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Recovery of big sagebrush communities after burning in south-western Montana

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*Prescribed burning of big sagebrush (*Artemisia tridentata *Nutt.) communities is conducted with the intention of increasing either the productivity of the understory plants or the big sagebrush. It was our objective to compare the recovery of big sagebrush communities from prescribed fire at as many sites as we could locate in south-western Montana with environmentally paired unburned portions. We located and sampled 13 sites that had been burned over a span of two to 32 growing seasons earlier. Big sagebrush canopy cover, density, and production of winter forage were significantly greater ($P \leq 0.05$) in the unburned portions in 34 of 38 comparisons. Canopy coverage of Idaho fescue (*Festuca idahoensis *Elmer), the dominant herbaceous species, was greater in the burned portion at only one site while it was less ($P \leq 0.05$) at four sites. Total perennial grass canopy coverage was not different ($P \leq 0.05$) between treatments over the 13 sites. Managers considering prescribed burning of big sagebrush communities should be aware that herbaceous plant responses may be minimal while shrub values will likely be lost for many years. The loss of the dominant shrubs in any ecosystem will affect many other organisms and severely impact species that have an obligate habit with the shrubs.*

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Introduction

Big sagebrush (*Artemisia tridentata* Nutt.) is arguably the most important plant species on rangelands in the western United States. It was estimated by Beetle (1960) to occupy approximately 60 million hectares in the region. Since that estimate there have been significant reductions in the species distribution. A large portion of the species decline can be traced to its low preference for forage by cattle, despite a variety of ecosystem values the species offers. The impact of big sagebrush reduction has been especially negative to many native wildlife species, including a number of obligates such as the threatened sage grouse (Welch and McArthur, 1979; Wambolt, 1998; Welch, 1999). During the last 50 years the loss of millions of hectare of big sagebrush in the western United States from burning or other treatments to provide an anticipated advantage for herbaceous understory species and thereby livestock forage has occurred. It is interesting that big sagebrush reduction by a variety of treatments has not always resulted in anticipated increases of herbaceous production (Blaisdell, 1953; Daubenmire, 1975; Peek *et al.*, 1979; Anderson and Holte, 1981; Kuntz, 1982; McNeal, 1984; Mangan and Autenrieth, 1985; Sturges and Nelson, 1986; Wambolt and Payne, 1986; Fraas *et al.*, 1992; Wambolt and Watts, 1996). Where herbaceous production has increased following sagebrush reduction, the cause of the increase is often difficult to determine. In general, changes in grazing management or other improvements accompany the sagebrush treatment.

It is somewhat of a paradox that more recently, land managers have often stated an objective to increase productivity of big sagebrush taxa through prescribed burning programs similar to those practiced in the past to eliminate the same taxa. It is interesting that they usually cite all the values of a mature sagebrush community as their

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justification. This implies that recovery of sagebrush will occur soon after burning. However, research on a variety of sagebrush control treatments in south-western Montana (McNeal, 1984; Wambolt and Payne, 1986; Watts and Wambolt, 1989; Fraas *et al.*, 1992; Wambolt and Watts, 1996; Watts and Wambolt, 1996; Wambolt *et al.*, 1999) and south-eastern Idaho (Harniss and Murray, 1973) found that big sagebrush recovery was prolonged, with completion sometimes taking as long as 30 years. This was true even in the absence of heavy browsing which further suppresses recovery (Wambolt, 1996; Wambolt and Sherwood, 1999).

The studies, mentioned above, were conducted at only one location, with the exception of Wambolt *et al.* (1999). They often involved sagebrush control treatments other than burning. Therefore, we conducted this study in order to better understand the recovery of big sagebrush communities following prescribed fire in south-western Montana. This investigation was designed to consider burning treatments at multiple locations that could potentially have variable recovery intervals. This approach should determine if big sagebrush recovery is indeed a slow process following burning or if the limited previous findings were anomalies. Our objective was to compare the recovery of big sagebrush communities from prescribed fire at as many sites as we could locate with environmentally paired unburned portions. We intended to include as wide a range of time intervals between burning and sampling as possible over the sites. This should ensure that future prescribed burning of big sagebrush communities will have a factual basis for treatment-related expectations. We anticipate that the results of this study may lead to similar investigations in other native shrub ecosystems.

Methods

Study sites

Thirteen sites located throughout south-western Montana were studied (Figure 1). The 13 sampled sites were the only sites we found to meet our criteria for inclusion. First, sites had to be typical of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* [Rydb.] Beetle) and Wyoming big sagebrush (*A. t.* ssp. *wyomingensis* Beetle and Young)—grass communities in the region. Second, we wanted to study prescribed burns only, not wildfires, with a wide range of ages. Third, sites had to differ in either season of burn, slope, aspect, soil characteristics, or elevation (Table 1). Finally, each of the study sites had to consist of environmentally paired burned and unburned portions of ≥0·25 ha each, located adjacent to one another. This ensured meaningful comparisons of community parameters.

At each site, the burned and unburned paired portions were similar in all the environmental characteristics mentioned above. Mountain big sagebrush and Idaho fescue (*Festuca idahoensis* Elmer) were the dominant shrub and grass on all but three sites. These latter sites had an overstory of Wyoming big sagebrush with an understory dominated by bluebunch wheatgrass (*Agropyron spicatum* [Rydb.] Scribn.). Wyoming big sagebrush was a minor shrub component to mountain big sagebrush at seven sites (Table 2). All sites had loam soils; predominately clay loam at the three Wyoming big sagebrush sites, sandy loam at the Steep Mountain and Jeff Davis sites, and silt loam at the remainder. Although precipitation records are sparse, isohyets in the region indicate that annually the amounts vary between 356 mm and, 425 mm at the 13 sites. Half of the annual precipitation is received as snow, with May and June being the wettest months.

Sampling and analysis

Sampling was carried out during late summer in 1995 and 1996. This timing, in combination with the distribution of precipitation, assured that each year nearly all the annual growth had occurred at the site prior to sampling. Therefore, sampling occurred near the time of peak standing crop at each site. Big sagebrush taxa and herbaceous species were both evaluated. At each site, all vegetation measurements were taken in a similar manner within the burned and unburned treatments.

Big sagebrush recovery was evaluated on the basis of canopy coverage, plant density, and production of winter forage for browsers.

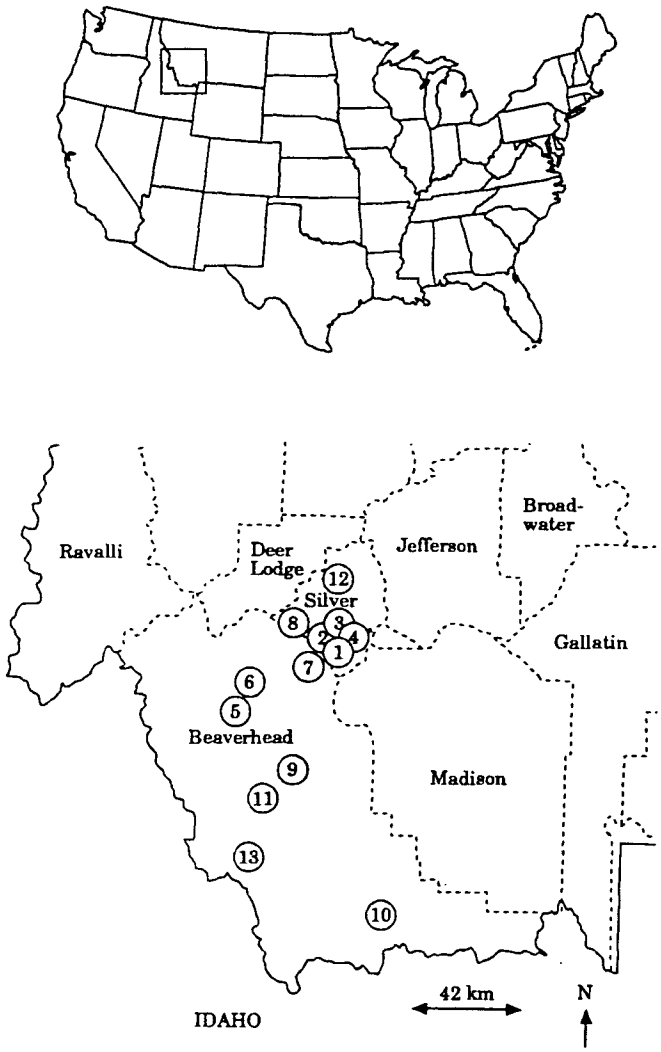

Figure 1. Locations of the 13 big sagebrush sites in south-western Montana. Sites: 1, Wise River South; 2, Wise River West; 3, Wise River North; 4, Wise River East; 5, Wisdom Plat; 6, Wisdom Slope; 7, Sawmill Gulch; 8, West Fork; 9, Badger Pass; 10, Snowline; 11, Exclosure; 12, Steep Mountain; 13, Jeff Davis.

Canopy coverage of big sagebrush and other shrubs was measured along six stratified 30-m transect lines in each of the burned and unburned treatments. The six transects provided an adequate sample (Steel and Torrie, 1980). The six transects were stratified so that each transect would represent an equal-sized portion of the treatment at a site. The line interception method, modified after Canfield (1941) was used along each transect to obtain percent shrub canopy coverage. All shrub canopy segments of at least 3 cm were included. Only live canopy was measured. Density and production of winter forage was recorded for established big sagebrush plants (≥15 cm average crown cover from four measurements). Previous observations in this region found that plants with an average crown cover <15 cm are not reliably established and do not contribute significant production to the community (Wambolt and Sherwood, 1999). However, the juvenile big sagebrush plants with average crown cover <15 cm were also counted separately from established plants. Density of big sagebrush was determined using six stratified belt transects 2-m wide, centered on the 30-m transect lines used to measure cover. Therefore,

Table 1. Date of prescribed burn, number of growing seasons between burning and sampling, and topographic characteristics at 13 big sagebrush study sites in south-western Montana

Site	Date of burn	Growing seasons	Slope (%)	Aspect (degrees from N)	Elevation
Wise River South	Apr. 1989	7	3	175	2000
Wise River West	26 Oct. 1987	8	6	270	2000
Wise River North	26 Oct. 1987	8	6	330	2000
Wise River East	26 Oct. 1987	8	5	30	2000
Wisdom Flat	6 Apr. 1987	9	0	0	1830
Wisdom Slope	6 Apr. 1987	9	4	20	1840
Sawmill Gulch	19 Apr. 1989	7	16	90	2220
West Fork	Apr. 1994	2	7	70	1950
Badger Pass	1 Oct. 1981	14	8	310	2090
Snowline	1985	11	4	30	2040
Exclosure	4 Sept. 1964	32	2	330	1890
Steep Mountain	3 Nov. 1981	15	22	200	1950
Jeff Davis	29 Sept. 1980	16	20	140	2290

Table 2. Big sagebrush percent canopy cover by subspecies and burning treatment at 13 study sites in south-western Montana with year of observation and number of growing seasons between burning and sampling

Site	Mountain big sagebrush[1]		Wyoming big sagebrush[2]		Observation year	Growing seasons
	Burned (%)	Unburned (%)	Burned (%)	Unburned (%)		
Wise River South	0·0[a]	8·7[b]	0·0[c]	0·9[d]	1995	7
Wise River West	3·5[a]	12·7[b]	0·5[c]	3·0[d]	1995	8
Wise River North	4·2[a]	13·4[b]	0·3[c]	1·0[d]	1995	8
Wise River East	2·9[a]	15·4[b]	0·0[c]	1·4[d]	1995	8
Wisdom Flat	—	—	11·1[c]	11·6[c]	1995	9
Wisdom Slope	—	—	13·4[c]	13·9[c]	1995	9
Sawmill Gulch	0·6[a]	16·9[b]	0·0[c]	3·8[d]	1995	7
West Fork	0·0[a]	18·2[b]	0·0[c]	4·1[d]	1995	2
Badger Pass	3·7[a]	28·3[b]	0·0[c]	1·6[d]	1995	14
Snowline	0·0[a]	22·9[b]	—	—	1995	11
Exclosure	—	—	9·1[c]	12·6[d]	1996	32
Steep Mountain	0·5[a]	12·9[b]	—	—	1996	15
Jeff Davis	3·1[a]	24·0[b]	—	—	1996	16

[1]Means between burned and unburned mountain big sagebrush differ ($P \leq 0{\cdot}001$) at a common site when followed by a different letter.
[2]Means between burned and unburned Wyoming big sagebrush differ ($P \leq 0{\cdot}05$) at a common site when followed by a different letter.

360 m^2 was sampled in each burned and unburned treatment. Estimates of production of winter forage from big sagebrush were based on big sagebrush subspecies and browse form classes following procedures ($R^2 = 0{\cdot}94$) detailed by Wambolt *et al.* (1994).

Production estimate measurements were taken on 60 plants per treatment, selecting 10 plants on each of the six transect lines. The big sagebrush plant closest to the 2-m mark was sampled first with remaining plants sampled at 3-m intervals.

Herbaceous plant recovery was evaluated by comparing canopy cover between burned and paired-unburned portions of each study site. Grass and forb canopy covers were estimated using the canopy-coverage method of Daubenmire (1959). Thirty 20 cm × 50 cm plots measured at each meter along the 30-m shrub cover transects were used to record herbaceous canopy.

Exploratory data analysis found unequal variances from site to site. As a consequence, two-sample t procedures (Steel and Torrie, 1980) were used at each site and over all sites to test for differences ($P \leq 0{\cdot}05$)

in big sagebrush canopy coverage, density, and production of winter forage, along with canopy coverage for grasses and other shrubs where they occurred. At individual sites, transect means for each treatment parameter were compared with the t-test. To test treatment parameters over all 13 sites a paired t-test was used to compare site means. Simple and multiple regression analyses (Steel and Torrie, 1980) were conducted ($P \leq 0.05$) over all study sites to learn if any site or temporal variables were significantly correlated with the shrub parameters, mentioned above.

Results and discussion

Shrub canopy cover

The overall comparison between burned and unburned treatments at the study sites dominated by mountain big sagebrush found that sagebrush canopy cover was lower ($P \leq 0.001$) on burned areas than on unburned areas. Comparisons at individual study sites found mountain big sagebrush was greater ($P \leq 0.001$) in unburned treatments at all 10 sites where it was the dominant sagebrush, regardless of the time elapsed since the burn (Table 2). This indicates that burning may decrease mountain big sagebrush canopy cover for more than 16 years. On the Jeff Davis site, 16 years after burning, sagebrush cover in the burned area was only 13% of that in the unburned area.

Fraas *et al.* (1992) reported mountain big sagebrush canopy cover in the burned treatment at the Steep Mountain site was 1·0%, 9 years after burning in 1990. In July 1996, at the same location, we found canopy cover was a similar 0·5%. However, Fraas *et al.* (1992) reported mountain big sagebrush canopy cover in unburned treatments was 7·2% in 1990 compared to the 12·9% we found in 1996. Big sagebrush did not re-establish on the burned area at this site during this 6-year sampling interval (10–15 years after burning), while its canopy cover almost doubled on the unburned portion of the site. The increase in sagebrush on the unburned portion indicates that desirable environmental conditions for sagebrush growth existed between 1990–1996.

Canopy cover at the three sites dominated by Wyoming big sagebrush was more variable than at the 10 mountain big sagebrush sites. The two sites in the Wisdom area had no difference ($P \leq 0.05$) in canopy cover between burned and unburned treatments (Table 2). However, the exclosure site still had greater canopy cover ($P \leq 0.05$) in the unburned portion 32 growing seasons after the burn. Harniss and Murray (1973) and Watts and Wambolt (1996) suggested big sagebrush required 30 years after burning before canopy cover was not different from control plots. The exclosure site indicates more than 30 years may be required for Wyoming big sagebrush recovery. Canopy cover was reduced ($P \leq 0.05$) by burning for the pooled mountain and Wyoming big sagebrush in the Sawmill Gulch, West Fork, Badger Pass, and Snowline sites.

Several sites had important shrubs in addition to mountain or Wyoming big sagebrush. At the Snowline site, nine growing seasons following fire, three-tip sagebrush (*Artemisia tripartita* Rydb.) was reduced ($P \leq 0.001$) by burning with 4·8% and 1·3% cover in the unburned and burned treatments, respectively. Green rabbitbrush (*Chrysothamnus viscidiflorus* (Hook.) Nutt.) was not affected by fire at this site, while gray horsebrush (*Tetradymia canescens* D.C.) cover increased ($P \leq 0.001$) from 2·3% where unburned to 7·2% where burned. Green rabbitbrush at the Steep Mountain site was still benefited ($P \leq 0.01$) 15 growing seasons after burning with 1·7% cover where burned and 0·5% where unburned. At the Jeff Davis site the difference between green rabbitbrush canopy cover in the burned portion of the site at 0·6% was not different ($P \leq 0.05$) than 0 where unburned after 16 growing seasons.

Bitterbrush (*Purshia tridentata* Pursh), an important shrub for browsing ungulates in the winter, is a common species on the Steep Mountain site. However, bitterbrush was reduced ($P \leq 0.05$) by fire with 3·1% and 4·6% cover in burned and unburned treatments, respectively, in 1996 after 15 growing seasons. Fraas *et al.* (1992) studied the same site in 1990 and reported bitterbrush canopy cover where burned was 4·6% and where unburned was 11·2%. Therefore during this 6-year period bitterbrush canopy cover decreased by 33% in burned areas and

by 59% where unburned. This may be due to excess browsing by ungulates, as nearly every bitterbrush plant in the area appeared to have been heavily browsed. The loss of bitterbrush, due to fire, in burned areas may have caused heavier browsing of bitterbrush in unburned areas, thereby harming the bitterbrush population. This scenario is substantiated because the growth since burning has been too little for the burned bitterbrush to be available above the snow on this winter range for browsing ungulates. The larger, unburned plants are not only more scarce after the fire, but also more available.

Shrub density

The overall density comparison of established plants (crown cover ≥15 cm) of mountain big sagebrush between burned and unburned treatments showed that density was also reduced ($P \leq 0.001$) by burning. At all 10 sites dominated by mountain big sagebrush, density was greater ($P \leq 0.001$) in unburned areas (Table 3). Density of unestablished juvenile (crown cover <15 cm) mountain big sagebrush showed the same general trend. Only the Wise River East site had more ($P \leq 0.05$) juvenile plants in the burned portion than unburned portion. The burned and unburned treatments were equal in juveniles at Wise River West and Wise River North. The remaining seven sites had more ($P \leq 0.05$) juvenile plants where unburned.

The response of Wyoming big sagebrush density to burning varied among sites. The Wisdom Flat site had greater ($P \leq 0.01$) Wyoming big sagebrush density for established plants in the unburned treatment, while the Wisdom Slope site had greater ($P \leq 0.001$) density in the burned treatment (Table 3). Burning appeared to have no effect ($P \leq 0.05$) on Wyoming big sagebrush density at the Exclosure site. At the seven sites where Wyoming big sagebrush was not dominant, density of the taxon was greater ($P \leq 0.05$) in unburned than burned areas. The juvenile density findings for Wyoming big sagebrush were also mixed. The Wisdom Flat and Exclosure sites had no differences ($P \leq 0.05$) between treatments, while the Wisdom Slope site had more ($P \leq 0.05$) juvenile plants in the burned treatment.

At the Snowline site three-tip sagebrush density was greater ($P \leq 0.01$) in the unburned treatments as compared to burned areas. Green rabbitbrush density was the same ($P \leq 0.05$) between treatments on this site, while gray horsebrush density increased

Table 3. Big sagebrush density of established plants (average canopy cover ≥15 cm) by subspecies and burning treatment at 13 study sites in south-western Montana with year of observation and number of growing seasons between burning and sampling

Site	Mountain big sagebrush[1]		Wyoming big sagebrush[2]		Observation year	Growing seasons
	Burned (plants/m²)	Unburned (plants/m²)	Burned (plants/m²)	Unburned (plants/m²)		
Wise River South	0.02[a]	0.65[b]	0.00[c]	0.08[d]	1995	7
Wise River West	0.24[a]	1.05[b]	0.03[c]	0.20[d]	1995	8
Wise River North	0.17[a]	1.11[b]	0.06[c]	0.10[d]	1995	8
Wise River East	0.13[a]	0.55[b]	0.00[c]	0.05[d]	1995	8
Wisdom Flat	—	—	0.80[c]	1.01[d]	1995	9
Wisdom Slope	—	—	1.66[c]	1.14[d]	1995	9
Sawmill Gulch	0.03[a]	0.93[b]	0.00[c]	0.16[d]	1995	7
West Fork	0.00[a]	1.00[b]	0.00[c]	0.25[d]	1995	2
Badger Pass	0.22[a]	1.08[b]	0.00[c]	0.08[d]	1995	14
Snowline	0.00[a]	1.01[b]	—	—	1995	11
Exclosure	—	—	0.99[c]	0.92[c]	1996	32
Steep Mountain	0.09[a]	0.79[b]	—	—	1996	15
Jeff Davis	0.16[a]	1.14[b]	—	—	1996	16

[1]Means between burned and unburned mountain big sagebrush differ ($P \leq 0.001$) at a common site when followed by a different letter.
[2]Means between burned and unburned Wyoming big sagebrush differ ($P \leq 0.05$) at a common site when followed by a different letter.

from 0·45 plants/m^2 in the unburned area to 1·28 plants/m^2 in the burned area ($P \leq 0{\cdot}001$).

At the Steep Mountain site, bitterbrush density averaged 0·3 plants/m^2 and was not different ($P \leq 0{\cdot}05$) between treatments, 15 growing seasons following fire. Fraas *et al.* (1992) also reported no significant difference in bitterbrush density between treatments at this site in 1990, after eight growing seasons. Green rabbitbrush density where unburned was 0·1 plants/m^2, while density where burned was 0·23 plants/m^2 ($P \leq 0{\cdot}001$). At the Jeff Davis site, green rabbitbrush density was greater ($P \leq 0{\cdot}001$) in burned treatments 16 growing seasons after burning ($P \leq 0{\cdot}001$).

Big sagebrush production of winter forage

Big sagebrush plants at 12 sites produced more ($P \leq 0{\cdot}05$) winter forage in the unburned treatments than the burned treatments (Table 4). Big sagebrush was not present in the burned portion at the West Fork site (not included in Table 4) therefore, production of winter forage was obviously greater in the unburned portion.

It is interesting to consider the Wyoming big sagebrush production of winter forage at the two Wisdom sites. Although the treatments at each site did not differ in canopy cover, the unburned treatment had over twice the production of winter forage of the burned treatments. This is attributed to the larger size individual plants in the unburned portion.

The burned treatments at the Exclosure site had less ($P \leq 0{\cdot}05$) Wyoming big sagebrush production of winter forage than where unburned, 32 growing seasons after treatment. The only significant correlation ($r = 0{\cdot}88; P \leq 0{\cdot}001$) found among sagebrush parameters and site or temporal variables was that between sagebrush production where burned and the number of growing seasons since burning occurred. No significant correlations ($P \leq 0{\cdot}05$) were found between big sagebrush canopy cover or density and site or temporal variables.

Herbaceous canopy cover

Harniss and Murray (1973) working on a site in near-by south-eastern Idaho suggested Idaho fescue was damaged severely by burning in the short-term, but nearly recovered 30 years after burning. Our overall comparison for the 13 study sites between burned and unburned treatments indicates that Idaho fescue canopy cover may not necessarily be significantly reduced by burning ($P \leq 0{\cdot}05$). However, we found four out of the 13 sites had significantly greater ($P \leq 0{\cdot}05$) canopy

Table 4. Total big sagebrush production of winter forage by burning treatment at 11 of the 13 study sites[1] in south-western Montana with year of observation and number of growing seasons between burning and sampling

Site	Burned[2] (kg/ha)	Unburned[2] (kg/ha)	Observation year	Growing seasons
Wise River South	4[a]	908[b]	1995	7
Wise River West	50[a]	1035[b]	1995	8
Wise River North	33[a]	860[b]	1995	8
Wise River East	2[a]	614[b]	1995	8
Wisdom Flat	165[a]	346[b]	1995	9
Wisdom Slope	155[a]	397[b]	1995	9
Sawmill Gulch	3[a]	1165[b]	1995	7
Snowline	0[a]	1137[b]	1995	11
Exclosure	431[a]	783[b]	1996	32
Steep Mountain	80[a]	667[b]	1996	15
Jeff Davis	139[a]	1182[b]	1996	16

Only established plants (average crown cover ≥15 cm) are included.
[1]The West Fork site had no sagebrush present in the burned treatment, thus, sampling was not required to determine that indeed a significant difference existed. At the Badger Pass site missing data prevented reporting these results.
[2]Means between burning treatments are significantly different ($P \leq 0{\cdot}05$) at a common site when followed by a different letter.

cover of Idaho fescue in unburned treatments (Table 5). The Badger Pass and Jeff Davis sites burned 14 and 16 growing seasons prior to sampling, respectively. Burning, however, still reduced Idaho fescue canopy cover. Idaho fescue was significantly greater in the burned treatment at only the Wise River South site. The remaining eight sites showed no difference between treatments. No clear relationship was observed between burn age and Idaho fescue recovery. The degree of damage to this species likely depends on site-specific burn conditions.

Total perennial grass canopy cover over all 13 sites was not different ($P \leq 0.05$) between burned and unburned treatments. However, perennial grass response was quite variable (Table 5). Although generally not statistically different ($P \leq 0.05$), perennial grass canopy cover was numerically greater in unburned treatments at seven sites and greater in burned treatments at six sites. Only the Wise River South and North sites had significant differences ($P \leq 0.05$) in perennial grass cover between burned and unburned treatments. It is interesting that the West Fork site had no difference ($P \leq 0.05$) between treatments two growing seasons after the fire (50% cover in burned vs. 47% in unburned). This was a site where logically burning might be expected to produce more perennial grasses because most herbaceous responses to burning are thought to occur the first few years following fire (Harniss and Murray, 1973). The Exclosure site after 32 years also had similar perennial grass canopy cover in the burned and unburned treatments. Perennial forb canopy cover response to burning was similar to the grasses with no overall difference ($P \leq 0.05$) between treatments. These data indicate that reducing big sagebrush cover may not result in additional herbaceous understory production.

Conclusions and management implications

Our results at 13 locations confirm earlier indications from research in south-western Montana (McNeal, 1984; Wambolt and Payne, 1986; Watts and Wambolt, 1989; Fraas *et al.*, 1992; Wambolt and Watts, 1996; Watts and Wambolt, 1996; Wambolt *et al.*, 1999) that non-sprouting shrubs, like big sagebrush taxa, can take longer than 30 years to re-establish to pre-burn conditions. It is interesting that no clear short or long-term benefits to grasses or forbs have become evident while the shrubs, often used extensively by wildlife (Welch and McArthur, 1979; Wambolt, 1996, 1998; Wambolt and Sherwood, 1999; Welch, 1999) are suppressed by burning. We found that Idaho fescue, the dominant grass and livestock forage species, was only benefited by burning at one site. At the remaining 12 sites, Idaho

Table 5. Idaho fescue and total perennial grass percent canopy cover by burning treatment at 13 study sites in south-western Montana with year of observation and number of growing seasons between burning and sampling

Site	Idaho fescue[1]		Total perennial grass[1]		Observation year	Growing seasons
	Burned (%)	Unburned (%)	Burned (%)	Unburned (%)		
Wise River South	10.0[a]	5.8[b]	54.7[a]	36.0[b]	1995	7
Wise River West	19.3[a]	21.8[a]	44.2[a]	30.1[a]	1995	8
Wise River North	10.2[a]	5.4[a]	32.7[a]	20.8[b]	1995	8
Wise River East	3.0	0.6[a]	46.5[a]	44.9[a]	1995	8
Wisdom Flat	6.1[a]	14.1[b]	44.3[a]	52.2[a]	1995	9
Wisdom Slope	4.8[a]	7.7[a]	47.0[a]	61.7[a]	1995	9
Sawmill Gulch	9.0[a]	8.8[a]	59.9[a]	51.6[a]	1995	7
West Fork	9.9[a]	14.8[a]	49.6[a]	46.8[a]	1995	2
Badger Pass	7.3[a]	14.8[b]	43.2[a]	45.5[a]	1995	14
Snowline	13.6[a]	17.3[a]	48.7[a]	58.1[a]	1995	11
Exclosure	7.3[a]	7.0[a]	16.3[a]	20.9[a]	1996	32
Steep Mountain	0.0[a]	9.8[b]	38.8[a]	40.0[a]	1996	15
Jeff Davis	14.4[a]	40.0[b]	35.9[a]	48.6[a]	1996	16

[1]Means between burned and unburned columns within either Idaho fescue or total perennial grass differ ($P \leq 0.05$) at a common site when followed by a different letter.

45.6%

fescue was decreased in canopy cover at four sites and not impacted at the others. This failure to benefit from prescribed burning was also found for total perennial grasses and forbs. Therefore, we conclude that the opportunity to increase livestock forage from prescribed burning of sagebrush communities under environmental conditions similar to those investigated in this study are minimal. The absence of additional herbaceous production from various sagebrush control treatments has been found elsewhere in the western United States (Blaisdell, 1953; Daubenmire, 1975; Peek *et al.*, 1979; Anderson and Holte, 1981; Kuntz, 1982; Mangan and Autenrieth, 1985; Sturges and Nelson, 1986).

As Daubenmire (1970) stated, 'Range management in North America has been dominated by the narrow view that only the few plants of direct use or detriment are worth consideration'. Daubenmire (1970) pointed out that simplification of big sagebrush communities by removal of the dominant has to have significant consequences for other organisms. It is certain that this occurred on our study sites where big sagebrush canopy cover, density, and production of winter forage were significantly greater ($P \leq 0.05$) in the unburned portions in 34 of 38 comparisons. Land managers should include all the effects of burning in their decision-making. Burning has often been prescribed for big sagebrush communities without concern for long-term monitoring for potential environmental impacts. While the list of sagebrush dependent organisms grows (Welch, 1999), so do the prescribed burns in this extensive vegetative type in the western United States. This illogical process may cease as knowledge regarding the value of big sagebrush and the consequences of reducing it become better known. It seems likely that similar circumstances exist in other woody vegetative types where many organisms may have a partial or completely obligatory habit with the native shrubs.

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