are actually bacteria, i.e., definitely prokaryotic), it is nonetheless the status quo—nomenclatural regulation, and de facto treatment, of Cyanobacteria as “plants” by the botanical code (not explicit inclusion by the bacteriological code)—that continues to hold sway (ICBN, 2006, p. 2).

But, the argument need not be over. Taxonomic considerations of groupings of bacteria have, on occasion (e.g., Trüper & Imhoff, 1999; Oren, 2004), continued to include Cyanobacteria in discussion—implying that code governance of this group is not resolved. In comparing codes, it can be noted that the botanical code (ICBN, 2006) operates by a generally strict, historical method of name priority (exceptions by conservation allowed), within the context of a formal, somewhat complex, starting-point system—dating from 1753 to 1900, depending on the taxonomic group (cf. Article 13, ICBN). Though steadily endorsing the principle of name priority, and allowing name conservation as well, the code for bacteria (ICNB, 1992) functions now (more pragmatically, if more arbitrarily, than the botanical code) by one, much more recent starting-point (Jan. 1, 1980; see Rule 23a, Note 3)—this in connection with approved name-lists (document developed

by Skerman et al., 1980); see discussion of “approved lists” of bacterial names in Sneath (2005). Since the botanical code has continued to usurp the prerogative for inclusion of cyanophytes, the bacteriological code—though professing application to all bacteria—has not typically (i.e., with relatively few exceptions) been invoked to validate cyanobacterial names. However, contrary to Lewin’s (1979) belief, if the botanical code relinquished control of the naming of Cyanobacteria, it could be a fairly simple matter, under the bacteriological code, to add names of cyanobacterial genera to new listings for taxa (in issues of *IJSEM* = *International Journal of Systematic and Evolutionary Microbiology*). If such name-addition occurred, existing names for blue-greens, as mentioned, would probably be employed. However, the bacteriological code would not be obliged to honor names (or spellings, or authorities) putatively conserved by the botanical code, since these codes are autonomous (with the exception of avoiding use of identical names for different kinds of organisms). As a case in point, *Anabaina* Bory (1822) could be recognized by the bacteriological code (name lists) as the correct citation for the genus it represents—not *Anabaena* Bory ex Bornet & Flahault (1886)—thereby resolving this particular dilemma.

Transference of blue-green algal nomenclature from the botanical to the bacteriological code could possibly solve the problem for Cyanobacteria, and would be more reflective of the biology of these organisms (as prokaryotes). But, such an approach is not without potential problems. The bacteriological code indicates (Rule 18a) that “the type” of a bacterial species or subspecies should be a strain in pure culture. The requirements for deposition of such type strains are now even more stringent (cf. Tindall et al., 2006). One may surmise from Kantz and Bold (1969) and Baker and Bold (1970) difficulties of achieving axenic cultures of some cyanophytes, or adequate growth in such cultures. With rewording of the rules, though, special allowance could be made for the “purity” of cyanobacterial strains deposited as type material. Or, preserved (even frozen) specimens (of Cyanobacteria) could be designated as acceptable in the bacteriological code, as under the botanical code (Article 8, ICBN, 2006). In fact, a component of one of the recommendations in Hoffmann (2005), for “unification” of cyanobacterial nomenclature (under both codes), was to provide a statement in the bacteriological code permitting “botanical

types” for Cyanobacteria—this, in essence, had been suggested earlier in Friedmann and Borowitzka (1982). If a few points, such as this, could be resolved, Cyanobacteria could find at last a more appropriate nomenclatural home, indicative of the true nature of their biology.

However, a mechanism for “reselecting” the appropriate name for certain organisms (including Cyanobacteria) could be achieved as well if the *three*, present, major kingdom-based codes (botanical, bacteriological, and zoological) were reconstituted as a “unified code” (cf. Corliss, 1990; Spamer and Bogan, 1997; Blackwell and Powell, 1999) for “all” biological kingdoms (Blackwell, 2004). Less well known, perhaps, there are also separate codes for viruses and for cultivated plants (cf. Spamer and Bogan, 1997). If, though, one code of nomenclature, with one set of rules, could be established for all organisms (how to consider viruses being debatable), then the problem of nomenclatural regulation of any “misplaced” group could finally have a uniform forum for resolution. Also, a consolidated code could provide a venue for more permanent solutions than simply shifting groups between existing codes. Earlier efforts aimed at producing a *BioCode* (Greuter et al., 1996) did not meet with success; the draft document resembled the botanical code too closely to be acceptable to those involved with zoological nomenclature (see mention in Spamer and Bogan, 1997; Blackwell and Powell, 1999; Blackwell, 2002). However, there is no insuperable reason not to try again. In fact, efforts to develop an acceptable *BioCode* may be reinvigorated (Oren, 2004; Hawksworth, 2007). New attempts at code unification may become associated with the development of accepted name lists (as with the present bacteriological code), cf. Hawksworth (2000, 2007). If so, it would be well if these lists—destined, considering all organisms, to become extraordinarily extensive—remain open to modification, should preferable (more correct) names or spellings become manifest.

Yet another approach—in light of improved understanding of phylogeny of major groups of organisms—would be to establish a separate code for each kingdom of organisms (discussed in Corliss, 1990, 1993; Blackwell and Powell, 1999). Not only would plants, animals, and bacteria have their own codes, but other kingdoms such as Fungi (cf. Margulis, 1981; Kendrick, 1992), Chromista (i.e., “Stramenopiles,” cf. Cavalier-Smith, 1989; Blackwell and Powell,

2000) and even Protozoa (Cavalier-Smith, 1993; Blackwell and Powell, 2001) would as well. Such “nomenclatural partitioning” is, in fact, how the code for bacteria came into being. Bacteria, because they were once thought of as “fungi” (i.e., “Schizomycetes”), were for many years prior to 1958 (when the first edition of the bacteriological code was published) simply “covered” by the botanical code (cf. Lapage et al., 1992; Sneath, 2003)—as the Cyanobacteria remain today. By a similar token, nomenclature of viruses was umbrelled by the bacteriological code (i.e., in 1958), but subsequently transferred to the International Congress of Virology (cf. Sneath, 2003). So, some precedent exists for code (name-governance) proliferation, to match better understanding of the delimitation of the most major groups of organisms. However, the problem with this approach (potentially, a code for each kingdom) is that it has been standard practice, recently, that seven, eight, or even nine kingdoms of organisms are recognized (discussed in Cavalier-Smith, 1993; Blackwell & Powell, 1995, 1999; Blackwell, 2004), compared to the five recognized by Whittaker (1969), Margulis (1981), and Margulis and Schwartz (1988). A multiple-code approach (to keep pace with kingdoms recognized) could eventually prove more cumbersome, and uneven, than the current three-kingdom code system. And, at what point could we be sure that we are finished establishing, or at least proposing, “new” kingdoms (or new delimitations of major groups of organisms)? Leedale (1974) once suggested that there are, possibly, as many as 19 kingdoms. Clearly, the number of kingdoms has been debatable, and remains so (cf. Blackwell, 2004). It is worth mentioning, in this context, that the idea of establishing a special “Cyano-Code,” dealing specifically with Cyanobacteria, has generally been dismissed (cf. Oren and Tindall, 2005; also, Hoffmann, 2005).

Hence, it is doubtful that code-proliferation, to match recognized kingdoms—“Kingdom” being the “highest” grouping or rank or organisms (because “Domain,” cf. Woese et al., 1990, though putatively “greater” than Kingdom, is not a category recognized by codes of nomenclature, cf. Blackwell, 2004)—will provide a satisfactory, long-term solution. Such an approach would result in unduly complicated nomenclatural governance. Another extreme approach, that of establishing “rankless” systems of classification (e.g., Hibbett and Donoghue, 1998), likewise does not provide a reasonable alternative when there is still so much need to render order from chaos

in classification—And, when there can be little doubt that classifications are inherently hierarchical (Blackwell, 2002).

It appears, thus, that the possibility of attaining one code for naming all organisms has become the “holy grail” of biological nomenclature. If code unification could be achieved, obviously we would no longer need worry about which code should cover exactly which groups of organisms (Blackwell and Powell, 1999), or how appropriate the inclusion of the nomenclature of a given group in a particular code really is. Cyanobacteria would, for example, hold as unquestioned a place in a unified code as any other group. However, the difficulty is to bring various factions (botanists, bacteriologists, mycologists, zoologists, protistologists, cyanobacteriologists, etc.) involved—each with a particular nomenclatural viewpoint and history—into agreement on the multitude of specifics involved in developing a “consensus code.” So far, attempted code “harmonizations” have met with very limited success (cf. Corliss, 1990; Blackwell and Powell, 1999; Hawksworth, 2000)—due to the numerous minor (and sometimes major) differences between existing codes of nomenclature. As one example of disparity among codes, the bacteriological code mandates, in effect, registration of new names—in this case, currently, publication (or validation, if published elsewhere) in one designated journal, *IJSEM* (mentioned previously), cf. Sneath (2003, 2005), Tindall et al. (2006). The zoological code rejected name registration (cf. Spamer and Bogan, 1997). Registration was initiated in the botanical code and then withdrawn (cf. Hawksworth, 2000). The viral code requires name registration (Spamer and Bogan, 1997). However, regardless of many examples of discordance, all codes have the same general objective—promoting proper naming of the entities and groups they “oversee.” And, probably, virtually all nomenclaturists, professedly or not, would wish to see the process of nomenclature simplified, and unified into an unambiguous set of rules—applicable to the naming of all organisms—that could be “universally” agreed upon. But, regardless of similar goals, and wishes, it remains clear that “the devil is in the details.”

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**EUPATORIASTRUM POCHUTLANUM (ASTERACEAE:  
EUPATORIEAE), A NEW SPECIES FROM OAXACA, MEXICO**

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Routine identification of Mexican plants has revealed the following novelty:

**EUPATORIASTRUM POCHUTLANUM** B.L. Turner, **sp. nov.** Fig.1

*Eupatoriastrum angulifolium* (B.L. Rob.) King & H. Rob. similes sed caulibus ac pedunculis ultimis dense glandulosi-pubescentibus (vs non glandulosis), foliis laminis e basi palmatim 7-nervatis (vs pinninervatis) supra ac infra pubescentibus (vs glabris).

**Perennial herbs** to 30 cm high (label data). **Stems** densely pubescent with a vestiture of glandular hairs ca 0.5 mm high, scattered amongst these a sparse array of eglandular trichomes ca 1 mm long. **Leaves** ca 25 cm long; blades cordate, 18 cm long, 20 cm wide; sparsely pubescent above and below; petiole ca 10 cm long, pubescent like the stem. **Capitulescence** a terminal corymbose panicle ca 20 cm high, 16 cm across, the ultimate peduncles 1-2 cm long. **Heads** campanulate, 7-9 mm high, 8-10 mm wide. Involucre 6-7 seriate, markedly imbricate, the outer series ca 2 mm long, glandular-pubescent, the inner series ca 8 mm long. **Receptacle** convex, ca 3 mm across, endowed with 8-10 narrowly linear pales ca 8 mm long. **Florets** ca 50 per head, reportedly "moradas" but seemingly pale lavender. **Achenes** 2.5-3.0 mm long, hispidulous; pappus of ca 40 readily deciduous bristles ca 4 mm long.

**TYPE: MEXICO. OAXACA: Mpio. San Miguel del Puerto, "Arroyo Arena,"** (15 58 31.4 N, 96 06 34 W), ca 1147 m, 19 Nov 2002, *Jose Pasquel 661* (Holotype: TEX).

Counting the above novelty, *Eupatoriastrum* is a genus of only six species (Turner 1994). Four of these are illustrated in my treatment of the Mexican species (Turner 1997). The present species is noteworthy for its glandular pubescence and poorly developed receptacular pales. As noted, it appears to be most closely related to *E. angulifolium*, a species restricted to Chiapas and closely adjacent Guatemala.

According to label data, the species is a herb "30 cm high," but appears to be taller from the mounted material. The taxon is named for the Distrito Pochutlana, whence the type.

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Fig. 1. Holotype of *Eupatoriastrium pochutlanum*.

SEVEN NEW SPECIES OF *AGERATINA*  
(ASTERACEAE: EUPATORIEAE) FROM MEXICO

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ABSTRACT

Seven new species of *Ageratina* are described from Mexico: *A. colimana* B.L. Turner, *A. pochutlana* B. L. Turner, *A. soejimana* B.L. Turner, *A. solana* B.L. Turner, *A. spooneri* B.L. Turner, *A. textitlana* B.L. Turner and *A. yaharana* B.L. Turner. Their relationships to previously described species are discussed and photographs of their holotypes are provided. *Phytologia* 90(3): 358-374 (December, 2008).

**KEY WORDS:** Asteraceae, Eupatorieae, *Ageratina*, Mexico, Jalisco, Oaxaca, Veracruz

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*Ageratina* is a speciose member of the family Asteraceae. In my treatment of the genus for Mexico (Turner 1997) 131 species were recognized. Subsequently eight additional species were added (Turner 1996a, 1996b, 2006, 2007). The present contribution brings to 18 the number added to Mexico since my initial treatment, the grand total now numbering 149 species.

**AGERATINA COLIMANA** B.L. Turner, **sp. nov.** Fig 1

*Ageratinae herbaceae* (A. Gray) King & H. Rob. similis sed differt foliis glabris, petiolis plerumque 3-4 cm longis (vs. 1.0-2.5 cm), et pedunculis ultimis brevioribus (2-4 mm longis vs. 4-15 mm) trichomatibus glandulosi-pubescentibus (vs. non glandulosis).

**Perennial herbs** 50 cm high or more. **Stems** terete, ca 3 mm across, minutely pubescent with up-curved hairs. **Leaves** opposite throughout, 6-10 cm long, 4-7 cm wide; petioles of primary leaves mostly 3-4 cm long; blades decidedly deltoid, 3-5 nervate from the base, glabrous and smooth on both surfaces, the margins coarsely dentate and minutely pubescent. **Capitulescence** a terminal congested corymb, the ultimate peduncles 2-4 mm long, clearly glandular-pubescent. **Heads** ca 6 mm high, each containing ca 15 florets; involucre bracts 4-5 mm long. **Corollas** white, ca 3 mm long, glabrous, the lobes 5, ca 0.8 mm long. **Achenes** 2.0-2.5 mm long, sparsely pubescent; pappus of 20-30 readily deciduous white bristles ca 3 mm long.

TYPE: **MEXICO. JALISCO:** E slope of Nevada de Colima; "12.7 km W of JCT to Route 110, on lumber road to Fresnito. Roadside, in open pine-oak forest," 2150 m, 7 Mar 1998, *T. Yahara, A. Soejima & T. Kajita 1451* (Holotype: TEX).

*Ageratina colimana*, in habit and leaf shape, resembles *A. herbacea*, as noted in the above diagnosis, the latter seemingly restricted to northeastern Mexico and closely adjacent U.S.A. In the treatment of *Eupatorium* (including *Ageratina*) by McVaugh (1984), the novelty is not accounted for, nor will it key in my treatment of *Ageratina* for Mexico (Turner 1992). In short, the species is quiet distinct and deserving of specific status.

The species is named for the Nevada de Colima, along whose eastern slopes the type was collected.

#### **AGERATINA POCHUTLANA** B.L. Turner, *sp. nov.* Fig 2

*Ageratinae acevedoanae* B.L. Turner similis sed differt foliis laminis ovatis (vs. cordatis vel subdeltatis), petiolis brevioribus (1.5-2.5 cm longis vs. 4-6 cm), et trichomatibus glandulosis multo brevioribus (ca 0.2 mm altis vs. 0.6-1.3 mm).

**Perennial herbs** to 70 cm high. **Mid-stems** pubescent with crinkly hairs ca 0.5 mm high, beneath these a minute array of glandular-pubescent hairs. **Leaves** opposite throughout; blades broadly ovate, 3-5

palmate from above the base, 8-11 cm long, 4-6 cm wide, moderately pubescent above and below, especially along the ribs, the margins crenulate; petioles 1.5-2.5 cm long, grading into the blades. **Capitulescences** both terminal and axillary, 4-6 cm high, 7-10 cm across, the ultimate peduncles 8-10 mm long, glandular-pubescent. **Heads** numerous, ca 6 mm high; involucre bracts linear-lanceolate, ca 5 mm long, glandular-pubescent, their apices acute. **Florets** 30-40 per head (estimated); corollas white, ca 3 mm long; tubes ca 2 mm long, their lobes bearing at least a few spreading hairs. **Achenes** ca 1.5 mm long, sparsely hispid; pappus of ca 20 readily disarticulating bristles 3 mm long.

TYPE: MEXICO. OAXACA: Mpio. San Miguel del Puerto, "Oreja de Leon, Selva mediana subperennifolia. con cafe, suelo colorado." ca 1378 m, 3 Nov 2004, (15 58 47.8 N, 96 0725.5 W), Jose Pasqual 1053 (Holotype: TEX).

Because of its glandular-pubescent capitulescence, this novelty will key to the more northern *A. acevedoana* in my treatment of Mexican *Ageratina* (Turner 1997), with which it is compared in the above diagnosis. *Ageratina pochutlana* might also be reasonably compared with the superficially similar, more widespread, highly variable, *A. pichinchensis* (H.B.K.) King & H. Rob, the latter lacking glandular hairs and having smaller, mostly non-tapering blades and shorter ultimate peduncles (3-5 mm long vs. 8-10 mm).

The species name derives from Distrito Pochutla, whence the type.

**AGERATINA SOEJIMANA** B.L. Tuner, *sp. nov.* Fig 3

*Ageratinae ovillae* (Standl. & Steyererm.) King & H. Rob. similis sed differt habitu (frutices (?) erecti vs. vineae scandentes), involucri minoribus (4-5 mm altis vs. 7-8 mm) flosculis numerosioribus (ca 15 vs. 8-10), et acheniis hispidis (vs. glandulosi-pubescentibus) trichomatibus ascendentibus.

**Shrub** to 1 m (?) high. **Stems** terete, 2-3 mm across, minutely puberulent to glabrate. **Leaves** opposite throughout, 6-8 cm long, 3-4

cm wide; petioles 1.0-1.5 cm long; blades ovate, glabrous above, sparsely pubescent and reticulately veined beneath, the margins serrulate. **Capitulescence** a leafy terminal corymbose panicle, ca 10 cm high and 15 cm across, the ultimate peduncles mostly 3-5 mm long. **Heads** 8-9 mm high, ca 5 mm wide, each containing ca 15 florets; receptacle plane, ca 0.8 mm across, glabrous. **Involucres** ca 4 mm high; bracts ca 10, all very similar and uniseriate, abruptly acute apically, beneath these 1-3 linear bracts somewhat longer than the involucre. **Corollas** white, glabrous, 4-5 mm long, the throats indistinct; apical lobes 5, ca 1 mm long. **Achenes** ca 2 mm long, pubescent with stiff ascending hairs; pappus of 40-50 persistent uniseriate bristles 3-4 mm long.

TYPE: MEXICO. OAXACA: **Mpio. Diaz Ordaz**, along "road to Cuajimoloyas. In edge of oak and Acacia thicket," 2300 m, 17 01.8 N, 96 28.3 W, 9 Nov 1997, *T. Yahara, M. Mishima, T. Kajita & K. Ooi 1070* (Holotype: TEX).

In my treatment of *Ageratina*, subgenus *Neogreenella* for Mexico, this novelty, because of its 8-10 involucre bracts will key to or near *A. ovilla*, a clambering shrub of Chiapas. *Ageratina soejimana* is clearly a shrub, much resembling in habit a species of *Koanophyllon* but having floral features of *Ageratina*.

The species name honors Akiko Soejima of Osaka Prefecture Univ., Osaka, Japan. He has been part of the remarkable *Stevia* team associated with Prof. Yahara (cf. *Ageratina yaharana*, described below, and Watanabe et al. 2001.).

#### AGERATINA SOLANA B.L. Turner, *sp. nov.* Fig 4

*Ageratinae leptodictyon* (A. Gray) King & H. Rob. similis sed differt statura minore, foliis midcaulinibus minoribus (1-2 cm longis vs. 2-5 cm), capitulis majoribus flosculis numerosioribus (50 vel plures vs. 10-15), et involucris majoribus (6-7 mm longis vs. ca 4 mm).

**Perennial herbs** to 50 cm high. **Stems** pubescent with both crinkly hairs and spreading glandular-pubescent trichomes. **Mid-stem leaves**

much-reduced, opposite throughout, their internodes 4-8 cm long; blades 1-2 cm long, 0.5-1.5 cm wide; petioles 1-4 mm long. **Lower leaves** 3-4 cm long, 1.5-4.0 cm wide, essentially glabrous above and below, their margins irregularly serrate; petioles 1-2 cm long. **Capitulescence** terminal, bearing 5-6 heads on ultimate peduncles 2-7 cm long, pubescent like the stems. **Heads** 6-7 mm high; involucre bracts linear-lanceolate, 6-7 mm long, their apices acute. **Florets** 50 or more per head; corollas white, glabrous, ca 4 mm long. **Achenes** ca 2 mm long, hispidulous; pappus of ca 30 bristles ca 5 mm long.

TYPE: MEXICO. OAXACA: **Mpio. Santiago Textitlan**, "Paraje El Tambor, Bosque de pino-encino. Suelo blanco." (16 42 57.2 N, 97 19 42.5 W), ca 1922 m, 13 Nov 2006, *Idalia Trujillo Olazo 902* (Holotype: TEX).

In my treatment of Mexican *Ageratina* (Turner 1997) *A. solana* will key to or near the more northern *A. leptodictyon*, to which it is compared in the above diagnosis. It differs from the latter in being a much smaller plant with smaller leaves and having larger heads with more numerous florets. It should be noted that the type is composed of three mounted sprigs, one of these possessing glandular trichomes, the other two not so.

The novelty is named, in part, for the Distrito Sola de Vega, whence the type.

#### AGERATINA SPOONERI B.L. Turner, *sp. nov.* Fig 5

*Ageratinae triangulatae* (DC.) B.L. Turner similis sed differt lobis corollarum, caulibus, et foliis pubescentibus (vs. glabris) et capitulis minoribus (ca 5 mm altis vs. 6-7 mm).

**Stiffly erect perennial herbs** to 1 m (?) high. **Stems** purple, evenly pubescent with minute up-curved hairs. **Leaves** opposite throughout, mostly 6-10 cm long, 4-6 cm wide; petioles 2-3 cm long; blades broadly ovate to deltoid, 3-nervate from the very base, sparsely pubescent on both surfaces, especially along the nerves. **Capitulescence** a terminal stiffly divaricate corymbose panicle ca 5-8



cm high and as wide, the ultimate peduncles 10-20 mm long, pubescent like the stems. **Heads** ca 5 mm high, 4 mm wide, each with 15-20 florets. **Involucres** ca 3 mm high, the bracts linear-lanceolate, subequal. **Receptacles** plane, ca 1 mm across. **Corollas** ca 2 mm long with well defined tubes and throats, the lobes clearly pubescent. **Achenes** black, ca 1.5 mm long, sparsely pubescent along the ribs; pappus of ca 20 white fragile awns ca 2 mm long.

TYPE: MEXICO. VERACRUZ: Mpio. Villa Aldama, " In pine forests on S side of Jalapa-Veracruz RD., ca. 4 mi. W of Prof. R. Ramirez." 2450 m, 9 Dec 1984, David M. Spooner 2875 (Holotype: TEX).

While not technically positioned in the subgenus *Neogreenella*, the present novelty seems best compared with *A. triangulata* (DC.) B.L. Turner of that taxon, under which name it has resided for many years at TEX, due to my neglect of the sheet concerned. In my key to the species of *Ageratina* for Mexico (Turner 1997), the present novelty, due to poor key construction on my part, will key to the widespread *A. pasquarensis*, which it resembles not at all. The name honors the collector of the type, Prof. Spooner of the Univ. of Wisconsin, extraordinary scholar of the genus *Solanum*, not to mention his expertise in yet other groups. On top of that he is an excellent field collector, having wide interests in plants generally, or else he would not have gathered the present novelty. In short, his eponymous immortality offered here is well deserved

#### AGERATINA TEXTITLANA B.L. Turner, *sp. nov.* Fig 6

*Ageratinae oaxacanae* (Klatt) King & H. Rob. similis sed differt foliis tenuioribus angustioribus marginibus paene integris (vs. manifeste serratis), capitulis minoribus (5-6 mm altis vs. 7-8 mm), et setis pappi brevioribus (ca 3 mm longis vs. 5-6 mm) monomorphis (vs. dimorphis).

**Perennial herbs**, reportedly 0.5-1.0 m high. **Stems** glabrous. **Leaves** opposite throughout, pinninervate, linear-lanceolate, 8-14 cm long, 1-2 cm wide, glabrous, the margins entire or weakly dentate; petioles 1-2

cm long, grading into the blades. **Capitulescence** terminal, more or less flat-topped, 5-8 cm high, 5-10 cm across, the ultimate peduncles 5-10 mm long. **Heads** 5-6 mm high; involucre bracts linear-lanceolate, 3-4 mm long, ca 0.8 mm wide, glabrous, their apices rounded. **Florets** ca 25 per head; corollas white, glabrous, 2.0-2.5 mm long, the lobes deltoid, 1.0-1.5 mm long. **Achenes** hispid, ca 2.5 mm long; pappus of ca 50 monomorphic deciduous bristles ca 3 mm long, these arranged in a single series.

TYPE: **MEXICO. OAXACA: Mpio. Santiago Textitlan**, "Paraje Rio Aguacate. Bosque de pino-encino secundario. Guamil. Orilla de arroyo o rio." ca 1875 m, 14 Dec 2006, *Idalia Trujillo Olazo1128* (Holotype: TEX).

ADDITIONAL SPECIMENS EXAMINED: **MEXICO. OAXACA. Mpio Santiago Textitlan**, "Paraje El Cajon," ca 1921 m, 13 Nov 2006, *Olazo 968* (TEX); ca 1921 m, 13 Nov 2006, *Olazo 968* (TEX); "Paraje portillo de Cerro Espino," ca 1936 m, 25 Nov 2006, *Salinas 1091* (TEX); "Arriba de Barranca Nube," ca 1891 m, 27 Dec 2006, *Salinas 1307* (TEX); "Camino rumbo a Nuevo Leon," ca 1842 m, 29 Dec 2006, *Vasquez 1066* (TEX).

This very distinctive species belongs to the subgenus *Neogreenella* and will key to or near the more northern *A. oaxacana* (cf Fig 4, this based upon specimens at TEX) in my treatment of the Mexican species (Turner 1997). It differs from the latter in leaf shape, head size and pappus structure, as noted in the above diagnosis. Indeed, the relationship of *A. textitlana* to taxa within the subgenus is moot; I have compared it to *A. oaxacana* more out of convenience than conviction. In short, *A. textitlana* has a decidedly different pappus than that of *A. oaxacana*, and does not belong within or near the phyletic grouping to which the latter belongs (*A. mairetiana* and cohorts; cf. Turner 2006).

*Ageratina textitlana* is presumably relatively common in the area concerned, to judge from the specimens assembled to date. The species is named in part from the Municipio from which the type was collected.

**AGERATINA YAHARANA** B.L Turner, **sp. nov.** Fig 7

*Ageratinae rubricauli* (H.B.K.) King & H. Rob. similis sed differt laminis foliorum minoribus, crassioribus, infra magis subtiliter reticulatis et globulis aureis numerosis vestitis.

**Perennial herbs.** **Stems** terete, ca 3 mm across, minutely puberulent to white-tomentose, amongst the vestiture an abundant array of minute golden globules. **Leaves** (upper) opposite throughout, markedly thickened, 5-7 cm long, 3.0-4.5 cm wide; petioles 2-3 cm long, pubescent like the stems; blades ovate-deltoid, the lower surfaces 5-nervate from the base, puberulent, especially along the veins, markedly fine-reticulate and well endowed with golden globules, the margins irregularly crenate. **Capitulescence** a terminal corymbose panicle ca 7 cm high, 9 cm across, the ultimate peduncles mostly 1-3 mm long. **Heads** ca 8 mm high, each containing ca 15 florets; receptacle plane, glabrous. **Involucre**s ca 4 mm high; bracts subequal, 2-3 seriate, pubescent like the stems and well endowed with golden globules. **Corollas** white, glabrous, ca 5 mm long, the 5 lobes ca 0.8 mm long. **Achenes** (immature) ca 2.5 mm long, sparsely pubescent; pappus of 40-50 persistent bristles ca 4 mm long.

In my treatment of *Ageratina* subgenus *Neogreenella* for Mexico (Turner 1997) the present novelty will key to or near *A. rubricaulis* but the latter possesses very different leaves, both in shape and texture, not to mention yet other characters. In short, I find it difficult to relate *A. yaharana* to any of the Mexican *Ageratins* known to me, hence its description here.

The species is named for Prof. Tetsukazu Yahrara of Kyushu Univ., Fukuoka, Japan, who assembled a team of workers to study the genus *Stevia* in North and South America, the present novelty a product of that venture.

### ACKNOWLEDGEMENTS

I am grateful to my long-time colleague Guy Nesom for translations of the Latin diagnoses and helpful suggestions on the manuscript itself.

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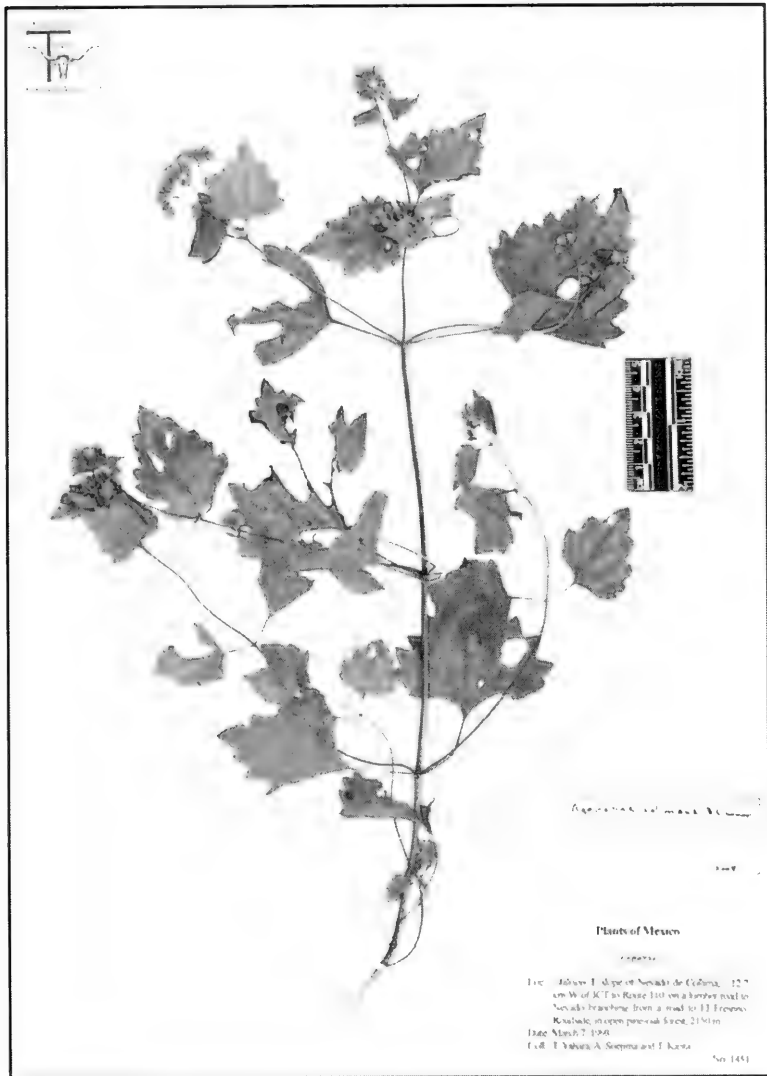


Fig. 1. Holotype of *Ageratina colimana*.



Fig. 2. Holotype of *Ageratina pochutlana*.

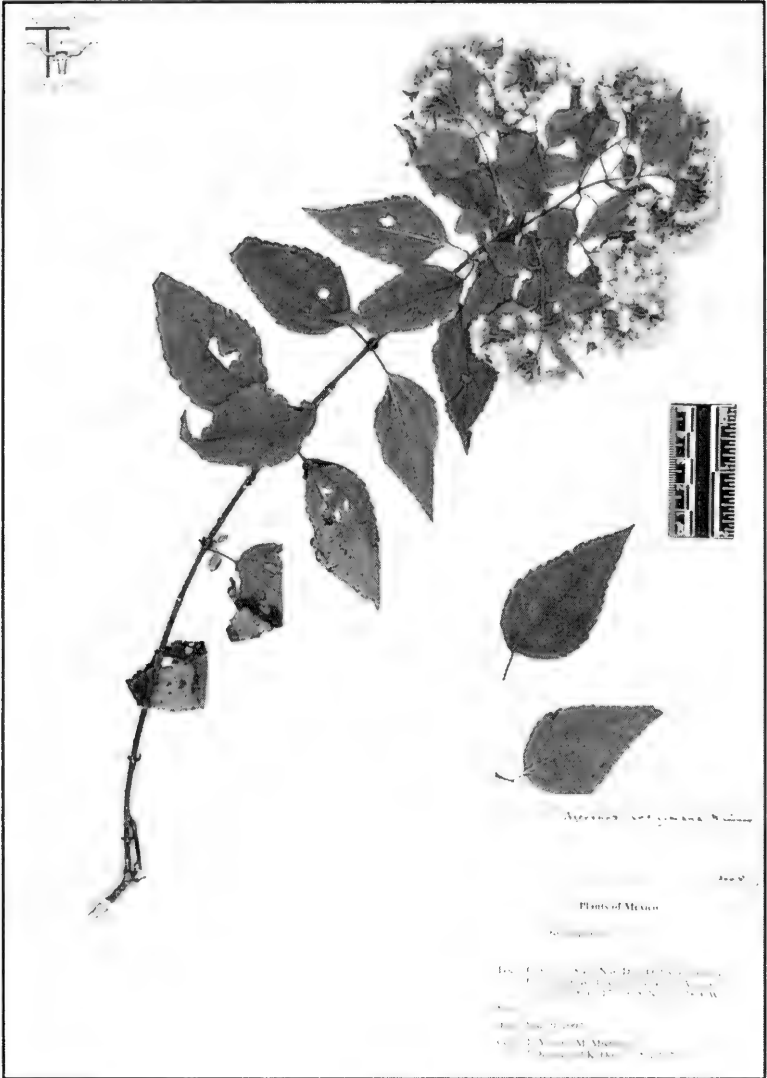


Fig. 3. Holotype of *Ageratina soejimana*.

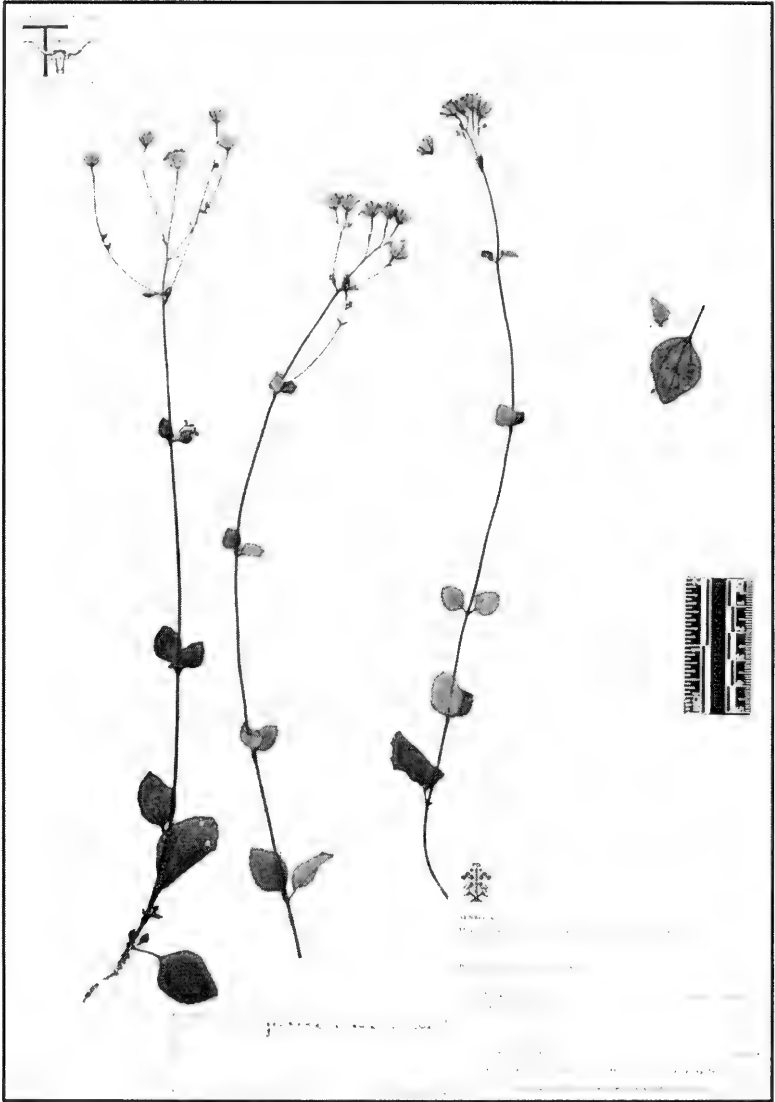


Fig. 4. Holotype of *Ageratina solana*.



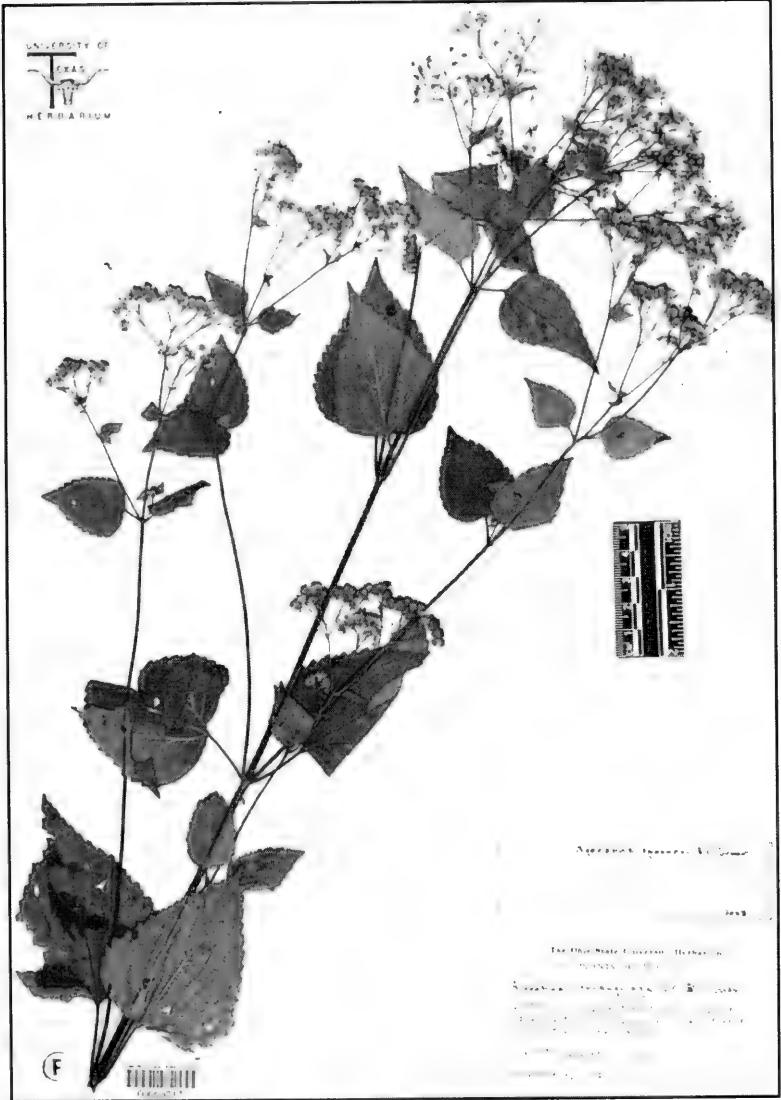


Fig. 5. Holotype of *Ageratina spooneri*.



Fig. 6. Holotype of *Ageratina textitlana*.

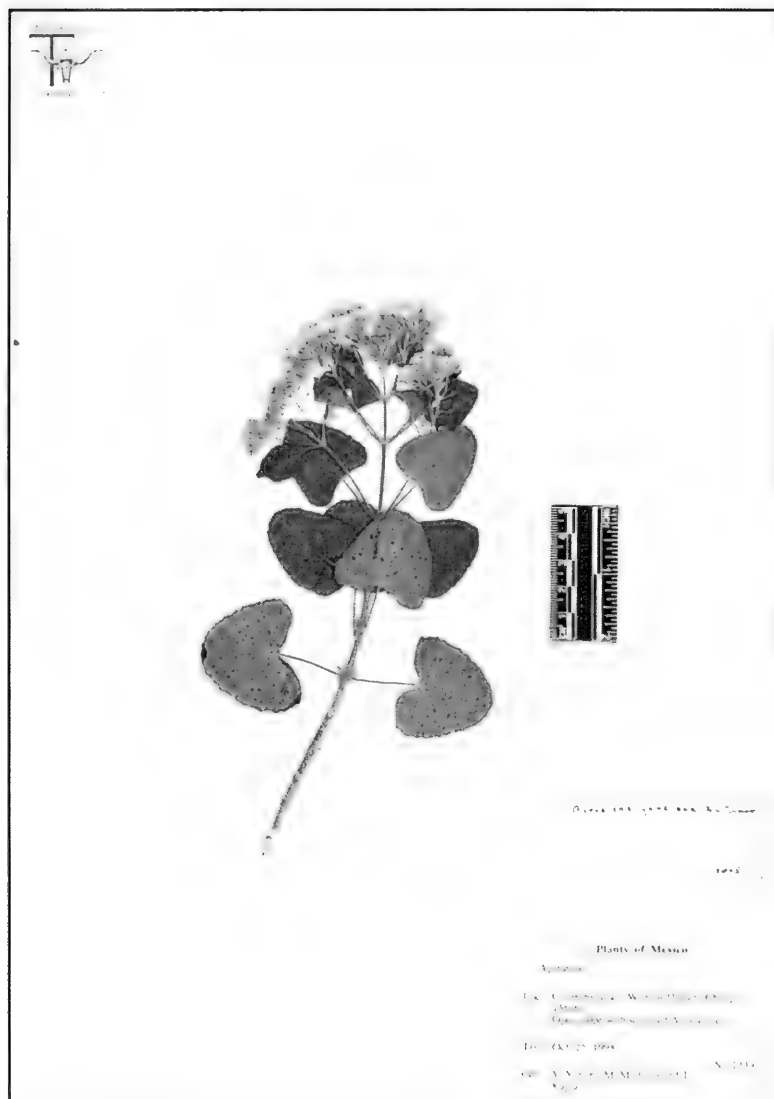


Fig. 7. Holotype of *Ageratina yaharana*.

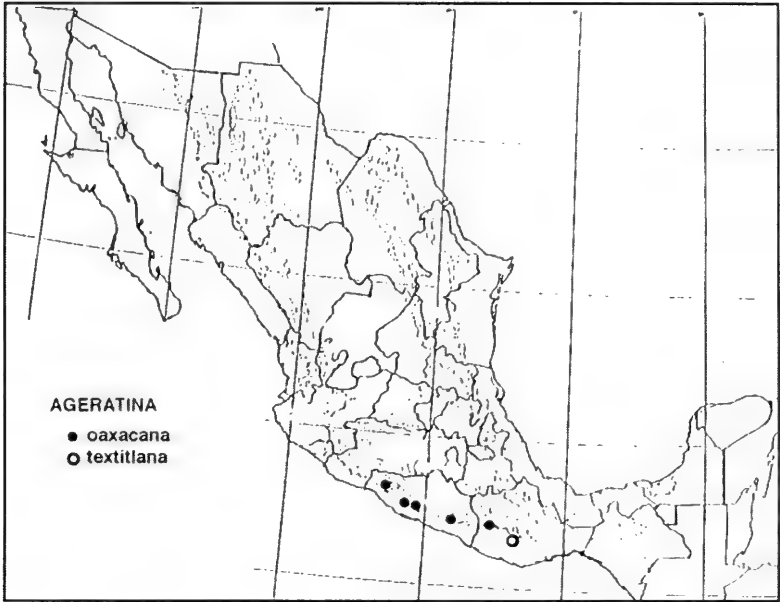


Fig. 8. Distribution of *Ageratina* *oaxacana* and *A. textitlana*.

**PHOTINIA SERRATIFOLIA (ROSACEAE)  
NATURALIZED IN TEXAS**

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**ABSTRACT**

Voucher documentation is provided for plants of *Photinia serratifolia* naturalized in Tarrant Co, Texas. Naturalized plants also occur in Parker Co. and Travis Co., as indicated by online photos and locality documentation by the Citizen Science program of Invaders of Texas. *Phytologia* 90(3): 375-377 (December, 2008).

**KEY WORDS:** *Photinia serratifolia*, naturalized, Texas

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*Photinia serratifolia* (Desf.) Kalkm. (Chinese photinia, Chinese hawthorn) is documented here as occurring outside of cultivation in Texas. Online photographic documentation (see below) exists for its occurrence in Texas, but there are no herbarium records at SMU-BRIT (pers. obs.), TEX-LL (Flora of Texas Database 2008), TAES (S.L. Hatch pers. comm.), or TAMU (M.D. Reed pers. comm.). The species was mapped by Turner et al. (2003), but the records apparently all were based on cultivated plants.

**VOUCHERS:** Tarrant Co. Fort Worth: Alton Road, immediately W of TCU campus, edge of vacant lot among houses, with *Prunus caroliniana*, *Celtis laevigata*, multi-stemmed shrub 12 feet tall, 10 feet wide, 8 May 2008, *Nesom FW08-03* (TEX, US). City park walking trail paralleling Overton Park Drive West and Overton Creek, just N of Ranch View crossing, shrubby margin between creek and trail, with *Ligustrum sinense*, *Ligustrum lucidum*, *Bumelia lanuginosa*, *Acer negundo*, *Cornus drummondii*, single young plant 2 feet tall, leaves sharply and coarsely toothed, 8 May 2008, *Nesom FW08-04* (TEX).

*Photinia serratifolia* and *P. x fraseri* Dress (red tip) are among plants listed by the Invaders of Texas (2008) Citizen Science early

detection program. These are species “known to occur in or around Texas that are suspected of causing invasive problems.” Of the three Texas records for *P. x fraseri*, one is clearly *P. serratifolia* (the same record also listed for that species) and the other two appear to be planted, persistent hedges of *P. glabra*. Numerous observations are posted for *P. serratifolia*—from Parker County, Tarrant County, and Travis County. From Tarrant Co., the Overton Park record is the same plant vouchered here by *Nesom FW08-04*; the other two are from the Fort Worth Nature Center. The Parker Co. record is from Holland Lake Park in Weatherford. Eleven records from Travis Co. are all from the Bull Creek area in northwest Austin. Habitats of these plants are open woods, thickets, disturbed sites, and creek beds and creek banks. The Web site for the City of Austin in Travis Co. (Austin City Connection 2008) includes “Chinese Photinia” among “plants that have already invaded preserves and greenbelts in Austin.”

*Photinia serratifolia* is native to China (including Taiwan), Japan, Indonesia, the Philippines, and India. It is reported by the PLANTS Database (USDA-NRCS 2008) to be naturalized in Alabama, Georgia, Louisiana, and Mississippi.

*Photinia glabra* (Thunb.) Maxim. (Japanese photinia) appears to be considerably more abundant in Fort Worth than *P. serratifolia*, particularly in recent plantings. It is highly fecund but there is no evidence of its escape from cultivation here, although it is reported to be naturalized in Louisiana (USDA-NRCS 2008). *Photinia glabra* is native to China, Japan, Myanmar, and Thailand and is naturalized in New Zealand and Australia.

The two species can be distinguished by the following contrasts (Nesom in press):

1. Leaf blades (6–)9–20 cm, lateral veins 20–30 pairs, margins usually sharply serrate, sometimes serrate to serrulate; young leaves green with reddish tinge; corymbs 10–18 cm wide.... **Photinia serratifolia**
1. Leaf blades 5–9 cm, lateral veins 10–15(–18) pairs, margins crenate-serrulate to serrulate; young leaves red to copper-red; corymbs 4–10 cm wide..... **Photinia glabra**

### ACKNOWLEDGEMENTS

The Citizen Scientists of the Invaders of Texas program provide a remarkable service in documenting invasive species. Each record is documented with a close-up and habit photo and the precise location is provided for each. *Photinia* records—Parker Co.: Marilyn Sallee; Tarrant Co.: Karan Rawlins and Marilyn Sallee; Travis Co.: David Nicosia, Kevin Stockton, Jim Weber, and Lynne Weber. I'm grateful to Stephan Hatch (TAES) and Monique Dubrule Reed (TAMU) for checking for herbarium records. An account, with updates, of non-native species documented since 1980 as occurring in Texas is at <<http://guynesom.com/>>.

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**INFRASPECIFIC CATEGORIES OF *HIBISCUS MOSCHEUTOS*  
(MALVACEAE) IN TEXAS**

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*Phytologia* 90(3): 378-381 (December, 2008).

Blanchard (2008) treated *Hibiscus moscheutos* as having two infraspecific categories: subsp. *moscheutos* and subsp. *lasiocarpus* (Cav.) O.J. Blanchard. Correll and Johnston (1970), in their compendium of the Flora of Texas, treated these as species, distinguishing between these with the following couplet:

1. Leaves commonly elliptic-lanceolate and broadly cuneate to rounded at base, with age usually becoming glabrous above, gray-pannose beneath; capsules glabrous .....**H. moscheutos**
1. Leaves ovate to ovate-lanceolate, rounded to cordate at base, permanently pubescent on both surfaces; capsules more or less pubescent.....**H. lasiocarpus**

In my evaluation of the taxa concerned for my Atlas of Texas Plants (Turner et al. 2003), I concluded that the populational variation used to separate the two taxa in Texas was weak at best and treated the two taxa as but part of a widespread highly variable *H. moscheutos*.

Appearance of Blanchard's paper led me to re-examine the problem from his perspective. Blanchard notes that in the typical subspecies "the capsules are glabrous and dark brownish black, the bracts of the involucre usually lack cilia, and the upper leaf surface is usually glabrous;" in subspecies *lasiocarpus* "the capsules are variously pubescent so that the dark surface is more or less obscured, the bracts of the involucre are usually ciliate, and the upper leaf surfaces are usually pubescent." One can hardly be unaware of the "usually" factor in his comparisons. Which is certainly true for the Texas plants I examined, hence my reluctance to recognize two taxa for the state.



My re-examination of the complex from throughout the United States leads me to agree with Blanchard's biological assessment of the entities concerned: there indeed appears to be two intergrading taxa, this expressed succinctly by Blanchard:

The eastern, glabrous-fruited *Hibiscus moscheutos* subsp. *moscheutos* is distributed from New Hampshire to Florida and westward, where it gives way to the more western pubescent-fruited subspecies *lasiocarpus* in a narrow zone that extends from southern Illinois and Indiana to coastal Mississippi and Alabama.

My examination of specimens on file at LL-TEX (Figs. 1, 2, the various intergrades not mapped) suggests that such is the case, but perhaps not as clearly so as suggested by Blanchard. This is especially true for eastern Texas and most of Louisiana where the recognition of this or that taxon might be decided with whim, hence my reluctance to accept their recognition in Turner et al. (2003), as noted above.

Finally, a choice exists regarding infraspecific rank. Turner and Nesom (2000) and Nesom and Lipscomb (2005) noted that the ICBN (2000 and prior) appeared to support the initial use of "variety," followed by "subspecies" as a mechanism for clustering closely related varieties. The most recent ICBN (2006, Article 4.2, Note 1) responded by explicitly noting that designation of infraspecific taxa may begin with either rank. It has been the consistent practice in Texas botanical nomenclature to use varietal rank to first recognize distinct but intergrading entities.

Following the rationale above, I have opted to treat *H. m.* subsp. *lasiocarpus* at the varietal level, as follows:

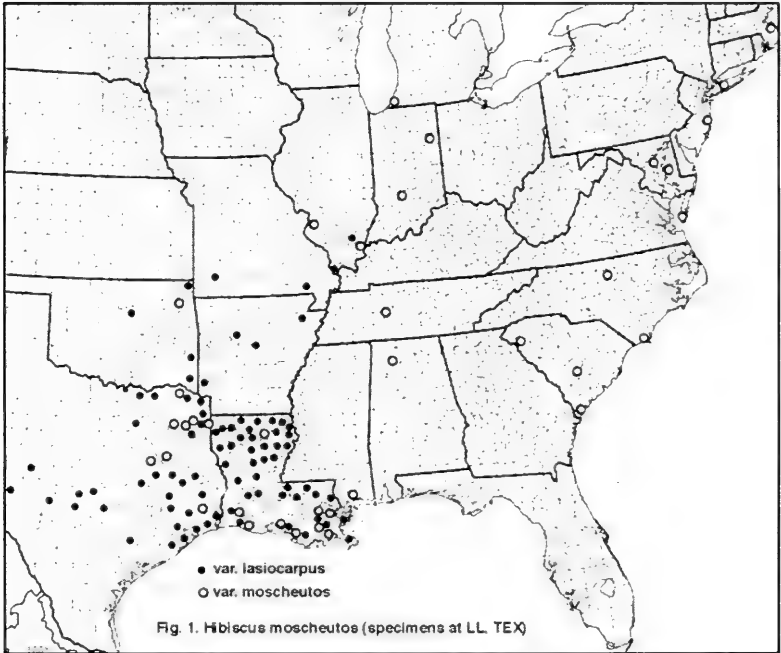
*Hibiscus moscheutos* var. *lasiocarpus* (Cav.) B.L. Turner, **stat. nov.**  
Based upon *Hibiscus lasiocarpus* Cav., Diss. 3: 159. 1787.

#### ACKNOWLEDGEMENTS

I am grateful to my colleague, Guy Nesom for reviewing the paper and providing helpful suggestions.

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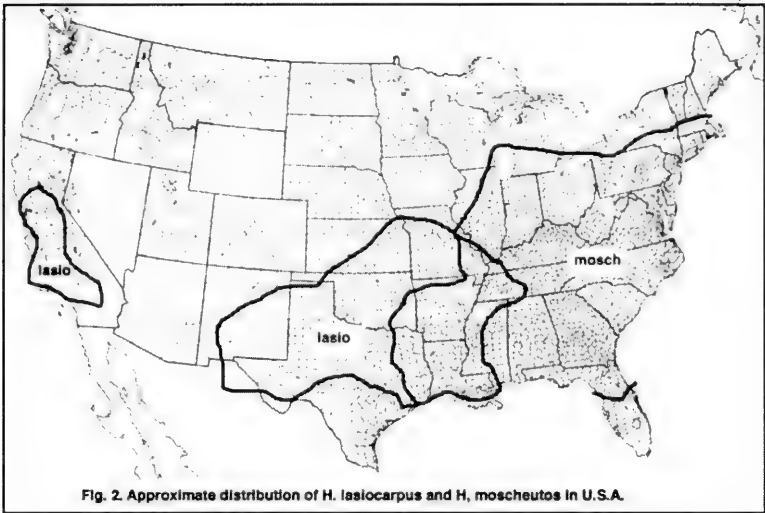


Fig. 2. Approximate distribution of *H. lasiocarpus* and *H. moscheutos* in U.S.A.

**A NEW SESSILE-FLOWERED *TRILLIUM*  
(LILIACEAE: SUBGENUS PHYLLANTHERUM)  
FROM SOUTH CAROLINA**

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**ABSTRACT**

*Trillium oostingii*, a new sessile-flowered *Trillium* from Kershaw and Richland County, South Carolina is described. It is closely related to *Trillium lancifolium* Raf. and *Trillium recurvatum* Beck. All known populations of this plant are found just below the Fall Line in the floodplain of the Wateree River. *Phytologia* 90(3): 382-390 (December, 2008).

**KEY WORDS:** sessile-flowered *Trillium*, *Trillium oostingii*, *Trillium lancifolium*, *Trillium recurvatum*, Wateree River, floodplain.

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In April of 2002, I found an unusual sessile-flowered *Trillium* along the Fall Line in Kershaw County, South Carolina. Its petals were green to yellowish-green with maroon, clawed bases. The plant was growing in rich floodplain woods along the Wateree River in the Inner Coastal Plain of South Carolina. Although I immediately recognized the plant as one of the sessile *Trillium*, I could not determine the species.

From 2003 to 2007 I revisited the general area each year and discovered additional nearby subpopulations of the *Trillium* and continued research on the identity of the plants. While reviewing the database of the South Carolina Natural Heritage Program in 2002, I had noticed that a *Trillium* collection by H. J. Oosting on April 7, 1937 was known from same general area. Oosting had originally called the plant *Trillium viride* Beck; Oosting's specimen was later annotated *Trillium lancifolium* Raf. by S. J. Smith (1947) and by J. D. Freeman (1967). After an examination of Oosting's specimen (housed at DUKE), I concluded that the plant I was observing in the Wateree floodplain was the same plant he had collected in 1937.

Most of the plants on the Wateree were more robust and had broader petals than any *T. lancifolium* I had ever seen. Furthermore, the intrafloral structure of the plants' flowers was significantly different from that of the flowers of *T. lancifolium*. I, therefore, concluded the plant was not *T. lancifolium* (as the DUKE specimen had been annotated). After examining images of the Wateree trillium, Mr. Tom Patrick of the Georgia Natural Heritage Program, an expert on the genus *Trillium*, pointed out to me that the plant appeared to exhibit some morphological elements of *Trillium recurvatum* Beck, a Midwestern species never reported from South Carolina, and could represent a relict population of that species. Mr. Patrick's observations were partially borne out after measurements and images of the Wateree trillium were compared to those of *T. recurvatum*, but, in the end, I also concluded that the plants were not *T. recurvatum*.

After five years of morphological and biogeographical research and a review of the Wateree trillium's DNA and chromosome data, I have concluded that the Wateree trillium is a new species and hereby name it *Trillium oostingii*, in honor of its original collector Henry John Oosting, professor of Botany at Duke University from 1932 to 1968.

**TRILLIUM OOSTINGII** Gaddy, *sp. nov.*, Fig. 1.

A *T. lancifolium* et *T. recurvatum* filamentis minus quam 1/2 longioribus quam antheris differt; a *T. lancifolium* bracteis et petalis multis latioribus differt; a *T. recurvatum* bracteis sine petiolis differt.

**Scapes** (stems) 10-30 cm tall; **bracts** (leaves) elliptic-ovate to attenuate, rarely petiolate, 5-10 cm wide, 8-24 cm long; **sepals** elliptic-lanceolate, green to maroon, 20-60 mm long, 10-20 mm wide, acute-tipped, reflexed to semi-erect; **petals** broadly spatulate, to 30 mm wide and 80 mm long; 2.5 to 5 times longer than wide, clawed, claws 1/7 to 1/5 petal length; **stamens** 8-15 mm in length, slightly longer than gynoecium; anther connectives erect to slightly incurved, anther connective slightly exceeding filaments, filament length less than 1/2 the length of anther; **ovary** hexagonal, 6-16 mm long, deeply grooved to winged, globose to subglobose with persistent non-spreading

stigmas; stigmas (to 8 mm long) about the same length as the ovary.  $2n=10$ .

**TYPE: U. S. A., SOUTH CAROLINA:** Kershaw County. West side of Wateree River, several miles downstream from Camden, 03 April 2007, *L. L. Gaddy 04040701* (Holotype: USCH; isotypes, DUKE, GA, GH, MO, NCU, NY, TENN, US).

**ADDITIONAL SPECIMENS EXAMINED: U. S. A. South Carolina: Kershaw County.** In rich floodplain woods above junction of Big Pine Tree Creek with Wateree River, 11 April 2002, *L. L. Gaddy 041102*, (USCH); **Kershaw County.** In rich floodplain woods one-half mile upstream from Wateree River on Big Pine Tree Creek, 02 May 2004, *L. L. Gaddy 050204* (USCH); **Kershaw County.** Rich wooded floodplain, Wateree River just south of Camden, 7 April 1937, *H. J. Oosting 310* (DUKE); **Richland County.** In rich floodplain woods with *Carya cordiformis*, *Quercus pagoda*, *Podophyllum peltatum*, and *Carex cherokeensis* in English Swamp just west of the Wateree River and just south of the Kershaw-Richland County line. 100s of plants in area, 23 April 2008, *L. L. Gaddy 04230801 with Sudie Daves Thomas* (USCH).

*Trillium oostingii* is closely allied to *T. lancifolium* and *T. recurvatum*. The nearest known population of *T. lancifolium* is in South Carolina 100 km to the west in the Savannah River drainage, and the closest population of *T. recurvatum* is a disjunct population in central North Carolina about 120 km to the north. (*Trillium recurvatum* is known from the Midwest and Mississippi Valley and ranges east to eastern Alabama and central Tennessee. The North Carolina disjunct population is in Catawba County, in the same drainage system as the Wateree River.)

*Trillium oostingii* has the tall and elongate "look" of these two species, and like both of these species, it has relatively thin (usually less than 20 mm in diameter) creeping rhizomes and forms small to large clones. Its intrafloral structure, however, is more similar to other sessile-flowered *Trillium* unrelated to *T. lancifolium* and *T. recurvatum*. The stamens of *T. oostingii* are shorter than those of *T. lancifolium* and *T. recurvatum* (Fig. 1), and, unlike those of *T. lancifolium* and *T.*

*recurvatum*, whose filaments are about the same length or slightly shorter than the anthers, *T. oostingii*'s filaments are less than one-half the length of its anthers. Furthermore, its anthers are only slightly incurved, and the stamens are only slightly taller than the stigma (Table 1). The intrafloral region in *T. oostingii* is, therefore, compact, with the area inside of the stamens completely filled with the ovary and its tall stigma (Fig. 1). On the other hand, in *T. lancifolium* and *T. recurvatum*, the strongly incurved stamens and the short ovary creates an open area within the stamens.



Figure 1. *Trillium oostingii* (left) and *T. lancifolium* (right). Note the wider petals, shorter stamens, shorter claws in *T. oostingii*, and differences in proportional size of intrafloral parts.

When *T. oostingii* first appears in late March, its leaves (bracts) angle downward like those of *T. lancifolium* (not arching upward as do those of *T. recurvatum*), but as the plant matures, the

leaves become parallel to the ground. The sepals are strongly reflexed early in some *T. oostingii* plants, but, again, as the plants mature, the sepals become parallel to the ground. Most mature *T. oostingii* plants are large, broad-leaved, robust plants with broad, long petals, with little resemblance to *T. lancifolium*. Occasionally, however, a narrow-leaved, narrow-petaled plant is found in a *T. oostingii* subpopulation; an examination of the intrafloral parts of the flower then becomes necessary to separate the two species. No flowering *T. oostingii* plants in any of the 20 subpopulations had petiolate leaves, as is usually the case in *T. recurvatum*.

Several hypotheses concerning the origin of *T. oostingii* can be advanced, none of which is satisfactory in explaining how this species arose. When I first saw *T. oostingii*, I thought that it was *Trillium maculatum* Raf. *forma similans* Freeman, a form of *T. maculatum* with yellow petals and maroon claws, or a hybrid between *forma similans* and *T. lancifolium*. After further research, however, the only real similarity between the two taxa is flower color and intrafloral structure. It later occurred to me that *T. oostingii* may be a natural hybrid between *T. lancifolium* and *T. recurvatum*, but DNA sequences indicate that the all three species are unique. In fact, according to the DNA sequence presented in Figure 2 (courtesy of Dr. Susan Farmer), *T. lancifolium* and *T. recurvatum* are more closely related to each other than either is to *T. oostingii* (Fig. 2).

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ATATGCGTTCCTTTATCTTCTATTTTTTCT~~~~~CCGATCTTCTC
ACATGCGCTCCTTTATATTCTCTTTTTTCT~~~~~CCAATCTTTTC
ATATTCGTTCTTTCATATT~~~~~CTCATAATCCGATATTCTA
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

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TT~~~~~CTTTTATCTTCTATTTT~AACCTCG   lanc.
TT~~~~~CTATTCTCTT~CTATTC~GAAACTCG   recurv.
TTCTATTTTTTCTTTTCTATT~CTTTTTTGAACTAG   oost.
**                ** *  *  *  *  *  *  *  *  *  *

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Figure 2. DNA sequences: *Trillium lancifolium*, *T. recurvatum* and *T. oostingii* (top to bottom). Sequence is based on the psbA-trnH intergenic spacer, a non-coding cp gene region (Farmer, 2007).



Furthermore, chromosome counts revealed that the Wateree plant had a chromosome number of  $2n=10$  (Fig. 3), the same number as all known North American *Trillium* species (Hill, 2005), and is probably not a hybrid. [All known *Trillium* hybrid species are polyploids (Samejima and Samejima, 1962)].

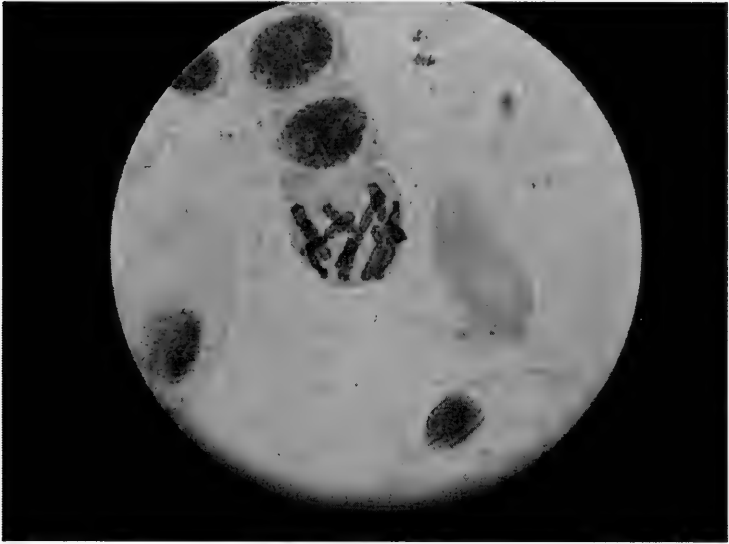


Figure 3. Chromosome division in *Trillium oostingii*.

**Key to *Trillium oostingii* and Allies**

[based on keys in Case and Case (1997), Case (2003), and Freeman (1975)]

Sepals frequently strongly reflexed at bases; rhizomes horizontal, elongated, slender (usually less than 20 mm in diameter), brittle, forming clones

1. Anther connectives strongly incurved; filaments long, more than  $\frac{1}{2}$  anther length
  2. Petals ca. 2 X longer than wide, attenuate to weakly clawed; bracts petiolate.....*T. recurvatum*
  2. Petals ca. 4-7 X longer than wide, strongly clawed; bracts not petiolate.....*T. lancifolium*
1. Anther connectives slightly incurved; filaments short, less than  $\frac{1}{2}$  anther length.....*T. oostingii*.

Found on both sides of the Wateree River, just southwest of Camden, in Kershaw County, SC, and along the Wateree River 15 km southward in Richland County, SC, *Trillium oostingii* grows in large colonies in rich, floodplain alluvium along creek banks and on natural river levees under a canopy of *Carya cordiformis* (Wang.) K. Koch, *Juglans nigra* L., *Ulmus rubra* L., *Quercus phellos* L., *Quercus pagoda* Raf., *Quercus shumardii* Buckl., and *Acer negundo* L. In the understory, *Philadelphus inodorus* L., *Viburnum prunifolium* L., *Ilex longipes* Chapm., *Ligustrum sinense* Lour., *Arundinaria gigantea* (Walt.) Muhl., *Cercis canadensis* L., *Tilia heterophylla* L., *Vitis rotundifolia* L., and *Menispermum canadense* L. occur. In the herbaceous layer, *Cardamine concatenata* (Michx.) Ahles, *Carex abscondita* Mackenzie, *Carex cherokeensis* Schwein., *Carex crebriflora* Wieg., *Corydalis flavula* (Raf.) DC, *Erigeron strigosus* Muhl. ex Willd., *Erythronium umbilicatum* Parks & Hardin, *Galium aparine* L., *Nemophila aphylla* (L.) Brummit, *Osmorhiza longistylis* (Torr.) DC., *Podophyllum peltatum* L., *Verbesina officinalis* L., *Viola affinis* Le Conte, and *Viola pubescens* var. *scabriuscula* Schwein. ex T. & G. were common associates. Nearly every colony of *T. oostingii* was associated with a large colony of *Podophyllum peltatum*. Thousands of stems of *T. oostingii* occur in about 20 subpopulations.

#### ACKNOWLEDGMENTS

Dr. Susan Farmer of the University of Tennessee conducted the DNA analysis (Fig. 2) and reviewed early drafts of this paper. Dr. Gerald Smith of High Point College (North Carolina) counted and photographed (Fig. 3) the chromosomes for this species. Mr. Tom Patrick of the Georgia Natural Heritage Program examined images of *Trillium oostingii* and reviewed drafts of this paper. Finally, Dr. John

Byron Nelson, Curator of the A. C. Moore Herbarium (USCH) at the University of South Carolina, assisted me with loans and collections and also reviewed the paper. I would like to sincerely thank these four individuals.

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Table 1. *Trillium oostingii* and allies.

Character	<i>T. oostingii</i>	<i>T. lancifolium</i>	<i>T. recurvatum</i>
Stems (scapes)	1-2 times longer than longest leaf	More than 2 times longer than longest leaf	More than 2 times longer than longest leaf
Leaves (bracts)	Darkly mottled to faintly streaked; ovate to broadly elliptical; <b>bases cuneate to attenuate</b>	Mottled to darkly streaked; elliptical to linear-elliptical; <b>bases attenuate</b>	Mottled to darkly streaked, elliptical to linear-elliptical; <b>bases petiolate</b>
Rhizomes	Thin (< 20 mm)	Thin (< 20 mm)	Thin (< 20 mm)
Sepals	Strongly reflexed to semi-erect	Weakly to strongly reflexed	Strongly reflexed
Petals	Lanceol. to ovate; green to yellow with purple bases; long clawed; <b>2.5-5 times longer than wide</b>	Ellipt. to narrowly spatulate; purple to yellow with purple bases; long clawed; <b>4.5-7 times longer than wide</b>	Lanceol. to ovate; green, purple, or yellow with purple bases; attenuate to weakly clawed; <b>2-3 times longer than wide</b>
Androecia	<b>Stamens slightly incurved; slightly taller than ovary; filaments short, less than ½ length of anthers</b>	<b>Stamens strongly incurved; 1.5-2 times taller than ovary; filaments long, equal to the anthers</b>	<b>Stamens strongly incurved; much taller than ovary filaments long; equal to or shorter than the anthers</b>
Gynoecia	Sharply six-angled; <b>stigmas erect</b>	Sharply six-angled; <b>stigmas spreading</b>	Sharply six-angled; <b>stigmas spreading</b>

**MAJOR PLANT COMMUNITIES  
OF LAKE MEREDITH NATIONAL RECREATION AREA  
AND ALIBATES FLINT QUARRIES NATIONAL MONUMENT**

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**ABSTRACT**

The plant communities of the parkland in LAMR/ALFL can be described as 12 major types, referred to here by their physiographic/geological setting: (1) sandhills and sand flats, (2) sandy valley bottoms, (3) gravelly slopes, (4) dolomite caprock, (5) red slopes, (6) gypsum outcrops, (7) river and creek sides (subdivided into riparian of larger tributaries; sedge meadows and corridors; cottonwood gallery forest; and hackberry-soapberry dry woodland), (8) lakeshore, (9) marsh, (10) borrow area, (11) lawns and mowed roadsides, and (12) old home sites. *Phytologia* 90(3): 391-405 (December, 2008).

**KEY WORDS:** Lake Meredith National Recreation Area, Texas, plant communities.

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Lake Meredith National Recreation Area (LAMR) and Alibates Flint Quarries National Monument (ALFL) include Lake Meredith, which is about 25 miles long, and a relatively narrow rim of boundary property in Hutchinson, Moore, and Potter counties in the north-central panhandle region of Texas. LAMR includes 44,998 acres of water and land; ALFL (which is essentially imbedded within LAMR) includes 1371 acres. The primary topographic feature is the Canadian River, which runs through a steep-walled canyon about 1.5–2 miles wide; tributary streams feed from side canyons.

Major plant communities in LAMR and ALFL have been characterized by Wright and Meador (1987), Bell et al. (2000), and the National Park Service (2001)—our survey provides comparisons and other commentary relating to these studies. The NPS discussion is generalized and applicable with difficulty to the parkland under consideration. After an initial reconnaissance, Wright and Meador identified five major community types in LAMR and ALFL (bottomland, steep slope, gravelly slope, mesa top, and sandhill), selected sampling sites to characterize each community type, and constructed descriptions and a vegetation map from data taken by a 'step point' sampling method. Bell et al. identified four major community types in ALFL (clay loam, gravelly hills, rough breaks, and sandy and loamy bottomland), selected two transects to characterize each community type, and constructed descriptions from data obtained by the sampling procedures. In a study of 'breaks' vegetation in the vicinity of Ranch Creek in Potter County, Sikes and Smith (1975) recognized three relatively inclusive associations: mesquite-grassland, juniper-hairy grama, and salt cedar-dropseed.

Conclusions of the present assessment are similar in many respects to those of the previous studies, but our more subjective approach perhaps allows a more detailed regional characterization. We have attempted to define the major plant associations based primarily on physiographic and geologic boundaries, as these generally are correlated with the sharpest discontinuities between vegetation types, with recognition that overlap in species composition occurs among these communities and that some species are common in more than one community type. Geological concepts and terminology are drawn from a recent discussion by the National Park Service (2001: "Geologic Resources," adapted from Davis and Northcutt 1991).

Community descriptions are drawn from observations made from April 2002 through October 2002 (Nesom & O'Kennon 2003). Repeated visits to various areas within the parkland allowed modification and refinement, but objective tests of our subjective assessments are desirable.

## 1. SANDHILLS and SAND FLATS

Rolling hills and flats of relatively deep, loose sand (Ogallala Group: Clarendon Formation – Pliocene) are dominated by *Artemisia filifolia*, *Eriogonum annuum*, *Yucca glauca*, various grasses, and scattered *Prosopis glandulosa*. *Eriogonum annuum*, *Centaurea americana*, *Erigeron bellidiastrum*, and *Penstemon ambiguus* are relatively common and restricted to the deep sands and may be considered as indicators of sandy habitat. Other common species are *Aphanostephus ramosissimus*, *Cirsium undulatum*, *Gaillardia pulchella*, *Gutierrezia sarothrae*, *Hymenopappus flavescens*, *Machaeranthera pinnatifida*, *Ipomoea leptophylla*, *Mentzelia nuda*, *Monarda punctata*, *Monarda pectinata*, *Calylophus serrulatus*, *Gaura villosa*, *Krameria lanceolata*, *Chamaesyce fendleri*, *Croton texensis*, *Stillingia sylvatica*, *Cryptantha cinerea* var. *jamesii*, *Eriogonum longifolium*, *Tradescantia occidentalis*, *Commelina erecta*, *Chamaesyce missurica*, and *Corispermum americanum*. Common grasses are *Buchloe dactyloides*, *Vulpia octoflora*, *Schizachyrium scoparium*, *Sporobolus cryptandrus*, *Andropogon hallii*, *Bouteloua curtipendula*, *Bouteloua hirsuta*, *Bouteloua pectinata*, *Bouteloua eriopoda*, *Aristida purpurea*, *Eragrostis curvula*, and *Muhlenbergia capillaris*. *Baccharis wrightii* is local in occurrence on sand flats of the Bugbee peninsula. *Chrysothamnus pulchellus* is local but abundant along a long, shallow draw in the deep sand above Spring Creek.

This community is equivalent to the “sandhills” community of Wright and Meador (1979), and probably also includes their “mesatop” category, at least in part. The most extensive sandhill area is along the margin of the northernmost portion of LAMR (south of Hwy 687); others are east of the Ranger Station in the Sanford-Yake area, the high part of the Fritch Fortress peninsula, and on the Blue West and Bugbee peninsulas. More recently deposited ‘valley fill’ sands occur widely and support communities somewhat similar in floristic composition (see below, Sandy Valley Bottoms).

Ogallala sand caps the Fritch Fortress peninsula, but species diversity there is low, perhaps reflecting relatively recent grazing or other human modification. The area was controlled-burned in spring of 2002. We record the following as common species (post-burn): *Salsola tragus*, *Psilostrophe villosa*, *Solanum elaeagnifolium*, *Yucca glauca*,

*Setaria leucopila*, *Kallstroemia parviflora*, *Bouteloua eriopoda*, *Sporobolus cryptandrus*, *Munroa squarrosa*, *Bassia scoparia*, *Chamaesyce glyptosperma*, *Bouteloua gracilis*, *Sphaeralcea coccinea*, *Ipomoea leptophylla*, *Helianthus annuus*, *Machaeranthera pinnatifida* var. *pinnatifida*, *Croton texensis*, and *Bothriochloa barbinodis*.

An area of deep sand west of Hwy 1319 (along the northern park boundary) is highly reduced in plant diversity, probably reflecting recent overgrazing (before the property was acquired by the NPS). *Prosopis glandulosa*, *Eriogonum annuum*, *Mentzelia nuda*, *Yucca glauca*, *Prunus angustifolia*, *Artemisia filifolia*, and *Aristida purpurea* are the dominant species—few others occur. Cattle apparently do not eat the *Prosopis*, *Eriogonum*, and *Mentzelia*, or at least those species are low in grazing preference, because we have observed them in abundance in otherwise grazed sandy habitats outside the parkland.

Areas of deep, loose sand, alluvial and recent in origin, also occur in the bottom and along the margins of the Canadian River and larger streams, such as Big Blue Creek and Chicken Creek. Dune deposits are evident along the Canadian River in the Rosita area and an area slightly north of Bates Canyon. Conspicuous in these areas are *Prunus angustifolia*, *Artemisia filifolia*, *Mentzelia nuda*, *Eriogonum annuum*, *Dalea lanata*, *Cenchrus longispinus*, *Cycloloma atriplicifolium*, *Chamaesyce missurica*, *Euphorbia hexagona*, *Palafoxia sphacelata*, *Helianthus petiolaris*, *Heliotropium convolvulaceum*, *Polanisia dodecandra*, *Amaranthus arenicola*, *Chenopodium leptophyllum*, and *Sporobolus cryptandrus*, *Andropogon hallii*, *Triplasis purpurea*, *Panicum capillare*, and other grasses.

Drainages or other erosional features that are cut through the sandhills into the dolomite strata usually support a flora similar to that of the slopes—common woody species are *Artemisia ludoviciana*, *Mimosa borealis*, *Rhus aromatica*, and *Vitis acerifolia*.

## 2. SANDY VALLEY BOTTOMS

Gently sloping valleys and broad flats characteristically are filled with sand recently derived from immediately surrounding, easily eroding Permian “redbed” slopes. Such ‘valley fill’ areas are conspicuous in the Bates Canyon-Alibates area and the Plum Creek



area. They commonly are dominated by grasses, especially *Panicum obtusum* and *Pascopyrum smithii*, with *Sporobolus cryptandrus*, *Setaria leucopila*, and *Bouteloua curtipendula* in lesser abundance. Other common species are *Grindelia ciliata*, *Centaurea americana*, *Euphorbia davidii*, *Croton texensis*, *Eriogonum annuum*, *Cucurbita foetidissima*, *Solanum elaeagnifolium*, *Gaillardia pulchellus*, *Symphyotrichum ericoides*, *Tidestromia lanuginosa*, *Bassia scoparia*, *Ipomoea leptophylla*, *Asclepias latifolia*, *Proboscidea louisianica*, *Kallstroemia parviflora*, *Argythamnia humilis*, *Hoffmannseggia glauca*, *Amaranthus blitoides*, *Amaranthus retroflexus*, *Chenopodium berlandieri*, *Bouteloua hirsuta*, *Bouteloua pectinata*, *Eragrostis cilianensis*, and *Muhlenbergia* sp.

### 3. GRAVELLY SLOPES

This is the “gravelly slope” category of Wright and Meador (1979) — “ridges, knolls, and undulating areas of the uplands with gentle to moderately steep slopes.” These slopes, like the sandhills, lie above the dolomite caprock and are part of the Ogallala Group (Ogallala Group: Clarendon Formation – Pliocene), but the soil is a calcareous, gravelly loam “formed in stratified outwash beds of quartz gravel and sand” (Wright & Meador 1979, p. 20). Our observations are from the Sanford-Yake area. The “gravelly slopes” flora is similar to that of the steep slopes but species diversity is lower and the woody component is less evident. The dominant species are *Gutierrezia sarothrae*, *Yucca glauca*, *Mimosa borealis*, *Dalea formosa*, *Tetranneuris scaposa*, *Bouteloua curtipendula*, and *Bouteloua gracilis*. Other common species are *Ambrosia psilostachya*, *Berlandiera lyrata*, *Chaetopappa ericoides*, *Gaillardia pulchella*, *Machaeranthera pinnatifida*, *Machaeranthera tanacetifolia*, *Plantago patagonica*, *Croton texensis*, *Chamaesyce lata*, *Sphaeralcea coccinea*, *Lesquerella ovalifolia*, *Salsola tragus*, *Aristida purpurea*, *Bouteloua eriopoda*, *Bouteloua hirsuta*, *Buchloe dactyloides*, and *Muhlenbergia asperifolia*.

### 4. DOLOMITE CAPROCK

Surface exposures of white dolomite caprock (Quartermaster Group: Alibates Dolomite Formation – Permian), often flat or gently sloping, support characteristic communities similar to the red slope communities. In general, fewer species occur in the shallow soil accumulations and crevices of these limited areas, and several species

occur here that are uncommon on the slopes. The most common and characteristic species of the dolomite caprock community are *Dalea formosa*, *Mimosa borealis*, *Yucca glauca*, *Minuartia michauxii* var. *texana*, *Paronychia jamesii*, *Eriogonum longifolium*, *Tetranneuris scaposa*, *Gutierrezia sarothrae*, *Calylophus hartwegii* var. *pubescens*, *Tragia ramosa*, *Krameria lanceolata*, and *Aristida fendleri*. *Cercocarpus montanus* and *Tetranneuris acaulis* occur only on the caprock (and gypsum, in the LAMR area) and are very local in occurrence. *Calylophus hartwegii* var. *pubescens* and *Minuartia michauxii* var. *texana* also apparently are more or less restricted to the surface exposures of caprock. Other species commonly found in the caprock community are these: *Erioneuron pilosum*, *Panicum hallii*, *Chaetopappa ericoides*, *Machaeranthera pinnatifida* var. *pinnatifida*, *Melampodium leucanthemum*, *Thelesperma filifolium* var. *intermedium*, *Zinnia grandiflora*, *Comandra umbellata*, *Chamaesyce fendleri*, *Chamaesyce lata*, *Echinocereus reichenbachii*, *Opuntia polyacantha*, *Oenothera macrocarpa* subsp. *incana*, *Polygala alba*, *Rhus aromatica*, and *Yucca glauca*. *Opuntia leptocaulis*, *Opuntia phaeacantha*, and *Krascheninnikovia lanata* are conspicuous species also recorded from caprock communities but they are local in occurrence and occur in other communities as well.

## 5. RED SLOPES

Slopes of soft red sandstone and shale (Quartermaster Group: Whitehorse Sandstone – Permian) strewn with white dolomite boulders and fragments from decomposition of the upper caprock are a prominent feature over much of the park. The most abundant and conspicuous woody species of the red slopes, depending on slope aspect, are *Dalea formosa*, *Artemisia ludoviciana*, *Rhus aromatica*, *Ptelea trifoliata*, *Mimosa borealis*, *Forestiera pubescens*, *Vitis acerifolia* (in moist areas), *Juniperus monosperma* (locally common in the southeastern part of the park), and *Prosopis glandulosa* (scattered). Characteristic herbaceous species are *Gutierrezia sarothrae*, *Chaetopappa ericoides*, *Cirsium undulatum*, *Erigeron modestus*, *Hymenopappus tenuifolius*, *Liatris punctata*, *Solidago petiolaris*, *Tetranneuris scaposa*, *Hedeoma drummondii*, *Penstemon fendleri*, *Penstemon albidus*, *Evolvulus nuttallianus*, *Eriogonum longifolium*, *Calylophus serrulatus*, *Oenothera macrocarpa* subsp. *incana*, *Polygala alba*, *Comandra umbellata*, *Chamaesyce fendleri*, *Chamaesyce lata*,

*Tragia ramosa*, *Gilia rigidula*, *Lesquerella gordonii*, *Lesquerella ovalifolia*, *Mentzelia oligosperma*, *Krameria lanceolata*, *Astragalus lotiflorus*, *Astragalus missouriensis*, *Astragalus mollissimus*, *Oxytropis lambertii*, *Pediomelum linearifolium*, *Astragalus gracilis*, *Pascopyrum smithii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua hirsuta*, *Bouteloua pectinata*, and *Schizachyrium scoparium*. *Echinocereus reichenbachii* and *Opuntia polyacantha* are common cacti.

The ALFL “gravelly hills site” of Bell et al. (2000) is included in our “red slopes” community. The basic substrate is the same as the steeper slopes—the red sandy-clay directly derived from the Whitehorse Formation—but the dolomite rocks are absent on low hills (“gravelly slopes”) much below the caprock level. Plant associations on these low hills are essentially similar to those of the steeper slopes but lack a set of species that apparently are calciphilic (e.g., *Gilia rigidula*, *Astragalus gracilis*, *Tragia ramosa*, others etc.), perhaps reflecting the lack of influence of the disintegrating dolomite. The ‘steep slope’ community of Wright and Meador (1979), as well as part of their ‘gravelly slope’ association, is included within the ‘red slopes’ community. On the steepest slopes, which form the margins of the Canadian River ‘breaks,’ recurring landslides and erosion apparently prevent all but few species from holding to life.

## 6. GYPSUM OUTCROPS

Large exposures of gypsum (Quartermaster Group: Cloud Chief Gypsum Formation – Permian) occur in the Plum Creek area. The very sparse vegetation on these outcrops apparently is primarily due to the nature of the substrate, but ORV use across some of the Plum Creek outcrops apparently has eliminated portions of the flora. Other smaller accessible areas of gypsum or gypseous outcrops have been studied in Cedar Canyon, McBride Canyon, Spring Canyon picnic area, and the Rosita area. Transitions are generally sharp between the gypsum communities and adjacent habitats and communities (on steep red slopes and sand). The common gypsum-occurring species (in the park and immediately outside of it) are *Aristida purpurea*, *Calylophus hartwegii* var. *fendleri*, *Calylophus serrulatus*, *Lithospermum incisum*, *Hymenopappus filifolius*, *Phacelia integrifolia*, *Sporobolus cryptandrus*, and *Schizachyrium scoparium*. Other species include *Chamaesyce fendleri*, *Chamaesyce lata*, *Coryphantha vivipara*,

*Echinocereus reichenbachii*, *Opuntia phaeacantha*, *Oenothera macrocarpa* subsp. *incana*, *Oenothera macrocarpa* subsp. *oklahomensis*, *Mentzelia nuda*, *Mirabilis linearis* var. *subhispidata*, *Allionia incarnata*, *Asclepias engelmanniana*, *Dalea arenicola*, *Dalea candida*, *Dalea tenuiloba*, *Polygala alba*, *Hedyotis nigricans* var. *papillacea*, *Echinacea angustifolia*, *Gaillardia pinnatifida*, *Haploesthes greggii*, *Hymenopappus tenuifolius*, *Liatris punctata*, *Machaeranthera tanacetifolia*, *Melampodium leucanthemum*, *Psilostrophe villosa*, *Tetraneuris acaulis*, *Tetraneuris scaposa*, *Thelesperma megapotamicum*, *Bouteloua curtipendula*, and *Aristida fendleri*. Species that may be considered “gypsum indicators” (observed only on gypsum outcrops) are *Phacelia integrifolia*, *Allionia incarnata*, *Oenothera macrocarpa* subsp. *oklahomensis*, *Calylophus hartwegii* var. *fendleri*, *Haploesthes greggii*, and *Hymenopappus filifolius*.

*Mentzelia decapetala* and *Eriogonum jamesii* are uncommon in LAMR—they apparently are restricted to sites with eroding red slopes and little competition from other plant species. Narrow veins of gypsum at these sites or the close proximity of larger gypsum deposits suggest that these species of *Mentzelia* and *Eriogonum* are gypsophiles, although they have not been observed growing directly on the gypsum outcrops.

## 7. RIVER AND CREEK SIDES

Riparian habitats vary in width and in species diversity. Some have broad, sandy terraces such as McBride Creek, Chicken Creek, and Big Blue Creek. Others are narrow bands along relatively small tributaries with permanent flow, such as Spring Creek (Spring Canyon) and an unnamed creek tributary to Big Blue Creek.

### Riparian of larger tributaries

Along the larger drainages, in the wettest habitats are *Schoenoplectus pungens*, *Juncus torreyi*, *Phragmites australis*, and *Typha domingensis*. On the lowest terraces, usually in moist sand, are *Equisetum laevigatum* and *Apocynum cannabinum*. Slightly higher are *Populus deltoides* var. *monilifera*, *Salix nigra*, *Sapindus drummondii*, *Prunus angustifolia*, *Celtis reticulata*, *Rosa woodsii*, *Rosa arkansana*, *Vitis acerifolia*, *Toxicodendron rydbergii*, *Rhus aromatica*, *Salix interior*, *Salix exigua*, *Salix amygdaloides*, *Glycyrrhiza lepidota*, and

*Amorpha fruticosa*. Several species of grass are common: *Tridens flavus*, *Panicum virgatum*, *Sorghastrum nutans*, *Leersia oryzoides*, *Dichanthelium acuminatum*, *Echinochloa crus-galli*, *Elymus canadensis*, and *Schizachyrium scoparium* (upper terraces). More or less typical sand communities (see above, "Sandhills and Sand Flats") may develop on upper terraces.

### Sedge meadows and corridors

Along relatively narrow channels of permanent or seasonal flow, sedge meadows (dominated by Cyperaceae) are characteristic, with *Eleocharis montevidensis*, *Eleocharis rostellata*, *Schoenoplectus pungens*, *Fuirena simplex*, *Dichanthelium acuminatum*, *Polypogon monspeliensis*, *Polypogon viridis*, *Sphenopholis obtusata*, and other grasses, *Equisetum laevigatum*, *Ranunculus sceleratus*, *Cicuta maculata*, *Berula erecta*, *Lycopus americanus*, *Verbena hastata*, *Lobelia cardinalis*, *Strophostyles leiosperma*, *Apocynum cannabinum*, *Oenothera jamesii*, *Pluchea odorata*, *Pyrrhopappus pauciflorus*, *Bidens frondosa*, *Vernonia baldwinii*, and *Solidago gigantea*. This plant association grades into that of the wider, sandy channels or may be abruptly distinct. Accessible examples of narrow channels with sedge meadows (or margins) are upper Mullinaw Creek, parts of upper Spring Creek, Chicken Creek, and Bugbee Creek.

### Cottonwood gallery forest

A stand of mature, closely spaced cottonwoods (*Populus deltoides* var. *monilifera*, averaging about 80 feet tall, over an area of about five acres, occurs along the east terrace of the Canadian River, just north of the mouth of Chicken Creek. Numerous individuals of *Celtis reticulata* form an understory less than half the height of the cottonwoods. *Rhus aromatica* forms a distinct shrub layer, with scattered *Ribes aurea*, *Forestiera neomexicana*, *Vitis acerifolia*, *Prunus angustifolia*, *Prunus virginiana*, *Cephalanthus occidentalis*, and *Opuntia* aff. *macrorhiza*. *Parthenocissus vitacea* is a common vine. Common herbaceous species are *Panicum virgatum*, *Vernonia baldwinii*, *Tripsacum dactyloides*, and *Commelina erecta*. As far as known (fide J.W. Phillips, Fritch), this is the only large "gallery" stand of such large cottonwoods inside the park. Large (areal) cottonwood stands occur elsewhere in the Canadian River bottomland, and a

distinctive, extensive stand of small, relatively widely spaced cottonwood trees occurs over clay soil in the Rosita Creek bottomland.

### Hackberry-soapberry dry woodland

On slightly higher creek and river terraces, a woodland similar in composition to the cottonwood gallery sometimes occurs, but the tall cottonwoods are absent. Cottonwoods are scattered on lower terraces. The canopy of these dry woodlands is dominated by *Celtis reticulata* (along the north side of lower Chicken Creek) or *Sapindus drummondii* (in lower McBride Canyon, Plum Creek, Big Blue Creek). *Rhus aromatica* forms a distinct subcanopy/shrub layer, with scattered *Ptelea trifoliata*, *Forestiera pubescens*, *Ribes aurea*, and *Juniperus monosperma*. Abundant *Artemisia filifolia* forms a lower shrub layer. *Opuntia macrorhiza*, *Cirsium ochrocentrum*, and various grasses are common.

## 8. LAKESHORE

On the exposed banks (sandy clay) of the immediate lake shore, various species appear as first colonizers. Where fluctuation of the water level is greatest (newly exposed substrate), the most common among these species are *Bassia scoparia*, *Salsola tragus*, *Salsola collina*, *Heliotropium curassavicum*, *Chenopodium glaucum*, *Chenopodium berlandieri*, *Chenopodium pratericola*, *Cycloloma atriplicifolia*, *Tamarix ramosissima*, *Schoenoplectus pungens*, *Schoenoplectus maritimus*, *Polygonum amphibium*, *Polygonum arenastrum*, *Polygonum ramosissimum*, *Panicum capillare*, *Echinochloa crus-galli*, *Leptochloa fascicularis*, *Cyperus odoratus*, *Sporobolus texanus*, *Symphotrichum divaricatum*, *Pluchea odorata*, *Eclipta prostrata*, and *Sonchus asper*. Slightly higher on the reddish lakeshore alluvium are *Cynodon dactylon*, *Distichlis spicata* var. *stricta*, *Baccharis salicina*, *Grindelia ciliata*, *Populus deltoides* var. *monilifera*, *Salix interior*, and *Salix amygdaloides*.

Where the slope of the shore is less steep, sandy terraces may be present and species segregate ecologically in dense stands. In the lowest and wettest areas, where the lake shores grade into marsh, *Typha domingensis* occurs in extensive stands, exclusive of all other species; colonies of *Phragmites australis* may be intermixed. *Baccharis salicina*, *Populus deltoides* var. *monilifera*, *Tamarix ramosissima*,

*Panicum virgatum*, *Distichlis spicata* var. *stricta*, *Chenopodium berlandieri*, *Conyza canadensis*, and *Ambrosia psilostachya* occur slightly further upslope on sandy terraces. *Prunus angustifolia* may occur in moist microsites.

Floating aquatics apparently are uncommon in the lake, but a population of *Ranunculus trichophyllus* occurs in a shallow inlet at Cedar Canyon and *Myriophyllum spicatum* occurs in abundance at various sites: along the N-facing shore below the Sanford-Yake picnic area and other coves around the lake, including Harbor Bay, Bugbee Canyon, and Cedar Canyon.

The overlapping “lakeshore,” “marsh,” and “riparian” communities as described here are all treated within the “bottomland association” of Wright and Meador (1979), who noted that this association represents a “mosaic of microcommunities corresponding to a mosaic pattern of habitats.” The discrete divisions represented in our analysis can be seen in many places, but intergradation is common and the mosaic pattern is the predominant feature at other sites. A relatively easily accessible place to observe an extreme mosaic is in the Canadian River bottom in the area of the McBride Creek entrance.

The “sandy and loamy bottomland sites” category of Bell et al. (2000) appears to combine our ‘riparian’ and “sandhills and sand flats” categories.

## 9. MARSH

Marsh habitat is common on the south end of the lake, where water levels are shallow and the lake is commonly not even filled. Extensive areas of *Typha domingensis*, exclusive of all other species, occur in various areas of the Canadian River bottom, and *Typha* populations of various sizes fill or line stream channels in many places (e.g. Mullinaw Canyon, Chicken Creek). A large *Typha* marsh is easily accessible to the northeast of the Bates Canyon boat ramp. An extensive marsh also begins relatively abruptly immediately below Sanford Dam—dominated by *Typha domingensis* and *Schoenoplectus pungens* in areas of deeper water, with *Phragmites australis* and *Chloracantha spinosa* around the edges.

In shallow but wet areas, *Schoenoplectus pungens*, *Schoenoplectus maritimus*, *Eleocharis montevidensis*, *Eleocharis rostellata*, *Polypogon monspeliensis*, *Phragmites communis*, *Distichlis spicata* var. *stricta*, *Puccinellia fasciculata*, *Sporobolus texanus*, *Sphenopholis obtusata*, *Pluchea odorata*, *Rayjacksonia annua*, *Suaeda calceoliformis*, *Flaveria campestris*, *Symphyotrichum expansum*, and *Atriplex patula* grow intermixed. Narrow channels with floating *Lemna valdiviana* and lined with *Typha domingensis* and *Schoenoplectus pungens* interlace through the shallower areas. *Zannichellia palustris* and *Potamogeton pectinatus* occur in deeper channels and pools. *Baccharis salicina*, *Tamarix ramosissima*, and *Distichlis spicata* var. *stricta* are characteristic of slightly higher ground of hummocks or periodically dry margins of the marsh. Shrubby *Salix interior* and *Salix exigua* also may form dense colonies in slightly raised, sandy sites within an otherwise marshy area.

In areas where shallow water has evaporated (by mid June) to leave a salty crust, *Distichlis spicata* var. *stricta*, *Suaeda calceoliformis*, *Rayjacksonia annua*, and several others constitute the few species growing there. Small salt flats such as these are evident on the northeast side of Spring Lake (below Sanford Dam).

## 10. BORROW AREA

On the northwest side of Sanford Dam, between North Canyon and Hwy 1319, large amounts of rock and soil were removed ca. 1962-1968 for construction of the dam. This area is now relatively flat, consistently scraped down to a level of reddish sandstone and sandy clay within the Whitehorse Formation and naturally revegetated over the last 40 years. *Prosopis glandulosa* is the dominant shrub/small tree of the borrow area; *Tamarix angustissima* is scattered through the habitat. Common subshrubby and herbaceous species are *Gutierrezia sarothrae*, *Symphyotrichum ericoides*, and the grasses *Bothriochloa ischaemum*, *Bouteloua curtipendula*, and *Sporobolus cryptandrus*. Others are *Grindelia ciliata*, *Dalea enneandra*, *Heterotheca stenophylla*, *Solanum elaeagnifolium*, *Desmanthus illinoiensis*, *Opuntia macrorhiza*, *Bothriochloa laguroides*, *Aristida fendleri*, and *Buchloe dactyloides*. In some areas along the east side of the borrow (almost certainly with gypseous substrate), *Isocoma pluriflora* is a dominant subshrub and the most conspicuous floristic element.



## 11. LAWNS and MOWED ROADSIDES

Lawns and periodically closely mowed roadsides occur in the sandy soils in the vicinity of Ranger Station and the Water Control Authority headquarters. Common species of these sites and others are *Bromus catharticus*, *Bromus japonicus*, *Buchloe dactyloides*, *Cenchrus longispinus*, *Cynodon dactylon*, *Hordeum pusillum*, *Chamaesaracha sordida*, *Descurainia pinnata*, *Descurainia sophia*, *Erodium cicutarium*, *Salsola tragus*, *Bassia scoparia*, *Evax prolifera*, *Evolvulus arvensis*, *Portulaca pilosa*, *Sphaeralcea coccinea*, *Plantago patagonica*, and *Verbena bracteata*. Other relatively common species are *Cryptantha minima*, *Eragrostis cilianensis*, *Elymus elymoides*, *Aphanostephus ramosissimus*, *Taraxacum officinale*, *Lactuca serriola*, *Tragopogon dubius*, and *Verbena pumila*.

Several species of trees are planted and healthy along the fenceline on the north side of the LAMR Ranger Station: *Fraxinus pennsylvanica*, *Morus alba*, and *Maclura pomifera*. *Thuja occidentalis* is planted at the 'check station' at the Cedar Canyon/Sanford-Yake road junction.

## 12. OLD HOMESITES

Near the west end of NPS property in Plum Creek Canyon, in the immediate vicinity of Plum Creek campground, concrete slabs and planted lines of cottonwood (*Populus deltoides* var. *monilifera*) and American elm (*Ulmus americana*) mark the site of an old ranch house. Individuals of *Ulmus americana*, *Ulmus pumila*, *Morus alba*, *Maclura pomifera*, and *Gleditsia triacanthos* apparently were planted in the close vicinity of the house, probably ca. 1920-1930. We did not observe successful reproduction by any of these non-native tree species, but all except the *Gleditsia* appear to be vigorous and healthy. All individuals are on or slightly above the upper terrace of the creek. Also in the close vicinity of the homesite (in a narrow draw, mixed with *Sapindus*) is the only known LAMR-ALFL occurrence for *Juglans microcarpa*, but this species (represented by two individuals) apparently occurs naturally here.

Another residence, about the same age as the one at Plum Creek, was located near the mouth of Chicken Creek. A large, healthy

tree of *Ulmus pumila* persists at this site, on a low, sandy bluff on the north side of the creek; we located two smaller individuals of the same species, ca. 5 meters and 8 meters tall, within the cottonwood gallery forest about 100 meters from the cultivated tree—these smaller ones almost certainly arose spontaneously from seeds of the persistent parental individual. In areas close to the town of Fritch, *U. pumila* is extremely abundant as a naturalized colonizer.

### ACKNOWLEDGEMENTS

We are grateful to J.W. Phillips, of Fritch, Texas, for pointing us to interesting sites within LAMR and guiding us to others.

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**CRYPTANTHA GEOHINTONII (BORAGINACEAE), A NEWLY DESCRIBED GYPSOPHILE FROM NUEVO LEON, MEXICO****Billie L. Turner**Plant Resources Center  
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Routine identification of Mexican plants has revealed the following novelty from gypsum outcrops in southern Nuevo Leon, Mexico:

**CRYPTANTHA GEOHINTONII** B.L. Turner, sp. nov. **Fig. 1**

*Cryptantha gypsites* I.M. Johnst. similes sed trichomatibus caulinis patentibus (vs patentibus et appressis), spicis floralibus longioribus (5-8 cm longis vs 1-4 cm). scapis styliaribus brevioribus (ca 0.5 mm longis vs 0.6-0.8 mm), et mericarpiis labra distincte evoluta carentibus.

**Perennial herbs**, much-branched from the base and forming low bushy, somewhat rounded herbs 8-12 cm high. **Stems** pubescent with stiff white spreading hairs ca 1 mm long, appressed hairs essentially absent. **Leaves** at mid-stem lanceolate, sessile, mostly 6-8 mm long, 1-2 mm wide, pubescent like the stems. **Flowering spikes** mostly 5-8 cm long; bracts lanceolate, 4-6 mm long; flowers sessile or nearly so. **Calyx** of 5 separate lanceolate sepals 2.2-2.4 mm long. **Corollas** white, ca 2 mm long (with lobes erect); lobes flared, ca 0.5 mm long. **Anthers** 5, ca 0.4 mm long, nestled at the throat of the tube. **Style** ca 0.5 mm long at anthesis; in fruit the style extending beyond the mericarps for ca 0.2 mm. **Mericarps** (or nutlets) trianguloid, ca 1.5 mm long, 1.0 mm wide, weakly flanged, if at all, the outer surface ornamented with numerous irregularly shaped white warts.

TYPE: MEXICO. NUEVO LEON: **Mpio. Mina**, NE of Carricitos ("26. 01386 N, 100. 47018 W"), 23 Jul 2007, *Hinton et al.* 28655 (Holotype: TEX).

ADDITIONAL SPECIMENS EXAMINED: MEXICO. NUEVO LEON: **Mpio. Mina**, Gypsum hillside, W of Los Molina, 943 m, 23 Jul 2007, *Hinton et al.* 28616 (Hinton herb.); Gypsum hillside, NE of Carricitos, 965 m, 23 Jul 2007, *Hinton et al.* 28635 (Hinton herb.); 10.5 km N of Rancho Las Estacas on road to Rancho Lechuguillal (26.26 N, 100.50 W), 685 m, 16 Mar 1973, *Johnston et al.* 10255e (LL); 1 km W of Rancho Potrillos in Canon de Potrerillos (26.03 N, 100.45 W), 850 m, 17 Mar 1973, *Johnston et al.* 10246 (LL); 105 km NW of Monterrey on road to Monclova, 3 Sep 1971, *Turner* 6375 (TEX).

The new species occurs on gypsum outcrops about 55 airline km northwest of Monterrey. Near the type locality there are two large gypsum outcrops about 5.5 km apart and covering a total of 3.5 hectares, as noted by Nesom (2007) in his description of the gypsophile, *Erigeron heleniae*. He further notes (pers. comm.) that this area of outcrops probably is the total extent of the range of the two taxa concerned

When first examined I took material of this species to be aberrant forms of the oft collected *C. gypsites*, which it superficially resembles. George Hinton prevailed upon me to take a second look, especially at the fruit characters, calling to my attention the absence of well-defined flanges or lateral ridges on the mericarps of *C. geohintonii*, this character holding up well as a discriminatory feature, along with yet others mentioned in the above diagnosis.

*Cryptantha geohintonii* and *C. gypsites*, both relatively localized gypsophiles, are closely related to the widespread *C. mexicana*, the latter having smaller corollas, with much smaller lobes, shorter stylar shafts, somewhat smaller nutlets and stems with more appressed hairs, as indicated in the following key:

1. Corollas 1.0-1.2 mm long, the lobes not especially flaring; stylar shaft just barely extending beyond the mature nutlets; mostly spring-flowering.....**C. mexicana**

1. Corollas 2.0-2.5 mm long, the lobes markedly flaring; stylar shafts extending beyond the mature nutlets for 0.5-0.8 mm; nutlets w/o lateral ridges; mostly fall-flowering.....(2)
2. Nutlets with very distinct lateral ridges; pubescence of lower stems composed of both spreading and appressed hairs; gyp soils S of Monterrey.....**S. gypsites**
2. Nutlets w/o distinct lateral ridges; pubescence of lower stems mostly stiffly-spreading, appressed hairs few, if any; gyp soils NW of Monterrey (Mpio. Minas).....**S. geohintonii**

Distributions of the several taxa discussed in the above are shown in figures 2 and 3.

The species name refers to George S. Hinton, grandson of the legendary Mexican plant collector, George B. Hinton (cf. Hinton and Turner 2007). As noted in the above, *Cryptantha geohintonii* joins another newly described species from the same area of gypsum outcrops: *Erigeron heleniae* (Nesom 2007), named for George S. Hinton's mother.

### ACKNOWLEDGEMENTS

I am grateful to George Hinton for forcing my attention upon the taxon concerned, and to my colleague Guy Nesom for the Latin diagnosis and for additional comments on the manuscript itself. Distribution maps are based upon collections on file at LL, TEX.

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Fig. 1. *Cryptantha geohintonii*, growing in the field.

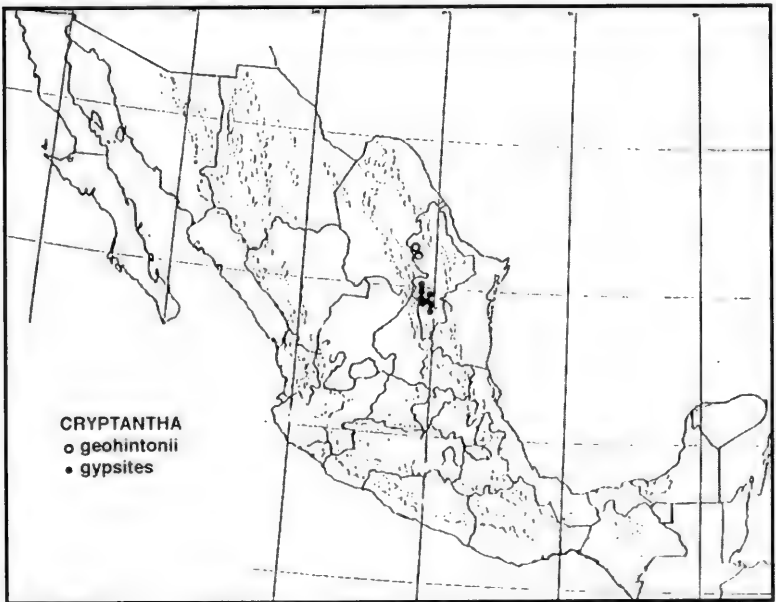


Fig. 2. Distribution of *Cryptantha gypsites* and *C. geohintonii*.

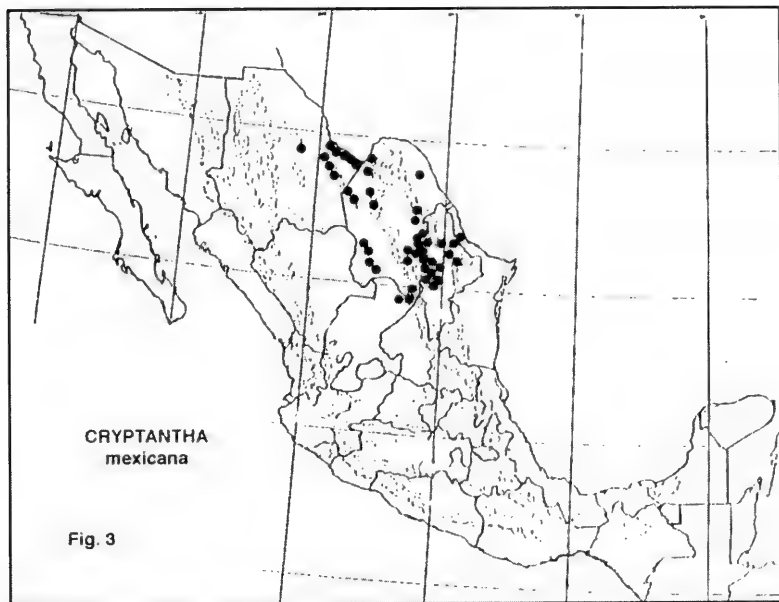


Fig. 3. Distribution of *Cryptantha mexicana*.



**TAXONOMIC STATUS OF *CLINPODIUM MACROSTEMUM*  
(LAMIACEAE)**

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**ABSTRACT**

*Clinopodium macrostemum* (Benth.) Kuntze was long treated as a member of the large genus *Satureja*. Recent DNA studies (Cantino and Wagstaff 1998) suggest that it is best treated as a member of the genus *Clinopodium*. Appropriate transfers of the six or so Mexican species that relate to the latter have been made by various authors, all of these lacking infraspecific taxa. Two varieties have been recognized within *C. macrostemum*, one of these requiring a formal name change, which is provided herein. An accounting of their biological and geographical status is also provided. *Phytologia* 90(3): 411-413 (December, 2008).

**KEY WORDS:** Lamiaceae, *Satureja*, *Clinopodium*, Mexico

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***Clinopodium macrostemum* var. *laevigatum* (Standl.) B.L. Turner, comb. nov.**

Based on *Clinopodium laevigatum* Standl., Contr. U. S. Nat. Herb. 23: 1273. 1924.

*Satureja laevigata* (Standl.) Standl.

*Satureja macrostema* var. *laevigata* (Standl.) McVaugh & Schmid

*Clinopodium macrostemum* is a relatively widespread species of the more montane regions of western Mexico. The taxonomy of the complex was treated in considerable detail by McVaugh & Schmid (1967). The latter authors recognized two infraspecific taxa within its fabric, a relatively restricted var. *macrostemum* and a very widespread var. *laevigatum*, the latter delimited almost entirely by its glabrous primary stems and foliage. A map showing the distribution of the two

taxa was also provided, along with comments regarding their taxonomic status.

The authors stated that the var. *laevigatum* "can under no circumstances be considered an independent species, as we cannot distinguish it from *Satureja macrostema* in any way except by the amount of pubescence on vegetative parts." They further noted that the typical var. *macrostema* was restricted to a small area of south-central Mexico, but that both varieties occasionally occur together or near each other. Lastly, they stated that "Because of the almost completely allopatric distribution of the glabrous and pubescent extremes, we suppose they have evolved separately, to the extent that they may be recognized as varieties of a single species."

Their Fig. 3, showing the distribution of the two taxa, records their co-occurrence in at least three populations, two of these removed from the more restricted geographical region of var. *macrostema*. I have included herein a new map (Fig.1) of the distribution of the taxa concerned, this based upon their records and those at LL, TEX; noteworthy is the range extension of var. *macrostema* to the state of Oaxaca (*Breedlove & Almeda 60149; Hinton et al. 26009*). Indeed, the two taxa co-occur in the Municipio of Miahuatlan, Oaxaca, but label data suggest that the var. *macrostema* occurs at somewhat lower elevations (ca 2200 m vs. ca 2900 m). Nevertheless, I concur with the observations of McVaugh and Schmid: the two taxa are weakly differentiated and show signs of intergradation in regions of contact, this possible due to hybridizations. Alternatively, the glabrous individuals may be no more than local populational forms of a widespread, mostly glabrous *Clinopodium macrostema*. Additional field studies will be needed to resolve the problem.

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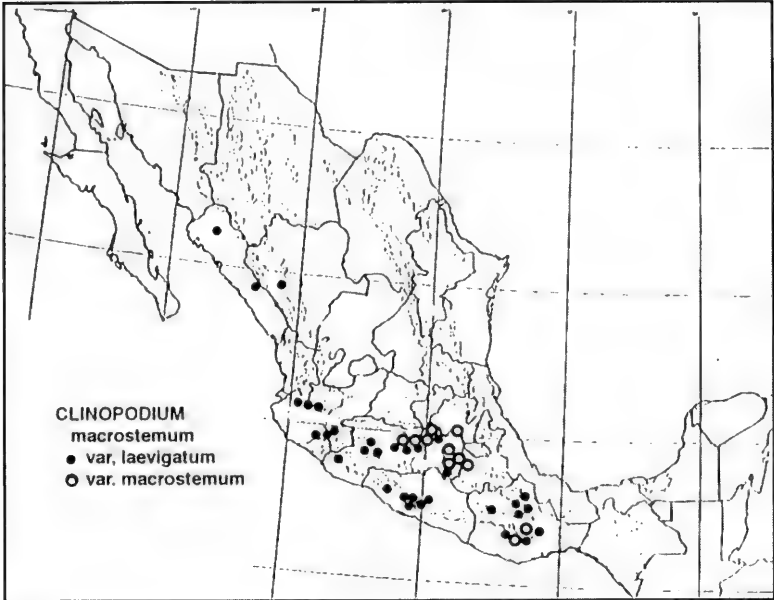


Fig. 1. Distribution of the *Clinopodium macrostemum* complex.

**VULPIA OCTOFLORA (WALTER) RYDBERG VAR. TENELLA  
(WILLDENOW) FERNALD: THE CORRECT NAME FOR  
WHAT HAS BEEN CALLED VULPIA OCTOFLORA (WALTER)  
RYDBERG VAR. GLAUCA (NUTTALL) FERNALD**

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*Phytologia* 90(3): 414-415 (December, 2008).

When Nuttall published *Festuca tenella* Willdenow var. *glauca* Nuttall (Trans. Amer. Philos. Soc. 5:147. 1837), the autonym var. *tenella* was created (Articles 26.3 & 32.6, ICBN 2000). The var. *tenella* has priority over the name (var. *glauca* Nuttall) that created it (Article 11.6, ICBN). If these two taxa are merged taxonomically and the names synonymized, as done by Lonard (1974, 2007) and nearly all subsequent workers, then the correct name and synonymies for this taxon at the varietal rank are as follows:

**Vulpia octoflora** (Walter) Rydberg var. **tenella** (Willdenow) Fernald, *Rhodora* 47:107. 1945.

*Festuca tenella* Willdenow var. *tenella*, Trans. Amer. Philos. Soc. 5:147. 1837, created by the publication of *Festuca tenella* Willdenow var. *glauca* Nuttall. *Vulpia tenella* (Willdenow) Heynhold, Nom. 1:854. 1840. *Festuca octoflora* Walter var. *tenella* (Willdenow) Fernald, *Rhodora* 34:209. 1932.

*Festuca tenella* Willdenow var. *glauca* Nuttall, Trans. Amer. Philos. Soc. 5:147. 1837. *Festuca octoflora* Walter var. *glauca* (Nuttall) Fernald, *Rhodora* 34:209. 1932. *Vulpia octoflora* (Walter) Rydberg var. *glauca* (Nuttall) Fernald, *Rhodora* 47:107. 1945.

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**NEW SUPRAGENERIC NAMES FOR  
VASCULAR PLANTS****Alexander Doweld**

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**ABSTRACT**

Five suprageneric names in current use are validated formally:  
Peridisciales, Ixerbaceae, Lophiocarpaceae, Saccolomataceae, and Stixaceae.  
*Phytologia* 90(3): 416-417 (December, 2008).

**KEY WORDS:** Peridisciales, Ixerbaceae, Lophiocarpaceae, Saccolomataceae, Stixaceae

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An unanticipated delay in publication by Doweld of a summary of the classification of plants in a broad sense requires publication of five suprageneric names presently in current use (Thorne & Reveal 2007; Smith et al. 2006) so that they might be used. Justification and placement of these taxa are found in the above publications.

**Peridisciales** Doweld, **ord. nov.**

Based on a full and direct reference to the description in Latin associated with *Peridiscaceae* Kuhl. in *Arq. Serv. Florest.* 3: 4. 1950, *nom. cons.*

**Ixerbaceae** Griseb. ex Doweld & Reveal, **fam. nov.**

Arbor glabra, ramis teretibus rugosis; folia opposita, alterna et subverticillata, coriacea, sempervirentia, lineari-elongata, glanduloso-serrata; flores 5-merus, in panicula brevi pauciflora axillari; ovarium superium, 5-lobum, 5-loculare, styli 5; capsula coriacea, dehiscens loculicide, semina 1-2 per loculum.

**Lophiocarpaceae** Doweld & Reveal, **fam. nov.**

Frutex vel herbae; folia alterna sessilia linearia, integerrima; flores hermaphroditi virides in spicis; bractae et bracteolae rhachidis persistentes

membranaceae; perianthium 5-partitum cum segmentis herbaceis persistentibus in fructu immutatis; ovarium superum substipitatum, stigmata 3-4; semina erecta.

**Saccolmataceae** Doweld, **fam. nov.**

Herbae terrestres, rhizomata repentes vel erecta aliquantum truncata; fila vascularia petioli  $\omega$ -formia; laminae pinnatae vel decompositae, articuli pilorum nulli, venae discretae; sori in venis; indusia scrotiformia vel cyathiformia.

**Stixaceae** Doweld, **fam. & stat. nov.**

Basionym: *Stixaeae* Hallier in Beih. Bot. Centralbl. 39: 26. 1923.

**ACKNOWLEDGEMENTS**

I wish to thank Billie Turner (TEX) and Guy Nesom for reviewing the paper. I am especially gratefully for Nesom's thorough review of the Latin.

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**SHARED MOLECULAR SIGNATURES SUPPORT THE  
INCLUSION OF *CATAMIXIS* IN SUBFAMILY PERTYOIDEAE  
(ASTERACEAE).**

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**ABSTRACT**

Two conserved indels and one consistent nucleotide substitution provide evidence to choose between competing hypotheses of relationship for a rare Himalayan endemic sunflower. Indel patterns in the intergenic spacer *ndhI-ndhG* of the chloroplast DNA as compared across all major lineages of Asteraceae show that *Catamixis* shares with the genera *Ainsliaea*, *Myriopsis*, and *Pertya* a 145 base pair deletion. In addition, sequence data of the chloroplast gene *matK* show that *Catamixis*, *Ainsliaea*, and *Pertya* share a mutation unique to the Pertyoideae lineage. These molecular signatures support the inclusion of *Catamixis* in subfamily Pertyoideae. *Phytologia* 90(3): 418-424 (December, 2008).

**KEY WORDS:** Rare genomic changes, conserved indels, indel pattern, molecular signature, *Catamixis*, Pertyoideae, Asteraceae, Himalayas

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*Catamixis baccharoides* is a rare shrub endemic to steep limestone canyons of the Himalayan region of north central India and westernmost Nepal and considered endangered due to habitat loss (Nayar and Ahmedullah, 1985). Because of its ligulate corollas, tailed anthers, and imbricate involucre with multiple series of phyllaries, *Catamixis* has traditionally been viewed as a member of tribe Mutisieae sensu lato (Hansen, 1991; Bremer, 1994), a grouping of some 82 genera (Hind, 2007) that has been shown in molecular phylogenetic analyses to consist of a paraphyletic grade of lineages (Panero and Funk, 2008). The name given to this monotypic genus by Thomson (1867) meaning "mixed affinity" refers to its combination of characteristics of several genera belonging to this large grade. Consequently, the position of



*Catamixis* among these lineages has not been easy to ascertain based on morphological comparisons. The genus has been variously allied to *Leucomeris* (Thomson, 1867), viewed as an isolated member of Mutisieae s.l. (Bremer, 1994; Hind, 2007), or as a member of tribe Pertyeae (Jeffrey, 2007). Perhaps owing to the rarity of tissue for analysis, no molecular phylogenetic study has yet included *Catamixis*.

To clarify the position of *Catamixis* in the tree of life of Asteraceae and distinguish between these alternative hypotheses DNA was extracted from a single leaf included in the fragment package of specimen Parker s. n. collected in northern India (HUH barcode 00263953). Although it would be desirable to amplify multiple genes and include *Catamixis* in a supermatrix analysis of phylogeny, we were unable to obtain enough high quality DNA to amplify many genes. Phylogenetic analysis of only two chloroplast DNA markers was insufficient to resolve the placement of *Catamixis* among the lineages of Asteraceae. Alternatively, we screened for rare genomic changes in short standardized DNA regions that might allow us to either eliminate or identify known clades of Asteraceae to which *Catamixis* could belong. *Catamixis* was compared with homologous sequences sampled from 108 species representing all subfamilies and tribes of Asteraceae and corresponding to the ingroup taxon sampling of Panero and Funk (2008).

## MATERIALS AND METHODS

DNA was extracted from 0.25g dried leaf material of *Catamixis* using Qiagen's DNeasy Plant Mini Kit following the manufacturer's protocol for dried leaf material. Efficacy of the DNA extract was tested empirically using standard polymerase chain reaction (PCR) protocols and primers detailed in Panero and Crozier (2003) and Panero and Funk (2008) for the following chloroplast loci: *ndhD*, *ndhF*, *rbcL*, *rpoB*, *rpoC1*, *trnT-trnL* IGS, *ndhI* gene, *ndhI-ndhG* IGS, and *matK*. PCR reactions were screened using agarose gel electrophoresis. Reactions with visible results were cleaned using QIAquick PCR purification columns and 4 microliters of each used as template DNA in cycle sequencing reactions following the protocols of the ABI Big Dye Terminator 3.1 Cycle Sequencing Kit. Cleaning of the sequencing reactions using the Millipore MultiScreen 96-Well Filtration Plate and

sequencing was performed by the University of Texas ICMB Core DNA Facility on an ABI 3730 DNA analyzer. Raw sequence data was proofread using Sequencher 4.8 (Gene Codes Corporation). *Catamixis* sequences were aligned by eye with the 108-taxon *matK* and *ndhI-ndhG* intergenic spacer alignments used in previous phylogenetic studies (Panero and Funk, 2008).

Phylogenetic trees were constructed for the 108-taxon *ndhI* and *matK* data sets individually and in combination using the maximum parsimony criterion and TBR branch swapping was implemented in PAUP\*4b10 and limiting the heuristic search to 10,000 most parsimonious trees saved. The strict consensus of each set of trees was then constructed and checked for the resolution of *Catamixis* relationships.

Indel characters observed during alignment of *Catamixis* with homologous *ndhI-ndhG* sequences of other Asteraceae were checked for character consistency (sensu Farris, 1969) when character states were optimized on the tree topology of Panero and Funk (2008) including *Catamixis* in the Pertyoideae. Observing this, the *matK* alignment was then inspected visually for nucleotide characters that might also be 100% consistent on a tree including *Catamixis* in the Pertyoideae. To confirm the visual observation, a Neighbor Joining tree based on *matK* data using the Maximum Parsimony criterion was constructed and described including a list of apomorphies for each branch using PAUP\*. The resulting list of characters supporting Pertyoideae, including *Catamixis*, was checked for phylogenetically consistent characters. Apomorphies with 100% consistency due to gaps (scored as missing data in our analysis), or those not completely consistent, were ignored.

## RESULTS AND DISCUSSION

Parsimony analysis was unable to resolve the placement of *Catamixis* to any subfamily of Asteraceae. However, rare genomic changes mapped to a statistically well-supported best estimate of Asteraceae phylogeny previously published in Panero and Funk (2008) and compared with new data for *Catamixis* revealed two phylogenetically consistent indel characters in the *ndhI-ndhG* intergenic

spacer region. Presence of a rare mutation shared consistently by members of a single clade and *Catamixis* is interpreted as evidence for the inclusion of *Catamixis* in that clade (shared ancestry). Shared insertions/deletions (indels) have provided diagnostic signatures for such identifications in the Asteraceae (Panero and Funk, 2008) and in widely divergent organisms from microbes (Gupta and Johari, 1998) to placental mammals (De Jong et al., 2003). The Asteraceae topology of Panero and Funk (2008) conveniently distinguishes between the lineages to which *Catamixis* has been historically allied, including *Leucomeris* (Wunderlichioideae: Hyalideae) and Pertyeae (Pertyoideae) as well as six other lineages of Mutisieae s. l.

Using the *ndhI-ndhG* intergenic spacer as a reference molecular marker, we were able to exclude *Catamixis* from the Gymnarrhenoideae-Asteroideae clade of Asteraceae (Fig. 1) and provide evidence in support of Jeffrey's (2007) assignment of *Catamixis* to the Pertyoideae (GenBank, Accession # FJ154843). We found that *Catamixis* lacks the 17 bp deletion located 4-20 nucleotide sites downstream of the *ndhI* stop codon that is shared by all members of the clade Gymnarrhenoideae-Asteroideae sampled in the chloroplast phylogenetic study of Panero and Funk (2008; Fig. 1). This result confirms historical hypothesis of relationships based on morphology that allied the genus to members of Mutisieae s. l. grade. Further, *Catamixis* shares with *Pertya*, two species of *Ainsliaea*, and *Myriphnois* a 145 bp deletion not found in any lineage except Pertyoideae.

In addition to the indel patterns, a phylogenetically consistent single nucleotide substitution was observed in the *matK* gene that is unique to members of Pertyoideae. This synapomorphy is found in aligned position 274 and characterized by a change from A to C in the sequences of *Ainsliaea*, *Pertya* and *Catamixis*. Alignment of the *matK* sequence of *Catamixis* (GenBank, Accession # FJ179462). in this data matrix shows that the genus shares with *Ainsliaea* and *Pertya* this diagnostic substitution.

The indel patterns and nucleotide substitution described above appear to be diagnostic of members of Pertyoideae. These allow us to predict that molecular phylogenetic studies that include broad taxonomic sampling with all members of the subfamily represented and

concomitant character sampling would also include *Catamixis* in Pertyoideae.

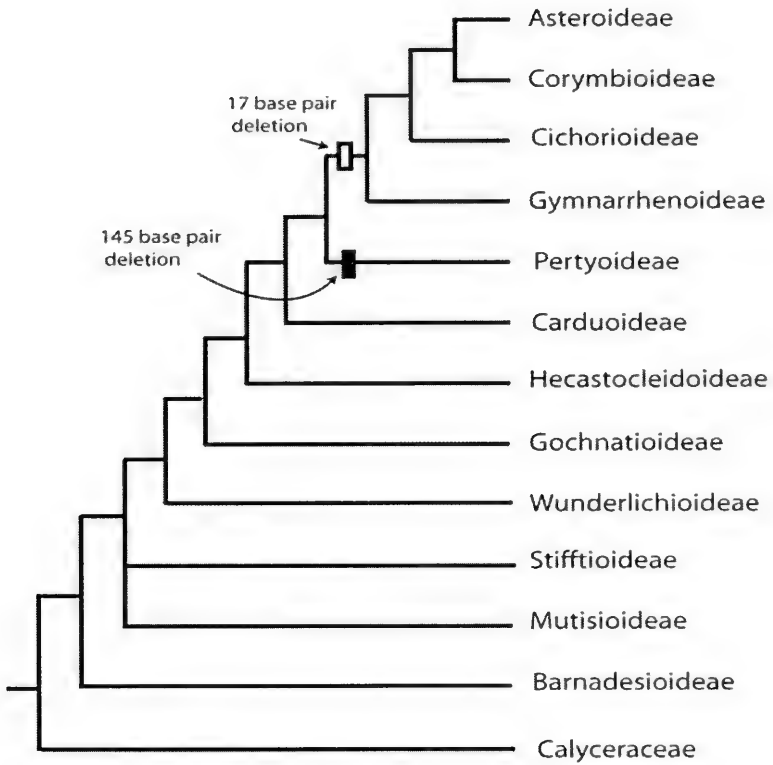


Fig. 1. *NdhI-ndhG* IGS synapomorphies mapped to the Asteraceae tree. Indel shared with *Catamixis* (solid bar) and lacking in *Catamixis* (open bar) shown on topology of Panero and Funk (2008).

With the addition of *Catamixis*, tribe Pertyeae of subfamily Pertyoideae contains six genera of perennial herbs and shrubs of eastern and central Asia including *Ainsliaea*, *Diaspananthus*, *Macroclinidium*, *Myripnois* and *Pertya*. The molecular signatures observed in the *ndhI-*

*ndhG* IGS and the *matK* gene unfortunately do not shed any light on the affinities of *Catamixis* within Pertyoideae.

### ACKNOWLEDGEMENTS

I thank James Macklin of Harvard University Herbaria for permission to remove tissue samples for DNA analysis and T. Wendt, TEX-LL herbarium curator for locating specimens of *Catamixis*. I thank Bonnie S. Crozier, Guy Nesom, B. L. Turner, and A. Schwarzbach for reviewing the manuscript. Sequencing of the *matK* and *ndhI* genes was funded by grant NSF DEB 0344116.

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**Errata**

**RECENSION OF *SALVIA* SECT. *FARINACEAE* (LAMIACEAE)**

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*Phytologia* 90(3): 425-432 (December, 2008).

The figures for the type specimens for the newly described types of four *Salvia* species were inadvertently omitted from *Phytologia* 90(2): 1163-175 (2008). These figures are presented.

***SALVIA GYPSOPHILA* B.L. Turner, sp. nov. Fig. 1, Map 3**

*Salviae rubropunctatae* B. Rob. & Fernald similis sed differt labio supero calycis 3-venoso (vs. 5-7-venoso) et tubo corollae trichomatibus non ramosis (vs. ramosis).

TYPE: **MEXICO. NUEVO LEON: Mpio. Aramberri**, "On exposed gypsum hills...about 7 miles north of La Escondida, 24 Sep 1973, *J.L. Reveal & N.D. Atwood 3421* (holotype: TEX).

***SALVIA JACALANA* B.L. Turner, sp. nov. Fig. 2, Map 4**

*Salviae jaimehintonianae* Ramamoorthy similis sed differt caulibus dense albopubescentibus trichomatibus patentibus (vs glabris vel paene glabris) et foliis pubescentibus subter secus venas (vs glabris).

TYPE: **MEXICO. HIDALGO: Mpio. Jacala**, "6.5 air km E-NE of Jacala, between Cuesta Colorado and El Pinalito on Mex 85. At a sharp bend in road. Limestone boulders covered with cacti and many ferns in woodland of pine and oak." 1700 m, 13 Jul 1991. *M Mayfield, A. Hemple & A. Jack 820* (holotype: TEX).

**SALVIA RICHARDSONII** B.L. Turner, *sp. nov.* **Fig. 3, Map 3**

*Salviae zaragozanae* B.L. Turner similis sed foliis midcaulinis longioribus (9-12 cm longis vs 6-8 cm) laminis lineari-lanceolatis (vs ovatis) latissimis ad vel prope medium et bracteis floralibus longioribus plus minusve persistentibus (vs deciduis).

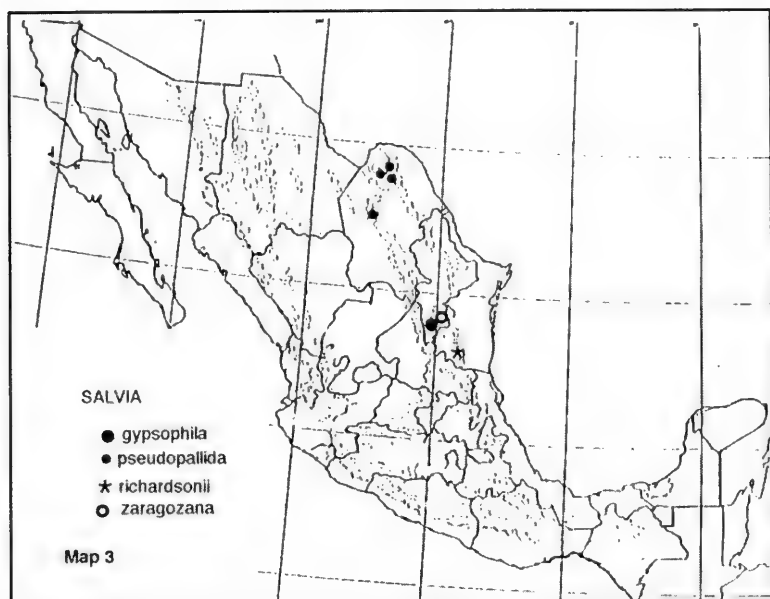
**TYPE: MEXICO. TAMAULIPAS: Mpio. Gomez Farias,** Rancho Del Cielo, "Between La Perra and Indian Springs," 26 Nov 1968, *Alfred Richardson 1050* (holotype: TEX).

**SALVIA ZARAGOZANA** B.L. Turner, *sp. nov.* **Fig. 4, Map. 3**

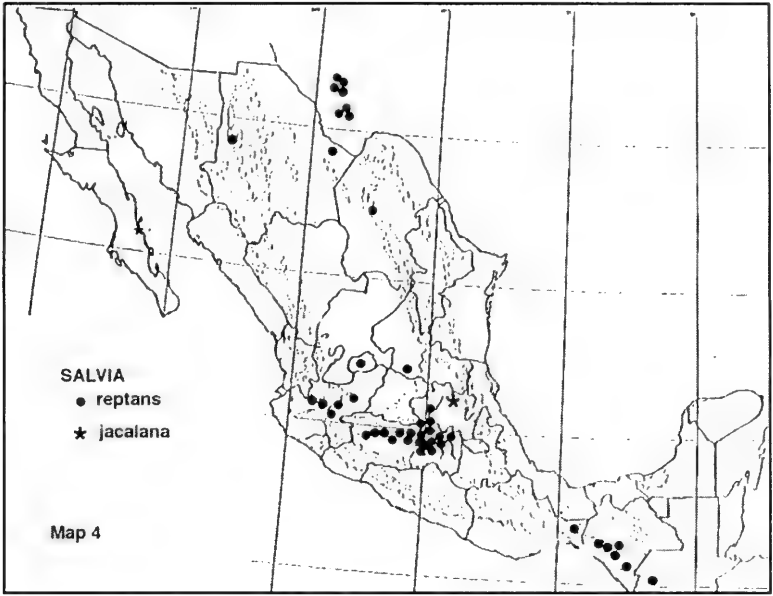
*Salviae gypsophilae* B.L. Turner similis sed differt foliis subter appressi-pilosis (non gossypinis) venatione perspicue visibili et calycibus aliquantum majoribus non dense floccosis.

**TYPE: MEXICO. NUEVO LEON: Mpio. Zaragoza,** Cerro El Viejo, pine-oak woodlands, 2375 m, 5 Oct 1992, *Hinton et al. 22382* (holotype TEX).





Map 3. Distributions of *Salvia gypsophila*, *S. pseudopallida*, *S. richardsonii* and *S. zaragozana*.



Map 4. Distributions of *Salvia reptans* and *S. jacalana*.

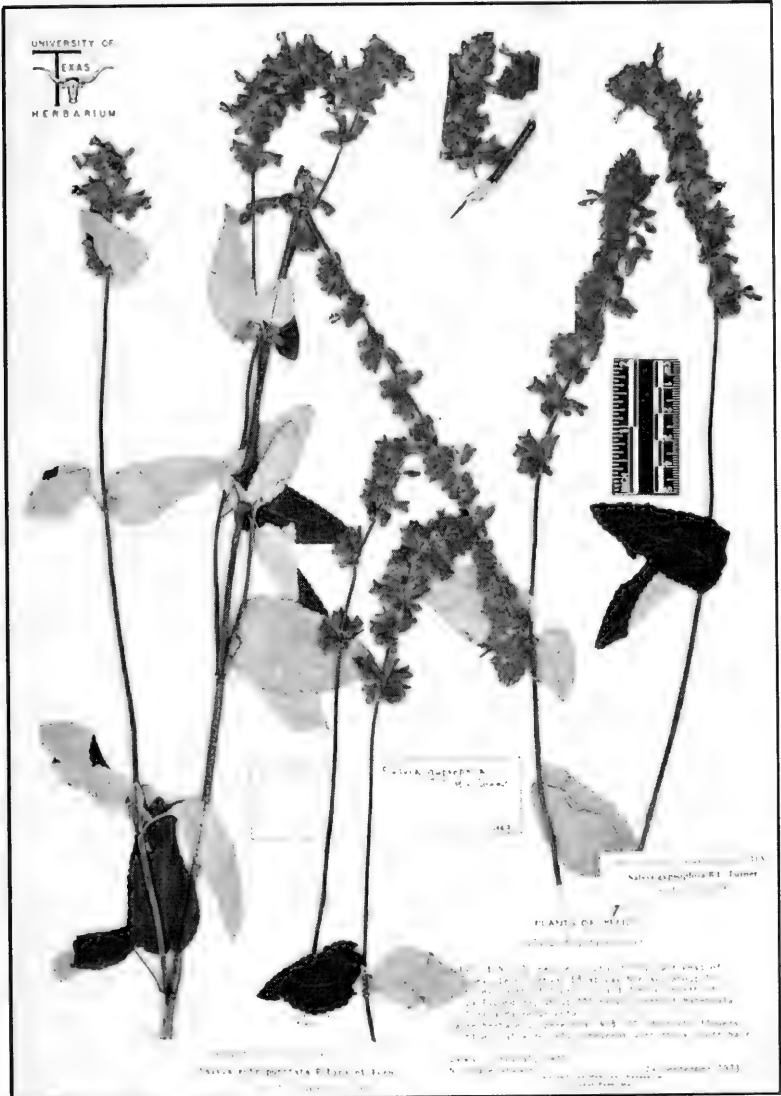


Figure 1. *Salvia gypsophila* B. L. Turner, holotype.



Figure 2. *Salvia jacalana* B. L. Turner, holotype.

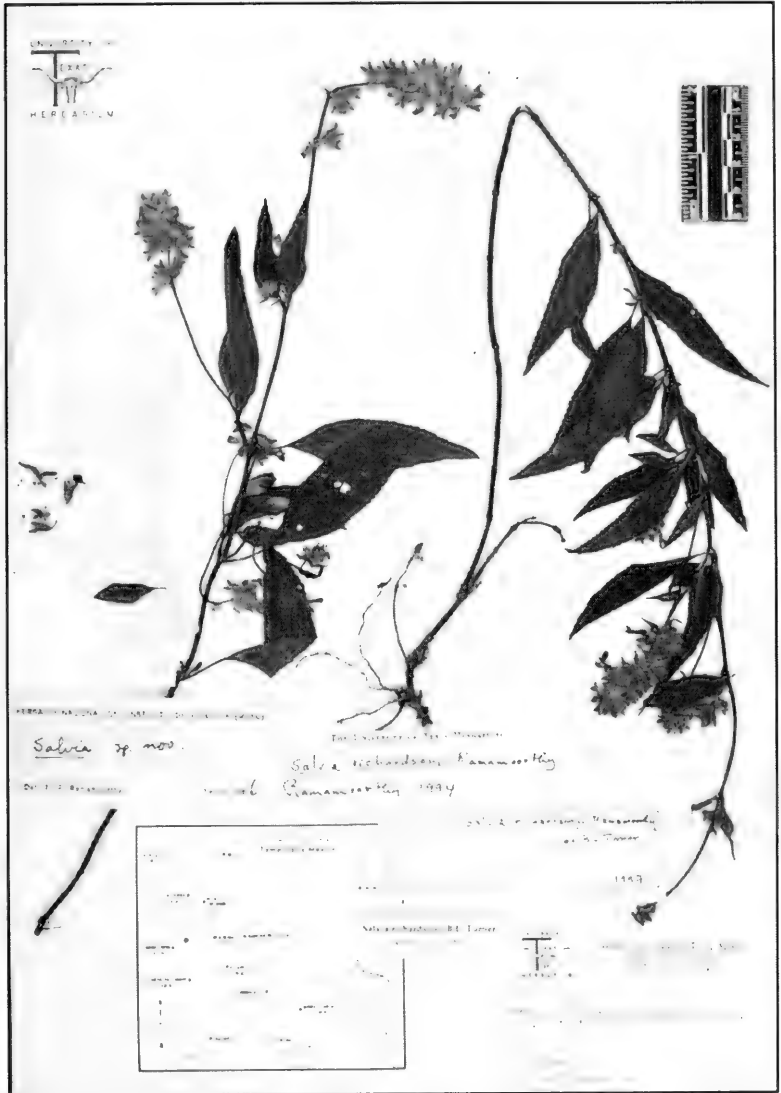


Figure 3. *Salvia richardsonii* B. L. Turner, holotype.



Figure 4. *Salvia zaragozana* B. L. Turner, holotype.

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