# PINCUSHION FLOWER

## *Chaenactis fremontii* (A. Gray)

## Asteraceae - Sunflower Family

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## NOMENCLATURE

Pincushion flower (*Chaenactis fremontii* A. Gray) is in the sunflower family, or Asteracaceae (ITIS 2023).

### NRCS Plant Code.

CHFR (USDA NRCS 2023).

### Synonyms.

None.

### Common Names.

Morningbride, pincushion flower, Fremont's pincushion (ITIS 2023).

### Subtaxa.

There are no subtaxa of pincushion flower recognized by FNA or ITIS.

### Chromosome Number.

The chromosome number for pincushion flower is 2n=10, n=5 (Kyhos 1965, Morefield 2012).

### Hybridization.

In the few areas of co-occurrence, pincushion flower can hybridize with desert pincushion (*C. stevioides*) and yellow pincushion (*C. glabriuscula*) (Kyhos 1965, Morefield 2020a). Some observations reported an increase in hybridization frequency between yellow pincushion and pincushion flower—from less than five percent to over ten percent—after surface disturbance (Kyhos 1965). However, yellow pincushion is not commonly found in the Mojave Desert.

## DESCRIPTION

Pincushion flower is an annual forb, generally growing 10-40 cm in height, with one to twelve stems branching proximally (Morefield 2020b). Pincushion flower is covered in cobwebby hairs at early stages of growth, but glabrous when mature and flowering (Morefield 2020b). Pincushion flower has basal leaves that wither away as the plant develops and cauline leaves with an alternate arrangement that have a fleshy and non-glandular surface. Leaves (1-10 cm long) are 0-1 times pinnately lobed with up to five pairs of lobes per leaf. The largest leaf blades have a linear and terete shape or more or less elliptic and plane (Morefield 2020b). White to pink discoid flower heads grow terminally on stems, with up to five flower heads per stem. Inner individual disc flowers grow 5-8 mm long with outer flowers having zygomorphic symmetry and growing larger than inner flowers. Peduncle length ranges from 2-10 mm long with a generally hairy and glandular surface (Morefield 2012). The involucre, or ring of bracts wrapped around the flower head, have a hemispheric to obconic shape with bracts or phyllaries (8-12 mm long) with pale bases. Achenes of pincushion flower are 3- mm long, topped with a pappus of 1-5 scales, with the longest scale extending beyond corolla tops during flowering (Morefield 2020b).

Pincushion flower can be distinguished from desert pincushion by its glabrescent outer phyllaries compared to desert pincushion's hairy or glandular outer phyllaries (Morefield 2020a).

Pincushion flower can be distinguished from the geographically overlapping pebble pincushion (*C. carphoclinia*) by its 1-2 times pinnately lobed leaves compared to pebble pincushion's 3-4 (occasionally 2) times pinnately lobed leaves (Morefield 2020a). Pebble pincushion has powdery or scaly hairs as opposed to pincushion flower's cobwebby hairs. Pebble pincushion is also distinguished by being the only *Chaencactis* with paleae on the receptacle (Morefield 2020a).

**Figure 1:** A pincushion flower individual. Photo: BLM SOS NV052

**Figure 2:** The inflorescence of pincushion flower. Photo: BLM SOS AZ010

# DISTRIBUTION AND HABITAT

Pincushion flower is one of the most abundant annuals in the Mojave and northern Sonoran Deserts (Morefield 2020b). Its distribution is centered in the Mojave Desert and extends southward into Baja California, southeast into the Sonoran Basin and Range, and northwest into the Central California Foothills and Coastal Mountains ecoregion (Figure 3). There are isolated records in the Great Basin and Central Valley of California.

### Habitat and Plant Associations.

Pincushion flower occurs in a variety of habitats in the Mojave Desert including desert scrub, sandy bajadas, and gravelly washes where it is commonly found growing through shrub canopies (Morefield 2020b, SEINet 2022).

Commonly observed associated species in the Mojave Desert include creosotebush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), Joshua tree (*Yucca brevifolia*), Mojave yucca (*Yucca schidigera*), Mojave indigobush (*Psorothamnus arborescens*), desert lavender (*Hyptis emoryi*), Eastern Mojave buckwheat (*Eriogonum wrightii*), and blackbrush (*Coleogyne ramosissima*) (BLM SOS 2022, SEINet 2022). Co-blooming annual species that occur with pincushion flower include bristly fiddleneck (*Amsinckia tessellata*), Phacelia (*Phacelia* spp.), Cryptantha (*Cryptantha spp.*), browneyes (*Chylismia claviformis*), smooth desert dandelion (*Malacothrix glabrate*), and many others (SEINet 2022).

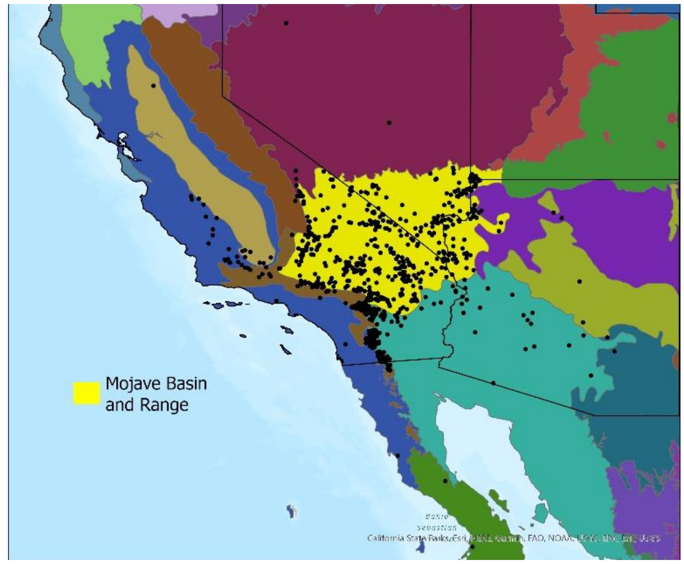


**Figure 3:** Distribution of pincushion flower based on georeferenced herbarium specimens and verified observations (black circles, SEINet 2022) with EPA Level III Ecoregions (US EPA 2015). The Mojave Basin and Range ecoregion is shown in yellow.

**Figure 4:** Pincushion flower growing in an open desert habitat. Photo: BLM SOS CA930A

**Figure 5:** Pincushion flower growing on a gravelly slope. Photo: BLM SOS CA930A

## Climate.

The Mojave Desert is characterized by low annual precipitation (5-25 cm or 2-10 inches 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).

Climate information is derived from the climate-based provisional seed transfer zones (PSZs) where pincushion flower is documented (Shryock et al. 2018; Table 1). According to herbarium specimen locations (SEINET 2022), pincushion flower is documented in all PSZs in the Mojave Desert ecoregion. It is most frequently documented in Zone 26, 21, and 24 and least documented in Zones 22 and 28 (Table 1). The average annual precipitation in the PSZs where pincushion flower occurs in the Mojave Desert ecoregion is 17.8 cm (7.0 inches), with an average of 5.7 cm (2.2 inches) falling in the summer and an average of 12.1 cm (4.7 inches) falling in the winter. Note, herbarium specimen locations may not represent the full distribution and abundance of pincushion flower due to sampling biases.

**Table 1:** Climate of the provisional seed zones (PSZ) where pincushion flower occurs within the Mojave Desert ecoregion (Shryock et al. 2018).# = the number of herbarium or verified observations of pincushion flower 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) |
|---|---|---|---|---|---|---|
| 26 | 168 | 14.5 | 2.7 | 11.8 | 16.8 | 34.9 |
| 21 | 149 | 15.6 | 6.2 | 9.4 | 18.8 | 38.4 |
| 24 | 123 | 10.7 | 2.8 | 7.9 | 18.8 | 38.6 |
| 25 | 87 | 16.5 | 6.2 | 10.3 | 18.9 | 34.6 |
| 29 | 60 | 25.5 | 4.2 | 21.4 | 13.8 | 31.7 |
| 27 | 57 | 9.6 | 3.3 | 6.3 | 20 | 36.7 |
| 23 | 24 | 15.8 | 5.4 | 10.4 | 16.1 | 35.9 |
| 20 | 13 | 25.5 | 10.5 | 14.9 | 15.3 | 34.5 |

## Elevation.

Pincushion flowers occurs at elevations from sea level up to 5,249 ft (1600 m) (Morefield 2020b).

## Soils.

Pincushion flower prefers sandy or gravelly soils, often in alluvial deposits, derived from a variety of parent materials including various volcanic rocks, dolomite, limestone, and quartzite (Morefield 2020b, BLM SOS 2022).

## ECOLOGY AND BIOLOGY

NatureServe classifies pincushion flower as Apparently Secure (G4) on a global level, but it is considered Imperiled (S2) in Utah (NatureServe 2024). Pincushion flower is considered an indicator species to define a "good wildflower year" in the Mojave Desert (Bowers 2005) and it is often the most abundant spring wildflower in the lower Mojave and northern Sonoran Deserts (Morefield 2020b).

### Reproduction.

#### *Breeding System.*

Pincushion flower is strongly self-incompatible and relies on insect pollination for outcrossing (Kyhos 1965).

#### *Reproductive Phenology.*

Pincushion typically flowers from February through May and sets seed from April through June (Morefield 2020b, BLM SOS 2022).

#### *Pollination.*

There is little information available on pollinator visitors of pincushion flower. Other *Chaenactis* species are visited by a diversity of bees (Cane et al. 2012). In Cabazon, California the most commonly observed pollinator on desert pincushion was a small beetle, *Byturosoma fusca* (Kyhos 1965).

### Seed and Seedling Ecology.

Pincushion flower seeds are generally wind-dispersed and are likely carried aloft directly from the parent plant when ripe (Maddox and Carlquist 1985). If seeds fall to the ground, their dispersal distance is likely much shorter. Harvester ants (*Vermessor pergandei*) have been observed carrying the seeds, and though they likely consume or damage a significant portion, they may also inadvertently disperse intact seeds to suitable germination sites (Tevis 1958). The pappus attached to the fruit moves hygroscopically, meaning it moves in a spiral motion in response to moisture fluctuations, effectively driving the seed into the ground with the radicle positioned downward for optimal germination (Maddox and Carlquist 1985).

Pincushion flower germinates in the winter, typically in response to cold and moist conditions after winter precipitation (Juhren et al. 1956). Field observations from Joshua Tree, California show that it typically appears when day temperatures are between 12 °C (53 °F) and 30 °C (86 °F) and night temperatures are between 10 °C (50 °F) and 4 °C (39 °F). Germination was only recorded after night temperature had reached freezing at some point prior to germination (Juhren et al. 1956).

### Species Interactions.

#### *Belowground Interactions.*

No information on belowground interactions of pincushion flower was found in the literature or through personal communication.

#### *Wildlife and Livestock Use.*

Pincushion flower is a preferred forage plant for the federally threatened Mojave desert tortoise (*Gopherus agassizii*) during early- to mid-spring (Oftedal et al. 2002, Jennings and Berry 2015). Tortoise will eat an average of 18% of a pincushion flower plant's biomass and prefer flowers and leaves over stems and fruits (Jennings and Berry 2023).

Rodents and lizards consume parts of pincushion flower plants. Pincushion flower seeds were found in food pouches of Merriam's kangaroo rat (*Dipodomys merriami*) at 5.5% frequency across 54 individuals in a study area near Las Vegas, Nevada (Bradley and Mauer 1973). In a study of chuckwalla (*Sauromalus obesus*) diets in Nye County, Nevada, floral material of pincushion flower was found in lizard's stomach contents at about 11.5% frequency (Sanborn 1972).

### *Other Notable Species Interactions.*

Pincushion flower is often found growing beneath the canopy of shrubs where it likely benefits from increased soil moisture and nutrients (Morefield 2020b). For example, pincushion flower plants growing under burrobush (*Ambrosia dumosa*) had higher survival rates, biomass production, and seed production than plants growing in the open (Holzapfel and Mahall 1999). Similarly, pincushion flower has been found growing in higher abundance under mature turpentine broom (*Thamnosma montana*) where larger amounts of wind-blown soil and debris have accumulated beneath the shrub compared to younger shrubs and open spaces (Muller and Muller 1956).

Pincushion flower is considered a likely larval host plant for the spotted straw sun moth (*Heliothis phloxiphaga*), common Eupithacia moth (*Eupithecia miserulata*), and the Ni moth (*Trichoplusia ni*) (Calscape 2024).

## Disturbance Ecology.

There is limited information on the response of pincushion flower to wildfire in the Mojave Desert. Since pincushion flower preferentially grows beneath shrubs, its seed bank may be exposed to high fire temperatures during wildfires that could cause higher rates of seed mortality (Brooks 2002). After a large fire in Joshua Tree National Park, pincushion flower was abundant in some of the burned areas where shrubs had died back (Esque et al. 2021). Competition from invasive annual grass species that increase in abundance following fire may inhibit the recovery of pincushion flower and other desert annuals, even if they are present in the seed bank or can naturally disperse into the burned area (Steers and Allen 2010).

Soil compaction from vehicles generally decreases the abundance of pincushion flower. Although pincushion flower is documented in areas with disturbance from outdoor recreational vehicle (ORV) use, intense compaction from ORV use decreases the presence of deep taprooted annuals, such as pincushion flower (Adams et al. 1982). In drier years, observers saw an increase in abundance of the invasive, common mediterranean grass (*Schismus barbatus*) in all levels of ORV use and a decrease in presence of pincushion flower, most likely due to ease of germination and establishment for fibrous root systems and more available water due to less competition (Adams et al. 1982). Similarly, pincushion flower had reduced density and cover in tank tracks from military activities, most likely because compaction inhibited establishment of the annual's long taproot (Prose and Wilshire 2000).

In an assessment of the effects of air pollution from urbanization and coal-fired electric power generating facilities in the Mojave Desert, pincushion flower plants exhibited 20% leaf necrosis when exposed to ozone ($O_3$) at 0.3 ppm in open-top field champers (Thompson et al. 1984). It showed 60% necrosis when exposed to sulfur dioxide ($SO_2$) at 1.5 ppm. Pincushion flower showed less sensitivity to common air pollutants caused by urbanization than other native Mojave plants, such as smallflower globemallow (*Sphaeralcea parvifolia*) and whitest evening-primrose (*Oenothera albicaulis*) (Thompson et al. 1984).

## Ethnobotany.

There are no documented uses for pincushion flower, though several related species are traditionally used by indigenous people as medicine (NAEB 2023).

### Horticulture.

Pincushion flower is not currently available for retail purchase (as either seeds or container plants) for horticultural or landscape use (Calscape 2024).

## 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), evidence of local adaptation and its influence on restoration outcomes can take decades to emerge for long-lived species (Germino et al. 2019) Further, plants have coevolved with interacting organisms, such as pollinators and herbivores, that can exhibit preferential behavior for local materials (Bucharova et al. 2016, 2022).

Empirical seed transfer zones have not been developed for pincushion flower. The Desert Southwest Provisional Seed Zones (PSZs) may be used to plan seed sourcing in the absence of species-specific information. 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.

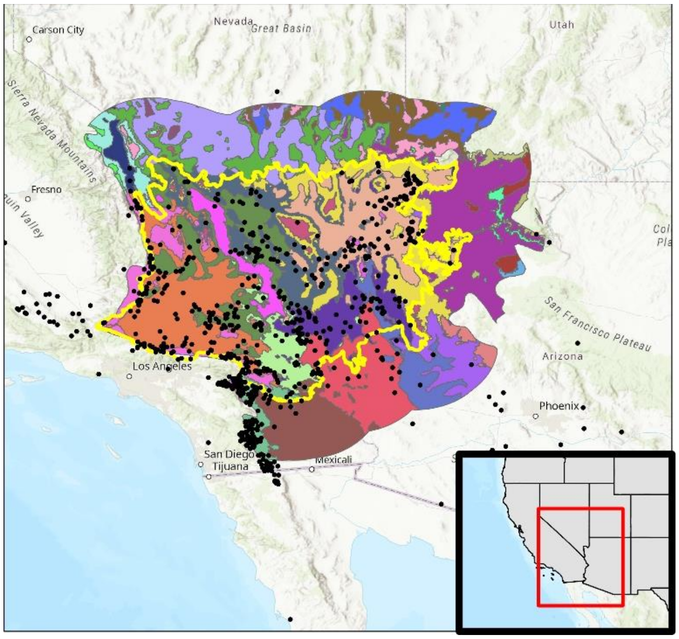

**Figure 6:** The distribution of pincushion flower across the Desert Southwest Provisional Seed Zones (Shryock et al. 2018). Occurrences (black dots) are based on georeferenced herbarium specimens and verified observations (SEINet 2023). The Mojave Basin and Range Level III ecoregion (yellow outline) is buffered up to 100 km in all directions. PSZs do not always extend a full 100 km beyond the Mojave ecoregion.

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.

Pincushion flower does not appear to be commonly available for purchase from large-scale commercial seed vendors. There have been no conservation plant releases of pincushion flower.

### 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 are intended to prevent overharvesting by limiting harvests to no more than 20% of available seed (BLM 2021). However, in arid regions and in drought conditions, it may be best to adapt this guidance to collect no more than 10% of available seed due to limited regeneration and low-density populations (Asbell 2022, personal communication). Several practices are in place 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 and temporal diversity (BLM 2021).

#### *Seed Collection Timing.*

In the Mojave Desert, pincushion flower has been collected from April to June, with most collections occurring in April (BLM SOS 2022).

#### *Collection Methods.*

Similar methods for collecting the related Douglas' dustymaiden (*C. douglasii*), as described in Gucker and Shaw (2022), may be followed for pincushion flower due to the species' shared morphology. Seed can be collected by hand by plucking or stripping ripe seeds from the flowerhead or shaking or knocking seeds into a container. Whole seedheads may be collected by snapping or snipping them off at the base, but this will result in a collection with more inert material and require more labor-intensive cleaning methods.

#### *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). 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.

No cleaning methods specific to pincushion flower were noted in the literature or through personal communication. However, methods for other *Chaenactis* species with similar seed morphology may apply. For example, methods for cleaning yellow pincushion seeds when whole seedheads are collected involve first rubbing material on a rubber mat to break up the chaff and release the fruit from involucres followed by repeated sieving and a blower to sort material (Wall and MacDonald 2009).

**Figure 7:** A mature seedhead of pincushion flower. Photo: BLM SOS AZ010

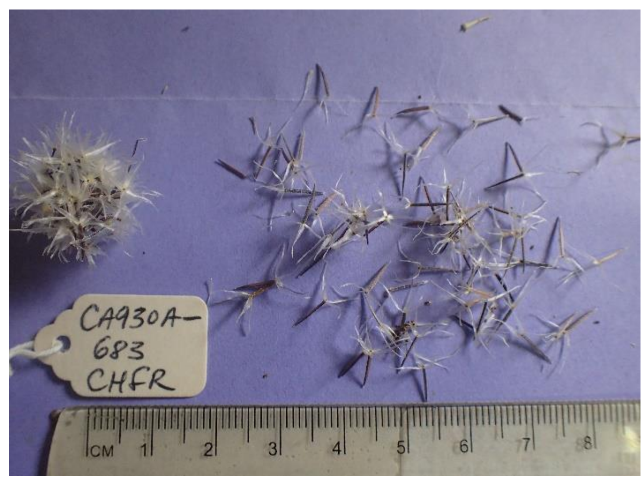


**Figure 8:** A seedhead and loose seed of pincushion flower; scale shown in cm. Photo: BLM SOS CA930A

### Seed Storage.

There is little information on the storage behavior of pincushion flower seeds. It is assumed to be orthodox based on taxonomic grouping and fruit anatomy (SER SID 2023).

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).

### 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.

There are no AOSA rules for testing germination or viability of pincushion flower seed (AOSA 2016).

#### *Wildland Seed Yield and Quality.*

Wild-collected pincushion flower seed is generally high quality, with an average of 93% fill, 92% purity and 94% viability indicated by tetrazolium tests across 39 Seeds of Success collections (BLM SOS 2022, Table 2). Wild collections contain an average of over 1 million pure live seeds (PLS) per pound (BLM SOS 2022, Table 2).

**Table 2:** Seed yield and quality of pincushion flower 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) | 0.4 | 0.07-2.77 | 39 |
| Clean weight (lbs) | 0.07 | 0.01-0.64 | 39 |
| Purity (%) | 92 | 66-99 | 39 |
| Fill (%) | 93 | 80-99 | 39 |
| Viability (%) | 94 | 79-98 | 39 |
| Pure live seeds/lb | 1,028,245 | 596,842-6,474,491 | 39 |

### 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

Pincushion flower has not been grown in large scale agricultural settings for seed increase. Small scale trials to test effective methods for seed increase have been ongoing at the Mojave Desert Land Trust (MDLT) in Joshua Tree, California and are summarized in the following sections.

### 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).

There are no specified seed certification standards for pincushion flower crops in the state of California. However, Table 3 outlines the prevariety germplasm (PVG) certification standards for a congeneric species, Douglas' dustymaiden (*Chaenactis douglasii*), with a minimum of a ¼ pound sample size to be submitted for testing (CCIA 2019). 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).

**Table 3:** Pre-varietal Germplasm (PVG) standards for seed analysis results of the related species, Douglas' dustymaiden, in California.

| Factor | G1 | G2 | G3 to G10 |
|---|---|---|---|
| **Pure Seed (minimum)** | 90% | 90% | 90% |
| **Inert Matter (maximum)** | 10% | 10% | 10% |
| **Total Other Crop Seed (maximum)** | 0.20% | 0.40% | 0.50% |
| **Weed Seed (maximum)** | 0.20% | 0.40% | 0.50% |
| **Noxious Weed** | None | None | None |
| **Germination and Hard Seed (minimum)** | 65% | 65% | 65% |

## *Isolation Distances.*

Sufficient isolation distances are required to prevent cross-pollination across seed production crops of pincushion flower from different sources or other *Chaenactis* species. Table 4 summarizes the isolation distances required for PVG certification in both Utah and California. Because there are no specified seed certification standards for pincushion flower crops in the state of California, the isolation distances are those required for the related species, Douglas' dustymaiden (CCIA 2019). The Utah standards are general for outcrossing annual species (UCIA 2023). Nevada and Arizona do not specify these standards for Source Identified PVG seed of Pincushion flower.

**Table 4:** Crop years and isolation distance requirements for pre-varietal germplasm crops of Douglas' dustymaiden. 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.

Fields should be as weed-free as possible prior to planting. Site preparation to reduce undesirable vegetation should be planned and implemented well in advance of field establishment (USDA NRCS 2004). If fields are uncultivated or fallow and have perennial or annual weeds, one or more years of intensive cultivation (i.e. cover cropping) and herbicide treatment may be necessary (USDA NRCS 2004). After managing undesirable species, final seedbed preparation can include shallow tilling followed by packing to promote a finely granulated, yet firm seedbed that allows soil to seed contact, as well as facilitation of capillary movement of soil moisture to support seedling development (USDA NRCS 2004).

### Seed Pre-treatments.

At MDLT, no seed pretreatment was applied (Asbell 2024, personal communication).

Seed germination trials on two seed collection lots from the California Botanic Garden have found germination rates ranging from 0 to 70%, with 3 of 5 trials resulting in no germination (CalBG 2023; Table 5). The highest germination rate (70%) was from a five-year-old collection that was exposed to cool smoke from combustion of green vegetation for 10-15 minutes. The same collection exhibited no germination when no pre-treatment was applied across two trials (at 5 and 8 years), and when a smoke water treatment was applied (at 13 years). The only other trial that resulted in germination (52%) was from fresh seed that receive no pre-treatment.

**Table 5:** A summary of five germination trials at the California Botanic Garden. NT= No Treatment; SMW= seeds are soaked in smoked water; SM= seeds exposed to cool smoke

| Lot # | Seed Age (years) | Pre-Treatment | Germination (%) |
|---|---|---|---|
| 1107 | 13 | SMW | 0.0 |
| 1107 | 5 | NT | 0.0 |
| 1107 | 5 | SM | 70.0 |
| 1107 | 8 | NT | 0.0 |
| 5865 | <1 | NT | 52.0 |

### Seeding Techniques.

At MDLT, growers conducted an experimental comparison of direct seeding versus plug transplanting to establish seed increase plots of pincushion flower (Asbell 2023, personal communication). For direct seeding, they sowed 0.4g of seed into a 100 square foot size plot. Seeds were sown by hand by scuffing the soil with fingertips, sprinkling seed over the surface, and then sweeping soil over the seeds to lightly cover them. A total of 468 seedlings emerged, 70% of which survived to produce seed (329 total plants). The plug transplanting involved growing 115 plugs in the nursery, and then transplanting them into a 100 square foot size plot. 81% of the seedling survived the transplanting and produced seed (94 total plants) Generally, the plants established from direct seeding were more robust and had higher seed output (Asbell 2023, personal communication). See Seed Yields and Stand Life for a detailed comparison of the yields resulting from the two different methods.

### Establishment and Growth.

Flowering began at about 4 months after sowing for both direct seeding and plug transplanting at MDLT (2 months after transplanting). No additional information on the establishment and growth of pincushion flower crops was available.

## Weed Control.

Generally, weeds can be manually removed or carefully spot-sprayed with non-selective herbicide as they emerge. In smaller fields, hand rogueing weeds can be sufficient (Hagman 2023, personal communication).

There are a 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.

At MDLT, the plots were fenced with sheets of 2-foot-wide corrugated metal or plastic to exclude rodents and rabbits. No invertebrate pests were observed (Asbell 2024, personal communication).

No information about pest management for pincushion flower crops was found in the literature or through personal communication.

## 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).

## Irrigation.

At MDLT, plots were watered using a combination of hand watering and drip irrigation. Growers hand-watered using a Dramm RedHead nozzle to keep soil moist after direct seeding and outplanting plugs. They switched to an inline drip irrigation system after seeds germinated and/or plugs were established (Asbell 2024, personal communication).

Many growers apply uniform watering techniques regardless of species due to their set infrastructure and labor resources. For example, at the Tucson Plant Materials Center, all fields are watered with flood irrigation (Dial 2023, personal communication). After seeding, fields are irrigated to maintain a moist soil surface and avoid soil crusting that would interfere with germination. Once plants are established, fields are flooded approximately every four weeks during the growing season. Irrigation frequency will depend on heat and precipitation levels and may be as frequent as every two weeks during the hottest part of the year to minimize plant stress which can decrease seed yield (Dial 2023, personal communication).

Other growers utilize drip irrigation and find flood irrigation does not adequately penetrate the soil in arid growing conditions (Hagman 2023, personal communication).

## Seed Harvesting.

Methods for wildland seed collection may be applied in small-scale seed increase fields (see Collection Methods). Methods for harvesting Douglas' dustymaiden—such as using combines, flailvacs, or vacuum-type harvesters described in Gucker and Shaw (2022)—may be applicable to pincushion flower.

Growers at MDLT found that pincushion flower seeds need to be harvested by hand daily during their ripening period because it flowers continuously over an 8-week period (Asbell 2024, personal communication). Seeds can quickly blow away upon ripening. However, seeds can be harvested before seedheads fully opened and release seeds, as long as the seeds are black. This helps collect a larger amount of seed during single harvest events since both unopened and open seed heads can be harvested (Asbell 2024, personal communication).

Growers at MDLT also attempted bagging sed heads with fine mesh bags to prevent seed from being lost to wind dispersal. However, this did not prove to be cost effective or reduce labor since bagging required more time than harvesting daily by hand (Asbell 2024, personal communication).

### Seed Yields and Stand Life.

At MDLT, plants established through direct seeding produced an average of 45.8 seeds per head while those established from plug transplanting produced an average of 36.2 seeds per head (Asbell 2023, personal communication). A total of 6547 heads from 329 plants were collected from the direct seeded plot (estimated 300,000 seeds total). A total of 4825 heads from 94 plants were collected from the plug transplanted plot (estimated 175,000 seeds total). Further investigation is needed to understand which method is more effective for growing pincushion flower in agricultural settings. If direct seeding is effective and results in similar or higher yields to plug transplanting, it would be more cost effective since plug transplanting is more labor intensive and requires more materials (soil media, pots, etc.).

## NURSERY PRACTICE

Nursery propagation is not commonly practiced for annual species, except in some cases for small-scale seed increase or starting seedlings from limited seed stock in preparation for agricultural seed production (Brooks and Gault 2023, personal communication). If needed, seeds can be planted in flats filled with a well-draining soil (including perlite, sand, and/or coir in the potting mix). Seeds can be sprinkled over the soil surface and lightly pressed in to improve seed-soil contact. Flats should be kept moist during the germination and seedling emergence period. After seedlings are fully emerged, watering can be reduced (Immel 2009).

To grow the plugs that were transplanted into the field trials at MDLT, seeds were sown into an at a rate of 5 seeds per cell, sown approximately 1/8 inch deep (Asbell 2024, personal communication). The pots were hand watered immediately after sowing and kept moist until germination was observed. The plugs were transplanted two months after sowing (Asbell 2024, personal communication).

## REVEGETATION AND RESTORATION

Pincushion can improve pollinator resources, augment desert tortoise habitat, and help stabilize a site after fire or other disturbances (Esque et al. 2021). However, there are few documented examples of desert pincushion flower use in revegetation and restoration projects, likely due to limited seed availability.

Pincushion flower's abundance and seed dispersal abilities may allow it to rapidly colonize disturbed areas after fires without intervention (Esque et al. 2021). Treating invasive annual grasses with herbicide after a fire in the Mojave

Desert has been shown to significantly increase the abundance of pincushion flower and other desert annuals compared to sites that were not treated (Steers and Allen 2010).

### Wildland Seeding and Planting.

#### *Wildland Seedings.*

At the California Botanic Garden (formerly Rancho Santa Ana Botanic Garden) in Claremont, California, desert pincushion has been successfully established by directly seeding into open soil, though specific details such as seeding timing and rate were not described (Everett and O'Brien 2012).

#### *Wildland Plantings.*

Annual species are generally not recommended as plug transplants and will likely perform better with direct seeding methods (Immel 2009).

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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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