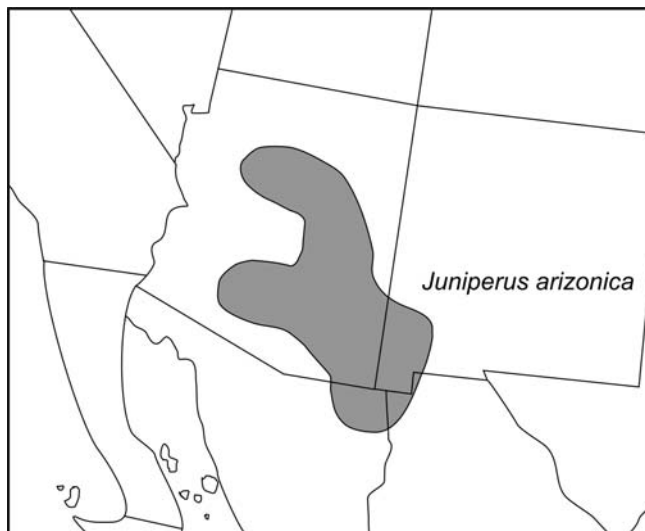
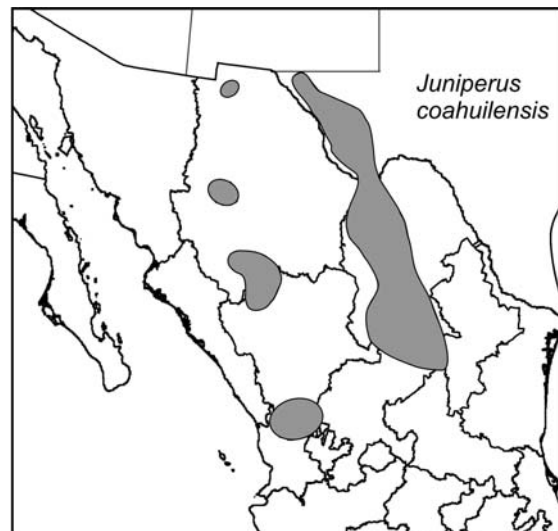


Juniperus arizonica* (R. P. Adams) R. P. Adams, new to Texas.*Robert P. Adams**Biology Department, Baylor University, Box 97388, Waco, TX
76798, USA, email Robert_Adams@baylor.edu**ABSTRACT**

Juniperus arizonica, previously known only from Arizona and New Mexico, has now been verified, by DNA sequencing, to occur in trans-Pecos Texas in the Franklin Mtns., Hueco Tanks State Park, Quitman Mtns., Eagle Mtns. and Sierra Vieja Mtns. on granitic material. These trans-Pecos juniper populations have previously been identified as *J. coahuilensis*. Revised distribution maps are presented for *J. arizonica* and *J. coahuilensis*. Published on-line www.phytologia.org *Phytologia* 98(3)179-185 (July 6, 2016). ISSN 030319430.

KEY WORDS: *Juniperus arizonica*, *J. coahuilensis*, Cupressaceae, revised distribution maps, petN-psbM DNA.

Juniperus arizonica and *J. coahuilensis* are essentially cryptic species in Arizona, New Mexico, Texas and Mexico (Figs. 1, 2). The taxa appear to differ in the relative length of the whip leaf glands (shorter in *J. arizonica*). However, in routine examination specimens at UNM (University of New Mexico Herbarium) to verify SEINET distribution maps for the new Flora of New Mexico, I found the relative whip leaf gland length of *J. arizonica* was quite variable, overlapping that of *J. coahuilensis*. These taxa have very distinct differences in their DNA and they are in separate clades (Figure 3). The cp region petN-psbM is especially efficient in separating these taxa, as 5 SNPs occur in the 794 bp region. Additional examination of specimens at UA (Univ. Arizona), SJNM (San Juan College), UTEP (Univ. Texas at El Paso), and SRSC (Sul Ross State University) revealed that many of the *J. coahuilensis* specimens were not morphologically distinct from *J. arizonica*. To reconcile this problem, a survey was initiated to sequence petN-psbM from about 10 mg of specimen leaves to verify its identity. The purpose of this paper is to report on the revised distribution based on petN-psbM sequencing of herbarium material and new collections in trans-Pecos Texas.

Figure 1. Distribution of *J. arizonica* (Adams 2014).Figure 2. Distribution of *J. coahuilensis* (Adams 2014).

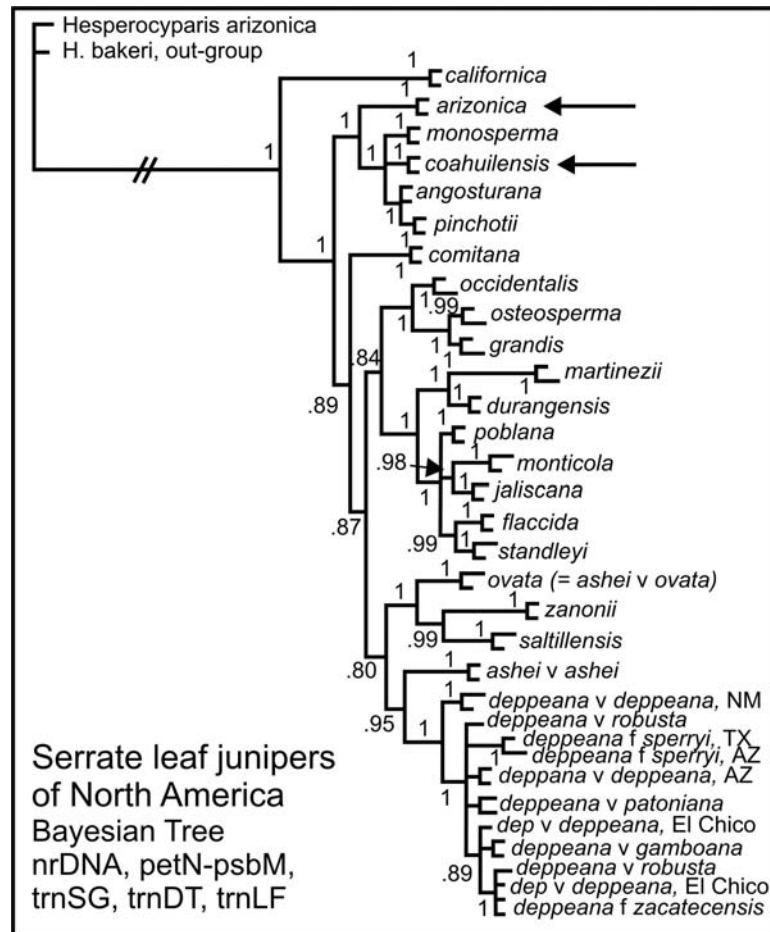


Figure 3. Bayesian tree for the serrate *Juniperus* of the North America. Note the position of *J. arizonica* and *J. coahuilensis* in well supported, separate clades. (from Adams 2014)

MATERIALS AND METHODS

Plant material:

UNM:

- J. arizonica* by petN DNA, Dona Ana Co., NM, Portillo Mtns, 31.865257° N, 106.9397° W, 4500', UNM 101883, *Worthington 19806*, 13 Jul 1991, Lab Acc. *Robert P. Adams 14696*,
- J. arizonica* by petN DNA, Hidalgo Co., NM, Animas Mtns, 31.61176° N, 108.7791° W, 5750', Seinet Cat # 57778, *Wagner 1283*, 22 Jul 1975, Lab Acc. *Robert P. Adams 14697*,
- J. arizonica* by petN DNA, Luna Co., NM, Tres Hermanos Mtns, 31.9010° N, 107.7794° W, 4250', Seinet Cat # 85666, *J L Carter 1246*, 14 Aug 1993, Lab Acc. *Robert P. Adams 14698*,
- J. arizonica* by petN DNA, Luna Co., NM, Florida Mtns, 32.1266° N, 107.6413° W, 5800', UNM 85854, *J L Carter 1247*, 14 Aug 1993, Lab Acc. *Robert P. Adams 14699*,
- J. monosperma* by petN and trnLF, Luna Co., NM, Cooke's Range Mtns, 32.5386° N, 107.7055° W, 5848' (Google Earth) Seinet Cat # 85987, JP Hubbard sn, 25 Apr 1978, Lab Acc. *Robert P. Adams 14700*,
- J. arizonica* by petN DNA, Hidalgo Co., NM, Animas Mtns, 31.5938° N, 108.7684° W, 6000', Seinet Cat # 57776, *Wagner 1005*, 17 Jun 1975, Lab Acc. *Robert P. Adams 14701*,
- J. monosperma* by petN and trnLF, Dona Ana Co., NM, blue cones, about 100 yds e of St. Nicholas Camp, San Andreas Mtns., ca 32.580 N, 106.5283 W, 5-6000', UNM 55607, lvs for DNA taken 10/29/2015 Jim Von Loh 27, 25 Mar 1975, Lab Acc. *Robert P. Adams 14702*,
- J. monosperma* by petN and trnLF, Otero Co., NM, Alamo Mtns., ca. 32° 01' 46" N, 105° 38' 20" W, 6500' (Google Earth), J S Findley ns, 16 Arp 1962, Lab Acc. *Robert P. Adams 14703*,
- J. arizonica* by petN DNA, no cones, Luna Co., NM, Florida Mtns., ca. 32.1266° N, 107.6413° W, 5800', UNM 31814, *J S Findley ns*, 31 Jan 60, Lab Acc. *Robert P. Adams 14704*,

- J. arizonica* by petN DNA, no cones, Hidalgo Co., NM, Animas Peak, Animas Mtns., 31.5813° N, 108.7843° W, 8452' (Google Earth), Seinet Cat # 25131, *WC Martin 4678*, 29 Oct 1960, Lab Acc. *Robert P. Adams 14705*,
- J. arizonica* by petN DNA, no cones, Hidalgo Co., NM, Floor of Skeleton Canyon, Peloncillo Mtns., ca. 31.590° N, 109.028° W, 4900' (Google Earth), Seinet cat # 22333, *E F Castetter 11257*, 20 Aug 1956, Lab Acc. *Robert P. Adams 14706*,
- J. arizonica* by petN DNA, no cones, Hidalgo Co., NM, e side of McGee Peak, ca. 4 mi. s of Steins, Peloncillo Mtns., 32.1666° N, 108.992° W, 5150 Seinet cat # 112666, *RC Sivinski 6275*, 21 Mar 2007, Lab Acc. *Robert P. Adams 14707*,
- J. arizonica* by ptN DNA, Hidalgo Co., NM, 0.8 mi. e of gate to Guadalupe Ranch, Guadalupe Canyon, 31.3613° N, 109.0438° W, 4400', Seinet cat # 85707, *JL Carter 274*, 14 Aug 1991, Lab Acc. *Robert P. Adams 14708*,
- SJNM:**
- J. arizonica* by petN DNA, Hidalgo Co., NM, Big Hatchet Mtns., with Quercus, Parthenium, Ocotillo, Mesquite, Agave 31.6249° N, 108.36425° W, 5350', *Ken Heil 9254*, 28 May 2010, Lab Acc. *Robert P. Adams 14716*,
- J. arizonica* by petN DNA, Grant Co., NM, ca 1.5 mi. s of NM hwy 9, near 'Old Hachiti' townsite. Chihuahuan desert scrub - creosote, Lycium koberlina and Dalea formosa. 31.9139° N, 108.41472° W, 4745', *Ken Heil 32357*, 29 Apr 2010, Lab Acc. *Robert P. Adams 14717*,
- UA:**
- J. arizonica* by petN, UA363788, Sonora, Sáric Municipio, Rancho La Tinaja, Arroyo El Silencio, 31.36° N, 111.4° W, 1035 m, *T. R. Van Devender, 2002-913*, 10/6/2002, Lab Acc. *Robert P. Adams 14777*,
- J. arizonica* by petN, UA372017, Sonora, Nogales Municipio, Canada El Aguaje de Zorrillo, near Rancho Esmeralda, 31.205° N, 111.1° W, 1133 m, *A. L. Reina G., 2004-952*, 8/18/2004, Lab Acc. *Robert P. Adams 14778*,
- J. arizonica* by petN, UA373061, Sonora, Agua Prieta Municipio, NE of Sierra Anibacachi, Rancho La Calera, ca. 10 km (by air) SW of Agua Prieta, 31.233° N, 109.6° W, 1287 m, *T.R. Van Devender, 2004-843*, 8/15/2004, Lab Acc. *Robert P. Adams 14779*,
- J. arizonica* by petN, UA396885, Sonora, Agua Prieta, Municipio, Rancho El Diablo, Arroyo Cajón Bonito, Cuenca Los Ojos, 31.291° N, 109° W, 1252 m, *A. L. Reina-G., 2010-473*, 5/16/2010 Lab Acc. *Robert P. Adams 14780*,
- J. arizonica* by petN, UA400214, Sonora, Agua Prieta Municipio, Rancho El Pinito, Arroyo Cajón Bonito, 56.5 km (by air) ESE, 31.191° N, 108.9° W, 1432 m, *T. R. Van Devender, 2009-1366*, 9/23/2009, Lab Acc. *Robert P. Adams 14781*,
- J. arizonica* by petN, UA405935, Sonora, Bavispe Municipio, 9.0 km (by air) S of Colonia Morelos, 59.5 km (by air) NE of., 30.746° N, 109.2° W, 1009 m, *A. L. Reina-G, 2010-295*, 3/21/2010, Lab Acc. *Robert P. Adams 14782*,
- J. arizonica* by petN, UA406347, Sonora, Imuris Municipio, Arroyo el Catrín, Rancho El Salto, 31.3 km (by air) ESE of í..., 30.684° N, 110.6° W, 1256m, *T. R. Van Devender, 2010-1086*, 10/4/2010, Lab Acc. *Robert P. Adams 14783*,
- J. arizonica* by petN, UA406806, Sonora, Arizpe Municipio, 3.8 km (by air) ENE of Arizpe along Río Sonora, 30.349° N, 110.1° W, 833m, *A. L. Reina G., 2011-18 2/8/2011*, Lab Acc. *Robert P. Adams 14784*,
- J. arizonica* by petN, UA407978, Sonora, Imuris Municipio, Remedios, Arroyo Los Remedios, 30.762° N, 110.7° W, 1044m, *T. R. Van Devender, 2005-635*, 4/8/2005, Lab Acc. *Robert P. Adams 14785*,
- J. arizonica* by petN, UA408981, Sonora, Arizpe Municipio, Sierra San Antonio, Arroyo Tirinagua, 30.375° N, 110.4° W, 1200m, *George M. Ferguson, 2371*, 5/5/2000, Lab Acc. *Robert P. Adams 14786*,
- J. arizonica* by petN, UA409144, Sonora, Arizpe Municipio, Sierra San Antonio, Arroyo Tirinagua, 30.374° N, 110.4° W, 1230m, *George M. Ferguson, 3117*, 5/2/2011, Lab Acc. *Robert P. Adams 14787*,

- J. arizonica* by petN, UA410254, Sonora, Magdalena, Magdalena Palm Canyon. 30.47° N, 110.8° W, 1150m, *Benjamin T. Wilder*, 10-582, 8/30/2010, Lab Acc. *Robert P. Adams 14788*,
- J. arizonica* by petN UA410257, Sonora Magdalena, 6.5 mi E of Magdalena, 30.564° N, 110.9° W, 830 m, *Benjamin T. Wilder*, 10-495, 8/27/2010, Lab Acc. *Robert P. Adams 14789*,
- J. arizonica* by petN, Mexico, Chihuahua, Municipio Janos, Sierra San Luis, along road in N tributary of Arroyo Las Chimeneas (Cajon Bonito drainage), foothills on W side of range at 1.0 km N Rancho San Antonio, Sonora, 31.2303° N, 108.864° W, 1690 m, *George M. Ferguson*, 99027, May 1996, Lab Acc. *Robert P. Adams 14790*,
- J. arizonica* by petN, Mexico, Sonora, Municipio Agua Prieta, Sierra Guadalupe (=Peloncillo Mts.), along Mex hwy 2 at milepost 104, airline 2.5 km N and 3.5 km E confluence Arroyo El Diablo-Cajon Bonito. 1460 m, 31° 18' 45" N, 109° 00' 30" W, *George M. Ferguson 1730*, 27 June 1999, Lab Acc. *Robert P. Adams 14791*,
- J. coahuilensis* by petN, Mexico, Durango, Municipio Villa Ocampo, ca. 13 km SE of Canutillo, along Mex hwy 45, at milepost 326.5, 26° 20' 23.7" N, 105° 13' 58.7" W, 1800 m, *George M. Ferguson 2177*, 2 July 1999, Lab Acc. *Robert P. Adams 14792*,
- J. arizonica* by petN, female, Mexico, Chihuahua, Municipio Ascencion, along Mex hwy 2 at milepost 127.5, at 5 km NE jct to Microondas Palomas, and 16 km W jct of hwy to Palomas. on limestone 31° 23' 39.3" N, 107° 44' 48.9" W, 1340 m, *George M. Ferguson 2107a*, 17 June 1999, Lab Acc. *Robert P. Adams 14793*,
- J. arizonica* by petN, male Mexico, Chihuahua, Municipio Ascencion, along Mex hwy 2 at milepost 127.5, at 5 km NE jct to Microondas Palomas, and 16 km W jct of hwy to Palomas. on limestone 31° 23' 39.3" N, 107° 44' 48.9" W, 1340 m, *George M. Ferguson 2107b*, 17 June 1999, Lab Acc. *Robert P. Adams 14794*,
- J. arizonica* by petN, New Mexico, Hidalgo Co., Big Hatchet Mountains, Thompson Canyon, on limestone, 31° 37' 02.5" N, 108° 22' 51.5" W, 6200', *George M. Ferguson 2544*, 22 Sept 2001, Lab Acc. *Robert P. Adams 14795*,
- J. arizonica* by petN, Mexico, Sonora, Municipio Huachinera, 4 km (by road) E Huachinera, 0.5 km W of Rancho San Ignacio de Cobora, 30° 12' 20"N, 108° 55' 00" W, 1150 m, *George M. Ferguson 2852*, 1 August 2006, Lab Acc. *Robert P. Adams 14796*,

SRSC:

- J. pinchotii* by petN and trnLF, Brewster Co., TX, Dead Horse Rg., non-glaucous, 29° 24' N, 103° 00' W, 5250', *J Fenstemacher1240*, 2005, Lab Acc. *Robert P. Adams 14836*,
- J. pinchotii* by petN and trnLF, Brewster Co., TX, 10 mi s Alpine, rare non-glaucous, *Powell 5185*, 1985, Lab Acc. *Robert P. Adams 14837*,
- J. coahuilensis* by petN, Brewster Co., TX, Basin, Big Bend National Park, ca. 29° 18' 23" N, 103° 18' 06" W, 5250' (Google Earth), *SC Bartel 575*, 2001, Lab Acc. *Robert P. Adams 14838*,
- J. pinchotii* by petN and trnLF, Presidio Co., TX, Friedrich Mesquite Ranch, Cinco de Mayo Pasture, 5800', *Warnock 590*, Oct 1990, Lab Acc. *Robert P. Adams 14839*,
- J. arizonica* by petN, large trees, 1m diam!, Sierra Vieja, Indian Peak Canyon, 30° 33' 25" N, 104° 40' 15" W, 5185', *Powell 6838*, 2010, Lab Acc. *Robert P. Adams 14840*,
- DNA, all degraded! Jeff Davis Co., TX, Haystack Mtn, 1959, coah, TJ Allen 247, May 1959! Lab Acc. *Robert P. Adams 14841*,
- J. arizonica* by petN, Hudspeth Co., TX, Eagle Mtns, *BG Hughes 392*, 1991, Lab Acc. *Robert P. Adams 14842*,

UTEP

- DNA all degraded! El Paso Co., TX, Indian Spring, Franklin Mtns, 31° 54' 19" N, 106° 28' 09" W, 4900', *Worthington 2266*, 1978, Lab Acc. *Robert P. Adams 14843*,
- J. arizonica* by petN, El Paso Co., TX, Franklin Mtns, no fruit, 31° 52' 40" N, 106° 28' 56" W, 5600', *Worthington 1838*, 1978, Lab Acc. *Robert P. Adams 14844*,
- DNA degraded, Hudspeth Co., TX, Hueco Mtn, (not Hueco Tanks), 31° 49' 12" N, 106° 07' 11" W, 4300', *Worthington 1844*, 1978, Lab Acc. *Robert P. Adams 14845*,

- J. arizonica* by petN, Hudspeth Co., TX, Eagle Mtns, Wind Canyon, 30° 54' N, 105° 04' W, 6000', *N Hutchings #5*, 1972, Lab Acc. *Robert P. Adams 14846*,
J. coahuilensis, by petN, Indio Mtns, Hudspeth Co, TX, 30° 47' 05" N, 104° 58' 20" W, 4350', *CS Licks 933*, 1988, Lab Acc. *Robert P. Adams 14847*,
J. arizonica by petN, Franklin Mtns. El Paso Co., TX, 31° 55' 15" N, 106° 30' 13" W, 5700', *Worthington 2112*, 1978, Lab Acc. *Robert P. Adams 14848*,

New Collections by RP Adams:

- J. arizonica* by petN, Hudspeth Co., TX, common on degraded granite, north face of Quitman Mtns., with desert-scrub. On south side of I10, ~6.3 mi. w of Sierra Blanca, TX, 31°12' 25" N; 105° 27' 51" W, 4629', *Robert P. Adams 14798-14806*, 12 March 2016,
J. coahuilensis, by petN, Brewster Co, TX, abundant in grassland, 11.2 s of Alpine, TX on Tex 118. 30° 14' 08" N; 103° 34' 00" W, 5222', *Robert P. Adams 14807-14811*, 15 March 2016,
J. coahuilensis, by petN, Brewster Co, TX, 11.0 mi w of Alpine on US 90, abundant in grassland, in Paisano Mtns., 30° 17' 42" N; 103° 48' 02" W, 4967', *Robert P. Adams 14812-14816*, 15 March 2016,
J. coahuilensis, Jeff Davis Co., TX, common locally, in grassland. 4.2 mi se of Ft. Davis, on Tex 118, e 1.0 mi into Chi. Desert Res. Inst., 39° 09' 27.54" N; 86° 18' 23.31" W, 5050', *Robert P. Adams 14817-14821*, 16 March 2016,
J. coahuilensis, by petN, Presidio Co., TX, common in grassland, 19.4 mi. s of Marfa, on US 67, 30° 04' 07" N; 104° 10' 19" W, 5137', *Robert P. Adams 14822-14826*, 16 March 2016,
J. arizonica by petN El Paso Co., TX, uncommon, 50- 100 trees seen, on granite, Hueco Tanks St. Park, 31° 54' 49.7" N; 106° 02' 6.8" W, 4560', *Robert P. Adams 14827-14835*, 18 March 2016.
J. monosperma, Dona Ana Co. NM, common, blue berries, ca. 1 mile nw of Lower Ash Spring, San Andres Mountains, 32° 38.131' N, 106° 32.785' W, 5622', *Kelly Allred sn*, 18 Nov 2015 Lab Acc. *Robert P. Adams 14718*.

Voucher specimens for new collections are deposited in the Herbarium, Baylor University (BAYLU).

One gram (fresh weight) of the foliage was placed in 20 g of activated silica gel and transported to the lab, thence stored at -20° C until the DNA was extracted. DNA was extracted from juniper leaves by use of a Qiagen mini-plant kit (Qiagen, Valencia, CA) as per manufacturer's instructions.

Amplifications were performed in 30 µl reactions using 6 ng of genomic DNA, 1.5 units Epi-Centre Fail-Safe Taq polymerase, 15 µl 2x buffer E (petN-psbM), D (maldehy) or K (nrDNA) (final concentration: 50 mM KCl, 50 mM Tris-HCl (pH 8.3), 200 µM each dNTP, plus Epi-Centre proprietary enhancers with 1.5 - 3.5 mM MgCl₂ according to the buffer used) 1.8 µM each primer. See Adams, Bartel and Price (2009) for the petN-psbM primers utilized.

The PCR reaction was subjected to purification by agarose gel electrophoresis. In each case, the band was excised and purified using a Qiagen QIAquick gel extraction kit (Qiagen, Valencia, CA). The gel purified DNA band with the appropriate sequencing primer was sent to McLab Inc. (San Francisco) for sequencing. Sequences for both strands were edited and a consensus sequence was produced using Chromas, version 2.31 (Technelysium Pty Ltd.).

RESULTS AND DISCUSSION

Sequencing petN-psbM yielded 794 bp with 5 SNPs separating *J. arizonica* and *J. coahuilensis*. Based on these data, samples were classified accordingly (see MATERIALS AND METHODS). Figure 4 shows the distribution of *J. arizonica* and *J. coahuilensis* in trans-Pecos Texas and New Mexico based on petN-psbM data. The junipers at all the Texas and new Mexico locations (except Rock Hound SP) of *J. arizonica*, have previously been classified as *J. coahuilensis*.

In Texas, *J. arizonica* was found in the Franklin Mtns., Hueco Tanks State Park, Quitman Mtns., Eagle Mtns. and Sierra Vieja Mtns. on granitic material. Worthington (pers. comm.) said that granitic

outcrops (such as Huecho Tanks) are common in southwestern New Mexico where he has found junipers. It is interesting that on the George Ferguson specimens from Sonora (Materials and Methods, above), he notes the substrates as limestone. *Juniperus coahuilensis* in trans-Pecos seems to grow mostly in grasslands over limestone and volcanic soils. As far as known, the two species are not sympatric, however, the area from Sierra Vieja to Indio Mtns. to Quitman Mtns. may contain sympatric populations.

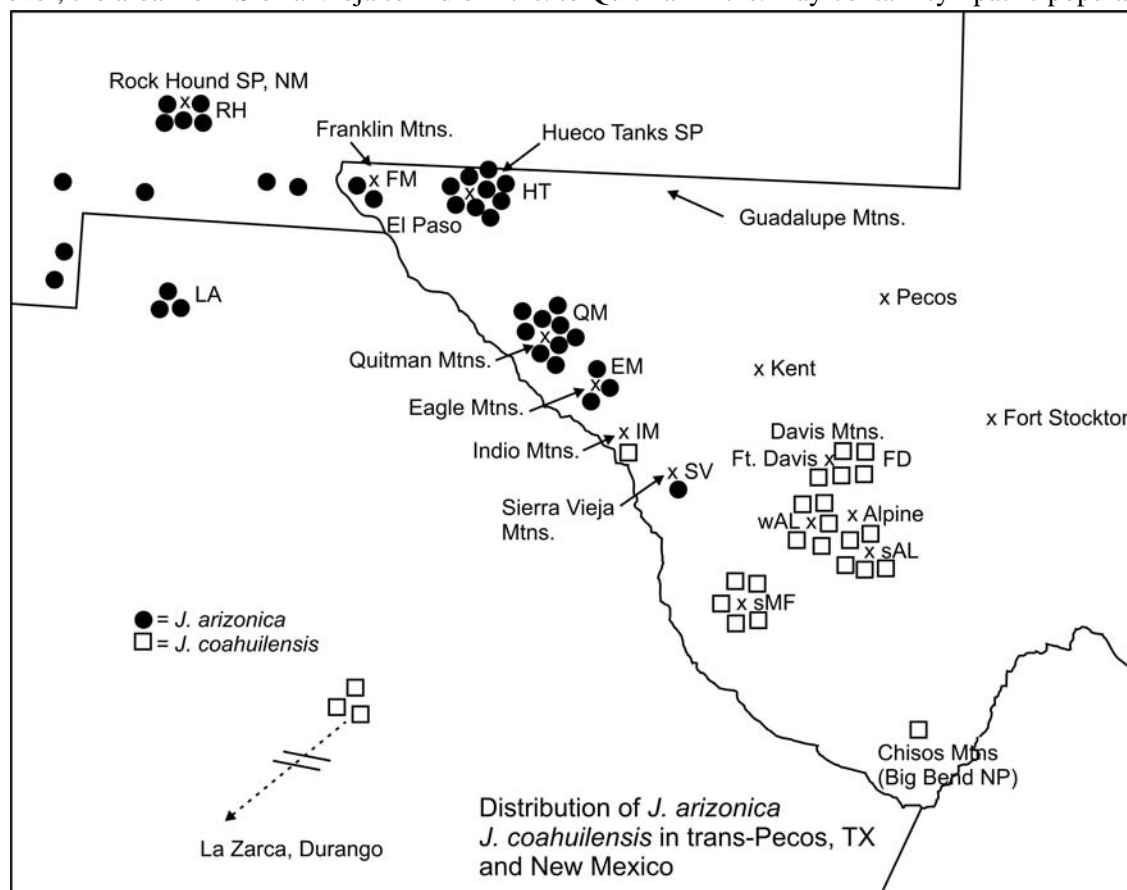


Figure 4. Distribution of *J. arizonica* and *J. coahuilensis* based on petN-psbM data. All the Texas and new Mexico locations of *J. arizonica*, (except Rock Hound SP) have previously been called *J. coahuilensis*.

Revised species distribution maps for *J. arizonica* and *J. coahuilensis* are shown in Figures 5 and 6. The Xs show the new populations discovered (and discussed in this paper) in trans-Pecos Texas. It seems likely that hybridization and, possibly, introgression is occurring, but that is beyond the scope of this paper.

ACKNOWLEDGEMENTS

Thanks to George M. Ferguson (UA), Ken Heil (SjNM), Tim Lowrey (UNM), Mike Powell (SRSC) and Richard Worthington (UTEP) for letting me sample (or sending small fragments) herbarium specimens. This research was supported in part with funds from Baylor University. Thanks to Amy TeBeest for lab assistance.

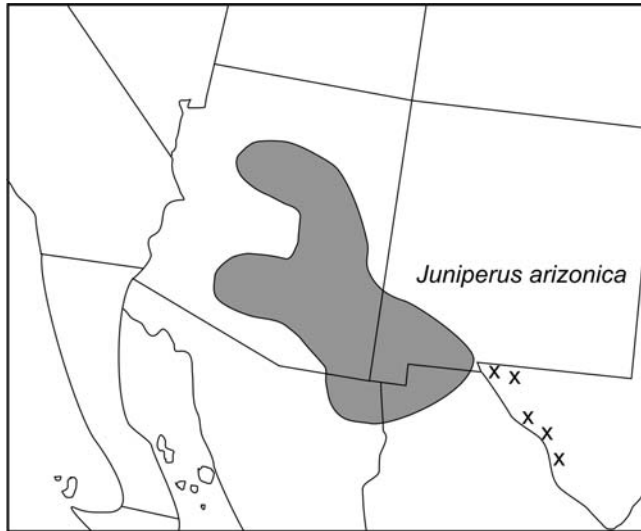


Figure 5. Distribution of *J. arizonica*.

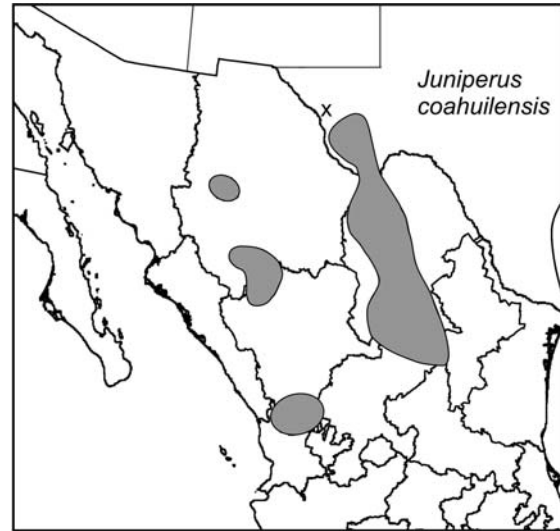


Figure 6. Distribution of *J. coahuilensis*.

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