
Two New Species of *Phacelia* (Hydrophyllaceae) from the Southwestern United States

N. Duane Atwood

Life Science Museum, Brigham Young University, Provo, Utah 84602, U.S.A.

Frank J. Smith

Western Ecological Services, Inc., Box 422, Millville, Utah 84326, U.S.A.

Teri A. Knight

The Nature Conservancy, 1771 E. Flamingo Road, Suite 111B, Las Vegas, Nevada 89119, U.S.A. Present address: 1924 Quimper Court, Henderson, Nevada 89014, U.S.A.

ABSTRACT. *Phacelia filiae* N. D. Atwood, F. J. Smith & T. A. Knight is an undescribed species from Clark, Nye, and Lincoln Counties, Nevada. It is closely related to *Phacelia parishii* of California, Arizona, and Nevada and *Phacelia beatleyae* of southern Nevada. *Phacelia petrosa* N. D. Atwood, F. J. Smith & T. A. Knight from Arizona, Nevada, and Utah is also described as new. It is most closely related to *Phacelia crenulata*, which is known from Arizona, California, Nevada, and Utah. The most prominent differences among these species are the shape of the seeds and appearance of the seed coats.

Key words: Arizona, Hydrophyllaceae, Nevada, *Phacelia*, U.S.A., Utah.

The genus *Phacelia* comprises about 250 taxa mostly native to the New World and is best developed in the western United States and northern Mexico. This genus is known for its large number of endemic taxa. The two species described below are narrow endemics, with *Phacelia filiae* restricted to the Mojave Desert and the transition zone of the Mojave Desert and the Great Basin, and *Phacelia petrosa* to the lower drainages of the Colorado River in southern Nevada, southern Utah, and northwestern Arizona. One of the key characters used to distinguish species of *Phacelia* is seed morphology. Other morphological features that are useful are: size, shape, and color of flowers; duration; leaf size, shape, and pubescence; as well as stamen and style length in contrast to the corolla length. In addition, geographic distributions are useful in distinguishing taxa.

Phacelia filiae N. D. Atwood, F. J. Smith & T. A. Knight, sp. nov. TYPE: U.S.A. Nevada: Clark Co., Nellis Range, 36°38'02"N, 115°30'57"W, Three Lakes Valley, 45 air km NW of Las Vegas, 3080 ft. elev., 2 May 1998, *F. J. Smith & P. Dwyer* 4217 (holotype, UNLV; isotypes, ARIZ, ASC, BRY, CAS, GH, MO, NY, NTS, OSU, RM, RSA, UNLV, US, UTC). Figures 1–3.

Similis *Phacelia parishii* sed in floribus et lobis corollarum majoribus foliis caulinum plus numerosis et seminibus grandibus paucioribus differt et a *P. beatleyae* in foliis plerumque basalibus nec vulgo caulinis et planis nec revolutis admodum integris seminibus parvioribus et plus numerosis absimilis.

Plants annual, 2.3–6.0 cm high, branched at or near the base; stems 2.5–7 cm long, curved upward; leaves mostly basal, petiolate, the blade 0.7–3.0 × 0.5–1.5 cm, ovate, elliptic, or oblong, entire to few toothed, the petiole 1.5–15 mm long; inflorescence of terminal secund cymes, 0.6–3.5 cm long; calyx united basally, the lobes heteromorphic, of unequal widths with 3 distinct veins, from narrowly spatulate to broadly obovate, 4–5 × 1.2–2.7 mm in flower, fruiting calyx 4.5–8 × 1.2–3.5 mm; corolla tubular-campanulate, 6–7 × 2.5–3.5 mm, the lobes 1.5–2.4 mm long, finely puberulent externally, the tube pale yellow, the limb lavender; stamens and style included, filaments 3–4 mm long, glabrous, attached at the base of the corolla tube; the style 1.1–1.2 mm long, bifid, glabrous; capsules 4.2–5.5 × 3.2–3.5 mm, finely glandular puberulent; seeds 18–26, 1.3–1.8 × 0.5–0.6 mm, angular, and with rounded or narrowed tips, black with evident pits.

Distribution. *Phacelia filiae* occurs in southern Nevada on Nellis Range (Clark County), Nevada

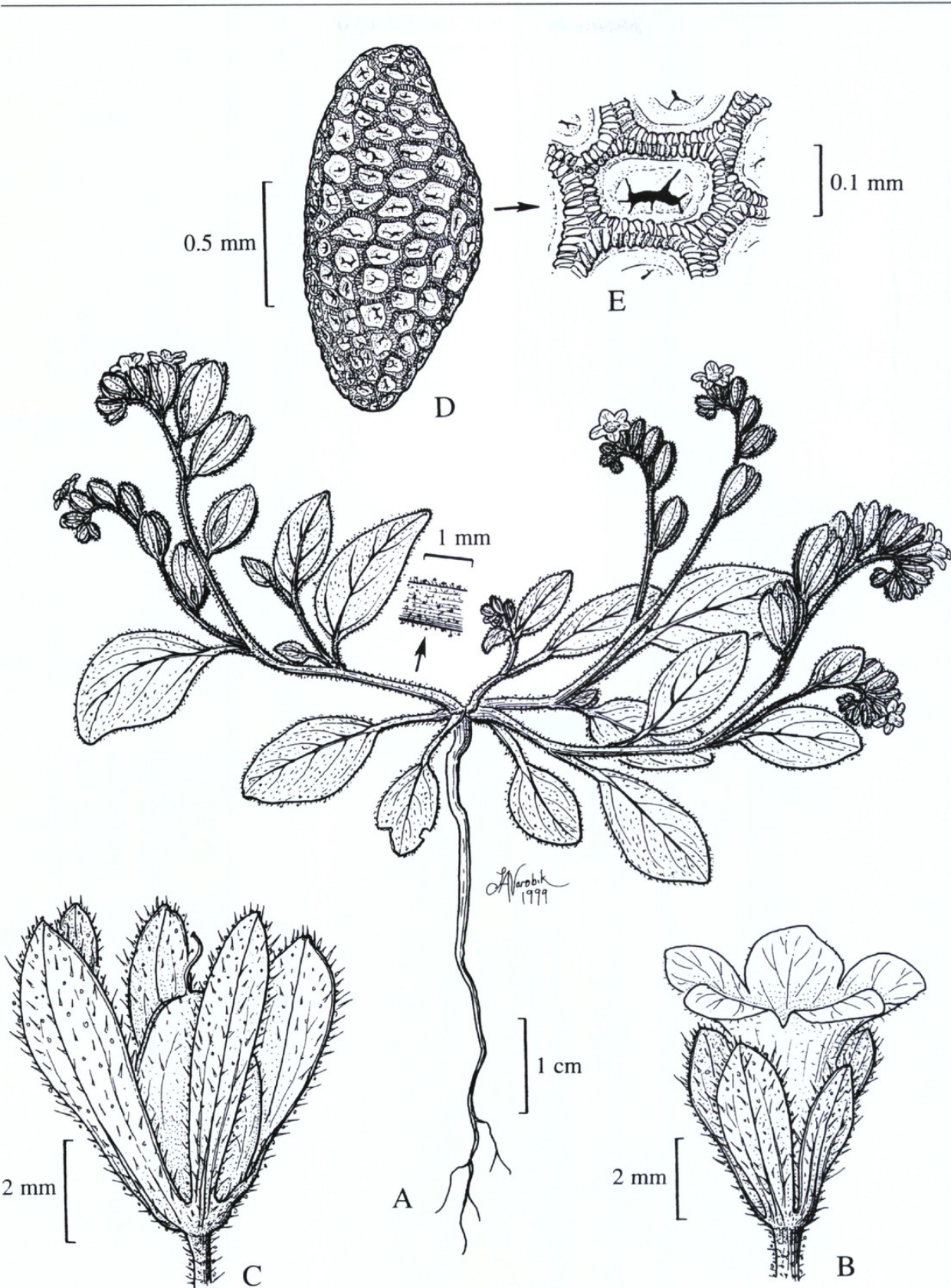


Figure 1. *Phacelia filiae* N. D. Atwood, F. J. Smith & T. A. Knight. —A. Habit. —B. Flower. —C. Fruit and calyx. —D. Seed. —E. Seed detail. Drawn by Linda A. Vorobik (plant based on the holotype Smith & Dwyer 4217, seed based on Smith & Ackerman 3880).

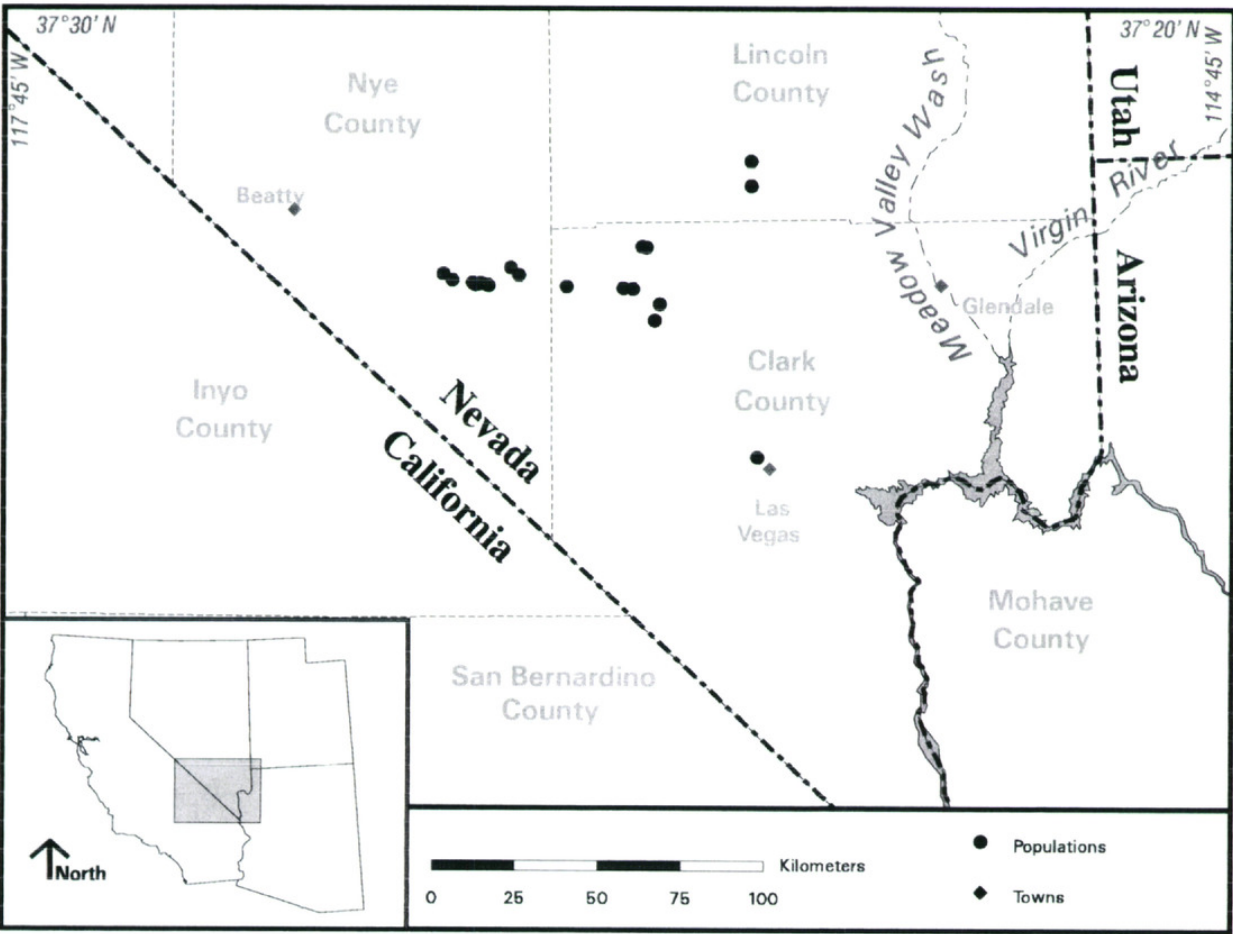


Figure 2. Known distribution (●) of *Phacelia filiae* in Clark, Lincoln, and Nye Counties, Nevada (◆ = towns).

Test Site (Nye County), Desert National Wildlife Refuge (Clark and Lincoln Counties) and in urban Las Vegas (Fig. 2).

Habitat. Plants of *Phacelia filiae* are found on relatively flat areas or on low knolls of the valley floor, mostly above the playas and in the foothills of desert mountains. This species grows in light-colored soils of calcareous sandstone, siltstone, tuffaceous claystone, and limestone substrates. Elevation ranges from 2000 to 4000 feet, where it occurs in shadscale, blackbrush, and creosote bush scrub.

Paratypes. U.S.A. **Nevada:** Clark Co., near Las Vegas, 8 May 1941, A. Eastwood & J. Howell 8958 (CAS, GH, POM, RM, UTC); foothills of Spotted Range, 13 May 1941, H. D. Ripley & R. C. Barneby 3425 (CAS, RSA); along Cheyenne Ave. near the drive-in theaters, Las Vegas, 25 Apr. 1979, P. Leary 2941 (UNLV); Indian Springs Valley, T13S, R57E, S29, 15 May 1993, F. J. Smith & E. Watkins 3670 (UNLV); Pintwater Range, T15S R56E S1, 3660 ft. elev., 23 Apr. 1995, F. J. Smith & R. Schofield 3847 (UNLV); Indian Springs Valley, T15S, R56E, S3, 23 Apr. 1995, F. J. Smith & R. Schofield 3848 (UNLV); Indian Springs Valley, T13S, R57E S29, 6 May 1995, F. J. Smith & T. Cox 3861 (UNLV); W of Pintwater Range, T13S, R56E S28, 7 May 1995, F. J. Smith & T. Cox 3862 (UNLV); W of Pintwater Range, T13S R56E S25, 7 May

1995, F. J. Smith & T. Cox 3863 (UNLV); Spotted Range, T15S, R55E, S5, 28 May 1995, F. J. Smith, J. Heers & E. Watkins 3893 (UNLV); Three Lakes Valley, T16S R57E S3, 30 Apr. 1995, F. J. Smith & E. Watkins 3858 (UNLV); Lincoln Co., E side of Desert Lake, 28 May 1983, T. Ackerman 83-562 (UNLV); SE end of Desert Lake, T11S, R60E, 10 May 1987, A. Tiehm 10994 (RM, RSA, UNLV, UTC); Desert Lake, T11S, R60E S1, 22 Apr. 1995, F. J. Smith, R. Schofield & B. Benjamin 3845 (UNLV); E side of Desert Lake, T11S, R60E, 16 May 1995, F. J. Smith & T. Ackerman 3880 (UNLV); Desert Lake, T11S, R60E, S36, 28 Apr. 1995, F. J. Smith & S. Sheldon 3854 (BRY, MO, NY, UTC); Nye Co., NW side of Rd. 28-03, 0.8 mi. NE of its junction with Jackass Flats Rd., E Rock Valley, 26 May 1976, M. Williams 145 (UC); Rd. 28-03, 0.8 mi. NE of junction with Jackass Flat Road, E Rock Valley, 20 May 1976, M. Williams 120 (NTS); 1 mi. E of Pink Holes Hill W of Frenchman Flat, 8 June 1976, M. Williams 173 (NTS); W side of low hills 1.0 mi. S of Little Skull Mountain, W of Jackass Flat Road, Rock Valley, 26 Apr. 1978, S. Cochrane & M. Williams 1010 (UNLV); NW Rock Valley off the W side of Jackass Flats Road S of the pass into Jackass Flats, 26 Apr. 1978, M. Williams 450 (UNLV); 3.7 mi. W of 28-03 Road, W Rock Valley, 9 May 1978, S. Cochrane & Timbrook 1092 (UNLV, RENO); E side of Burma Road, 1.4 mi. NW from Mercury Highway at Mercury Pass, NW slopes of Mercury Ridge, Red Mountain, 28 Apr. 1978, M. Williams 461 (UNLV); Rock Valley, UTM 567482E, 4064091N, 4 May 1995, G. Lyon 300 (UNLV); Rock Valley, along N and S sides of Jackass

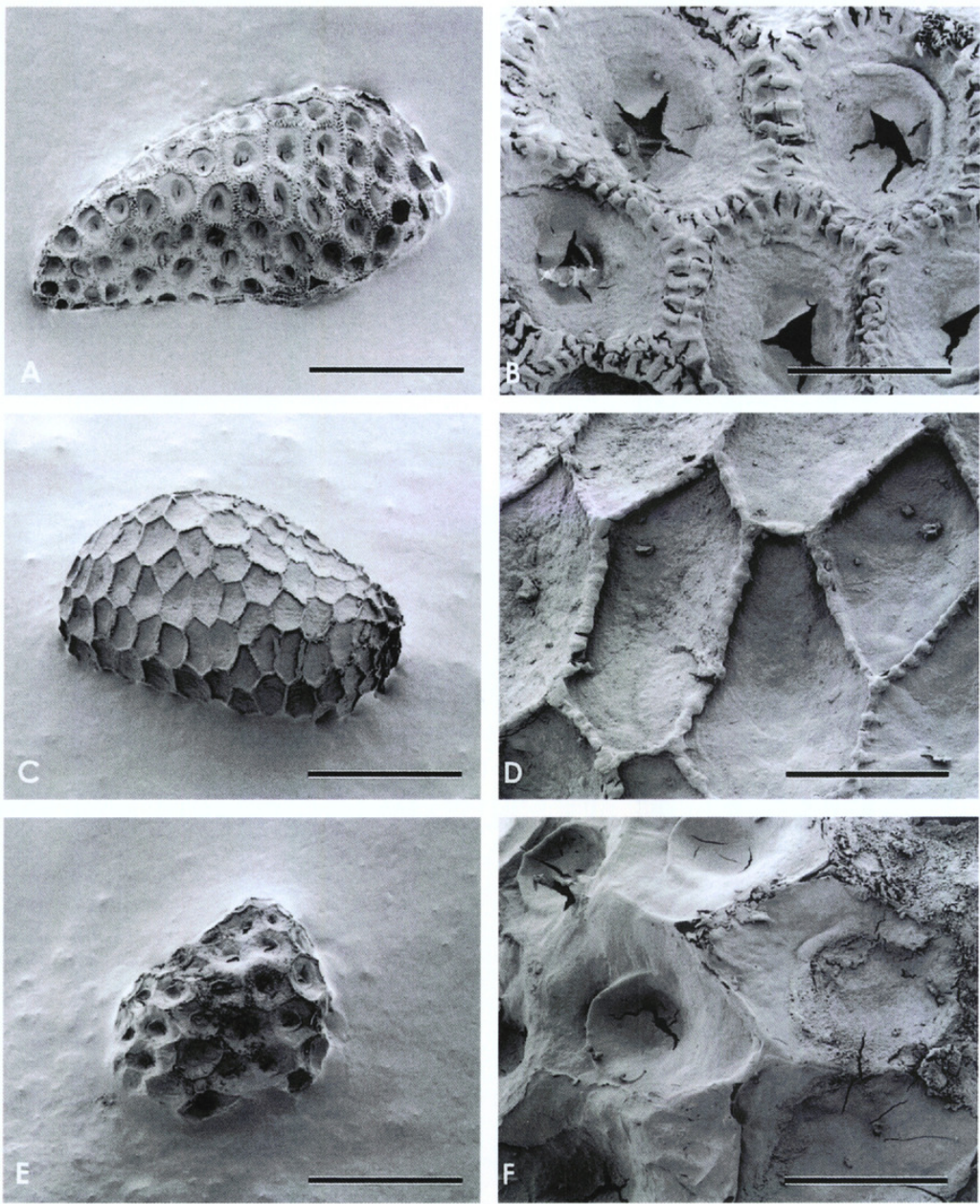


Figure 3. Scanning electron micrographs of seed and seed coat. A, B. *Phacelia filiae* from Smith & Ackerman 3880 (UNLV). —A. Seed. —B. Seed coat. C, D. *Phacelia parishii* from Anderson 95–9 (ASU). —C. Seed. —D. Seed coat. E, F. *Phacelia beatleyae* from Beatley 5585 (UTC). —E. Seed. —F. Seed coat. Scale bar in A, C, E = 0.5 mm. Scale bar in B, D, F = 0.075 mm.

Flats Road, S of Skull Mtn., UTM 570164E, 4062190N, 8 May 1995, *T. Lindemann* 47 (UNLV); Rock Valley, UTM 576247E, 4061394N, 8 May 1995, *T. Lindemann* 48 (UNLV); Rock Valley, UTM 577080E 4060820N, 8 May 1995, *T. Lindemann* 50 (UNLV); Rock Valley, UTM 580561E, 4060888N, 8 May 1995, *T. Lindemann* 52 (UNLV); Rock Valley, UTM 581013E 4060575N, 9 May 1995, *G. Lyon* 301 (UNLV); Rock Valley, UTM 579200E 4061100N, 1130 m elev., 9 May 1995, *G. Lyon* 302 (UNLV); Rock Valley, UTM 578490E 4061200N, 9 May 1995, *G. Lyon* 303 (UNLV); Rock Valley, UTM 577820E 4060960N, 9 May 1995, *G. Lyon* 304 (UNLV); Frenchman Flat, UTM 590270E 4063720N, 10 May 1995, *G. Lyon* 305 (UNLV); Frenchman Flat, UTM 587780E 4065920N, 10 May 1995, *G. Lyon* 306 (UNLV).

In the spring of 1995, a new annual species of *Phacelia* was discovered on the Nellis Ranges by the second author. During that same year, the second author was conducting an inventory of *Phacelia parishii* for the Nevada Natural Heritage Program. In May, Smith visited known sites (Fig. 2) of *P. parishii* and *P. beatleyae* on the Nevada Test Site. Plants from there did not match the description or fit the key for *P. parishii* or *P. beatleyae*. They appeared to be the same undescribed *Phacelia* found on the Nellis Ranges. Surveys for this new *Phacelia* continued on Nellis lands through 1999, with pop-

ulations appearing in high precipitation years. Approximately 30 populations comprise the currently known range.

The most significant differences among these species are the seeds: their number, shape, and the appearance of the seed coats. The seeds of these three species are distinct. The seeds of *P. filiae* are 1.3–1.8 mm long, 18 to 26 per capsule, long-angular in shape and rounded or narrowed to the ends, with more and deeper pits. The seeds of *P. parishii* are smaller, more numerous (30 to 40 per capsule), mostly rounded in shape with round tips and shallow pits; and the seeds of *P. beatleyae* are 40 to 50 per capsule, angular in shape, round at the tips, and deeply pitted. These distinguishing characters are observed readily in the electron micrographs (Fig. 3). In addition, the stems of *P. filiae* and *P. beatleyae* are always leafy, but some stems of *P. parishii* can be leafless. Also, the stems of *P. beatleyae* are erect while those of *P. filiae* and *P. parishii* are decumbent. *Phacelia filiae* differs from *P. parishii* in having larger tubular-campanulate flowers (6–7 mm long vs. 4–5 mm long), larger corolla lobes (1.5–2.4 mm long vs. 0.7–1.3 mm long), and more cauline leaves. It further differs from *P. beatleyae*, which lacks a basal rosette and has strongly revolute and essentially entire leaves.

Phacelia filiae should be placed with *P. parishii* and *P. beatleyae* in the subgenus *Eutoca*. According to Howell (1943), *Phacelia* subg. *Eutoca* is characterized by plants that are chiefly annual (some perennial) with leaves entire to shallowly lobed, corollas tubular or tubular-campanulate, stamens shorter than the corolla, style bifid or at most parted 1/3 its length, and by capsules that are generally elliptic or oblong and obtuse or truncate below the terminal apiculation. The species name *filiae* is used to honor the third author's daughter, with Clarke's *phacelia* the suggested common name.

The following key separates *P. filiae* from closely related species of *Phacelia* that occur in Nevada.

- 1a. Leaves essentially entire, revolute, all cauline; seeds 40 to 50 per capsule, 0.6–1.0 mm long, short angular or rounded *P. beatleyae* Constance & Reveal
- 1b. Leaves entire-crenate, not revolute, basal and cauline; seeds 40 or fewer per capsule, 1.1–1.8 mm long, roundish oblong or long angular.
 - 2a. Corolla 6–7 mm long, the lobes 1.5–2.4 mm long; seeds 18–26 per capsule, 1.3–1.8 mm long, deeply pitted (crater-like), long angular with narrowed or rounded ends and deeper pits *P. filiae* N. D. Atwood, F. J. Smith & T. A. Knight
 - 2b. Corolla 4–5 mm long, the lobes 0.7–1.3 mm long; seeds 30 to 40 per capsule, 0.9–1.1 mm long, roundish oblong with round ends and shallow pits *P. parishii* A. Gray

Phacelia petrosa N. D. Atwood, F. J. Smith & T. A. Knight, sp. nov. TYPE: U.S.A. Arizona: Mohave Co., T32N, R9W, S24, Mohave Strip, 1 mi. N of the Colorado River, E of Whitmore Canyon-Colorado River overlook on limestone talus slopes, 22 Apr. 1999, *D. Atwood & B. Furniss 24210* (holotype, BRY; isotypes, ARIZ, ASC, BM, CAS, GH, K, MO, NTS, NY, OSU, POM, RM, RSA, UNLV, US, UTC). Figures 4–6.

A *Phacelia crenulata* in pilis hispidis et glandularibus floribus minoribus et pedicellis longioribus infra, staminibus exsertis minoribus seminibus foveis nullis differt, a *P. ambigua* in seminibus pagina ventrali corrugata intus et cristam latum unum pagina dorsali bruneo pallide e margine stramineo pallido cicatricibus dorsalis rotundatis et elevatis et e radiis stellatis et floribus parvioribus et pubescentibus glandularibus infra inflorescentiis praecipue differt.

Plants annual, 1.0–3.2 dm tall; basal leaves 3.3–7.5 cm long, rounded to oblong, petiole up to 3 cm long, the blade 2.5–5.0 cm long, toothed, pinnatifid; cauline leaves irregularly dentate, reduced upward, 0.8–3 cm long, 0.8–2.0 cm broad, petiole 1.1–2.4 cm long; pubescence densely hispid with spreading, shiny hairs, and glandular villous; inflorescence of paired terminal cymes with capitate multicellular hairs, cymes elongating to 6 cm long in fruit; pedicels 0.8–1.5 mm long in flower, lower pedicel to 5.4 mm long; calyx 3.0–3.4(4.2) mm long, the lobes oblanceolate, separate to near the base, 0.9–1.5 mm wide, not enlarging in fruit; corolla campanulate, 5.8–6.0 mm long and broad, blue, lighter at base, the lobes glabrous to pubescent externally; stamens and style exerted, stamens subequal to the style, 3.7–4.3 mm long, filaments purple and glabrous, style 2.8–4.5 mm long, bifid, lower portion pubescent with glandular hairs; capsule globose, mature capsules 3.0–4.0(4.6) mm broad and long, equaling to exceeding the calyx lobes, finely puberulent with some glandular hairs especially on the upper half; seeds 4, oblong, 3.3–3.8 mm long, 1.5–3.1 mm wide, the ventral surface corrugated along the inside margin and one side of the ridge, dorsal surface with a lighter stramineous margin and light brown surface, dorsal cells round in shape and raised with star-like rays.

Distribution. *Phacelia petrosa* occurs in southwestern Utah (Washington County), southeastern Utah along the San Juan River (San Juan County), northwestern Arizona along the Colorado River in Mohave and Coconino Counties, and southern Nevada in Lincoln and Clark Counties (Fig. 5).

Habitat. The species is generally found on dry limestone and volcanic talus slopes of foothills,

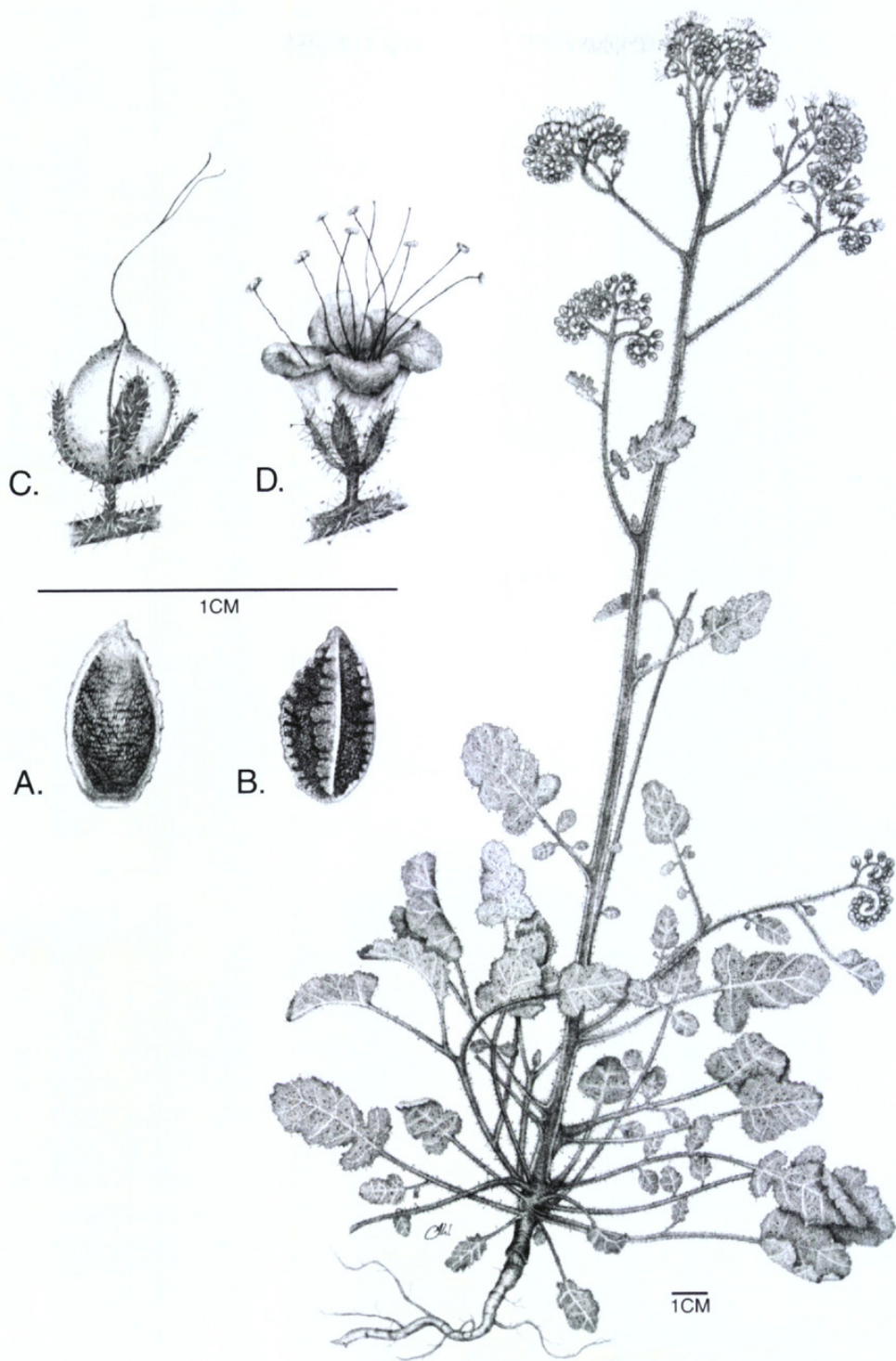


Figure 4. *Phacelia petrosa* N. D. Atwood, F. J. Smith & T. A. Knight. —A. Dorsal surface of seed. —B. Ventral surface of seed. —C. Capsule, sepals, and style. —D. Flower with exserted stamens and style. Drawn by Shannon Workman (based on the type specimen *Atwood & Furniss* 24295 (BRY)).

washes, and gravelly canyon bottoms. It grows mostly on calcareous parent material but has been collected on dry volcanic talus slopes. The elevation range is 2500 to 5800 feet, where it occurs in mixed desert shrub, creosote bush, and blackbrush communities.

Paratypes. U.S.A. **Arizona:** Coconino Co., Bright Angel trail, 16 Apr. 1938, *Darrow s.n.* (UC); Bright Angel

trail near first creek crossing above river, 9 May 1940, *Bailey & Bailey 1097* (UC); beyond Miner's cabins, Havasu Canyon, 3 May 1947, *Deaver 2085* (ASC); Hualapai Canyon, 28 May 1950, *J. Howell 26588* (CAS); above House Rock Rapids and Hot Na Na Wash, 8 May 1973, *A. Phillips s.n.* (ARIZ); about 1 mi. downstream from House Rock Rapids and Rider Canyon, 9 May 1973, *A. Phillips s.n.* (ARIZ); first canyon downstream from Unkar Canyon on N, 13 May 1973, *A. Phillips s.n.* (ARIZ); 18.5 mi. campground, Colorado River, 18 May 1976, *Hevly s.n.*

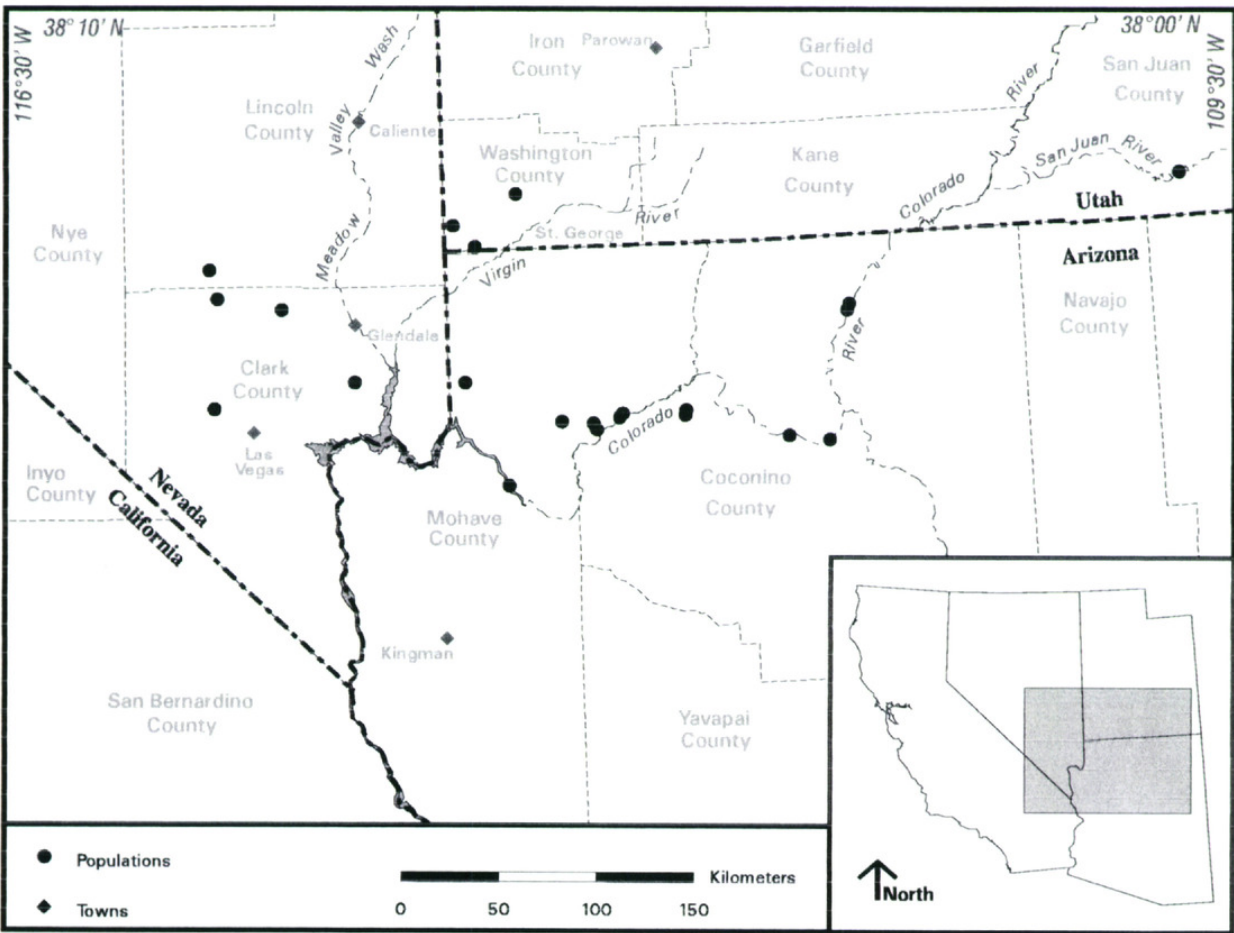


Figure 5. Known distribution (●) of *Phacelia petrosa* in northwestern Arizona, Clark and Lincoln Counties, Nevada, and San Juan and Washington Counties, Utah (◆ = towns).

(ASC); Cottonwood Canyon, 22 Apr. 1979, *Van Devender, Cole, Markgraf & Martin s.n.* (ARIZ); Mohave Co., Toroweap Valley, ca. 4250 ft. elev., 30 Apr. 1952, *E. McClintock 52-277a* (CAS); S of Toroweap Point, halfway between Devil's Bathtub and Burro Canyon, 1 May 1952, *E. McClintock 52-348* (CAS); inner gorge of Grand Canyon, along lava slide on trail to river, 5 May 1952, *E. McClintock 52-406* (CAS); below Emery Falls, opposite Rampart Cave, 8 Apr. 1971, *Martin s.n.* (ARIZ); side canyon at Grand Canyon mile 254.6R, 8 Apr. 1993, *A. Phillips & B. Phillips 9381* (ASC); T35N, R15W, S31 NW ¼, black lava ridge SE of Pakoon Ranch, 15 May 1985, *D. Atwood 10945* (BRY); T32N, R10W, S6, Andrus Canyon 3 mi. W of Andrus Point, 26 Apr. 1999, *D. Atwood & B. Furniss 24295* (BRY, MO, NY, US); T32N, R9W, S11 NWSE, 2 mi. E of Whitmore Point, 22 Apr. 1999, *D. Atwood & B. Furniss 24222* (ARIZ, ASU, BRY, MO, NY, UNLV). **Nevada:** Clark Co., SE end of Las Vegas Range, 14 May 1976, *T. Ackerman 76-56* (UTC); NNW foothills of Charleston Mts., T17S, R56E, S4 SW ¼, 5 air mi. S of Indian Springs, 2 May 1985, *D. Atwood & K. Thorne 10854* (BRY, RENO); Las Vegas Range, Second Canyon S of Peek-a-boo Canyon, 29 May 1976, *T. Ackerman 4996* (UC, UNLV); Desert Range, T13S, R59E S20, 22 May 1993, *F. J. Smith, T. A. Knight & J. Pedrick 3680* (UNLV); Valley of Fire, T18S, R66E, S1, 17 May 1995, *F. J. Smith & T. Ackerman 3882* (UNLV); Lincoln County, Las Vegas Range, Elbow Canyon, T14S, R62E, S1 NE¼, 15 May 1995, *F. J. Smith & T. Ackerman 3877* (UNLV, UTC); Desert Range, T12S, R59E, S6, 1 May 1993, *F. J. Smith*

& R. Schofield 3634 (UNLV). **Utah:** San Juan Co., Mile 40.6 at the lower end of the Goosenecks of the San Juan River, 6 May 1997, *N. D. Atwood et al. 21911* (BRY, MO); mi. 59.2, 0.7 mi. below Johns Canyon along the San Juan River, 7 May 1997, *N. D. Atwood et al. 21934* (BRY); Washington Co., T42S, R19W, S18, Beaver Dam Wash 3 mi. S of Lytle Ranch, 17 Apr. 1986, *D. Atwood & K. Thorne 12000a* (BRY); SW of Bulldog Canyon, 17 May 1986, *L. C. Higgins 16552* (BRY); Diamond Valley volcano, 26 May 1986, *L. C. Higgins 16665* (BRY), 2 June 1998, *L. C. Higgins 19641* (BRY, GH, MO, NY, OSU, RSA, US); T41S, R16W, S3 SWSE, NE corner of Snow Canyon State Park at Winter Quarters, 20 May 1992, *M. F. Franklin 7484* (BRY); T43S, R18W, S33, S of Bull Dog Canyon, 3 May 1986, *K. Thorne et al. 4505* (BRY); T43S, R18W, S28 SE ¼, Bull Dog Knolls, 1 May 1986, *G. Baird & S. Welsh 2395* (BRY); T43S, T18W, S28, S slope of Bull Dog Knolls, 30 Apr. 1986, *S. Welsh & G. Baird 23698, G. Baird 2323 do* (BRY).

In 1970, the senior author examined collections of this species from the Grand Canyon. An attempt was made to find the species in the field in 1971 without success. The species became a forgotten entity until Smith and Knight discovered it while doing fieldwork on Nellis Ranges in 1993. They collected a *Phacelia* in the Desert Range (Lincoln County, Nevada) with pubescence much different

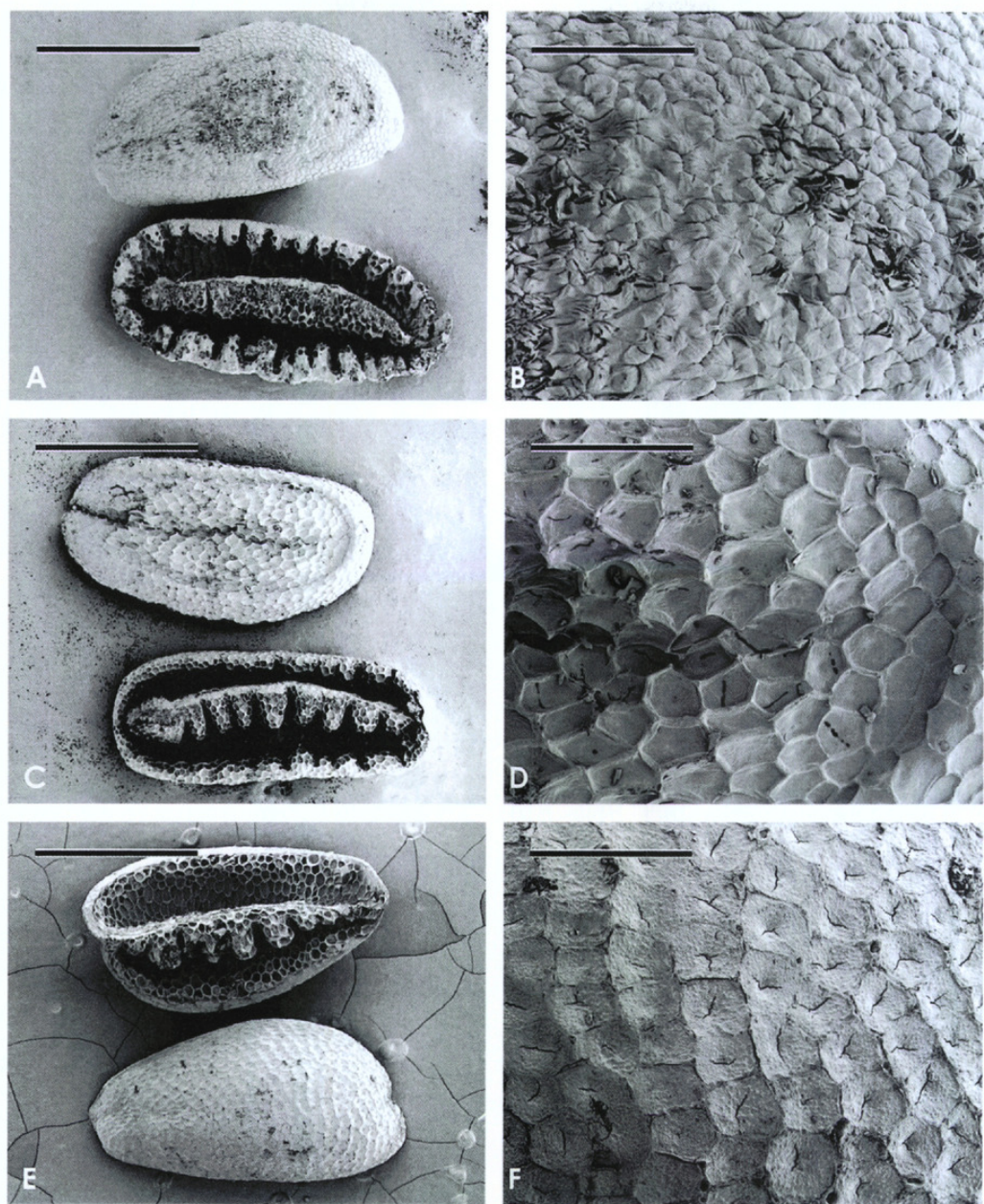


Figure 6. Scanning electron micrographs of seeds and seed coat. A, B. *Phacelia petrosa* from Atwood 10945 (BRY). —A. Seed. —B. Seed coat. C, D. *Phacelia crenulata* from Holmgren & Reveal 1031 (UTC). —C. Seed. —D. Seed coat. E, F. *Phacelia ambigua* from Higgins 15475 (BRY). —E. Seed. —F. Seed coat. Scale bar in A, C, E = 1.5 mm. Scale bar in B, D, F = 0.3 mm.

than typical *Phacelia ambigua* and *P. crenulata*. Based on close examination, the seed morphology of *P. petrosa* differs from that of *Phacelia ambigua* and *Phacelia crenulata*. *Phacelia petrosa* has been identified on herbarium sheets in the past as *P. crenulata*, *P. pedicellata*, *P. ambigua*, *P. minutiflora*, and *P. ambigua* var. *minutiflora*.

Phacelia petrosa belongs to the Crenulatae group of species in the subgenus *Phacelia* in section *Phacelia*. The Crenulatae group is distinguished by the four-seeded capsule and excavated ventral surface of the seeds (Atwood, 1975). *Phacelia petrosa* is most closely related to *P. crenulata* and *P. ambigua*.

The most significant differences among these species are the appearance of the seed coat, flower size, and pubescence. As can be seen on electron micrographs, the seed coat morphology for each of the species is distinctive (Fig. 6A–F). *Phacelia petrosa* differs from *P. crenulata* in being more hispid, with shorter and less glandular pubescence, smaller flowers, longer pedicels on the lower flowers, stamens less exserted, and the seeds not foveolate. The new species differs from *P. ambigua* in having the ventral surface of the seeds corrugated along the inside margin and one side of the ridge, dorsal surface with a lighter stramineous margin and light



Atwood, N. Duane, Knight, Teri A., and Smith, F J. 2002. "Two new species of *Phacelia* (Hydrophyllaceae) from the southwestern United States." *Novon a journal of botanical nomenclature from the Missouri Botanical Garden* 12, 18–26.

View This Item Online: <https://www.biodiversitylibrary.org/item/14672>

Permalink: <https://www.biodiversitylibrary.org/partpdf/36467>

Holding Institution

Missouri Botanical Garden, Peter H. Raven Library

Sponsored by

Missouri Botanical Garden

Copyright & Reuse

Copyright Status: In copyright. Digitized with the permission of the rights holder.

License: <http://creativecommons.org/licenses/by-nc-sa/3.0/>

Rights: <https://biodiversitylibrary.org/permissions>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.