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RECIRCUMSCRIPTION OF *PHYSARIA INTERMEDIA* (BRASSICACEAE) AND A NEW SEGREGATE SPECIES, *PHYSARIA FALLAX*

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ABSTRACT

The widespread species *Physaria intermedia* is recircumscribed and most of the individuals previously included in it are now regarded as a new species, **Physaria fallax** K.A. Mathis & O'Kane, **sp. nov.** *Physaria intermedia* is limited to north-central New Mexico while *P. fallax* occurs in southern Utah, northern and eastern Arizona, and southwest New Mexico.

Physaria intermedia (S. Wats.) O'Kane & Al-Shehbaz (Brassicaceae), as currently circumscribed, occupies two disjunct regions in the USA, one in north-central New Mexico and the other IN southern Utah, northern and eastern (northern two-thirds) Arizona, and southwest New Mexico. There has been speculation whether the plants in north-central New Mexico are the same as *P. intermedia* to the west, because of the combination of their morphology and isolation from the rest of the species, which may indicate they are more similar to other species (e.g., *P. parvula* (Greene) O'Kane & Al-Shehbaz of north-central Colorado and southwestern Wyoming) or a new species all their own (O'Kane 2010, Holmgren et al. 2005).

A molecular and morphological study by Mathis (née Arp, 2012) showed that *Physaria intermedia* from and near the type locality near Sante Fe, New Mexico, is disjunct, monophyletic, and somewhat morphologically different from plants in Arizona, Utah, and southwestern New Mexico, which also form a monophyletic group. Given this, the more widespread plants from outside of north-central New Mexico represent an unnamed species, for which we provide the name *Physaria fallax*.

Figure 1 illustrates the monophyly of both *Physaria intermedia* and *P. fallax*. This tree is the result of a maximum likelihood analysis (Arp 2012) of a combined data set of nuclear ITS sequences and two sequences from the chloroplast genome, *ndhC/trnV* intergenic spacer (Goodson et al. 2006) and *rps16* (Oxelman et al. 1996) intron. Table 1 gives accession data for specimens used in the molecular analysis. Samples were chosen from throughout the range of the species and were borrowed from BRY, ISTC, NMC, NMCR, and UNM.

Further study of the morphology of these cryptic species was done to establish a means of identification. Their morphology is remarkably similar and led researchers for many years to believe they were conspecific. Finding a distinct characteristic of each to identify them was difficult, a situation similar to the species pair *P. navajoensis* (O'Kane) O'Kane & Al-Shehbaz/*P. tumulosa* (Barneby) O'Kane & Al-Shehbaz (O'Kane 2010). The caudex of *P. intermedia* is substantially more robust than that of *P. fallax*, and *P. intermedia* often has narrow hyaline margins on the lateral sepals. Another important factor is their difference in geography (Fig. 4).

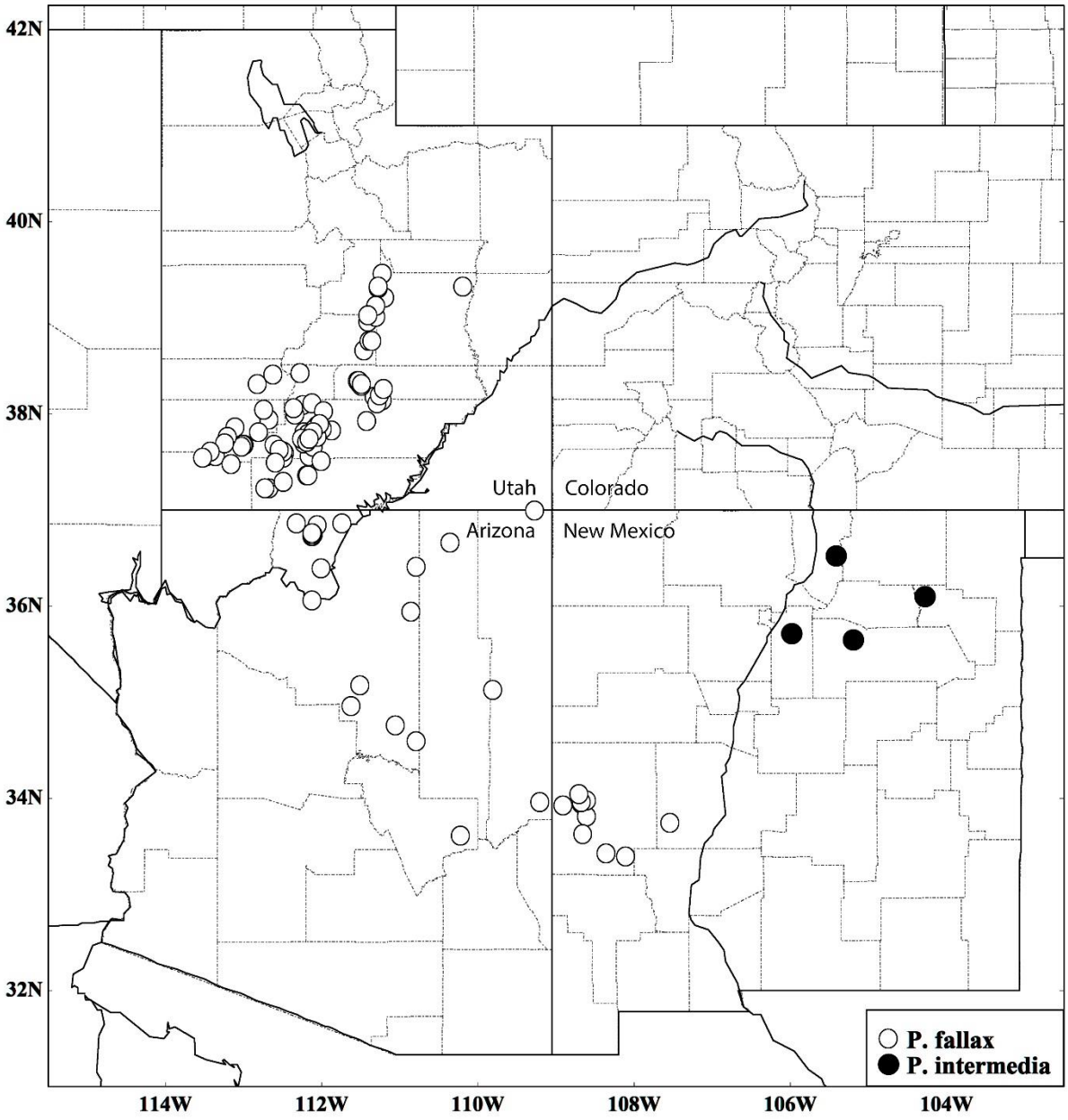

Figure 1. Distribution of *Physaria fallax* (open circles) and *P. intermedia* (filled circles).

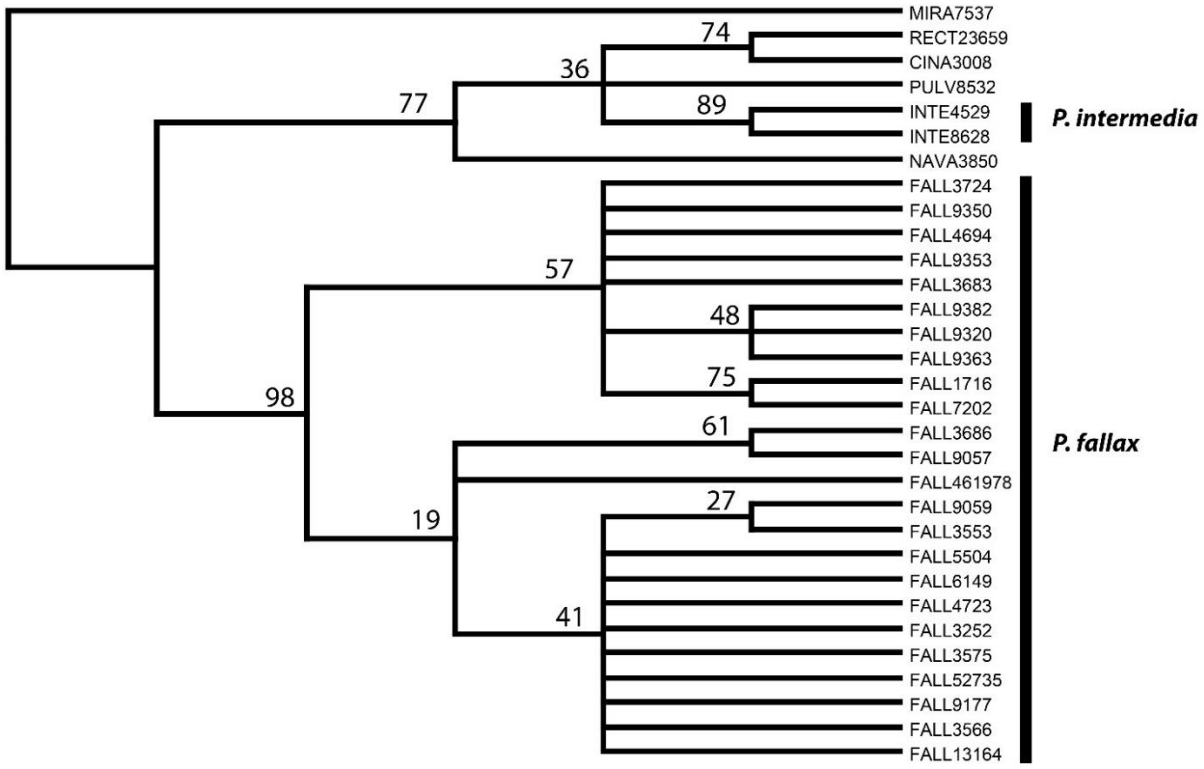

Figure 2. Maximum likelihood tree. Numbers at nodes are bootstrap proportions from 500 random samples.

Table 1. Voucher information and localities for tissues used in the DNA analysis of this study. Voucher information is represented by collector(s), collector number and herbarium. Specimens are housed at the Grant Herbarium (ISTC) unless otherwise noted. Herbarium acronyms follow Index Herbarium (https://sweetgum.nybg.org/science/ih/).

Taxon	**Voucher Information**	**Locality**
P. cinerea	Atwood, Allen & Marino 3008 (BRY)	Coconino Co., Arizona
P.fallax	Allred 7202	Catron Co., New Mexico
P.fallax	Welsh, Taylor & Peabody 13164 (BRY)	Washington Co., Utah
P.fallax	Atwood 6149 (BRY)	Apache Co., Arizona
P.fallax	Holmgren 13566	Coconino Co., Arizona
P.fallax	Holmgren 13553	Garfield Co., Utah
P.fallax	O'Kane 4723	Garfield Co., Utah
P. fallax	Holmgren 13575	Kane Co., Utah
P.fallax	Holmgren & Holmgren 13252 [holotype]	Sevier Co., Utah
P.fallax	O'Kane 5504	Navajo Co., Arizona
P.fallax	O'Kane 9320	Catron Co., New Mexico
P.fallax	O'Kane 9350	Catron Co., New Mexico
P.fallax	O'Kane 9353	Apache Co., Arizona
P.fallax	O'Kane 9063	Catron Co., New Mexico
P.fallax	O'Kane 9382	Catron Co., New Mexico
P.fallax	Castetter 4694 (UNM)	Catron Co., New Mexico

P.fallax	Gerisch 3724 (UNM)	Catron Co., New Mexico
P.fallax	Sivinski & Lightfoot 1716 (UNM)	Catron Co., New Mexico
P.fallax	Gierisch 3683 (UNM)	Coconino Co., Arizona
P.fallax	Giersich 3686 (UNM)	Coconino Co., Arizona
P.fallax	O'Kane 9177	Socorro Co., New Mexico
P.fallax	O'Kane 9057	Coconino Co., Arizona
P.fallax	O'Kane 9059	Coconino Co., Arizona
P. fallax	Howell 1935 (UNM)	Navajo Co., Arizona
P.fallax	Hubbard 1978 (UNM)	Catron Co., New Mexico
P. intermedia	O'Kane 8628 [topotype]	Santa Fe Co., New Mexico
P. intermedia	Schiebout 4529 (UNM)	San Miguel Co., New Mexico
P. navajoensis	O'Kane & Heil 3850	McKinley Co., New Mexico
P. mirandiana	O'Kane & Grady 7537	Nuevo Leon, Mexico
P. pulvinata	Reveal & Broome 8532	San Miguel Co., Colorado
P. rectipes	Heil, Clifford & Schleser 23659	Apache Co., Arizona

Below is an updated physical description of *Physaria intermedia*, now understood as an endemic of north-central New Mexico.

PHYSARIA INTERMEDIA (S. Wats.) O'Kane & Al-Shehbaz. **LECTOTYPE: New Mexico.** Santa Fe Co.: On the lesser hills west of Sante Fe, in pebbly and dry soil, on gently sloping declivities, 1847, *A. Fendler 38* (GH; isolectotypes: GH-Fig. 3, MO, NY, UC, US).

Perennials; caudex massive, buried, branched, thickened with persistent leaf bases, each branch up to 9 mm thick, cespitose, plants forming clumps up to 2.5 dm across; densely pubescent, grayish-green, trichomes sessile or short stalked, spreading, several-rayed, rays furcate or bifurcate, slightly fused at base, tuberculate or finely tuberculate. **Stems** (1) 4–50+ per plant, erect to decumbent, unbranched, stout, densely leafy sterile shoots sometimes present, 1.8–7.5 cm. **Basal leaves** clustered at stem base; blade linear to linear-spatulate, 7–70 × 1–2 mm, margins entire, usually involute, sometimes flattened, apex acute to rounded-acute. **Cauline leaves:** 2–7 per stem, blade linear-oblanceolate to linear, 8–28 × 1–1.5 mm, margins entire, involute, sometimes nearly flat distally. **Racemes** compact, strongly compact raceme to subumbellate. **Fruiting pedicels** ascending usually straight or slightly curved, 3–12 mm, stout. **Flowers:** sepals greenish yellow to pale green, ovate or oblong, 2.8–6 mm, lateral pair sometimes slightly cucullate and usually with a narrow hyaline margin, median pair tapering at both ends, thickened apically, slightly cucullate; petals spatulate or oblong, 5.3–11 mm, base sometimes widened, apex rounded or retuse. **Fruits** 4–12 per stem, sessile or substipitate, subglobose to slightly ovoid, 3–5 × 3–4 mm, apex acute, slightly flattened; valves sparsely pubescent, trichomes appressed; ovules 6–12 per ovary; style 2.5–4 mm. **Seeds** flattened, 1–1.6 × 1–1.2 mm.

Flowering May–July. Dry chip-rock, pebbly soil of open knolls and open piñon-juniper woodlands on calcareous substrates; 1500-2100 m. Because of its limited range and few known localities, this species should be considered rare and potentially endangered.

Specimens studied: **New Mexico.** Harding Co.: 36:04.44N 106:16.0SW *Spellenberg, Soreng & Ward 5995* (NMCR). San Miguel Co.: 35:39.07N 105:14.23W *Schiebout 4529* (UNM). Santa Fe Co.: 5.41.73N 105:59.70W *O'Kane 8628* (ISTC – topotype). Taos Co.: 36:31N 105:25W *Wooton sn.* (NMC).

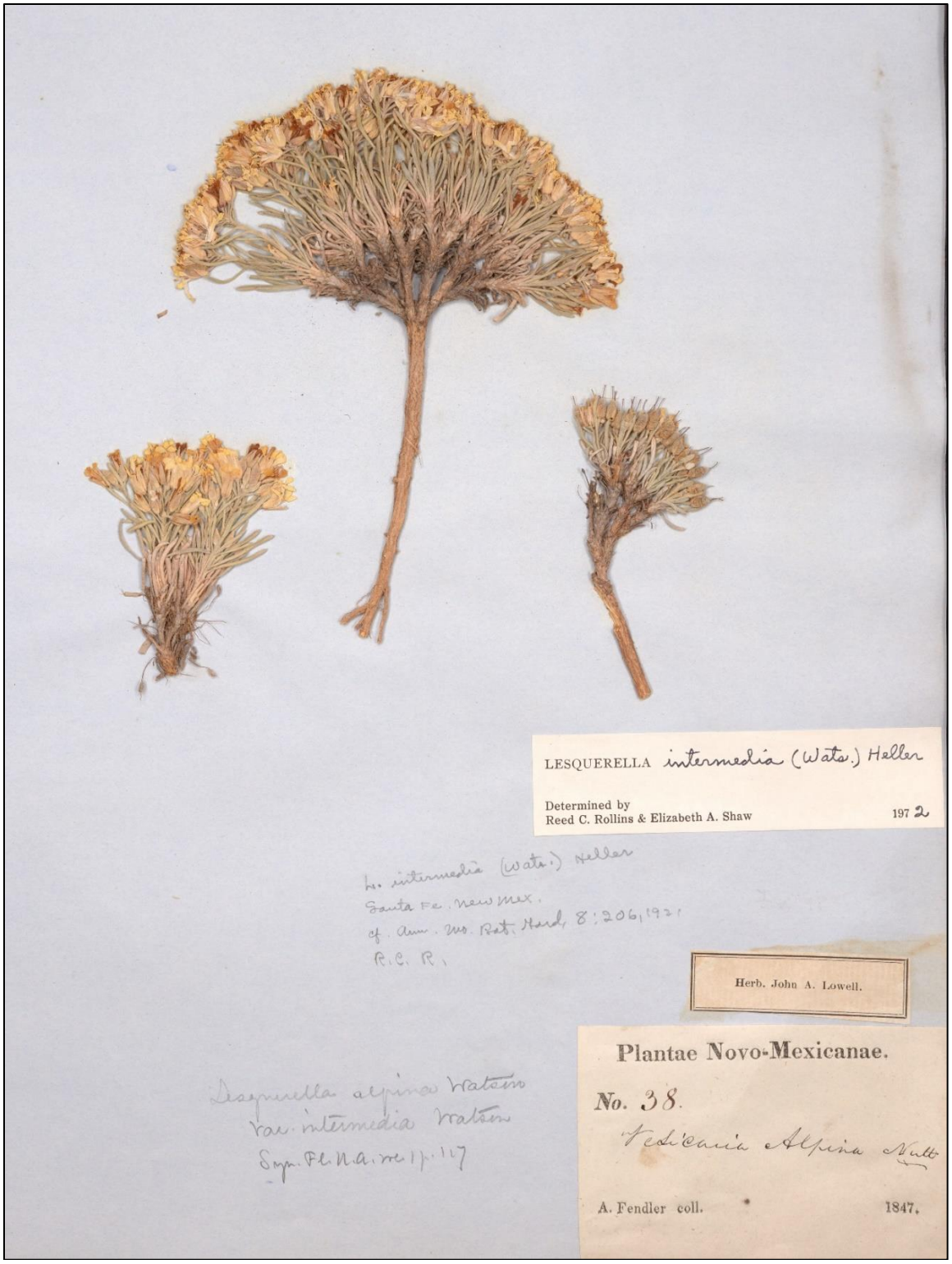

Figure 3. Isolectotype of *Physaria intermedia* (photo courtesy of Harvard University).

Figure 4. Holotype of *Physaria fallax* Arp & O'Kane. Photo NY Botanical Garden.

PHYSARIA FALLAX K.A. Mathis & O'Kane, **sp. nov. TYPE: Utah.** Sevier Co.: Fish Lake Plateau, a short distance up the Last Chance Creek road from Utah Highway 72, 34.5 air km (21.5 mi) SW of downtown Emery, 38.6533333 -111.4502778, 2377 m, 26 Jun 1998, *N.H. Holmgren & P.K. Holmgren 13252* (holotype: NY; isotypes ISTC, UTC). Figure 4.

Similar to *Physaria intermedia* but differing in its less robust caudex and lateral sepals lacking hyaline margins.

Perennials; caudex buried, branched, thickened with persistent leaf bases, each branch up to 6 mm thick cespitose, plants forming clumps up to 8 cm across; densely pubescent, usually grayish-green, trichomes sessile or short stalked, spreading, several-rayed, rays furcate or bifurcate, slightly fused at base, tuberculate or finely tuberculate. **Stems** (1)6–26+, erect to decumbent, unbranched, stout, densely leafy sterile shoots sometimes present, (0.5–)4–1.5(2.5) dm. **Basal leaves** clustered at stem base; blade linear to linear-oblanceolate, (3)5–62 × 1–3 mm, margins entire, usually involute, sometimes flattened, apex obtuse to subacute. **Cauline leaves:** blade linear-oblanceolate to linear, 1–3.5(–5) cm, margins entire, usually involute. **Racemes** compact, often nearly umbellate. **Fruiting pedicels** often expanded distally, ascending or recurved, usually straight or slightly curved, rarely nearly sigmoid, (2.5)4–15 mm, stout. **Flowers:** sepals yellowish or greenish yellow, ovate or oblong, 3.2–6.3(–9) mm, lateral pair sometimes cucullate, median pair tapering at both ends, thickened apically, cucullate; petals spatulate or oblong, (5)6.5–10.5(15) mm, base sometimes widened, apex rounded or retuse. **Fruits** 2–30 per stem, sessile or substipitate, subglobose to slightly ovoid, 2–7 × 1.5–5 usually inflated, sometimes a little compressed or obcompressed, 4–6(–10) mm, apex acute, slightly flattened; valves sparsely pubescent, trichomes appressed; ovules (4–)12–16(–20) per ovary; style (1–)3–4.5(–7) mm. **Seeds** flattened, 1–1.9 × 0.6–2 mm.
2n = 18, 20, 36.

Flowering April–August. Dry sandy, gravelly, or rocky soil, clayey hillsides, open limestone chip-rock, dry stream beds, gravel bars, open knolls, open piñon-juniper woods, open stands of sagebrush, Gambel oak or ponderosa pine communities, calcareous substrates; 1600–2400 m.

The epithet *fallax* (Latin, deceptive or deceitful) alludes to the nature of the plant — the species has deceived researchers in its close resemblance to *P. intermedia*. As possible vernacular name for the species might be Tricky Bladderpod.

Specimens examined. **Arizona.** Apache Co.: 35:07.07N 109:48.06W *Atwood 6149* (BRY). 36:59.56N 109:16.56W *Heil, Clifford & Schleser 23659* (ISTC). 33:57.53N 109:12.50W *O'Kane 9353* (ISTC). Coconino Co.: 36:23.93N 112:00.56W *Atwood 30111* (BRY). 35:56.43N 110:51.58W *Atwood 6135* (BRY). 36:50.90N 112:03.30W *Fertig 23900* (BRY). 36:24.73N 110:47.05W *Atwood 6093* (BRY). 35:56.42N 110:51.50W *Atwood 6135* (BRY). 36:51.12N 111:44.23W *Franklin 7523* (BRY). 35:10.12N 111:30.50W *Clark 12009* (UNM). 36:44.96N 112:07.18W *Gierisch 3694* (UNM). 34:35.13N 110L:47.45W *Gierisch 3683* (UNM). 36:44.68N 112:06.85W *Holmgren, Halgren & Joseph 13566* (BRY). 36:44.41N 112:06.51W *O'Kane 3566* (ISTC). 36:43.56N 112:07.49W *Holmgren, Holmgren & Joseph 13567* (ISTC). 36:03.92N 112:07.08W *O'Kane 9057* (ISTC). 36:44.03N 112:07.79W *O'Kane 9059* (ISTC). 36:51.57N 112:19.04W *Windham 4194* (ISTC). 34:45.21N 111:03.50W *Windham 97-206* (ISTC). 34:35.13N 110:47.45W *Gierisch & Wagner 3583* (UNM). Kaibab Co.: 36:45.08N 112:07.01 W *Guerisch 3694* (UNM). Navajo Co.: 34:58.84N 110:38.31W *Gierisch & Wagner 3686* (UNM). 33:36.09N 110:14.00W *Howell 81* (UNM). 36:39.59N 110:21.09W *O'Kane 5504* (ISTC).

New Mexico. Catron Co.: 33:56.29N 108:40.24W *Allred 7202* (NMCR). 33:37.06N 108:39.09W *Castetter 1932* (UNM). 33:58.82N 108:36.77W *Gierisch 3724* (UNM). 33:46.49N 108:41.12W *Hubbard 1978* (UNM). 33:25.27N 108;22.00W *O'Kane 9063* (ISTC). 33:55.97N 108:54.59W *O'Kane 9382* (ISTC). 33:23.95N 108:06.25W *O'Kane 9320* (ISTC). 33:48.09N 108:36.68W *O'Kane 9350* (ISTC). 34:02.97N 108:42.12W *Sivinski & Lightfoot 1716* (UNM). 33:57.32N 108:40.16W *Wagner 3164* (UNM). 33:57.32N 108:40.16W *Wagner 3165* (UNM). Socorro Co.: 33:44.85N 107:32.90W *O'Kane 9177* (ISTC).

Utah. Beaver Co.: 38:24.19N 112:37.54W *Atwood 11106* (BRY). 38:18.10N 112:49.40W *Franklin 4797* (BRY). Emery Co.: 39:19.55N 111:16.92W *Grady 140* (ISTC). 38:08.00N 111:13.47W *Lewis 4666* (BRY). 39:27.0lN 111:13.02W *Lewis 4745* (BRY). 39:12.04N 111:11.03W *Lewis 13* (BRY). 39:19.47N 110:11.45W *Neese & Welsh 7641* (BRY). 39:08.02N 111:16.23W *Welsh 15002* (BRY). Garfield Co.: 37:53.14N 112:0l.23W *Atwood 8167* (BRY). 37:49.61N 112:52.95W *Beck & Tanner 8215* (BRY). 37:44.52N 112:15.47W *Foster & Foster 4323A* (BRY). 37:39.37N 112:06.15W *Franklin 6389* (BRY). 37:35.40N 1112:28.33W *Higgins & Higgins 15800* (BRY). 37:50.06N 111:59.53W *Higgins, Welsh & Thorne 14729* (BRY). 37:44.50N 112:09.15W *Holmgren & Holmgren 13786* (ISTC). 37:42.35N 111:11.26W *Holmgren, Holmgren & Joseph 13553* (ISTC). 37:43.59N 112:1 l.33W *Madsen 1196* (BRY). 37:55.84N 111:25.34W *Lewis 5729* (BRY). 37:48.21N 112:13.40W *Madsen 372* (BRY). 37:50.06N 112:05.11W *Madsen 426* (BRY). 37:50.06N 112:05.11W *Madsen 426* (ISTC). 37:38.45N 52:13.14W *Madsen 604* (BRY). 37:33.30M 112:09.26W *Madsen 2338* (BRY). 38:05.15N 112:14.17W *Madsen 4070* (BRY). 37:52.43N 112:03.04W *Madsen, Cox & Hansen 2268* (BRY). 32:41.22N 112:13.40W *Madsen, Boylan, Cox & Hansen 2241* (BRY). 37:45.44N 112:13.40W *Mutz & Zarnekee 82-89* (BRY). 37:47.29N 112:13.40W *Mutz & Zarnekee 82-107* (BRY). 37:44.52N 112:12.36W *Mutz & Zarnekee 87-72* (BRY). 37:40.82N 112:36.21W *Mutz & Zarnekee 82-324* (BRY). 37:42.14N 112:10.29W *Neese 17126* (BRY). 37:32.42N 112:29.15W O*'Kane 4194* (ISTC). 37:37.12N 112:32.16W O*'Kane 4723* (ISTC). 38:0l.60N 111:58.95W *Reveal 4448* (BRY). 37:59.40N 112:20.35W *Rollins & Rollins 83156* (BRY). 37:45.48N 112:03.33W *Rollins & Rollins 83170* (BRY). 38:03.89N 112:21.13W *Rollins & Rollins 79164* (BRY). 38:06.84N 112:07.81W *Rollins & Rollins 83164* (BRY). 37:47.39N 112:10.29W *Welsh & Clark 15611* (BRY). 37:48.22N 112:06.51W *Windham 00-137* (ISTC). 37:36.06N 112:29.16W *Windham 4718* (ISTC). Iron Co.: 37:45.30N 113:12.18W *Atwood 29505* (BRY). 37:40.62N 112:59.65W *Atwood 31390* (BRY). 37:41.59N 113:14.39W *Franklin 7650* (BRY). 37:51.98N 113:06.07W *Holmgren & Holmgren 15223* (BRY). 37:56.52N 112:40.23W *Madsen 4430* (BRY). 38:02.26N 112:44.53W *Mutz & Zarnekee 82-301* (BRY). 37:48.58N 112:48.12W *Mutz & Zarnekee 82-285* (BRY). 37:40.lON 113:00.18W *Neese 15684* (BRY). 37:33.43N 113:28.26W *Rollins & Rollins 81101* (BRY). 37:39.l7N 113:0l.23W *Thorne 4487* (BRY). 37:33.0SN 113:21.16W *Warrick 1180* (BRY). Kane Co.: 37:21.44N 112:10.36W *Atwood 20043* (BRY). 37:30.0lN 112:00.57W *Franklin 8413* (BRY). 37:21.57N 112:11.18W *Holmgren, Holmgren and Joseph 13575* (ISTC). 37:21.95N 112;1 l .30W *Holmgren, Holmgren & Joseph 13575* (BRY). 37:29.53N 112:35.l0W *O'Kane 4718* (ISTC).37:13.SlN 112:40.83W *Rollins & Rollins 8173* (BRY). 37:21.44N 112:11.42W *Thorne & Welsh 10514* (BRY). 37:17.22N 112:29.38W *Thorne & Thorne 10822* (BRY). 37:13.0lN 112:43.45W *Welsh & Thorne 25137* (BRY). 37:33.03N 112:29.38W *Welsh 20687* (BRY). Piute Co.: 38:25.11N 112:16.41W *Greenwood 1979* (BRY). 38:23.26N 112:14.27W *Taye 2022* (BRY). 38:09.19N 111:55.39W *Welsh 14966* (BRY). Sanpete Co.: 39:00.21N 111:18.27W *Clark 2626* (BRY). 39:07.32N 111:18.31W *Clark & Taylor 2475* (BRY). 38:20.41N 113:14.39W *Harrison 7344* (BRY). 37:07.32N 111:18.31W *Lewis* 7099(BRY). 39:01.31N 111:24.16W *Lewis 7143* (BRY). Sevier Co.: 38:45.10N 112:49.04W *Cronquist 11561* (BRY). 38:45.l0N 111:21.47W *Thorne 9423* (BRY). Washington Co.: 38:16.32N 111:20.59W *Anderson 360* (BRY). 38:17.24N 111:29.47W *Atwood 15543* (BRY). 38:57.06N 111:24.03W *Cottam 4500* (BRY). 38:20.55N 111:31.70W *Cottam 4500* (BRY). 37:36.39N 113:25.40W

Franklin 7050 (BRY). 38:20.1SN 111:31.28W *Harrison 1337* (BRY). 38:15.40N 111:12.0SW *Holmgren, Reveal & La France 2090* (BRY). 38:06.19N 111:17.87W *Kass & Franklin 2691* (BRY). 37:32.1 lN l 13:14.39W *Welsh, Taylor & Peabody 13164* (BRY). 38:10.30N 111:19.53W *Madsen 4673* (BRY). 38:19.54N 111:37.25W *Madsen 3427* (BRY). 38:25.02N 111:25.23W *Porter 3864* (BRY). 37:28.04N 113:09.12W *Thorne & Franklin 5503* (BRY). 38:16.32N 111:27.35W *VanBuren & Aanderud 97-33* (BRY). 37:32.1 lN 113:31.l0W *Warrick 1660* (BRY). 37:33.0SN 113:28.58W *Warrick 1160* (BRY). 37:32.11N 2:31.l0W *Warrick 2996* (BRY). Wayne Co.: 38:18.16N 111:30.53W *Welsh & Atwood 26273* (BRY). 38:18.16N 111:29.47W *Welsh & Welsh 14351* (BRY). 38:11.17N 111:15.23W *Welsh 13357* (BRY).

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