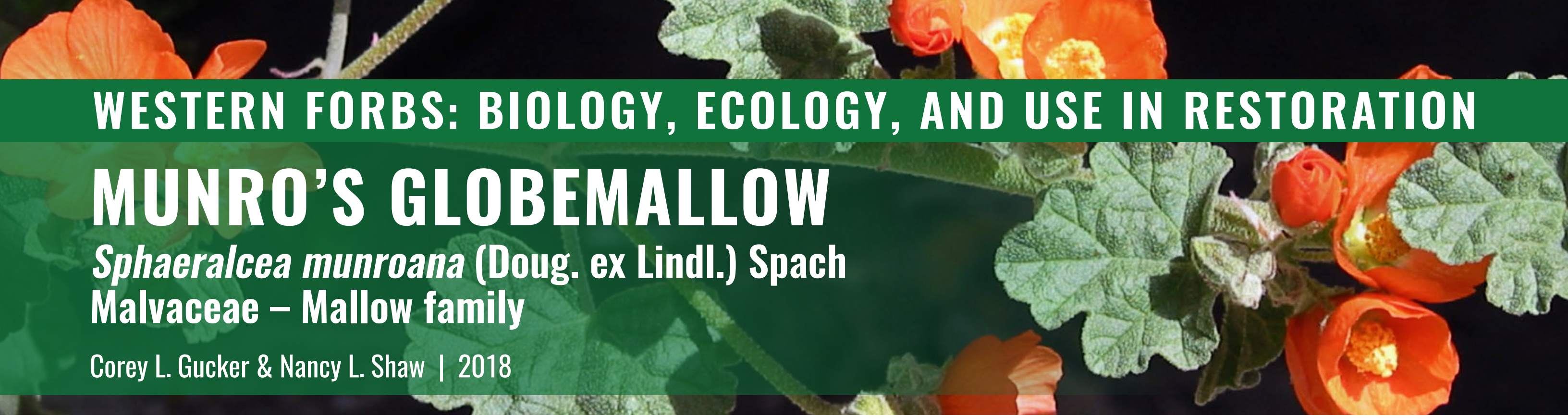

WESTERN FORBS: BIOLOGY, ECOLOGY, AND USE IN RESTORATION

MUNRO'S GLOBEMALLOW

Sphaeralcea munroana (Doug. ex Lindl.) Spach
Malvaceae – Mallow family

Corey L. Gucker & Nancy L. Shaw | 2018

ORGANIZATION

NOMENCLATURE

Commonly referred to as Munro's globemallow, *Sphaeralcea munroana* (Douglas ex Lindley) Spach., belongs to the Malvaceae family and the Malveae tribe (Kearney 1935; La Duke 2016).

NRCS Plant Code. SPMU2 (USDA NRCS 2017).

Subtaxa. The Flora of North America does not recognize any subspecies or varieties (La Duke 2016).

Synonyms. *Malva munroana* Douglas ex Lindley, *M. creeana* Graham; *Malvastrum munroanum* (Douglas ex Lindley) A. Gray, *Malveopsis munroana* (Douglas ex Lindley) Kuntze, *Nuttallia munroana* (Douglas ex Lindley) Nuttall, *Sphaeralcea munroana* subsp. *subrhomboidea* (Rydberg) Kearney, *S. munroana* var. *subrhomboidea* (Rydberg) Kearney, *S. subrhomboidea* Rydberg (La Duke 2016).

Common Names. Desert mallow, Munroe globemallow, orange globemallow, salmon globemallow, scarlet globemallow, whitestem globemallow (Andersen and Holmgren 1976; Gautier and Everett 1979; Welsh et al. 1987; USDA NRCS 2000; Pavek et al. 2011; La Duke 2016).

Chromosome Number. Chromosome numbers are: 2n = 10 or 20 (Rumbaugh and Pendery 1993; Holmgren et al. 2005).

Hybridization. Munro's globemallow and small-leaf globemallow (*S. parvifolia*) may be conspecific (Holmgren et al. 2005; La Duke 2016). Intergradation of Munro's globemallow with gooseberryleaf globemallow (*S. grossulariifolia*) and small-leaf globemallow is suspected where species distributions overlap (Kearney 1935; Rumbaugh and Pendery 1993; Holmgren et al. 2005). Hybrid swarms between seeded and natural populations of Munro's globemallow, gooseberryleaf globemallow, and desert globemallow (*S. ambigua*) were suspected when allozymes and molecular genetic markers were evaluated (McArthur and Sanderson 2005).

DISTRIBUTION

Munro's globemallow is a western species occurring in southern British Columbia, east of the Cascades in Washington and Oregon, as far south as Nevada and Utah and as far east as southwestern Wyoming (Welsh et al. 1987; Holmgren et al. 2005; La Duke 2016; LBJWC 2018). Munro's globemallow is more common in northern Utah and the Wasatch Plateau, whereas gooseberryleaf globemallow is more common in the southern part of the state (Pendery and Rumbaugh 1986).

Habitat and Plant Associations. Munro's globemallow is commonly found on xeric plains and slopes receiving 6 to 14 inches (152-356 mm) of annual precipitation (Ogle et al. 2012; La Duke 2016). It is often found growing in mixed desert shrub, sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), juniper (*Juniperus* spp.), and mountain brush communities (Fig. 1, 2) Welsh et al. 1987; Rumbaugh and Pendery 1993; Holmgren et al. 2005).

Figure 1. Munro's globemallow growing in sagebrush habitat in Oregon. Photo: USDI BLM OR030 SOS.

Elevation. Munro's globemallow populations occupy sites ranging from 330 to 8,000 feet (100-2,440 m) in elevation across its range (Welsh et al. 1987; Holmgren et al. 2005; La Duke 2016). It occurs from 4,500 to 8,000 feet (1,370-2,440 m) in Utah (Welsh et al. 1987).

Soils. Munro's globemallow grows in many soil types but is most common on sandy to clay-loam or gravelly soils (Taylor 1992; Pendery and Rumbaugh 1993). It is often found on open, disturbed sites with light soils of volcanic origin (Kearney 1935; Pendery and Rumbaugh 1993).

DESCRIPTION

Munro's globemallow is a cool-season perennial with a woody, branching crown from a long, thick, strong woody taproot (Pendery and Rumbaugh 1986; Taylor 1992; Kildisheva and Davis 2012). The taproot is branched with several surface roots (USDA NRCS 2000). Several to many slender, erect stems (7-35 inches [18-90 cm] tall) arise from the caudex (Fig. 3) (Munz and Keck 1973; Welsh et al. 1987; La Duke 2016). Stems are up to 6 mm in diameter at the base, sparsely to densely hairy, and unbranched or with short branches (Kearney 1935; Munz and Keck 1973; Holmgren et al. 2005; La Duke 2016).

Leaves range from bright to dark green or gray-green with a dense covering of star-shaped hairs (Welsh et al. 1987; Taylor 1992). Plants do not produce basal leaves; stem leaves are arranged alternately (Holmgren et al. 2005; Pavek et al. 2011). Leaf blades are thin, egg-shaped to triangular, and distinctly but generally shallowly 3- to 5-lobed with round-toothed margins and stellate pubescent surfaces (Kearney 1935; Munz and Keck 1973; Pavek et al. 2011; La Duke 2016). Lobes generally extend half way to the midvein (Parkinson 2003). Leaves are about 0.4 to 2 inches (1-6 cm) long and wide with 0.8 to 1.5-inch (2-4 cm) long petioles (Munz and Keck 1973; Welsh et al. 1987). Leaves are palmately 5-veined from the base, but veins are not prominent on the undersides of leaves (Kearney 1935; Holmgren et al. 2005).

Figure 2. Munro's globemallow growing along the roadside in sagebrush habitat in Utah. Photo: USDI BLM UT931 SOS.

Figure 3. Munro's globemallow growing in Idaho. Photo: USDI BLM ID931 SOS.

Flowers (often >25) are clustered in the leaf axils of leafy, narrow, spike-like inflorescences (Fig. 4) (Welsh et al. 1987; Rumbaugh and Pendery 1993; La Duke 2016; LBJWC 2018). Individual flowers are about 2 cm in diameter with five pale orange to brick red petals. Petals overlap at the base to form a bowl containing a column of numerous stamens, stamens, and the pistil (Taylor 1992; Holmgren et al. 2005; Pavek et al. 2011; La Duke 2016). Sepals are densely pubescent with star-shaped hairs and are retained through anthesis (Munz and Keck 1973; Welsh et al. 1987; Holmgren et al. 2005). Munro's globemallow produces rounded schizocarps, which are divided into 10 to 13 generally single-seeded or rarely two-seeded segments (mericarps) at maturity (Fig. 5; Taylor 1992). The mericarps are partially dehiscent and contain the seeds, which are brown, kidney-shaped, slightly hairy, and about 1.7 mm long (Fig. 6) (Welsh et al. 1987; Holmgren et al. 2005; La Duke 2016).

Figure 4. Munro's globemallow flowers on plant growing in Utah. Photo: USDI BLM UT931 SOS.

Figure 5. Munro's globemallow schizocarps and what are generally single-seeded mericarps collected from plants in Idaho. Photo: USDI BLM ID931 SOS.

Figure 6. Munro's globemallow seed. Photo: J. Cane, USDA ARS.

It can be difficult to distinguish Munro's globemallow from gooseberryleaf globemallow and small-leaf globemallow (Holmgren et al. 2005; La Duke 2016). In general, Munro's globemallow occupies more northern habitats and is larger than small-leaf globemallow (La Duke 2016). Munro's globemallow foliage is often bright green, and it is more common at lower elevations than gooseberryleaf globemallow (Parkinson 2003). Munro's globemallow mericarps dehisce more readily than those of other globemallow species (*Sphearalcea* spp.) (Pendery and Rumbaugh 1986).

Reproduction. Munro's globemallow reproduces entirely from seed (Pendery and Rumbaugh 1986).

Breeding system. Flowers are strongly outcrossing and insect-pollinated (Pendery and Rumbaugh 1986; 1993). In the greenhouse, few schizocarps and little seed were produced when flowers were self-pollinated. When manually outcrossed, 8 to 10 times more schizocarps and 5 to 9 times as many seeds/fruit were produced, which was similar to seed production by openly visited plants growing outdoors in Logan, Utah (Cane 2009).

Pollination. Munro's globemallow is a good pollinator species (Ogle et al. 2012), and its flowers are visited by a variety of specialist and generalist bee and wasp species (Fig. 5) (Pendery and Rumbaugh 1986). Important pollinators include sweat bees (*Agapostemon* and *Halictus* spp.), aphid wasps (*Ammoplanus* spp.), honey bees (*Apis* spp.), panurgine bees (*Calliopsis* spp.), sunflower bees (*Diadasia* spp.), and long-horned bees (*Melissodes* spp.) (Pendery and Rumbaugh 1986). At sites in Idaho, Nevada, Utah, and Wyoming, an average of 14.5 native bee visitors were observed for every 100 globemallow (gooseberryleaf and Munro's) plants examined (Cane and Love 2016).

Ground nesting bees (*Diadasia diminuta*, *D. lutzi*, and *Colletes sphaeralcea*) are globemallow and related species specialists (Cane cited in Pavek et al. 2011). Native sunflower bees (*Diadasia* spp.) were present in every wild population of globemallows sampled across Nevada, eastern Oregon, southern Idaho, and northwestern Utah in 2006. These ground nesters were also found nesting in globemallow seed production plots planted in Ontario, Oregon (Cane cited in Pavek et al. 2011).

ECOLOGY

Munro's globemallow is often described as growing on disturbed or open sites (Andersen and Holmgren 1976; Pendery and Rumbaugh 1993). It is common to see globemallow populations fluctuate over time, establishing in large numbers during favorable conditions or on favorable sites, surviving and reproducing for a few years, and then disappearing or becoming less abundant but persisting at low densities or in the seed bank (Pendery and Rumbaugh 1993).

Seed Ecology. Munro's globemallow seed has a hard seed coat that requires scarification to become water permeable (Kildisheva et al. 2011), however, its longevity in the seedbank is unknown. In Wyoming big sagebrush vegetation in Tooele County, Utah, Munro's globemallow was more common in the seed bank than in aboveground vegetation (Pekas and Schupp 2013).

Seed production can vary by site, climatic conditions, and pest pressure. Birds, rabbits, and weevils (*Macrophoptus* spp.) feed on globemallow seeds and are capable of limiting seed production (Pendery and Rumbaugh 1986). When plant growth was compared at two dryland nursery sites in northern Utah and southern Idaho, precipitation differences were the likely cause of differences in Munro's globemallow seed production. Much more seed was produced at the Utah site, which received 2 to 16 inches (59-405 mm) more annual precipitation over the 4-year study period (Pendery and Rumbaugh 1990).

Harvester ants (*Pogonomyrmex occidentalis*) may be important dispersers of Munro's globemallow seed. In big sagebrush-rabbitbrush vegetation near Kemmerer, Wyoming, Munro's globemallow seed was recovered from 13 of 30 harvester ant middens (the collection of materials discarded by the ants over time). An average of 50.7 seeds/ft^2 (557.5/m^2) were recovered from the middens, which were located near the entrances to the ant mounds. Seed was not recovered from soil samples from areas beyond the mounds or middens, which included the denuded areas surrounding the mounds and middens to a distance of 16 feet (5 m) from mound centers (Mull 2003).

An experiment evaluating the fate of broadcast seeds on disturbed sites suggests that seed fate depends on the terrain and substrate. When seeds of Munro's globemallow seed were broadcast at a rate of 5.5 viable seeds/ft^2 (60/m^2) at a windy, severely disturbed mining site near Kemmerer, Wyoming, the greatest number of seeds was recovered from artificially constructed large holes (20 inches [50 cm] wide and 4 inches [10 cm] deep), followed by 0.8-inch (2 cm) thick gravel layers. The third highest seed total was recovered from small, artificially constructed, and uniformly spaced holes. Overall emergence of all seeded species was low (<2%) but greatest from large holes. Emergence from small hole and gravel treatments was negligible (Chambers 2000).

Seedling Ecology. Studies suggest that Munro's globemallow seedlings grow quickly under ideal conditions. In the greenhouse, seedling relative growth rate (RGR) averaged 0.13 g/g/day at 14 days, 0.15 g/g/day at 28 days, and 0.14 g/g/day 42 days after cotelydons appeared. The RGR of Munro's globemallow was comparable to that of the invasive species investigated (spotted knapweed [*Centaurea stoebe*], rush skeletonweed [*Chondrilla juncea*], Dalmatian toadflax [*Linaria dalmatica*], whitetop [*Cardaria draba*], Fuller's teasel [*Dipsacus fullonum*], and Scotch cottonthistle [*Onopordum acanthium*]) with RGRs ranging from 0.09-0.17 g/g/day (James and Drenovsky 2007). In another greenhouse study, the RGR of Munro's globemallow seedlings was 0.41 mg/mg/week for shoots, 0.53 for roots, and 0.41 mg/mg/week overall. Seedling root systems were fan-shaped with similar lateral and vertical development and considerable branching at the soil surface and throughout the depth of the container (18 inches [45 cm]). Seedling biomass averaged 2.0 g at 6 weeks, 8.8 g at 9 weeks, and 24 g at 12 weeks. Seedling biomass at 12 weeks was 1 to 3 times that of other native species evaluated (hoary tansyaster [*Dieteria canescens*], royal penstemon [*Penstemon speciosus*], sulphur-flower buckwheat [*Eriogonum umbellatum*], and lomatium [*Lomatium* spp.]). When grown in the presence of grass seedlings, biomass of Munro's globemallow was significantly reduced by cheatgrass (*Bromus tectorum*) ($P < 0.001$) but not by the native grasses, Sandberg's bluegrass (*Poa sandbergii*) or squirreltail (*Elymus elymoides*) (Parkinson 2008; Parkinson et al. 2013).

Warm temperatures and disturbance may encourage growth of Munro's globemallow seedlings. In greenhouse experiments, seedlings grown from wildland seed collected from five Oregon and Idaho locations were less well developed and produced less biomass under cool (63/37 °F [17/3 °C]) than warm (73/48 °F [23/9 °C]) diurnal (8/16 hour) temperatures. Seedlings grown under moisture-limited conditions (irrigated every 9 or 12 days) produced greater belowground biomass than seedlings watered every 3 or 6 days ($P = 0.03$). Seedling mortality was rare under the temperature and moisture regimes tested, suggesting seedlings are relatively resistant to temperature and moisture fluctuations (Kildisheva and Davis 2013). In field experiments, Munro's globemallow seedling transplants were not affected by increased air and soil temperatures created with warming open-top chambers. A 2 °F (1.1 °C) increase in air temperature to a daily high of 97 °F (36 °C) with a corresponding 2.5 °F (1.4 °C) increase in soil temperature to a daily high of 88 °F (31 °C) had no significant effect on plant size or biomass. Seedling densities were greater with soil disturbance (created by movement of the warming chamber) and warming. Warmed plants also senesced later than controls. Findings suggested that in restoration project planning, Munro's globemallow is a good choice for withstanding future temperature increases associated with climate change (Whitcomb 2011).

Seedling growth is improved in nutrient-rich environments, as was found in controlled experiments comparing above- and below-ground biomass of plants grown with and without biological soil crust amendments (Pendleton et al. 2003). Two-week-old seedlings were transplanted into 6-inch (15 cm) pots and grown for 70 days in a glasshouse in either sand collected near Moab, Utah, sand with an added 1-cm top layer of excised soil crust (from the same location), or in a container filled entirely with crushed crust material. Plants growing with crusts (both treatments) were significantly larger ($P < 0.05$) than those grown in sand. The fibrous root system was extensive for all seedlings but particularly for those grown entirely in crushed crust (Table 1). Those plants were largest and flowered after 70 days. Available nitrogen, magnesium, and organic matter content were greater in crust topped sand and crushed crust material than in sand alone (Pendleton et al. 2003).

Table 1. Size of Munro's globemallow plants grown in a glasshouse in the presence or absence of biological crust amendments for 70 days (Pendleton et al. 2003).

Growth media	Height (in)	Shoot biomass (g)	Root biomass (g)	Total biomass (g)	Root diameter (mm)	Total root length (ft)
Crushed crust*	13.2a	3.91a	0.86a	4.77a	0.23a	20,105a
Crust topped sand	1.7b	0.51b	0.29b	0.80b	0.25a	8,852b
Sand	1.1c	0.30c	0.25b	0.55c	0.21a	10,686b

*Only plants grown in crushed crust material flowered after 70 days.

Disturbance Ecology. Munro's globemallow often occurs on disturbed sites (Pendery and Rumbaugh 1993; Whitcomb 2011). Cover of Munro's globemallow was greater on burned (2%) than on adjacent unburned sites (0%) 4 years following a fall prescribed fire in mountain big sagebrush on the Uinta National Forest (Goodrich 2006). In defoliation experiments, clipping did not significantly affect Munro's globemallow biomass or pools of total non-structural carbohydrates (TNC), nitrogen, phosphorus, potassium, calcium or magnesium. Clipping experiments were conducted in a dryland nursery where Munro's globemallow and crested wheatgrass seedlings were transplanted in May 1985. Munro's globemallow seedlings were surrounded by 4 crested wheatgrass (*Agropyron cristatum*) seedlings and half of the field was clipped to 2 inches (5 cm) on May 10, 1986. When values were averaged for the year and all plant parts (roots, crowns, shoots, or whole plants), the carbohydrates and nutrients of clipped and unclipped plants were not significantly different ($P < 0.05$) (Pendery et al. 1993). Total structural carbohydrate pools also did not differ (Pendery and Rumbaugh 1993).

Wildlife and Livestock Use. Reported value of Munro's globemallow to big game, other wildlife, and livestock ranged from good to none (Hermann 1966). Its importance may depend on the availability of more palatable forage. Ogle et al. (2012) reported that livestock and big game utilize Munro's globemallow when it is green in early spring and following summer and fall precipitation. At times, deer (*Odocoileus* spp.) consume all foliage, leaving only the woody base (Pavek et al. 2011). When pronghorn (*Antilocapra americana*) diets were evaluated over a period of about 1.5 years in salt desert and Wyoming big sagebrush vegetation in southeastern Oregon, Munro's globemallow made up a high of 6% of spring and 10% of fall diets (McInnis and Vavra 1987).

As forage for domestic cattle and sheep, Munro's globemallow is considered acceptable but not preferred (Pendery and Rumbaugh 1993). At the US Sheep Experiment Station (USSES) near Dubois, Idaho, Munro's globemallow production was greater on spring and fall than on fall only sheep use paddocks. At the time of paddock construction, herbage density of Munro's globemallow was similar across the study area. After 25 years of grazing, production was 0.49 lb/acre (0.56 kg/ha) in fall-grazed and 0.64 lb/acre (0.72 kg/ha) in spring and fall-grazed paddocks (Mueggler 1950).

Munro's globemallow flowers and seeds are eaten by various birds, small mammals, and lizards (Mayhew 1963; Johnson and Hansen 1979; Pendery and Rumbaugh 1986). Munro's globemallow was found at greater sage-grouse (*Centrocercus urophasianus*) brood-rearing plots in south-central Owyhee County, Idaho (Wik 2002). Over a one-year period, the relative density of Munro's globemallow recovered from the feces of Nuttall cottontails (*Sylvilagus nuttallii*) was 9.2% and from bushy-tailed woodrats (*Neotoma cinerea*) was 17.3%. Feces were collected from basin big sagebrush vegetation in south-central Idaho (Johnson and Hansen 1979). Munro's globemallow flowers were found in the digestive tracts of chuckwalla lizards (*Sauromalus obesus*), which are considered strict vegetarians (Mayhew 1963).

In a common garden experimental array, grasshopper use and damage was severe for native grasses but minimal for Munro's globemallow. Seedlings were planted in a common garden in March 1997 and subjected to natural densities (1.4-1.8/ft^2 [15-20/m^2]) of red-shanked grasshoppers (*Xanthippus corallipes*) and little pasture spur-throated grasshoppers (*Melanoplus confuses*). When the cumulative effect of grasshopper herbivory was evaluated in June 1998 (near the end of the grasshopper's life cycles), about 1% of individual Munro's globemallow plants were consumed. Grasshoppers consumed more than 70% of individual squirreltail, western wheatgrass (*Pascopyrum smithii*), and Indian ricegrass (*Achnatherum hymenoides*) plants and 30% or less of individual Sandberg bluegrass and needle and thread (*Hesperostipa comata*) plants (Beckstead et al. 2008).

Nutritive value. Forage characteristics of Munro's globemallow in new pastures near Kimberly, Idaho (Table 2), met the nutrient requirements for sheep and medium-sized yearling heifers in the fall and spring (Rumbaugh et al. 1993).

Table 2. Nutritional content (evaluated and averaged for fall and spring) of Munro's globemallow plants growing near Kimberley, Idaho (Rumbaugh et al. 1993).

Measurement	Microminerals (µg/g)					Macrominerals mg/g				
Element	Cu	Fe	Mn	Na	Zn	Ca	Mg	N	P	K
Leaves	16	1200	58	150	41	27	6.0	37	3.6	18
Stems	14	360	20	280	28	13	5.6	21	2.3	22

Clipping 1-year old transplants to 2 inches (5 cm) in a Munro's globemallow and crested wheatgrass pasture once in spring did not significantly ($P < 0.05$) affect nutritional content of Munro's globemallow (Table 3; Pendery et al. 1993).

Table 3. Concentrations of nutrients and elements in Munro's globemallow shoots (evaluated and averaged for clipped and unclipped plants) for seven sampling dates in Cache Valley, UT (Pendery et al. 1993).

Date	May 1	May 20	Jun 1	Jul 11	Sept 22	Nov 5
	---------------mg---------------					
TNC*	52.5	62.5	72.8	74.4	84.2	58.5
N	19.1	15.2	16.5	11.6	7.8	6.4
P	2.6	2.3	2.6	2.2	1.1	1.1
K	11.4	15.5	21.2	20.1	13.0	10.3
Ca	14.1	13.9	13.5	12.8	17.0	14.8
Mg	4.1	3.9	3.4	2.7	4.1	4.3

*Total non-structural carbohydrates.

Ethnobotany. Munro's globemallow was noted as a plant traditionally used in fertility regulation (Brondegaard 1973 cited in Kumar et al. 2012). The Gosiute of Utah, pounded plants into a gummy paste that was used to smooth the rough inner surfaces of dishes (Moerman 2003).

Horticulture. Showy flowers, attractiveness to pollinators, and tolerance of harsh conditions make Munro's globemallow a desirable species for use in horticulture. It is available commercially for residential native gardens (Meyer et al. 2009) and is hardy to USDA zone 4 (Pavek et al. 2011). At a native plant garden in Boise, Idaho, plants were easily grown from seed. They were watered 4 times in the first year and once a month in subsequent years (Parkinson 2003).

REVEGETATION USE

Munro's globemallow has many traits and characteristics that make it a desirable species for revegetation (Fig. 7). It tolerates disturbances and harsh environments, occurs on exposed or eroded sites, and is important to pollinators. It is utilized by wildlife and livestock, providing green forage early in the spring and after summer and fall precipitation (Gautier and Everett 1979; Ogle et al. 2012; Eldredge et al. 2013). It may also be a good candidate for soil stabilization (Kildisheva et al. 2011).

Figure 7. Second year Munro's globemallow seeded on a burned site in northern Utah. Photo: USFS.

DEVELOPING A SEED SUPPLY

For restoration to be successful, the right seed needs to be planted in the right place at the right time. This involves a series of steps that require coordinated planning and cooperation among partners to first select appropriate species and seed sources and then properly collect, grow, certify, clean, store, and distribute seed for restoration (PCA 2015).

Developing a seed supply begins with seed collection from native stands. Collection sites are determined by current or projected revegetation requirements and goals. Production of nursery stock requires less seed than large-scale seeding operations, which may require establishment of agricultural seed production fields. Regardless of the size and complexity of any revegetation effort, seed certification is essential for tracking seed origin from collection through use.

Seed Sourcing. Because empirical seed zones are not currently available for Munro's globemallow, generalized provisional seed zones developed by Bower et al. (2014) may be used to select and deploy seed sources. These provisional seed zones identify areas of climatic similarity with comparable winter minimum temperature and aridity (Bower et al. 2014). In Figure 8, Omernik Level III Ecoregions (Omernik 1987) overlay the provisional seeds zones to identify climatically similar but ecologically different areas. For site-specific disturbance regimes and restoration objectives, seed collection locations within a seed zone and ecoregion may be further limited by elevation, soil type, or other factors.

The Western Wildland Environmental Threat Assessment Center's (WWETAC) Threat and Resource Mapping (WWETAC) Seed Zone application provides links to interactive mapping features useful for seed collection and deployment planning. The Seedlot Selection Tool (Howe et al. 2017) can also guide restoration planning, seed collection, and seed deployment, particularly when addressing climate change considerations.

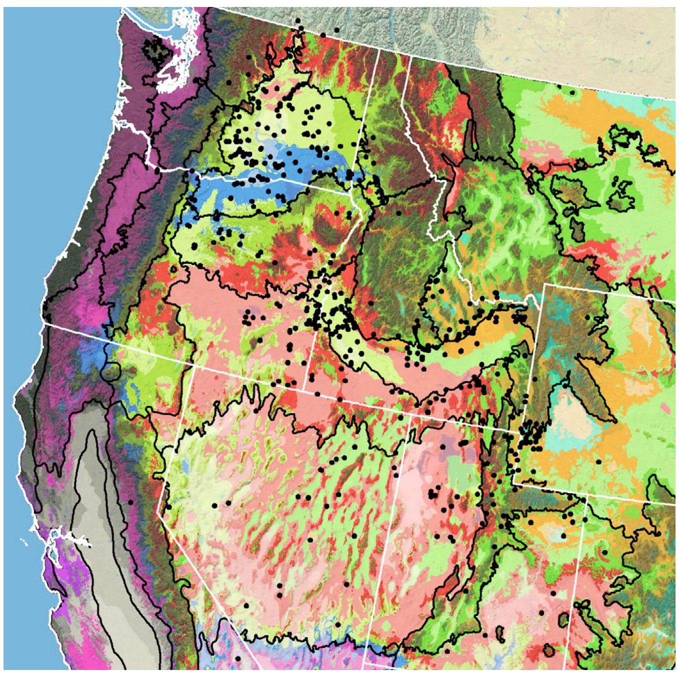

Figure 8. Distribution of Munro's globemallow (black circles) based on geo-referenced herbarium specimens and observational data from 1886-2016 (CPNWH 2017; SEINet 2017; USGS 2017). Generalized provisional seed zones (colored regions) (Bower et al. 2014) are overlain by Omernik Level III Ecoregions (white outlines) (Omernik 1987; USDI EPA 2018). Interactive maps, legends, and a mobile app are available (USFS WWETAC 2017; www.fs.fed.us/wwetac/threat-map/TRMSeedZoneMapper2.php?). Map prepared by M. Fisk, USGS.

Releases. Munro's globemallow, ARS 2892, a Selected Germplasm was released for commercial increase use in restoration (Rumbaugh and Pendery 1993; Stevens et al. 1996). The release was selected because of its large shoot size, succulence, leafy growth, and excellent seed yield potential. It was one of 13 accessions grown and evaluated in non-competitive plant nurseries in northern Utah and southern Idaho from 1987 to 1992 (Table 4). Germplasm ARS 2892 came from wildland seed collected at 4,350 feet (1,325 m) elevation near Hyrum Lake Dam in Cache County, Utah. At this site, annual precipitation averages 16 inches (406 mm) and soils are disturbed, sandy, and rocky. The release is tetraploid (2n = 20). It is drought tolerant, heat tolerant, winter hardy, and survives well in semiarid environments (Rumbaugh and Pendery 1993).

Table 4. Growth characteristics of Munro's globemallow accessions (including Selected Germplasm ARS 2892) grown in non-competitive conditions in northern Utah and southern Idaho (Rumbaugh and Pendery 1993).

Attribute	ARS-2892	All other accessions
Survival (%)	97	95
Plant weight (g)	188	102
Stems (no/plant)	22	18
Stem length (in)	15	14
First flower (Julian day)	174	169
Schizocarps ripe at harvest (%)	39	33
Seed weight (g/plant)	1.1	0.7

Wildland Seed Collection. Seed can generally be harvested from Munro's globemallow starting in June and continuing through mid- to late summer (Andersen and Holmgren 1976; Shaw 1995). Seed collection windows, however, vary with site and weather conditions (Holmgren et al. 2005).

Wildland seed certification. Wildland seed collected for direct sale or for establishment of agricultural seed production fields should be Source Identified through the Association of Official Seed Certifying Agencies (AOSCA) Pre-Variety Germplasm Program that verifies and tracks seed origin (Young et al. 2003; UCIA 2015). For seed sold for direct for use in revegetation, collectors must apply for certification prior to making collections. Applications and site inspections are handled by the state in which collections will be made. For seed that will be used for planting agricultural seed fields or nursery propagation more details of the collection site and procedures are required. Seed collected by most public and private agencies following established protocols may enter the certification process directly without certification agency site inspections when protocols include collection of all data required for Source Identified certification (see Agricultural Seed Field Certification section). Wildland seed collectors should become acquainted with state certification agency procedures, regulations, and deadlines in the states where they collect. Permits or permission from public or private land owners are required for all collections.

Collection timing. Munro's globemallow flowers indeterminately, which suggests a broad collection window. However, length of flowering and seed ripening vary by location. Flowering in southeastern Idaho and southwestern Wyoming was ephemeral with all buds within an inflorescence opening over a short period of time. Duration of flowering was longer for plants growing in locations further south (Holmgren et al. 2005).

Based on records spanning 7 years and 28 collections, BLM SOS collection crews reported an earliest harvest date of June 7 and a latest date of September 3. The June harvest was made in 2009 from a 6,098-foot (1,859 m) site in Toole County, Utah. The September harvest was made in 2010, from a 7,650-foot (2,330 m) site in Wasatch County, Utah. Harvests were most commonly made in late June or July (USDI BLM SOS 2017).

Seed collectors for the Great Basin Native Plant Project (GBNPP) suggest that hand harvests can be maximized by collecting when at least 40% of the schizocarps are open or have begun to split and schizocarps near the top of the inflorescence are still greenish and have not split. Plants will be gray-green and have few to no flowers remaining at this time (A. Malcomb, Upper Snake River Tribes Foundation [USRT] and M. Fisk, USGS, personal communications, August 2018). Pendery and Rumbaugh (1993) suggest that seed yield of individual plants is at a maximum when about 25% of the schizocarps are ripe, light green to brown, and just about to open. At this time, the lowest schizocarps (commonly referred to as globes) have started to split. These differences in collection timing may relate to collection methods (hand vs. mechanical, commercial). Additional seed ripening that may occur following harvest was not reported.

Collection methods. Wildland seed was harvested by GBNPP collectors by wrapping a gloved hand gently around the inflorescence and pulling upward. Munro's globemallow is often covered with fine irritating hairs, making skin and eye protection important. Ripe schizocarps will strip off easily and can be deposited into a paper bag. Bug-repellent tabs in the collection bags can prevent continued seed damage, as schizocarps can harbor seed-feeding insects. Because flowering and seed maturation are indeterminate, collections can be made from the same plants and populations multiple times to maximize ripe seed harvests and genetic diversity. Munro's globemallow plants that have senesced almost fully and retain an abundance of unopened schizocarps should be avoided. This is a sign of seed damage. To maximize collection efforts, check that full seeds are being harvested (A. Malcomb, USRT; M. Fisk, USGS, personal communications, August 2018).

Several collection guidelines and methods should be followed to maximize the genetic diversity of wildland collections: collect seed from a minimum of 50 randomly selected plants; collect from widely separated individuals throughout a population without favoring the most robust or avoiding small stature plants; and collect from all microsites including habitat edges (Basey et al. 2015). General collecting recommendations and guidelines are provided in online manuals (e.g. ENSCONET 2009; USDI BLM SOS 2016). As is the case with wildland collection of many forbs, care must be taken to avoid inadvertent collection of weedy species, particularly those that produce seeds similar in shape and size to those of Munro's globemallow.

Post-collection management. Seed should be dried fully before cleaning or moving to cold storage. If collections include plant material, which greens up following summer precipitation, drying may be a longer process. Munro's globemallow harvest collections should be stored in a breathable sack containing bug-repellant tabs in a dark, dry location (A. Malcomb, USRT; M. Fisk, USGS, personal communications, August 2018).

Seed Cleaning. Dry seed can be cleaned using a debearder to remove seeds from the schizocarps. If necessary, a clipper or fanning mill can be used to further clean the seed (Pendery and Rumbaugh 1993). For agricultural seed fields in Utah, seed was collected by windrowing and combining plants. Once dried, the lot was processed through a debearder and then an air-screen separator and gravity table (Stevens et al. 1996). Protective clothing, masks, and eyewear are recommended when handling Munro's globemallow seed collections (A. Malcomb, USRT; M. Fisk, USGS, personal communications, August 2018).

The USFS Bend Seed Extractory developed detailed cleaning procedures for a small seed lot (1.6 lbs [0.7 kg]) of wildland collected seed. Dry seed was first processed using a Westrup Model LA-H, (Seedburo Equipment Co., Des Plaines, IL), laboratory brush machine, using a #28 mantel and medium speed. Seed was then air-screened using an office Clipper with a 6 round top screen and 1/20 bottom screen and medium speed and air (Barner 2009).

Seed Storage. Munro's globemallow seed is orthodox and reports suggest it can be stored dry without substantial loss of viability for 6 to 15 years (Pendery and Rumbaugh 1986; Stevens et al. 1996). General storage guidelines for native seed suggest storage at or below 15% relative humidity at 59 °F (15 °C) for less than 5 years of storage and at -0.4 °F (-18 °C) for more than 5 years of storage (Erickson and Merritt 2016). Seed was stored cold at Bend Seed Extractory (33-38 °F [0.6-3.3 °C]) (Barner 2009), but longevity in storage was not reported. Because seed is attractive to insects and small mammals, it should be stored in a protected area and frozen or insecticide treated as necessary (Pendery and Rumbaugh 1986).

Seed Testing. There is no AOSA germination protocol available for Munro's globemallow (AOSA 2016). Guidelines for tetrazolium chloride (TZ) viability testing are available. These include seed preparation and staining procedures (AOSA 2010).

Germination. Munro's globemallow seed exhibits physical dormancy. Dormant seeds are unable to take up water, a critical step in the germination process, due to the presence of an impermeable seed coat and a cap-like structure, which also blocks water uptake. Dislodging this structure or abrasion of the seed coat through natural or artificial scarification is necessary to enable germination of fresh or cold-stored seeds (Kildisheva et al. 2011).

In wildland settings, scarification likely occurs naturally over time and may represent an evolutionary survival tactic for the species. For restoration projects, rapid and uniform germination is often desired. Many have researched the mechanisms and methods for improving germination of Munro's globemallow. Mechanical scarification that detached the water restrictive structure with a scalpel was best for seed germination, but it is not a feasible large-scale seed treatment (Kildisheva et al. 2011). Boiling water scarification (Kildisheva et al. 2013) and pneumatic scarification using a Mater seed scarifier (Mater Seed Equipment, Corvallis, OR) (Kildisheva et al. 2018) worked well as potential large-scale seed treatments. The variation in the extent of germination across studies may suggest a high degree of variation in the depth of dormancy across seed lots, which may be affected by population genetics, growing season, collecting, cleaning, or storage conditions (Kildisheva et al. 2011).

Water uptake was improved by abrading the seed coat with a scalpel more than by submerging seed in boiling water (10 s in 212 °F [100 °C]) (Kildisheva et al. 2011). For fresh seed collected near Payette, Idaho, seed mass increased 86% following water uptake after seeds were cut and increased 22% following boiling water treatments (Kildisheva et al. 2011). For cold-stored seed (6 months at 35 °F [1.5 °C]) collected from the Wasatch Mountains of northern Utah, germination of mechanically scarified seeds on blotter paper was 87%, and increased to 93.4% when scarified seeds were hydro-primed (soaked in aerated deionized water) for 24 hours (Kildisheva et al. 2011). For seeds collected in west-central Idaho, submergence in sulfuric acid did not significantly increase germination ($P > 0.05$) (Roth et al. 1987). Soaking seeds in dioxane produced the highest germination levels (up to 56%) when compared to sulfuric acid and sulfuric acid plus dioxane treatments. However, dioxane is a highly flammable, cancer causing agent that is not readily available and is not recommended for use.

In additional studies, boiling water, tumbling, burning, heating, and burning with heating were evaluated as potential methods to increase germination of Munro's globemallow seed on a large scale (Table 5; Kildisheva et al. 2013). Germination was best (49%) after boiling water treatments. The other treatments produced germination of 20% or less. Treatments were conducted on cold-stored seeds (6 months at 35 °F [1.5 °C]) collected from the Wasatch Mountains of Utah, and germination was monitored for 21 days. For boiled seeds, the germination curve failed to reach its asymptote after 21 days, suggesting that with continued monitoring germination may have continued at a low rate (Kildisheva et al. 2013).

Table 5. Germination of cold-stored Munro's globemallow seed at 21 days following various scarification treatments. Post-treatment germination conditions: incubation at 75 °F (24 °C) day/63 °F (17 °C) night (Kildisheva et al. 2013).

Treatment	Germination (%)
Control	10.7
Boiling (10 s in 212 °F water)	49.0
Tumbling (72 h in rotary rock tumbler with dry Al_2O_3 grit)	20.3
Burning (1 min alcohol soak then 10 s burning with butane torch)	17.0
Heating (176 °F oven for 60 min)	10.7
Burning + Heating (combination of above)	4.2

In an attempt to find and mimic natural seed scarification through abrasion, temperature fluctuations, and burning, Kildisheva et al. (2018)

evaluated the following seed treatments: wet heat (5-300 s in 194 °F [90 °C] water), freezing + wet heat (2 h at -112 or -4 °F [-80 or -20 °C] then 5 or 30 s in 194 °F [90 °C] water), freeze-thaw cycle (2 h at -112 or -4 °F [-80 or -20 °C] then 2 h at 73 °F [23 °C] repeated 1-6 times), pneumatic scarification (10-160 s in a Mater seed scarifier), and manual scarification (120-grit sand paper). Seed permeability was increased by wet heat (90-94%), pneumatic scarification for 80 or more seconds (82-88%), and manual scarification (88%). Germination percentages were viability adjusted and included a cut-test to assess embryo condition and final seed viability. Germination was tested only for mechanically scarified seeds and was highest (>75%) with manual scarification and reached about 50% with 80 or 160 seconds of pneumatic scarification. Researchers advised testing the effects of a longer pneumatic scarification period on germination, because this type of treatment is feasible for use in treating large seed lots. Because the loss of physical dormancy is irreversible, seeds could be treated and stored in a "restoration-ready" state (Kildisheva et al. 2018).

Wildland Seed Yield and Quality. Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 6 (USFS BSE 2017). The results indicate that Munro's globemallow seed can generally be cleaned to high levels of purity but that seed fill and viability are variable. The seed weights reported by others (USFS GBNPP 2014; RGB Kew 2017) fall within the range reported in Table 6.

Table 6. Seed yield and quality of Munro's globemallow seed lots collected in the Intermountain region, cleaned by the Bend Seed Extractory, and tested by the Oregon State Seed Laboratory or the USFS National Seed Laboratory (USFS BSE 2017).

Seed lot characteristic	Mean	Range	Samples (no.)
Bulk weight (lb)	2.9	0.05-25	16
Clean weight (lb)	0.5	0.02-3.26	16
Clean-out ratio	0.35	0.06-0.74	16
Purity (%)	95	80-99	16
Fill (%)[1]	87	65-98	16
Viability (%)[2]	88	65-97	15
Seeds/lb	317,423	249,088-378,000	16
Pure live seeds/lb	268,996	187,596-350,278	15

[1] 100 seed X-ray test
[2] Tetrazolium chloride test

Marketing Standards. Acceptable seed purity, viability, and germination specifications vary with revegetation plans. Purity needs are highest for precision seeding equipment used in nurseries, while some rangeland seeding equipment handles less clean seed quite well.

For Munro's globemallow seed, acceptable viability is reported as 90% and purity as 80% or higher if vendors use a gravity table in the cleaning process. Germination can be expected to be erratic due to dormant seed (Stevens et al. 1996). In 2010, Munro's globemallow seed averaged $57/lb. This cost was a standardized market price based on end-user market price and suggested Plant Materials Center (PMC) stock seed prices (Young and Bouck 2011).

AGRICULTURAL SEED PRODUCTION

Researchers growing Munro's globemallow in Cache Valley, Utah, reported it was more easily grown in an agronomic environment than many other wildland forbs (Fig. 9) (Pendery and Rumbaugh 1986).

Figure 9. Munro's globemallow seed production field growing near Willow Creek, OR. Photo: USFS.

Agricultural Seed Certification. It is essential to maintain and track the genetic identity and purity of native seed produced in seed fields. Tracking is done through seed certification processes and procedures. State seed certification offices administer the Pre-Variety Germplasm (PVG) Program for native field certification for native plants, which tracks geographic source, genetic purity, and isolation from field production through seed cleaning, testing, and labeling for commercial sales (Young et al. 2003; UCIA 2015). Growers should plant certified seed (see Wildland Seed Certification section) and apply for certification of their production fields prior to planting. The systematic and sequential tracking through the certification process requires pre-planning, understanding state regulations and deadlines, and is most smoothly navigated by working closely with state certification agency personnel.

Site Preparation. Weed-free planting sites are recommended for Munro's globemallow seed production plots (Stevens et al. 1996).

Seed Pretreatments. Mechanical seed treatments can be used to improve the amount and uniformity of germination (see Germination section). Stratification (to remove physiological dormancy) is not required as seed dormancy is entirely physical. Submergence in boiling water can be an effective pre-sowing treatment for nursery production (Jensen 2011 cited in Pavek et al. 2011). In establishment of seed production plots at the USFS Provo Shrub Sciences Laboratory (PSSL), seeds were submerged in boiling water for 1 minute, rinsed with cool water, then dried prior to seeding. This pretreatment at times resulted in high seedling emergence following fall or spring planting but at other times resulted in almost no emergence. Rapid and thorough drying of the boiled seed was critical because seed that remained moist often germinated within days (S. Jensen, USFS, personal communication, July 2018). Cool moist stratification for 90 days failed to improve germination of Munro's globemallow at the Pullman PMC. Seed from three accessions was planted in containers in mid-October and stratified outdoors for 90 days. Germination began within 14 days of moving containers into the greenhouse, but germination was low (6-25%) (Pavek et al. 2011), because stratifcation does not relieve physical dormancy.

Weed Management. Weed control by hand weeding is recommended, although cultivation and pre-emergence herbicides can also be utilized (Stevens et al. 1996). Herbicides are not registered for this species, and results or findings presented here do not constitute an endorsement of specific products or recommendations for use. In research plots in Provo, Utah, Munro's globemallow emergence was nearly equal with pre-emergent herbicide treatments of bromoxynill, pendimethalin, and imazethapyr at all rates tested and to ammonium salt of imazapic at medium and low application rates (Roundy et al. 2005).

Seeding. Fall planting of non-scarified Munro's globemallow seed is recommended. Spring or late summer seeding is possible if seed has been scarified (see Germination section) but may delay seed production beyond the second year. A seeding rate of 20 to 40 PLS/linear foot (67-133/m) of row with 28 to 36-inch (71-91 cm) row spacing and seeding depths of 0.13-0.25 inch (0.3-0.6 cm) in sandy loam to clay-textured soils is recommended for seed production stands (Stevens et al. 1996).

Establishment and Growth. Munro's globemallow seed is eaten by birds and rabbits. Fields may need protection from predation in the establishment and early growth phases (Pendery and Rumbaugh 1986). Seed is not produced until the second year, reaching 50 to 75% of full yield. By the third growing season, seed production reaches full yield (Stevens et al. 1996). According to a private seed producer, Munro's globemallow establishment is easy, but due to the physical dormancy of seed (hard seed coats), seedling emergence may span several years if the seeds are not scarified (Dunne cited in Pavek et al. 2011).

Irrigation. Stands do well with 11 to 14 inches (280-360 mm) of annual precipitation. Irrigation is recommended as needed for seedling establishment and again in the spring and during the flowering and seed-set period (Stevens et al. 1996).

Pollinator Management. Outcrossing increases Munro's globemallow seed production. In one study, seed production was increased 4 times when flowers were outcrossed. When flower visits were monitored, 37 of 57 bee visitors to flowers of Munro's globemallow (and relatives) were ground-nesting specialists including globemallow bees (*Diadasia* spp.) and plasterer bees (Colletidae). The other 20 bee visitors were generalist ground-nesters. To protect pollinators, cultivation should be avoided in seed production plots when plants are blooming (Cane cited in Pavek et al. 2011).

Pest Management. Munro's globemallow is a host species for the following fungi: *Puccinia malvacearum*, *P. schedonnardi*, and *P. sherardiana* (Farr and Rossman 2017). Planthoppers (*Oecleus glochin*) were collected from plants in Nevada and Utah (Kramer 1977). The degree to which these pests may impact seed production plots was not reported.

Seed Harvesting. Indeterminate flowering and seed ripening make mechanical seed harvest challenging for Munro's globemallow. With summer precipitation, plants remain green, flowering continues throughout the growing season, and seeds shatter soon after they have ripened. In areas lacking summer precipitation, it is possible to manipulate flowering and seed ripening by withholding water early in the growing season (Dunne cited in Pavek et al. 2011). In Utah, fields were harvested between early July and early August by windrowing plants when lower schizocarps were dry and had started to open. Windrows were harvested by combining (Stevens et al. 1996).

Seed Yields and Stand Life. Munro's globemallow will produce seed in the second growing season but it generally takes 3 years to reach maximum yields (Stevens et al. 1996), which can range annually from 300 to 1,400 lbs/acre (340-1,580 kg/ha) (Stevens et al. 1996; Anderson et al. 2007). Longevity of seed production fields can be 3 to 5 years (Stevens et al. 1996). Seed production may be increased with fertilization and by clipping plants after seed set (Gautier and Everett 1979).

In research plots growing in Provo, Utah, Munro's globemallow seed production on a per plant basis was greatest from plants spaced 18 inches (46 cm) apart (22.3-31 g of seed/plant), but production on a per acre basis was greatest for plants spaced 6 inches (15 cm) apart (1,000-1,400 lb of seed/acre [1,125-1,575 kg/ha]) (Roundy et al. 2005; Anderson et al. 2007). Fields with plastic mulch to control weed competition produced the greatest amount of seed. Production was less with fabric mulch, even less without mulch, and least with paper mulch (Roundy et al. 2005). When fields were at least 3 years old, seed yield was a little less than 900 lbs/acre (1,010 kg/ha) at 6-inch (15 cm) between row spacing. When fields were at least 4 years old, seed yield was less than 200 lbs/acre (225 kg/ha) and stand mortality was substantial. Seed collection methods also differed between the high and low yield years. Seed was harvested by hand over an extended period in the high yield year and once mechanically in the low yield year (Anderson et al. 2007).

In experiments on container-grown Munro's globemallow, fertilizing and clipping increased seed production, but timing of the treatments was important (Table 7). Schizocarp production was greatest when clipping occurred after seed set and fertilization occurred at the early flowering stage and again after clipping. Flowering period was extended when clipping occurred after seed set, and clipped plants continued growing until the first hard frost. Clipping at the early flowering stage resulted in significantly lower seed production ($P < 0.05$). Unclipped plants produced mature seed in late July and then stopped growing. For this study, treatments and harvests occurred in the same year. Seed came from a single site, and plants were grown in low nitrogen, low phosphorus, loamy sandy soils in a greenhouse for 3 months before being transferred to a lathhouse (Gautier and Everett 1979).

Table 7. Schizocarp and biomass production of container-grown Munro's globemallow. Fertilizer treatments were 89 lbs/acre of nitrogen and 45 lbs/acre phosphorus. Values within a column followed by different letters are significantly different ($P < 0.05$). (Gautier and Everett 1979).

Treatment	Schizocarps (no/16 plants)	Biomass of foliage and stems (g)
Unclipped, unfertilized	37.5bc	3.0c
Unclipped, fertilized at early flowering stage	53.5ab	8.3bc
Clipped at early flowering, unfertilized	0.8d	4.6c
Clipped and fertilized at early flowering	2.3d	25.0a
Clipped at early flowering, fertilized after clipping	15.6cd	16.4b
Clipped and fertilized at early flowering, fertilized after clipping	9.5cd	36.6a
Clipped after seed set, fertilized after clipping	24.3bcd	14.0bc
Clipped after seed set, fertilized at early flowering and after clipping	76.5a	28.8a

NURSERY PRACTICE

Munro's globemallow was grown successfully in greenhouse experiments designed to monitor growth, resource use, and biomass allocation (see Seedling Ecology section). Seed was germinated on moist blotter paper in a growth chamber at 75 °F (24 °C) with 14 hr light/10 hr dark conditions. Seedlings were transplanted into containers and grown in the greenhouse at 64 to 75 °F (18-24 °C) with 14 hours of light. Seedling roots were fan-shaped, distributed as much laterally as vertically with considerable branching at the soil surface and throughout the depth of the container (18 inches [45 cm]) (Parkinson 2008; Parkinson et al. 2013).

In a study evaluating growth in high and low nitrogen and water conditions, biomass and RGR of Munro's globemallow were greatest in high nitrogen and high water treatments and root mass ratio was greatest in low nitrogen and low water treatments (Drenovsky et al. 2012). Plants were grown in a 1:2 fritted clay: sandy loam mix. Two weeks following development of true leaves, plants were provided 2 g slow release 10-10-10 NPK fertilizer or no fertilizer, and 6 weeks after true leaves appeared, plants were subjected to drought or well-watered treatments. Munro's globemallow growth differences and biomass allocation were not significantly different between the treatments (Drenovsky et al. 2012). When a companion study evaluated the distribution of fertilizers in the soil profile, researchers concluded that Munro's globemallow had biomass and root foraging traits similar to the invasive species evaluated (whitetop, spotted knapweed, rush skeletonweed, and Dalmatian toadflax) (Drenovsky et al. 2008).

WILDLAND SEEDING AND PLANTING

Munro's globemallow has been seeded and planted successfully in semi-arid western environments. On fertile sites or sites receiving more than 12 inches (305 mm) of annual precipitation, globemallow recruitment occurred but seedlings failed to produce as much biomass as other forbs. Globemallows can also establish on harsher, disturbed, or lower precipitation sites making this species useful for sites with a high level of heat and drought stress (Pendery and Rumbaugh 1993; Ogle et al. 2012).

Seeding. Dormant fall seeding is recommended (Ogle et al. 2012). Seeds can be scarified to encourage high initial germination rates (Pavek et al. 2011) or for success with spring seeding (S. Jensen, USFS, personal communication, July 2018). In wildland settings, Munro's globemallow occurs at low to moderate densities and relies heavily on the seedbank for persistence. Because of this, seeding methods that add a dormant portion of seed to the seedbank, may benefit long-term persistence (Kildisheva et al. 2013).

Seeds should not be planted deeper than 0.25 inch (0.6 cm) (Ogle et al. 2012). Recommended pure stand seeding rates for globemallows range from 0.25 to 2 lbs/acre (0.28-2.25 kg/ha) considering the desired stand composition. This species is not recommended for pure stands (Pendery and Rumbaugh 1993; Ogle et al. 2012).

A mid-April planting of Munro's globemallow seed failed at a Curlew Valley site in southern Idaho but not at a cooler, wetter Cache Valley site in northern Utah, supporting the overall recommendation for fall seeding (Pendery and Rumbaugh 1990). Researchers suggested insufficient moisture, annual weed competition, and soil crusting as potential reasons for failed seedling establishment in southern Idaho. Seed was scarified with sandpaper and seeded in a 3:1 crested wheatgrass: Munro's globemallow mix at a rate of 5 PLS lbs/acre (5.6 kg/ha). At the Cache Valley site, Munro's globemallow established before alfalfa or crested wheatgrass (alfalfa was also seeded 3:1 with crested wheatgrass). Density of Munro's globemallow dropped dramatically after the first year and average yield for 4 years after seeding was 76 g/m^2, compared to 389 g/m^2 for alfalfa. Gooseberryleaf globemallow was also seeded at the 3:1 ratio with crested wheatgrass, its 4-year yield average was 48 g/m^2. Plots seeded with gooseberryleaf globemallow had fewer relatively large plants while those seeded with Munro's globemallow had more relatively small plants (Pendery and Rumbaugh 1990).

Wildland Restoration Examples. In a study evaluating strategies for increasing diversity in crested wheatgrass stands, Munro's globemallow was the most abundant forb 3 to 5 years after seeding glyphosate-treated crested wheatgrass stands. Munro's globemallow was seeded as part of a mixture at a rate of 5 PLS lbs/acre (0.56 kg/ha) with a minimum till drill on sandy loam soils southeast of Elko, Nevada (McAdoo et al. 2017).

In another study attempting to establish native species in crested wheatgrass stands, Munro's globemallow established at two sites, but survival to post-seeding year 2 or 3 was limited to one site (Table 8; Hulet et al. 2010). Munro's globemallow was drill seeded at rate of 5 PLS lbs/acre (0.56 kg/ha) in a mixture in October 2005 and 2006. Seeding occurred in disked, double disked, or herbicide-treated crested wheatgrass stands in Toole County, Utah. Loss of Munro's globemallow from the Skull Valley site was likely due to 51% below average precipitation in 2008 (Hulet et al. 2010).

Table 8. Average density of Munro's globemallow plants/m^2 averaged across undisturbed, mechanical, and herbicide control treatments in crested wheatgrass (Hulet et al. 2010).

Lookout Pass (Seeded 2005)			Lookout Pass (Seeded 2006)		Skull Valley (Seeded 2005)			Skull Valley (Seeded 2006)	
----------Density (plants/m^2)----------									
2006	2007	2008	2007	2008	2006	2007	2008	2007	2008
0.13	0.11	0.03	0.10	0.03	0.08	0	0	0.03	0

In a post-fire restoration study, Ott et al. (Ott et al. 2015) found that Munro's globemallow density increased as time since seeding increased even when a second fire burned restoration plots (Fig. 10). Seed collected from Uintah County, Utah, at 5,085 feet (1,550 m) was seeded the fall or winter following a June 2010 fire in Wyoming big sagebrush in Elmore County, Idaho, at 3,940 feet (1,200 m). Munro's globemallow was part of a mixture seeded at a rate of 3.6 PLS/ft^2 (40/m^2). Density of Munro's globemallow in the seeded area was 282 plants/acre (705/ha) in 2011 and 624 plants/acre (1,560/ha) in 2013. Because a portion of the restoration area burned again in July 2012, burned and unburned areas were monitored separately in 2013. There were 1,305 Munro's globemallow plants in burned and 279 plants in unburned areas (Ott et al. 2015).

Figure 10. Munro's globemallow growing in a post-fire restoration seeding in Elmore County, Idaho. Photo: USFS.

Greenhouse studies evaluating the growth rate of Munro's globemallow suggest it may be competitive with invasive species (Parkinson 2008; Parkinson et al. 2013). See Seedling Ecology section for details.

Planting. Use of transplants in restoration generally results in more rapid maturity and greater survival than seeding. Munro's globemallow seedlings can be produced by planting scarified seeds in the greenhouse in January. Plants need 2 to 4 weeks of hardening before transplanting in the field. Recommended spacing between transplants is 10 to 30 inches (25-75 cm) (Pavek et al. 2011). In field experiments at Utah State University's Green Canyon Research Area, 16% of Munro's globemallow transplants flowered in their transplant year; however, seedlings originating from direct fall seeding failed to flower in their first growing season (Whitcomb 2011). Average survival was high for Munro's globemallow (95%) a year after transplanting in dryland nurseries in Cache Valley, northern Utah and Curlew Valley, southern Idaho. Transplants were grown from sand paper-scarified seed in 150 cm^3 cones filled with four parts sand, two parts peat moss, and one part vermiculite. Transplanting occurred in clean-tilled sites in mid-April 1987. In summer 1988, transplants weighed an average of 102 g (range: 83-183 g), produced an average of 18 stems (range: 16-19) with maximum length averaging 14 inches (35 cm) (range: 10-17 in [25-44 cm]). Plant biomass was greater, plants flowered earlier, and seed production was greater at Cache Valley, where annual precipitation from 1985 to 1988 was 2 to 16 inches (59-405 mm) greater than at Curlew Valley (Pendery and Rumbaugh 1990).

ACKNOWLEDGEMENTS

Funding for *Western Forbs: Biology, Ecology, and Use in Restoration* was provided by the USDI BLM Great Basin Native Plant Materials Ecoregional Program through the Great Basin Fire Science Exchange. Great thanks to the chapter reviewers: Olga Kildisheva, University of Western Australia and Matt Fisk, USGS.

LITERATURE CITED

Andersen, B.A.; Holmgren, A.H. 1976. Mountain plants of northeastern Utah. Logan, UT: Utah State University, Extension Services. 148 p.

Anderson, V.; Johnson, R.; Roundy, B. 2007. Agronomic and cultural care of wildland plants and seed yield losses in forbs (Asteraceae) due to fruit flies (Tephritidae). In: Shaw, N.; Pellant, M., eds. Great Basin Native Plant Project: 2006 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 53-59.

Association of Official Seed Analysts [AOSA]. 2010. AOSA/SCST Tetrazolium Testing Handbook. Contribution 29. Lincoln, NE: AOSA.

Association of Official Seed Analysts [AOSA]. 2016. AOSA rules for testing seeds. Vol. 1. Principles and procedures. Washington, DC: Association of Official Seed Analysts, eds. Principles and procedures. Washington D.C: AOSA.

Barner, J. 2009. Propagation protocol for production of propagules (seeds, cuttings, poles, etc.) *Sphaeralcea munroana* (Douglas) Spach. Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. http://npn.rngr.net/propagation/protocols [Accessed 2018 June 13].

Basey, A.C.; Fant, J.B.; Kramer, A.T. 2015. Producing native plant materials for restoration: 10 rules to collect and maintain genetic diversity. Native Plants Journal. 16(1): 37-53.

Beckstead, J.; Meyer, S.E.; Augsperger, C.K. 2008. The indirect effects of cheatgrass invasion: Grasshopper herbivory on native grasses determined by neighboring cheatgrass. In: Kitchen, S.G.; Pendleton, R.L.; Monaco, T.A.; Vernon, J., comps. Proceedings-Shrublands under fire: Disturbance and recovery in a changing world; 2006 June 6-8; Cedar City, UT. Proc. RMRS-P-52. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 41-48.

Bower, A.D.; St. Clair, J.B.; Erickson, V. 2014. Generalized provisional seed zones for native plants. Ecological Applications. 24(5): 913-919.

Cane, J.H. 2009. Pollination and seed predator studies. In: Shaw, N.; Pellant, M., eds. Great Basin Native Plant Project: 2008 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 62-65.

Cane, J.H.; Love, B. 2016. Floral guilds of bees in sagebrush steppe: Comparing bee usage of wildflowers available for postfire restoration. Natural Areas Journal. 36(4): 377-391.

Chambers, J.C. 2000. Seed movements and seedling fates in disturbed sagebrush steppe ecosystems: Implications for restoration. Ecological Applications. 10(5): 1400-1413.

Consortium of Pacific Northwest Herbaria [CPNWH]. 2017. Seattle, WA: University of Washington Herbarium, Burke Museum of Natural History and Culture. http://www.pnwherbaria.org/index.php2017 [Accessed 2017 June 29].

Drenovsky, R.E.; Khasanova, A.; James, J.J. 2012. Trait convergence and plasticity among native and invasive species in resource-poor environments. American Journal of Botany. 99(4): 629-639.

Drenovsky, R.E.; Martin, C.E.; Falasco, M.R.; James, J.J. 2008. Variation in resource acquisition and utilization traits between native and invasive perennial forbs. American Journal of Botany. 95(6): 681-687.

Eldredge, E.; Novak-Echenique, P.; Heater, T.; Mulder, A.; Jasmine, J. 2013. Plants for pollinator habitat in Nevada. Fallon, NV: U.S. Department of Agriculture, Natural Resources Conservation Service. 65 p.

Erickson, T.E.; Merritt, D.J. 2016. Seed collection, cleaning, and storage procedures. In: Erickson, T.E.; Todd, E.; Barrett, R.L.; Merritt, D.J.; Dixon, K.W., eds. Pilbara seed atlas and field guide: Plant restoration in Australia's arid northwest. Dickson, Australian Capital Territory: CSIRO Publishing: 7-16.

European Native Seed Conservation Network [ENSCONET]. 2009. ENSCONET seed collecting manual for wild species. Edition 1: 32 p.

Farr, D.F.; Rossman, A.Y. 2017. Fungal databases, U.S. National Fungus Collections. U.S. Department of Agriculture, Agricultural Research Service. https://nt.ars-grin.gov/fungaldatabases/ [Accessed 2018 June 13].

Gautier, C.; Everett, R. 1979. Fertilizing and clipping effects on seed capsule and forage production of orange globemallow. Res. Note INT-251. Ogden, UT: U.S. Department of Agriculture, Forest Service. 6 p.

Goodrich, S. 2006. Trout Creek 1999 burn. In: Kitchen, S.G.; Pendleton, R.L.; Monaco, T.A.; Vernon, J., eds. Shrublands under fire: Disturbance and recovery in a changing world. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 147-150.

Hermann, F. 1966. Notes on western range forbs: Cruciferae through Compositae. Agric. Handb. 293. Washington, DC: U.S. Department of Agriculture, Forest Service. 365 p.

Holmgren, N.H.; Holmgren, P.K.; Cronquist, A. 2005. Intermountain flora: Vascular plants of the Intermountain West, U.S.A. Volume Two, Part B: Subclass Dilleniidae. Bronx, NY: New York Botanical Garden Press. 488 p.

Howe, G.; St. Clair, B.; Bachelet, D. 2017. Seedlot Selection Tool. Corvallis, OR: Conservation Biology Institute. https://seedlotselectiontool.org/sst/ [2017 Accessed June 29].

Hulet, A.; Roundy, B.A.; Jessop, B. 2010. Crested wheatgrass control and native plant establishment in Utah. Rangeland Ecology and Management. 63(4): 450-460.

James, J.J.; Drenovsky, R.E. 2007. A basis for relative growth rate differences between native and invasive forb seedlings. Rangeland Ecology and Management. 60(4): 395-400.

Johnson, M.K.; Hansen, R.M. 1979. Foods of cottontails and woodrats in south-central Idaho. Journal of Mammalogy. 60(1): 213-215.

Kearney, T.H. 1935. The North American species of *Sphaeralcea* subgenus *Eusphaeralcea*. Berkeley, CA: University of California Press. 127 p.

Kildisheva, O.A.; Davis, A.S. 2012. Restoration potentials and challenges for *Sphaeralcea munroana*. In: Haase, D.L.; Pinto, J.R.; Riley, L.E., eds. National proceedings: Forest and Conservation Nursery Associations-2011; 2011 July 25-28, Huntington, WV. RMRS-P-68. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 65-71.

Kildisheva, O.A.; Davis, A.S. 2013. Role of temperature and moisture in the survival and seedling physiology of a Great Basin perennial. Ecological Restoration. 31(4): 388-394.

Kildisheva, O.A.; Dumroese, R.K.; Davis, A.S. 2011. Overcoming dormancy and enhancing germination of *Sphaeralcea munroana* seeds. Hortscience. 46(12): 1672-1676.

Kildisheva, O.A.; Dumroese, R.K.; Davis, A.S. 2013. Boiled, tumbled, burned, and heated: Seed scarification techniques for Munro's globemallow appropriate for large-scale application. Native Plants Journal. 14(1): 43-47.

Kildisheva, O.A.; Erickson, T.E.; Merritt, D.J.; Madsen, M.D.; Dixon, K.W.; Vargas, J.; Amarteifio, R.; Kramer, A.T. 2018. Do abrasion- or temperature-based techniques more effectively relieve physical dormancy in seeds of cold desert perennials? Rangeland Ecology and Management. 71(3): 318-322.

Kramer, J.P. 1977. Taxonomic study of the planthopper genus *Oecleus* in the United States (Homoptera: Fulgoroidea: Cixiidae). Transactions of the American Entomological Society. 103(2): 379-449.

Kumar, D.; Kumar, A.; Prakash, O. 2012. Potential antifertility agents from plants: A comprehensive review. Journal of Ethnopharmacology. 140(1): 1-32.

La Duke, J. 2016. 48. *Sphaeralcea*. In: Flora of North America Editorial Committee, ed. Flora of North America North of Mexico. Volume 6 Malvaceae. Online. https://www.efloras.org.

Lady Bird Johnson Wildflower Center [LBJWC]. 2018. *Sphaeralcea munroana* Nutt. Native Plant Database. Austin, TX: Lady Bird Johnson Wildflower Center. https://www.wildflower.org/plants-main [Accessed 2018 June 13].

Mayhew, W.W. 1963. Some food preferences of captive *Sauromalus obesus*. Herpetologica. 19(1): 10-16.

McAdoo, J.K.; Swanson, J.C.; Murphy, P.J.; Shaw, N.L. 2017. Evaluating strategies for facilitating native plant establishment in northern Nevada crested wheatgrass seedings. Restoration Ecology. 25(1): 1-10.

McArthur, D.; Sanderson, S. 2005. Forb and shrub genetics research. In: Shaw, N.; Pellant, M., eds. Great Basin Native Plant Project: 2004 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 5-8.

McInnis, M.L.; Vavra, M. 1987. Dietary relationships among feral horses, cattle, and pronghorn in southeastern Oregon. Journal of Range Management. 40(1): 60-66.

Meyer, S.E.; Kjelgren, R.K.; Morrison, D.G.; Varga, W.A. 2009. Chapter 6: Native landscape pioneers tell their stories. In: Landscaping on the new frontier: Waterwise design for the Intermountain West. Logan, UT: Utah State University Press. 131-158.

Moerman, D. 2003. Native American ethnobotany: A database of foods, drugs, dyes, and fibers of Native American peoples, derived from plants. Dearborn, MI: University of Michigan. http://naeb.brit.org/ [Accessed 2018 June 13].

Mueggler, W.F. 1950. Effects of spring and fall grazing by sheep on vegetation of the Upper Snake River Plains. Journal of Range Management. 3(4): 308-315.

Mull, J.F. 2003. Dispersal of sagebrush-steppe seeds by the western harvester ant (*Pogonomyrmex occidentalis*). Western North American Naturalist. 63(3): 358-362.

Munz, P.A.; Keck, D.D. 1973. A California flora and supplement. Berkeley, CA: University of California Press. 1905 p.

Ogle, D.; St. John, L.; Stannard, M.; Hozworth, L. 2012. Conservation plant species for the Intermountain West. Plant Materials Technical Note 24. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 57 p.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (Omernik 1987). Annals of the Association of American Geographers. 77(1): 118-125.

Ott, J.; Shaw, N. 2015. Seeding native species following wildfire in Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*): Effects of a new fire incident. In: Kilkenny, F.; Halford, A.; Malcomb, A., eds. Great Basin Native Plant Project: 2014 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 181-190.

Parkinson, H. 2003. Landscaping with native plants of the Intermountain Region. Tech. Ref. 1730-3. Boise, ID: U.S. Department of Interior, Bureau of Land Management. 46 p.

Parkinson, H.; Zabinski, C.; Shaw, N. 2013. Impact of native grasses and cheatgrass (*Bromus tectorum*) on Great Basin forb seedling growth. Rangeland Ecology and Management. 66:174-180.

Parkinson, H.A. 2008. Impacts of native grasses and cheatgrass on Great Basin forb development. Bozeman, MT: Montana State University. Thesis. 73 p.

Pavek, P.L.; Cane, J.H.; Kildisheva, O.A.; Davis, A.S. 2011. Plant guide: Munro's globemallow (*Sphaeralcea munroana*) (Douglas) Spach. Aberdeen, ID: U.S. Department of Agriculture, Natural Resources Conservation Service, Aberdeen Plant Materials Center. 5 p.

Pekas, K.M.; Schupp, E.W. 2013. Influence of aboveground vegetation on seed bank composition and distribution in a Great Basin Desert sagebrush community. Journal of Arid Environments. 88: 113-120.

Pendery, B.M.; Rumbaugh, M.D. 1986. Globemallows: forbs for Utah rangelands. Utah Science: 41-45.

Pendery, B.M.; Rumbaugh, M.D. 1990. Survival and growth of globemallow (*Sphaeralcea*) species in dry land spaced-plant nurseries. Journal of Range Management. 43(5): 428-432.

Pendery, B.M.; Rumbaugh, M.D. 1993. Globemallows. Rangelands. 15(3): 127-130.

Pendery, B.M.; Rumbaugh, M.D.; Mayland, H.F.; Harrison, P.A. 1993. Nonstructural carbohydrate and element pools in globemallow (*Sphaeralcea*): Defoliation effects and seasonal trends. Great Basin Naturalist. 53(4): 332-340.

Pendleton, R.L.; Pendleton, B.K.; Howard, G.L.; Warren, S.D. 2003. Growth and nutrient content of herbaceous seedlings associated with biological soil crusts. Arid Land Research and Management. 17(3): 271-281.

Plant Conservation Alliance [PCA]. 2015. National seed strategy for rehabilitation and restoration 2015-2020. Washington, DC: U.S. Department of Interior, Bureau of Land Management. 52 p.

Roth, T.E.; Holechek, J.L.; Hussain, M.Y. 1987. Germination response of three globemallow species to chemical treatment. Journal of Range Management. 40(2): 173-175.

Roundy, B.; Anderson, V.J.; Johnson, R. 2005. Forb production cultural practices. In: Shaw, N.; Pellant, M., eds. Great Basin Native Plant Project: 2004 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 38-42.

Royal Botanic Gardens, Kew [RBG Kew]. 2017. Seed Information Database (Kew). Version 7.1. http://data.kew.org/sid/ [Accessed 2018 June 13].

Rumbaugh, M.D.; Pendery, B.M. 1993. Registration of ARS-2892 Munroe globemallow germplasm. Crop Science. 33(5): 1108.

Rumbaugh, M.D.; Mayland, H.F.; Pendery, B.M.; Shewmaker, G.E. 1993. Element concentrations in globemallow herbage. Journal of Range Management. 46(2): 114-117.

SEINet–Regional Networks of North American Herbaria Steering Committee [SEINet]. 2017. SEINet Regional Networks of North American Herbaria. https://Symbiota.org/docs/seinet [Accessed 2017 June 16].

Shaw, R.J. 1995. Utah wildflowers: A field guide to northern and central mountains and valleys. Logan, UT: Utah State University Press. 218 p.

Stevens, R; Jorgensen, K.R.; Young, S.A.; Monsen, S.B. 1996. Forb and shrub seed production guide for Utah. AG 501. Logan, UT: Utah State University Extension. 52 p.

Taylor, R.J. 1992. Sagebrush country: A wildflower sanctuary. Missoula, MT: Mountain Press Publishing Company. 211 p.

USDA Forest Service, Bend Seed Extractory [USFS BSE]. 2017. Nursery Management Information System Version 4.1.11. Local Source Report 34-Source Received. Bend, OR: U.S. Department of Agriculture, Forest Service, Bend Seed Extractory.

USDA Forest Service, Great Basin Native Plant Project [USFS GBNPP]. 2014. Seed weight table calculations made in-house. Report on file. Boise, ID: U.S. Department of Agriculture, Forest Service, Boise Aquatic Sciences Laboratory. Available: https://www.fs.fed.us/rm/boise/research/shrub/Links/Seedweights.pdf

USDA Forest Service, Western Wildland Environmental Threat Assessment Center [USFS WWETAC]. 2017. TRM Seed Zone Applications. Prineville, OR: U.S. Department of Agriculture, Forest Service, Western Wildland Environmental Threat Assessment Center. https://www.fs.fed.us/wwetac/threat-map/TRMSeedZoneMapper.php [Accessed 2017 June 29].

USDA Natural Resources Conservation Service [USDA NRCS]. 2000. Washington and Oregon guide for conservation seedings and plantings. Portland, OR: U.S. Department of Agriculture, Natural Resources Conservation Service. 126 p.

USDA Natural Resources Conservation Service [USDA NRCS]. 2017. The PLANTS Database. Greensboro, NC: U.S. Department of Agriculture, Natural Resources Conservation Service, National Plant Data Team. https://plants.usda.gov/java [Accessed 2018 June 13].

USDI Bureau of Land Management, Seeds of Success [USDI BLM SOS]. 2016. Bureau of Land Management technical protocol for the collection, study, and conservation of seeds from native plant species for Seeds of Success. Washington, DC: USDI Bureau of Land Management. 37 p.

USDI Bureau of Land Management, Seeds of Success [USDI BLM SOS]. 2017. Seeds of Success collection data. Washington, DC: USDI Bureau of Land Management, Plant Conservation Program.

USDI Environmental Protection Agency [USDI EPA]. 2018. Ecoregions. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/eco-research/ecoregions [Accessed 2018 January 23].

USDI Geological Survey [USGS]. 2017. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. https://bison.usgs.gov/#home [Accessed 2017 June 29].

Utah Crop Improvement Association [UCIA]. 2015. How to be a seed connoisseur. Logan, UT: UCIA, Utah Department of Agriculture and Food, Utah State University and Utah State Seed Laboratory. 16 p.

Welsh, S.L.; Atwood, N.D.; Goodrich, S.; Higgins, L.C., eds. 1987. A Utah flora. The Great Basin Naturalist Memoir 9. Provo, UT: Brigham Young University. 894 p.

Whitcomb, H.L. 2011. Temperature increase effects on sagebrush ecosystem forbs: Experimental evidence and range manager perspectives. Logan, UT: Utah State University. Thesis. 125 p.

Wik, P.A. 2002. Ecology of greater sage-grouse in south-central Owyhee County, Idaho. Moscow, ID: University of Idaho. Thesis. 128 p.

Young, S.; Bouck, M. 2011. Stock seed production of native plants for the Great Basin. In: Shaw, N.; Pellant, M., eds. Great Basin Native Plant Project: 2010 Progress Report. Boise, ID: U.S. Department of Agriculture, Forest Sevice, Rocky Mountain Research Station: 131-135.

Young, S.A.; Schrumpf, B.; Amberson, E. 2003. The Association of Official Seed Certifying Agencies (AOSCA) native plant connection. Moline, IL: AOSCA. 9 p.

RESOURCES

AOSCA NATIVE PLANT CONNECTION
https://www.aosca.org/wp-content/uploads/Documents///AOSCANativePlantConnectionBrochure_AddressUpdated_27Mar2017.pdf

BLM SEED COLLECTION MANUAL
https://www.blm.gov/sites/blm.gov/files/programs_natural-resources_native-plant-communities_native-seed-development_collection_Technical%20Protocol.pdf

ENSCONET SEED COLLECTING MANUAL
https://www.publicgardens.org/resources/ensconet-seed-collecting-manual-wild-species

HOW TO BE A SEED CONNOISSEUR
http://www.utahcrop.org/wp-content/uploads/2015/08/How-to-be-a-seed-connoisseur20May2015.pdf

OMERNIK LEVEL III ECOREGIONS
https://www.epa.gov/eco-research/ecoregions

CLIMATE SMART RESTORATION TOOL
https://climaterestorationtool.org/csrt/

SEED ZONE MAPPER
https://www.fs.fed.us/wwetac/threat-map/TRMSeedZoneMapper.php

AUTHORS

Corey L. Gucker, Great Basin Fire Science Exchange Support
University of Nevada, Reno
Boise, ID | cgucker@unr.edu

Nancy L. Shaw, Research Botanist (Emeritus)
USDA Forest Service, Rocky Mountain Research Station
Boise, ID | nancy.shaw@usda.gov

Gucker, Corey L.; Shaw, Nancy L. 2018. Munro's globemallow (*Sphaeralcea munroana*). In: Gucker, C.L.; Shaw, N.L., eds. Western forbs: Biology, ecology, and use in restoration. Reno, NV: Great Basin Fire Science Exchange. 19 p. Online: http://greatbasinfirescience.org/western-forbs-restoration

COLLABORATORS