Trend of Mountain Big Sagebrush Crown Cover and Ground Cover on Burned Sites, Uinta Mountains and West Tavaputs Plateau, Utah

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Abstract—Photography and notes on file at the Supervisors Office, Ashley National Forest make it possible to date many fires in mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) communities on this National Forest. Crown cover of mountain big sagebrush and other shrubs was measured in repeat visits to many burned sites. Burned areas studied varied in age from 1 year to 42 years. Crown cover measurements in these burns demonstrate high capability of mountain big sagebrush to return to burned sites. Crown cover of mountain big sagebrush was highly variable in post burn environments. After 15 years post burn, crown cover of mountain big sagebrush varied from 4 to 46 percent at the various study sites. This variability indicates highly diverse structure and cover of mountain big sagebrush in post burn environments. In addition to crown cover, ground cover was also measured. These measurements demonstrate rapid return of ground cover in mountain big sagebrush communities. Most burned sites had greater than 80 percent ground cover after 5 years post burn.

Introduction

Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) communities are extensive in montane areas of the West. They have high value for sagebrush obligate species such as sage grouse (*Centrocercus urophasianus*). They are a major source of browse and herbaceous forage for wild ungulates, and they are among the most highly selected lands for livestock grazing in the Intermountain West.

Fire appears to have been a major factor in the ecological history of these communities on the Ashley National Forest. Evidence of a strong fire history is provided by the understory species and associated shrub species. Nearly all of the perennial understory species are highly capable of sprouting after fire. Most of the associated shrubs sprout vigorously after fire. Mountain big sagebrush does not sprout after fire, and it is one of the slower species to return in abundance to burned areas. Although it is slower to recover, mountain big sagebrush generally returns to burned areas.

Capability to produce fuel is another indicator of fire potential. A range of annual production of 392 to 1,413 kg/ha (350 to 1261 lbs/acre) is indicated for mountain big sagebrush communities (Goodrich and Huber 2001; Harniss and Murray 1973; Jensen 1989; Tart 1996; Tew 1988). A value near the low end of the range (418 kg/ha or 373 lbs/acre) was reported from near Dubois, Idaho, (Harniss and Murray 1973) where sample sites were likely near the ecotone with Wyoming big sagebrush (*Artemisia tridentata* var. *wyomingensis*). Production was generally lower where bluebunch wheatgrass (*Elymus spicatus*) and blue gramma (*Bouteloua gracilis*) were indicators of community type than where mountain snowberry (*Symphoricarpos oreophilus*) and slender wheatgrass (*Elymus trachycaulus*) were indicators of community type.

Litter and vegetation often cover over 85 percent of the ground surface. Biomass production and continuous fuels of these communities have high potential to carry fire. These factors are major differences of fire potential between mountain big sagebrush communities and Wyoming big sagebrush communities. Both productivity and ground cover are lower in Wyoming big sagebrush communities than in mountain big sagebrush communities (Goodrich and Huber 2001).

History of fire is also indicated for mountain big sagebrush communities by the relative ease with which fire is started and carried in these communities. In the area of this study, mountain big sagebrush communities have been prescribed-burned under weather conditions that did not support fire in adjacent communities.

At mountain big sagebrush sites of the Uinta Mountains with a history of about 100 years of livestock grazing, ground cover has been found at 87 to 95 percent with an average of 92 percent (Goodrich and Huber 2001). For the Fishlake National Forest, Tew (1988) considered mountain big sagebrush communities at potential to have between 7 and 22 percent bare soil. This indicates ground cover potential of between 78 and 93 percent for that National Forest. Tart (1996) listed percent bare soil at 8 to 13 percent for two mountain big sagebrush plant associations at late seral condition on the West Flank of the Wind River Mountains. This indicates potential for ground cover of about 87 to 92 percent or about the same as data from the Uinta Mountains indicates (Goodrich and Huber 2001).

In: Kitchen, Stanley G.; Pendleton, Rosemary L.; Monaco, Thomas A.; Vernon, Jason, comps. 2008. Proceedings—Shrublands under fire: disturbance and recovery in a changing world; 2006 June 6–8; Cedar City, UT. Proc. RMRS-P-52. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

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Ground cover is greatly reduced by fire. Plants and litter are consumed leaving ash and rock for ground cover. Ash is readily removed by wind and by overland flow of water. Although ash might provide some protection against raindrop-splash, its overall value for watershed protection is relatively low. The most fire-resistant ground cover is rock. However, some big sagebrush communities have low percent rock cover. Depending on rock cover, mountain big sagebrush communities can be left with essentially no resistant ground cover immediately following fire.

Return intervals for sagebrush crown cover and for ground cover after fire are important to the management of these plant communities. Considerations for rehabilitation following fire should be based on the inherent capability of plant communities to provide ground cover following fire. Also considerations for grazing and other management practices need to be coordinated with return of ground cover and development of the flora following fire. Dynamics of sagebrush crown cover and ground cover following fire are the focus of this study.

Study Area and Site Selection

This study was conducted in the Uinta Mountains and on the Tavaputs Plateau on the Ashley National Forest in northeastern Utah. Crown cover data (table 1) and ground cover data (table 2) were taken from many sites. Some sites were visited more than once, and these sites provide multiple reference points for comparing time with return of crown cover of shrubs and ground cover. Each site represents an area of about 0.28 ha (0.72 acre). All sites selected for study were in mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*)/grass communities with a known history of fire. Burned areas of this study varied in age from 1 to 40 years (table 1).

Yellowbrush (*Chrysothamnus viscidiflorus* var. *lanceolatus*) and mountain snowberry (*Symphoricarpos oreophilus*) were present in 75 percent and 65 percent of the readings respectively. At the majority of sites, mountain needle-and-thread (*Stipa comata* var. *intermedia*) was the understory plant that indicated community type. On some sites of warm aspect, bluebunch wheatgrass (*Elymus spicatus*) indicated community type. At a few sites on the Tavaputs Plateau, Salina wildrye (*Elymus salinus*) was the understory-indicator of community type.

Livestock grazing has been a part of the history of most of the study sites for over 100 years. Livestock grazing has been discontinued for a decade or more on a few of the sites. We did not find a sufficient number of sites without current livestock grazing to make a comparison between livestock-grazed and ungrazed sites. All of the study sites have a history of use by elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*). However, elk and mule deer have used the study sites only in light winters, and use of sagebrush by these animals has been light.

Methods

Burned sites and years since each site was burned was determined from monitoring studies filed at the Supervisor's Office and District Offices of the Ashley National Forest. Sites with a known history of fire were visited, and permanent belt-line transects were established in these burned areas. In some cases permanent transects had been established prior to burns. In these cases, data was taken along existing transects.

At most sites, crown cover of shrubs was determined from 152 m (500 ft) of line intercept. At a few sites, line intercept measurements were limited to 91 m (300 ft). Protocol found in the *Rangeland Ecosystem Analysis and Management Handbook* (USDA FS 1993) was used for taking line intercept data. This included measuring the intercept of each shrub along the transect line by species. Gaps in crowns of shrubs of 15 cm (0.5 ft) or greater were omitted from crown cover measurements.

Ground cover was determined from 400 points along the same belt transects used to determine crown cover of shrubs. Point size was the sharp end of a spike or about 1 mm. Basal area of vegetation, plant litter, and rock 2 cm (0.75 in) or greater in diameter were considered ground cover. Plant litter in contact with the soil surface was considered ground cover. Standing litter was not included. Bare soil and rock or pavement less than 2 cm diameter were not included in ground cover.

Results

Return of crown cover of mountain big sagebrush and other shrubs was highly variable as demonstrated in table 1 and in the scatter diagram of figure 1. Crown cover of mountain big sagebrush varied from 4 percent to 46 percent after 15 years post burn. After 15 years post burn, crown cover of mountain big sagebrush was greater than 15 percent at most of the burned sites. Shrubs other than sagebrush included bitterbrush (*Purshia tridentata*), mountain snowberry and yellowbrush. Mountain snowberry is particularly capable of rapid increase in cover after fire. At some sites and especially on the Tavaputs Plateau, yellowbrush increased rapidly after fire. Crown cover of other shrubs appeared to decrease as mountain big sagebrush increased in cover (fig. 1).

Ground cover increased rapidly following fire (table 2 and fig. 2). After 5 years, ground cover was 80 percent or greater on most burned sites.

Discussion

Return of sagebrush crown cover was highly variable. Some of the variation was likely site related. Work in Idaho (Jensen 1984) and Utah (Woodward 1981; Woodward and others 1984) strongly suggests that sites with high K-Mg ratios in the soil favor the growth of shrubs and sites with low K-Mg ratios favor grass production. On sites deficient in magnesium but having adequate potassium, plant species having large root-cation exchange capacity may be at a competitive advantage. In the Utah study dicots were found with high root-cation exchange capacity and monocots (grasses) were found with low cation exchange capacity. Big sagebrush was found with about 2.6 times greater root-cation exchange capacity than bluebunch wheatgrass and other perennial grasses included in the study (Woodward and others 1984). Recovery of sagebrush crown cover might be related to elemental ratios in the soil.

Table 1—Postburn crown cover of shrubs (percent) (ARTRV: mountain big sagebrush. CHVIL4: yellowbrush. PUTR2: bitterbrush. SYOR: mountain snowberry. ARSP8: spiked big sagebrush, CHNA2: rubber rabbitbrush).

Study #	Year burned	Year read	# YEARS	ARTRV	CHVIL4	PUTR2	SYOR	AMAL2	ARSP8	CHNA2	Total
37-4B	2002	2003	01	4.7	0.3	0.0	0.0	0.0	0.0	0.0	5.0
37-22A	1999	2000	01	0.0	4.0	0.0	2.4	0.0	0.0	0.0	6.4
37-22A	1999	2000	01	0.0	4.0	0.0	2.4	0.0	0.0	0.0	6.4
37-29A	2002	2003	01	0.1	0.4	0.0	0.8	0.0	0.0	0.0	1.3
39-48A	1998	1998	01	0.0	0.0	0.1	2.7	1.3	0.0	0.0	4.1
42-8A	1988	1989	01	0.7	0.5	0.0	0.8	0.0	0.0	0.0	2.0
42-8B	1988	1989	01	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.6
42-11	1990	1991	01	0.1	0.3	0.9	0.1	0.2	0.0	0.0	1.6
44-3B	2002	2002	01	0.9	0.5	0.0	0.0	0.0	0.0	0.0	1.4
65-21	2002	2003	01	0.0	1.4	0.1	2.4	0.1	0.0	0.0	4.0
67-83C	1999	2000	01	0.0	0.1	0.0	1.6	0.0	0.0	0.0	1.7
67-93	2000	2001	01	0.0	0.0	0.0	0.5	0.0	0.0	4.7	5.2
67-93	2000	2005	01	0.0	0.0	0.0	1.0	0.0	0.0	2.3	3.3
68-62A	1998	1999	01	0.0	8.7	4.1	0.0	0.0	0.0	0.0	12.8
19-30	1993	1995	02	0.0	1.1	0.3	0.0	0.0	0.0	0.0	1.4
32-78	1993	1995	02	0.2	0.7	4.8	0.0	0.0	0.0	0.0	5.7
32-85A	1998	2000	02	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2
37-22A	1999	2001	02	0.0	10.2	0.0	2.1	0.0	0.0	0.0	12.3
37-24C	1999	2001	02	0.0	2.6	1.7	4.4	0.0	0.0	0.0	8.7
37-28A	1999	2001	02	0.0	3.1	0.0	9.4	0.3	0.0	0.0	12.8
39-28	1999	2001	02	0.1	0.0	0.0	4.3	0.0	0.0	0.0	4.4
42-10	1991	1993	02	0.1	1.0	0.0	30.2	0.0	0.0	0.0	31.3
43-24	1988	1990	02	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.4
64-1	1987	1989	02	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
65-21	2002	2004	02	0.0	7.3	0.3	7.3	0.5	0.0	0.0	15.4
67-86A	1999	2001	02	0.0	4.2	0.0	7.4	0.0	0.0	0.0	11.6
32-85A	1998	2001	03	0.3	0.1	0.0	0.3	0.0	0.0	0.0	0.7
32-85W	1998	2001	03	0.0	0.3	0.0	1.3	0.0	0.0	0.0	1.6
37-19A	1998	2001	03	0.0	0.6	0.0	13.9	0.6	0.0	0.0	15.1
37-19B	1998	2001	03	0.0	0.4	6.0	4.2	0.1	0.0	0.0	10.7
39-22B	1999	2002	03	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
39-48A	1998	2001	03	0.0	0.0	0.2	3.5	3.2	0.0	0.0	6.9
40-5C	1999	2002	03	3.7	10.9	1.0	0.0	4.4	0.0	0.0	20.0
43-28	1988	1991	03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44-26	2000	2003	03	0.1	0.6	0.0	1.0	0.0	0.0	0.0	1.7

Table 1—(Continued)

Study #	Year burned	Year read	# YEARS	ARTRV	CHVIL4	PUTR2	SYOR	AMAL2	ARSP8	CHNA2	Total
51-1	1998	2001	03	8.1	1.7	2.3	23.5	0.9	0.0	0.0	36.5
51-6A	1998	2001	03	2.7	2.6	0.0	8.0	0.0	0.0	0.0	13.3
51-15B	1999	2002	03	0.1	0.8	0.0	3.1	0.1	0.0	0.0	4.1
67-68	1999	2002	03	0.0	1.2	0.0	0.6	0.0	0.0	0.0	1.8
67-76	1999	2002	03	0.4	4.5	0.0	0.6	0.0	0.0	0.0	5.5
67-83B	1999	2002	03	0.3	0.4	0.0	7.7	0.0	0.0	0.0	8.4
31-10A	1998	2002	04	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
31-10H2	1998	2002	04	0.0	0.7	0.0	15.2	0.0	0.0	0.0	15.9
39-34A4	1999	2003	04	0.0	0.0	0.0	7.6	0.0	0.0	0.0	7.6
43-17	1988	1992	04	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
51-9B	1998	2002	04	0.0	4.6	0.0	1.1	0.0	0.0	0.0	5.7
68-67A	1998	2002	04	0.0	1.9	0.0	0.9	0.0	0.0	0.0	2.8
68-67B	1998	2002	04	0.3	2.3	0.0	0.0	0.0	0.0	0.0	2.6
68-67C	1998	2002	04	0.0	7.8	0.0	0.7	0.0	0.0	0.0	8.5
19-30	1993	1998	05	0.0	2.5	0.9	0.0	0.0	0.0	0.0	3.4
32-70	1993	1998	05	1.5	2.7	0.0	0.0	0.0	0.0	0.0	4.2
64-1	1987	1992	05	11.8	0.1	0.0	0.0	0.0	0.0	0.0	11.9
37-19B	1998	2004	06	0.1	3.6	7.6	3.9	0.0	0.0	0.0	15.2
42-11	1990	1996	06	1.5	1.2	8.1	0.0	0.1	0.0	0.0	10.9
43-24	1988	1994	06	0.7	1.2	0.0	0.1	0.0	0.0	0.0	2.0
43-46B	1994	2000	06	0.0	2.4	0.0	20.0	0.0	0.0	0.0	22.4
58-7	1992	1998	06	0.6	40.3	0.8	4.6	0.8	0.0	0.0	47.1
68-8	1996	2002	06	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
68-51	1996	2002	06	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.5
68-54	1996	2002	06	4.6	0.7	0.0	0.4	0.0	0.0	0.0	5.7
32-78	1993	2000	07	1.2	1.8	8.8	0.7	0.0	0.0	0.0	12.5
41-8A	1989	1996	07	0.0	0.0	0.0	2.3	0.0	0.0	0.0	2.3
42-4B	1988	1995	07	3.4	0.3	0.1	0.0	0.0	0.0	0.0	3.8
42-15	1988	1995	07	0.1	0.0	0.6	0.0	0.6	0.0	0.0	1.3
19-30	1993	2001	08	0.2	3.5	2.3	0.0	0.0	0.0	0.0	6.0
32-83B	1993	2001	08	2.4	0.6	0.0	0.0	0.0	0.0	0.0	3.0
32-83C	1993	2001	08	0.1	5.7	0.0	0.0	0.0	0.0	0.0	5.8
42-8A	1988	1996	08	2.8	11.3	0.0	0.7	0.0	0.0	0.0	14.8
42-8B	1988	1996	08	3.5	3.4	0.0	0.0	0.0	0.0	0.0	6.9
43-28	1988	1996	08	0.7	0.7	0.7	0.0	0.0	0.0	0.0	2.1
19-30	1993	2002	09	0.2	4.1	2.2	0.0	0.0	0.0	0.0	6.5

Table 1—(Continued)

Study #	Year burned	Year read	# YEARS	ARTRV	CHVIL4	PUTR2	SYOR	AMAL2	ARSP8	CHNA2	Total
32-70	1993	2002	09	4.0	2.6	0.0	0.5	0.0	0.0	0.0	7.1
32-78	1993	2002	09	2.1	3.8	9.8	0.7	0.0	0.0	0.0	16.4
38-14	1990	2000	10	0.2	3.5	0.0	0.0	0.0	0.0	0.0	3.7
38-41B	1990	2000	10	0.0	0.1	0.0	1.0	0.0	0.0	0.0	1.1
42-4B	1988	1998	10	6.3	0.7	0.1	0.0	0.0	0.0	0.0	7.1
43-14C	1988	1998	10	8.8	0.4	1.3	0.0	0.0	0.0	0.0	10.5
43-46B	1994	2004	10	0.8	1.2	0.0	24.0	0.0	0.0	0.0	26.0
68-60A	1992	2002	10	3.9	0.1	0.0	3.5	0.0	0.0	5.6	13.1
68-60B	1992	2002	10	18.4	0.3	0.0	0.2	0.0	0.0	0.0	18.9
42-10	1991	2002	11	0.5	1.4	0.0	30.8	2.8	0.0	0.0	35.5
42-11	1990	2001	11	4.1	0.9	12.6	0.1	0.7	0.0	0.0	18.4
64-1	1987	1998	11	34.8	0.0	0.0	0.0	0.0	0.0	0.0	34.8
68-104	1992	2003	11	5.1	10.0	0.0	0.9	0.0	0.0	0.0	16.0
42-4B	1988	2000	12	8.2	0.3	0.5	0.0	0.0	0.0	0.0	9.0
42-6	1988	2000	12	1.7	0.8	9.8	0.0	0.0	0.0	0.0	12.3
41-8A	1989	2002	13	0.4	0.0	0.0	2.4	0.0	0.0	0.0	2.8
41-10A	1989	2002	13	0.9	0.0	0.0	3.3	0.0	0.0	0.0	4.2
42-8B	1988	2001	13	7.4	3.8	0.0	0.1	0.0	0.0	0.0	11.3
43-24	1988	2001	13	1.8	0.5	0.0	0.0	0.0	0.0	0.0	2.3
43-24B	1988	2001	13	0.2	0.8	0.0	0.0	0.0	0.0	0.0	1.0
64-1	1987	2001	13	30.9	0.0	0.0	0.0	0.0	0.0	0.0	30.9
42-4B	1988	2002	14	10.3	0.3	0.0	0.0	0.0	0.0	0.9	11.5
43-14C	1988	2002	14	11.3	0.5	2.7	0.1	0.0	0.0	0.0	14.6
43-28	1988	2002	14	2.5	0.9	0.6	0.5	0.0	0.0	0.0	4.5
41-6H	1985	2000	15	0.9	0.8	21.5	6.0	0.0	0.0	0.0	29.2
44-9	1976	1991	15	5.6	7.5	0.0	1.3	0.0	0.0	0.0	14.4
41-6A3B	1985	2002	17	19.8	0.1	0.4	0.6	0.0	0.0	0.0	20.9
41-6C	1985	2002	17	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4
42-15	1988	2005	17	1.6	0.0	1.3	0.0	1.8	0.0	0.0	4.7
43-54	1980	1997	17	6.2	4.3	0.0	13.5	0.0	0.0	0.0	24.0
39-10	1961	1979	18	18.6	0.0	0.9	4.5	0.0	0.0	0.0	24.0
39-28	1978	1996	18	22.4	0.0	0.0	11.6	0.1	0.0	0.0	34.1
38-9	1978	1997	19	32.3	0.1	0.0	15.3	0.0	0.0	0.0	47.7
38-33	1978	1997	19	46.0	0.0	0.0	18	0.0	0.0	0.0	64.0
42-39	1978	1997	19	6.3	1.5	16.7	0.0	0.0	0.0	0.2	24.7
43-8A1	1978	1997	19	22.7	0.0	0.0	2.6	0.0	0.0	0.0	25.3

Table 1—(Continued)

Study #	Year burned	Year read	# YEARS	ARTRV	CHVIL4	PUTR2	SYOR	AMAL2	ARSP8	CHNA2	Total
64-11	1982	2001	19	28.2	6.6	0.0	1.0	0.0	0.0	0.0	35.8
68-10	1977	1996	19	21.4	2.8	0.0	9.1	0.0	0.0	0.0	33.3
68-9	1976	1996	20	33.5	0.7	0.0	0.3	0.0	0.0	0.0	34.5
42-39	1978	1999	21	6.6	1.3	20.7	0.0	0.0	0.0	0.0	28.6
44-1A	1976	1997	21	26.0	0.6	0.0	7.3	0.0	0.0	0.0	33.9
44-1B1	1976	1998	21	38.0	0.0	0.0	1.5	0.0	0.0	0.0	39.5
44-9	1976	1997	21	10.0	10.6	0.0	0.1	0.0	0.0	0.0	20.7
43-54	1980	2002	22	7.1	3.4	0.0	14.0	0.0	0.0	0.0	24.5
38-35A	1978	2001	23	20.1	0.0	0.0	6.6	0.0	0.0	0.0	26.7
39-15U2	1979	2002	23	29.1	0.0	1.0	0.0	0.0	0.0	0.0	30.1
38-9	1978	2002	24	32.6	0.0	0.0	13.4	0.0	0.0	0.0	46.0
39-15U	1979	2003	24	43.7	0.0	0.0	0.1	0.0	0.0	0.0	43.8
42-39	1978	2002	24	7.6	1.2	18.5	0.0	0.0	0.0	0.0	27.3
43-8A1	1978	2002	24	31.0	0.1	0.0	2.3	0.0	0.0	0.0	33.4
64-6A	1978	2002	24	7.5	20.7	0.0	0.5	0.0	16.8	0.0	45.5
64-18A	1978	2002	24	8.8	1.2	0.0	0.0	0.0	0.0	0.0	10.0
68-32	1978	2002	24	26.7	0.1	0.0	0.0	0.0	0.0	0.3	27.1
68-10	1977	2002	25	38.2	2.0	0.0	4.4	0.0	0.0	0.0	44.6
68-11B	1977	2002	25	12.3	0.8	0.0	4.8	0.0	0.0	0.0	17.9
68-9	1976	2002	26	33.0	0.1	0.0	0.5	0.0	0.0	0.0	33.6
68-13A	1976	2002	26	29.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0
68-18B	1976	2002	26	33.0	0.0	0.0	0.2	0.0	0.0	0.0	33.2
41-6A5B	1978	2005	27	29.5	0.2	0.4	0.0	0.0	0.0	0.0	30.1
41-6A6B	1978	2005	27	28.7	0.5	2.2	0.1	0.1	0.0	0.0	31.6
44-1A	1976	2003	27	33.1	0.2	0.0	7.8	0.0	0.0	0.0	41.1
44-9	1976	2003	27	14.4	7.5	0.0	0.0	0.0	0.0	0.0	21.9
39-10	1961	1996	35	17.8	0.0	0.6	0.7	0.0	0.0	0.0	19.1
39-10	1961	2001	40	36.6	0.0	0.0	0.0	0.0	0.0	0.0	36.6
39-10	1961	2003	42	32.3	0.0	0.3	0.0	0.0	0.0	0.0	32.6

Table 2—Trend of ground cover following fire

Study #	Year burned	Year read	Years post-fire	Percent Cover
5-11	1976	1991	15	91
5-11	1992	1997	5	91
5-61A	1999	2002	3	63
19-30	1993	2002	9	nd
31-10A	1998	2002	4	76
31-10H2	1998	2002	4	84
32-70	1993	2002	9	82
32-78	1993	2002	9	87
32-83B	1993	2001	8	90
32-83C	1993	2001	8	nd
32-85A	1998	2001	3	81
32-85W	1998	2001	3	82
37-4B	2002	2003	1	92
37-12A	1998	2002	4	92
37-19A	1998	2001	3	81
37-19B	1998	2004	6	80
37-22A	1999	2001	2	81.5
37-24C	1999	2001	2	70
37-28A	1999	2001	2	14
37-29A	2002	2003	1	85
38-9	1978	2002	24	86
38-14	1990	2000	10	97
39-10	1961	2003	42	87
39-15U	1979	2003	24	93
39-15U2	1979	2002	23	83
39-22B	1999	2002	3	92
39-27C2	2000	2002	2	30
39-34A4	1999	2003	4	97
40-5C	1999	2002	3	75
41-8A	1989	2002	13	93
41-10A	1989	2002	13	81
42-8A	1988	1989	1	90
42-8A	1988	1996	8	83
42-8B	1988	1989	1	45
42-10	1991	1993	2	92
42-10	1991	2002	11	87
42-11	1990	1991	1	59
42-39	1978	2002	24	77
43-8A1	1978	2002	24	94
43-14C	1988	1998	10	87
43-14C	1988	2002	14	87
43-17	1988	1992	4	76
43-24	1988	1990	2	83
43-24	1988	1994	6	96
43-24	1988	2001	13	94
43-24B	1988	2001	13	85
43-28	1988	1991	3	76
43-28	1988	1996	8	88
43-28	1988	2002	14	84
44-1A	1976	2003	27	95
44-3B	2002	2002	0	61
44-9	1976	1991	15	84
44-9	1976	2003	27	92
44-26	2000	2003	3	85
51-6A	1998	2001	3	90
51-9B	1998	2002	4	84
51-15B	1999	2002	3	78
64-1	1987	1989	2	31
64-1	1987	1992	5	47
64-1	1987	2001	14	59
64-6	1978	1980	2	71
64-6A	1978	2002	24	94
64-18A	1978	2002	24	91
65-21	2002	2003	1	11
65-21	2002	2004	2	46
67-68	1999	2000	1	11
67-68	1999	2002	3	63
67-76	1999	2002	3	64
67-83B	1999	2002	3	56
67-86A	1999	2001	2	48
68-8	1996	2002	6	95
68-9	1976	2002	26	78
68-10	1977	2002	25	89
68-11B	1977	2002	25	97
68-13A	1976	2002	26	79
68-18B	1976	2002	26	81
68-32	1978	2002	24	80
68-51	1996	2002	6	82
68-54	1996	2002	6	91
68-60A	1992	2002	10	77
68-60B	1992	2002	10	77
68-67A	1998	2002	4	58
68-67B	1998	2002	4	70
68-67C	1998	2002	4	71
68-72A	1999	2002	3	74

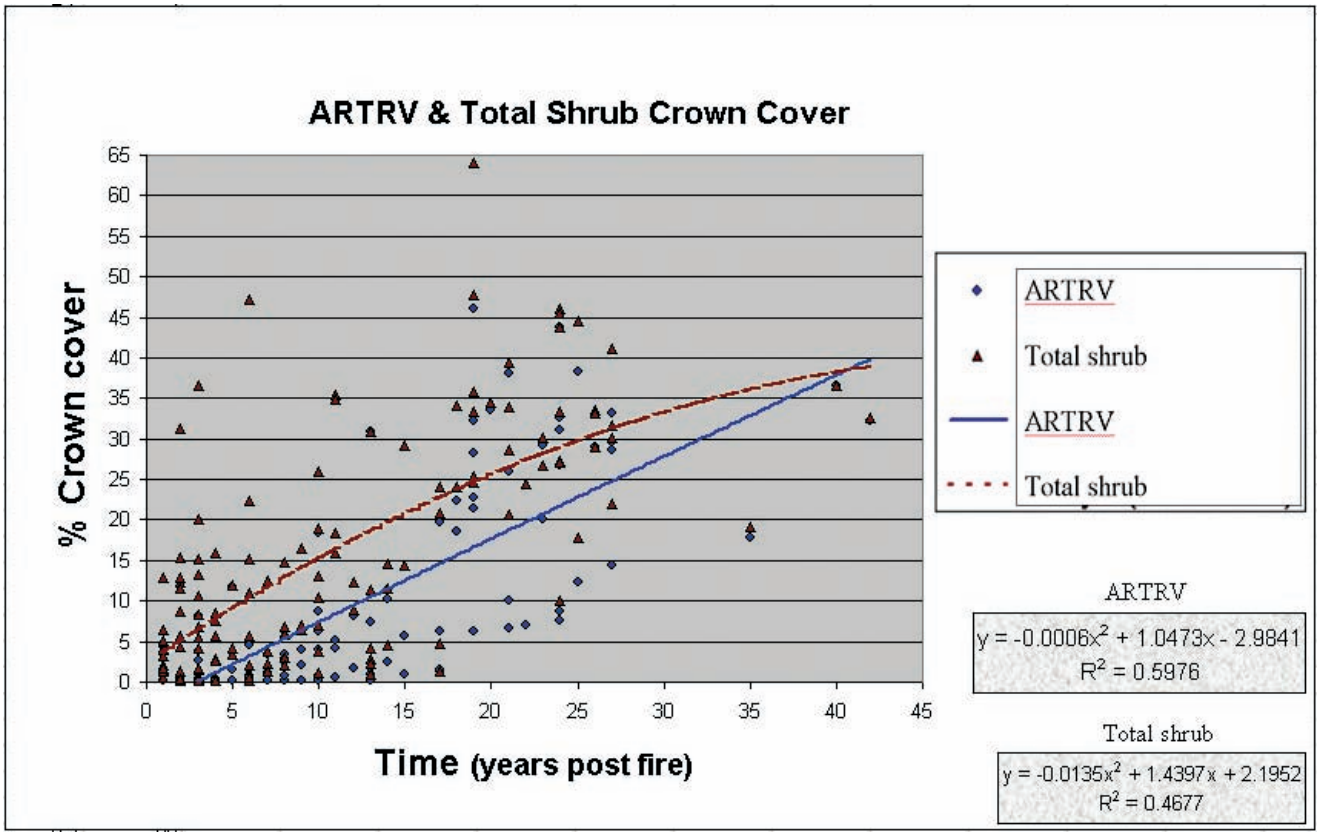

Figure 1—Trend of shrub crown cover following fire.

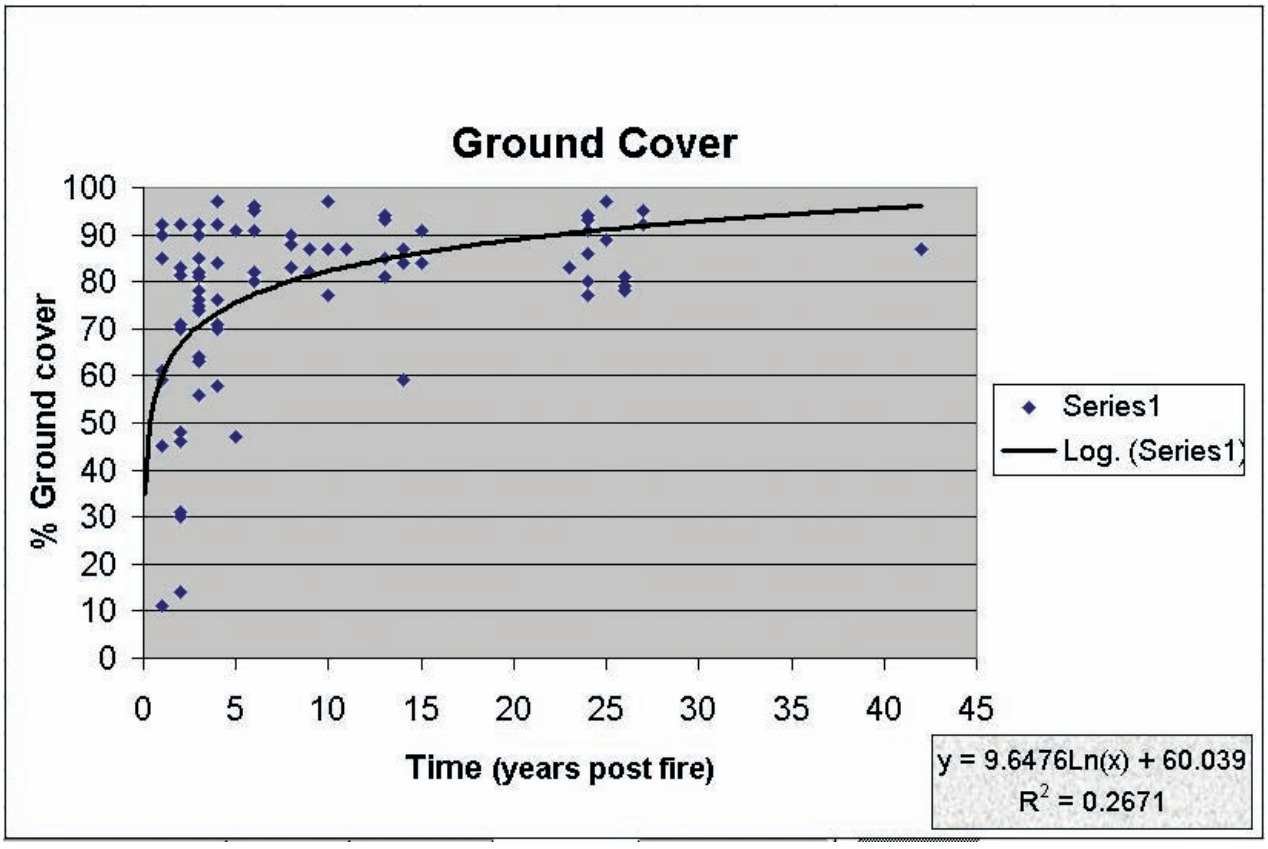

Figure 2—Trend of gound cover following fire.

Twenty percent or greater crown cover of mature sagebrush capable of high seed production in pre-burn communities appears to be important to recruitment of sagebrush seedlings in post-burn communities. This seemed to be a dominant feature of stands in which there was rapid return of sagebrush cover.

Weather patterns could also be a factor. Low recruitment of sagebrush seedlings in post-burn communities might be expected following fire in years of low seed production. Seedling establishment could also be influenced by season and amount of precipitation following fire. At several of the monitoring sites of this study, high numbers of sagebrush seedlings were observed in the favorable years of 2004 and 2005. It seems noteworthy to point out this high recruitment of sagebrush seedlings followed a drought in 2002.

Sites of this study include various intensities of use by livestock. This could also be a factor in the variable rate of return of sagebrush at our sites. Return of sagebrush might be expected to be accelerated by increasing levels of livestock grazing. As stated above, there were too few sites without a current history of livestock use to test this concept.

In addition to measurements of crown cover of shrubs, observations were made of herbaceous species at burned sites of this study. The herbaceous layer was dominated by native species at most sites. Native species seen in adjacent unburned sites and pre-burn sites were generally present in post burn sites. Essentially all native perennial herbaceous species sprouted after fire. This is consistent with return of species recorded for a burned site in Strawberry Valley, Utah (Goodrich, this proceedings). These observations indicate the indigenous herbaceous species are highly adapted to fire.

Shrubs except sagebrush sprouted after fire. Bitterbrush showed various capacities to sprout, and the other shrub species showed vigorous sprouting. Rubber rabbitbrush (*Chrysothamnus nauseosus*) was found at only one site, and, as expected, it sprouted after fire. However, it did not show increase in cover between the first and fifth years post burn. Spiked big sagebrush was found at one high elevation site where it provided nearly 17 percent crown cover at 24 years post burn while mountain big sagebrush had returned to about 8 percent. Higher crown cover value for spiked big sagebrush likely reflects its ability to sprout following fire. Serviceberry (*Amelanchier alnifolia*) was found with minor cover at several sites. This reflects influence from mountain brush communities that are often found near mountain big sagebrush communities of this study area.

Crown cover of other shrubs appeared to decrease as mountain big sagebrush increased in cover (fig. 1). Measurements of several other sites without a history of burning (not included in this study) indicated lower cover values for other shrubs where crown cover of mountain big sagebrush exceeded 30 percent.

Management Implications

The following management implications are intended for the area of this study only. They are not intended for broad extrapolation to other areas. Sites of this study are typically not winter range for deer and elk, and use of sagebrush by these animals has been light. Implications of this paper should not be applied to areas where wild ungulates concentrate in winter.

High variability of shrub cover in post burn environments demonstrates diversity in cover and structure achieved by fire. Although the data indicate low predictability for precise return intervals of sagebrush at a given site, the variability is a positive factor where diversity of habitat is desired. The data show sagebrush strongly trending toward greater than 25 percent crown cover in the absence of fire or other disturbance. The data strongly indicate that without some disturbance that reduces sagebrush cover, the great majority of the mountain big sagebrush type on the Ashley National Forest will persist in high percent cover of sagebrush. Where a diversity of sagebrush cover is desired, fire is demonstrated as an effective tool to achieve diversity.

The data strongly indicate many stands of mountain big sagebrush are sustainable under a fire regime that allows sagebrush to mature to 20 percent or more crown cover with a high level of seed production. Greater than 20 percent crown cover is documented for many stands of mountain big sagebrush within 25 years of burning. The data suggest sustainability of many stands of mountain big sagebrush at a fire interval of 25 to 30 years. However, we recommend that the application of fire be based on actual recovery of sagebrush crown cover at individual sites rather than on modeled fire intervals.

A 30-year interval would indicate that burning an average of about 3.3 percent per year of a mountain big sagebrush landscape would maintain highly diverse cover of sagebrush with mature stands well represented on the landscape. Where sagebrush was able to fully recover from fire within 20 years, about 5 percent of the landscape per year might be burned and still maintain high percent canopy cover of sagebrush over most of the landscape.

Unless the understory has been displaced by cheatgrass (*Bromus tectorum*) or other highly invasive species, there appears to be no need for seeding mountain big sagebrush communities following fire in the area of this study. The indigenous shrubs and associated understory species have demonstrated high resilience and adaptability to fire, and they can be expected to provide cover for watershed protection and wildlife habitat.

Ground cover returned to greater than 80 percent within 5 years after fire at most burned sites. At many sites this recovery was concurrent with light to moderate livestock grazing with some rest from livestock grazing for 1 and sometimes 2 growing seasons after fire.

Litter was the major component in the increase of ground cover. Basal area of live-plant cover was comparatively minor. However, litter production is dependent on plant production. Grazing intensities that remove a major portion of production in the early post-fire years can be expected to prolong recovery of ground cover. However, our studies indicate rapid recovery of ground cover can be concurrent with managed livestock grazing in mountain big sagebrush/grass communities. In some cases rapid recovery was achieved where light use (up to about 30 percent use by weight) was allowed the first year after fire where this use was delayed until fall after herbaceous species were mature.

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