Effectiveness of Rehabilitation Practices Following Wildfire in a Degraded Big Sagebrush-Downy Brome Community

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Highlight: Alternative rehabilitation practices were evaluated on a big sagebrush/grassland community burned in a wildfire. One and two years after the fire, perennial grasses were seeded and sprouts of rabbitbrush and other sprouting species were sprayed with 2,4-D for control. Grazed and ungrazed conditions were compared. Results indicated the desirability of promptly rehabilitating burned rangeland communities by seeding crested or intermediate wheatgrass the first fall after wildfire before downy brome had an opportunity to dominate the site. Reestablishment of brush was by sprouting and by natural seeding. Brush encroachment after fire was lessened by occupying the site with perennial grasses. The effects of spraying brush sprouts was transitory, especially with rabbitbrush. Rehabilitation after fire without grazing management was unsuccessful.

Wildfires in the big sagebrush (*Artemisia tridentata*) grasslands of the Great Basin are paradoxical in that their effects can be extremely detrimental or beneficial, depending on rehabilitation efforts. They present the land manager with problems of suppression, repair of physical damage to improvements, temporary loss of grazing resources, and rehabilitation of the land. Destruction of degraded big sagebrush communities by wildfires also presents an opportunity for improvement in the condition of ranges by seeding with perennial grass and browse species. This opportunity can be lost quickly because the weed control effects of a wildfire are temporary. Failure to rehabilitate burned areas quickly will risk further environmental degradation. Pechanec and Stewart (1944) outlined the stages of degradation of sagebrush rangelands following wildfires, especially in areas where downy brome replaces perennial grasses. They also emphasize the deleterious effects of improper grazing following burning.

The success of techniques for revegetation of degraded big sagebrush communities burned in wildfires often depends on the level of competition from downy brome (*Bromus tectorum*) (Young et al. 1976). Longevity of useful rehabilitation treatments often depends on dynamics of the root sprouting shrubs, green rabbitbrush (*Chrysothamnus viscidiflorus*), and horsebrush (*Tetradymia canescens*) (Young and Evans 1974). How do alternate revegetation techniques affect downy brome and root sprouting shrub competition? Further, how does livestock grazing affect burned and rehabilitated communities?

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Our purpose was to evaluate the impact of alternative rehabilitation practices, with and without grazing, on a sagebrush/grassland community burned in a wildfire.

Methods

Field trials were in the Red Rock wildfire area located 35 km north of Reno, Nev. The fire burned in July, 1972, and treatments were initiated in October of that year. The site is located at 1,600-m elevation in a 20- to 25-cm precipitation zone. Precipitation in years of this study were in normal range for this locality, varying from 17.8 cm to 25.4 cm. Soils are arigerolls derived from decomposing quartz diorite. Preburn vegetation consisted of a degraded big sagebrush/thurber needlegrass (*Stipa thurberiana*) community with downy brome (*Bromus tectorum*) dominating the understory.

The experimental design consisted of four replications of each treatment in a randomized block, with 12- by 12-m plots. Before establishment of the trials, an area containing half the plots was fenced to exclude grazing by livestock and all treatments were duplicated inside and outside the exclosure. Little or no deer use was observed in the area. Treatments consisted of: (a) seeding one-half (12 by 6 m) of the plots with crested wheatgrass (*Agropyron desertorum*) and the other with intermediate wheatgrass (*A. intermedium*) in October, 1972; (b) seeding plots in the same manner and applying 0.5 kg/ha of 2,4-D [(2,4-dichlorophenoxy)acetic acid] in May 1973, for control of brush sprouts; (c) not seeding and applying 3.4 kg/ha of 2,4-D in May, 1973, followed by seeding of the wheatgrasses in October, 1973; (d) applying 3.4 kg/ha of 2,4-D in May, 1973, without seeding; and (e) untreated control. The ungrazed plots sprayed with 2,4-D in May, 1973 and seeded the following October [i.e., treatment (c) above] were repeated in October, 1974, with 1.1 kg/ha of atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine] because of complete stand failure. These plots were reseeded in October of 1975 to crested wheatgrass and bitterbrush (*Purshia tridentata*).

Grasses were seeded in 10-cm deep furrows. The furrows were prepared with tractor-drawn shovels, but they approximated those obtained with a modified rangeland drill (Asher and Eckert 1973).

A lower rate of 2,4-D was used in the seedling year (1973) because grass seedlings would probably have been injured by the higher rate generally recommended for brush control in this area (Evans and Young 1975). Herbicides were applied with a backpack sprayer and hand-held boom. Brush control treatments were applied with 80° flat spray tip nozzles with 1.4 kg/cm^2 pressure. Atrazine was applied with whirlchamber, 49 by 49 nozzles (Klingman 1964), with 0.7 kg/cm^2 pressure. All herbicides were applied in 94 L/ha of water.

Weed control was evaluated by measuring the density (number of plants per 144 m^2) of shrubs and large perennial forbs and by estimating the ground cover of herbaceous species. Wheatgrass seedling establishment was evaluated by counting the number of seedlings per m of row.

The unenclosed plots were in a grazing management system, but they sustained considerable trespass grazing during the course of the

Table 1. Density (number per m²) of perennial grasses and forbs immediately after (1972) and four growing seasons following (1976) rehabilitation treatments on an area burned by wildfire.[1]

Plant groups		Seeded		Seeded and sprayed		Sprayed		Control	
		Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Native perennial grasses									
	1972	0.40	0.38	0.41	0.40	0.32	0.35	0.40	0.38
	1976	0.35	0.70bc	0.40	0.35c	0.70	1.60a	0.35	1.04b
Native perennial forbs[2]									
	1972	0.36	0.41	0.42	0.32	0.52	0.44	0.48	0.54
	1976	0.48a	0.46ab	0.31b	0.34b	0.08c	0.03c	0.85a	0.88a
Exotic perennial grasses[3]									
	1976	1.02	10.00	0.90	14.00	—	—	—	—
Total	1972	0.76	0.74	0.83	0.72	0.84	0.79	0.88	0.92
	1976	1.85b	11.16a	1.16b	14.64a	0.78b	1.63b	1.20b	1.92b

[1] Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Duncan's multiple range test. No letters indicate no significance. All comparisons were made horizontally within specific grazing treatment, except for the 1976 totals, where all means are compared.
[2] Only the tufted perennial forbs, silver lupine, wyethia, and balsam root, were included in this group.
[3] Only crested wheatgrass was included because of difficulty in determining density of intermediate wheatgrass.

investigation. The area was grazed in 1972 after the burn but before treatments were begun. In 1973, sufficient trespass grazing occurred for total utilization of all perennial grasses (seeded and native) but not of downy brome. In 1974, the area was grazed very heavily with 80 to 90% utilization of downy brome. In 1975, the pasture was heavily grazed after seedripe, but again trespass grazing placed heavy use on native perennial grasses early in the season. The area was rested in 1976.

Results and Discussion

Perennial Grasses and Forbs

Densities of perennial forbs and grasses were relatively uniform in the ara of the experimental plots immediately after the wildfire in 1972 (Table 1). Four years after the rehabilitation program, no differences in the native perennial grass densities existed among treatments in the grazed plots. In the corresponding treatments where grazing was excluded, density of native perennial grass was significantly ($p = 0.05$) higher on plots sprayed with 2,4-D for brush control. Density of perennial forbs was lowest on plots sprayed with 2,4-D for brush control, even the low rate of herbicide used on seeded areas reduced forb density (Table 1). Density of silver lupine (*Lupinus caudatus*) and arrowleaf balsam root (*Balsamorhiza sagittata*) markedly increased on control plots, but remained relatively stable on plots that were seeded but not sprayed. No great differences existed between grazed and ungrazed treatments in regard to these coarse perennial forbs because they are generally avoided by grazing animals. Excellent stands of perennial wheatgrasses were obtained with both seeding treatments of 1972 where grazing animals were excluded (Table 1). We present data for crested wheatgrass only because density is a meaningless parameter for the rhizomatous intermediate wheatgrass. On a cover basis, intermediate wheatgrass stands were superior to those of crested wheatgrass. When densities for 1976 of all classes of herbaceous perennials were totalled, the seeded/ungrazed treatments were markedly higher than other treatments in 1976 or in 1972, immediately after the wildfire.

Table 2. Wheatgrass or bitterbrush seedling density (number/m of row) on plots seeded after wildfire.[1]

Treatment	Species	Grazed	Ungrazed
1973-seeded year of fire			
Seeded only	Crested wheatgrass	15	15
	Int. wheatgrass	12	17
Seeded and sprayed	Crested wheatgrass	12	11
	Int. wheatgrass	11	10
1974-seeded 1 year after fire			
Sprayed and seeded	Crested wheatgrass	1	3
	Int. wheatgrass	2	2
1976-seeded after atrazine fallow	Crested wheatgrass	—	40
	Int. wheatgrass	—	20
	Bitterbrush	—	12

[1] Plots sampled spring following seeding.
[2] Atrazine was not applied to grazed plots.

Perennial Wheatgrass Seedling Establishment

Seeding perennial wheatgrasses the October following the wildfire resulted in excellent stands of seedlings the next spring (Table 2). Note that seedling establishment was equally as good in the grazed and ungrazed areas. Seedlings in the grazed treatment were largely lost within 4 years of rehabilitation. The light rate of 2,4-D for brush control did not enhance or reduce seedling establishment.

Success in seeding the first fall after the wildfire was directly related to reduced competition from downy brome. The wildfire destroyed most of the reserve of germinable seeds of downy brome (Young et al. 1976). On plots where seeding was delayed until the second fall after the fire to allow application of a higher rate of 2,4-D for brush control, a dense stand of downy brome developed. This represents the typical pattern of downy brome dynamics after wildfires (Young and Evans 1978). Once the downy brome was established, the plots were closed to the establishment of wheatgrass seedlings (Table 2). This competition was overcome by application of 1.1 kg/ha of atrazine to provide a herbaceous fallow for one growing season. When wheatgrasses and bitterbrush were seeded at the end of the fallow period, excellent stands of all three species resulted (Table 2). The atrazine-fallow method is a proven and appropriate technology for conversion of downy brome sites to productive mixtures of grasses, forbs, and shrubs (Eckert et al. 1974). For rehabilitation after wildfires, this technology is unnecessary if the burned area is seeded before the downy brome is allowed to deveop.

Herbaceous Species Diversity

One of the goals of public land managers is to maintain a diversity of plant species for the broad spectrum of habitat users on rangelands. The number of herbaceous spcies is one index of diversity. In 1973, the first spring after the wildfire, ungrazed plots that were seeded or sprayed were not significantly different from each other or from the control ($p = 0.05$) in number of herbaceous species (Table 3). The second year after the fire,

Table 3. Diversity of plant species on ungrazed plots receiving various treatments 1 year after the burn (1973), the year after application of the treatments (1974), and 4 years after the wildfire (1976).[1]

Plant species	Number of Plant Species								
	Seeded			Sprayed			Control		
	1973	1974	1976	1973	1974	1976	1973	1974	1976
Native species									
Annual	5	2	1	6	2	2	5	0	0
Perennial forb	5	6	7	5	3	3	5	5	3
Perennial grass	2	2	3	3	3	4	3	3	3
Alien annuals	1	1	2	2	3	3	3	3	2
Exotic perennial grasses	2	2	2	0	0	0	0	0	0
Total	15a	13ab	15a	16a	11ab	12ab	16a	11ab	8b

[1] Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Duncan's multiple range test.

number of native annual species was reduced on all three treatments; on control plots they were nearly eliminated. Native annuals were reduced in response to complete preemption of site potential by downy brome (Young and Evans 1978). By 1976, 4 years after the wildfire, herbaceous species diversity was significantly ($p = 0.05$) lower on the control plots than on the plots seeded to wheatgrasses (Table 3).

The species diversity index is not completely indicative of vegetation dynamics; it does not differentiate between mere presence of a species and overwhelming dominance. Downy brome was the overwhelming herbaceous dominant on both grazed and ungrazed control plots by the second growing season after the fire. Even though this index has shortcomings, it was important in this study because it indicated that the species diversity did not necessarily decrease after seeding or spraying.

Shrub Vegetation

Post-fire succession of shrub species, especially in relation to rehabilitation treatments, was difficult to interpret because good control of horsebrush root sprouts with 2,4-D was not achieved. We had no previous experience with chemical control of horsebrush or green rabbitbrush root sprouts and could find no references to it in the literature. We based the timing of herbicide application on the criteria developed by Hyder et al. (1962) for control of green rabbitbrush. At times, we have found horsebrush to be more difficult to control with herbicides than green rabbitbrush (Evans and Young 1977). Unfortunately, for the desired comparisons in this experiment, many horsebrush sprouts emerged after the herbicide was applied. The only relatively clearcut trend of horsebrush succession on the rehabilitated plots as that the number of horsebrush plants 4 years after the burn were significantly reduced on both grazed and ungrazed areas in plots seeded with perennial grasses (treatment a, Table 4). Spraying with 3.4 kg/ha of 2,4-D had no significant ($p = 0.05$) effect in ungrazed plots, but resulted in a significant increase of horsebrush plants with grazing (treatments b and d). Spraying with 3.4 kg/ha of 2,4-D followed by seeding and grazing had no effect on horsebrush density (treatment c). However, when the plots with inadequate wheatgrass establishment seeded October, 1973) were fallowed with atrazine and reseeded without grazing (treatment c), a marked increase in horsebrush resulted. Remember that only the ungrazed plots, previously sprayed and seeded, were treated with atrazine. We cannot explain why the seeded with spraying treatment produced significantly more horsebrush plants than the seeded without spraying treatment because perennial grass stands were very similar after both treatments.

The response of green rabbitbrush to the rehabilitation treatments was more consistent. All of the ungrazed rehabilitation treatments, except sprayed and nonseeded, had significantly ($p = 0.05$) fewer green rabbitbrush plats than the ungrazed and grazed controls (Table 4). On the grazed plots, only those seeded had markedly fewer green rabbitbrush plants than the control. Again, as was noted for horsebrush, the seeded and sprayed plots supported many more shrubs than the plots that were only seeded. The perennial grass stands were similar after the two treatments.

Green rabbitbrush differs considerably from horsebrush in sprouting habit. It sprouts from the crown near the soil surface, produces abundant achenes, and increases in density through seedling establishment (Young and Evans 1974). Horsebrush sprouts from roots well below the soil surface and produces several apparently new plants from a single plant burned in the wildfire. The stands of horsebrush at the end of the experiment directly resulted from our failure to control the sprouts with 2,4-D. Stands of green rabbitbrush resulted from a more complex process of sprouting and seedling establishment. This is readily apparent because any treatment that was seeded and

Table 4. Shrub density (number per 1000 m^2) in 1976 on plots established in 1972 and given rehabilitation treatments after a wildfire.[1]

Treatments[2]	Horsebrush		Rabbitbrush		Desert Peach		Total shrubs[3]	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Seeded (a)	49d	43d	15cd	4d	13cd	25b	84cd	74d
Seeded and sprayed (b)	76a	63bc	59a	17c	8d	20bc	148a	112bc
Sprayed, seeded, and retreated (c)	53cd	78a	69a	8cd	5d	10d	153a	97c
Sprayed (d)	70ab	64bc	39b	37b	5d	43a	120b	114b
Control (e)	55c	55c	41b	33b	7d	23bc	116b	119b

[1] Means followed by same letter are not significantly different at 0.05 level of probability as determined by Duncan's multiple range test. All comparisons are made vertically within species.
[2] Detailed explanation of treatments is given in methods section and refers to specific letters following treatments.
[3] Total shrubs include green ephedra, currant, and big sagebrush.

ungrazed had significantly ($p = 0.05$) fewer rabbitbrush plants. We had good initial control of green rabbitbrush on the sprayed plots, but seedling establishment of rabbitbrush negated this control by the end of the experiment. Note that the atrazine fallow greatly reduced the population of young green rabbitbrush plants, but failed to eliminate the horsebrush root sprouts on the sprayed and seeded and then retreated plots (treatment c, Table 4).

The apparent key to suppression of green rabbitbrush is establishment of sufficient perennial grasses to compete with seedlings of the shrubs. The large number of green rabbitbrush seedlings that were established in sprayed or nonseeded plots (treatment d) increased shrub density on these plots (Table 4).

Desert peach (*Prunus andersonii*) increased greatly in the ungrazed treatments, except for the sprayed and seeded treatment (Table 4). This spiny shrub usually is totally rejected by browsing animals. Desert peach is a clonal species that spreads by underground stems from lignatubers (Young and Evans 1978).

When all shrubs were considered, only the seeded (grazed and ungrazed) (treatment a) and the single ungrazed treatment that was fallowed with atrazine and reseeded (treatment c) had markedly fewer shrubs than the control. Note that there were no significant differences ($p = 0.05$) between shrubs in the grazed and ungrazed control plots (treatment e) and those in the plots sprayed without seeding (treatment d).

Conclusions

This study shows the desirability of promptly rehabilitating burned big sagebrush communities before downy brome has a chance to establish dominance of the site. It also shows that rehabilitation without close livestock control is futile and a waste of money.

The role of root-sprouting shrubs in post-burn succession is obviously complex. It is important to establish perennial grasses to occupy the site after fire for control of shrub reestablishment.

The value of spraying brush sprouts after fire to lessen shrub reestablishment is in doubt from results of this study. The factors governing shrub establishment in relation to competition from downy brome or perennial forbs and grasses is an intriguing aspect of this succession and one that is not clearly understood.

Wildfire creates the opportunity to convert degraded big sagebrush-downy brome communities into high-producing, stable perennial grass rangelands. Failure to grasp this opportunity results in further degradation. With greater emphasis on multiple use of land and our need for more forage, rehabilitation after fire by seeding both perennial grasses and browse species should be stressed.

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