

# Response of Shrubs in Big Sagebrush Habitats to Fire on the Northern Yellowstone Winter Range

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**Abstract**—A wildfire on the Northern Yellowstone Winter Range (NYWR) was studied 19 years after burning to compare relative re-establishment of three big sagebrush (*Artemisia tridentata* Nutt.) and three rabbitbrush (*Chrysothamnus* Nutt.) taxa. Recovery was minimal for all three subspecies of big sagebrush, while rabbitbrush abundance was much greater after burning. At other NYWR locations prescribed burned mountain big sagebrush (*A. t. vaseyana* [Rydb.] Beetle) characteristics at seven sites were compared with 33 unburned sites to determine the amount of recovery 10 to 14 years after burning. Mountain big sagebrush canopy coverage on unburned sites averaged 12 times that of burned sites and densities of established shrubs on unburned sites were 15 times those of burned sites.

Sagebrush (*Artemisia* L.) habitat types are important winter foraging areas for ungulates on the Northern Yellowstone Winter Range (NYWR) (Wambolt and McNeal 1987; Wambolt 1996; Wambolt 1998; Wambolt and Sherwood 1999). Basin big sagebrush (*Artemisia tridentata* Nutt. *tridentata*), Wyoming big sagebrush (*A. t. wyomingensis* Beetle and Young), and mountain big sagebrush (*A. t. vaseyana* [Rydb.] Beetle) are the dominant taxa. All three are non-sprouting and at least temporarily eliminated by fire. In addition, browsing on the NYWR is very intense (Kay 1990) and has been found to reduce sagebrush populations (Wambolt 1996; Wambolt and Sherwood 1999). The loss of big sagebrush taxa can impact numerous wildlife populations for which they provide habitat requirements (Welch 1997). Big sagebrush is particularly important for ungulates during winter as a nutritious forage (Welch and McArthur 1979) and for thermal and security cover. When big sagebrush is reduced, long-term reductions may be expected in some wildlife populations. Given the importance of big sagebrush to wildlife, natural resource managers need to appreciate that these taxa should often be maintained. Therefore, it is necessary to understand the long-term dynamics of big sagebrush communities following fire on ranges where browsing is intense like on the NYWR. This

research was conducted because fire may interact with browsing to further influence shrubs. Our objective was to investigate shrub recovery following prescribed and wild-fire in big sagebrush communities in the Gardiner Basin of the NYWR.

## Methods

### Study Area

The study was conducted in the Gardiner Basin of the NYWR adjacent to Yellowstone National Park (YNP) in southwestern Montana (fig. 1). Along the Yellowstone River annual precipitation averages 305 mm. The nearby benchlands receive 406 mm of precipitation. Half of the annual precipitation is in the form of snow and June is the wettest month. Orographic effects on precipitation of mountain peaks up to 3,353 m make the benches and adjacent slopes of the Gardiner Basin a natural winter range for ungulates. Elk (*Cervus elaphus nelsoni*) and mule deer (*Odocoileus hemionus hemionus*) are the important ungulates on the sites used in this research.

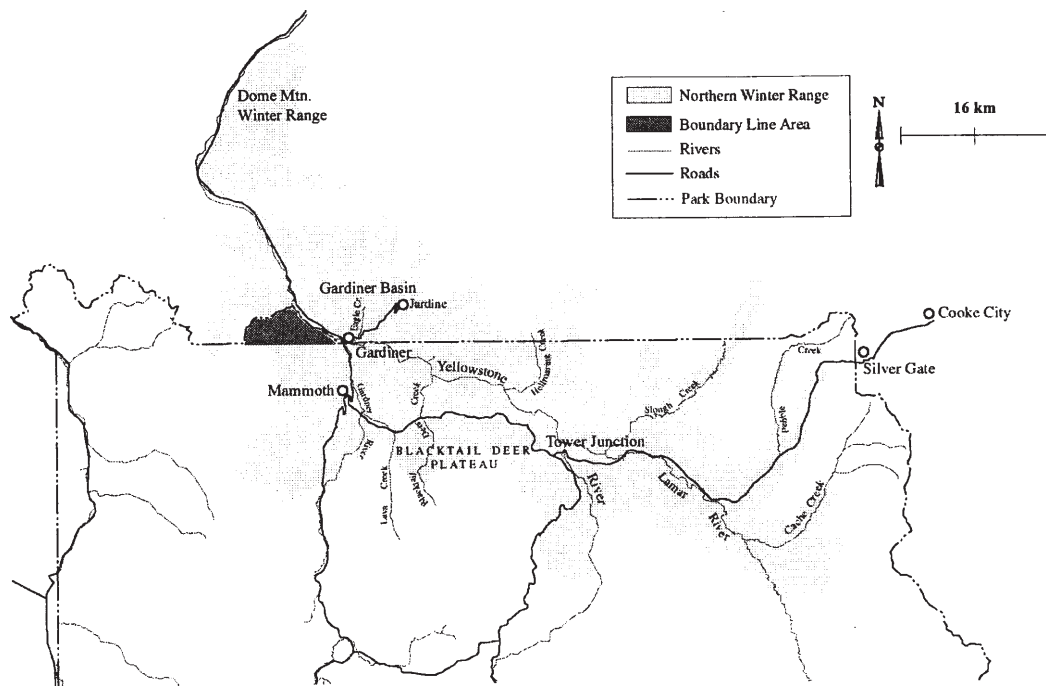
Glacial scouring and deposition have been strong influences on the soils. Parent materials include granites and limestones deposited by glaciers as well as basalts and breccias. The soil regolith in the study area may range from a few cm in areas scoured by glaciers to over 1.5 m in depositional areas. Mollisols are the dominant soil order. Soil textures are most commonly loams and sandy loams (Wambolt and McNeal 1987).

Four sagebrush taxa, basin big sagebrush, Wyoming big sagebrush, mountain big sagebrush, and black sagebrush (*Artemisia nova* Nels.), occur sympatrically but with varying frequency. Mountain big sagebrush is the dominant on the majority of the area. Threadleaf rubber rabbitbrush (*Chrysothamnus nauseosus consimilis* [Greene] Hall & Clem.), mountain low rabbitbrush (*C. viscidiflorus lanceolatus* [Nutt.] Hall & Clem.), narrowleaf low rabbitbrush (*C. v. viscidiflorus* var. *stenophyllus* [Hook.] Nutt.), and gray horsebrush (*Tetradymia canescens* D.C.) occur throughout the sagebrush-dominated portions of the area.

Bluebunch wheatgrass (*Agropyron spicatum* [Pursh.] Scribn.) and Idaho fescue (*Festuca idahoensis* Elmer) are the principal grasses found as sagebrush understory. Other common grasses are prairie junegrass (*Koeleria macrantha* Ledeb.), needle-and-thread (*Stipa comata* Trin. & Rupr.), and Indian ricegrass (*Oryzopsis hymenoides* [R. & S.] Ricker).

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**Figure 1**—The Northern Yellowstone Winter Range. This study was conducted north of Yellowstone National Park in the Gardiner Basin. That area is especially important for wintering ungulates (National Park Service map).

## Sampling and Analysis

A wildfire burned approximately 80 ha in July 1974. During summer 1993, shrub canopy cover, density, and production of winter forage were measured within the 1974 wildfire and also in three adjacent, environmentally paired, unburned sagebrush communities. One-hundred-eighty 30 m transects were located every 10 m over the burned area. The three adjacent unburned areas were sampled with 30 transects each for comparison with the burned area. Belt transects of 60 m<sup>2</sup> were established by measuring 1 m on each side of the line transect. A plumb bob was used to determine canopy cover to the nearest cm along each 30 m transect. Plant density was determined by counting all sagebrush plants rooted within the belt transect. Measurements for determining production of winter forage were made on 10 large plants per line transect using models developed on the NYWR (Wambolt and others 1994).

To make comparisons among the shrub taxa, data from the burned and unburned areas were combined into ratios (burned/unburned) for each measured parameter. This ratio represented the extent (percentage) to which each shrub taxon recovered since the 1974 wildfire. Because both the numerator and denominator of the ratio have distinct variability values, a combined variance term was calculated for each ratio (Cochran 1977). The ratios were then compared using multiple *t*-tests.

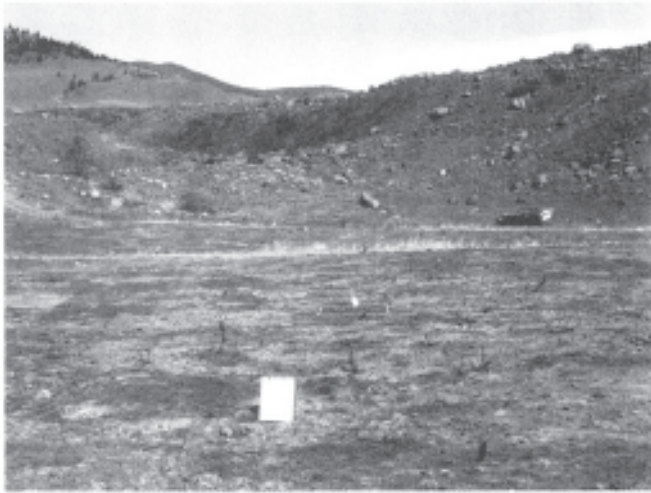
Also during summer 1993, 33 unburned and seven prescribed burned mountain big sagebrush sites were studied in the Gardiner Basin (fig. 1). Each site was a stand of mountain big sagebrush that was homogeneous in characteristics of slope, aspect, and elevation. These sites ranged between 0.25 and 3 ha in area. Plant characteristics mea-

sured were percent canopy cover of shrubs, density of large and small shrubs, and age. Large plants were  $\geq 22$  cm across the widest portion of crown and small plants were  $< 22$  cm. At each site, two line transects, 30 m long and 10 m apart, were established with the slope of the site. Procedures used to obtain shrub canopy cover and density followed those described above for studying the wildfire. Aging was accomplished by counting annual growth rings in cross-section. Production was not a consideration as the sagebrush plants in the burns were too small for the models minimum size requirements. Student's *t*-tests were used to compare parameters between burned and unburned sites.

## Results and Discussion

On the portion of the Gardiner basin burned by wildfire in 1974 and studied 19 years later, overall recovery was minimal for three subspecies of big sagebrush (figs. 2-6), while rabbitbrush abundance was much greater than that of unburned areas (fig. 7). Wyoming big sagebrush and mountain big sagebrush canopy cover recovery was only 0.6 and 1.6%, respectively, that of unburned paired sites (fig. 6). Basin big sagebrush canopy cover recovered to 20% of that of the paired unburned sites. The recoveries of burned compared to unburned Wyoming, mountain, and basin big sagebrushes were 2, 12, and 16% for density and 0.1, 14, and 11% for production of winter forage, respectively (fig. 6). All parameters were significantly greater ( $P < 0.0001$ ) in the unburned treatment.

Rabbitbrush canopy cover and density for all taxa were greater in the burned than paired unburned sites. Threadleaf rubber rabbitbrush, mountain low rabbitbrush, and



**Figure 2**—Photo following fire in 1974. Compare to scene 20 years later (1994) in Fig. 3.



**Figure 4**—Photo following fire in 1974. Compare to scene 20 years later (1994) in Fig. 5.



**Figure 3**—Photo in 1994. Compare to scene the year of fire (1974) in Fig. 2. Note lack of sagebrush recovery in 20 years.



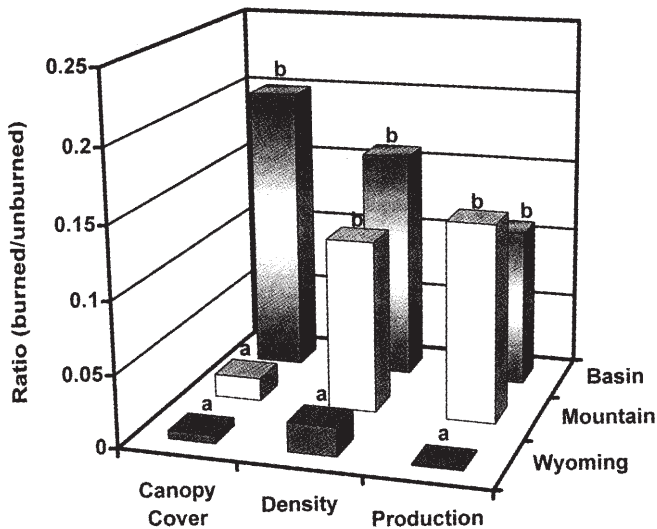
**Figure 5**—Photo in 1994. Compare to scene the year of fire (1974) in Fig. 4. Note lack of sagebrush recovery in 20 years.

narrowleaf low rabbitbrush recovery in canopy cover were not different (fig. 7). The only difference found in recovery among the three rabbitbrush taxa was that mountain low rabbitbrush established to a greater density than either threadleaf rubber or narrowleaf low rabbitbrush ( $P \leq 0.02$ ). A large number of seedling and small mountain low rabbitbrush plants collectively did not contribute much to canopy cover. Because of heavy browsing a large proportion of seedlings did not reach maturity, thus canopy cover was probably a better indicator of long-term establishment than was density.

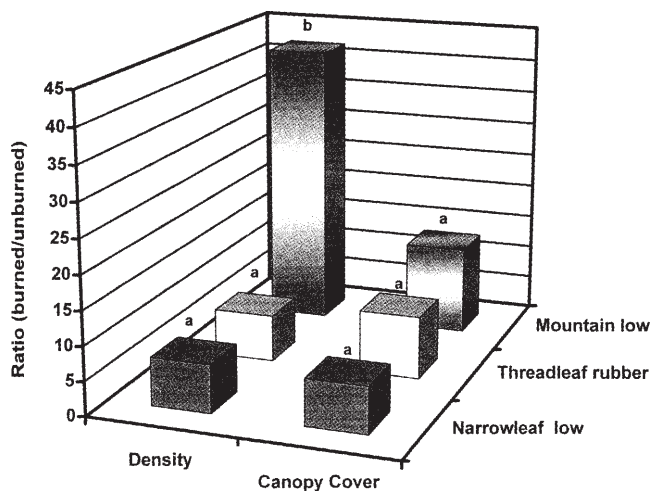
Logically the sprouting rabbitbrush taxa should have been benefited by the burn and been plentiful, until successional replacement by the dominant big sagebrush taxa. Although there was significantly ( $P < 0.01$ ) more canopy cover and individuals for all three rabbitbrush taxa in the burn, the canopy cover was still low in the burn at 1.3, 1.6, and

5.6% for mountain low rabbitbrush, narrowleaf low rabbitbrush, and threadleaf rubber rabbitbrush, respectively. Wambolt and Sherwood (1999) found that even sprouting rabbitbrushes may decline from the levels of ungulate browsing on the NYWR.

The comparison of the 33 unburned and seven prescribed burned mountain big sagebrush sites provided results quite similar to the wildfire above. All seven mountain big sagebrush prescribed burned areas sampled also indicated that recovery of the taxon following fire is slow (table 1). Although sites had burned between 9 and 13 years previous to sampling, none had significantly recovered (table 2). Mountain big sagebrush canopy cover averaged 1.2%, but this value was highly dependent on a single site (table 1, site 5) that had 6.7% sagebrush cover. This was the only burned site to exceed 1% canopy cover. This compared with an average cover of 14.2% for the 33 unburned sites. Average canopy



**Figure 6**—Canopy cover, density, and production of winter forage expressed as ratios (burned/unburned) for three big sagebrush subspecies compared between a 19 year old wildfire and paired unburned sites. Different letters above columns are significantly different ( $P \leq 0.05$ ) among taxa within each measured parameter.



**Figure 7**—Canopy cover and density expressed as ratios (burned/unburned) for three rabbitbrush taxa compared between a 19 year old wildfire and paired unburned sites. Different letters above columns are significantly different ( $P \leq 0.05$ ) among taxa within each measured parameter.

coverage of unburned sagebrush was over 12 times that on burned sites. Mountain big sagebrush density was also reduced by burning. The highest density of large plants on a burned site was 14/transect ( $0.23 \text{ plants/m}^2$ ) at site 5. The average density on unburned sites was 52 plants/transect ( $0.86/\text{m}^2$ ). The density of small plants followed a similar trend with an average on unburned sites of 11 times that on burned sites. The differences in canopy cover and densities of large and small plants between burned and unburned sites were all significant (table 2).

**Table 1**—Characteristics of mountain big sagebrush on seven burned sites in 1993.

Site	Year burned	Canopy cover %	Density <sup>a</sup> (plants/m <sup>2</sup> )		
			Large	Small	Total
1	1982	0.0	0.0	0.0	0.0
2	1979	0.4	0.1	0.0	0.1
3	1978	0.0	0.0	0.0	0.0
4	1979	0.0	0.0	0.1	0.1
5	1984	6.7	0.2	0.3	0.5
6	1984	0.8	0.1	0.1	0.1
7	1982	0.3	0.0	0.1	0.1
Average		1.2	0.1	0.1	0.1

<sup>a</sup>Large plants measured  $\geq 22$  cm across widest portion of crown and small plants  $< 22$  cm.

**Table 2**—Student's *t* test comparisons of burned and unburned mountain big sagebrush sites.

	B/U <sup>a</sup>	n	$\bar{x}$	Prob > t
Percent cover of sagebrush	B	7	1.2	0.0001
	U	33	14.2	
Density of large <sup>b</sup> plants/m <sup>2</sup>	B	7	0.06	0.0000
	U	33	0.86	
Density of small <sup>b</sup> plants/m <sup>2</sup>	B	7	0.08	0.04
	U	33	0.91	

<sup>a</sup>B = Burned site, U = Unburned site.

<sup>b</sup>Large plants measure  $\geq 22$  cm across the widest portion of crown and small plants  $< 22$  cm.

Our results are similar to Blaisdell (1953) who found little re-establishment of mountain big sagebrush 12 years after burning. Wambolt and Payne (1986) and Watts and Wambolt (1996) found that Wyoming big sagebrush exhibited a similar pattern in southwestern Montana. While plants as young as 2 years are capable of producing seed (Young and others 1989), no plants growing in our burned areas, less than 10 years old, had reproductive stalks. Some of the aged plants were found to be older than the burns. This indicated that they had not established after the fire, but had survived the burn. These residual plants represent the most important seed source for stand regeneration (Frischknecht and Bleak 1957).

Big sagebrush taxa are declining from browsing on this important ungulate winter range (Wambolt 1996; Wambolt 1998; Wambolt and Sherwood 1999) and our data indicate burning will probably accelerate this decline. In addition, browsing may substantially reduce seed production in sagebrush. Heavy browsing on Wyoming big sagebrush at lower elevations of the study area were found to nearly preclude the growth of reproductive structures (Hoffman and Wambolt 1996). Combined effects, such as browsing with the difficulty of seed production by a limited number of parent plants that may survive burning, will logically restrict the ability of big sagebrush to re-establish after fire. Burning big sagebrush stands that provide cover and forage to ungulates will likely concentrate ungulates on unburned areas and accelerate the decline in sagebrush.

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