# Desert Globemallow

## *Sphaeralcea ambigua* (A. Gray)

## Malvaceae - Mallow Family

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## NOMENCLATURE

Desert globemallow (*Sphaeralcea ambigua* A. Gray) (USDA NRCS 2022) belongs to the Malvaceae or mallow family.

### NRCS Plant Code.

SPAM2 (USDA NRCS 2022).

### Synonyms.

*Sphaeroma ambiguum* (A. Gray) Kuntze, *Sphaeralcea ambigua* var. *keckii* Munz, *Sphaeralcea macdougalii* Rose & Standl., *Sphaeralcea rosacea* Munz & I.M. Johnst. (Tropicos 2023); *Sphaeralcea ambigua var. pulchella*, *Sphaeralcea purpurea* Parish ex Jeps. (SEINet 2023).

### Common Names.

Desert globemallow, apricot mallow, roughleaf apricot mallow, desert mallow, mal de ojo, Parish mallow, desert hollyhock, sore-eye poppy (Wolf and Evancho 2016, SEINet 2023).

### Subtaxa.

Both the Flora of North America (FNA 2023) and the Integrated Taxonomic Information System (ITIS 2023) recognize four varieties of desert globemallow:

- *Sphaeralcea ambigua* var. *ambigua* A. Gray
- *Sphaeralcea ambigua* var. *rosacea* (Munz & I.M. Johnst.) Kearney

- *Sphaeralcea ambigua* var. *rugosa* (Kearney) Kearney
- *Sphaeralcea ambigua* var. *versicolor* (Kearney) Kearney

### Chromosome Number.

Chromosome numbers for desert globemallow are 2n=10, 20, 30, 37 (La Duke 2012, CCDB 2023).

Since desert globemallow possesses intraspecific variation in chromosome numbers between populations, it may be necessary to assess the cytotypes of populations prior to mixing seed sources or starting propagation. Combining incompatible cytotypes can potentially result in losses of fitness and fertility in plantings (Kramer et al. 2018).

### Hybridization.

Interspecific hybridization within globemallows is extremely common and intermediate forms make identification difficult (Atwood and Welsh 2002). In an experimental garden setting, desert globemallow was shown to freely hybridize in both directions (as a seed parent and as a pollen donor) with most other globemallow species where ranges overlap (Dreher 2014). Hybrids between desert globemallow and sympatric species may vary in fertility: crosses with Emory's globemallow (*Sphaeralcea emoryi*) resulted in mostly fertile F1 individuals, while crosses with caliche globemallow (*Sphaeralcea laxa*) were infertile or resulted in poorly formed fruits (Dreher 2014). Emory's globemallow is sympatric with desert globemallow in both the Mojave and Sonoran Deserts. Evaluating landscape genetic patterns to identify the geographic distribution of globemallow hybrids could inform plant materials development and restoration planning (Winkler and Massatti 2020).

## DESCRIPTION

Desert globemallow is a perennial subshrub with canescent herbage. Stems become woody at the base, with a taproot giving rise to 100 or more stems (Figure 1; Kearney et al. 1960). Desert globemallow's green to yellowish-green leaves measure 15-50 mm in length, are generally triangular in outline, and weakly three-lobed with wedge-shaped, truncate, or cordate bases (Figure 2; La Duke 2012). The leaves are covered in starlike hairs that give the foliage a greyish tone (Wolf and Evancho 2016). The inflorescence is most commonly an open panicle, although narrower and denser thyrsoid or raceme-like inflorescences are occasional. Desert globemallow has the largest flowers among globemallows with petals up to 3.8 cm long (Figure 3; Wolf and Evancho 2016). Petal color ranges across varieties and can be red-orange, apricot, lavender, or pink (La Duke 2012). The fruit is a schizocarp (3.5 mm wide) consisting of 9-13 two-seeded mericarps which dehisce 60-70% open to expose seeds at maturity (La Duke 2012, Wolf and Evancho 2016). Seeds are brown, glabrous to hairy, and kidney-shaped (Wolf and Evancho 2016).

**Figure 1:** A robust desert globemallow individual. Photo: Jean Pawek

**Figure 2:** The three-lobed leaves of desert globemallow. Photo: Sue Carnahan

**Figure 3:** Desert globemallow flower. Photo: Jean Pawek

**Figure 4:** Desert globemallow variety *rosacea* with pink petals. Photo: Sue Carnahan

### Varieties or Subspecies.

Variety *ambigua* has red-orange to apricot petals and a hairy filament tube measuring 3-9 mm in length, with yellow-purple anthers (La Duke 2012).

Variety *rosacea* has lavender to pink petals (Figure 4) and a typically glabrous filament tube measuring 11 mm in length, with purple-grey anthers (La Duke 2012).

Variety *rugosa* is primarily distinguished by its markedly wrinkled (rugose) leaves. It has red-orange petals and a glabrous filament tube measuring about 5mm in length with yellow anthers (La Duke 2012).

No physical description for variety *versicolor* is readily available. However, it is only found on islands in the Gulf of California between Baja California and Sonora, Mexico where it is sympatric with other desert globemallow varieties (SEINet 2023).

## DISTRIBUTION AND HABITAT

Desert globemallow is distributed from northern Nevada, south into Baja California and Sonora, Mexico (Figure 5). It is common in the Mojave and Sonoran Deserts but only occurs sporadically in the northern extent of its range in the Central Basin and Range ecoregion in Nevada.

Desert globemallow is also found in interior chapparal and pinyon-juniper woodlands within the Southern and Baja California Pine-Oak Mountains, Arizona-New Mexico Mountains, Arizona-New Mexico Plateau, and Colorado Plateau ecoregions.

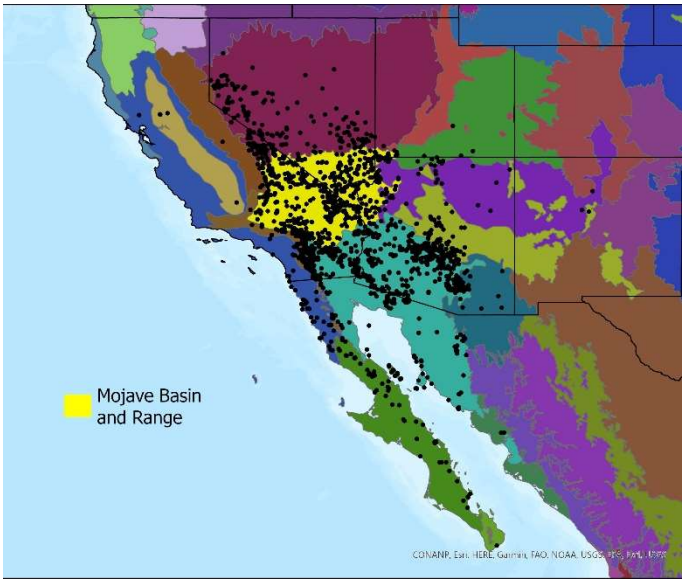


**Figure 5:** Distribution of desert globemallow based on georeferenced herbarium specimens and verified observations (black circles, SEINet 2022) with EPA Level III Ecoregions (US EPA 2015). The Mojave Basin and Range ecoregion is shown in yellow.

## Habitat and Plant Associations.

Referred to as the most xerophytic of the globemallows (Kearney et al. 1960, Wolf and Evancho 2016), desert globemallow is found in open habitats on dry, rocky slopes, along the margins of ephemeral sandy washes, and in disturbed areas such as roadsides and burned areas (Figures 6-8; SEINet 2023).

NatureServe recognizes one habitat alliance (Desert Globemallow–Scarlet Globemallow–Small-leaf Globemallow Dry Meadow Alliance) and one habitat association (Broom Snakeweed/Big Galleta–Desert Globemallow Shrub Grassland, ranked as imperiled in Arizona) defined by the presence of desert globemallow (Faber-Langendoen et al. 2018, NatureServe 2022).

### *Mojave and Sonoran Deserts.*

Within the Mojave and Sonoran Basin and Range ecoregions, desert globemallow is found in desert scrub, Joshua tree and juniper woodland, and semidesert grassland habitats.

Common associates in these habitats include creosote bush (*Larrea tridentata*), brittlebush (*Encelia* spp.), burrobush (*Ambrosia dumosa*), Joshua tree (*Yucca brevifolia*), Utah juniper (*Juniperus osteosperma*), prickly pear (*Opuntia* spp.), Mojave yucca (*Yucca schidigera*), sweetbush (*Bebbia juncea*), Mojave woodyaster (*Xylorhiza tortifolia*), and blackbrush (*Coleogyne ramosissima*) (BLM SOS 2022, SEINet 2023).

**Figure 6:** Desert globemallow in a rocky, exposed habitat in California. Photo: BLM SOS CA930A

## Climate.

The Mojave Desert is characterized by low annual precipitation (2-10 inches or 5-25 cm in valley areas), with most rainfall occurring in the winter and a smaller amount during summer thunderstorms (Randall et al. 2010).

Heterogenous climate patterns across the region are influenced by large-scale patterns and regional topography and are important drivers of local adaptation and intraspecific variation (Shryock et al. 2018, Baughman et al. 2019) and phenological events (Beatley 1974).

Specifically, the reproductive phenology of many desert plant species is highly responsive to pulses in rainfall over short time scales (Bowers and Dimmitt 1994, Zachmann et al. 2021).

**Figure 7:** Desert globemallow habitat along an ephemeral drainage in California. Photo: BLM SOS CA930

**Figure 8:** Desert globemallow habitat on a steep, rocky slope in California. Photo: Sara De Groot, BLM SOS CA930A

Climate information is derived from the climate-based provisional seed transfer zones (PSZs) where desert globemallow occurs (Shryock et al. 2018; Table 1). The average annual precipitation in the PSZs where desert globemallow occurs in the Mojave Desert ecoregion is 6.8 inches (17.2 cm), with an average of 2.3 inches (5.9 cm) falling in the summer and an average of 4.5 inches (11.4 cm) falling in the winter. Note, herbarium specimen locations may not represent the full distribution and abundance of desert globemallow due to sampling bias towards accessible locations.

**Table 1:** Climate of the provisional seed zones (PSZ) where desert globemallow occurs within the Mojave Desert ecoregion (Shryock et al. 2018).# = the number of herbarium or verified observations of desert globemallow within the PSZ (SEINet 2022); MAP=mean annual precipitation; SP=summer precipitation, or the mean precipitation that falls in the summer (May-October); WP= winter precipitation, or the mean precipitation that falls in the winter (November-April); MAT=monthly average temperature; Range= Average of the monthly temperature ranges (monthly maximum minus monthly minimum).

| PSZ | # | MAP (cm) | SP (cm) | WP (cm) | MAT (C) | Range (C) |
|---|---|---|---|---|---|---|
| 21 | 149 | 15.6 | 6.2 | 9.4 | 18.8 | 38.4 |
| 26 | 132 | 14.5 | 2.7 | 11.8 | 16.8 | 34.9 |
| 20 | 126 | 25.5 | 10.5 | 14.9 | 15.3 | 34.5 |
| 23 | 124 | 15.8 | 5.4 | 10.4 | 16.1 | 35.9 |
| 25 | 103 | 16.5 | 6.2 | 10.3 | 18.9 | 34.6 |
| 29 | 91 | 25.5 | 4.2 | 21.4 | 13.8 | 31.6 |
| 24 | 66 | 10.7 | 2.8 | 7.9 | 18.8 | 38.6 |
| 27 | 30 | 9.6 | 3.3 | 6.3 | 20.0 | 36.7 |
| 22 | 10 | 36.1 | 13.3 | 22.8 | 10.0 | 32.4 |
| 28 | 4 | 7.8 | 2.4 | 5.3 | 22.3 | 41.3 |

### Elevation.

Desert globemallow is found at elevations below 3500 ft (1067 m) (Kearney et al. 1960, Wolf and Evancho 2016).

### Soils.

Desert globemallow is tolerant of a variety of soil textures (sand, silt, and clay), as long as there is adequate drainage (Wolf and Evancho 2016). It grows in soils derived from various parent materials including weathered limestone, sandstone, granite, and other igneous rocks (BLM SOS 2022). Desert globemallow is categorized as a gypsovag, meaning it occurs regularly on both gypsiferous soils and common non-gypsum substrates (Meyer 1986). Desert globemallow is positively associated with soil surface attributes such as rock cover and cryptogram (biological soil crust) cover (Meyer 1986).

Desert globemallow is a drought- and disturbance-tolerant plant with several benefits to wildlife and pollinator species.

## ECOLOGY AND BIOLOGY

### Reproduction.

#### *Breeding System.*

Similar to other globemallow species, desert globemallow is outcrossing and no indications of self-compatibility were found in the literature (Pendery and Rumbaugh 1993).

#### *Reproductive Phenology.*

Desert globemallow flowers throughout the year in response to precipitation, but peak flowering is typically March to April across its range (Wolf and Evancho 2016, SEINet 2023).

Based on seed collection data, seeds are typically mature in April to June in the Mojave Desert (BLM SOS 2022).

#### *Pollination.*

In general, globemallows are insect-pollinated and especially attractive to a variety of bees, including the specialists globemallow bee (*Diadasia diminuta*; Figure 9) and globemallow andrena bee (*Andrena sphaeralceae*). Bee visitors to globemallows in the Mojave Desert include *Melissodes subagilis*, *Perdita arcuate*, *Triepeolus helianthin* and the *Exomalopsis*, *Megandrena*, and *Anthophorula* genera (Esque et al. 2021).

**Figure 9:** A globemallow bee in a desert globemallow flower. Photo: Jillian Cowles

### Seed and Seedling Ecology.

Desert globemallow mericarps open most of the way, allowing naked seeds to be shed individually (Martínez-Berdeja 2015). Seeds are categorized as weakly serotinous (Martínez-Berdeja 2015). Seeds typically germinate in open habitats and nurse plant facilitation is unlikely (Howe and Wright 1986). Seedlings are described as having high vigor (Granite Seed 2023).

Desert globemallow seeds are susceptible to removal by granivores, particularly ants and rodents. In a study of seed predation by ants in

the Sonoran Desert, roughly 10-45% of desert globemallow seeds were taken by ants (Martyn et al. 2023). The authors suggest that this relatively low rate of ant predation compared to other study species may be due to the papery mericarp casing, which was retained with the seed, creating a higher structure to seed ratio that deters ants (Martyn et al. 2023).

Another study in the Mojave Desert found that ants removed 90% of desert globemallow seeds in unburned habitats and more than 50% in burned habitats (Suazo et al. 2013). Rodents removed nearly 30% of desert globemallow seeds across all sites. The authors attribute the high rate of seed removal by ants to the small size and weight of desert globemallow seeds relative to other species in the study (Suazo et al. 2013).

Gambel's quail (*Callipepla gambelii*) eat desert globemallow seeds (Gullion 1960) and may play a role in dispersal, though dispersal potential is not specified in any literature.

## Species Interactions.

### *Belowground Interactions.*

Desert globemallow is associated with arbuscular mycorrhizal fungi (Titus et al. 2002, Granite Seed 2023). In spring sampling at the Nevada Test Site, over 20% of desert globemallow roots had arbuscular mycorrhizae hyphae colonizing their roots (Titus et al. 2002).

### *Parasites and Predation.*

Desert globemallow seeds may be susceptible to predation by weevils (WCI 2015). Some globemallow species are hosts for the cotton root rot fungus, (*Phymatotrichum omnivorum*), which causes root rot of cotton and many other cultivated plants (Wolf and Evancho 2016).

See Pest Management for further discussion on these pests and their treatment in propagation settings.

### *Wildlife and Livestock Use.*

Desert globemallow serves as an important forage and cover plant for the endangered desert tortoise (*Gopherus agassizii*) (Esque et al. 2021). Its ability to readily establish after fires allows desert globemallow to provide short term cover and food for desert tortoises to bridge the gap while longer lived species re-establish (Drake et al. 2015).

Desert globemallow has also been noted as a food plant for desert bighorn sheep (*Ovis canadensis mexicana*) (Miller and Gaud 1989), chuckwallas (*Sauromalus obesus*) (Hansen 1974), kangaroo rats (*Dipodomys* spp.) (Bradley and Mauer 1971), and Gambel's quail (Gullion 1960).

### *Other Notable Species Interactions.*

Desert globemallow is noted as a larval host plant for at least eight different butterflies or moths: northern white skipper (*Heliopetes ericetorum*), common checkered-skipper (*Pyrgus communis*), small checkered-skipper (*Pyrgus scriptura*), gray hairstreak (*Strymon melinus*), a noctuid moth (*Acontia major*), west coast lady (*Vanessa annabella*), painted lady (*Vanessa cardui*), and a Sessidae moth (*Zenodoxus palmii*) (Robinson et al. 2010).

In one study, leafcutter ants (*Atta mexicana*) targeted desert globemallow—cutting and collecting leaf parts, flowers and stem sections—while leaving conspecifics and other species alone (Mintzer 1979).

### Disturbance Ecology.

Desert globemallow is broadly considered an early successional species and is categorized as an "increaser" in response to disturbance (Abella 2010). It is frequently observed recolonizing after natural and human-caused disturbances including in fallow agricultural fields (Carpenter et al. 1986), pipeline rights-of-ways (Vasek et al. 1975), and even bladed areas surrounding the Nevada Test Site for atomic bomb detonation tests (Shields et al. 1963). Collection notes from herbarium specimens indicate other disturbances associated with desert globemallow including feral horse and cattle grazing, corrals, roadsides, and invasive grass dominance (SEINet 2023).

In southeastern Arizona grasslands, desert globemallow was recorded as the most abundant perennial forb in cattle-grazed areas and did not differ in density between grazed sites and protected sites (Roundy and Jordan 1988). Further, desert globemallow had higher density in areas that had been root-plowed to remove woody vegetation compared to undisturbed sites (Roundy and Jordan 1988).

Desert globemallow has been noted to quickly colonize after fires in the Mojave Desert (Abella et al. 2021, SEINet 2023). Abella et al. (2021) recorded that desert globemallow had higher cover in burned compared to unburned areas in 87% of their study sites 2-20 years post-fire.

### Ethnobotany.

The Yavapai used stems of desert globemallow to weave trays for drying saguaro fruit or agave for mescal (Gifford 1936, as cited in Wolf and Evancho 2016).

Several tribes whose ancestral lands overlap with the current range of desert globemallow—including the Pima, Tewa, Keres, Hopi, and Navajo—are noted to use other species of globemallow for medicinal, food, and decorative purposes (NAEB 2022). Traditional uses of globemallow species include as a venereal disease treatment, eye wash, cold remedy, contraceptive, upset stomach treatment, and as an emetic to induce vomiting. Poultices of globemallow roots and leaves have been used topically for rheumatism or swelling (NAEB 2022).

While there are reports of globemallow use as an eye wash, the common names "sore-eye poppy" and "mal de ojo" have been attributed to eye irritation from the leaf hair (Wolf and Evancho 2016).

### Horticulture.

Desert globemallow is a popular addition to xeriscape and pollinator gardens due to its drought tolerance, showy blooms, and attractiveness to a variety of pollinators (CNPS Calscape 2023). It is commonly available from retail nurseries in both seed packets and container plants (CNPS Calscape 2023). For ornamental establishment from seed, sow to a depth of ¼ inch (Wolf and Evancho 2016).

## DEVELOPING A SEED SUPPLY

A robust and stable supply of genetically appropriate seed is needed to meet restoration demands in response to expanding environmental stressors from land degradation, invasive species, and climate change. Restoration success is, in part, predicated on applying the right seed in the right place, at the right time (PCA 2015). Developing a restoration seed supply involves coordination across many partners in all steps of the process: from conducting wildland collections to propagating materials in nurseries and agricultural fields to eventual seeding or outplanting at restoration sites. Appropriate protocols for preserving genetic diversity and adaptive capacity should be

in place (Erickson and Halford 2020) and seed origin should be documented for certification purposes and other seed planning considerations.

### Seed Sourcing.

Seed sourcing can influence restoration outcomes due to local adaptation (Custer et al. 2022), landscape genetic patterns (Massatti et al. 2020, Shryock et al. 2021) and differing ability to adapt to current and future climate conditions (Bucharova et al. 2019). However, there has been relatively little research evaluating seed sourcing strategies in actual restoration settings where many additional factors influence performance (Pizza et al. 2023). While non-local sources can perform well in meeting initial restoration goals such as establishment and productivity (Pizza et al. 2023), plants have coevolved with interacting organisms, such as pollinators and herbivores, that can exhibit preferential behavior for local materials (Bucharova et al. 2016, 2022). Further, evidence of local adaptation and its influence on restoration outcomes can take decades to emerge for long-lived species (Germino et al. 2019).

Researchers with the United States Geological Survey (USGS) developed empirical seed zones for desert globemallow within the Mojave Desert ecoregion based on landscape genomic and climate threshold analyses (Figure 10; Shryock et al. 2015). These species-specific seed zones indicate areas within which desert globemallow seed can be sourced and applied with reduced risk of maladaptation.

Outside of the Mojave Desert, the Desert Southwest Provisional Seed Zones (PSZs) may be used to plan seed sourcing for desert globemallow. The Desert Southwest PSZs use twelve climatic variables that drive local adaptation to define areas within which plant materials may be transferred with higher probability of successful establishment and reduced risk of introducing maladapted ecotypes (Shryock et al. 2018). Overlaying PSZs with Level III ecoregions can serve to further narrow seed transfer by identifying areas of both climate similarity inherent in the PSZs and ecological similarity captured by the ecoregion, namely vegetation and soils. Within the PSZs and ecoregion areas, further site-specific considerations such as soil, land use, species habitat and microclimate affinities, and plant community may be relevant to seed sourcing decisions.

The USGS Climate Distance Mapper Tool incorporates the Southwest Deserts Seed Transfer Zones with climate models and can serve to guide seed sourcing according to current and projected climate conditions.

### Commercial Seed Availability and Germplasm Releases.

Desert globemallow is sometimes available for purchase from large-scale commercial seed vendors. However, availability may be inconsistent, and sources may be limited to a narrow range of appropriate seed zones. Commercially available seed may not be Source Identified, and source seed zone information may not be available. There have been no conservation plant releases of desert globemallow.

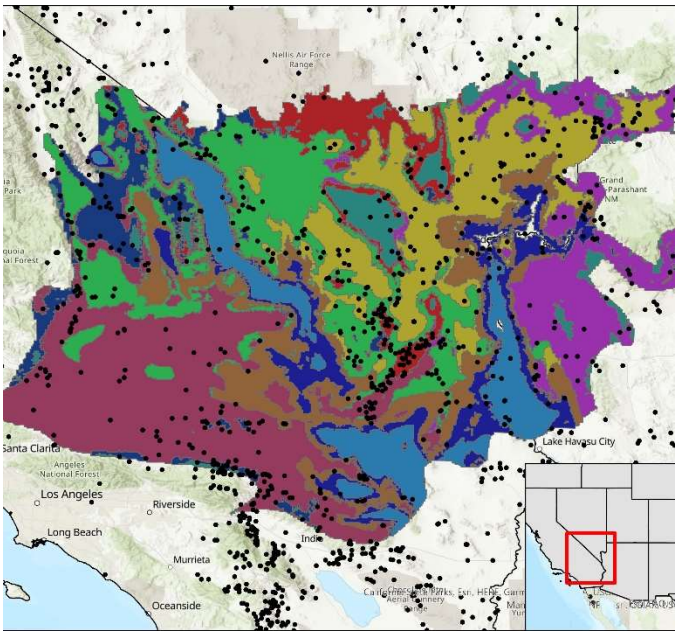


**Figure 10:** Distribution of desert globemallow based on georeferenced herbarium specimens and verified observations (black circles, SEINet 2022) across its species-specific empirical seed zones (colored polygons) within the Mojave Desert delineated using genomic and climate analyses (Shryock et al. 2015).

## Wildland Seed Collection.

Wildland seed collection involves visiting naturally occurring populations of target species to provide source seed for propagation, restoration, and research. Ethical practices include preventing overharvesting, typically by not harvesting more than 20% of available seed (BLM 2021). In arid regions and in drought conditions, it may be best to collect no more than 10% of available seed due to limited regeneration and low-density populations (Asbell 2022, personal communication). There are several practices to ensure proper genetic diversity is captured from the source population. These include collecting from the entire population uniformly, sampling a diversity of phenotypes and microclimates, and collecting in various time windows to capture phenological diversity (BLM 2021).

### *Seed Collection Timing.*

Desert globemallow seed is typically collected from April to June (BLM SOS 2022). However, it can flower and set seed throughout the year in response to favorable precipitation, and seed collections have also been made June through November (Johnson 2023, personal communication).

### *Collection Methods.*

In general, desert globemallow can be collected by hand, plucking whole schizocarps (Figure 11) off the plant and placing them into a paper bag. Collection methods described for other globemallow species in Gucker and Shaw (2018) may also be effective for desert globemallow. These methods include swatting seed heads with a tennis racquet over a container to collect ripe seed, or mechanical harvesting with a combine when the stand is dense and the terrain is fairly level. Gloves are recommended for protection from desert globemallow's irritating hairs.

**Figure 11:** A partially opened schizocarp of desert globemallow holding seed. Photo: BLM SOS NV040

**Figure 12:** Desert globemallow with dried schizocarps ready for collection. Photo: BLM SOS CA170

### *Post-Collection Management.*

Immediately following collection, seeds should be properly managed to avoid damage or declines in viability during transport and temporary storage. Seed should be dried and ventilated to prevent molding (Pedrini and Dixon 2020). Ventilation can be achieved by collecting and storing seed in breathable containers, such as paper or cloth bags.

To dry material before storage or processing, spread it in a single layer on trays or newspaper indoors in a well-ventilated room, or outdoors in a shaded area (BLM 2021). Desert globemallow seeds should be dried for 4 to 6 weeks in paper bags in a warm, dry room prior to processing (Graham 2003). Collected material should be visually inspected for seed-predating insects (Pedrini and Dixon 2020). If seed predation is observed, consider fumigation with No-Pest Strips. After collection, prevent exposure to excessively hot or cold temperatures during transportation and temporary storage by keeping seed in a dry, insulated container (e.g., a cooler) in a shaded area while in the field (BLM 2021).

### Seed Cleaning.

Seed cleaning techniques for desert globemallow will vary depending on the plant material collected and the type of equipment available. Most commonly, whole schizocarps are hand collected (Figure 13) and the segments of the schizocarp must be separated and then opened, followed by chaff separation (Allen-Cantú et al. 2018). To break apart the segments and release the seed, material can be rubbed through a #12 sieve either by hand, or with sandpaper to help break down the papery fruit segments (Wall and MacDonald 2009, Allen-Cantú et al. 2018). This can also be achieved using a blender with nylon filament line attached to the propellor (similar to weed-eater string) and running at the lowest speed for about one minute (Wall 2009). After the segments have been broken down and seeds have been released, chaff and unfilled seed can be separated using several techniques. Sieving through #12 and #18 sieves followed by running material through a blower at medium speed can separate threshed seed from different sizes of floral chaff (Wall 2009). Separating chaff may also be accomplished with light air winnowing using a handheld blow dryer (Allen-Cantú et al. 2018).

**Figure 13:** Collected material of desert globemallow before seed cleaning. Photo: BLM SOS CA660

At the Bend Seed Extractory (BSE), a Seeds of Success (SOS) collection of desert globemallow from the Sonoran Desert was cleaned using a brush machine (Westrup Model LA-H) with a #40 mantel at medium speed followed by an air screen through the Clipper with screen size determined through a test of seed size on the working material (Barner 2008).

Similarly, material harvested from agricultural fields with mechanical equipment can be cleaned using a brush machine or hammer mill to break down the vegetative plant material and release the seed followed by running the material through air screening equipment (Wolf and Evancho 2016).

Cleaning desert globemallow down to "black seed" (Figure 14) by removing the papery mericarp casings allows seed to be more accurately weighed and likely slows decay in medium- to long-term storage. However, seed producers have recorded no difference in germination in agricultural seed increase fields between black seed and seeds retained in the casings (Hagman 2023, personal communication).

Planting seed in mericarp casings may save effort in cleaning when there is a short period between cleaning and sowing (Hagman 2023, personal communication).

**Figure 14:** Clean desert globemallow seed. Photo: Bend Seed Extractory

## Seed Storage.

In general, seeds should be stored in cool and dry conditions, out of direct sunlight, to maintain viability. Optimal conditions for medium-term storage of orthodox seeds (up to 5 years) are 15% relative humidity and 15°C (59°F). For long-term storage (>5 years), completely dried seeds should be stored at -18°C (0°F) (De Vitis et al. 2020, Pedrini and Dixon 2020).

Desert globemallow seed is orthodox (SER SID 2023). Seeds maintained at -15°C at the Kew Royal Botanic Gardens have maintained germination rates above 84% after 22 years and a collection stored for 14 years maintained a 94.7% germination rate (SER SID 2023). Additionally, seed stored at the Rancho Santa Ana Botanic Gardens exhibited 81% germination after 27 years in storage (Wall 2009). However, in a study of seed longevity, desert globemallow seeds exhibited zero germination after 12 years of storage in poor conditions (a glass jar exposed to direct sunlight and occasional extreme heat) (Went and Munz 1949). Other reports indicate that desert globemallow seed can have low germinability initially (<10%), but germination rates can increase after storage for up to 2 years, after which rates begin to decline (Kay et al. 1988 as cited by Esque et al. 2021).

## Seed Testing.

After collection, a representative sample of each seed lot must be tested in an appropriate seed lab to ensure purity and germination meet minimum standards defined by the Association of Official Seed Analysts (AOSA) (2016) and species standards from state-level certification programs, as available. A set of "principles and standards for native seeds in ecological restoration" (Pedrini and Dixon 2020) outlines further guidelines specific to native plants, including procedures for obtaining representative samples of seed lots

and incorporation of dormancy measures into seed testing and labels.

Pre-treatments prior to germination testing at the Kew Royal Botanic Gardens include chipping the seed coat with a scalpel to encourage imbibition, resulting in germination rates of 84-94% in a 1% agar solution (SER SID 2023).

The AOSA does not specify guidelines for testing germination or purity of desert globemallow seed or congeners (AOSA 2016). An AOSA tetrazolium test protocol for the Sphaeralcea genus may be followed to assess desert globemallow seed viability (AOSA 2010). The tetrazolium test protocol for Sphaeralcea seed viability assessments first involves preconditioning seed by soaking overnight at 20-25 °C. Desert globemallow can have hard seeds with impermeable seed coats and chipping the seed coat with a sharp blade prior to soaking can encourage imbibition. After soaking, seeds are cut longitudinally so that part of the seed coat is intact and holding the two halves together. Seeds are then placed in a 0.1 or 1% tetrazolium solution overnight at 35° C.

Viability can then be quantified by assessing the percentage of seeds where the entire embryo and endosperm are evenly stained (AOSA 2010).

### *Wildland Seed Yield and Quality.*

Wild-collected desert globemallow seed is of fairly high quality, with an average of 86% fill, 96% purity and 91% viability indicated by tetrazolium tests across 32 Seeds of Success (SOS) collections (BLM SOS 2022, Table 2). Wild collections contain an average of over 276,000 PLS/lb (BLM SOS 2022, Table 2).

**Table 2:** Seed yield and quality of desert globemallow seeds collected in the Mojave Basin and Range Ecoregion, cleaned by the Bend Seed Extractory, and tested by the Oregon State Seed Laboratory or the USFS National Seed Laboratory (BLM SOS 2022). Fill (%) was measured using a 100 seed X-ray test. Viability was measured using a tetrazolium chloride test.

| | Mean | Range | Samples |
|---|---|---|---|
| Bulk weight (lbs) | 1.86 | 0.08-8.18 | 32 |
| Clean weight (lbs) | 0.24 | 0.007-1.28 | 32 |
| Purity (%) | 96 | 83-99 | 32 |
| Fill (%) | 86 | 67-99 | 32 |
| Viability (%) | 91 | 71-98 | 32 |
| Pure live seeds/lb | 276,801 | 197,540-421,604 | 32 |

## Wildland Seed Certification.

The Association of Official Seed Certifying Agencies (AOSCA) sets the standards for seed certification and provides guidance on production, identification, distribution, and promotion of all certified seed, including pre-varietal germplasm. Pre-varietal germplasm (PVG) refers to seed or other propagation materials that have not been released as varieties (AOSCA 2022). Pre-varietal germplasm certification programs for Source Identified materials exist in several states encompassing the Mojave Desert ecoregion including California (CCIA 2022), Utah (UTCIA 2015), and Nevada (NDA 2021). Arizona does not have a PVG certification process at this time. Source Identified (SI) germplasm refers to seed collected directly from naturally occurring stands (G0), or seed grown from wildland-collected seed in agricultural seed increase fields (G1-Gx) that have not undergone any selective breeding or trait testing. These programs facilitate certification and documentation required for wildland-collected seed to be legally eligible for direct sale or seed increase in an agricultural

setting. Certified SI seed will receive a yellow tag, also referred to as an SI-label, noting key information about the lot including the species, the generation of seed (G0-Gx), source location, elevation, seed zone, etc. (UTCIA 2015, NDA 2021, CCIA 2022).

Wildland seed collectors should be aware of documentation required for seed certification. The Seeds of Success data form and protocol (BLM 2021) include all appropriate information and procedures for site documentation and species identification verification to meet certification requirements for wildland sourced seed. Seed certifying agencies may also conduct site inspections of collection locations prior to certification—specific requirements for inspections vary by state and are at the discretion of the certifying agency.

## AGRICULTURAL SEED PRODUCTION

Desert globemallow grows best in full sun and in coarse to moderately coarse soils with a neutral pH (Granite Seed 2023).

### Agricultural Seed Field Certification.

As with wildland source seed (see Wildland Seed Certification section), seed grown in an agricultural seed increase field must also be certified by an official seed certifying agency, where programs exist. Field grown seed is also certified and labeled as Source Identified (SI), as long as it has not undergone selective breeding or testing. Seed field certification includes field inspection, seed testing for purity and germination (see Seed Testing section), and proof of certification for all source or parent seed used to start the field (AOSCA 2022). The SI-label or "yellow tag" for seed from a seed increase field denotes information about source seed, field location, and generation level (G1-Gx) indicating if there is a species-specific limitation of generations allowed to be grown from the original source (e.g., in a species with a three-generation limit, G1/G3, G2/G3, G3/3) (AOSCA 2022). Fields must be free of any prohibited noxious weeds. Restricted noxious weeds and common weeds difficult to separate must be controlled. Fields may be refused certification due to unsatisfactory appearance caused by weeds, poor growth, poor stand, disease, insect damage, and any other condition which prevents accurate inspection or creates doubt as to identity of the variety.

Table 3 outlines the pre-variety germplasm certification standards for desert globemallow seed in the state of California with a minimum of 0.5 ounce sample size required for testing (Schlosser 2022). The Nevada and Arizona Departments of Agriculture do not specify standards for PVG crops. The Utah Crop Improvement Association does not specify standards for PVG crops but may apply standards of similar species or crop groupings (UCIA 2023).

#### *Isolation Distances.*

Sufficient isolation distances are required to prevent cross-pollination of desert globemallow from different conspecific sources or other *Sphaeralcea* species. Table 4 summarizes the isolation distances required for PVG certification in both Utah and California. California standards are described specifically for desert globemallow (Schlosser 2022), while the Utah standards are general for outcrossing perennial species (UCIA 2023). Nevada and Arizona do not specify these standards for Source Identified PVG seed. The distances recommended by California (15-60 feet) may be insufficient to prevent pollinator-facilitated gene flow between different Source Identified desert globemallow crops and related species.

**Table 3:** Pre-varietal Germplasm (PVG) standards for seed analysis results of desert globemallow seed increase crops in California.

| Factor | G1 | G2 | G3 to G10 |
|---|---|---|---|
| Pure Seed (minimum) | 70% | 70% | 70% |
| Inert Matter (maximum) | 30% | 30% | 30% |
| Total Other Crop Seed (maximum) | 0.20% | 0.30% | 0.50% |
| Weed Seed (maximum) | 0.20% | 0.30% | 0.50% |
| Noxious Weed | None | None | None |
| Germination and Hard Seed (minimum) | 60% | 60% | 60% |

**Table 4:** Crop years and isolation distance requirements for pre-varietal germplasm crops of desert globemallow. CY= crop years, or the time that must elapse between removal of a species and replanting a different germplasm entity of the same species on the same land. I= isolation distance, or the required distance (in feet) between any potential contaminating sources of pollen.

| | G1 | | G2 | | G3+ | |
|---|---|---|---|---|---|---|
| State | CY | I | CY | I | CY | I |
| Utah | 3 | 900-600 | 2 | 450-300 | 1 | 330-165 |
| California | 5 | 60 | 5 | 30 | 2 | 15 |

## Site Preparation.

Desert globemallow seeds are sown into a firm, weed-free bed. If soil health is depleted and mycorrhizal fungi are likely absent from the soil biota, mycorrhizal soil inoculation may improve desert globemallow plant growth (Hagman 2023, personal communication).

## Seed Pre-treatments.

Due to physical dormancy from an impermeable seed coat (Baskin and Baskin 2014), desert globemallow seeds often exhibit improved germination with scarification and stratification treatments. Dunn (2011) saw 85% germination of desert globemallow seeds after scarification with sandpaper followed by cold stratification for 30 days under moist conditions at 4 °C compared to 12% and 44% germination with scarification alone. As with other globemallow species with physical dormancy, care should be taken to not damage the seed embryo during mechanical scarification (Page et al. 1966).

Using Mojave Desert seed sources, growers have found that cold stratification encourages germination and seedlings will generally emerge within 1-3 weeks after sowing in nursery propagation (Thomas et al. 2022, personal communication).

They observe zero germination when cold stratification is not applied (Thomas et al. 2022, personal communication).

Hot water scarification followed by a cool water soak has resulted in an 11% germination rate for desert globemallow seeds prior to nursery propagation (Graham 2003). This is accomplished by placing seeds in boiling water and immediately removing the heat source, followed by a cool water soak for 12-24 hours (Graham 2003).

## Seeding Techniques.

Seed can be directly sown ¼-½ inches deep at 2-4 lbs per acre into furrows by hand for smaller acreages (Hagman 2023, personal communication), or with a seed drill for larger acreages (Wolf and Evancho 2016). Denser seeding rates (5-10 lbs per acre) for native forbs in general can better ensure stand establishment, especially when dormancy

breaking treatments are not applied (Hagman 2023, personal communication). Following establishment, seedlings can be rogued by hand to allow proper spacing (Hagman 2023, personal communication). Ideal within-row spacing is from 24-40 inches and between-row spacing can vary from 36-40 inches (Wolf and Evancho 2016) and is dependent on available equipment.

Fall seeding allows untreated seed to germinate in the winter when, presumably, the seed coat can be worn down by cool and moist conditions. Winter germination is usually followed by rapid growth in the spring (Wolf and Evancho 2016). Sowing in the spring can be effective for field establishment, but flowering will likely not occur until the following year (Hagman 2023, personal communication).

The Tucson Plant Materials Center has successfully established desert globemallow seed production fields from plug planting and found that weed control was easier with plugs compared to direct seeding (Dial 2023, personal communication). Growers at Victor Valley College have also established desert globemallow fields from plug transplants that were grown in containers for a full year (Brooks and Gault 2023, personal communication). In general, plug planting may be more effective than direct sowing when there is a limited amount of seed available, if seed has low viability, or if the seed lot has weed seed contaminants that can be more easily weeded out in a nursery (Winters 2023, personal communication).

### Establishment and Growth.

Fall-sown desert globemallow can yield seed the following spring (Hagman 2023, personal communication). Nutrient additions based on soil test results can encourage growth (Wolf and Evancho 2016).

### Weed Control.

Weeds can be manually removed or carefully spot-sprayed with a non-selective herbicide as they emerge. Preemergent herbicide may be used to control weeds after desert globemallow plants have developed at least 3-5 leaves (Wolf and Evancho 2016). In smaller fields, hand rogueing weeds can be sufficient (Hagman 2023, personal communication).

There are limited number of herbicides registered and labeled for use on native plant crops. See the Native Seed Production guide from the Tucson Plant Materials Center (USDA NRCS 2004) for further details on weed management in native seed production fields.

### Pest Management.

Seed predating weevils, including the Sphaeralcea weevil (*Anthonomus sphaeralciae*) and an unidentified straight-snouted weevil (*Apion* sp.) have been found on globemallows in seed increase fields in Colorado (WCI 2015). Larvae of these insects feed on developing fruits and can cause significant damage to seed crops. Insecticides can be applied when adults are detected to prevent egg laying. However, since these pests are active during the flowering period of the globemallow crop, precautions to protect pollinators and beneficial insects should be taken. No records were found of weevil predation on desert globemallow specifically, but it is recommended to monitor for their presence (WCI 2015).

Some globemallow species are hosts of the cotton root rot fungus, (*Phymatotrichum omnivorum*), which causes root rot of cotton and other cultivated plants (Wolf and Evancho 2016). If this pathogen is a concern due to proximity to or field rotations with susceptible cultivated plants, methods to mitigate the fungus' proliferation are described by Damicone (2017).

### Pollination Management.

Growing native plants in or near their native range increases the likelihood that compatible pollinators will be able to find and pollinate the crop (Cane 2008). In general, growers can consider implementing pollinator management and stewardship practices to augment and attract existing pollinator communities. Specific practices will depend on the plant species' pollination needs, and the biology of the pollinators. For example, if a plant relies on native solitary bees, growers can create nesting opportunities adjacent to or within the field perimeter with downed woody material or crafted bee boxes (Cane 2008, MacIvor 2017). In some cases, there may be a need to supplement with managed pollinators through honeybee or bumblebee rental services to ensure pollination of wildflower crops for seed increase (Cane 2008).

Since the globemallow bee is a ground nesting bee, maintaining small areas of clear or unvegetated ground in sunny, well-drained areas may support this pollinator (Xerces Society 2019).

### Irrigation.

With flood irrigation, initial plantings should be irrigated to maintain a moist soil surface and prevent soil crusting while plants establish (Wolf and Evancho 2016; Mndowla 2023, personal communication).

After establishment, irrigation can be applied every four weeks on average during the growing season (Wolf and Evancho 2016).

Other growers have had success with drip irrigation for desert globemallow fields and found flood irrigation did not adequately penetrate into soil, resulting in significant evaporation in an aridland farm setting (Hagman 2023, personal communication).

No metrics were found relating irrigation methods and regimes to plant performance or seed yield of desert globemallow.

### Seed Harvesting.

Desert globemallow seeds may not be uniform in their ripening and harvest period within a single crop field. In smaller fields, seeds can be harvested by hand throughout the seeding period similar to wildland collection methods (Hagman 2023, personal communication). After collecting schizocarps by hand throughout the ripening period, whole inflorescence stalks can be cut with garden snips at the end of the seeding period to obtain remaining seed and maximize harvests (Schaff 2023, personal communication). For larger fields where mechanical harvest is more practical, Wolf and Evancho (2016) recommend using a seed stripper or combine.

### Seed Yields and Stand Life.

Flood irrigated fields of desert globemallow at the Tucson Plant Materials Center produced seed from spring to fall, with an estimated annual yield of 100–200 lbs per acre, depending on harvesting equipment used (Wolf and Evancho 2016; Mndowla 2023, personal communication).

No information on stand life was found in the literature or through personal communication.

## NURSERY PRACTICE

In general, desert globemallow can be propagated in nurseries from seed by sowing to a depth of approximately ¼ inch in well-drained soil (Wolf and Evancho 2016). Recommended growing mediums include 2:1:1 sand, mulch, and perlite (Graham 2003); 2:1 sand and organic potting soil; and calcine clay with a light fertilizer (Plath 2023, personal communication).

Desert globemallow can be seeded into conetainers at 3-4 seeds per plug. Seedlings can be thinned out after they emerge, retaining the most robust individual (Johnson 2023, personal communication). After their roots have filled in, the plugs can be transplanted into one-gallon containers. Alternatively, sowing directly into one-gallon containers can reduce plant loss from stress during transplanting (Johnson 2023, personal communication).

Propagation practices to grow desert globemallow in 2-gallon PVC containers at the Joshua Tree Native Plant Nursery in southern California are detailed by Graham (2003) and described here:

After a hot water seed pre-treatment, seeds are placed between sheets of blotter paper in nursery trays wrapped in plastic bags to retain moisture. Seeds are checked daily and when they start to germinate—indicated by radicle emergence—they are transplanted into flats and watered with drip irrigation. When at least two true leaves emerge (after about four weeks), seedlings are transplanted into newspaper cylinders (29 cm tall and 7.5 cm in diameter) held in plastic food wrap. After 8 to 12 weeks, the plants are transplanted along with their newspaper cylinders (minus the plastic wrap) directly into 2-gallon PVC pots, their final container for restoration outplantings. An Osmocote™ time release fertilizer is incorporated into the medium. Prior to delivery to a restoration site, plants undergo four to eight weeks of hardening off where irrigation frequency and duration is gradually reduced, and plants are moved into an open growing area. This whole process, including time for plants to develop sufficient roots for wildland restoration outplanting, can range in duration from 6 to 15 months (Graham 2019).

Vegetative propagation via stem cuttings is also effective (Plath 2023, personal communication). To do this, parent plants can be cut at stem nodes in late winter and placed in soil with one node in the substrate and at least one node above ground. No rooting hormone is necessary to establish plants vegetatively (Plath 2023, personal communication).

Desert globemallow may be susceptible to aphids which can be treated by spraying with soapy water (Johnson 2023, personal communication).

## REVEGETATION AND RESTORATION

Desert globemallow provides a variety of ecosystem functions and services including wildlife forage and habitat, pollinator resources, and ability to thrive in disturbed environments under drought conditions (see Ecology and Biology). For these reasons, desert globemallow is an important and commonly used species in a variety of revegetation and restoration projects. Desert globemallow has been effectively used in the Mojave Desert for post-fire restoration (DeFalco et al. 2009) and has been shown to effectively outcompete annual invasive grasses (Figure 15; Abella et al. 2012).

Desert globemallow establishment may be increased when planting methods are paired with other restoration actions such as herbicide treatments (DeFalco et al. 2009), topsoil salvage (Abella et al. 2015b), and herbivore exclusion (Abella and Newton 2009). Direct seeding, salvage, and plug planting have all been trialed and outcomes are detailed below.

**Figure 15:** Desert globemallow growing among invasive annual grasses. Photo: Jean Pawek

## Wildland Seeding and Planting.

### *Wildland Seedings.*

The Natural Resource Conservation Service recommends seeding desert globemallow in the fall at a rate of 2.2 pure live seed (PLS) lbs per acre if planted with a drill and 4.4 PLS lbs per acre if broadcast (Wolf and Evancho 2016). See Seed Pre-Treatments for a discussion on methods to break dormancy prior to seeding to improve germination rates. Direct seeding of desert globemallow has had mixed results.

In one study, pelletizing locally-sourced desert globemallow seeds (coating seeds with a commercial product containing mineral and organic material and binding agents) significantly increased establishment in the first 10 months following a Mojave Desert seeding, but plants did not persist and were absent from plots 20 months after seeding (Abella et al. 2015a).

In a trail reclamation project in the Sonoran Desert, desert globemallow seed was purchased from a commercial vendor and included in a seed mix with nine other native species, each applied at 100 seeds per species per 1.5 x 1 m plot (Rowe et al. 2022). Seeds were broadcasted by hand within plots and rolled with a Garden Weasel to press them into the soil. Some plots underwent soil ripping to reduce compaction prior to seeding, while others were seeded with no soil ripping. Desert globemallow was one of a few species that persisted 4 years after seeding, potentially due to its seed dormancy characteristics that help spread germination across several years (Rowe et al. 2022).

In an assessment of post-fire seeding in the Mojave Desert in Clark County, Nevada, DeFalco et al. (2009) examined results of seeding in burned areas where desert globemallow was included in a multispecies mix and applied through aerial seeding or hand broadcasting, with or without herbicide application to treat invasive annual grasses. Heavy seeding rates combined with herbicide application, especially those with the active ingredient imazapic, reduced invasive annual grasses and increased perennial plant establishment from the seed mix, including desert globemallow (DeFalco et al. 2009). Desert globemallow was the most abundant seeded species in monitoring plots 5 years following seeding but was equally abundant in control plots that were not seeded. Seed source (i.e. commercially purchased or locally collected) was not specified. Table 5 summarizes the results for desert globemallow across different seeding methods and seeding rates.

**Table 5:** A summary of methods and results for post-fire seeding of desert globemallow in Clark County, NV (DeFalco et al. 2009). Seedling frequency measurements were recorded in 1 m2 plots in 2011, five years after seeding. Seedling frequency was not reported for the Southern Nevada Fire Complex data, but desert globemallow was said to comprise 11% of the total plant cover in treated areas.

| Method/Location | Seeding Rate (PLS lbs/acre) | Results (seedling frequency %) |
|---|---|---|
| Aerial/Goodsprings Fire | 0.3 | 95 |
| Hand broadcast/Bonnie Springs Fire | 1.58 | 100 |
| Hand broadcast/S. NV Fire Complex | 1.4 | Not given |
| Hand broadcast with herbicide/ S. NV Fire Complex | 15.6 | Not given |

Desert globemallow has also been applied in a seed mix for remediation of a nuclear test site in the Mojave Desert, which included topsoil replacement and irrigation treatments (Hall and Anderson 1999). The seed mix consisted of 14 species applied at 23.5 kg/ha (~21 lbs per acre) with desert globemallow making up 1% of the total mix. However, desert globemallow did not germinate and was not detected in the two years following seeding, potentially due to the low seeding rate (Hall and Anderson 1999).

### *Wildland Plantings.*

Planting nursery stock of desert globemallow has been shown to be more successful than direct seeding. One study of the two methods found that globemallow seedlings were not observed on direct-seeded plots, while outplanted seedlings survived at a rate of 65% and grew by an average of 20 inches (51 cm) over the course of three years (Abella et al. 2012).

In a restoration research project at Lake Mead National Recreation Area (NRA) in Nevada, desert globemallow was grown from locally collected seed and planted at a restoration site. Irrigation was applied at a rate of 0.7 inches (0.2 cm) per week for 18 months following planting. Monitoring results six years after planting showed desert globemallow averaged 50% cover in monitoring plots (Abella 2017).

Container plants were grown from locally collected seed and outplanted to restore plant communities at an abandoned mine site in Joshua Tree National Park (Rodgers 1996). Plants were installed in February and monitored in April and June to assess survival by container size for three different containers. They found plants grown in a tree pot (18 inches tall and 7.5 inches diameter) had the highest survival rate across all species (97% in April and June). Specific survival rates based on container size for desert globemallow were not provided in the report, but the author notes desert globemallow among species with greater than 90% survival rates in general (Rodgers 1996).

Desert globemallow has also been shown to successfully survive and establish after bare-root salvage and transplant at Lake Mead NRA (Abella et al. 2015b). Plants were dug up prior to a construction-related disturbance, transplanted into a nursery container, tended to in a nursery setting, and then outplanted back into the construction site. Desert globemallow was among the most successful species for salvage and had an average of 50% establishment across different watering treatments. Hand watering (0.5 L/month to each plant for 27 months) significantly improved establishment (80% establishment) compared to using DriWATER (a slow-release gel; ~35% establishment) or no

water (~25% establishment). The addition of salvaged topsoil nearly doubled survival of all species in the study (Abella et al. 2015b).

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## 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/default/files/docs/2021-12/SOS%20Technical%20Protocol.pdf

### OMERNIK LEVEL III ECOREGIONS

https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

### CLIMATE SMART RESTORATION TOOL

https://climaterestorationtool.org/csrt/

### MOJAVE SEED TRANSFER ZONES

https://www.sciencebase.gov/catalog/item/5ea88c8482cefae35a1faf16

### MOJAVE SEED MENUS

https://rconnect.usgs.gov/MojaveSeedMenu/

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