

CYPERUS GRANITOPHILUS (CYPERACEAE), A GRANITE OUTCROP ENDEMIC,  
NEW FOR TEXAS AND OKLAHOMA (U.S.A.)

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ABSTRACT

*Cyperus granitophilus* McVaugh (Cyperaceae) has been discovered at Enchanted Rock State Natural Area in Gillespie and Llano counties in the Llano Uplift of Central Texas. Examination of herbarium specimens of the closely related *C. squarrosus* L. revealed 18 additional collections (total of 27) of *C. granitophilus* from the Llano Uplift of Texas, 10 collections from the Wichita Mountains in Comanche and Greer counties, Oklahoma, and one collection from the Arbuckle Uplift in Johnston County, Oklahoma. All collections were from regions with granitic outcrops. These collections represent the first documented occurrences of *C. granitophilus* in Texas and Oklahoma and are disjunct approximately 1270 km from the nearest previously documented populations in the Piedmont of Alabama.

RESUMEN

*Cyperus granitophilus* McVaugh (Cyperaceae) ha sido descubierto en la Enchanted Rock State Natural Area en los condados Gillespie y Llano en el Llano Uplift de Texas Central. El examen de especímenes de herbario del muy relacionado *C. squarrosus* L. reveló 18 colecciones adicionales (total de 27) de *C. granitophilus* del Llano Uplift de Texas, 10 colecciones de las montañas Wichita en los condados Comanche y Greer, Oklahoma, y una colección del Arbuckle Uplift en el condado de Johnston, Oklahoma. Todas las colecciones proceden de regiones con afloramientos graníticos. Estas colecciones representan las primeras ocurrencias documentadas de *C. granitophilus* en Texas y Oklahoma y tienen una disyunción de unos 1270 km desde las poblaciones documentadas más próximas en el Piedmont de Alabama.

INTRODUCTION

*Cyperus granitophilus* McVaugh was first described by Rogers McVaugh in 1937 from a granite outcrop in Georgia (McVaugh 1937). This granite outcrop endemic is primarily restricted to the Piedmont region of the southeastern United States (Ware et al. 2011) with records from Georgia (McVaugh 1937), South Carolina (Hill & Horn 1997), Alabama, North Carolina, Tennessee, and Virginia (Estill & Cruzan 2001) (Fig. 1). *Cyperus granitophilus* is typically found in the dry, shallow soil zone bordering exposed granite bedrock and is often dominant in these areas (Ware et al. 2011). Burbanck and Platt (1964) refer to this zone as the “lichen-annual herb” community with a maximum soil depth of 7 to 15 cm. The species is also found in “scattered tufts” in the shallow soil areas of their “annual-perennial herb” communities which typically have deeper soils, up to 39 cm.

*Cyperus granitophilus* is often found growing in association with the closely related species *C. squarrosus* L. (Murdy 1968). McVaugh (1937) distinguished *C. granitophilus* from *C. squarrosus* by its slightly longer and wider spikelets, longer scales, 4 vs 3 lateral nerves on the scale, and non-stipitate achene (Fig. 2). McVaugh (1937) indicates that *C. granitophilus* can also be distinguished by its “somewhat stiffer culms, its densely crowded capitate inflorescence and somewhat coarser appearance, and by the awns of its spikelet-scales, which are spreading instead of reflexed as they often are in *C. inflexus* (*C. squarrosus*).” McVaugh indicates that while there is some overlap in the size measurements of the two species there is no intergradation in the achene character. *Cyperus granitophilus* is documented as an autotetraploid derivative of *C. squarrosus* (Garoni & Murdy 1964; Wynne 1964) with consistently higher chromosome numbers in *C. granitophilus* ( $2n = \text{ca. } 80, 88, 96$ ) versus *C. squarrosus* ( $2n = \text{ca. } 48, 56, 64$ ) (Murdy 1968).

METHODS AND RESULTS

During a study of the flora of Enchanted Rock State Natural Area, Llano and Gillespie counties, Texas, during the summer of 2014, *Cyperus granitophilus* was discovered at six locations, one in Gillespie County and five in

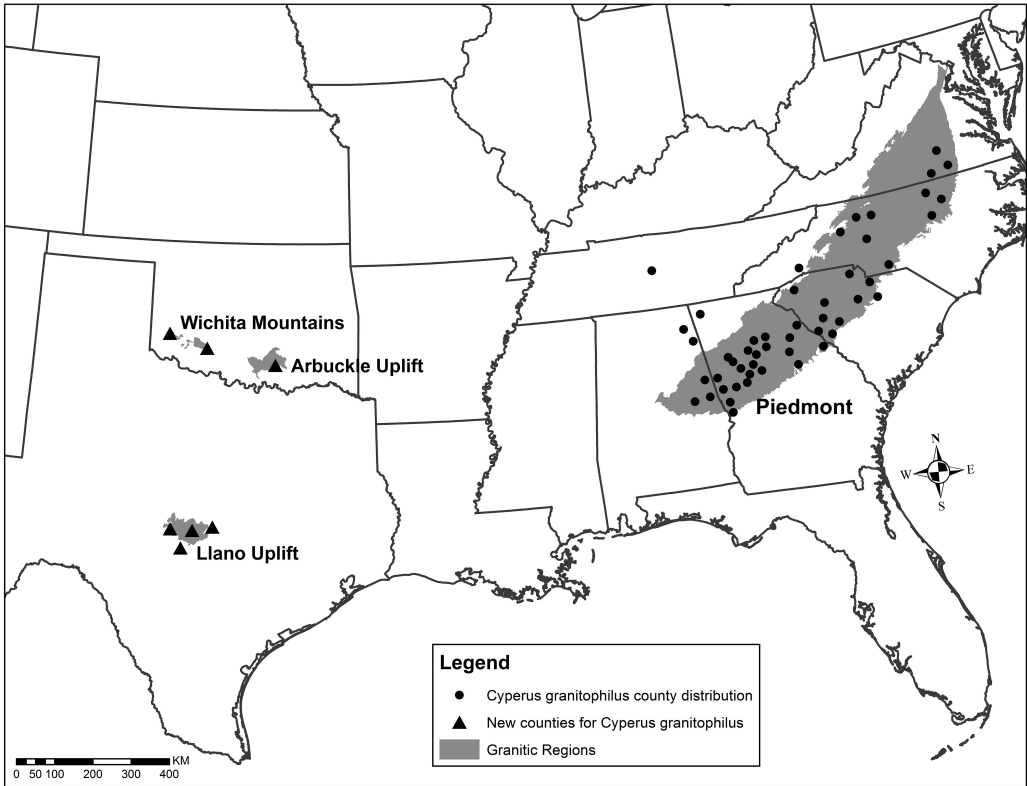


FIG. 1. Map showing updated county level distribution for *C. granitophilus* in the Eastern United States (Kartesz 2014; US Environmental Protection Agency 2013).

Llano County. The five main population centers within the park include 1) vernal pools on the summit of Enchanted Rock, 2) vernal pools on Little Rock, 3) seasonal seepage areas over granite rock west of Little Rock, 4) granitic sand over granite bedrock on Sandy Creek, and 5) a granite dike approximately 30 cm wide intruding in an area of Packsaddle Schist. This last population consisted of very few plants and is surrounded by habitat that is not suitable for the species.

Plants at Enchanted Rock State Natural Area were found growing in shallow soil no more than 15 cm in depth, but typically less than 5 cm. These shallow soil zones were found on the edges of exposed granite on the margins of vernal pools, cracks in granite, and granitic sand along drainage ways (Fig. 3). The plant was typically found in areas with slightly increased moisture relative to surrounding areas. Associated species include *Bulbostylis capillaris* (L.) Kunth ex C.B. Clarke, *Calibrachoa parviflora* (Jussieu) D'Arcy, *Cyperus haspan* L., *C. squarrosus*, *Elatine brachysperma* A. Gray, *Hypericum drummondii* (Grev. & Hook.) Torr. & A. Gray, *Hypericum gentianoides* (L.) B.S.P., *Ipomoea costellata* var. *edwardsensis* R. O'Kennon & Nesom, *Isoetes lithophila* N.E. Pfeiffer, *Lepuropetalon spathulatum* Ell., *Lindernia dubia* var. *anagallidea* (Michx.) Cooperrider, *Plemeranthus parviflorus* (Nutt.) Kiger, *Portulaca pilosa* L., *Sedum nuttallii* Torr. & James ex Eat., *Selaginella corallina* (Riddell) Wilbur & Whitson, *Steinchisma hians* (Ell.) Nash, *Tripogon spicatus* (Nees) Ekman, and *Utricularia cornuta* Michx.

The authors conducted a thorough examination of specimens of the closely related species *Cyperus squarrosus* (= *C. aristatus*, *C. inflexus*) from the following herbaria: BRIT, OKL, SMU, TAMU, TEX-LL, VDB. During this process, 18 additional specimens of *C. granitophilus* (total of 27) were discovered in four Texas counties:

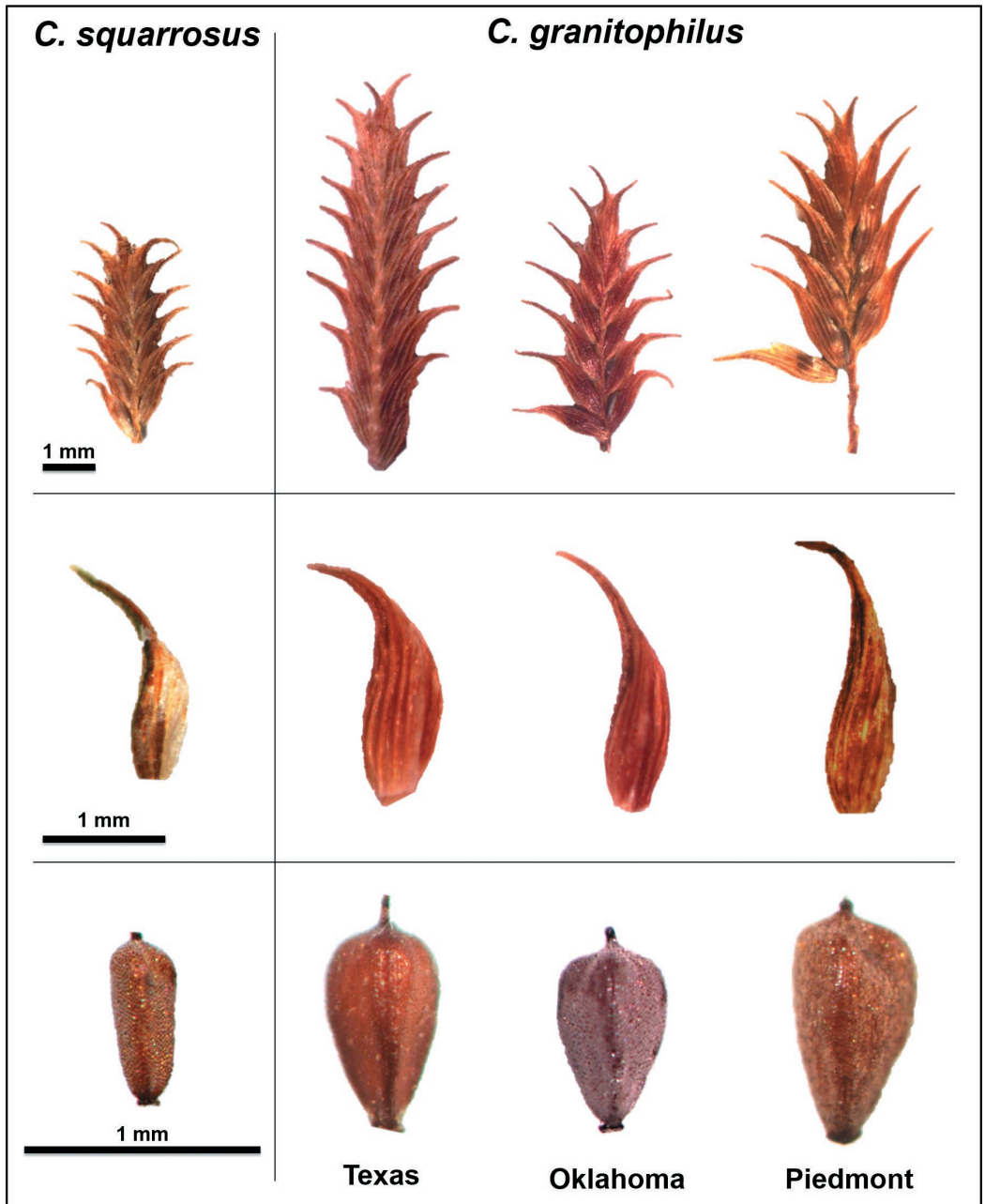


FIG. 2. Spikelets (top), floral scales (middle), and achenes (bottom) of *C. squarrosus* (O'Kennon 8128a, BRIT), and *C. granitophilus* from the Llano Uplift of Texas (O'Kennon, Taylor & Rehman 26142, BRIT), the Wichita Mountains of Oklahoma (Waterfall 2904, OKL), and the Piedmont Granite of South Carolina (Hill 20023, BRIT).



FIG. 3. Images of *C. granitophilus* and its habitat at Enchanted Rock State Natural Area. Top left: vernal pool on summit of Enchanted Rock; top right: image of plant; bottom: *C. granitophilus* growing in shallow soil near edge of granite rock.

Burnet, Gillespie, Llano, and Mason; and 11 specimens in three Oklahoma counties: Comanche, Greer, and Johnston. All of the Texas collections are from the Llano Uplift while all of the Oklahoma specimens are from the Wichita Mountains or Arbuckle Uplift (Fig. 1). These new populations in Texas and Oklahoma are disjunct approximately 1270 km (790 mi) from the western most location in Alabama.

Since *Cyperus granitophilus* does not occur in any regional floras within Texas or Oklahoma it is not surprising that specimens from the region were misidentified as *C. squarrosus*. *Cyperus granitophilus* is widely distributed across the Llano Uplift and observations at Enchanted Rock State Natural Area suggest it is likely a common member of the granitic flora in the region. Additional exploration of granite outcrops in both Texas and Oklahoma will undoubtedly reveal additional populations.

#### DISCUSSION

The Llano Uplift of central Texas, and the Wichita Mountains and Arbuckle Uplift of Oklahoma are all regions with large expanses of exposed granite, similar to that in the Piedmont of the southeastern United States where *Cyperus granitophilus* is wide-spread. The Llano Uplift of Texas spans 10 counties and includes approximately 5180 km<sup>2</sup> on the eastern margin of the Edwards Plateau (Walters & Wyatt 1982). It is composed of Precambrian granites, gneisses, and schists surrounded by escarpments of Paleozoic and Mesozoic limestone and sandstone. The region was once covered by Cretaceous limestone and sandstone with the granite basement rock being exposed due to erosion during the Miocene and Pliocene (Walters & Wyatt 1982). Therefore the Llano Uplift is a "topographical basin consisting of exposed Precambrian metamorphic rocks and large massifs of Precambrian granite surrounded by a discontinuous rim of Cretaceous limestone" (Walters & Wyatt 1982).

The Wichita Mountains of Oklahoma are primarily in Comanche County, but enter four additional counties, covering approximately 945 km<sup>2</sup> (US Environmental Protection Agency 2013). These rugged hills of igneous granite, granite-porphry, diabase (dolerite), and gabbro rise above a relatively flat plain of Cambrian and Ordovician sandstone and limestone (Taff 1928).

The Arbuckle Uplift of Oklahoma, including the Arbuckle Mountains, is a plateau moderately elevated above the surrounding plain entering seven counties and covering approximately 3066 km<sup>2</sup> (US Environmental Protection Agency 2013). The area is predominately Cambrian to Devonian limestone with Carboniferous shales, sandstones, and conglomerates on the borders. A mass of granite, granite-porphry, diabase, and associated crystalline rocks can be found in the central part of the uplift. Igneous rocks are exposed in three areas, with the largest in the east composed mostly of granite and diabase dikes. The surface granite is nearly flat and much of it is concealed by materials produced by its own disintegration (Taff 1928).

The granites of the Wichita Mountains, Arbuckle Uplift, and Llano Uplift are markedly similar in structure (Taff 1928) and all possess similar plant communities, particularly near exposed granite rock. Burbank and Platt (1964) note the similarities between the Piedmont granite and the Llano Uplift of Texas stating "although the species are different, the types of plants and the stages of succession on exposed granite and accumulated gravel at Enchanted Rock, Texas...are similar to conditions in Georgia." Walters and Wyatt (1982) echo this sentiment by stating "that granite outcrops provide similar types of microenvironments despite major differences in the climate and surrounding vegetation of each region."

While the granitic regions west of the Mississippi River (Llano Uplift, Wichita Mountains, and Arbuckle Uplift) share similar geology and microenvironments to that of the Piedmont granite, their floras are quite different (Walters & Wyatt 1982). This lack of similarity in characteristic and endemic species between the eastern and western granitic outcrops "suggests that each region contains a unique group of plants independently derived from the native plants of that region" (Walters & Wyatt 1982). When examined at the generic level this is not necessarily the case though, with several genera having "highly specialized representatives in both regions" (Walters & Wyatt 1982).

These widely separated regions possess similar floras, including disjunct taxa such as *Cyperus granitophilus*, as a result of a shared flora during the Tertiary period. The Madro-Tertiary Geoflora of western and south-

western North America shows remarkable floristic similarities to that of the Llano Uplift, Wichita Mountains, Arbuckle Uplift and Piedmont granite rock outcrop floras (Walters & Wyatt 1982). Warmer and drier climates during the Late Tertiary allowed plants from western and southwestern North America to expand their ranges into the southeastern United States (Braun 1955). Thus, it is likely that the Llano Uplift, Wichita Mountains, Arbuckle Uplift, and Piedmont once had a shared flora and that flora was adapted to warmer and drier conditions than what exist today across most of the region. Cooler and wetter temperatures in the Pleistocene subsequently forced xerophytes in the Southeast to take refuge on rock outcrops. Once isolated, subsequent speciation would result in narrowly restricted endemics within each system, such as *Isoetes lithophila* in the Llano Uplift and *I. melanospora* Engelm. in the Piedmont.

Alternatively, the absence of species divergence after isolation would result in highly disjunct populations. This distribution pattern is not atypical for ecological endemics with highly restrictive specificity to a single substrate. This is seen with *Cyperus granitophilus*, *Eriocaulon koernickianum*, and *Isoetes piedmontana* (N.E. Pfeiffer) C.F. Reed on granite outcrops and *Isoetes butleri* Engelm. (Taylor et al. 2012), *Gratiola quartermaniae* D. Estes (Taylor & O'Kennon 2014), and *Oenothera macrocarpa* Nutt. ssp. *macrocarpa* (Kartesz 2014) on limestone outcrops. Additionally, environmental differences between outcrop communities and the surrounding habitats is markedly more intense in the Piedmont where the incident radiation, temperatures and high levels of evapotranspiration are drastically more severe on the rock outcrops than the surrounding habitats. Warmer and drier overall climates in Texas and Oklahoma result in a less extreme environmental difference between outcrops and surrounding vegetation, less isolation from congeners, and a lower degree of endemism (Walters & Wyatt 1982).

Voucher Specimens. **U.S.A. OKLAHOMA. Comanche Co.:** Elk Mountain, Wichita Mountain Wildlife Refuge, 34.725819 -96.721114, 19 Jun 2015, O'Kennon, Taylor, Jensen, & Rylander, 28463 (BRIT); Northwest Sunset Peak, 21 May 1983, Rose 85 (OKL); wet, sandy shoreline, Quannah Parker Lake, Wichita Mts., 2 Jun 1949, Penfound P-197 (OKL); sandbar, head of Lake Elmer Thomas, 9 Jul 1948, Penfound P-54 (OKL); Wichita Mts. Wildlife Refuge, Sugar Creek, open prairie near North boundary, 29 Jul 1942, Rouse 405 (OKL); growing in soil collected among granite boulders near top of Mt. Scott, Wichita Mts., 4 Jul 1941, Waterfall 2925 (OKL); clay and shale on granite with a mixed grass-sedge association, N of Mt. Scott about 1 mi E of Meers, Wichita Mts., 4 Jul 1941, Waterfall 2904 (OKL); Medicine Park, 20 Oct 1934, Bradbury 593 (OKL); s.d., Stevens 1330 (OKL); s.d., Stevens 1358 (OKL). **Greer Co.:** at edge of small mountain near granite, 17 Jun 1913, Stevens 1027 (OKL). **Johnston Co.:** granite rock at 10 Acre Rock, 34.328989 -96.762469, 13 Jun 2015, O'Kennon 28420 (BRIT); granite rock area W of town of Mill Creek, 19 May 1967, Taylor & Taylor 3690 (OKL). **TEXAS. Burnet Co.:** Granite Mountain along Farm Road 1431, 1.8 mi W of F.M. 1431 and U.S. 281, W of Marble Falls, 7 Jun 1988, Urbatsch 4791 (BRIT); growing in loose small granite rocks, Granite Mountain, 16 Jun 1946, Cory 12729 (SMU). **Gillespie Co.:** Enchanted Rock State Natural Area, in moist granitic glade south of Little rock, N30.495971, W98.829125, 26 Jun 2014, O'Kennon, Taylor, & Rehman 26146 (BRIT); Enchanted Rock State Natural Area, in moist granitic grass, S of Little Rock, N30.4959566, W98.8291267, 16 Jul 2014, Taylor, O'Kennon, & Rehman 2852 (BRIT); in granite gravel on outcrop near Coal Creek, N of Willow City, 10 Jul 1958, Correll & Johnston 19582 (TEX-LL); in shallow depressions in granite on Bear Mt., just N of Fredericksburg, 29 Jun 1957, Correll & Johnston 17258 (TEX-LL); 5 Aug 1940, Strandtmann s.n. (TEX-LL). **Llano Co.:** Enchanted Rock State Natural Area, vernal pool on Enchanted Rock, N30.506892, W98.81962436, 21 Oct 2014, Taylor & O'Kennon 2935 (BRIT); granite dike E of Enchanted Rock, N30.51247, W98.8026, 19 Sep 2014, Taylor & O'Kennon 2908 (BRIT); drainage over granite, N30.50604, W98.8348, 18 Sep 2014, Taylor & O'Kennon 2885 (BRIT); vernal pool on West Rock, N30.50006, W98.8229, 17 Sep 2014, Taylor & O'Kennon 2860 (BRIT); Enchanted Rock SNA, N30.500257, W98.819718, 15 Jul 2014, Taylor, O'Kennon & Rehman 2776 (BRIT); Enchanted Rock State Natural Area, in moist granitic sand along margin of Sandy Creek that runs near the southern and eastern base of Enchanted Rock, N30.510462, W98.804992, 15 Jul 2014, O'Kennon, Taylor, & Rehman 26142 (BRIT); Enchanted Rock SNA, Moss Lake, 14 Jul 2014, O'Kennon, Taylor, & Rehman 26145 (BRIT); Enchanted Rock SNA, along moist bank of Moss Lake, N of Enchanted Rock, N30.50888, W98.825086, 4 Oct 1990, O'Kennon 8128g (BRIT); 9.6 mi SW on FM 2323 from its jct with TX 16, then S ca 100 m on an unnamed paved rd, E side of rd, SW of Llano, granitic outcrop between the road and fence, associated species other *Cyperus*, *Leptochloa*, *Digitaria*, *Bouteloua*, *Tripogon*, and *Bothriochloa*, 26 Sep 1987, Wipff 563 (TEX-LL); granite outcrop 1.4 km W on Ferguson Rd from intersection of Ferguson Rd and RR 2147 at Horseshoe bay, 11 Aug 1979, Walters 1000 (TAMU); granite outcrop 3.4 km N on W side of RM2241 from the intersection of RM 2241 and U.S. Hwy 21 at Bluffton, 18 Jun 1979, Walters 681 (TAMU); common sedge in many of the vernal pools on the summit of Enchanted Rock, 2 Oct 1976, Butterwick & Smith 3376 (TEX-LL); common annual sedge in vernal pools on summit of Enchanted Rock, 24 Jul 1976, Butterwick & Lamb 3020 (TEX-LL); Watch Mountain, granite outcrop 17.2 km W on N side of Inks Ranch Rd, from the intersection of Inks Ranch Rd and U.S. Hwy 16, 13 Jun 1974, Walters 496 (TAMU); Enchanted Rock, 20 Aug 1936, Sharp s.n. (BRIT); granitic areas, 5 Aug 1931, Wolff 3157 (BRIT); Enchanted Rock, 11 Jun 1930, Whitehouse & Sharp s.n. (TEX-LL); Enchanted Rock, Jul 1892, Nealley 80 (TEX-LL). **Mason Co.:** Mason Mountain WMA, in moist cracks in granite, N30.826464 W99.220053, 14 Aug. 2012, O'Kennon, Taylor, & Rehman 25348 (BRIT); granite outcrop and sandy creek bottom, 14.2 mi E of Mason by highway TX 29, local in thin sand over rock, 16 Aug 1989, Carter 8214 (SAT, VSC); granite outcrop 2.6 km E on S side of RM

1222 from intersection of U.S. Hwy 87 and RM 1222 at Camp Air, *Walters 441* (TAMU); granite outcrop 2.7 km S on U.S. Hwy 87 from intersection of U.S. Hwy 87 and RM 1222 at Camp Air, W 0.2 km, 11 Jun 1979, *Walters 424* (TAMU).

## ACKNOWLEDGMENTS

We thank David Riskind, Doug Cochran, and Scott Whitener from Texas Parks and Wildlife for permits and assistance in accessing Enchanted Rock; Richard Carter for his advice and help with identification; and the following herbaria for loans or use of facilities to examine specimens: Botanical Research Institute of Texas (BRIT, SMU, VDB), University of Oklahoma (OKL), Texas A&M University (TAMU), and University of Texas (TEX-LL). We also thank Gordon Tucker (EIU) and Bruce Hoagland (OKL) for their helpful reviews of the manuscript.

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