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ABSTRACT

Declines in Gunnison sage grouse populations are thought to be related to habitat loss, fragmentation, and human induced habitat changes. In an attempt to improve the quality of early brood rearing habitat the Bureau of Land Management, Gunnison Field Office in Gunnison Colorado implemented a series of mechanical treatments designed to reduce sagebrush canopy cover and increase cover of graminoids and forbs. Brush mowing and Dixie harrow were utilized in 2005 to treat 30 percent of six 14 ac sites. In 2006 and 2007 shrub canopy cover, graminoid cover, forb cover, heights, and species richness were assessed to determine the vegetative response to each treatment. Sagebrush canopy cover was reduced to approximately 15 percent by both treatments. Mowing appeared to have no effect on forb or non-sagebrush shrub canopy cover, however, graminoid cover increased slightly post-treatment. Sites treated with the Dixie harrow had increased non-sagebrush shrub canopy cover, graminoid cover, and forb cover in post treatment years as compared to pretreatment. Heights for graminoids and forbs did not differ pre and post treatment ($p > 0.05$*) nor did species richness (*$p > 0.05$*) for either treatment.*

INTRODUCTION

The recently described Gunnison sage grouse (*Centrocercus minimus*) inhabits southwestern Colorado and eastern Utah. This species is a sagebrush (*Artemesia* sp.) obligate whose population has been declining due to habitat loss, fragmentation, and human induced habitat changes (Oyler-McCance and others 2001; Young and others 2000). The historic range of the Gunnison sage grouse is thought to include Grand and San Juan counties in Utah, fifteen southwestern counties in Colorado, and northern counties in New Mexico (Braun 1995; Young and others 2000). Currently the distribution has been reduced to six counties in Colorado and one in Utah comprising eight known populations with a total of fewer than 5000 breeding individuals (Young and others 2000). The largest of these is the Gunnison Basin population located in Gunnison County Colorado, containing approximately 3700 breeding individuals (Spicer and Diamond 2007).

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Habitat use by sage grouse (*Centrocercus* sp.) varies temporally and spatially. Sagebrush cover, herbaceous cover, and food availability, which is dictated by sagebrush and herbaceous cover, are the characteristics that drive habitat selection by nesting hens and hens with broods. Nesting habitats are typically distinguished by having 17 to 22 percent canopy cover of sagebrush which exhibits a greater percent cover than sites randomly selected which contain 7 to 15 percent sagebrush cover (Connelly 1991; Sveum 1998; Klebenow 1969; Gregg 1991). Increased levels of sagebrush cover appear to be preferred during nesting where concealment is a desired habitat characteristic. However following hatching habitat use shifts to areas with higher food availability.

The primary dietary component for young sage grouse consists of forbs and insects (Klebenow 1969; Drut 1994b, Peterson 1970). The availability of their primary food becomes the driving force for habitat selection for both early and late brood rearing. Early brood rearing, zero to six weeks, represents a habitat transition from sagebrush dominated sites used for nesting to riparian, meadow, or agricultural areas where food is more abundant. Brood rearing sites are typically characterized by a decrease in shrub canopy cover to 10 to 15 percent and an increase in forb cover, 10 to 27 percent (Connelly and others 2000; Drut 1994a, Klebenow 1969; Gunnison Sage-grouse Rangewide Steering Committee 2005).

Severe declines in Gunnison sage grouse populations resulting from loss of habitat and decreased habitat quality prompted the Bureau of Land Management Gunnison Field Office to implement habitat improvement projects. In an effort to improve early brood rearing habitat areas of big sagebrush (*Artemesia tridentata*) were treated using either a tractor pulled brush mower or Dixie harrow. Both treatments were designed to reduce sagebrush canopy cover releasing forbs and grasses from competition with sagebrush. Little research currently exists evaluating the response of grasses, forbs, and shrubs of a sagebrush system to mechanical treatment (Dahlgren 2006). The effects of sagebrush mowing and harrowing have rarely been documented despite their widespread use (Dahlgren 2006). As the prevalence of sagebrush treatments increases on BLM land, we were interested in the short-term vegetative response associated with mowing and harrowing as it applies to improving the condition of sage grouse habitat.

METHODS

Study Site

The treatment sites were located on lands managed by the Bureau of Land Management's Gunnison Field Office located in Gunnison, Colorado (38° 32' 45" N, 106° 55' 54" W). The sites were in the Sage Hen pasture of South Parlin Flats located 22.5km (14 miles) south east of Gunnison (figure 1). The sites are generally characterized as high elevation, 2500m (8200 ft), low precipitation, 13.7cm during the course of the study, with shrub communities comprised of a mosaic of mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*) dominated sites and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) dominated sites. The pasture is typically grazed by cattle but grazing was suspended during the time of the study. Within the Sage Hen pasture there is an inactive lek last utilized in 1995. An active lek is located approximately 200m (1/8 mile) to the northeast of the pasture with portions of the treatment area utilized by sage grouse for both summer and winter habitat.

Vegetation Treatments

The Dixie harrow utilized consisted of a 4.2m (14 foot) wide draw bar with ten 3m long heavy steel tubes attached to it. Each tube has many alternating 30cm (12 inch) steel fins attached. As the harrow is dragged behind a tractor the fins catch on plants and either uproot entire sagebrush plants or breaks portions off leaving plants with a reduced or altered canopy. A broadcast seeder was attached to the front of the tractor dispensing seed in the path of the harrow, which disrupts the soil surface adequately enough to assist in seedbed preparation. A grass/forb seed mix comprised of Sandberg bluegrass (*Poa secunda*), bottlebrush squirreltail (*Elymus elymoides*), western wheatgrass (*Pascopyrum smithii*), Indian ricegrass (*Achnatherum hymenoides)* alfalfa (*Medicago* sp.), small burnet (*Sanguisorba minor*), blue flax (*Linum perenne*), and sulfur buckwheat (*Eriogonum umbellatum*) was broadcast seeded at a rate of 4.4 kg (10 lbs) per ac. Three sites were selected for treatment by Dixie harrow, each approximately 14 ac. Thirty percent of each site was treated using a single pass from the harrow. Serpentine paths were created to reduce the potential threat of predation from ground predators and mimic a more natural pattern of disturbance.

The brush mowing treatment consisted of an approximately 4.6 m (15 ft) wide tractor-pulled mower set to a height of 20.3 cm (8 inches). The previously described grass/forb seed mix was dispensed at a rate of 4.4 kg (10 lbs) per ac from a seeder mounted in front of the tractor. Compared to harrowing, mowing resulted in less soil surface disturbance and thus was less effective at preparing a seedbed. Three sites were selected for treatment by brush mowing, each approximately 14 ac. Thirty percent of each site was treated in a serpentine pattern using a single pass from the mower.

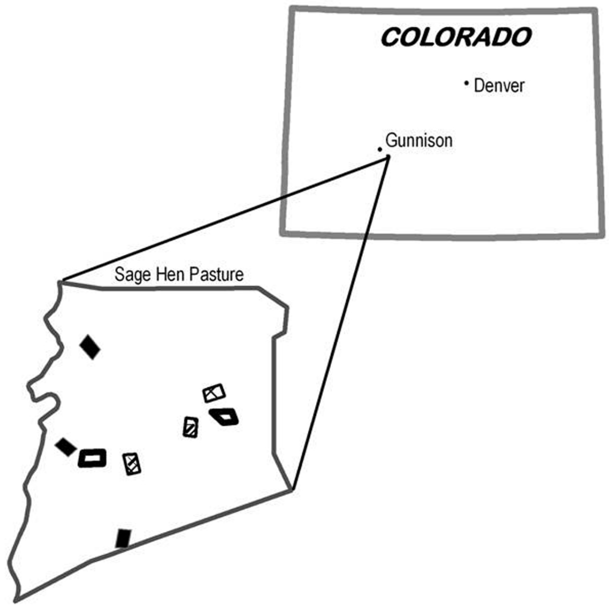

Figure 1—Location of treatment sites in Sage Hen Pasture near Gunnison Colorado. Solid fill sites are mowing, cross hatched sites are Dixie harrow, and open fill sites are controls.

Vegetation Analysis

One 30 m transect was established per treatment site by permanently marking the beginning and end points. Each transect was read pretreatment in 2005. Mechanical treatment was conducted in the fall of 2005 with each transect being marked and deliberately treated for its entire length. Two control sites were established in similar vegetation types as the treatments. All transects were read post treatment in August 2006 and 2007.

Estimates of cover for sagebrush (*Artemisia tridentata*) and non-sagebrush shrubs (*Chrysothamnus* sp., *Tetradymia canescens*, *Opunita polyacantha*, and *Symphoricarpos rotundifolius*) were determined by measuring the horizontal linear length of live and dead portions of shrub plants using line-intercept methodology. Measurements were made to the nearest 3 cm (1/10 ft) excluding spaces of 6cm (2/10 ft) and smaller between branches or foliage with live plant material taking precedence over dead when overlapping occurred.

Canopy cover for graminoids and forbs was determined by estimating the cover by species and lifeform of a 20 x 50 cm (7.8 x 19.6 inch) microplot placed every three m along the transect. Estimates of canopy cover were placed into one of thirteen cover classes (0 to 1 percent, 1 to 5 percent, 5 to 10 percent, 10 to 20 percent, 20 to 30 percent, 30 to 40 percent, 40 to 50 percent, 50 to 60 percent, 60 to 70 percent, 70 to 80 percent, 80 to 90 percent, 90 to 99 percent, 99 to 100 percent), which were averaged to determine percent cover per transect. In addition, estimates of ground cover (live and standing dead vegetation, litter, gravel, cobble, stones, and bedrock) and bare soil were also recorded. Average height, measured as the height where the bulk of the live and residual foliage occurs, maximum height, measured as the height of the tallest naturally occurring leaf or inflorescence (in the case of forbs), and density were recorded for each species encountered within the microplot. This paper will address shrub, graminoid, and forb canopy cover as well as height comparisons and species richness.

Statistical Analysis
Percent change, calculated as A-B/B, was used to determine if a change existed between pre and post treatment shrub, graminoid, and forb canopy cover. Since only one cover value was assigned per transect it generates a small sample size (n = 3) which precluded a statistical analysis. However height measurements generated a larger sample size since each measurement is independent allowing for a single factor analysis of variance (ANOVA) to be performed to determine if differences in height existed within species between pre and post treatment. Species richness was determined per transect and compared using a Wilcoxson signed-rank test to determine if a difference existed between pre and post treatments.

RESULTS

Sagebrush Canopy Cover
Mowing reduced the amount of sagebrush canopy cover along the transects from 21.9 percent pretreatment in 2005 to 16.4 percent and 14.8 percent for 2006 and 2007 respectively (figure 2). This represents a canopy reduction of 25.2 percent between 2005 and 2006 and 32.2 percent between 2005 and 2007. Dixie harrow also reduced the sagebrush canopy along the transects from 37.4 percent in 2005 to 13.7 percent in 2006 with an increase to 16.9 percent in 2007. This represents a decrease in canopy cover of 63.3 percent between 2005 and 2006 and a decrease of 54.9 percent between 2005 and 2007. Controls showed a reduction in sage canopy cover of 2.9 percent in both 2006 and 2007 (table 1).

Non-Sagebrush Shrub Canopy Cover
Non-sagebrush shrub canopy cover along the transects was increased by mowing from 1.4 percent pretreatment in 2005 to 2.2 percent and 2.8 percent in 2006 and 2007, respectively. This represents a 61.0 percent increase between 2005 and 2006 and a 104.9 percent increase between 2005 and 2007 (figure 2). Dixie harrow increased non-sagebrush canopy cover along the transects from 7.3 percent in 2005 to 12.5 and 13.9 percent in 2006 and 2007. This represents a 71.0 percent increase between 2005 and 2006 and 89.2 percent increase between 2005 and 2007. The control's non-sagebrush canopy cover increased from 6.9 percent in 2005 to 8.0 and 8.3 percent in 2006 and 2007. This represents a 16.1 percent increase in 2006 and a 20.4 percent increase between 2005 and 2007 (table 1).

Graminoid Canopy Cover
Graminoid canopy cover along the transects in mowed treatments decreased from 33.5 percent in 2005 pretreatment measurements to 22.1 percent post treatment in 2006 a decrease in cover of 34.2 percent. It then increased to 39.7 percent in 2007 representing an increase of 18.3 percent when comparing 2005 to 2007. Graminoid canopy cover along the transects in Dixie harrow treatments also declined post-treatment from 11.7 percent in 2005 to 6.7 percent in 2006 a decrease of 43.3 percent. In 2007 canopy cover along the transects increased to 26 percent representing a 121.9 percent increase between 2005 and 2007 (figure 3). Controls also experienced a decline in graminoid canopy cover between 2005 and 2006. Cover decreased 42.0 percent from 27.4 to 15.9 percent with an increase in 2007 to 23.8 percent but canopy cover remained 13.1 percent lower than pretreatment measurements (table 1).

Forb Canopy Cover
Forb canopy cover, consisting of both annual and perennial forbs, decreased along the transects in mowed treatments from pretreatment levels of 3.9 percent to 3.0 percent in 2006 a decrease of 21.9 percent cover. Forb cover increased in 2007 to 3.3 percent representing an overall decrease of 16.3 percent between 2005 and 2007. Forb canopy cover in Dixie harrow treatments increased from 0.9 percent in 2005 to 7.0 percent in 2006 this represents a 679.6 percent increase. In 2007 forb cover decreased to 4.8 percent along the transects, representing an overall forb canopy cover increase of 427.8 percent between 2005 and 2007 (figure 3). Forb canopy cover of controls decreased from 11.8 percent in 2005 to 9.4 percent, a decrease of 20.3 percent. In 2007 canopy cover increased slightly to 9.7 percent but cover remained 17.8 percent lower than in 2005 (table 1).

Graminoid and Forb Height
The average bulk height of both graminoids and forbs, including annuals and perennials, for each treatment (mowing, Dixie harrow, and control) showed no significant difference between pre and post treatment heights (P >0.05).

Species Diversity
Shrub, graminoid, and forb species richness did not significantly change during the two years post-treatment in any transect regardless of the treatment (P > 0.10). In 2006 seeded forb species were detected in five transects consisting of alfalfa found along one transect and small burnet found along four transects. These individuals were not subsequently detected along the transects in 2007. No detection of any seedling seeded grass species occurred along the transects in 2006 or 2007.

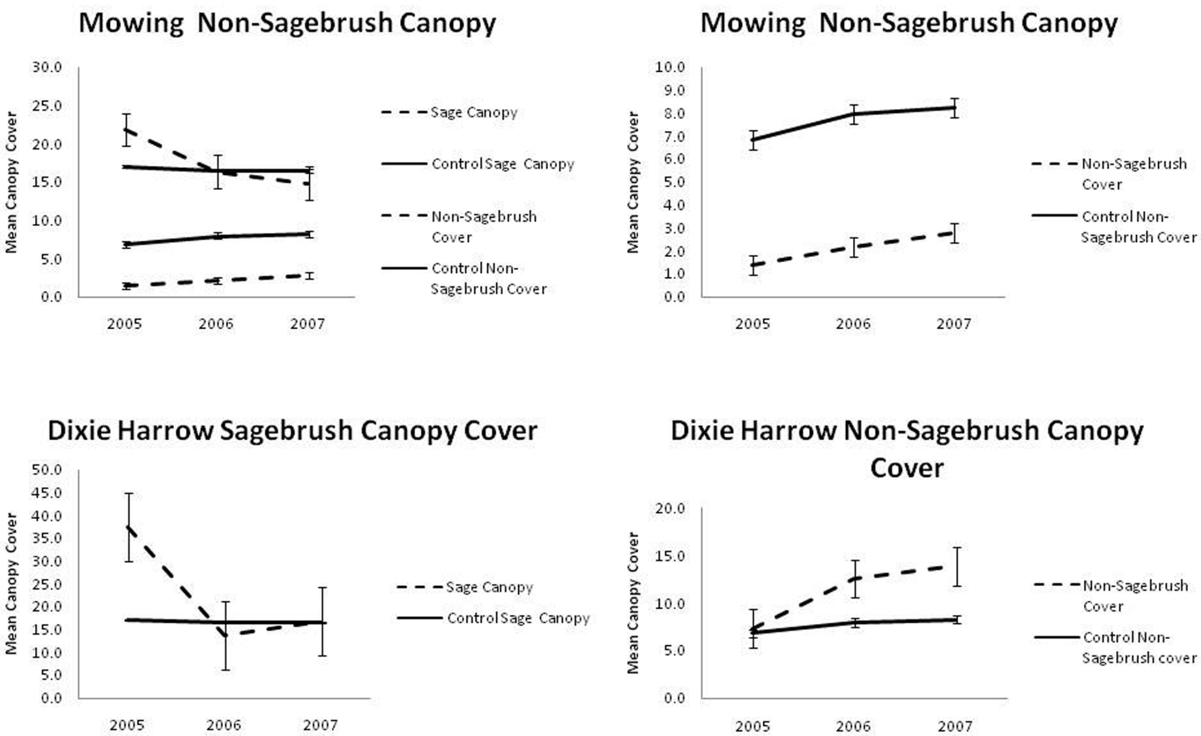

Figure 2—Mean canopy cover of live sagebrush and live non-sagebrush shrubs by treatment type. Error bars represent standard error.

DISCUSSION

Sagebrush canopy cover was reduced by both mowing and Dixie harrow, potentially allowing for competitive release of graminoids and forbs to improve early brood rearing habitat for the Gunnison sagegrouse. Controls maintained a consistent canopy cover over the course of the study indicating that the decrease seen from mowing and harrowing can be attributed to the treatment. In 2007 sagebrush in mowed transects experienced a continued decline in canopy cover while sagebrush in harrowed transects increased, by 97.5 cm (3.2 ft). The decrease seen in the mowing represents continued shrub dieback between 2006 and 2007. However sagebrush in harrowed sites increased in cover between 2006 and 2007 indicating that the plants responded to treatment. This increase may be seen as an unusually high change in a single growing season but given that transect cover values are compiled from numerous measurements of individual plants a relatively small increase that is seen uniformly across many individuals can quickly increase the overall cover of a site.

Non-sagebrush shrub canopy cover data, while containing measurements from four species, is predominantly comprised of rabbitbrush (*Chrysothamnus* sp.). Mowing created an increase of non-sagebrush shrub canopy cover of 104.9 percent between 2005 and 2007. Controls showed an increase of 20.4 percent between 2005 and 2007. When strictly comparing the mowing treatment percent difference with the control it would appear that mowing created a larger increase of non-sagebrush shrub cover. However, due to the initially low pretreatment canopy cover of 1.4 percent for mowed sites the increase to 2.8 percent cover will return a large percent change but this represents an artificially inflated representation of treatment effect. Comparison of the slopes of the lines, which indicates the degree of change from 2005 to 2007, offers a more accurate assessment of treatment effect. The slopes for mowed sites and controls are almost identical; y=0.7x for the controls and y=0.716x for mowing. This slope comparison indicates that there was almost no difference in the degree of change between mowed areas and controls for non-sagebrush canopy cover (figure 3). In Dixie harrow treatments non-sagebrush shrub canopy cover increased 89.2 percent between 2005 and 2007. Controls increased 20.4 percent between 2005 and 2007. Since the treatment and the control mean canopy cover were very similar in 2005, 7.3 and 6.8 percent respectively, the change seen in the harrowed sites can be interpreted as an effect of the treatment.

Graminoid canopy cover decreased between 2005 and 2006 for mowing (-34.2 percent), Dixie harrow (-43.3 percent), and controls (-42.0 percent). This was then followed by an increase in cover for all three treatments between 2006 and 2007. This initial decline in 2006 coincides with an abnormally low amount of precipitation in July, a critical growing period, indicating that this universal decrease is the result of climatic variation. In 2007 graminoid cover for mowings had increased to 18.3 percent above 2005 values.

While this represents an overall increase there is sufficient overlap in the variation within the samples for 2005 and 2007 to view this increase with caution. Changes in graminoid canopy cover in response to mowing remains unclear and further observation is needed to determine if there is a treatment effect. Dixie harrow graminoid cover increased in 2007 by 121.9 percent over 2005 values. The mean cover values and the variation that exists within these values are sufficiently different that it indicates the increase in graminoid cover is due to treatment by Dixie harrow (figure 3). The graminoid cover in the controls also experienced an increase in 2007 but it was still -13.1 percent below 2005 canopy values. The response of the controls further validates that the initial decline in 2006 can be attributed to environmental conditions. It also suggests that the increase seen in harrowed sites is due to the treatment.

Annual and perennial forb canopy cover decreased for controls (-20.3 percent) and mowing (-21.9 percent) between 2005 and 2006 then remained essentially the same in 2007 (figure 3). The similarity in response between mowing and controls suggests that there was no effect of mowing on forb cover within the first two years post-treatment. Dixie harrow forb cover increased between 2005 and 2006 then declined in 2007. The dramatic increase in 2006 is partially due to a large number of annual forbs. The decline in 2007 incorporates a weaker production of annual forbs and is more representative of the treatment effect on perennial forb production. Again percent difference within the harrowed treatments must be interpreted with some caution since the beginning value is small, 0.9, and any slight increase in cover will result in a dramatic change in percent difference. However it appears that within harrowed sites initially there is a trend for increased forb cover.

Seeding success for this study was marginal. No detection of seeded grass seedlings and only five individuals of forbs after two years suggests that seed germination and seedling survival is very low in this system, especially among non-local genotypes. Based on the low success rate at these sites, seeding may not provide any additional benefits in this ecosystem. This further reinforces the idea that if restoration of a site is desired it may be most effective to manage the area for the plants that already exist rather than trying to augment or change them through seeding.

These data represent the changes observed within a dynamic and complex sagebrush ecosystem two years post treatment. Two years is a short time-frame to assess the response of a plant community to disturbance. This should be kept in mind with interpreting these results. Continued study is required to fully understand how this particular sagebrush system responds to these disturbances.

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Table 1—Mean canopy cover of sagebrush, non-sagebrush, graminoids, and forbs by treatment by year. Percent difference represents difference between 2005, pretreatment, and 2006 and 2007, post-treatment.

Treatment	Sagebrush Cover	Percent Change	Non-Sagebrush Cover	Percent Change	Graminoid Cover	Percent Change	Forb Cover	Percent Change
Mowing 2005	21.9		1.4		33.5		3.9	
Mowing 2006	16.4	-25.2	2.2	61.0	22.1	-34.2	3.0	-21.9
Mowing 2007	14.8	-32.2	2.8	104.9	39.7	18.3	3.3	-16.3
Harrow 2005	37.4		7.3		11.7		0.9	
Harrow 2006	13.7	-63.3	12.5	71.0	6.7	-43.3	7.0	679.6
Harrow 2007	16.9	-54.9	13.9	89.2	26.0	121.9	4.8	427.8
Control 2005	17.0		6.9		27.4		11.8	
Control 2006	16.5	-2.9	8.0	16.1	15.9	-42.0	9.4	-20.3
Control 2007	16.5	-2.9	8.3	20.4	23.8	-13.1	9.7	-17.8

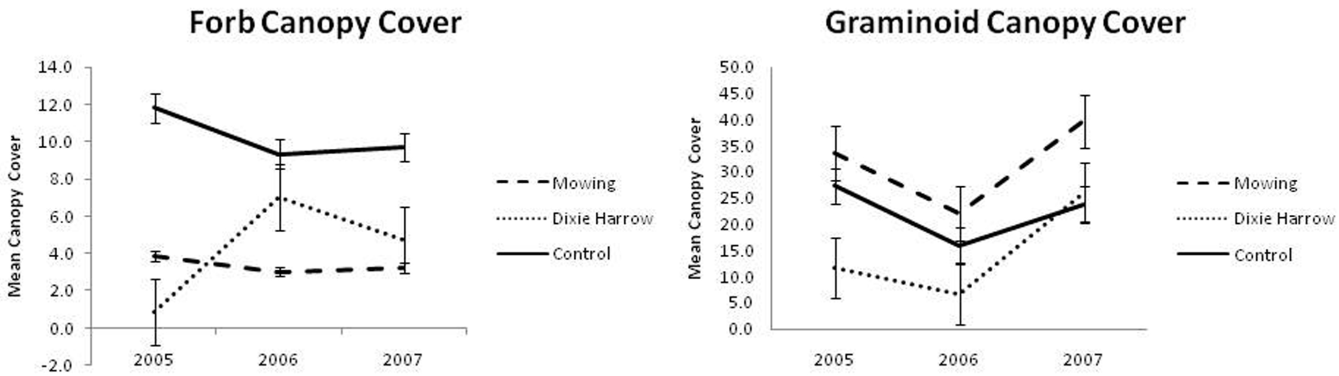

Figure 3—Mean canopy cover of graminoids and annual and perennial forbs by treatment. Error bars represent standard error.

REFERENCES

Braun, C.E. 1995. Distribution and status of sage grouse in Colorado. The Prairie Naturalist. 27(1):2-9.

Commons, M.L., Daybreak, R.K., Braun, C.E. 1997. Gunnison sage grouse *Centrocercus minimus* use of fragmented habitat in southwestern Colorado. Wildlife Biology. 3(4):283.

Connelly, J.W., Schroeder, M.A., Sands, A.R., Braun, C.E. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin. 28(4):967-985.

Connelly, J.W., Wakkinen, W.L., Apa, A.D., Reese, K.P. 1991. Sage grouse use of nest sites in southeastern Idaho. Journal of Wildlife Management. 55(3):521-524.

Dahlgren, D.K., Chi, R., Messmer, T.A. 2006. Greater sage-grouse response to sagebrush management in Utah. Wildlife Society Bulletin. 34(4): 975-985.

Drut, M.S., Crawford, J.A., Gregg, M.A. 1994a. Brood habitat use by sage grouse in Oregon. Great Basin Naturalist. 54(2): 170-176.

Drut, M.S., Pyle W.H., Crawford J.A. 1994b. Diets and food selection of sage grouse chicks in Oregon. Journal of Range Management. 47:90-93.

Gregg, M.A.1991. Use and selection of nesting habitat by sage grouse in Oregon. Thesis, Oregon State University, Corvallis, USA.

Gunnison Sage-grouse Rangewide Steering Committee. 2005. Gunnison sage-grouse rangewide conservation plan. Colorado Division of Wildlife, Denver, Colorado.

Hendrick, D.W., Hyder, D.N., Sneva, F.A., Poulton, C.E. 1966. Ecological response of sagebrush-grass range in central Oregon to mechanical and chemical removal of *Artemisia*. Ecology. 47(3):432-439.

Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. Journal of Wildlife Management. 33(3):649-662.

Oyler-McCance, S.J., Burnham, K.P., Braun, C.E. 2001. Influence of changes in sagebrush on Gunnison sage grouse in southwestern Colorado. The Southwestern Naturalist. 46(3):323-331.

Peterson, J.G. 1970. Food habits and summer distribution of juvenile sage grouse in central Montana. Journal of Wildlife Management. 34(1): 147-155.

Spicer, L., Diamond, B. 2007. Gunnison basin Gunnison sage-grouse lek count summary and population estimate. Colorado Division of Wildlife report.

Sveum, C.M., Edge, D.W., Crawford, J.A., 1998. Nesting habitat selection by sage grouse in southcentral Washington. Journal of Range Management. 51(3):265-269.

Wirth, T.A., Pyke, D.A. 2003. Restoring forbs for sage grouse habitat: fire, microsites, and establishment methods. Restoration Ecology. 11(3): 370-377.

Young, J.R., Braun, C.E., Oyler-McCance, S.J., Hupp, J.W., Quinn,T.W. 2000. A new species of sage-grouse (Phasianidae: *Centrocercus*) from southwestern Colorado. Wilson Bulletin. 112(4): 445-453.