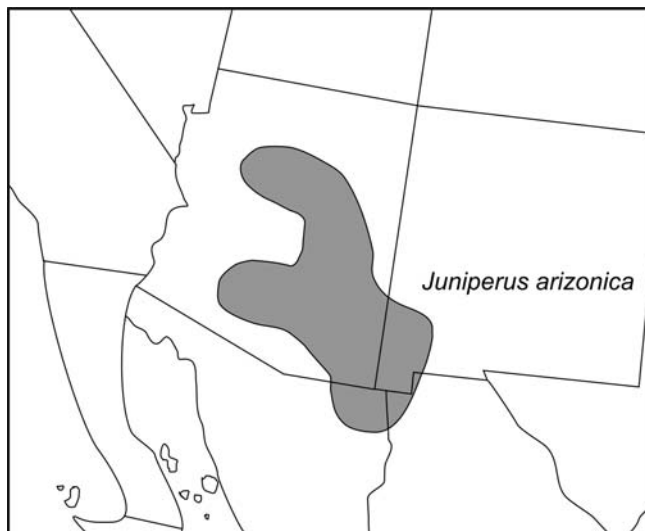
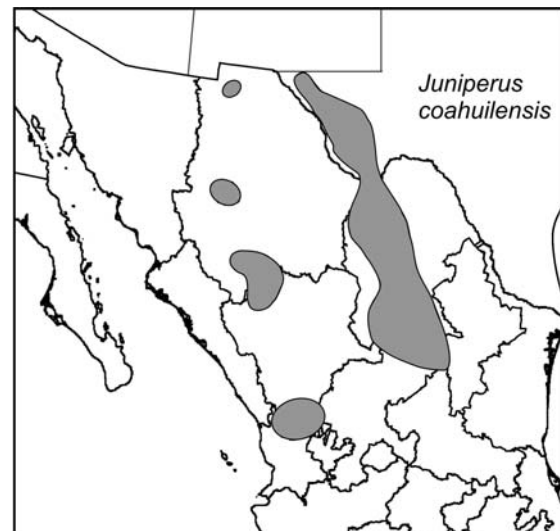


Juniperus arizonica* (R. P. Adams) R. P. Adams, new to Texas.*Robert P. Adams**Biology Department, Baylor University, Box 97388, Waco, TX
76798, USA, email Robert_Adams@baylor.edu**ABSTRACT**

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 Mtns., Hueco Tanks State Park, Quitman Mtns., Eagle Mtns. and Sierra Vieja Mtns. primarily on igneous 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).

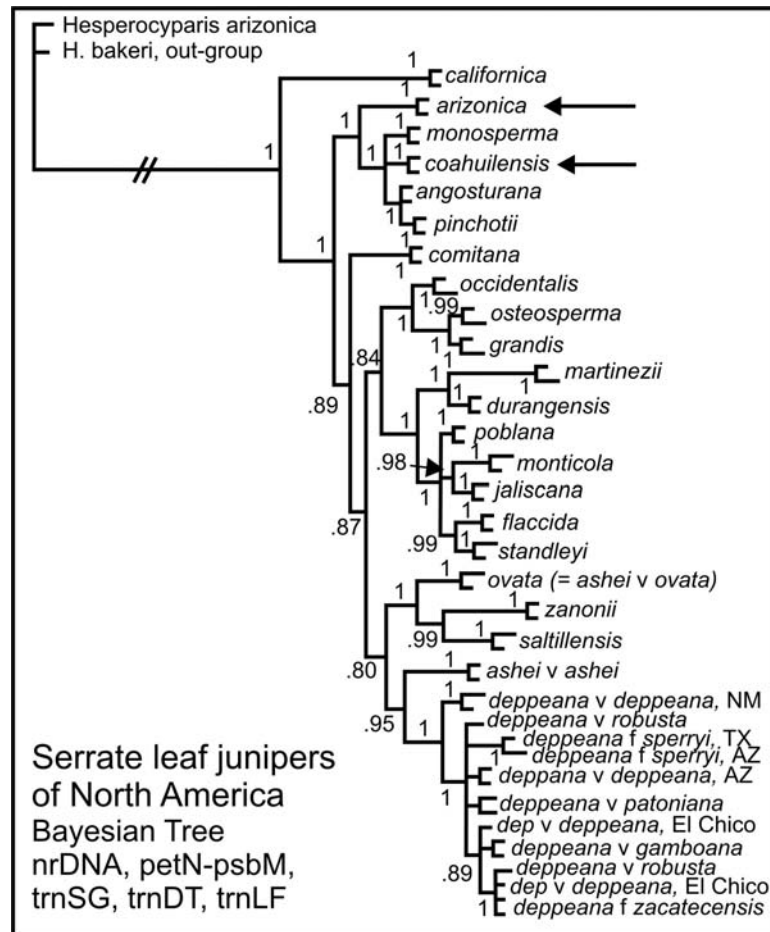


Figure 3. Bayesian tree for the serrate *Juniperus* of the North America. Note the position of *J. arizonica* and *J. coahuilensis* in well supported, separate clades. (from Adams 2014)

MATERIALS AND METHODS

Plant material:

UNM:

- J. arizonica* by petN DNA, Dona Ana Co., NM, Potrillo 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*, 990, 27 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,
- J. arizonica* by petN, Texas, Hudspeth Co., Eagle Mtns., 0.5 mi NNE of Oxford Spring, 6 mi (by air) SSE Eagle Peak, 4400', 30.824 N, 105.0351 W, *George M. Ferguson* 3570, 25 May 2014, Lab Acc. *Robert P. Adams* 14877,

SRSC:

- J. pinchotii* by petN and trnLF, Brewster Co., TX, Dead Horse Rg., non-glaucous, 29° 24' N, 103° 00' W, 5250', *J Fenstemacher* 1240, 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,

- J. arizonica* by petN, 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.

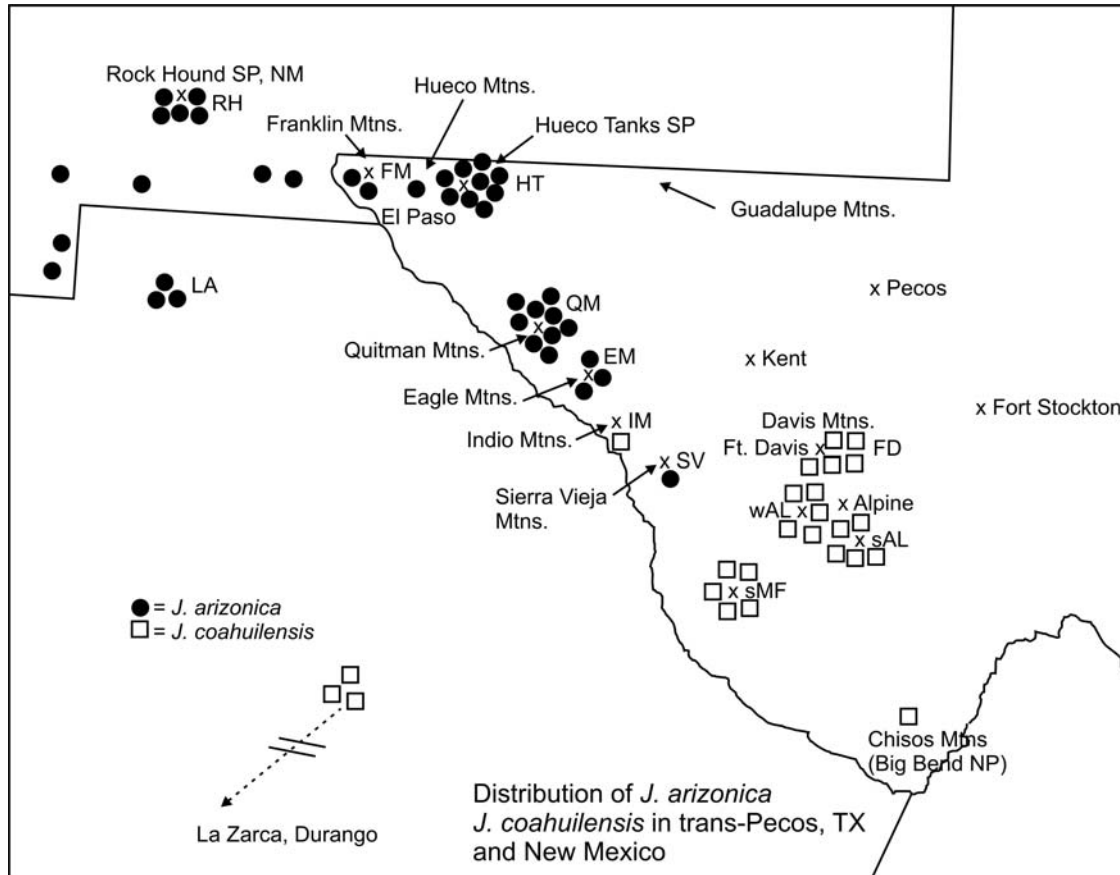
Amplifications were performed in 30 µl reactions using 6 ng of genomic DNA, 1.5 units Epi-Centre Fail-Safe Taq polymerase, 15 µl 2x buffer E (petN-psbM), D (maldehy) or K (nrDNA) (final concentration: 50 mM KCl, 50 mM Tris-HCl (pH 8.3), 200 µM each dNTP, plus Epi-Centre proprietary enhancers with 1.5 - 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 Mtns., Hueco Tanks State Park, Quitman Mtns., Eagle Mtns. and Sierra Vieja Mtns. primarily on igneous 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.

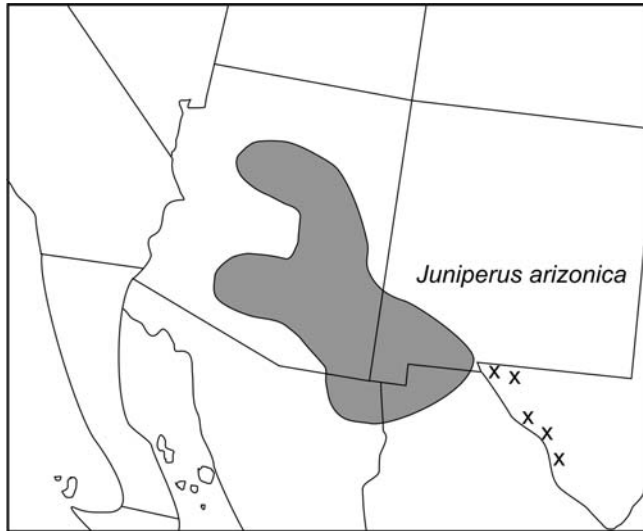


Figure 5. Distribution of *J. arizonica*.

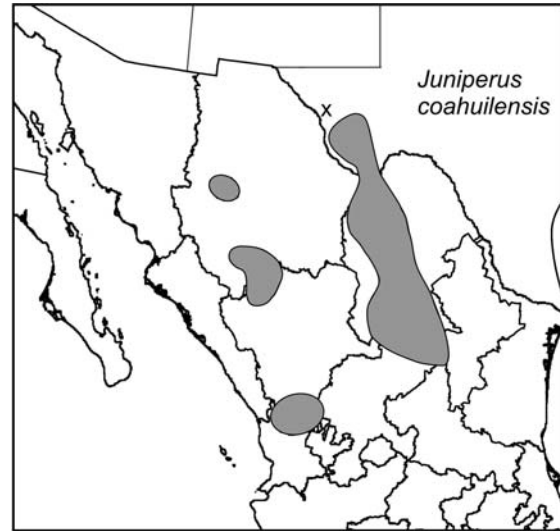


Figure 6. Distribution of *J. coahuilensis*.

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