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ABSTRACT

We measured 328 sites in northern, central, and southern Montana and northern Wyoming during 2003 to test the relationship of herbaceous cover to Wyoming big sagebrush (Artemisia tridentata wyomingensis*) cover. Long term annual precipitation at all sites was approximately 31 cm. Sagebrush and total herbaceous cover varied from 5 to 45 percent and 3.5 to 55 percent, respectively. Simple linear regression was the best fit model for predicting herbaceous cover from sagebrush cover using the highest* R_a^2 *values as the model selection criteria. In northern Montana, herbaceous vegetation was predicted by sagebrush cover with the following model:* $Y = 37.4 – 0.61X$ ($R_a^2 = 0.16$, $P < 0.001$, $n = 87$). *In central Montana, the model was* $Y = 14.0 – 0.00X$ ($R_a^2 = 0.00$, $P = 1.0$, $n = 155$). *In southern Montana, the model was* $Y = 35.9 – 0.39X$ ($R_a^2 = 0.14$, $P < 0.001$, $n = 86$). *When all sites were combined, the best fit model was* $Y = 23.7 – 0.15X$ ($R_a^2 = 0.01$, $P < 0.061$, $n = 328$). *This analysis determined that only 1 percent of the variation in herbaceous vegetation cover was associated with Wyoming big sagebrush cover. Management suggestions to reduce Wyoming big sagebrush in order to increase herbaceous production for greater sage-grouse (*Centrocercus urophasianus*) or livestock do not appear to be biologically sound.*

Keywords: Artemisia tridentata wyomingensis, *line intercept, grass cover,* Centrocercus urophasianus, *forb cover, greater sage-grouse, sage-grouse habitat.*

INTRODUCTION

It has been suggested that dense sagebrush (*Artemisia*) cover lowers greater sage-grouse (*Centrocercus urophasianus*) habitat quality and biological diversity (SRM 2006). The same publication states that sagebrush control can be used to enhance sage-grouse habitat by reducing sagebrush cover, which limits understory grass and forb production. Wright and Bailey (1982) recommended that removal of tall, thick sagebrush would release grasses and forbs from competition and result in increased yields for livestock grazing. In contrast, Miller and Eddleman (2001) concluded that there was little evidence that fire could be used to enhance sage- grouse habitat where there was a balance of native shrubs and perennial grasses and forbs. This statement implies there are conditions where shrubs and herbaceous vegetation were "unbalanced" and therefore might be manipulated. Welch and Criddle (2003) examined the relationship between big sage cover and percent bare ground from several data sets and concluded that the calculated R^2 values averaging 0.05 for mountain big sagebrush (*A. tridentata vaseyana*) and Wyoming big sagebrush (*A. t. wyomingensis*) cover and perennial herbaceous cover were not significant. We modeled the data from 328 sites to determine the best-fit relationship between Wyoming big sagebrush cover and herbaceous cover.

MATERIALS AND METHODS

Study Sites

Our three study areas were separated by a total of approximately 355 km from the northern most to the southern most locations sampled. Northern Montana samples were taken approximately 80 km south of Malta in southern Phillips County. Approximately 60 percent of this area is publicly owned by the U.S. Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (FWS), and the state of Montana (Moynahan 2004). Annual precipitation averaged 31 cm with peak precipitation between April and July (WRCC 2004). Soil taxonomic units that characterized this area included Absher, Elloam, and Thoeny (USDA 1981). Elevation varied from 600 – 1,060 m. Wyoming big sagebrush was the dominant shrub at all sample locations. Plains silver sagebrush (*Artemisia cana*), greasewood (*Sarcobatus vermiculatus*), and rubber rabbitbrush (*Chrysothamnus nauseosus*) were relatively common at many sites. Western wheatgrass (*Pascopyron smithii*), and blue grama (*Bouteloua gracilis*) were the common dominant grasses, while Sandberg bluegrass (*Poa secunda*), needle-and-thread (*Hesperostipa comata*), and threadleaf sedge (*Carex filifolia*) were measured frequently. American vetch (*Vicia americana*), scarlet globemallow (*Sphaeralcea coccinea*), yellow sweetclover (*Melilotus officinalis*), and dandelion (*Taraxacum officinale*) were the most common forbs. Fringed sagewort (*Artemisia frigida*), clubmoss (*Selaginella densa*), and prickly pear (*Opuntia polycantha*) were also common.

Measurements in the central Montana counties of Golden Valley and Musselshell were taken in an area centered about 30 km northwest of Roundup, Montana. Precipitation in this area averages 31 cm annually (NOAA 2004). Soil taxonomic units common to this area include Abor, Neldore, and Vanda (USDA 2003). Elevation is 826-1495 m. Wyoming big sagebrush was the dominant shrub although greasewood and plains silver sagebrush were also present. Western wheatgrass, Sandberg bluegrass, and blue grama were the dominant grasses, while green needlegrass (*Nassella viridula*), needle-and-thread, and threadleaf sedge

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were also common. Scarlet globemallow, wild onion (*Allium*), Hood's phlox (*Phlox hoodii*), and American vetch were the most abundant forbs.

Sampled sites in Bighorn County in southern Montana and adjacent Campbell County, Wyoming were mostly on private ranchland with some BLM and state land. Annual precipitation averaged 31 cm with peak precipitation occurring from April to June (NOAA 2003). Soil taxonomic units which characterize this area include Midway, Pierre, and Thedalun (USDA NRCS 2004). The elevation range is 762–1,314 m. Wyoming big sagebrush was the dominant shrub, although plains silver sagebrush, skunkbrush sumac (*Rhus aromatica*), common juniper (*Juniperus communis*) and rubber rabbitbrush were also present. Sandberg bluegrass, western wheatgrass, and Japanese brome (*Bromus japonicus*) were the dominant grasses, although green needlegrass, prairie junegrass (*Koeleria macrantha*), and bluebunch wheatgrass (*Psuedoroegneria spicata*) were also common. Desert alyssum (*Alyssum desertorum*), Hood's phlox, scarlet globemallow, American vetch, dandelion, and western yarrow (*Achillea millefolium*) were the most common forbs.

Sampling and Analysis

All sampling was conducted during late spring and early summer of 2003. Sagebrush cover was measured with the line-intercept method (Canfield 1941) using the procedures recommended as a standard and discussed by Connelly and others (2003) and Wambolt and others (2006). Line-intercepts were measured on two perpendicular 30 m N-S and E-W oriented transects. We measured sagebrush intercept in 3 cm units. We recorded openings in live foliage > 3 cm as nonsagebrush intercepts. Thus, we excluded both open spaces and dead portions of the plant. We obtained all measurements by vertically projecting a plumb bob from the transect line to plants to determine what intercepts from ground level to crown were directly beneath the line.

Herbaceous understory cover was measured using twenty 20 x 50 cm quadrats (Daubenmire 1959). The same N-S, E-W transects used to measure sagebrush cover were used to locate the quadrats for herbaceous sampling at 3 m intervals.

A number of linear and non-linear models were tested to determine the "best fit" relationship between sagebrush cover and herbaceous cover. Linear, quadratic, cubic, inverse, first order, sigmoidal, exponential decay, exponential growth and polynomial models were tested using Sigma Plot (2004). Maximum R_a^2 values were used to determine which model best fit our data.

RESULTS AND DISCUSSION

Simple linear regression models for all data sets resulted in the maximum R_a^2 values. In northern Montana, as sagebrush cover increased, herbaceous cover decreased (R_a^2 = 0.16, P < 0.001, n = 87), but only 16 percent of the variation in herbaceous cover was accounted for with change in sagebrush cover (figure.1). Although the regression is significant, this relationship indicates that if sagebrush cover at 20 percent were reduced to 5 percent, herbaceous cover would only be increased from 25 to 35 percent.

In central Montana, we found no relationship (R_a^2 = 0.00, P = 1.0, n = 155) between Wyoming big sagebrush cover and herbaceous cover (figure 1). We conclude that in this region, herbaceous cover is not influenced by Wyoming big sagebrush cover.

In southern Montana, herbaceous cover declined as sagebrush cover increased, but, 86 percent of the variation in herbaceous cover was not accounted for by sagebrush cover (R_a^2 = 0.14, P < 0.001, n = 86) (figure 1). Thus, if a site with 20 percent sagebrush cover was treated to reduce this cover to 5 percent, herbaceous cover would be expected to increase only 6 percent.

When all 328 sites were combined, a simple linear equation best explained the relationship between Wyoming big sagebrush cover and herbaceous cover (figure 1). There is a slight inverse relationship between the two variables (figure 1), but the R_a^2 = 0.01, (P < 0.06) indicates that across Montana and adjacent Wyoming, the variability in herbaceous cover cannot be explained by the amount of sagebrush cover. The model for all sites (n = 328) determined if an area had 20 percent sagebrush cover, the average herbaceous cover would be 20 percent. Thus, if sagebrush cover were reduced to 5 percent, our model predicts the herbaceous cover would only increase to 23 percent.

Some authors (Baxter 1996; SRM 2006) indicated that when big sagebrush cover increases over 12 to 15 percent, the understory production of other plants decreases as cover increases. However, Welch and Criddle (2003) found no significant relationship between sagebrush cover and bare ground (R^2 = 0.0003), which supports our conclusions with data from other regions. An additional concern arises from the fact that Baxter (1996) and SRM (2006) do not clarify the details of their sagebrush cover measurements and, therefore, it is possible, if not probable, that their 12 to 15 percent sagebrush cover would be much less using our methodology (Wambolt and others 2006).

Moynahan (2004) examined grass and forb cover from 2001 to 2003 in our northern Montana study area as part of a sage-grouse brood survival study. Perennial grass cover did not change appreciably in three years, but forb cover nearly doubled, largely due to the biennial yellow sweetclover responding to favorable growing conditions. Brood survival rates increased 3.5 fold from 2001 (drought year) to 2003 likely due to the increased abundance of herbaceous cover. Moynahan's (2004) findings in combination with our results indicate that precipitation has a much greater influence on herbaceous cover than does the amount of sagebrush cover. Welch and Criddle (2003) also concluded that precipitation, plant species, and soil properties influenced ground and perennial grass cover more than sagebrush cover.

MANAGEMENT IMPLICATIONS

It has been suggested that sagebrush control can be used to enhance herbaceous vegetation (SRM 2006). We determined that across our 328 study sites that a weak linear relationship exists between Wyoming big sagebrush cover and herbaceous cover ($Y = 23.7 - 0.15X$). However, 99 percent of the variation in herbaceous cover (3.5 to 55 percent) is not accounted for by changes in sagebrush cover (5 to 45 percent) alone ($R_a^2 = 0.01$, $P < 0.061$). Our data indicate a large majority of sites would fail to respond to sagebrush treatments as predicted with conventional wisdom (SRM 2006). Prescribed burning, prescribed grazing, herbicides and mechanical treatments have all been advocated to improve sage-grouse habitat where it is hypothesized that dense sagebrush cover limits herbaceous biomass (SRM 2006). Removing Wyoming big sagebrush cover to increase herbaceous vegetation for any purpose, including enhancing sage-grouse brood survival, does not appear to be biologically sound.

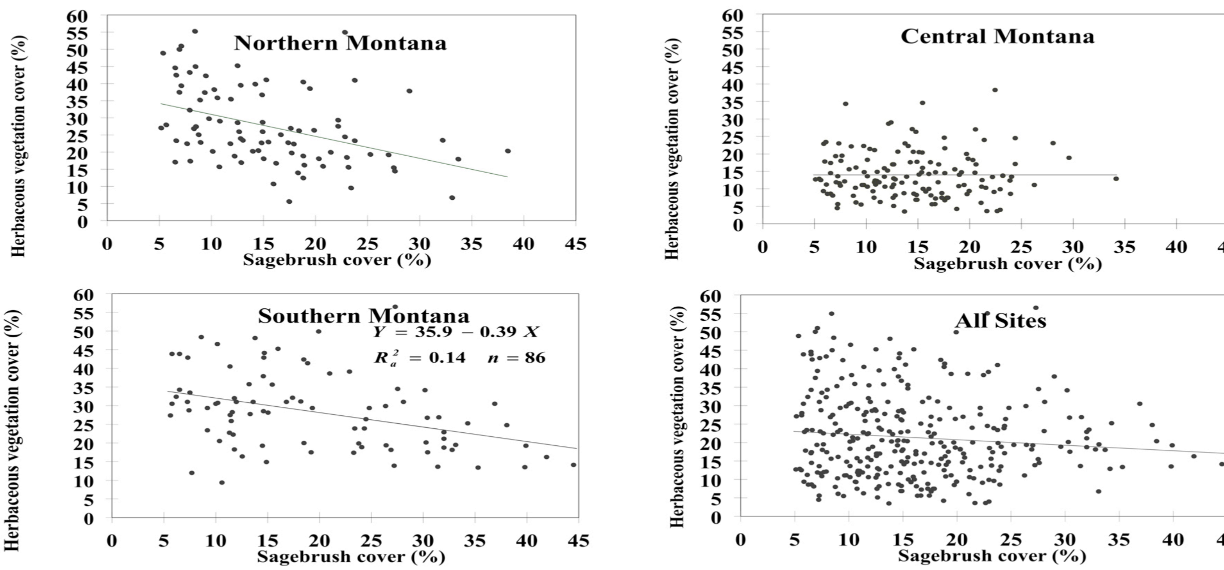

Figure 1—Relationship of Wyoming big sagebrush cover to herbaceous cover in northern, central, and southern Montana and over all sites. Funding and land for this research was provided by the Bureau of Land Management field offices in Montana, Montana Fish, Wildlife and Parks, and the Montana Agricultural Experiment Station.

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