

Chrysothamnus Nutt.

rabbitbrush

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Growth habit, occurrence, and use. Members of the rabbitbrush genus *Chrysothamnus* spp. are among the best-known of western shrubs (Johnson 1987; McArthur and Welch 1986; McArthur and Stevens in press; McArthur and others 1979). The genus is endemic to western North America and is made up of 16 species (Anderson 1986; McArthur and Meyer 1987). It has recently been partially subsumed under the new genus *Ericameria*, formerly an infraspecific taxon within the related genus *Haplopappus* (Anderson 1995; USDA NRCS 2001). Because the durability of this nomenclatural change has yet to be demonstrated, the decision here is to follow the traditional nomenclature (table 1).

Rabbitbrushes commonly occur on sites of natural or human disturbances such as washes, drainage-ways, and quarries; they may also occur as subdominants in later seral vegetation. Their conspicuous golden flowers are a familiar sight in autumn along roadsides throughout the West. Three of the species—rubber rabbitbrush, Parry rabbitbrush, and green rabbitbrush—are widespread, polymorphic taxa made up of multiple subspecies, whereas the remainder are taxonomically simpler and more restricted in distribution. Rubber rabbitbrush is made up of 22 subspecies, many of which are ecologically distinctive. Its more ecologically specialized subspecies are restricted to dunes, rock outcrops, shale badlands, alkaline bottomlands, or montane riparian communities. Most of the widely distributed subspecies are also broad in their ecological requirements but tend to be commonest on disturbed ground. Common garden studies have shown that marked ecotypic differentiation occurs within subspecies for such traits as growth form, growth rate, cold and drought hardiness, competitive ability, flowering time, achene weight, and germination patterns (McArthur and others 1979; Meyer 1997; Meyer and others 1989). Such ecotypic variation is to be expected in other widely distributed species as well. It is therefore important to consider ecotype as well as species and subspecies when selecting seed sources for artificial seeding projects.

Species, subspecies, and populations of rabbitbrush also vary widely in their palatability to livestock and wildlife. Certain unpalatable taxa such as threadleaf rubber rabbitbrush tend to increase on abused rangeland, and considerable energy has been invested in control methods (Whisenant 1987). A tendency to resprout after herbicide spraying, chopping, or burning, combined with an ability to reestablish from seed, can make rabbitbrush difficult to eradicate (Young and Evans 1974).

Basin and mountain whitestem rubber rabbitbrush races are highly palatable as winter forage for deer (*Odocoileus* spp.), sheep, and cattle, and have been included in seeding mixes for the

rehabilitation of big game winter range for over 30 years (Monsen and Stevens 1987). Other species and subspecies also provide winter forage for wildlife and livestock (McArthur and Stevens in press). Rabbitbrushes are extensively used for mined-land rehabilitation in the West (Romo and Eddleman 1988). Thousands of pounds of wildland-collected seed are bought and sold annually (McArthur and Stevens in press; Monsen and Stevens 1987). Rabbitbrushes may be seeded as pioneer species on harsh mine disturbances for erosion control and site amelioration and often invade such sites on their own (Monsen and Meyer 1990). They can act as nurse plants to facilitate establishment of later seral species, as they generally offer little competition to perennial grasses or later seral shrubs (Frischknecht 1963).

Rabbitbrushes have potential uses in landscape plantings, especially with the recent emphasis on xeriscaping. Rubber rabbitbrush has also been examined as a commercial source of natural rubber and other plant secondary metabolites such as resins (Weber and others 1987).

Flowering and fruiting. The perfect yellow disk flowers of rabbitbrushes usually occur in groups of 5 in narrowly cylindrical heads subtended by elongate, often keeled bracts. The heads are numerous and are clustered in often flat-topped terminal or lateral inflorescences that can be quite showy. Flowering occurs from late July through October, with higher elevation populations flowering earlier. The fruits ripen in September in the mountains but may not be ripe until December in warm desert populations. There may be considerable variation in flowering and fruiting phenology within populations and even on individual plants (Meyer 1997). Each flower has the potential of producing a single narrowly cylindrical achene that is completely filled by the elongate embryo (figure 1). The achene is topped with a ring of pappus hairs that aid in dispersal by wind. The pappus may also be involved in orienting and anchoring the achene during seedling establishment (Stevens and others 1986). Fully ripened fruits are easily detached from the plant by wind under dry conditions. Abundant flowering occurs most years, but fill is variable. Sometimes there is considerable damage by noctuid moth larvae during seed development. The damaged fruits remain attached to the plant, creating the appearance of an abundant harvest after all the sound fruits have dispersed.

Seed collection, cleaning, and storage. Dry, calm conditions are best for the harvest of rabbitbrush seed. Fully ripe fruits are fluffy and easily detachable, and they may be stripped or beaten into shoulder hoppers, bags, or boxes. Seed fill must average 30 to 50% in order to attain purities high enough for commercially profitable harvest. On favorable upland sites, harvestable crops occur in 4 of 5 years (Monsen and Stevens 1987). The purity of the bulk-harvested material is usually near 10%. Seeds are often moist at harvest and must be dried before cleaning.

Rabbitbrush seeds are difficult to clean. The elongate achenes are brittle and easily damaged in most mechanical cleaning equipment. Using flail-type cleaners such as barley debarbers results in less damage than using hammermills. After initial cleaning, the material can be fanned and screened in a fanning mill to achieve the desired purity. Cleaning removes sticks and large debris, separates the achenes from the inflorescences, detaches the pappus from the achenes, and removes unfilled fruits and other fine debris. These steps are necessary to raise purities to 20% or higher and to make it possible to use conventional seeders (Monsen and Stevens 1987).

Achene weight varies substantially among species, subspecies, and populations of rabbitbrush (table 2). In rubber rabbitbrush, weight is correlated with habitat; the largest achenes come from plants that are specialized for growing on dune and badland habitats, and the smallest come from

populations on temporarily open saline bottoms (Meyer 1997). There is a ninefold difference in achene weight among populations of rubber rabbitbrush, and other species also show achene weight variation (table 2). This makes it important to consider achene number per unit weight explicitly when calculating seeding rates.

Rabbitbrush seeds are not long-lived in warehouse storage. Substantial loss of viability may occur within 3 years, and storage beyond 3 years is not recommended (Monsen and Stevens 1987; Stevens and others 1981). Seeds should be retested immediately before planting so that seeding rates can be based on current values for pure live seed. Rabbitbrush seedlots with initially low vigor and viability values tend to lose their remaining viability more quickly in storage (Meyer and McArthur 1987). Because of late ripening dates, rabbitbrush seeds are usually held for a year (until the following autumn) before planting. Careful attention to moisture content (7 to 8% is probably near optimum) and storage at low temperature may prolong storage life, but data to substantiate this are lacking.

Germination. Germination requirements for rabbitbrush vary both among and within species. Rubber rabbitbrush germination is best understood (Khan and others 1987; McArthur and others 1987; Meyer and McArthur 1987; Meyer and Monsen 1990; Meyer and others 1989; Romo and Eddleman 1988). Seeds are usually nondormant at high incubation temperatures (30 °C) even when recently harvested, but display variable levels of dormancy at the intermediate temperatures characteristic of autumn seedbeds. Seeds of early-ripening high-elevation collections are most likely to be dormant or slow to germinate at autumn temperatures, whereas seeds of late-ripening warm-desert collections germinate completely and rapidly over a wide temperature range. The conditional dormancy of recently dispersed seeds is removed through moist chilling, so that all seeds are nondormant in the field by late winter. Germination rate at near-freezing temperature is even more closely tied to habitat. Collections from montane sites may require more than 100 days to germinate to 50% at 3 °C, whereas warm desert collections may reach 50% germination in as few as 5 days. These germination features act in concert with seasonal patterns of temperature and precipitation in each habitat to ensure complete germination in mid to late winter. Germination is often completed just before the snow melts, with little or no carryover of seed between years. The ecotypic variation in germination phenology results in reduced emergence and survival when seed-source habitat is not matched to planting site habitat (Meyer 1990; Meyer and Monsen 1990).

Preliminary data for Intermountain and Mojave Desert populations of other species of rabbitbrush suggest that they share the same basic habitat-correlated germination patterns. Information on germination response to temperature for 6 collections of green rabbitbrush indicates that it differs from rubber rabbitbrush in having 25 °C rather than 30 °C as an optimum germination temperature and in showing some dormancy even at this optimal temperature (table 3) (Meyer 1997). Habitat-correlated germination responses at autumn and winter temperatures were similar for the 2 species and also for collections of Parry, spearleaf, and Mojave rabbitbrushes.

Evaluation of the seed quality for rabbitbrush is not without pitfalls. Reasonably repeatable purity values are obtained when only filled achenes are included as pure seed (Meyer and others 1989). Germination tests for rubber rabbitbrush should be carried out at alternating temperatures of 20 to 30 °C or a constant 25 °C for 28 days (Meyer and others 1989). This procedure is the only one listed in the official testing rules for this genus (AOSA 1993). Seedlots from low and middle elevations should complete germination within 14 days, whereas seedlots from high elevations may

still show some dormancy even after 28 days, making post-test viability evaluation essential. Tests at 30 °C are not recommended even though relative germination percentage (that is, percentage of viable seeds germinating) may be higher because there are indications that 30 °C is more stressful to marginally viable seeds.

Tetrazolium viability testing of rabbitbrush seeds is also somewhat problematical. The embryos must be removed from the achene prior to immersion in the stain because of poor penetration of the stain, even with piercing or cutting of the achene wall. The process of removal often damages the embryo, making the staining patterns hard to interpret. We frequently obtained higher viability estimates from germination tests than from tetrazolium evaluation for these species (Meyer 1997).

Nursery and field practice. Rabbitbrush species are easily propagated as container stock (Deutschman and others 1974). Seeds are sown directly into containers that provide depth for root development, sometimes after a short wet chill to ensure uniform emergence (Long 1986). The seedlings grow rapidly and are ready for outplanting in 3 to 4 months, after a hardening period. They may be outplanted in fall or spring, whenever moisture conditions are optimal. Bareroot propagation of rabbitbrush has also been successful. In spite of considerable among-lot and among-plant variation in seedling size, transplants survive quite well. Fall-seeding in nursery beds is recommended. Plants require less water than most other shrubs and should not be overwatered or fertilized excessively (Monsen unpublished data).

Rabbitbrushes are among the easiest shrubs to establish from direct seeding, and most plantings on wildland sites use this method. Minimal seedbed preparation is required. Surface planting onto a firm but roughened seedbed in late fall usually results in adequate stands. This planting may be accomplished through aerial seeding; hand-broadcasting; or seeding with a thimble seeder, seed dribbler, browse seeder, or a drill with the drop tubes pulled so that the seed is placed on the disturbed surface behind the disk furrow openers (McArthur and Stevens in press). Seeds should not be planted too deeply. One millimeter of soil coverage is sufficient. Seeding rates of about 20 to 30 live seeds/m² (2 to 3/ft²) are usually adequate. This is equivalent to about 200 g/ha (ca 3 oz/ac) on a pure live seed basis for a seedlot that averages 1.5 million seeds/kg (680,400/lb). If the seedlot is cleaned to high purity, it may be necessary to dilute it with a carrier such as rice hulls in order to achieve uniform seeding rates. Seedlings emerge in early spring, and young plants grow rapidly, often producing seeds in their second growing season.

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Figure 1C *Chrysothamnus*, rabbitbrush: achenes with pappi intact, $\times 4$.

Figure 2C *Chrysothamnus viscidiflorus* spp. *lancedatus*, Douglas rabbitbrush: longitudinal section through an achene, $\times 16$.

Table 1C *Chrysothamnus*, rabbitbrush: ecology and distribution of some common species and subspecies

Taxon & species	Common name	Geographic distribution	Habitat
SECTION CHRYSOTHAMNUS			
<i>C. linifolius</i> Greene <i>Ericameria linifolia</i> (Greene) L.C. Anders.	spearleaf rabbitbrush, alkali rabbitbrush	Colorado Plateau N to Montana	Deep alkaline soils; low to mid-elevation
<i>C. viscidiflorus</i> (Hook.) Nutt. <i>E. viscidiflora</i> (Hook.) L.C. Anders.	green rabbitbrush	Intermountain	Wide amplitude
<i>ssp. lanceolatus</i> (Nutt.) Hall & Clements <i>E. viscidiflora</i> spp. <i>lanceolata</i> (Nutt.) L.C. Anders.	Douglas rabbitbrush	Intermountain	Montane
<i>ssp. viscidiflorus</i> (Hook.) Nutt. <i>E. viscidiflora</i> (Hook.) L.C. Anders.	low rabbitbrush	Intermountain	Low to mid-elevation
SECTION NAUSEOSI*			
<i>C. nauseosus</i> (Pallas ex Pursh) Britt. <i>E. nauseosa</i> (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush	W North America	Wide amplitude
<i>ssp. albicaulis</i> (Nutt.) Hall & Clements	mountain whitestem rubber rabbitbrush	Mostly Intermountain Rocky Mountain	Mostly coarse soils; mid-elevation
<i>ssp. hololeucus</i> (Gray) Hall & Clements	basin whitestem rubber rabbitbrush	Mostly Great Basin	Mostly coarse soils; low to mid- elevation
<i>ssp. consimilis</i> (Greene) Hall & Clements <i>E. nauseosa</i> ssp. <i>consilimus</i> (Greene) Nesom & Baird	threadleaf rubber rabbitbrush	Mostly Great Basin	Mostly fine soils; low to mid- elevation
<i>ssp. graveolens</i> (Nutt.) Piper	green rubber rabbitbrush	W Great Plains; Colorado Plateau	Wide amplitude; low to mid-elevation
<i>ssp. salicifolius</i> (Rydb.) Hall & Clements	willowleaf rubber rabbitbrush	N Utah	Montane
<i>C. parryi</i> (Gray) Greene <i>E. parryi</i> (Gray) Nesom & Baird	Parry rabbitbrush	Scattered; W US	Mostly montane

SECTION PUNCTATI*

C. teretifolius (Dur. & Hilg.) Hall

E. teretifolia (Dur. & Hilg.) Jepson

Mojave rabbitbrush, green rabbitbrush

Mojave Desert

Rocky washes; hot desert

Sources: Anderson (1995), Deitschman and others (1974), USDA NRCS (2001).

* These sections are placed in the genus *Ericameria* in recent nomenclature changes (Anderson 1995).

Table 2C *Chrysothamnus*, rabbitbrush: seed yield data

	Cleaned seeds (100% purity)/seed wt			
	Mean		Range	
	million seeds/kg	million seeds/lb	million seeds/kg	million seeds/lb
SECTION CHRYSOTHAMNUS				
<i>C. linifolius</i>	1.8	0.8	C	C
<i>C. viscidiflorus</i>	1.8	0.8	1.5B2.0	0.7B0.9
<i>ssp. lanceolatus</i>	1.8	0.8	1.1B2.2	0.5B1.0
	1.8	0.8	C	C
<i>ssp. viscidiflorus</i>	1.5	0.7	1.1B2.2	0.5B1.0
SECTION NAUSEOSI				
<i>C. nauseosus</i>	1.7	0.8	1.5B2.0	0.7B0.9
<i>ssp. albicaulis</i>	1.1	0.5	0.9B1.4	0.4B0.6
	1.5	0.7	C	C
<i>ssp. hololeucus</i>	1.3	0.6	1.1B1.5	0.5B0.7
	1.5	0.7	C	C
<i>ssp. consimilis</i>	1.5	0.7	0.9B2.4	0.4B1.1
	1.7	0.8	C	C
<i>ssp. graveolens</i>	1.3	0.6	0.9B1.1	0.4B0.5
<i>ssp. salicifolius</i>	0.9	0.4	0-9B1.1	0.4B0.5
<i>C. parryi</i>	0.9	0.4	C	C
SECTION PUNCTATI				
<i>C. teretifolius</i>	1.3	0.6	C	C

Sources: Belcher (1985), Deitschman and others (1974), Meyer (1995, 1997), McArthur and Stevens (in press).

Table 3C *Chrysothamnus*, rabbitbrush: germination percentage (as percentage of total viable seeds) after 28 days at 15 °C or at 25 °C, and days to 50% of total germination during 20 weeks at 3 °C for some common species and subspecies

	<u>Germination percentage at 15 °C</u>			<u>Germination percentage at 25 °C</u>			<u>Days to 50% Germination at 3 °C</u>		
	Mean	Range	No.	Mean	Range	No.	Mean	Range	No.
SECTION CHRYSOTHAMNUS									
<i>C. linifolius</i>	C	C	C	C	C	C	21	C	1
<i>C. viscidiflorus</i>									
<i>ssp. lanceolatus</i>	37	29B49	3	64	58B70	3	60	35B82	5
<i>ssp. viscidiflorus</i>	58	31B98	3	68	40B96	3	60	35B82	5
SECTION NAUSEOSI									
<i>C. nauseosus</i>									
<i>ssp. albicaulis</i>	37	29B45	2	85	78B92	2	41	9B88	2
<i>ssp. hololeucus</i>	75	17B97	8	91	74B96	8	21	7B70	12
<i>ssp. consimilis</i>	70	26B96	6	91	80B100	6	33	5B108	17
<i>ssp. graveolens</i>	76	28B100	7	91	58B100	7	33	10B105	17
<i>ssp. salicifolius</i>	25	9B55	6	65	44B92	6	89	60B100	6
<i>C. parryi</i>	C	C	C	C	C	C	34	12B54	4
SECTION PUNCTATI									
<i>C. teretifolius</i>	C	C	C	C	C	C	5	5	1

Sources: Meyer (1997), Meyer and McArthur (1987), Meyer and others (1989).