MOJAVE DESERT NATIVE PLANTS: BIOLOGY, ECOLOGY, NATIVE PLANT MATERIALS DEVELOPMENT, AND USE IN RESTORATION

DESERT NEEDLEGRASS

Achnatherum speciosum (Trin. &Rupr.) Barkworth

Poaceae - Grass family

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ORGANIZATION

NOMENCLATURE

Desert needlegrass (*Achnatherum speciosum* (Trin. & Rupr.) Barkworth) belongs to the Poaceae, or grass family (USDA NRCS 2022). It is in the subfamily Pooideae and the tribe Stipeae, a group which has undergone repeated taxonomic revisions based on morphological and molecular evidence (Barkworth et al. 2008). While the United States Department of Agriculture (USDA) is referenced for taxonomic nomenclature herein, other taxonomic classifications for desert needlegrass are also summarized for further context.

NRCS Plant Code.

ACSP12 (USDA NRCS 2022).

Synonyms.

According to the Integrated Taxonomic Information System (ITIS), the most current, accepted scientific name for desert needlegrass is *Pappostipa speciosa* Trin. & Rupr. (ITIS 2023).

The Flora of North America (FNA) classifies desert needlegrass as *Jarava speciosa* (Trin. & Rupr.) Penail (Arriaga 2021).

Additional synonyms include *Stipa speciosa* Trin. & Rupr., *Stipa humilis* var*. speciosa* (Trin. & Rupr.) Kuntze, *Stipa humilis* var. *jonesiana* Kuntze, *Stipa californica* Vasey ex S. Watson, *Stipa humilis* var. *speciosa* (Trin. & Rupr.) Kuntze, *Stipa patagonica* Speg., *Stipa speciosa* fo. *minor* Speg, *Stipa speciosa* var. *minor* Vasey, and *Stipa tehuelches* Speg. (Tropicos 2023).

Common Names.

Desert needlegrass, desert needle grass, needlegrass, desert stipa (Pavek 1993, Perkins and Ogle 2008).

Subtaxa.

At least 20 desert needlegrass subtaxa have been described, but none are presently recognized in North America (Arriaga 2021, Tropicos 2023).

Chromosome Number.

The chromosome numbers for desert needlegrass are 2n= 60, 66, 68, and ~74 (CCDB 2023).

Since desert needlegrass possesses intraspecific ploidy variation (differences 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 result in loss of fitness and fertility in plantings (Kramer et al. 2018).

Hybridization.

Desert needlegrass can hybridize with Indian ricegrass (*Achnatherum hymenoides*) with which it forms sterile offspring (Johnson 1960).

DESCRIPTION

Desert needlegrass is a perennial bunchgrass growing 30-60 cm tall in dense, non-rhizomatous clumps (Figure 1). Its sheaths are mostly glabrous, but occasionally pubescent with a densely ciliate throat. Basal sheaths are shiny, reddish-brown, and persistent on old stems. Leaf blades are 10-30 cm long and 0.5-2.0 mm wide when flat, but the margins are tightly rolled inwards (Columbus et al. 2012). Ligules vary within individual plants, with the upper ligules being generally longer (up to 2.5 mm) than lower ligules (0.3-1 mm). Lower ligules are densely ciliate with hairs extending longer than the basal membrane. Upper ligules can be hyaline to scarious, glabrous or hairy, but usually less hairy than lower ligules. Inflorescences are in dense panicles 5-15 cm long and are often partially included in the upper sheath, not extending far above the blades (SEINet 2023). Glumes are subequal, linear-lanceolate in shape with membranous tips and margins. Lower glumes are 16-24 mm long and one-veined, while upper glumes are 13-19 mm long and three- to five-veined. Lemmas are 7-10 mm long and uniformly covered in long, feather-like hairs that become slightly longer and stiffer on the callus (Columbus et al. 2012). Awns are longer than 6 mm with one sharp bend and can be either persistent or deciduous (Figure 2). Basal segments of the awns are plumose with hairs 4-8 mm long, while the terminal segments are glabrous (Allred 2005, Arriaga 2021, SEINet 2023).

Figure 1: A robust desert needlegrass individual growing in the open. Photo: BLM SOS CA930A

Figure 2: The inflorescence of desert needlegrass. Note the sharply bent awn and the lemmas covered in long silky hairs. Photo: BLM SOS NV040

DISTRIBUTION AND HABITAT

Desert needlegrass occurs in several arid and semiarid ecoregions of the southwestern United States and northern Mexico (Figure 3), as well as South America. In the Mojave and Sonoran Deserts, records are mostly restricted to mountain ranges and bajadas, with few occurrences in basin areas (SEINet 2023). It occurs most frequently on granitic substrates in full sun or in the shade of rocks or shrubs.

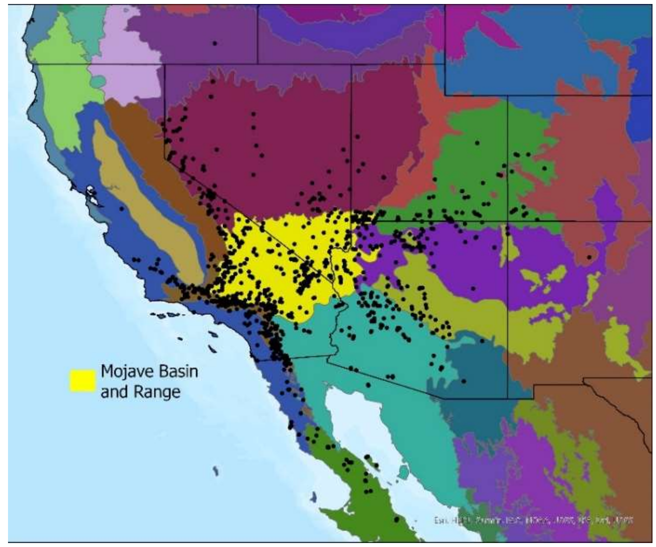

Figure 3: Distribution of desert needlegrass based on georeferenced herbarium specimens and verified observations (black circles, SEINet 2022) with EPA Level III Ecoregions (US EPA 2015). The Mojave Basin and Range ecoregion is shown in yellow.

Habitat and Plant Associations.

Desert needlegrass grows in sandy washes, canyons, dry rocky slopes, and desert flats in a variety of vegetation communities including pinyon-juniper woodlands, creosote bush shrublands, and desert riparian scrub (BLM SOS 2022).

NatureServe recognizes one habitat alliance and three habitat associations defined by the presence of desert needlegrass (NatureServe 2023). The alliance and two of the associations characterized by a dominance of desert needlegrass are all imperiled to some degree—they are considered to have been formerly widespread, but have declined severely due to overgrazing and competition from invasive plants (Schindel 2008, 2022, Hall 2022).

The Desert Needlegrass Grassland Alliance—characterized by >50% cover of desert needlegrass—is documented in the Mojave Desert, where it is designated as imperiled in the state of California (Hall 2022). The Desert Needlegrass Grassland (grassland) and Desert

Needlegrass Shrub Grassland (shrub-grassland) Habitat Associations are both considered critically imperiled in the state of California (NatureServe 2023). The grassland is characterized by desert needlegrass as the dominant ground cover with other cool-season grasses co-occurring, including foothill needlegrass (*Nassella lepida*), Indian ricegrass (*Achnatherum hymenoides*), nodding needlegrass (*Nassella cernua*), Sandberg bluegrass (*Poa secunda*), and squirreltail (*Elymus elymoides*). It is estimated that ten stands of this grassland association remain in southern California (Schindel 2022). The shrub-grassland association includes a shrub layer that often contains cheesebush (*Hymenoclea salsola*), in addition to the dominant cover of desert needlegrass and other cool-season grasses (Schindel 2008).

Additional associated species of desert needlegrass in the Mojave Desert include creosote bush (*Larrea tridentata*), Joshua tree (*Yucca brevifolia*), blackbrush (*Coleogyne ramosissima*), Mojave yucca (*Yucca schidigera*), desert globemallow (*Sphaeralcea ambigua*), big galleta (*Pleuraphis rigida*), and cheesebush (*Hymenoclea salsola*) (BLM SOS 2022, SEINet 2022).

Figure 4: Desert needlegrass in a Joshua Tree woodland habitat in California. Photo: BLM SOS CA930A

Figure 5: Desert needlegrass growing in an open desert habitat in California. 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 (Randall et al. 2010). While summer precipitation is very low in the western Mojave Desert, it may comprise up to 25% of annual precipitation in the eastern highlands adjacent to the Colorado River. 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 desert needlegrass occurs (Shryock et al. 2018; Table 1). According to herbarium specimen locations (SEINET 2022), desert needlegrass occurs in all PSZs in the Mojave Desert ecoregion but is most abundant in Zones 20, 26, and 29, and is least abundant in Zone 28 (Table 1). The average annual precipitation in the PSZs where desert needlegrass 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 desert needlegrass due to sampling biases.

Table 1: Climate of the provisional seed zones (PSZ) where desert needlegrass occurs within the Mojave Desert ecoregion (Shryock et al. 2018).# = the number of herbarium or verified observations of desert needlegrass 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)
29	145	25.5	4.2	21.4	13.8	31.7
20	119	25.5	10.5	14.9	15.3	34.5
26	119	14.5	2.7	11.8	16.8	34.9
25	60	16.5	6.2	10.3	18.9	34.6
23	48	15.8	5.4	10.4	16.1	35.9
21	43	15.6	6.2	9.4	18.8	38.4
24	18	10.7	2.8	7.9	18.8	38.6
22	3	36.1	13.3	22.8	10	32.4
27	2	9.6	3.3	6.3	20	36.7
28	1	7.8	2.4	5.3	22.3	41.3

Elevation.

Desert needlegrass occurs at elevations ranging from 610-1829 m (2,000-6,000 ft) (SEINet 2023).

Soils.

Desert needlegrass typically grows on coarse, well-draining soils with no profile development, and often on sandy or gravelly alluvial fans (Pavek 1993). It is most common on granitic parent materials but is more rarely found on limestone, dolomite, and schist (BLM SOS 2022). No specific associations with biological soil crusts were noted in the literature.

ECOLOGY AND BIOLOGY

Desert needlegrass is a drought-tolerant, cool-season grass with varying levels of tolerance to disturbances such as fire, soil compaction, and light grazing.

Reproduction.

Breeding System.

No literature describing desert needlegrass' breeding system was found.

Reproductive Phenology.

Desert needlegrass typically flowers and sets seed from March to July (SEINet 2023). In eastern zones where summer rainfall is more prominent, it may flower in August-September.

While desert needlegrass can produce a fair-sized seed crop that matures in May and June (Chase et al. 1951), seed set is reduced in times of low soil moisture and high temperatures (Pavek 1993).

Pollination.

Like all grasses, desert needlegrass is wind-pollinated (Connor 1979).

Seed and Seedling Ecology.

Desert needlegrass was speculated to have a persistent seed bank based on general classification by Webb et al. (1988), but no specific studies on soil seed banks for desert needlegrass were found.

The seeds are self-planting; cycles of wetting and drying cause their long awns to twist and untwist, driving the seed into the ground (Pavek 1993). The awns and sharp calluses at the base of the floret assist with seed dispersal by catching on animal fur and potentially aiding in wind dispersal (Pavek 1993).

In germination trials of desert needlegrass seeds collected from wild populations in the Great Basin, seeds were placed on germination paper, kept moist with water, and incubated for four weeks under various temperature regimes (Young and Evans 1980). Germination occurred across a wide range of temperatures, but rarely exceeded 50%. Germination was optimal when alternating between 10 °C (50 °F) for 16 hours and 15 °C (59 °F) for 8 hours, or when kept at a constant 15°C (59 °F). These temperatures represent moderate to cool seedbed temperatures in rangeland conditions (Young and Evans 1980).

There is year to year variation in overall seed set and germinability of desert needlegrass populations (Young and Evans 1980).

Species Interactions.

Belowground Interactions.

Desert needlegrass can have symbiotic associations with arbuscular mycorrhizal fungi where it occurs in South American desert regions (Cavagnaro et al. 2017). However, no studies on belowground interactions of desert needlegrass in North American desert regions were found.

Wildlife and Livestock Use.

Desert needlegrass has not been recorded in diets of the federally threatened desert tortoise (*Gopherus agassizii)*, but the related species, Indian ricegrass (*Achnatherum hymenoides*) is a known desert tortoise forage species (Esque et al. 2021).

Desert needlegrass is palatable to all classes of livestock, especially when young. As plants mature, they are moderately grazed by horses and cattle, but generally avoided by sheep (Chase et al. 1951). The awns and sharp calluses on the seeds can injure mouths and eyes of grazing animals (Chase et al. 1951). Trampling and overgrazing can cause desert needlegrass to be eliminated from areas with high concentrations of domestic livestock (Pavek 1993).

Desert bighorn sheep (*Ovis canadensis nelsoni*) and feral burros also graze desert needlegrass (Pavek 1993).

Other Notable Species Interactions.

Desert needlegrass is a potential host plant of several lepidopteran species including the Juba skipper (*Hesperia juba*), Common ringlet (*Coenonympha tullia*), Nevada skipper (*Hesperia nevada*), Uncas skipper (*Hesperia uncas*), and the white-lined sphinx (*Hyles lineata*) (Calscape 2023).

Disturbance Ecology.

There is some evidence of desert needlegrass being a stress-tolerant, early seral species (Webb et al. 1988, Pavek 1993). It can be among the first species to emerge in disturbed sites with compacted soils, including abandoned town sites, fallow agricultural fields, and roads in the Great Basin (Webb et al. 1988, McAuliffe 2016). At the Nevada Test Site, desert needlegrass gradually (within 14-24 years) became a dominate species within a crater formed from nuclear detonation (Romney et al. 1990). However, plants are sensitive to trampling and overgrazing (Pavek 1993), and are inhibited by competition from invasive species (Rafferty 2000, Rafferty and Young 2002).

In the Mojave Desert, desert needlegrass can regrow from its base following rapid, cool fires that do not kill the belowground root crowns (Hunter 1995). Fire can increase productivity of desert needlegrass in pinyon-juniper rangelands, although the number of postfire years to see an increase is not indicated in this study (Thatcher and Hart 1974). Desert needlegrass has also been reported to fuel the spread of wildfires (Minnich 1995, as cited in McAuliffe 2016). However, the seasonal timing of burning may affect the response of desert needlegrass to fires—early summer fires that burned during the primary growing season for cool-season grasses caused higher mortality than fall fires in the related species needle-and-thread (*Hesperostipa comata*) and Thurber's needlegrass (*Achnatherum thurberianum*).

Desert needlegrass may not establish in areas dominated with invasive species. Based on experimental seedings in greenhouse and field settings, desert needlegrass emergence and establishment seems to be inhibited by competition with the invasive annual cheatgrass (*Bromus tectorum*) (Rafferty 2000, Rafferty and Young 2002).

Although desert needlegrass is considered drought tolerant, it has been shown to decline in density in response to prolonged drought in the Mojave Desert (Roundy et al. 1995).

Ethnobotany.

Kawaiisu and Paiute tribes used desert needlegrass seeds for food, typically prepared as a porridge (Steward 1965, Zigmond 1981).

Horticulture.

Desert needlegrass can be an attractive addition to xeriscape landscapes and gardens. It is occasionally available from commercial retail nurseries for residential or landscaping use (Calscape 2023).

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), they may not persist long after initial establishment. Plants have also 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).

Empirical seed transfer zones have not been developed for desert needlegrass. 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 extant 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 needlegrass 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 needlegrass.

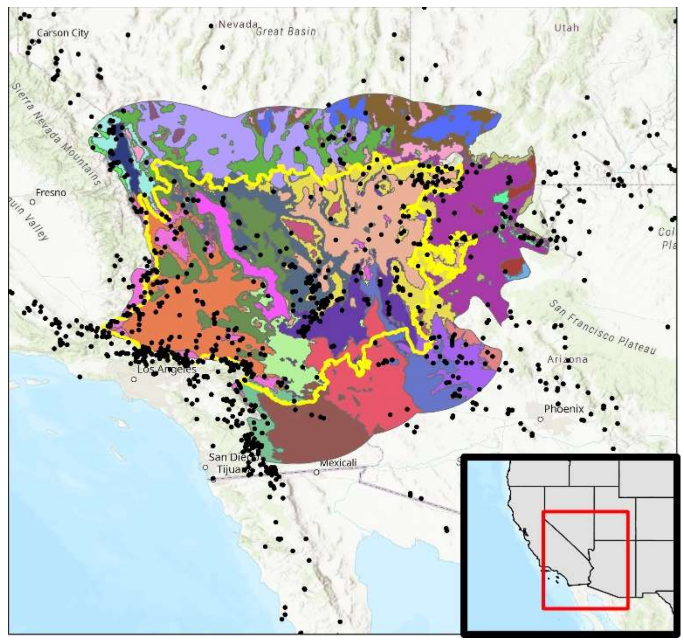

Figure 6: The distribution of desert needlegrass across the Desert Southwest Provisional Seed Zones (Shryock et al. 2018). Occurrences (black dots) are based on georeferenced herbarium specimens and verified observations (SEINet 2022). The Mojave Basin and Range Level III ecoregion (yellow outline) is buffered up to 100km in all directions. PSZs do not always extend a full 100km beyond the Mojave ecoregion.

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 harvesting 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.

Desert needlegrass is typically collected between April and June in the Mojave Desert, with the majority of collections occurring in May (BLM SOS 2022).

Collection Methods.

No collection methods specific to desert needlegrass were noted in literature or personal communications. However, it is assumed that stripping mature seed from the inflorescence by hand into a paper bag or other collection vessel would be an effective collection method for this species.

Figure 7: Collected seeds of desert needlegrass. Photo: BLM SOS CA930A

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).

No post-collection management practices specific to desert needlegrass were found in the literature or through personal communications.

Seed Cleaning.

As collected material dries, most seeds will be released from the flowering spikes into the collection bag (Wall and MacDonald 2009). To clean, florets can be gently rubbed over a rubber mat to remove the awns. Then placing the material in a blower or air separator will separate the floral chaff from the fruits. Increasing the blower speed will further separate sterile florets from the heavier fertile ones (Wall and MacDonald 2009). Based on guidelines for related species with similar seed morphology, running material through a Westrup LA-H Lab Brush Machine outfitted with a 0.5 mm brush and a #5 mantle can break apart the material. Then feeding the material through the brush machine again, but with a #10 mantle, can remove fuzz from the seeds. The material can then be run through an air separator at the highest speed to separate chaff and sterile seeds (Saidnawey and Cain 2023).

Seed Storage.

Desert needlegrass seed is likely orthodox (SER SID 2023). No information on the longevity or quality of desert needlegrass under any duration or conditions of storage was found in the literature or through personal communication.

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.

The pure seed unit—a combined unit of seed and attached structures that is classified as pure seed as opposed to inert material—for desert needlegrass is defined by AOSA as a "single floret…with or without awn(s), provided a caryopsis with some degree of endosperm development can be detected" (AOSA 2016).

The AOSA does not specify guidelines for testing germination or purity of desert needlegrass seed, but varying methods for several congeners are described (AOSA 2016). An AOSA tetrazolium test protocol for the *Achnatherum* genus may be followed to assess desert needlegrass seed viability (AOSA 2010). The tetrazolium test protocol for *Achnatherum* seed viability assessments first involves preconditioning the seed by placing it on moist media overnight at 20-25 °C, then cutting the seed longitudinally and retaining one half of each seed to place in a 0.1% tetrazolium (TZ) solution overnight at 20-30 °C. Viability can then be quantified by assessing the percentage of seeds where the entire embryo is evenly stained. The endosperm will not stain (AOSA 2010).

Wildland Seed Yield and Quality.

Wild-collected desert needlegrass seed is of fairly high quality, with an average of 91% fill, 95% purity and 84% viability indicated by tetrazolium tests across 17 Seeds of Success collections (BLM SOS 2022, Table 2). Wild collections contain an average of over 132,000 pure live seeds (PLS) per lb (BLM SOS 2022, Table 2).

Table 2: Seed yield and quality of desert needlegrass 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)	0.55	0.06-0.86	17
Clean weight (lbs)	0.09	0.014-0.297	17
Purity (%)	95	79-99	17
Fill (%)	91	75-100	17
Viability (%)	84	66-96	17
Pure live seeds/lb	132,818	105,395-171,236	17

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 needlegrass does not seem to be commonly grown in agricultural seed production, but there have been several recent efforts to establish fields from Mojave Desert wildland seed sources for use in regional restoration efforts. It will likely grow best in full sun and in moderately coarse, fast draining soil with a neutral pH (Calscape 2023, 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).

There are no specified seed certification standards for desert needlegrass crops in the state of California. However, Table 3 outlines the pre-varietal germplasm certification standards for a congeneric species, Indian ricegrass (*Achnatherum hymenoides*), with a minimum of ½ lb sample size to be submitted for testing (Schlosser 2021). 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, Indian ricegrass, in California.

Factor	G1	G2	G3 to G10
Pure Seed (minimum)	85%	85%	85%
Inert Matter (maximum)	15%	15%	15%
Total Other Crop Seed (maximum)	0.10%	0.25%	0.50%
Weed Seed (maximum)	0.15%	0.30%	0.50%
Noxious Weed	None	None	None
Germination and Hard Seed (minimum)	70%	70%	70%

Isolation Distances.

Sufficient isolation distances are required to prevent cross-pollination across seed production crops of desert needlegrass from different sources or other related 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 desert needlegrass crops in the state of California, the isolation distances shown are those required for the related species, Indian ricegrass (CCIA 2019). 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) are likely insufficient to prevent gene flow between different Source Identified desert needlegrass crops, especially considering it is a wind-pollinated species.

Table 4: Crop years and isolation distance requirements for pre-varietal germplasm crops of the related species, Indian ricegrass. 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).

No information about site preparation specific to desert needlegrass fields was found in the literature or through personal communication.

Seed Pre-treatments.

Desert needlegrass seeds possess some degree of physiological dormancy (Baskin and Baskin 1998). However, unlike many members of the Stipeae tribe of grasses which possess complex dormancy mechanisms, desert needlegrass can germinate readily (Young and Evans 1980). Some growers that have experience growing desert needlegrass from wildland Mojave Desert sources have found that it germinates readily with no pre-treatments (Asbell 2023, personal communication). However, some collections have shown poor germination and emergence in nursery settings and it is unclear if seed pre-treatments could improve germination. Leaching seed may improve imbibition prior to sowing—this involves washing seeds with fresh water by placing them over running water in a container with an outlet for 12 to 48 hours (Graham 2022, personal communication).

Seeding Techniques.

Growers at Victor Valley College in Victorville, California have established small-scale seed increase fields of desert needlegrass from Mojave Desert wildland seed collections. Seeds were directly sown in December (Brooks and Gault 2023, personal communication). A seeding rate of 5 lbs pure live seed (PLS) per acre is recommended (Granite Seed 2023).

Desert needlegrass fields have also been successfully established from plugs (Winters 2023, personal communication). See 'Nursery Practice' for more information on methods for producing container stock to establish seed increase fields.

Figure 8: Desert needlegrass growing in experimental seed increase trials at Victor Valley College, Victorville, California. Photo: Ashlee Wolf

Establishment and Growth.

With winter direct sowing at Victor Valley College, plants emerged in the following spring. The first harvest was a full year later in the second spring after planting (Brooks and Gault 2023, personal communication).

Weed Control.

Weeds can be manually removed or carefully spot-sprayed with a 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.

No examples of pests or pest management in desert needlegrass seed increase fields were found in the literature or through personal communications.

Pollination Management.

Since desert needlegrass is wind pollinated, plants should be able to readily exchange pollen within a seed production field without employing management strategies. See Isolation Distances for information on avoiding cross-pollination with crops of desert needlegrass from different sources or other *Achnatherum* species.

Irrigation.

No watering methods specific to desert needlegrass seeds were noted in the literature or through personal communications.

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), though desert needlegrass has not specifically been grown there. 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 avoid stressing plants and lowering seed yield (Dial 2023, personal communication).

Other growers administer water via drip irrigation and find flood irrigation does not adequately penetrate into soil, resulting in significant evaporation in aridland farm settings (Hagman 2023, personal communication).

Seed Harvesting.

Small-scale seed increase fields may be harvested by hand following similar methods as wildland collections (see Collection Methods). No methods for mechanical harvests were noted in the literature or personal communications. However, the morphologically similar and related species purple needlegrass (*Nassella pulchra*) is more commonly grown in agricultural settings and harvest methods may be transferrable to desert needlegrass. Purple needlegrass can be harvested with a seed stripper several times as seed matures at different intervals throughout the season (Tilley et al. 2009).

Seed Yields and Stand Life.

Of the growers consulted for this project, no fields have been established long enough to see declines in yield that would lead to field retirement.

NURSERY PRACTICE

Desert needlegrass has been grown in a nursery from wildland collected seed in Zion National Park (Decker 2003). Seeds were directly sown in Deepot-40 (D-40) containers into a 1.5:1:1:2 soil mixture of vermiculite, sterile sand, turface, and peat and then kept damp and allowed to experience natural cold conditions over the fall and winter months. The seedlings were then moved into a shade house from March to October prior to being outplanted in the fall. Seedlings were watered by hand throughout the growing season when containers were nearly dry, allowing plants to harden off in preparation for field conditions while being grown in a nursery setting. A balanced NPK time release fertilizer was occasionally incorporated into the media. This method takes approximately one year for plants to be ready for restoration outplanting (Decker 2003).

In an experimental greenhouse study that compared different planting depths (1, 3, 4, and 5 cm) for desert needlegrass seeds, optimum planting depth was 1 cm (0.4 inches). The same study found that removing the awn fully or partially did not improve emergence compared to seeds with the awn intact (Rafferty 2000).

The Living Desert Zoo and Gardens (TLD) conservation team has grown desert needlegrass seeds collected from wildland populations in the Mojave Desert. They sowed untreated seeds approximately 1.3 cm deep (0.5 inch) into 6” pots with a 90% perlite and 10% compost mixture (Thomas et al. 2022, personal communication). No information on the success of this method was recorded. The TLD horticultural team has had low germination rates when planting desert needlegrass into flats after an overnight soak in water. They recommend sowing extra seed to compensate for low germination rates (Sturwold et al. 2022, personal communication).

Growers at Joshua Tree National Park have successfully grown desert needlegrass from wildland Mojave Desert collections (Graham 2022, personal communication). Seeds were started in flats and then 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. There is little to no plant mortality after careful transplanting. Plants are grown for a maximum of 1.5 years until ready for outplanting (Graham 2022, personal communication).

At Lake Mead National Recreation Area, one Mojave Desert sourced-seed collection has been grown and showed poor germination after sowing into a flat with coir (coconut husk fiber) as the medium. It is unclear if it was the medium, seed quality, or other factors that resulted in poor emergence (Wallace 2023, personal communication).

REVEGETATION AND RESTORATION

Because of its ability to establish in compacted soils such as roads and townsites (see Disturbance Ecology), desert needlegrass may be a good species to include in a variety of restoration projects. Including desert needlegrass in restoration applications could serve to improve groundcover and stabilize soil through below and aboveground biomass production and augment forage for domestic livestock. However, there are few documented or anecdotal examples of the use or outcomes of desert needlegrass in wildland seeding or planting projects.

Wildland Seeding and Planting.

Wildland Seedings.

In a greenhouse experiment, seeding of desert needlegrass into stands of invasive annual cheatgrass (*Bromus tectorum*), desert needlegrass seedlings competed poorly and had significantly lower height in the presence of any amount of cheatgrass (Rafferty and Young 2002). Experimental field trials of seeding desert needlegrass into existing stands of cheatgrass, in addition to treating the cheatgrass with herbicide or nitrogen immobilization, also showed that desert needlegrass competes poorly in invaded areas (Rafferty 2000). The authors note that establishing desert needlegrass in areas invaded by cheatgrass will require intensive treatment to control the annual grass in addition to seeding.

Wildland Plantings.

Desert needlegrass was grown in one-gallon containers from locally-collected seed and then used to revegetate areas along highways in California (Clary and Slayback 1984). Plants were protected with plastic mesh and divided into treatment groups: irrigated (one gallon of water administered monthly) and non-irrigated. No desert needlegrass plants survived after five years regardless of irrigation treatment (Clary and Slayback 1984).

Desert needlegrass has been included in several revegetation plantings in Joshua Tree National Park with variable success (Wagner 2018). For these plantings, containerized plants were grown in the park's nursery and then outplanted at restoration sites (Jean Graham 2022, personal communication). Some individual plants were planted in a shallow basin surrounded by raised berms to capture moisture. Chicken wire cages were sometimes placed around individual plants to prevent herbivory. Plants were typically given supplemental water to increase establishment, though no information on frequency and duration of watering was found. In sites where desert needlegrass had been planted without protective chicken wire cages, some of the individuals experienced herbivory, though it is not clear to what extent and if it was detrimental to the survival of the plants. Desert needlegrass seems to do well when planted at the base of boulders where it can benefit from a more favorable microclimate (Wagner 2018).

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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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