

Seedstalk production of mountain big sagebrush enhanced through short-term protection from heavy browsing

FRED J. WAGSTAFF AND BRUCE L. WELCH

Abstract

Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* Nutt.) is an important browse species on many key mule deer winter ranges in the western United States. Big sagebrush on many of those ranges is declining due to the lack of recruitment. Plants subjected to heavy (> 80% use) browsing produce 50 to 93% fewer seedstalks than those not subject to such use. The objectives of this study were to determine: (1) whether protection from browsing for 1 winter would increase the number of seedstalks the following fall; (2) if protection increased length of seedstalk; (3) if there is a relationship between seedstalk length and number of seeds per seedstalk; and (4) if increasing seed production increased seedling establishment. Fifty-eight plots containing 344 plants at 4 sites in north-central Utah were established. At each plot, plants were randomly assigned to be either protected or browsed. The protected plants produced significantly ($P < 0.05$) more seedstalks than those browsed during the previous winter. Length of seedstalks on a given plant and among plants showed considerable variation, and the data indicated no clear differences between average seedstalk length on browsed and protected plants. Seed per unit length of seedstalk was also highly variable. No seedlings were found during 7 years of observations of the original plot or in 4 years for the 57 plots established in 1986, regardless of the numbers of seedstalks on a plant. Seed production does not appear to be a limiting factor in seedling establishment for the study populations.

Key Words: *Artemisia tridentata* ssp. *vaseyana*, mountain big sagebrush, seedstalk production, browsing, seed production

Big sagebrush (*Artemisia tridentata* Nutt.) is a major plant in a large and important ecosystem in western North America (Beetle 1960). Within the literature most early studies are descriptive in nature and a great number of papers deal with control by various means. The investigations of the effects of various control and management strategies revealed much about the biology of big sagebrush, and several workers have published studies about its taxonomy (Winward and Tisdale 1977, Hironaka et al. 1983, McArthur 1983, Winward 1983). Of the 4 major subspecies of big sagebrush, mountain big sagebrush (*A. tridentata* ssp. *vaseyana*) was utilized by wintering mule deer most frequently along the Wasatch Front of Utah. It also is important as browse in other areas (Nagy 1979, McAdoo and Klebenow 1979, Welch 1983b, Personius et al. 1987, Young et al. 1989). Some localities are known to produce plants that are exceptionally preferred (Welch 1983a, Welch et al. 1986, McArthur et al. 1987).

In sagebrush stands on the foothills adjacent to the urban area known as the Wasatch Front of Utah, much plant mortality of mountain big sagebrush is evident and is of concern because urban encroachment is reducing the area available for wintering mule deer.

Heavy winter browsing (>80% use) is believed to reduce the

number of seedstalks produced the following growing season. If continued, heavy browsing can reduce plant vigor and may cause large reductions in plant stands (Smith 1949, Smith and Gaufin 1950, Cook and Stoddard 1960, Welch et al. 1987, McArthur et al. 1988).

We believe the low production of seedstalks may be due to heavy mule deer browsing, and the resulting low seed production per sagebrush plant may be an important factor in the lack of recruitment in mountain big sagebrush populations along the Wasatch Front. We developed this study to determine: (1) if protection from browsing for 1 winter would increase the number of seedstalks, (2) if protection increased length of seedstalks, (3) if seed production was correlated with seedstalk length, and (4) if increased seed production increased seedling establishment.

Methods and Materials

This study was conducted in the foothills of the Wasatch mountains in north-central Utah near the city of Provo. The Hobble Creek and Pleasant Grove sites near the lower edge of the ssp. *vaseyana* type are about 1,027 m elevation and the Diamond Fork site is slightly higher, about 1,646 m. Soils, sampled at several locations at all of the sites, were derived from limestone parent material. The soils are alluvial and of a loamy texture with no restrictive layers. A chemical analysis of the soils found no major nutritive or chemical deficiencies or restrictions.

The 4 sites chosen for study are used as winter range by mule deer. At all sites big sagebrush plants exhibit the effects of heavy browsing. Cattle graze the Diamond Fork area on a rest rotation system, and the other 3 sites have been closed to livestock grazing for over 20 years. Sagebrush populations in each of the study areas have 40–50% dead plants and no observed recruitment for the past several years.

The site named Hobble Creek 1 includes the area fenced in 1983 to provide foundation seed for 'Hobble Creek' mountain big sagebrush. Since the area was quite small, only 1 plot was established. Six years of observation for this site are included in tables 1 and 4. The other sites were studied to expand the data base and to determine whether a one-season rest would have a significant effect on seedstalk production.

At each site plants of approximately the same size were randomly selected and grouped into plots of 4, 6, or 20 plants arranged so that no plant in a plot was more than 61 m away from the most distant plant in that plot. The plots were widely distributed across each site in case environmental differences within the site were present but not readily apparent. At the Hobble Creek 2 site, 21 plots of 6 plants each were established; at Pleasant Grove 27 plots of 6 plants each; at Diamond Fork 9 plots of 4 plants; and the Hobble Creek 1 site had 1 plot of 20 plants. A total of 58 plots with 344 plants total were included. At each plot, the treatment was assigned randomly to half of the plants. To prevent browsing, a wire cage was constructed of net field fencing sides and chicken wire tops supported by 2 steel posts 2 m tall, large enough to assure 30 cm of space around the plant and tall enough to provide 30 cm of headspace. Seedstalks were counted and measured on all of the

Range economist and principal research plant physiologist, Intermountain Research Station, Forest Service, USDA, Ogden, Utah 84401.

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plants on the Hobbie Creek 1 plot from 1984 to 1989, and on the other plots in the fall of 1986 to 1989. At each site we selected 100 seedstalks at random from protected plants and a like number from browsed plants. Four size classes and 2 form classes were used to stratify the sample, and the number of seeds per stalk were counted. Statistical analysis was completed using Student's *t*-test and analyses of variance procedures of the Minitab (tm) software package (Ryan et al. 1985). Comparisons on seedstalk numbers and length were made between treatments for 6 years on the Hobbie Creek 1 plot and 1 year on all other plots. The number-of-seeds per stalk study was conducted for 1987 only.

Results and Discussion

Analyses of data for the Hobbie Creek 1 site indicate a significant treatment difference in seedstalk production in each of the 6 years. The data in Table 1 show a trend toward increasing seed production for each year of protection. How long this trend will continue is uncertain. On this plot the relatively low plant density may be a partial explanation of this continual increase.

Table 1. Average number of seedstalks per plant on mountain big sagebrush at one site (Hobbie Creek 1) in north central-Utah.

Year	Protected	Browsed	Increase
1984	116	6	110*
1985	165	11	154*
1986	183	12	171*
1987	206	65*	141*
1988	240	18	222*
1989	336	6	330*

*Significant at the 0.05 level.

There were significant differences in various characteristics of the study plants due to the treatment (protection during 1 winter). Seed stalk production in 1987 was significantly greater at the 2 Hobbie Creek sites. The Diamond Fork site had significantly lower seed stalk production on both browsed and protected plants in 1987. Considerable variation was noted in our data because seedstalk production is a function of genetics, plant age, vigor, climate, site characteristics, and browsing pressure. Variation in seed production among sagebrush populations of the same subspecies has been noted in other studies (Young et al. 1989, Wagstaff and Welch 1990). Seedstalk production on protected plants for 1984-1989 increased significantly ($P < 0.05$) on the Hobbie Creek 1 site and for all plots in 1987. All browsed plants with the exception of those plots at the Diamond Fork site also had greater numbers of seedstalks in 1987. Browsed plants on all plots showed a return to low levels of seedstalk in 1989. Difference in production between years is probably due to a combination of factors including favorable moisture during the 1987 growing season. Additional information can be gained by looking at certain characteristics of the plants at each of the sites as shown in Tables 4 and 5.

We conclude that for the subject populations the protection of mountain big sagebrush plants from browsing by wintering mule deer for 1 winter resulted in an increased number of seedstalks.

Table 2. Average number of seedstalks per plant on mountain big sagebrush at 3 sites in north-central Utah.

Year	Hobbie Creek			Pleasant Grove			Diamond Fork		
	Protected	Browsed	Increase	Protected	Browsed	Increase	Protected	Browsed	Increase
1986		11			6			5	
1987	178	61	119*	153	11	142*	75	7	62*
1988		18			7			6	
1989		16			5			7	

*Significant at the 0.05 level.

Table 3. Seeds per seedstalk of single-stemmed and branched seedstalks of mountain big sagebrush in north-central Utah 1987.

Length of stem (cm)	Type of seedstalk					
	Single stem			Branched		
	Pct. with No. seed	Max No. seeds	Avg. No. seeds	Pct. with No. seed	Max No. seeds	Avg. No. seeds
0-15.24	50*	9	6	5	115	8
15.25-25.4	33*	104	17	3	718	156*
>25.5	0	183	69	0	1601	319*

*Significant at the 0.05 level.

Lengths of seedstalks were not significantly different at the 2 Hobbie Creek sites and Diamond Fork. The length difference at Pleasant Grove in 1987 may be attributable to heavier use of browsed plants, which was also indicated by seedstalk numbers (Table 2).

The data led us to conclude that lack of seed production is not responsible for the low recruitment of plants in the study populations. We found no recruitment around study plants even though mountain big sagebrush has been noted for aggressiveness and ability to increase (Blaisdell et al. 1982). Still, it may be desirable to enhance seed production because mountain big sagebrush propagates only from seed and climatic conditions suitable for establishment occur sporadically (Johnson and Payne 1968, Brunner 1972, Young and Evans 1975, Caldwell 1979, Walton et al. 1986).

Several studies show a considerable variability in germination and establishment of seedlings due to a combination of climatic factors such as temperature and moisture (Johnson and Payne 1968, Young and Evans 1975, Harniss and McDonough 1976).

We could find nothing in the literature to indicate a method of predicting whether conditions favorable to seedling establishment would occur in any given year. In a recent study we found considerable seedling establishment in 1988, after seedbed preparation, at various levels of seed production and dispersal by mother plants,

Table 4. Selected characteristics of seed stalks on mountain big sagebrush plants on 1 site (Hobbie Creek 1) in north-central Utah.

Characteristic	1984	1985	1986	1987	1988	1989
Seed stalks max/plants						
Protected	182*	389*	419*	429*	432*	460*
Browsed	26	11	12	65	14	6
Percent of plants with zero						
Protected	0	0	0	0	0	0
Browsed	20*	10*	10*	10*	10*	10*
Avg. length (cm)						
Protected	28.6	21.7	20.8	22.6	21.7	24.0
Browsed	19.7	18.7	18.1	18.2	19.0	22.2

*Differences significant at the 0.05 level.

Table 5. Selected characteristics of seed stalks on mountain big sagebrush plants on three sites in north-central Utah.

Characteristics	Hobble Creek 2			Pleasant Grove			Diamond Fork		
	1986	1987	1989	1986	1987	1989	1986	1987	1989
Seed stalks max/plants									
Protected	----- 535* -----			----- 476* -----			----- 426* -----		
Browsed	94	273	81	45	77	38	18	36	19
Percent of plants with zero									
Protected	----- 0 -----			----- 4 -----			----- 17 -----		
Browsed	49	2*	21	44	25*	42	42	50*	29
Avg. length (cm)									
Protected	----- 17.91 -----			----- 18.16* -----			----- 14.94 -----		
Browsed	18.24	17.91	23.4	6.46	9.68	7.2	13.97	11.25	12.1

*Difference significant at the 0.05 level.

although that winter and spring set records for low precipitation (Wagstaff and Welch 1989).

Presence of seed is a necessary condition to seedling establishment, but other factors such as plant competition and climate may also be limiting. We found no seedlings on our study plots during 6 years of observations, even though many plants produced seed sufficient to cover the effective distribution area at a rate of several hundred seeds per square meter. Managing those factors that can be controlled, such as increased seed production, by protecting or otherwise controlling browsing levels may enhance the chances of establishing seedlings.

We have also observed that within the study populations, some plants are not browsed to the degree most other plants are. Because these plants are not used as heavily, they are producing far more seed and stand a greater chance of leaving progeny. Therefore, it seems possible that the more desirable plants will be the first to disappear from the populations, and unless they receive periodic rest they will leave insufficient progeny to replace themselves. The population structure would then shift toward a higher proportion of apparently less desirable plants.

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