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

Burrobush

Ambrosia dumosa (A. Gray) Payne

Asteraceae - Sunflower family

Casey Hensen and Ashlee Wolf | 2023

ORGANIZATION

NOMENCLATURE

Burrobush (*Ambrosia dumosa* (A. Gray) Payne) is a member of the Asteraceae (sunflower) family and is within the tribe Heliantheae. The species name *dumosa* means shrubby or bushy. (SEINet 2023a, Strother 2020).

NRCS Plant Code.

AMDU2 (USDA NRCS 2023).

Synonyms.

Franseria dumosa (A. Gray), *Gaertnera dumosa* (A. Gray) Kuntze, *Gaertneria dumosa* (A. Gray) Kuntze (Gray 1964, Payne 1964).

Common Names.

bursage, burrobrush, white burrobrush, burro-weed, white bursage (SEINet 2023b, USDA NRCS 2023).

Subtaxa.

No varieties or subspecies are currently recognized by the Flora of North America or the Integrated Taxonomic Information System (ITIS 2023).

Chromosome Number.

The chromosome numbers for burrobush are 2n=36,72,108,126,144 (Keil 2012).

Previous research shows three major chromosome races for burrobush: 2n = 18, 36, and 54 (Raven et al. 1968). Ploidy level was also found to vary between burrobush populations based on location, however, this species is primarily diploid and tetraploid throughout its range (Raven et al. 1968). Hexaploids were found to most often occur in the California Desert. Due to intraspecific ploidy variation, 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.

Burrobush can hybridize with another common desert shrub, the cheesebush (*Hymenoclea salsola*) (Baldwin et al. 1996). Molecular studies suggest that species in the *Hymenoclea* and *Ambrosia* genera may be closely related contrary to previous understanding. However, pollen from crossed individuals is highly depressed and indicate potential sterility barriers between either species (Baldwin et al. 1996). Nonetheless, natural hybrids exist in areas of gene flow between sympatric populations.

DESCRIPTION

Burrobush is a highly branched, rounded perennial shrub. Its stems are stiff, erect and reach upwards of 10-40 cm (SEINet 2023, Figure 1). When young, its stems bear short stiff hairs and become glabrate with age. The leaves are grey, tomentose (woolly) on both sides, and alternate along the stem (Figure 2).

Each blade is ovate, 2-3 pinnately lobed and approximately 10-25 mm long. Burrobush flowers are yellow with pistillate (female) and staminate (male) heads intermingled on a spike-like inflorescence (Figure 3).

Figure 1: A burrobush individual. Photo: Sue Carnahan

The staminate heads are many flowered 3-5 mm in diameter while the pistillate heads are two flowered without corollas (Strother 1964). Burrobush fruits are burs, purple-to-brown, each 4-5.5 mm long with 2 beaks with 30-40 long spines (Strother 1964, Schoenerr 1992). During drought, burrobush becomes dormant by dropping its leaves to prevent water loss. It is recommended to rely on the presence of longitudinal stripes on the bark for field identification during this time (Schoenerr 1992).

Figure 2: Burrobush leaves, showing woolly texture from hairs. Photo: Sue Carnahan

Figure 3: Burrobush in flower. Photo: BLM SOS NV052

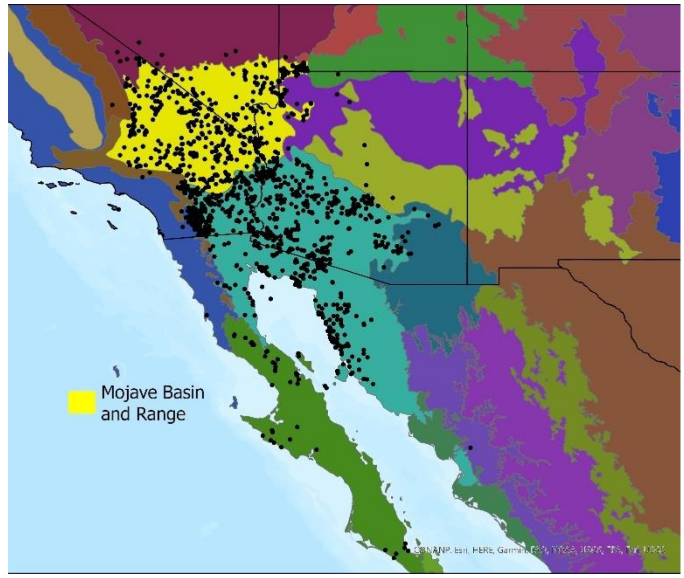

Figure 4: Distribution of burrobush (black circles) from georeferenced herbarium specimens and verified observations. (CCH2 Portal 2022, SEINet 2022) with Omernik Level III Ecoregions (Omernik 1987). The Mojave Basin and Range ecoregion is shown in yellow.

DISTRIBUTION AND HABITAT

Burrobush occurs in southern California, southwestern Utah, southern Nevada, southern Arizona, and into northwestern Mexico. It primarily grows within the Mojave Desert and spreads into the Sonoran Basin and the Baja California ecoregions. Small populations occur in the Central Basin, Sierra Nevada, and southern California mountains (Keil 2012, Calflora 2023).

Habitat and Plant Associations.

Burrobush occurs in fine, dry soils of alluvial plains and slopes and is a main constituent of the creosote-bush scrub community (Figure 5). It also occasionally occupies the Joshua tree woodland communities (Keil 2012, Calflora 2023, SEINet 2023, Figure 6).

NatureServe recognizes two habitat alliances and twenty-two habitat associations that are defined by the presence of burrobush (NatureServe 2023). Most of the association records are secure; however, one is found to be vulnerable (Creosote – Burrobush Shrubland) and another globally imperiled (Burrobush / Big Galleta Dwarf-Shrubland). Records indicate that conservation may be affected by impacts from off-road vehicles and limited distribution (NatureServe 2023).

The Mojave-Sonoran Bajada and Valley Desert Scrub group is broken into a burrobush dominated Desert Dwarf Scrub alliance and a co-dominated (burrobush and creosote) Bajada & Valley Desert Scrub alliance. All other association records are a combination of desert scrub to desert grasslands.

Of the twenty-two alliances, the primary associated species of burrobush include creosote (*Larrea tridentata*), Nevada ephedra (*Ephedra nevadensis*), rough joint-fir (*Ephedra aspera*), brittlebush (*Encelia farinosa*), water jacket (Lycium andersonii), Fremont's chaffbush (*Amphipappus fremontii*), shadscale (*Atriplex confertifolia*), desert-holly (*Atriplex hymenelytra*), Mojave yucca (*Yucca schidigera*), ocotillo (*Fouquieria splendens*), cheesebush (*Hymenoclea salsola*), and others.

Figure 5: Burrobush growing in open desert in Utah. Photo: BLM SOS UT930

Figure 6: Burrobush growing within the Nevada desert. BLM SOS NV052

Climate.

The Mojave Desert is characterized by low annual precipitation (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).

Climate information is derived from the climate-based provisional seed transfer zones (PSZs) where burrobush occurs (Shryock et al. 2018; Table 1). According to herbarium specimen locations (SEINET 2022), burrobush has been documented in all but one PSZ in the Mojave Desert ecoregion (Zone 22) but is most abundant in Zones 21 and 24 and least abundant in Zone 20 (Table 1). The average annual precipitation in the PSZs where burrobush occurs in the Mojave Desert ecoregion is 15.72 cm (6.19 inches), with an average of 4.86 cm (1.91 inches) falling in the summer and an average of 10.86 cm (4.27 inches) falling in the winter. Note, herbarium specimen locations may not represent the full distribution and abundance of burrobush due to sampling biases.

It is important to consider how species are often locally adapted to small climatic gradients within their home range (Custer et al. 2022). In the Mojave, a study using burrobush investigated this idea by raising seedlings in a greenhouse and transplanting them (after 1 year) into their respective common gardens (each with unique micro-climate variation). Results showed that burrobush populations that originated from more winter-mesic regions had faster growth in the more mesic gardens and low survivorship in the most arid garden. In sites with more variable summer precipitation, burrobush had greater overall growth. However, the larger the plant at the time of transplant, the lower the growth rate, but higher the survival across sites. Overall, populations of burrobush was found to be locally adapted to variation in summer and winter temperatures and precipitation (Custer et al. 2022).

Table 1: Climate of the provisional seed zones (PSZ) where burrobush occurs within the Mojave Desert ecoregion (Shryock et al. 2018), showing the number of herbarium records or verified observations of burrobush that occur within the PSZ. 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	# Records	MAP (cm)	SP (cm)	WP (cm)	MAT (C)	Range (C)
21	145	15.6	6.2	9.4	18.8	38.4
24	114	10.7	2.8	7.9	18.8	38.6
26	112	14.5	2.7	11.8	16.8	34.9
25	70	16.5	6.2	10.3	18.9	34.6
23	54	15.8	5.4	10.4	16.1	35.9
27	47	9.6	3.3	6.3	20	36.7
29	28	25.5	4.2	21.4	13.8	31.7
28	25	7.8	2.4	5.3	22.3	41.3
20	17	25.5	10.5	14.9	15.3	34.5

Elevation.

Burrobush grows between 80 to 1,700 ft (24 – 518 m) in elevation. (Strother 1964, Keil 2012).

Soils.

Generally, burrobush is found in well-drained, fine soils. It can occupy several parts of the landscape such as alluvial plains, slopes, washes, mesas, and erosional highlands. Soil attributes within and between burrobush populations vary greatly and are frequently underlain with igneous and calcareous rocks. The soil surface may be pavement-like and often inoculated with biological crusts between plants. Burrobush has been found to have no influence on lichen and moss recovery but does affect cyanobacteria composition (major taxonomic groups that comprise biocrust) (Titus et al. 2002, Chiquoine et al. 2016, CPNS 2023, SEINet 2023b).

ECOLOGY AND BIOLOGY

Burrobush is a long-lived, drought-deciduous rhizomatous shrub that frequently inhabits disturbed areas and is moderately palatable to several animal species.

Reproduction.

Breeding System.

No indications of self-fertility were found in the literature and it is thus assumed to be dependent on outcrossing (USDA 2023).

Burrobush is capable of vegetative reproduction (Muller 1953, Marshall 1994C). As plants mature, clones arise from their aerial shoots. The clone then grows up to 1 m in diameter. Sort rhizomes anchor the clone to the soil and the original plant stem will die off. Wind-blown debris and soil accumulate at the base of the clone and creates a mound, promoting success (Muller 1953).

Reproductive Phenology.

Flowering occurs primarily from February to June; however, burrobush may opportunistically flower later in the year in response to rainfall (Rodgers and Miller 2000). Seeds generally mature 3-4 months after flowering.

Pollination.

Burrobush, like other *Ambrosia* species, are wind pollinated. Each plant is estimated to release over a billion grains of pollen in just one season, making it a primary cause of hayfever. (Payne 1963, Wopfner and Gadermaier 2005)

Seed and Seedling Ecology.

Burrobush requires rainfall to induce germination of its seeds. According to one Mojave Desert study, late summer rainfall of 1 – 2 inches promoted germination while lower levels of 0.7 – 0.8 inches did not (Ackerman 1979). There are no detailed records of the longevity of burrobush seeds. However, some research indicates that seed quality can be poor, one reason why this species is an abundant seed producer (Rodgers and Miller 2000).

Burrobush seeds are covered with prickles that aid in attaching to hair and fur, suggesting that mammals are a major mechanism of seed dispersal (Marshall 1994). Another study suggested that the seeds can readily tumble, utilizing gusts of wind to move across the landscape (Maddox and Carlquist 1985).

Seedlings of burrobush often successfully establish in open spaces and are known to be a common pioneer (Prose et al. 1987, Miriti et al. 2001). Studies found that up to 83-92% of all young burrobush were in bare spaces (McAuliffe 1988), and that burrobush was the principle colonizer of open space in those communities.

Seed eating rodents and ants are very common in deserts, such as the Mojave, and can alter plant recruitment and species composition (Suazo et al. 2013). The fate of a seed will vary based on its size, location, and morphology. For example, rodents favor larger seeds which offer many benefits such as being more conspicuous, nutritionally dense, and easier to relocate if stored. Alternatively, ants select seeds based on the constraints of the size of their mouthparts (Davidson 1977). These outcomes are subject to other abiotic factors such as cover and habitat conditions. Overall, understanding how seed eaters select and distribute seeds is important to the success of restoration projects (Suazo et al. 2013).

Species Interactions.

Belowground Interactions.

Burrobush exhibits several belowground dynamics with its co-dominating shrub species, creosote. A secretion from creosote bush roots has been found to inhibit the growth of burrobush, as they are likely competitors for water resources in the arid desert landscape (Mahall and Callaway 1991, AZ-Sonora Desert Museum 2023). Burrobush is also capable of chemically detecting conspecific roots, which causes a shift in root growth patterns in order to avoid competition (Mahall and Callaway 1991).

Burrobush also forms belowground relationships with mycorrhizal fungi, which can supply phosphorus and nitrogen directly through root systems (Titus et al. 2002). This mutualism between desert plants and fungi also increases competitive abilities (Titus and Del Moral 1998), resistance to disease (Titus et al. 2002), herbivores (Gange and Bower 1997), and enhances plant-host drought resistance (Davies et al. 1992).

Parasites and Predation.

Over 89 species of phytophagous insects predate burrobush. Of those identified, only 5 species were found to be pests, feeding on foliage and sap (Goeden and Ricker 1976). The literature does not describe fungal or bacterial disease for burrobush. However, burrobush has been documented to be a host plant for sandfood (*Pholisma sonorae*), a succulent parasitic plant with a sweet flowerstalk used as a food resource for desert peoples (Marshall 1994).

Wildlife and Livestock Use.

Burrobush is a very important browse species across western rangelands, especially during drought years (Stark 1966, Webb and Stielstra 1979, Marshall 1994, DeVos Jr. and Miller 2005). Generally, burrobush is of intermediate forage value (Marshall 1994), attracting large species including horses, pronghorn, cattle, and sheep. Studies describe horses finding burrobush foliage the most palatable compared to cattle and sheep, which find the foliage fair-to-poor (Coville and Clark 1893, Stark 1966).

Several smaller desert species also utilize burrobush (Marshall 1994). One study found that in the Mojave Desert, up to 8% of mature burrobush was browsed by black-tailed jackrabbits (*Lepus californicus*). This percentage increased with seedlings (more palatable foliage), sometimes with over 90% consumption (Marshall 1994). Other animal species that utilize burrobush include kangaroo rats (*Dipodomys spp.*) which eat seeds (Reichman 1975) and chuckwallas (*Sauromalus obesus*) which consume leaves, stems, and even blossoms (Shaw 2004).

Burrobush is a useful cover and forage plant for the federally threatened Mojave Desert tortoise (*Gopherus agassizii*) (Berry and Turner 1986, Young et al. 2017, Esque et al. 2021).

Other Notable Species Interactions.

Burrobush creates fertile islands that can facilitate several annuals such as the California desert dandelion (*Malacothrix californica* var. *glabrata*), desert chicory (*Rafinesquia mexicana*), distant scorpionweed (*Phacelia distans* var. *australis*), Fremont's pincushion (*Chaenactis fremontii*), and waterpods (*Ellisia spp.*) (Muller 1953). It may also act as a nurse plant to one of its main competitors, the creosote, providing its seedlings protection from herbivory (McAuliffe 1988).

Additionally, burrobush is a host plant to 5 known lepidopteran species: geometrid moth *(Animomyia morta),* flower moth (*Schinia dobla*), tortricid moth (*Carolella beevorana*), omnivorous leafroller moth (*Platynota stultana*), and the southern emerald moth (*Synchlora frondaria avidaria*) (Robinson et al. 2010).

Disturbance Ecology.

Burrobush can survive in both disturbed and undisturbed habitats (Abella 2010). Herbarium records mention burrobush growing near disturbances such as agricultural development and recently burned areas (SEINet 2023). The Mojave has numerous agents of disturbance, however those of most concern for burrobush and its community are identified as soil trampling, pipe-line construction, tillage, and military activity (Prose et al. 1987).

Due to its ability to colonize and prolific seeding, burrobush is an excellent pioneer species (Prose et al. 1987). One study found that burrobush had an equal to greater cover value in disturbed sites when compared to non-disturbed control sites (Prose et al. 1987). More broadly, its community is adapted to small and continual disturbances and records have shown that the burrobush community can recover quickly (Vasek et al. 1975, Vasek 1979, Prose et al. 1987).

Not much information is known about the fire adaptations of burrobush, though it seems to sprout at low rates after low-severity fires. One study in the Sonoran Desert found that first year recruitment of burrobush in a burned site was poor but improved in later growing seasons (Brown and Minnich 1986).

Ethnobotany.

No current uses are identified by the Native American Ethnobotany Database, however, other species within the *Ambrosia* genus have many uses such as a gynecological aid for menstrual pain and a dermatological aid for insect stings (Barrows 1967).

Horticulture.

Burrobush can be sold as a xeriscape garden plant as it is known to be very drought and sun tolerant (CNPS Calscape 2023). While it can support a variety of native butterflies and moths, it is sometimes less popular for traditional gardening due to its non-showy flowers.

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). Although there has been relatively little research evaluating seed sourcing strategies in actual restoration settings where many additional factors influence performance (Pizza et al. 2023), common garden research, such as with burrobush described above (Custer et al. 2022), mimic restoration settings to a large degree. 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).

Empirical seed transfer zones have not been developed for burrobush. The Desert Southwest Provisional Seed Zones (PSZs) may be used to plan seed sourcing in absence of species-specific information (USDA NRCS 2022; Figure 8). 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.

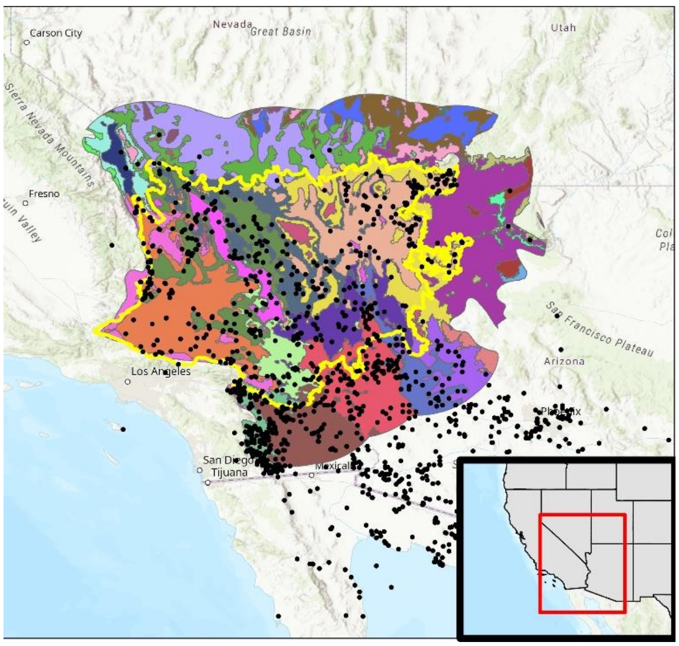

Figure 7: The distribution of documented burrobush (black dots) across the Desert Southwest Provisional Seed Zones (Shryock et al. 2018). Occurrences are based on georeferenced herbarium specimens and verified observations (CCH2 Portal 2022, SEINet 2022). The Mojave Basin and Range Level III ecoregion (yellow outline) is buffered up to 100km in all directions. PSZs do not always extend a full 100km beyond the Mojave ecoregion.

Commercial Seed Availability and Germplasm Releases.

Burrobush 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 for burrobush.

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.

In the Mojave Desert, burrobush is typically collected between April-July with the majority of collections occurring in May (BLM SOS 2022).

Collection Methods.

Burs from burrobush can be collected from its panicle by running a hand upward toward the terminal end of its spike (Rodgers and Miller 2000). The burs will subsequently be released and can be placed into a paper bag for temporary storage. Collection of burs that have fallen may be impractical since they easily blow away (Rodgers and Miller 2000).

One source notes that higher collection rates may be necessary as wild seed may have poor fill (Kay et al. 1984)

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.

Due to the nature of the spiny burs, seed cleaning burrobush can be difficult (Rodgers and Miller 2000). Burrobush fruits are tightly mingled with male flowers and are often sterile, consisting only of chaff material.

It is suggested to first rub the burs and flowers over a large screen to initially break up the material, followed by using a #16 sieve to separate the chaff and male flowers (Wall and MacDonald 2009). Then, a blower (set to 1.5-1.75 speed, gradually increased) will sort out sterile fruits. Repeat this process as necessary (Wall and MacDonald 2009).

Figure 8: Burrobush burrs post-harvest (top) and attached to spike pre-harvest (bottom). Photos: BLM SOS AZ010, NV052

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).

Burrobush seed is orthodox (SER SID 2023). There is no loss in viability even after 14 years of optimal storage at 4°C and 15°C (Kay et al. 1988). A short term (7 day) storage experiment

(8/16 light at 15°C) resulted in 100% germination in 1% agar (SER SID 2023).

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 burrobush is defined by AOSA as an "intact dry indehiscent one-seeded fruit with accessory structures, whether or not a seed is present" (AOSA 2016).

The AOSA does not specify guidelines for testing germination, viability, or purity of burrobush or congeners (AOSA 2016).

Wildland Seed Yield and Quality.

Wild-collected burrobush seed is generally of medium quality, with an average of 70% fill, 98% purity and 64% viability indicated by tetrazolium tests across 49 Seeds of Success collections (BLM SOS 2022, Table 2). Wild collections contain an average of over 59,000 PLS/lb (BLM SOS 2022, Table 2).

Table 2: Seed yield and quality of burrobush 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.

Seed lot characteristics	Mean	Range	Samples (no.)
Bulk weight (lbs)	7.04	0.3-91.68	49
Clean Weight (lbs)	2.73	0.04-42.68	49
Purity (%)	98	90-99	49
Fill (%)	70	10-95	49
Viability (%)	64	9-94	49
Pure live seeds/lb	59,698	11,936-132,052	49

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

Burrobush will grow best in sandy to granular soils, ideally with a soil pH near 7, but can tolerate slightly basic soils. Burrobush requires full sun (CNPS 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 species-specific certification standards for burrobush or related species in the states where it occurs.

Isolation Distances.

Sufficient isolation distances are required to prevent cross-pollination across seed production crops of burrobush from different sources or other *Ambrosia* species. However, there are no species-specific standards for burrobush or related species in the states where it occurs.

Site Preparation.

Fields should be as weed-free as possible prior to sowing or transplanting burrobush seeds or plugs. 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).

Burrobush is dependent on mycorrhizal associations (Granite Seed 2023); soil inoculation may improve plant growth in fields where soil health is depleted.

Seed Pre-treatments.

In the literature, burrobush was found to germinate at an optimum between 15-25°C. Also, 7 and 14 day germination tests were improved by activated carbon, scarification, and/or moist stratification (2°C for 30 days) (Burgess et al. 1977, Rodgers and Miller 2000). However, heat seems to have no effect on germination success. One experiment observed that seedlings grown in steam-sterilized soil did poorly in comparison to unsterilized soil, due to reliance on mycorrhizal association (due to low phosphorus levels) (Burgess et al. 1977).

Growers in the Mojave Desert found that no pre-treatment was needed to germinate burrobush in a nursery setting (Plath 2023, personal communication).

Seeding Techniques.

Burrobush is easier to establish by transplanting seedlings than to direct sow (Graves 1976). Outplantings typically use pots that have an elongated design (Rodgers and Miller 2000).

If directly seeded, Granite Seed suggests using approximately 5.40 lbs of pure seed per acre, as burrobush typically has 20,000-33,000 seeds per pound (Granite Seed 2023, Stevenson Intermountain Seed 2023).

Literature on the optimal depth of planting burrobush seeds ranges from 0.4 to 1 inch deep (Kay 1975, Stevenson Intermountain Seed 2023).

Burrobush should be planted during the late winter or early spring. Seed vigor is a more important factor than timing of seeding. (Clary and Slayback 1985).

Establishment and Growth.

Mature burrobush transplants can have a success rate of up to 90% (Rodgers and Miller 2000). One study found had survival rates of 44 and 48% over two years, respectively, following transplanting 2-month-old stock in February (Graves et al. 1978). Mortality may be explained by colder February temperatures. Additionally, up to 25% of plants flowered during the first year at one of the field sites.

Spot seeding is poor in comparison to transplantation, with a rate of 18 burs/spot resulting in 0-4% stocking success (Graves 1976).

Generally, burrobush grows fast in the greenhouse and can be pruned to improve strength. It is suggested that plants be hardened-off before transplanting into potentially freezing temperatures (Graves et al. 1978).

Weed Control.

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 2023) for further details on weed management in native seed production fields.

Pest Management.

Due to its palatability for numerous fauna, it is recommended to use rodent/browser protectors when transplanting younger burrobush (Clary and Slayback 1985). No additional information on pest susceptibility or management was described in literature.

Pollination Management.

Since burrobush is wind pollinated, plants should be able to readily exchange pollen within a seed production field without employing management strategies.

Irrigation.

A one-time irrigation treatment for burrobush did not improve results for either transplanting or spot seeding (Graves 1976). No further metrics were found relating irrigation methods and regimes to plant performance or seed yield of burrobush.

Seed Harvesting.

Collection by hand using techniques described in Collection Methods may be appropriate for smaller fields, otherwise, there is no information of large-scale production methods in the literature or dealing with indeterminate flowering phonologies. The density of the flower spikes would make it difficult to harvest only the "ready" seed.

Seed Yields and Stand Life.

No information on agricultural seed yields or vigor was found in the literature or through personal communications.

NURSERY PRACTICE

Nursery and experimental researchers have large success growing burrobush in containers. Seeds are typically started in the greenhouse before being transplanted into larger diameter pots (RNGR 2023). Other propagation methods include stem cuttings, which root easily by dipping ends in rooting hormone and placing them in a vermiculite misting box until rooted (Wieland et al. 1971).

Year-old burrobush plants have high survival in 30-inch tall by 6-inch in diameter pots. Other outplantings used 1, 1.8, and 2.6 gallon elongated pots that were 14 and 17-inches tall (Rodgers and Miller 2000). Other studies have used large PVC containers (15 inches tall by 6 inches in diameter) for their final outplantings (Graham 2004).

Using wild-collected seed from the Mojave Desert, growers at the Mojave Desert Land Trust sowed burrobush seed into mixed media (3 parts perlite, 1 part vermiculite, and a small addition of Osmocote 14-14-14) in seed flats about 1/4" deep in April. There was 37% germination. After six weeks, seedlings were transplanted and moved to an outdoor shade house with 63% cover (Asbell 2017, RNGR 2023). The protocol for another grower, Joshua Tree National Park (JTNP) uses a mixed media of 2 parts sand, 1 part mulch, and 2 parts perlite in seed flats which achieves 30% germination (Graham 2004). Osmocote (13-13-13, 9-month release) is applied at the final stage of transplanting (2 gal PVC containers) before being moved to an outdoor growing area with a 55% shade cloth (Graham 2004).

Graves (1976) and JTNP Native Plants Nursery describe burrobush seedling sensitivity to hardening-off in cold temperatures. Graves recorded 80% mortality when transplanting (without hardening-off) at 10 to -7°C (50°F to 19.4°F), with better survival by hardening-off and moving plants into 14 to 4°C (57.2°F to 39.2°F) (Graves 1976).

Limited information on greenhouse conditions is available, however the Mojave Desert Land Trust kept their burrobush in a greenhouse that ranged from 50°F (nighttime) to 90°F (daytime) (Asbell 2017).

Growers at the Las Vegas State Tree Nursery sow burrobush directly into 1-gallon pots--the final container size prior to outplanting for restoration—because they found it does not transplant well if started in smaller containers (Johnson 2023, personal communication). Seeds can be sown in the spring and seedlings are fairly hardy, though slow growing after germination (Thomas et al. 2022, personal communication; Graham 2022, personal communication). Plants can take up to 1.5 years before ready for outplanting, a timeline typical for many desert species. Plants can be subject to aphids in the nursery, which are treated with a mild insecticidal soap (Graham 2022, personal communication).

Figure 9: Burrobush in cultivation in newspaper pots at Joshua Tree National Park. Photo: Ashlee Wolf

REVEGETATION AND RESTORATION

Burrobush is recognized as a priority species to restore habitat for the desert tortoise (Esque et al. 2021), in addition to of a myriad of other wildlife species (see Wildlife and Livestock Use). Burrobush has been used in revegetation studies (Clary and Slayback 1985, Abella et al. 2015) and is high priority to the Bureau of Land Management's (BLM) Mojave Desert Native Plant Program. Its ability to establish in disturbed environments under drought conditions makes it a good candidate for restoration projects aimed at improving ground cover and soil stabilization. Additional projects have used burrobush along highways for erosion control where other perennial vegetation could not survive (Clary and Slayback 1985).

Wildland Seeding and Planting.

Wildland Seedings.

Developing seeding techniques for burrobush revegetation can be challenging. A study conducted in Arlington, Arizona at the Redhawk Power Plant attempted revegetation along a 1.2 hectare site on a post-agricultural cotton field (Banerjee et al. 2006). Four soil preparation treatments were used (mulching, imprinting, addition of fertilizer, and chiseling) along with three post-seed management techniques using irrigation, irrigation with removal of Russian thistle, and no irrigation or thistle removal. Burrobush comprised 13.7% of the native seed mix. Results showed that soil treatments did not have a significant effect on revegetation, but irrigation did. Burrobush was not among the few natives that did survive, as they described that thistle overtook 37% of the irrigated plots and 50% of the irrigated plots where it was initially removed (Banerjee et al. 2006). Researchers explain that abandoned farm soils can contain a large reservoir of summer and winter annual seeds and thus was a large component of preventing burrobush establishment. Similarly, in the Mojave, burrobush seed was used on post-fire plots on a BLM management area (Abella et al. 2012). The native seed mix contained native shrubs, forbs, and grasses (burrobush seeded at 257 pls). Various mitigation treatments were used such as granivory protection, irrigation, and shelter, all of which failed to help seeds establish (Abella et al. 2012).

Another study used burrobush in a native seed mix on degraded sites used by the U.S. Army's Fort Irwin National Training Center in Barstow, CA (DeFalco et al. 2012). The experimental design included expansive compacted and trenched areas that were assigned one of three seeding techniques (tackifier, harrowed, or untreated control). The burrobush live seed estimates was 149 ± 13. Additionally, seed traps were placed on plot perimeters to estimate seed movement out of plots. Results showed that a large proportion of seed moved within the first three weeks, however, this movement for burrobush was significantly reduced in harrowing and tackifier plots with seedling densities being highest on the harrowing plots (DeFalco et al. 2012). Trenched plots retained approximately three times as many seeds as the compacted sites regardless of seeding technique. Consideration should be taken for pre-seed treatments to increase germination rates for burrobush, as this study only observed 2% germination.

Wildland Plantings.

Burrobush was included in a project to restore habitat near the Lake Mead National Recreation Area, where a road was to be removed and re-routed through intact desert (Abella et al. 2015). The project approach was to salvage topsoil and plants from the road construction area. The plants were temporarily placed in a nursery before being outplanted. Abella (2015) found that the use of topsoil was essential to the success of transplants, with survival rates at 56% compared to 25% of those without salvaged topsoil. Over the 27-month monitoring period, the salvaged plants received either water by hand or DriWater slow-release gel. Results showed burrobush performing well, with approximately 45% survival after 27-months. The use of supplemental watering enhanced the burrobush survival by 1.4 times, regardless of treatment type (by hand or DriWater) (Abella et al. 2015). Another study by Abella (2012) had similar success with outplanting in the Mojave (Abella et al. 2012), with burrobush having 23% survival on post-wildfire plots. The addition of water and shelter treatments nearly doubled survival, with chances increasing if plants survived past the first year of the three year study (Abella et al. 2012).

A joint project with the U.S. Bureau of Mines and Joshua Tree National Monument examined ways to reclaim abandoned mines using native plants (Rodgers 1994). Seeds were collected and grown in a local seed nursery in either a 14, 15, or 18-inch-tall pot. Holes at the site were dug by a 2-person power auger and hand trowels. In February of 1993, seedlings were transplanted, watered, and were monitored for survival. Burrobush, by the end of the summer, had greater than 90% survival. Researchers found that plants in the smallest container size suffered the highest mortality, which may be due to reduced root growth potential, shorter growing time, and the quantity of fertilized nursery soil included with each transplant (Rodgers 1994).

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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://doi.org/10.5066/P9BQ6IYJ

MOJAVE SEED MENUS

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

AUTHORS

Casey Hensen, Conservation Technician, Institute for Applied Ecology, Tucson, AZ| caseyhensen@appliedeco.org

Ashlee Wolf, Ecologist, Institute for Applied Ecology, Tucson, AZ | ashleewolf@appliedeco.org

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