Greater Sage-Grouse Centrocercus urophasianus Use of Threetip Sagebrush Relative to Big Sagebrush in South-Central Idaho

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Original article

Greater sage-grouse *Centrocercus urophasianus* use of threetip sagebrush relative to big sagebrush in south-central Idaho

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Disturbances that change sagebrush *Artemisia* spp.-steppe communities may have an impact on greater sage-grouse *Centrocercus urophasianus* populations. Fire can rapidly alter sagebrush-steppe communities and may result in an increase in threetip sagebrush *A. tripartita* because this shrub is one of the few species of sagebrush that will sprout following fire. We examined the use of threetip sagebrush by sage-grouse as nest cover and compared nest success of grouse using threetip sagebrush to that of grouse using big sagebrush *A. tridentata*. Sage-grouse used threetip sagebrush as nest cover less than expected based on the abundance of this shrub. The only other species of sagebrush used as nest cover was big sagebrush, and sage-grouse used big sagebrush more than expected based on big sagebrush abundance. However, nest site selection was confounded by age of sage-grouse females. Sage-grouse that used big sagebrush as nest cover had greater nest success than grouse using threetip sagebrush. Our findings demonstrate another negative, but subtle, effect of fire on sage-grouse populations and further underscore the need for fire suppression and carefully implemented habitat rehabilitation projects.

Key words: Artemisia, big sagebrush, Centrocercus urophasianus, habitat, nest, sage-grouse, threetip sagebrush

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Greater sage-grouse *Centrocercus urophasianus* use a variety of sagebrush *Artemisia* spp. dominated habitats for nesting (Klebenow 1969, Wakkinen 1990, Connelly et al. 1991, DeLong et al. 1995, Aldridge & Brigham 2002). Although many shrub species are used by sage-grouse as nest cover, nest success is greater when sagebrush is used (Connelly et al. 1991). Nest success is positively correlated with sagebrush height and canopy cover (Wakkinen 1990, Fischer 1994, Sveum et al. 1998, Connelly et al. 2000). Moreover, the relatively long distance movements by greater sage-grouse in a comparatively short period of time (Eng & Schladweiler 1972, Connelly et al. 1988, Wakkinen 1990, Robertson 1991, Fischer 1994, Hausleitner 2003) provide this species with the opportunity to make nest site selections on a broad landscape scale.

Big sagebrush *A. tridentata* is an important nest cover for sage-grouse. In south-central Washington, 66 - 71% of sage-grouse nests were under big sagebrush although big sagebrush made up only 46% of the available habitat (Sveum et al. 1998). In Oregon, sage-grouse nest success was highest in mountain big sagebrush *A. tridentata vaseyana* (Gregg 1991). However, other sagebrush species such as low sagebrush *A. arbuscula*, silver sagebrush *A.*

cana, and threetip sagebrush *A. tripartita* are commonly used as nest cover by sage-grouse (Klebenow 1969, Connelly et al. 1991, Gregg 1991, Sveum et al. 1998, Aldridge & Brigham 2001, Aldridge & Brigham 2002).

Although current land use practices may increase the presence of threetip sagebrush (Passey & Hugie 1962) in sagebrush-steppe, little is known about the use of this sagebrush species by sage-grouse. Wildfire or prescribed burning can promote the formation of threetip sagebrush-dominated stands because of the ability of this shrub to sprout following fire (Passey & Hugie 1962, Wright & Bailey 1982, Hironaka et al. 1983). As fire frequency increases (Baker 2006), so does the likelihood of increases in the abundance of threetip sagebrush in some parts of the range of greater sage-grouse.

Although much of the habitat currently used by sage-grouse is dominated by big sagebrush, threetip sagebrush is the dominant shrub within sage-grouse habitat in several portions of Idaho (Klebenow 1969, West et al. 1979, Fischer et al. 1996). In southeastern Idaho, 78% of sage-grouse nests were under threetip sagebrush in an area dominated by this shrub (Klebenow 1969). Nevertheless, no study has yet assessed sage-grouse use of threetip sagebrush or compared the reproductive performance of sage-grouse using threetip sagebrush vs big sagebrush as nest canopy cover (Klebenow 1969, Sveum et al. 1998). Understanding sage-grouse use of threetip sagebrush in relation to other sagebrush species will expand our understanding of sage-grouse reproduction in threetip sagebrush dominated landscapes, and increase our ability to predict how sage-grouse will respond to fire and other disturbances that result in threetip sagebrush replacing big sagebrush. This information will also help guide sage-grouse management where threetip sagebrush communities represent a prominent component of habitat available to sage-grouse. Here, we evaluate the use of threetip sagebrush relative to big sagebrush as nest cover for sage-grouse and examine habitat characteristics associated with both sagebrush species. Specifically, we were interested in answering the following questions: 1) Do sage-grouse use threetip sagebrush and big sagebrush in proportion to their relative abundance within the landscape? 2) Does sage-grouse nest success differ between sagebrush species used as nest cover? 3) Is there a difference in the vegetation characteristics associated with different sagebrush species chosen as nest cover?

Materials and methods

Study area

We captured sage-grouse near leks in a high desert sagebrush community in south central Idaho (113°43'N, 43°59'W) located immediately southwest of Craters of the Moon National Monument approximately 28 km west of Arco, Idaho. Our study area encompassed approximately 90,000 ha within portions of Blaine, Lincoln and Minidoka counties. Elevations in our study area range from 1,300 m a.s.l. in the southern portion to 2,300 m a.s.l. near the northern boundary. Our study area is semi-arid with extreme seasonal temperature variation as temperatures range from -10° to 40°C. Annual precipitation ranges from 30 to 38 cm with most of the precipitation falling as snow. Rainfall is highest during May and June. The area contains large expanses of sagebrush-dominated rangeland surrounded by basalt lava flows. The rangeland within our study area was grazed by sheep with some portions also grazed by cattle.

Threetip sagebrush was the dominant shrub species throughout much of our study area with big sagebrush, antelope bitterbrush *Purshia tridentata*, and rabbitbrush *Ericameria* spp. also present. The understory consisted largely of bluebunch wheatgrass *Pseudoroegneria spicata*, Siberian wheatgrass *Agropyron fragile*, Sandberg bluegrass *Poa secunda*, cheatgrass *Bromus tectorum*, needle and thread grass *Stipa comata*, Indian ricegrass *Oryzopsis hymenoides*, and basin wildrye *Elymus cinereus*. Common forbs in our study area included desert madwort *Alyssum desertorum*, larkspur *Delphinium* spp., lupine *Lupinus* spp. and phlox *Phlox* spp.

Two wildfires burned portions of our study site in 1992 and 1996. The United States Department of Interior Bureau of Land Management (BLM) seeded large portions of these burns immediately following the fires. Seed stock included bluebunch wheatgrass, Snake River wheatgrass *Elymus wawawaiensis*, thick-spike wheatgrass *E. lanceolatus*, Siberian wheatgrass, Russian wild rye *Psathyrostachys juncea*, big sagebrush, four-wing saltbush *Atriplex canescens*, Lewis flax *Linum lewisii* and sainfoin *Onobrychis viciifolia* and in some cases, crested wheatgrass *Agropyron cristatum*. Additionally, in August 2005, a wildfire burned portions of the northeastern corner of the study site and a second wildfire burned along the southeastern corner.

Capture and marking

Adult and yearling female sage-grouse were captured at night using spotlighting techniques (Connelly et al. 2003) from 31 March to 23 April 2005 and from 30 March to 19 April 2006. Captures were made throughout our study site to ensure the sampling effort was evenly distributed throughout the possible range of habitat conditions (Fig. 1). All females were fitted with 16 g necklace-style radiotransmitters (Advanced Telemetry Systems, Isanti, MN, USA), and monitored using ground-based telemetry from 17 September 2005 to 31 September 2006. Aerial telemetry was used occasionally to locate individuals missing for >1 week.

Females were located at least twice per week from 25 April to 20 June 2005 and 2006 to determine nest initiation. We assumed that a female was incubating if she was in exactly the same location on two or more consecutive days or if a sage-grouse nest with eggs was observed at her location. Nests were checked daily during the week of anticipated hatch (approximately 27 days after estimated incubation initiation) to ascertain hatch date and nest fate. Observers kept a minimum distance of 10 m from nesting females to avoid flushing or otherwise disturbing the birds. Although many females that lost their nests to depredation renested, we only included the initial nest in our analyses.

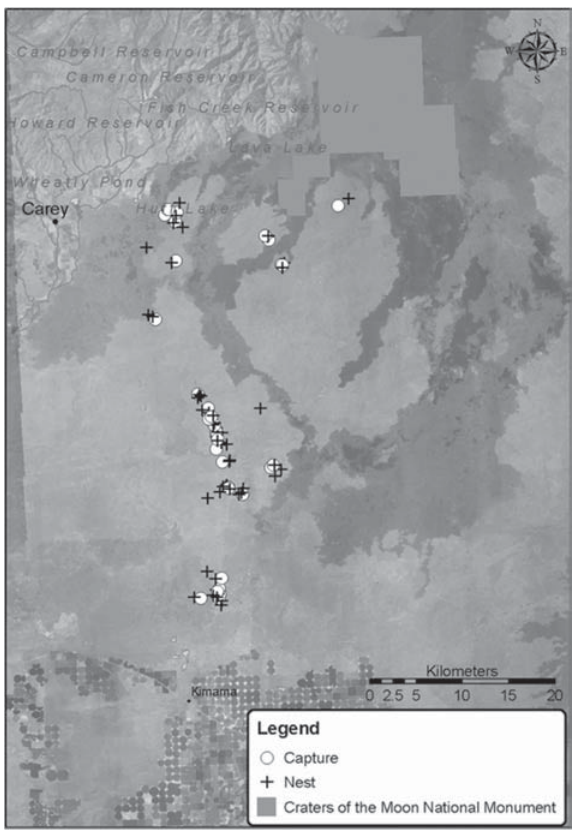

Figure 1. Capture and nest locations of female sage-grouse within the study site in south-central Idaho, 2005-2006.

Experimental design

We measured vegetation at the nest site after hatch or, in the case of depredated or abandoned nests, after the nest was estimated to have hatched. Four 10-m transects were centered at the nest bowl and the direction of the initial transect chosen randomly, with the remaining transects each spaced orthogonally 90° from the preceding transect. We measured grass height, percent grass cover, percent forb cover, percent horizontal cover, percent shrub canopy cover, shrub height, and shrub density in each transect.

Grass measurements included droop height of tallest flower, droop height of tallest living leaf blade, and droop height of tallest dead leaf blade. Shrub height measurements included height of the tallest living leaf and height of the tallest flower. For both grass and shrub heights, measurements of one plant per species were taken at 1 m, 3 m and 5 m along the transect. Only the plant closest to the transect line and within 1 m of each of the four transect lines was measured. Shrub density was estimated by counting the number of shrubs, by species, within 0.5 m of each transect line. Percent canopy cover of shrubs was estimated using the line intercept method (Canfield 1941). A Daubenmire frame was used to estimate percent grass and forb cover at 1 m, 3 m and 5 m (Daubenmire 1959). To avoid underrepresenting species composition, measurements of forb cover were made twice at each location by rotating the Daubenmire frame over the transect line. A Robel pole was placed 1 m, 3 m and 5 m from the nest bowl to obtain estimates of horizontal cover (Robel et al. 1970). An $18 \times 2.5 \times 5$ cm wooden board was placed between the observer's temple and the ground to allow observations from a consistent height.

Measurements made at nest sites were also made at randomly selected sites within our study area. Random sites were selected using a random number generator to obtain universal transverse mercator (UTM) coordinates within our study area. Random sites provided a comparison of use vs availability.

Statistical analyses

Because many females switched the shrub species chosen as nest cover between years and nest success was independent of the individual female, we included nests of 11 females that nested in both 2005 and 2006 for all analyses (Lowe 2006). We used percentage of shrub canopy cover for both big sagebrush and threetip sagebrush at random sites to calculate an expected number of nests under each species of sagebrush if nests were placed randomly. We used a G-test to determine whether nest site selection differed between years. Because age of sage-grouse may influence nest site selection due to experience or social behaviours, we also examined the relationship between age and species of sagebrush chosen as nest cover using a G-test. We then used a G-test to compare the expected frequency of nests under big sagebrush vs threetip sagebrush to the observed frequencies. We used a Cochran-Mantel-Haenszel test to assess the use of threetip sagebrush and big sagebrush as nest cover relative to their availability when accounting for age. A G-test was also used to determine if nest success differed when sage-grouse used threetip sagebrush or big sagebrush as nest cover. We considered nests successful if at least one egg hatched.

We used a multiple logistic regression approach to model factors associated with nest sites located under big sagebrush vs those located under threetip sagebrush and then used an information theoretic approach based on Akaike's Information Criterion (AIC) to select those logistic regression models that were best supported by the data. To eliminate correlated variables describing vegetation characteristics, we used principle components analysis (PCA) with a varimax rotation. Though no corrections were necessary, dispersion of the data was assessed by dividing the variance by the degrees of freedom. The resulting factors were then used to produce a series of candidate models describing the species of sagebrush chosen as nest cover.

Two steps were used to identify and evaluate candidate models. First, we clustered biologically related factors to create submodels for the purpose of identifying the most informative factors within clusters. Second, the most informative factors from each cluster were assembled into overarching models to allow informative factors to be compared to one another. In both steps, we used AIC to compare models. Specifically, AIC_c values were used to adjust for small sample sizes (Burnham & Anderson 2004), and because AIC and AIC_c values converge with increasing sample size, we did not specify a predetermined sample size for abandoning the small sample size adjustment. Based on lowest AIC_c values, the two best models from within each cluster of biologically related factors were identified and combined to create a set of overarching models consisting of all possible combinations of best factors from step one. Here we report only the best (lowest AIC_c) model and alternative models with a AIC_c of ≤ 3. All statistical tests were performed using SAS 9.0 or JMP 7.0 (SAS Institute, Inc.).

Results

We monitored 21 nesting females in 2005 and 26 in 2006 (including 11 females that were captured in 2005, Table 1). One unmarked female in 2005 was located on a nest and was included in the estimate of overall nest success.

Sage-grouse nested under big sagebrush (N = 23), threetip sagebrush (N = 16), a combination of big sagebrush and threetip sagebrush (N = 3), antelope bitterbrush (N = 2), rabbitbrush (N = 2), and dead shrubs (N = 1).

We sampled 21 random sites in 2005 and 29 in 2006. Threetip sagebrush was more abundant than big sagebrush at random sites in 2005, comprising 70.7% of the available sagebrush cover, but was the least abundant species in 2006, comprising 43.2% of the available sagebrush cover. The reduction of threetip sagebrush was likely due to two wildfires

Table 1. Capture, nest initiation and nest success of female sage-grouse in south-central Idaho, 2005-2006.

Females	Number captured		Number nested†			Nest success (%)			
	2005	2006	Threetip sagebrush	Big sagebrush	Other	Threetip sagebrush	Big sagebrush	Other	Overall
Adult	15	7	7	18	5	42.86	55.56	40.00	50.00
Yearling	8	12	8	5	3	12.50	80.00	0.00	31.25
Unknown	-	-	1*	-	-	100.00	-	-	100.00
Overall	23	19	16	23	8	31.25	60.87	25.00	44.68

* One unmarked female in 2005 was found nesting, but was never captured.

† Eleven nesting females in 2006 were captured in 2005.

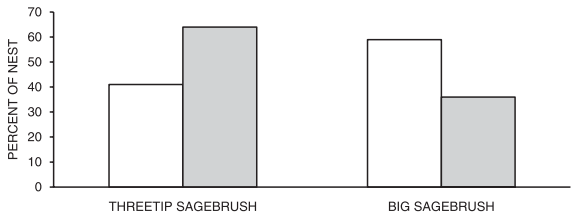

Figure 2. Expected proportion of nests (grey columns) under each species of sagebrush based on available habitat within our study site compared to the observed proportion (white columns) of each species of sagebrush used as nest cover by sage-grouse in south-central Idaho, 2005-2006.

that burned portions of the northeastern and southeastern corners of our study site in August 2005. The burns occurred in areas where threetip sagebrush was the predominant shrub, leaving much of the big sagebrush stands intact. This had an overall effect of altering the ratio of sagebrush composition in favour of big sagebrush. Big sagebrush was the only other sagebrush species encountered, constituting 29.3% and 56.8% of the available sagebrush cover in 2005 and 2006, respectively. There was no difference in shrub species selected as nest cover between years ($\chi^2_1 < 0.001$, $P = 0.987$), indicating that fires had little effect on the actual nesting habitat used by grouse during our study and allowing us to combine data from 2005 and 2006.

We observed a significant difference between the number of nests located under big sagebrush and threetip sagebrush vs the number of nests expected under each sagebrush species based on their availability ($\chi^2_1 = 8.480$, $P = 0.004$). Specifically, sage-grouse used big sagebrush in greater proportion than available within the study site (Fig. 2).

Age of sage-grouse females was significant in predicting the species of sagebrush used as nest cover ($\chi^2_1 = 4.011$, $P = 0.045$). Adult females frequently nested in big sagebrush (72.0%, N = 25), whereas yearling females often nested in threetip sagebrush (61.5%, N = 13). The difference between observed and expected counts of nests under threetip sagebrush and big sagebrush did not differ when accounting for age (Cochran-Mantel-Haenszel test: $\chi^2_1 = 0.985$, $P = 0.321$).

Overall, nest success was 44.7% (N = 47) (47.6% (N = 21) in 2005 and 42.3% (N = 26) in 2006) and did not differ between years ($\chi^2_1 = 0.133$, $P = 0.716$). Moreover, nest success did not differ between adults and yearlings using sagebrush as nest cover ($\chi^2_1 = 1.521$, $P = 0.218$). Because nest success did not differ between years, we combined years to evaluate the effect of shrub species on nest success. Nest success was greater ($\chi^2_1 = 3.376$, $P = 0.066$) for nests under big sagebrush (60.9%, N = 23) than those under threetip sagebrush (31.3%, N = 16).

Six factors were produced by the PCA representing shrub height, shrub diversity, grass height, horizontal cover, grass diversity and understory cover. These six factors described 84.02% of the variation within the data. Shrub height, grass height and horizontal cover were grouped as describing thermal or visual obstruction cover. Shrub diversity and grass diversity were grouped as describing habitat complexity. Understory cover was kept as a separate group. Five models employing these principal components met our selection criteria (Table 2). Components describing shrub height, grass height, shrub diversity and grass diversity were included in all of the best models. Shrub height values were lower near nests under threetip sagebrush relative to nests under big sagebrush while values for grass height, shrub diversity and grass diversity were greater near nests under threetip sagebrush (Fig. 3).

Discussion

Sage-grouse nested under big sagebrush more frequently than expected based on big sagebrush abundance and despite greater abundance of threetip sagebrush. This pattern resulted from differential

Table 2. Multiple logistic regression models predicting species of sagebrush used as nest cover by female sage-grouse in south-central Idaho, 2005-2006. Only models with $AIC_c \leq 3$ are reported. Variables entered into models included shrub height (SHHT), shrub diversity (SHDI), grass diversity (GRDI), grass height (GRHT), horizontal cover (HZCV), understory cover (USCV) and their interactions.

Model	-2ln(L)	K	AIC_c	AIC_c
SHHT + GRHT + SHDI + GRDI + USCV	30.618	6	45.248	0.00
SHHT + GRHT + SHDI + GRDI	35.461	5	47.279	2.04
SHHT + GRHT + SHDI + GRDI + (SHDI × GRDI) + USCV	30.270	7	47.883	2.64
SHHT + GRHT + HZCV + SHDI + GRDI + USCV	30.588	7	48.201	2.96
SHHT + GRHT + (SHHT × GRHT) + SHDI + GRDI + USCV	30.609	7	48.222	2.98

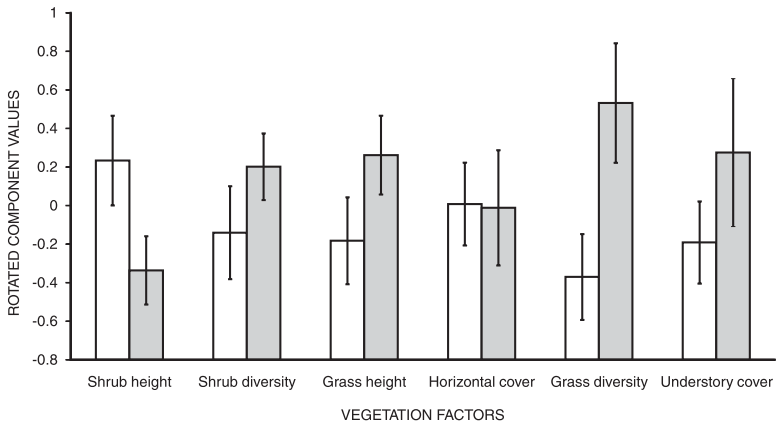

Figure 3. Mean rotated principal component values and associated standard error for sage-grouse nests located under big sagebrush (white columns) and threetip sagebrush (grey columns) in south-central Idaho, 2005-2006.

use of sagebrush species by adult and yearling sage-grouse. Adult female sage-grouse showed a tendency to select big sagebrush as nest cover despite relatively low abundance. Although our study is the first to address sage-grouse use of threetip and big sagebrush, our findings are generally consistent with results from other studies where sage-grouse appeared to prefer big sagebrush as nest cover or had greater success using big sagebrush compared to other species of sagebrush (Gregg et al. 1994, Sveum et al. 1998, Popham & Gutiérrez 2003).

Fires in 2005 likely had an impact on the availability of threetip sagebrush across our study site. Despite this impact, the proportion of sage-grouse that nested in big and threetip sagebrush was unchanged. Because sage-grouse often show strong nest site fidelity (Berry & Eng 1985, Fischer et al. 1993, Young 1994), similar nesting behaviour between years indicated that nesting habitat was not harmed by the fires and these fires had little impact on nest site selection during our study.

Nest success in big sagebrush was 60.9% which is relatively high for sage-grouse, whereas nest success in threetip sagebrush was 31.3% which is low for sage-grouse (Connelly et al. 1991, Gregg 1991, Schroeder et al. 1999). Low nest success in threetip sagebrush documented by our research contrasts to findings by Klebenow (1969) who reported nest success rates of up to 77% in threetip sagebrush in southeastern Idaho, but his work was based on ground searches for nests rather than on radiotelemetry. Ground searches would likely not allow detection of nests that were lost when all eggs were removed by predators. Moreover, Klebenow (1969) considered a nest as successful when egg shells with detached membranes were observed, but his success rate may have been inflated due to other factors that could detach shell membranes from the actual egg shell (e.g. desiccation of membranes, predation, scavenging).

Big sagebrush may have physical characteristics that make it a better quality nesting shrub than threetip sagebrush. For instance, the broader leaves of big sagebrush may provide more visual protection from predators or a better thermal environment for the incubating female or embryo development. Greater shrub height may allow the female to maneuver around the nest while remaining concealed. Big sagebrush may also provide more appropriate humidity and temperature conditions for incubation than other sagebrush species. Both of these factors are vital to proper embryonic development (Webb 1987, Walsberg & Schmidt 1992).

All six components were included in the subset of models meeting the AIC_c criteria. However, horizontal cover and understory cover components were not included in the best model describing species of sagebrush used as nest cover by sage-grouse. Shrub height, grass height, shrub diversity and grass diversity were all present in the subset of best models. High shrub and grass diversity may be a result of seedings in those areas that burned in 1992 and 1996. Components describing grass height, shrub diversity and grass diversity were likely greater near nests under threetip sagebrush than nests under big sagebrush because threetip sagebrush was found in more moist areas within our study site. Greater grass height and grass diversity near nests under threetip sagebrush may indicate a compensation for selecting what may be a poorer shrub for nest success (Connelly et al. 1991). For instance, higher numbers of grass species may increase the horizontal cover complexity and provide more visual obstruction. Though threetip sage-

brush and big sagebrush were often found within the same stand, one species was typically predominant within a given area. This may help to explain the significance that shrub height had in the models.

Sage-grouse may have selected big sagebrush in much greater disproportion than we documented. Random vegetation measurements made in 2006 included a substantial number of sites in areas that burned in late summer of 2005. These new burns appeared to have eliminated more threetip sagebrush than big sagebrush based on random samples obtained in 2005 and 2006 (Lowe 2006). Thus, with fewer stands of threetip sagebrush available, the relative availability of big sagebrush increased, making it more difficult to detect differential use of big sagebrush.

Management implications

The tendency of adult sage-grouse to select big sagebrush over threetip sagebrush as nest cover may have important management implications. Where land use results in the establishment of cheatgrass *Bromus tectorum* or other plant species that increase fire frequency such that threetip sagebrush becomes more abundant, the presence of desirable sage-grouse nesting habitat may be significantly reduced, despite an apparent abundance of sagebrush. A routine prescribed burning program in xeric sagebrush habitats could also have the same result. However, a more extensive evaluation of threetip sagebrush as nest cover for sage-grouse is needed to better understand the effects of this sagebrush species on sage-grouse population dynamics.

It was beyond the scope of our study to determine whether low nest success in threetip sagebrush was a function of grouse age or the sagebrush species. Even if low nest success was a result of threetip sagebrush providing poor quality nesting, sage-grouse use threetip sagebrush as nest cover. Thus, in the absence of other sagebrush species, threetip sagebrush, because of its more rapid establishment, may act to maintain sage-grouse populations or reduce the rate of population decline in areas where large fires have burned substantial amounts of nesting habitat for sage-grouse.

Careful consideration should be made when using prescribed fire as a management technique where there is a strong likelihood of substantial threetip sagebrush regeneration. In the event of large fires, where threetip sagebrush is likely to constitute a large portion of the seed base, it may be beneficial to seed big sagebrush to promote desirable sage-grouse nesting habitat.

Our research emphasized the importance of big sagebrush to breeding sage-grouse. When rehabilitating degraded sagebrush-steppe plant communities, planting big sagebrush should be considered over other species of sagebrush. Furthermore, sagebrush stands in breeding habitats should not be subjected to alterations that might result in decreasing shrub density, shrub cover or shrub height. Although forbs and grasses are important for the reproductive success of sage-grouse, their impact on sage-grouse nest site selection and nest success can be overshadowed by the importance of shrubs, both in terms of vegetation characteristics and species composition.

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