Persistence and Colonizing Ability of Rabbitbrush Collections in a Common Garden

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Abstract

Collections of 4 subspecies of both green and gray rabbitbrush [*Chrysothamnus viscidiflorus* (Hook.) Nutt. and *C. nauseosus* (Pallas) Britton] were grown for 10 years in a common garden located in northwest Nevada. Generally, the green rabbitbrush collections did not persist as long as the gray rabbitbrush collections. *C. viscidiflorus* spp. *pumilus* (Nutt.) Hall & Clem. had poor initial establishment and the shortest persistence of any collection tested. Only plants of *C. viscidiflorus* spp. *latifolius* (D.C. Eat.) Hall & Clem. persisted for 10 years. Among the gray rabbitbrush collections, there was considerable variation in persistence within subspecies. Plants of *C. nauseosus* ssp. *salicifolius* (Rydberg) Hall & Clem. were heavily utilized by jackrabbits *(Lepus californicus)*. Plants of the various subspecies of green rabbitbrush were apparently never browsed by jackrabbits. Seedlings of gray rabbitbrush established naturally in the garden, especially in the plots of gray rabbitbrush.

Rabbitbrush *(Chrysothamnus)* constitutes a diverse and economically important group of crown-sprouting shrubs commonly occurring on sagebrush *(Artemisia)* rangelands and, to a lesser extent, on salt desert rangelands. The last comprehensive monograph of the genus, published by Hall and Clements in 1923, lists 4 sections, 12 species, and 40 subspecies. The leading contemporary taxonomist of *Chrysothamnus* is Loran C. Anderson, Department of Biological Sciences, Florida State University (Anderson 1970, 1978, 1980, 1981).

Hall and Clements (1923) proposed 4 sections of the genus, 2 of which, Section 2 *Typici* and Section 4 *Nauseosi,* are of considerable interest to range managers. Section *Typici* includes green rabbitbrush [*Chrysothamnus viscidiflorus* (Hook.) Nutt.] and Section *Nauseosi* includes gray rabbitbrush [*C. nauseosus* (Pallas) Britton]. These plants are important because they are generally not preferred by browsing animals and compete with desirable browse and forage species.

Green rabbitbrush plants are often found growing in upland sagebrush communities. Green rabbitbrush is a subdominant shrub in these communities. When these communities are burned in wildfires, some rabbitbrush plants crown sprout, flower, and set seed profusely, which results in dynamic rabbitbrush seedling establishment and dominance of the site for a transitory period (Young and Evans 1974 a & b, and 1978). Green rabbitbrush plants are difficult to control with phenoxy herbicides and improperly timed applications of phenoxy herbicides for brush control in sagebrush communities have resulted in conversion of the sites from sagebrush to green rabbitbrush dominance (Hyder et al. 1958).

Members of the gray rabbitbrush group are usually characterized by more woody plants than are found in green rabbitbrush. These plants also, instead of being distributed landscape-wide as subdominants, tend to be associated with specific habitats. For example, salt rabbitbrush (*C. nauseosus* ssp. *consimilis* Greene) is often found growing in areas with a shallow water table in salt desert communities (Roundy et al. 1981). This species is plastic enough to be adapted to other environments, including upland sites without salt-affected soils. Hall and Clements (1923) reported that 47 subspecies of *C. nauseosus* had been proposed, all but 8 of which having been proposed at the species level at one time or another. Anderson (1978, 1980, 1981) recognizes 21 subspecies for *C. nauseosus*. The species is so variable that virtually any collection represents a morphologically distinct genotype.

The subspecies of *C. nauseosus* have preferred habitats (Plummer 1977), but occasionally 2 or more subspecies may be found together in the same habitat. Some hybridization and introgression may occur at these sites (Hanks et al. 1975), but because of flower structure the rabbitbrush species are largely self pollinated, and only minimally outcrossed (Anderson 1966, McArthur et al. 1979).

Our purpose was to evaluate the persistence and natural regeneration of collections of green and gray rabbitbrush grown in a common garden for 10 years.

Methods and Materials

A common garden was established in 1972 at Granite Peak 35 km north of Reno, Nev. The site is situated at 1,800-m elevation on a north, north-easterly facing slope. The soils are Typic Haplargids. The surface soil has a sandy-loam texture and is derived from decomposed granite. Average annual precipitation for the past 14 years was 32.5 cm. Precipitation largely occurs during winter and spring. The site supported a mid-seral community of mountain big sagebrush [*Artemisia tridentata* ssp. *vaseyana* (Rydb.) Beetle]-/green rabbitbrush [*C. viscidiflorus* ssp. *viscidiflorus* (Hook.) Nutt.] with a few scattered plants of Thurber's needlegrass (*Stipa thurberiana* Piper) in an understory generally dominated by Sandberg bluegrass (*Poa secunda* Presl.). The site was prepared for transplanting by plowing and disk-harrowing. Seedlings of the rabbitbrush plants that had been grown in 15-cm pots for 1 year were transplanted into the garden site during April. No supplemental water or weed control was provided after transplanting.

The transplants were established on 1-m centers with 5 plants per replication and 4 replications in a randomized block design.

We compared 2 collections of each of 4 widely distributed subspecies of gray and green rabbitbrush (Table 1).

Annually, in October, the persistence of the individual shrubs was recorded along with notes on flower production and utilization by jackrabbits *(Lepus californicus)*. Flower production was recorded on a scale of 1 to 10 with 1 indicating no flowers and 10 including the complete crown of the shrubs covered with flowers. Jackrabbit utilization was rated on a scale from 1 to 10 with 1 indicating no detectable use and 10 indicating the entire plant hedged to coarse stems.

In September 1982, the garden was sampled for the last time; 2-meter-square plots were located in each of the replications and the density of rabbitbrush seedlings was recorded. The sampled

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Table 1. Collections of green and gray rabbitbrush grown in a common garden 1972–1982.

Species and subspecies	Collection No.	Collection
Green rabbitbrush[a]		
Chrysothamnus viscidiflorus		
ssp. *viscidiflorus* (Hook.) Nutt.	1	Granite Peak, Nevada
	2	Doyle, California
ssp. *pumilus* (Nutt.) Hall & Clem.	3	Adin, California
	4	Eagle Lake, Lassen Co., California
ssp. *puberulus* (D.C. Eat.) Hall & Clem.	5	Ely, Nevada
	6	Benton, California
ssp. *latifolius* (D.C. Eat.) Hall & Clem.	7	Wells, Nevada
	8	Long Valley, Washoe Co., (north) Nevada
Gray rabbitbrush		
C. nauseosus		
ssp. *consimilis* (Greene) Hall & Clem.	9	Reno, Nevada
	10	Tooele Valley, Utah
ssp. *albicaulis* (Nutt.) Hall & Clem.	11	Deadman Summit (U.S. 395) Mono Co., California
	12	Jumbo Grade, Washoe Co., Nevada
ssp. *salicifolius* (Rydberg) Hall & Clem.	13	Hardware Ranch, Logan, Utah
	14	Salt Lake City, Utah
ssp. *hololeucus* (Gray) Hall & Clem.	15	Reno, Nevada
	16	Geiger Grade, Storey Co., Nevada

[a]Anderson (1980) considered *C. viscidiflorus* ssp. *latifolius* and ssp. *pumilus* to be synonymous with *C. viscidiflorus* ssp. *viscidiflorus*. The chromatographic work of McArthur et al. (1978) showed some differences between ssp. *latifolius* and ssp. *viscidiflorus*, but indicated an affinity between the two taxa.

rabbitbrush seedlings were recorded by species or subspecies if they could be so identified at juvenile growth stages. Analysis of variance with the Kruskall Wallace test was used for non-parametric statistics (Siegel 1956).

Results

Height and Flowering

Plants of gray rabbitbrush collections reached maximum heights of 10 to 12 dm, whereas the green rabbitbrush collections reached a maximum height of 4 to 5 dm, with the average height of 3 collections remaining below 3 dm (Table 2).

Most of the rabbitbrush collections flowered profusely (Table 2). There were significant ($P = 0.001$) differences among the flowering ratings for the rabbitbrush collections. The green rabbitbrush collections from the garden site (collection number 1) flowered profusely the first year. Several of the other collections of green rabbitbrush did not flower as profusely, but persisted longer. Collections of *C. nauseosus* ssp. *consimilis* and *albicaulis* survived and were still flowering at the end of 10 years.

Table 2. Maximum height, flower production at 2, 5, and 10 years, and jackrabbit utilization of green and gray rabbitbrush plants.[a]

Species and subspecies	Collection No.	Maximum[b] height (dm)	Flowering year 2	Flowering year 5	Flowering year 10	Jackrabbit utlization
Green rabbitbrush						
C. viscidiflorus						
viscidiflorus	1	4.5 cd	10	10	—	1
	2	4.0 cd	10	10	—	1
pumilus	3	3.5 d	8	—	—	1
	4	3.1 d	8	8	—	1
puberulus	5	2.8 d	6	6	3	1
	6	3.0 d	5	4	2	1
latifolius	7	2.3 d	8	8	8	1
	8	2.6 d	8	6	6	1
Gray rabbitbrush						
C. nauseosus						
consimilis	9	9.8 b	8	10	10	1
	10	10.1 ab	8	10	10	1
albicaulis	11	11.2 ab	6	10	10	7
	12	12.1 a	6	10	10	5
salicifolius	13	6.1 c	3	2	2	10
	14	10.1 ab	2	8	8	8
hololeucus	15	10.1 ab	6	10	—	3
	16	12.1 a	6	10	—	5

[a]Flowering scale 1 to 10 with 1 indicating no flowers and 10 indicating entire crown covered with flowers.
—Indicates plants were dead by 10th year.
Jackrabbit utilization on scale of 1 to 10 with indicating no utilization and 10 indicating entire shrub browsed to coarse twigs 0.75 cm in diameter.
[b]Means followed by the same letter are not significantly different at 0.01 level of probability as determined by Duncan's multiple range test.

Jackrabbit Utilization

The green rabbitbrush collections were apparently never browsed by jackrabbits (Table 2). The gray rabbitbrush collections differed significantly ($P = 0.001$) in their browsing indices according to the Kruskall-Wallace test (Siegel 1956). Collection number 13 of *C. nauseosus* ssp. *salicifolius* was severely hedged by jackrabbits. The average height of collection 13 was significantly ($P = 0.01$) reduced compared to collection 14, the other representative of the *C. nauseosus* ssp. *salicifolius.*

The shoots of collections 11 and 12 of *C. nauseosus* ssp. *albicaulis* were utilized by jackrabbits, but not to the extent that the plants were severely hedged or that flowering was reduced. We did not detect jackrabbit utilization of the stems of *C. nauseosus* spp. *consimilis.* Studies in Utah have shown that *C. nauseosus* ssp. *salicifolius* and *albicaulis* are more highly preferred by browsing animals than the shoots of *C. nauseosus* ssp. *consimilis* (Hanks et al. 1975).

Establishment and Persistence

The transplants of all collections of rabbitbrush had excellent first year establishment except collection number 4, *C. viscidiflorus* spp. *pumilus,* although 80% of the plants of this source became established (Table 3). The other collection of this subspecies had excellent establishment, but only persisted for 2 years.

Collection number 1 of green rabbitbrush, *C. viscidiflorus* ssp. *viscidiflorus,* was collected at the site of the common garden. When these plants were transplanted back on the site on 1-m centers, they initially established very well (95% survival), but were all dead by 8 years (Table 3). Studies of native stands in the general area have shown that when green rabbitbrush plants invade burned areas, they generally dominate the site for about 10 to 15 years (Young and Evans 1974b).

The subspecies of green rabbitbrush with the greatest persistence was *C. viscidiflorus* ssp. *latifolius,* but by 10 years only 5 and 15% of the plants of the 2 collections tested had survived.

All of the gray rabbitbrush plants of collection 10, *C. nauseosus* ssp. *consimilis,* and collection 12, *C. nauseosus* ssp. *albicaulis,* survived for the 10-year duration of the common garden (Table 3). The other collection of *C. nauseosus* ssp. *consimilis* (number 9) had only 10% survival at 10 years, and the other collection of *C. nauseosus* ssp. *albicaulis* (number 11) had only 5% survival at 10 years. The subspecies of gray rabbitbrush with the poorest overall survival was *C. nauseosus* ssp. *hololeucus.* The survival and persistence of plants of *C. nauseosus* ssp. *salicifolius* was probably limited by rather severe utilization by jackrabbits.

We developed regression equations for the relationship between survival and time in the common garden for each rabbitbrush collection. Some of these are meaningless, because all plants of a collection were still alive after 10 years when the last data collection was made (collections 10 and 12, Table 3). For collection number 1

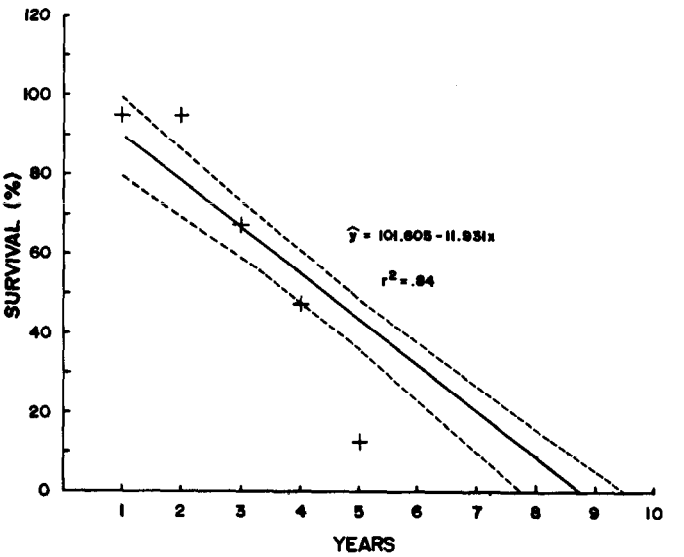

Fig. 1. *Multiple regression equation with confidence interval (P = 0.01) and coefficient of determination for relationship between survival of* Chrysothamnus viscidiflorus *ssp* viscidiflorus *plants and time in a common garden located at Granite Peak, Nev.*

Table 3. Survival of green and gray rabbitbrush plants grown in a common garden for 10 years.[a]

Species & Subspecies	Collection No.	Survival in Years						
		1	2	3	4	5	8	10
Green rabbitbrush								
C. viscidiflorus								
viscidiflorus	1	95a	95a	68cd	48f	15de	0g	0e
	2	100a	100a	33c	20g	10df	0g	0e
pumilus	3	95a	63e	74cd	10h	0g	0g	0e
	4	80b	78bc	36e	36f	10df	0g	0e
puberulus	5	100a	78bc	66cd	36f	10df	10df	0e
	6	100a	69ce	41e	41f	15de	5eg	0e
latifolius	7	95a	81b	81bc	43f	60b	25c	5de
	8	100a	100a	100a	93ab	80b	60b	15c
Gray rabbitbrush								
C. nauseosus								
consimilis	9	100a	100a	83bc	71cd	50b	35	10de
	10	100a	100a	100a	100a	100a	100	100a
albicaulis	11	95a	95a	95ab	66de	40b	20	5
	12	100a	100a	100a	100a	100a	100	100a
salicifolius	13	100a	71b-e	61d	48f	40b	40	40b
	14	95a	66de	66cd	53ef	55b	55	35b
hololeucus	15	100a	100a	100a	83bc	45b	15	0e
	16	100a	100a	78cd	65de	35c	0	0e

[a]Means within columns followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test.

of *C. viscidiflorus* spp. *viscidiflorus* the coefficient of determination (r^2) for the relationship between time and survival was 0.84 (Fig. 1). This was fairly typical for the green rabbitbrush collections.

The gray rabbitbrush collections were longer lived as typified by collection number 9 of the *C. nauseosus* ssp. *consimilis* (Fig. 2).

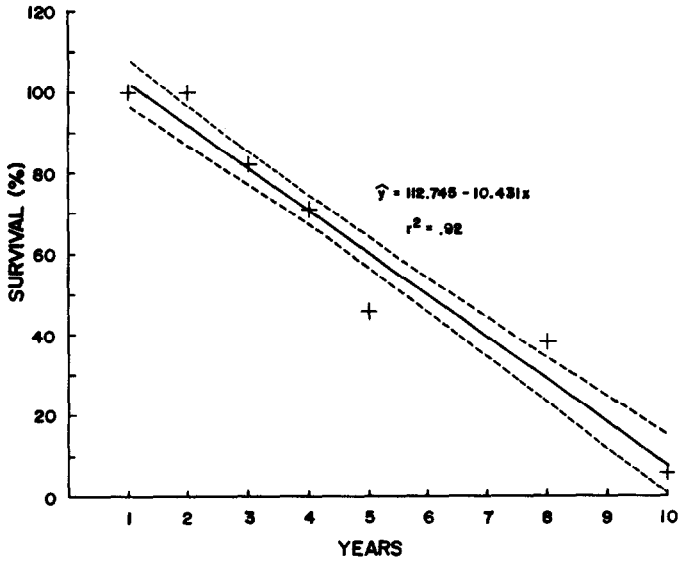

Fig. 2. *Multiple regression equation with confidence interval (P = 0.01) and coefficient of determination for relationship between survival of* Chrysothamnus nausosus *ssp.* consimilis *and time in a common garden located at Granite Peak, Nev.*

Correlation between persistence and time was low for collections 13 and 14 of *C. nauseosus* ssp. *salicifolius* because plant survival was influenced by rabbitbrush predation.

If the garden had been developed with greater spacing among plants, survival of all collections probably would have been extended. However, the same relative persistence probably would have been apparent. If one assumes equal chance of seed distribution from the randomized block arrangement of the common garden, it would appear that collection number 10 of *C. nauseosus* ssp. *consimilis* was the most successful colonizing plant material in the garden. This rating is based on the total density of seedlings in all plots and the exclusion of seedlings of other subspecies of gray rabbitbrush from plots of *C. nauseosus* ssp. *consimilis.*

The remarkable part of the persistence and colonizing ability of the collection of *C. nauseosus* ssp. *consimilis* is that the plant material is almost never found growing naturally on the soils or in the natural vegetation of the site of the common garden. The subspecies is adapted to saline/alkaline environments.

Rabbitbrush Seedling Establishment

Many rabbitbrush seedlings established naturally in the common garden, and most were seedlings of gray rabbitbrush (Table 4). Seedlings of *C. nauseosus* spp. *consimilis* were quite distinguishable from seedlings of other gray rabbitbrush subspecies and there were about 1.5 times as many of them as all other gray rabbitbrush seedlings. In many of the plots, the density of seedlings far exceeded what is ordinarily found in plant communities, and probably seedling numbers exceeded the site potential, although some of the seedlings were flowering in 1982.

The greatest density of rabbitbrush seedlings was found in plots of *C. nauseosus* ssp. *hololeucus* (Table 4). Seedlings in these plots were comprised of 46% *C. nauseosus* ssp. *consimilis* and the remainder of other gray rabbitbrush subspecies. Plots of *C. nauseosus* ssp. *consimilis* did not contain any seedlings of other subspecies of gray rabbitbrush. Plots of collection 12 of *C. nauseosus* ssp. *albicaulis* did not contain any seedlings of *C. nauseosus* ssp.

Table 4. Density (per m²) of green and gray rabbitbrush seedlings growing between mature rabbitbrush plants in a 10-year-old common garden. Gray rabbitbrush seedlings are classified as belong to the *C. nauseosus consimilis* or other subspecies.[a]

Species & Subspecies	Collection No.	Rabbitbrush Seedling Density			
		Green	Consimilis	Gray Other	Total
		——per m²——			
Green rabbitbrush *C. viscidiflorus*					
viscidiflorus	1	2	18b-d	0d	20bc
	2	0	22ab	0d	22bc
pumilus	3	0	5gh	5cd	10ef
	4	0	12fg	4d	16de
puberulus	5	0	4gh	11b	15de
	6	0	4gh	3d	7fg
latifolius	7	0	0h	1d	1g
	8	0	0hnf	3d	3g
Gray rabbitbrush *C. nauseosus*					
consimilis	9	0	21a-c	0d	21bc
	10	0	26a	0d	26ab
albicaulis	11	0	5gh	18a	23bc
	12	0	0h	18a	18cd
salicifolius	13	0	7f-h	8bc	15de
	14	0	13d-f	4	17cd
hololeucus	15	0	15c-e	18a	33a
	16	0	10e-g	11b	21bc

[a]Means followed by the same letter within columns are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test.

consimilis. In plots of the other collection of *C. nauseosus* ssp. *albicaulis* 22% of the seedlings belonged to *C. nauseosus* ssp. *consimilis.*

In contrast to the very high rabbitbrush seedling density in most plots of gray rabbitbrush, the plots of *C. viscidiflorus* ssp. *latifolius* had very few seedlings (Table 4). All plots of green rabbitbrush averaged only 12 seedlings per m², whereas the plots of gray rabbitbrush averaged 22 rabbitbrush seedlings per m². Remember all of the green rabbitbrush plants, except a low percentage of the plants of *C. viscidiflorus* ssp. *latifolius* were dead by the 10th year of the garden.

A complicating factor in rabbitbrush seedling establishment was the presence of cheatgrass (*Bromus tectorum* L.). This highly competitive annual infested the green rabbitbrush plots and utilized the environmental potential, especially after most of the shrubs died. The meter-tall and vigorous gray rabbitbrush plants growing on only 1-m centers largely suppressed the understory of cheatgrass. Cheatgrass can out compete seedlings of perennial grasses for moisture in this environment (Evans et al. 1970) and competition for moisture may play a role in rabbitbrush seedling establishment with high water tables (Roundy et al. 1981). Adaptation of subspecies of rabbitbrush to specific environments may be predicated on factors other than moisture availability, mineral nutrition, and light. Biotic factors such as insect predators (Young and Evans 1974b), susceptibility to grazing, or the nature and amount of sprouting after being burned in wildfires may be at least partly responsible for distribution patterns. Robertson and Cords (1957) suggest that some forms of gray rabbitbrush were relatively susceptible to fire because they sprouted from stem buds rather than crown buds. Hanks et al. (1975) indicated much variability in utilization by sheep among subspecies of gray rabbitbrush. Results of this study establish patterns of jackrabbit utilization similar to those found in sheep. Severe defoliation of rabbitbrush by rabbits, especially in dry zones, might be very detrimental.

Results of the study hint at the remarkable diversity among

subspecies of rabbitbrush in important characteristics that affect survivability in relation to many factors on rangelands. Knowledge of this diversity can also be utilized in decisions of range managers' control and revegetation projects.

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