Recovery of Sagebrush-Grass Vegetation Following Wildfire

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Abstract

Most studies of the impacts of fire in sagebrush-grass vegetation in the Great basin have involved recovery on sites seriously depleted of native perennial bunchgrasses. The usual recommendation is to promptly seed such areas artificially. This is costly, not always successful, and if unnecessary, could produce no more than a natural recovery. The natural recovery of a good condition sagebrush-grass site in central Utah was monitored for 2 years after a mid-summer wildfire. Total plant cover 1 year after the fire was similar to that before the fire and on unburned controls. Annual herbaceous growth 1 year later was almost twice that before the fire. Most of the plant growth the first year was due to cheatgrass *(Bromus tectorum)*. By the second year after fire, however, the perennial bunchgrasses had cover and production levels near those recorded prior to the burn. Two years after the fire, total grazable forage was 2.5 times that before the fire. Total precipitation, however, had been higher than average both years. Sagebrush-grass sites in good condition may be improved for cattle production with a few years of livestock exclusion following wildfire. Prescribed or controlled burns would probably be appropriate on similar high condition rangelands if cattle grazing is the dominant use and conflicts with wildfire are minor.

The relative amount of big sagebrush *(Artemisia tridentata)*[1] and perennial grasses in sagebrush-grasslands prior to the coming of European man is thought to have been at least partially related to fire frequency (West 1983). Big sagebrush does not resprout after fire (Young and Evans 1977). Wright and Bailey (1982) conclude that the probable return frequency of fire in such vegetation is between 50–100 years for a given piece of ground. Heavy livestock use since European settlement has reduced the proportion of palatable herbaceous species, thereby diminishing competition from the herbs and lessening the amounts of fine fuel. This and conscious fire control efforts have resulted in accentuated sagebrush dominance on many hectares of Intermountain rangeland.

In the past, managers often resorted to chemical and mechanical means of killing the brush, usually followed by seeding of introduced perennial grasses (Blaisdell et al. 1982). Due to increased costs and legal or administrative restrictions associated with mechanical and chemical brush control, many range managers are giving thought to the alternatives of prescribed or controlled burning. If fire destroys a large fraction of the undesirable brush and is relatively undamaging to the desired herbaceous species, then a landscape that is better for livestock production and watershed may be created.

The above assumes either that there is a set of desirable native species that can regenerate themselves or that seeding will be done after the fire. The latter greatly increases project costs. If seeding is unnecessary, then much time and expense may be saved by allowing natural recovery. Artificial seeding is mandatory if cheatgrass *(Bromus tectorum)* is a major component of the pre-burn community (Young et al. 1976). Whether sagebrush-dominated communities with a substantial remnant of native perennial grasses along with some cheatgrass can readily return to perennial grass dominance following fire remains a question. As Young and Evans (1977) point out, most of the native perennial grass stands that have remained after more than a century of livestock grazing are not sufficiently dense to utilize the environmental potential released by burning of the dominant sagebrush. Their studies however, did not involve dense stands of native grasses. We provide a case study of secondary succession following wildfire on a good condition sagebrush-grass site in central Utah. Thus, there was a high density of native perennial bunchgrasses present before the fire.

Materials and Methods

Study Area

A lightning-caused wildfire swept over about 11,000 ha (26,000 acres) on the northeast flank of the Oak Creek Mountains on 24-26 July 1981. Ten days earlier, for another intended study (Hassan and West 1984), we completed collection of vegetation data on plots

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[1]Latin names for plants follow Welsh et al. (1981), common names follow Bettle (1970).

near the northeastern edge of the burn. The plots were located on a 1-2% east sloping pediment remnant at 1,617-1,622 m (5,305-5,320 ft) elevation near the center of Section 30, R2W, T15S, Salt Lake Meridian, Juab Co., Utah.

We had used color infrared photography (1:8,000 scale) from the 1 July 1975 Apollo space mission to locate an area large enough to accommodate four 20 × 50-m macroplots on visually uniform topography and vegetation. This was part of a large tract of privately owned rangeland that was at least 8 km from a source of permanent livestock water. The vegetation there was thus thought to be in late seral condition.

Methods

Homogeneity of vegetation cover was assessed on 10 July 1981 with a sight tube device (Winkworth and Goodall 1962). A metric tape was strung down the center E-W long dimension of each macroplot. Another tape was strung out perpendicularly along the western boundary of each macroplot. Four randomly numbered (to nearest decimeter) starting points were chosen off the western boundary. The gimbaled tube was suspended by wire from an iron staff at about waist height. A transect was started at 1 of the random points and the observer started pacing across the macroplot to the east, trying to stay parallel to the center tape. The staff was driven into the ground in front of the observer on every second pace. After the gimbaled tube came to rest, the observer sighted through the tube and lined up the 2 sets of cross-wires. The object intersected in the line of sight was recorded as a living vascular plant species, standing dead, lichen, moss, litter, gravel, or bare ground. Two recordings per point were possible if plant canopy was intersected. Living plant canopy was first recorded and then the canopy moved aside to reveal what was on the ground surface underneath. In other words, a second reading was taken of ground cover at the locations where live plant cover was intersected. This process was continued until a total of 100 ground level points had been sampled on 4 lines per macroplot. This process was repeated on 28 July 1982 and 27 July 1983. All plots were fenced in the fall of 1981 to prevent livestock access.

Soil profiles (pedons) were exposed in the center of each plot. Detailed descriptions were made according to standards of the Soil Survey Staff (1975), with soils being classified at the phase of soil series level.

Use of Soil Conservation Service (SCS) range condition and trend guides requires herbage weight estimates. Accordingly, we first sampled herbage weight on 14 July 1981 after nearly all spring and summer plant growth had occurred. This procedure involved selection of 10 random locations per macro-plot. A 9.6-ft^2 circular quadrat was centered on these locations and all living higher plant material from the current growing season was harvested to 1-cm stubble height. Separate randomized locations were selected for the subsequent samples taken on 27 July 1982 and 28 July 1983. That is, the same locations were not clipped more than once. These standing crops were separated by species. The samples were placed in paper bags and air-dried for 5 days in the laboratory. The samples were then weighed to the nearest 0.1 g. The subsamples were then added together to get total standing crop. By dividing the total air-dry weight of forage by amounts per species, percent composition by weight was determined. This was compared to the percent composition by weight in climax condition for the "upland shallow hardpan" (Juniper savannah) range site (SCS 1978).

Similarity of the vegetation and ground surface at the initiation of the study was calculated 2 ways. The first used a percentage cover (based on sight tube points) weighting a calculation of Sorenson's K (West 1966). The second approach used a standing crop weighted index of similarity (Sorenson's K).

Fire had probably not occurred at this site for at least the last 100 years as judged by the size and form of the sagebrush and widely scattered Utah juniper *(Juniperus osteosperma).*

The fire consumed nearly all the above-ground vegetation on the 4 main macroplots. Some small areas closely adjacent (50 to 150 m) to the south, however, escaped the fire. To continue the originally planned study (Hassan and West 1984), we located 3 replicates of these unburned patches, and adjacent areas of similar size and shape that had been burned, and sampled the vegetation cover and soils on them similarly to the 4 main macroplots. Vegetation cover was sampled there on 5 August 1981, 28 July 1982, and 27 July 1983. These later plots were too small, however, to feasibly allow clipping for herbage weights over successive years. We saw the opportunity to use these plots for unburned "controls", so that fluctuations could be separated from successional trends in cover.

Precipitation data were taken in a recording raingauge from July 1981 to December 1982 and from a storage gauge read quarterly thereafter.

Results

Vegetation and ground cover were highly similar between the plots inventoried shortly before the fire and those that escaped the burn. (Table 1). The cover weighted indices of similarity between individual plots were all above 82%. Since remeasurement of the same stands often produces up to 15-20% variability in these indices (Mueller-Dombois and Ellenberg 1974), these plots can be considered essentially identical for our purposes.

All plots had soil profiles that were classified as Spager gravelly loam (loamy-skeletal, carbonatic, mesic, shallow Xerollic Paleorthid). Since the soils under burned and unburned vegetation were similar, we assumed that the set of plots could be considered homogeneous and data within a given year were averaged between plots. Fire is thus regarded as a randomly applied treatment unrelated to site differences. The vagaries of wind movement rather than lower fuel loads probably allowed a few patches to escape damage.

The differences in vegetation between years on the unburned plots, if successional stability is assumed, is due to a combination of fluctuation driven mainly by climate plus some sampling error. The changes in the vegetation on the burned plots over time are considered secondary succession. Since exactly the same points could not be resampled, sampling error also influences these results. The time series nature of the results precludes statistical tests of significance.

Immediately after the burn, aboveground vegetation on the burned plots was entirely removed (Table 1). The fraction of bare ground drastically increased immediately after the fire. Litter and microrophyte cover were lower on the burned plots compared to the controls.

One year after the burn, the total plant cover had increased to almost the same levels observed pre-fire and that on the unburned controls the same year. Fewer species, however, contributed to this cover. Small amounts of Douglas rabbitbrush *(Chrysothamnus viscidiflorus)* and much Nevada Mormon tea *(Ephedra nevadensis)* cover (from resprouting) re-appeared. No sagebrush cover was detected on the burned plots 1 year later. The perennial grasses *(Agropyron, Stipa, Poa, Sitanion* and *Oryzopsis)* had regained only a small portion of their pre-burn cover by mid-July 1982. Perennial forbs *(Erigeron, Eriogonum, Phlox,* and *Antennaria)* had recovered most of their cover ratings 1 year after the fire. The expansion of cheatgrass was, however, the major reason for the rapid 1 year recovery in total vascular plant cover. Cheatgrass provided about 5 times as much cover in mid-July of 1982 compared to mid-July 1981.

Bare ground decreased as vegetation recovered in the post-fire years. Cover of standing dead increased from 0% before the fire to 2.6% 1 year later. Most of this component was skeletons of the burned shrubs. Litter decreased from 15 to 17% pre-fire to about 8% post-fire. Microphytic crusts, mostly mosses, showed little recovery 1 year after the fire.

End of growing season total standing crops (Table 2) were nearly

Table 1. Summary of mean percent cover (one standard error of mean within parentheses) recorded on plots near Mills, Utah in 1981, 1982, and 1983.

Growth form/species	Measured Pre-burn (4 plots)			Control (unburned) (3 plots)			Burned (3 plots)		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
Trees and Shrubs									
Artemisia tridentata wyomingensis	6.5 (1.3)	0	0	2.3 (0.6)	3.7 (1.2)	5.7 (4.0)	0	0	0
Chrysothamnus viscidiflorus	7.3 (2.8)	0.3 (0.5)	0	8.0 (3.0)	6.3 (2.5)	3.0 (1.0)	0	0	0
Ephedra nevadensis	2.5 (1.3)	2.5 (1.0)	2.3 (0.5)	1.0 (1.0)	4.3 (0.6)	2.0 (1.0)		1.3 (0.6)	1.0 (0.9)
Juniperus osteosperma	0	0	0	0	0	0.7 (0.6)	0	0	0
Artemisia nova	0.3 (0.5)	0	0	0	0	0.7 (1.2)	0	0	0
Grasses									
Agropyron spicatum	12.9 (5.0)	6.5 (1.7)	12.3 (4.9)	13.3 (0.5)	16.0 (1.0)	13.3 (5.9)	0	5.3 (1.5)	9.3 (4.7)
A. smithii	3.3 (1.0)	0.3 (0.5)	0	1.5 (1.8)	1.7 (1.5)	0	0	0	0
Stipa comata	3.7 (2.3)	0	0.1 (1.0)	4.9 (1.7)	2.0 (1.0)	1.3 (2.3)	0	1.0 (1.7)	0.3 (0.6)
Poa secunda	3.0 (1.6)	1.0 (1.4)	1.3 (1.0)	5.6 (1.9)	4.0 (1.0)	1.0 (1.0)	0	1.0 (1.0)	0
Sitanion hystrix	3.3 (1.9)	0.5 (1.0)	0.6	0.4 (0.6)	1.3 (2.3)	0.3 (0.6)	0	0.7 (1.2)	0
Oryzopsis hymenoides	10.1 (2.4)	4.0 (2.9)	3.8 (2.1)	11.6 (3.5)	6.3 (4.5)	2.3 (1.5)	0	8.0 (2.7)	5.3 (1.2)
Bromus tectorum	6.6 (1.5)	34.8 (12.1)	56.8 (5.4)	6.8 (1.1)	11.0 (3.6)	24.0 (8.2)	0	35.7 (1.6)	50.0 (7.8)
Elymus multisetus	0	0	0.3 (0)	0	0	0	0	0	0
Forbs									
Erigeron engelmannii	0.3 (0.6)	0.5 (0.6)	0	1.5 (0.6)	1.3 (1.5)	0	0	0.7 (1.2)	0
Eriogonum cernuum	0.6 (0.7)	0	0	0	1.0 (1.0)	0	0	0.3 (0.6)	0
Phlox longifolia	1.5 (1.8)	1.0 (1.4)	0	0	3.0 (7.7)	0	0	0.3 (0.6)	0
Leptodactylon pungens	0.3 (0.6)	0 (1.0)	0	0	0	0	0	0	0
Antennaria rosea	1.8 (0.7)	1.8 (1.0)	0	0	0	0	0	0	0
Descurania pinnata	0	1.8 (0.9)	0.3 (0.5)	0	0	0	0	1.0 (0.0)	0
Sisymbrium altissimum	0	0	0.3 (0.5)	0	0	0	0	0	0
Total Plant Cover	64.5 (2.7)	53.4 (9.52)	77.5 (5.5)	56.9 (6.1)	62.7 (11.9)	54.3 (7.4)	0	55.0 (4.0)	67.0 (5.0)
Standing dead	0.9 (0.6)	0.3 (0.5)	1.0 (0.8)	0	1.3 (1.5)	2.3 (2.1)	2.7 (0.6)	0	0
Surface litter	16.8 (2.2)	7.8 (3.1)	69.5 (7.0)	15.4 (2.8)	18.3 (6.7)	50.0 (0.8)	9.3 (5.9)	10.3 (1.2)	49.0 (3.6)
Rock	0	0.3 (0.5)	0	0	0.3 (0.6)	0	0	0	0
Gravel	12.1 (1.2)	8.5 (3.5)	4.0 (3.5)	11.3 (1.2)	12.3 (4.2)	2.0 (1.0)	13.3 (3.1)	8.3 (4.2)	2.0 (1.0)
Bare ground	13.1 (2.3)	46.3 (9.2)	25.0 (6.1)	14.7 (3.1)	14.7 (5.0)	19.3 (11.8)	77.3 (6.7)	27.3 (5.5)	31.0 (4.4)
Moss	11.2 (1.4)	0	2.0 (3.4)	12.8 (0.6)	9.3 (0.6)	2.7 (0.6)	0	0	0
Lichen	0.9 (1.1)	0	0.5 (0.6)	0	1.7 (1.2)	0.7 (1.2)	0	0	0

twice as much 1 year post-fire as shortly before the fire. Eighty-eight percent of this increase was due to cheatgrass. This compares to only a 3% contribution of cheatgrass to current annual growth before the fire. None of the other species had more current phytomass than before the fire. Cheatgrass had 55 times as much phytomass 1 year after the fire as immediately before.

Herbage standing crop estimates obtained immediately prior to the fire are given in the left most column of Table 2. Use of the SCS range condition guides indicates that this range was in "good" condition prior to the burn. Burning stimulated increased herbage production the first year after the fire.

The recovery of total vegetal cover continued into 1983, the second year post-fire. In fact, the total vegetal cover on the burned plots was greater than that observed prior to the fire and on the unburned controls (Table 1). No further increase in shrubs were noted during the second year post-fire, but the perennial bunchgrasses all had increased cover ratings, nearly double those in the previous year. Their relative contribution to cover remained at 23%, however, primarily because cheatgrass cover increased further in 1983. Perennial forb cover virtually disappeared on both the unburned controls and burned plots (Table 2). This is puzzling since 1983 was the second year in a row with above average precipitation (Table 3).

Ground protection from litter had greatly increased by 1983. Even the microphytes showed some small recovery on 1 of the sets of plots.

The amount of new plant growth in 1983 (Table 2) exceeded both the pre-burn and 1982 levels. This trend is probably influenced by the 2 years of more than average precipitation (Table 3). The total weight of growth of the perennial bunchgrasses in 1983 was nearly as much as in the pre-burn sample. Whereas perennial bunchgrasses made up 67% of the annual forage standing crop before the fire, they contributed only 25% of the annual production in 1983. Both absolute and relative contributions of cheatgrass production declined in 1983 over 1982. The relative contribution of cheatgrass was 66% in 1983. Whether these trends will continue requires further monitoring. The mix of perennial and annual grasses is, however, more desirable for cattle grazing than was the mix of sagebrush and perennial grass that had occurred before the fire.

Conclusions

Even though cheatgrass may be a minor component of good condition sagebrush-grass range, it can quickly assume dominance after a midsummer wildfire. Total cover of living plants was almost as great 1 year after the fire as before, mainly due to cheatgrass. Under no livestock grazing and favorable precipitation conditions, perennial bunchgrasses are returned to nearly their pre-burn cover ratings and forage production within 2 years. Since most of the recovery of the perennial grass production was during the second year, the importance of excluding of livestock for at least that long is reaffirmed (Wright and Bailey 1982). Wyoming big sagebrush, black sagebrush, and Douglas rabbitbrush were taken out of these sites for the first 2 years after the wildfire. Nevada Mormon tea readily resprouted after fire. Mosses and lichens were slow to recover.

From a cattle grazing standpoint, the vegetation is now more desirable than before the burn. The production of palatable species was higher after than before the fire and it was accomplished without artificial seeding. Thus, where cattle production is a principal land use, land owners and managers should consider the possibilities of prescribed burns or letting unintentional fires burn

Table 2. Means (kg/ha) and one standard error of mean (within parentheses) of herbage standing crops on the four macroplots sampled before and after the wildfire.

Growth form/species	1981	1982	1983
Trees and Shrubs			
Artemisia tridentata wyomingensis	44.75 (114.39)	—	—
Chrysothamnus viscidiflorus	38.38 (80.40)	—	—
Ephedra nevadensis	23.98 (88.82)	10.18 (35.88)	95.01 (273.19)
Artemisia nova	9.33 (58.98)	—	—
Half Shrubs			
Leptodactylon pungens	8.08 (23.10)	0.78 (2.62)	3.32 (8.92)
Gutierrezia sarothrae	—	—	0.28 (1.74)
Grasses			
Agropyron spicatum	244.09 (271.68)	71.66 (124.00)	237.2 (376.09)
Stipa comata	3.03 (6.11)	—	—
Poa secunda	11.48 (8.65)	3.60 (9.16)	4.52 (8.62)
Sitanion hystrix	—	—	0.24 (1.50)
Oryzopsis hymenoides	50.03 (94.71)	14.59 (22.78)	48.96 (84.47)
Bromus tectorum	14.42 (11.70)	786.22 (460.82)	761.19 (286.24)
Forbs			
Erigeron engelmannii	1.3 (5.83)	0.5 (2.48)	—
Eriogonum cernuum	1.93 (11.85)	0.2 (1.26)	0.38 (1.84)
Phlox longifolia	0.50 (2.25)	—	0.05 (0.32)
Antennaria rosea	0.6 (3.79)	—	—
Descuirania pinnata	0.05 (0.32)	3.73 (20.13)	2.58 (8.09)
Sisymbrium attissumum	—	1.16 (6.19)	3.7 (23.40)
Opuntia polycantha	0.45 (2.85)	—	—
Vicia americana	8.68 (31.36)	—	—
Collinsia parviflora	—	—	0.018 (0.08)
Calochortus nuttallii	—	—	0.21 (0.64)
Ranunculus testiculatus	—	—	0.9 (5.7)
Total	460.91 (115.28)	892.6 (67.82)	1158.57 (140.34)

Table 3. Summary of crop-year (1 Sept.-30 June) (Sneva and Britton 1983) precipitation recorded at the study site compared to short and long-term precipitation at the closest comparable permanent station (Levan).

	Short term Total precipitation (mm)		Long term
Period	Study site	Levan	Levan
1 Sept. 81-30 June 82	319	330	
1 Sept. 82-30 June 83	590	499	
Long-term (50 year average)			301

through such vegetation in mid-summer. There should, however, be considerable perennial grasses present to recover since few seed (Hassan and West 1984) or seedlings of the perennial grasses were observed. Nearly all of their recovery was via vegetative growth. Burning of areas with a largely cheatgrass understory is likely to promote only more cheatgrass and its notoriously variable production (West 1983). Cheatgrass dominance also leads to more harmful earlier (seasonally and serally) reburns; thus, seeding of perennial grasses is recommended after burns on similar rangelands in lower condition (Young et al. 1976).

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