CHAPTER TWELVE

Resource Selection During Brood-Rearing by Greater Sage-Grouse

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Abstract. Understanding population dynamics and resource selection is crucial in developing wildlife resource management plans for sensitive species such as Greater Sage-Grouse (*Centrocercus urophasianus*). Little is known about sage grouse habitats on the eastern edge of their range. We investigated resource selection of Greater Sage-Grouse during brood-rearing in North and South Dakota during 2005–2007. Resource selection models suggested sage grouse females with broods selected sites with increased vegetative cover and grass height. Composition of forbs at brood-rearing sites has been identified as important elsewhere, but we found little support for a difference in forbs between brood and random sites. Despite being sagebrush obligates, sage grouse females with broods selected areas with low sagebrush cover. Brood habitats with increased invertebrate abundance and protective cover have been shown to increase sage grouse productivity. Land managers on the eastern edge of Greater Sage-Grouse range could focus on protecting critical brood-rearing areas by maintaining at least 67% herbaceous cover and 33 cm of grass height in association with sagebrush for sage-grouse broods.

Key Words: brood-rearing habitat, *Centrocercus urophasianus*, Greater Sage-Grouse, North Dakota, resource selection, sagebrush, South Dakota.

Knowledge of seasonal habitat selection is important in developing management strategies for sensitive wildlife species. Concerns about declining populations of Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter sage grouse) date back >90 years and continue today (Hornaday 1916, Aldridge et al. 2008). Sage grouse populations have declined range-wide at a rate of 2% per year since 1965 (Connelly et al. 2004). In North Dakota, populations may have declined by 67% from 1965 to 2003 and in South Dakota sage grouse populations declined steadily from 1973 to 1997, but may have recovered slightly from 1997 to 2007 (Sage and Columbian Sharp-tailed Grouse Technical Committee 2008). In the past decade, at least seven petitions have been filed to list sage

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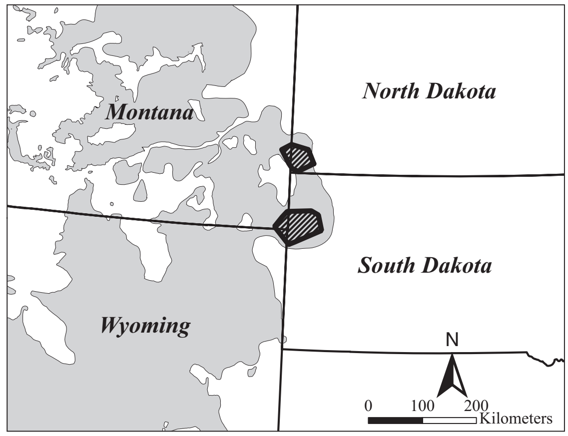

Figure 12.1. Location of study areas for Greater Sage-Grouse in northwestern South Dakota, southwestern North Dakota, southeastern Montana, and northeastern Wyoming. The dashed areas encompass all locations and the gray area is the current range of Greater Sage-Grouse (Schroeder et al. 2004).

grouse under the Endangered Species Act (ESA) of 1973, with an ESA status review recently completed by the U.S. Fish and Wildlife Service to determine the merit of the most recent petitions (Connelly et al. 2004, USFWS 2010).

Sage grouse in northwestern South Dakota and southwestern North Dakota occupy transitional vegetation communities between the northern wheatgrass (*Pascopyrum* spp.) – needlegrass (*Nassella* spp.) prairie that dominates most of the Dakotas and the big sagebrush (*Artemisia tridentata*) plains of Wyoming (Johnson and Larson 1999). In South Dakota, sage grouse are listed as a species of greatest conservation need (South Dakota Department of Game, Fish, and Parks 2006) and they are also a Priority Level 1 Species of Special Concern in North Dakota (McCarthy and Kobriger 2005). In addition, sage grouse are listed as a sensitive species for the Bureau of Land Management (BLM) and U.S. Forest Service (USFS). Despite well-understood reproductive ecology of sage grouse in the core of their range, knowledge of reproductive ecology and habitat selection by sage grouse occurring at the eastern edge of their distribution is limited. The objectives of this study were to develop an understanding of brood-rearing resource selection of sage grouse in the Dakotas. This information will be useful in developing conservation and management plans for sage grouse in eastern Montana, Wyoming, and the Dakotas.

STUDY AREA

Our study was divided into two sites, one in northwestern South Dakota and the other in southwestern North Dakota, with portions of Montana occurring in both sites and portions of Wyoming occurring in the South Dakota site (Fig. 12.1). The entire area has flat to gently rolling prairie, with a few buttes and intermittent streams. Approximately 73% of the area is privately owned. The U.S. Bureau of Land Management (BLM) manages 25% of the study area, and the remaining 2% is managed by the State School and Public Lands Divisions of North and South Dakota. Grazing is the predominant land use, with normal stocking rates between 1 and 4 hectares per animal unit month (AUM). In areas with rough terrain or less productive soils stocking rates can be as high as 6 hectares per AUM (M. Iverson, pers. comm.). In areas with large blocks of public land, livestock are rotated on a regular schedule, but may not be rotated as often in areas with less public land. Agricultural production of wheat and grass hay occurs on better soil types in both study sites. Exploration and development of oil and natural gas resources is common and has been identified as an ongoing threat to sage grouse in North Dakota (Connelly et al. 2004), with some areas having up to 16 well pads per 259 ha (square mile). Open-pit mining for bentonite occurs at the southern end of the South Dakota study site on Pierre soils (Charles Berdan, pers. comm.).

Mean annual precipitation is 35 cm, with 70% occurring during the months of April through August (South Dakota State Climate Office 2007). Temperatures in summer (May–August) average 20.1°C but can reach up to 43.3°C. Vegetation communities included mixed grass prairie with perennial and annual forbs and grasses and shrubsteppe, as described by Johnson and Larson (1999).

METHODS

Data Collection

We identified sage grouse leks within the study sites where we had land owner permission for trapping. We captured female sage grouse with large nets aided with spotlighting from all-terrain vehicles between March and mid-April of 2005–2007 (Giesen et al. 1982, Wakkinen et al. 1992). Females were weighed and equipped with 22-g necklace-style transmitters, which were approximately 1.4% of mean female sage grouse body mass and had a life expectancy of 434 days. Transmitters could be detected from approximately 2 to 5 km from the ground and were equipped with an 8-hour mortality switch. The South Dakota State University Institutional Animal Care and Use Committee approved trapping and handling techniques and study design (Protocol #07-A032).

We located radio-marked females during incubation twice per week and if the nest successfully hatched, we located females and their broods twice per week. Broods were approached cautiously to minimize the possibility of flushing or scattering the brood, with most locations taken within 50 m of actual locations. When chicks reached ~3–5 weeks of age, we flushed the brood and searched the area to obtain estimates of brood size. We discontinued telemetry of broods if no chicks were present with a female and subsequent locations of the female for two weeks showed no evidence of chicks.

We characterized vegetation at sites used by females with broods about 14 $\pm$ 2 SE days after recording the location. Two 50-m transects were established in the north–south cardinal directions, each starting at the marked brood location and terminating at their respective north–south ends. A modified Robel pole was used to quantify visual obstruction readings (VOR) and maximum grass height at 10 m intervals ($n = 11$; Robel et al. 1970, Benkobi et al. 2000). We estimated sagebrush (*Artemisia tridentata* spp. and *A. cana* spp.) density and height at 10-m intervals ($n = 11$) using the point-centered quarter method (Cottam and Curtis 1956). Canopy coverage was estimated using a 0.10-m^2 quadrat (Daubenmire 1959). At each 10-m interval, four 0.1 m^2 quadrats were placed in an H-shape with each leg of the H being 1 m long ($n = 44$ per site). We recorded percent cover in six categories for total vegetation, grass, forb, shrub, litter, bare ground, shrub species, grass species, and forb species cover in each quadrat (Daubenmire 1959). In addition, we characterized vegetation at an equal number of random sites during the same period. Random sites were generated within a 10-km buffer of capture leks with a Geographic Information System (GIS) with Hawth's Analysis Tool (Beyer 2004). Random points were reselected if they were on a road, in a road ditch, or on private lands where we did not have access.

Data Analyses

All measurements were summarized to a value for the site. Sagebrush density was estimated from a maximum likelihood estimate (Pollard 1971). We calculated average sagebrush height for each site from the sagebrush plants that were measured to estimate density. Values recorded for canopy coverage were recoded to mid-point values of categories and summarized to an average for the site (Daubenmire 1959). To reduce non-biologically important variables, we screened canopy coverage variables and excluded any variables with canopy coverage less than 1% on sites where they were present. We then conducted a principal components analysis (PCA) to distinguish important variables that captured the variation among sites. We identified seven biologically important variables from the PCA to investigate sage grouse brood habitat resource selection (Table 12.1). Variables included sagebrush height, visual obstruction, maximum grass height, total herbaceous cover, grass cover, forb cover, and sagebrush cover. We used the multi-response permutation process to test for differences between use and random sites and between study area sites of these variables with a critical value of $\alpha < 0.05$ (Mielke and Berry 2001). We used a cluster analysis based on Euclidean distance to investigate patterns of habitat for early (0–4 weeks post-hatch), middle (4–8 weeks), and late (8–12 weeks) age-classes of broods (Ball and Hall 1967).

To investigate resource selection, we used an information-theoretic approach to estimate the importance of 173 *a priori* nominal logistic regression models including global and null models

TABLE 12.1

Observed mean values for habitat variables and associated P-values between Greater Sage-Grouse brood-rearing and random sites used in logistic regression modeling in North Dakota, 2005–2006, and South Dakota, 2006–2007; all values are reported as $\bar{x} \pm$ (SE).

	North Dakota			South Dakota			Pooled		
Variable[a]	Brood (n = 132)	Random (n = 105)	$P \leqslant$	Brood (n = 119)	Random (n = 116)	$P \leqslant$	Brood (n = 251)	Random (n = 221)	$P \leqslant$
Sagebrush height (cm)	33.2 (0.8)	32.9 (1.1)	0.51	23.8 (1.0)	22.8 (0.8)	0.14	28.8 (0.7)	27.3 (0.8)	0.09
Visual obstruction (cm)[1]	8.3 (1.3)	5.0 (0.5)	0.06	6.2 (0.4)	3.5 (0.4)	0.01	7.3 (0.7)	4.2 (0.3)	0.01
Maximum grass height (cm)[1]	35.1 (1.9)	35.2 (1.2)	0.30	30.5 (1.0)	25.7 (0.9)	0.01	32.9 (1.1)	30.2 (0.8)	0.23
Herbaceous cover (%)[2]	74.2 (1.7)	54.7 (1.8)	0.01	58.4 (1.3)	51.0 (1.5)	0.01	66.7 (1.2)	52.7 (1.2)	0.01
Grass cover (%)[2]	31.7 (1.5)	20.3 (1.4)	0.01	31.3 (1.1)	26.6 (1.3)	0.01	31.5 (0.9)	23.8 (1.0)	0.01
Forb cover (%)	10.2 (0.9)	9.1 (0.9)	0.11	7.6 (0.4)	7.1 (0.4)	0.20	9.0 (0.5)	8.1 (0.5)	0.13
Sagebrush cover (%)	4.8 (0.3)	2.9 (0.3)	0.01	4.6 (0.4)	3.6 (0.4)	0.04	4.7 (0.3)	3.3 (0.3)	0.01

[a] Paired numbers represent correlated ($r > 0.70$) variables that subsequently were not modeled together.

crafted from the seven habitat variables (Burnham and Anderson 2002, SAS Institute 2007). Model sets were developed to evaluate resource selection for both study sites combined and individual brood sites. To reduce variable interactions in the models, variables that were correlated ($r > 0.70$) to one another were not included in the same model (Table 12.1). Due to a small sample size with respect to the number of parameters estimated ($n/K < 40$), we used the small-sample adjustment for Akaike's Information Criterion (AIC_c) to evaluate models (Burnham and Anderson 2002). We ranked our models based on differences between AIC_c for each model and the minimum AIC_c model (ΔAIC_c), and used Akaike weights (w_i) to assess the weight of evidence in favor of each model and the sum AIC_c weight for each variable (Burnham and Anderson 2002, Beck et al. 2006). In addition, when models differed by a single parameter, we inspected the change in model deviance and investigated the slope of the coefficient estimates (β) to determine variable effects (Burnham and Anderson 2002). Model goodness-of-fit was determined using a Hosmer–Lemeshow test (Hosmer and Lemeshow 2000).

RESULTS

Capture and Monitoring

We captured and fitted 43 females with radio transmitters during spring 2005–2006 in North Dakota, and 53 females in South Dakota during spring 2006–2007, for a total of 96 individual females. We monitored 60 females in North Dakota (2005: $n = 21$, 2006: $n = 39$) and 83 females in South Dakota (2005: $n = 40$, 2006: $n = 42$). A total of 17 and 29 females were monitored in both years in North and South Dakota, respectively. After losses to nest predation, we were able to monitor 19 females with broods in North Dakota (2005: $n = 9$, 2006: $n = 10$) and 24 females with broods in South Dakota (2005: $n = 10$, 2006: $n = 14$). Average hatch date was 20 May and 31 May in North and South Dakota, respectively. Dates of brood locations ranged from 25 May to 30 August.

Resource Selection

We measured 55 and 77 brood sites and 47 and 58 random sites in North Dakota from mid-June through August of 2005 and 2006, respectively. We also measured 59 and 60 brood sites and 56 and 60 random sites in South Dakota from mid-June through August of 2006 and 2007, respectively. All variables in both study sites, except sagebrush height, grass height, and forb cover, differed between brood and random sites ($P \leq 0.05$; Table 12.1). In addition, visual obstruction differed marginally between brood and random sites in North Dakota ($P = 0.06$). Most vegetative characteristics had higher values at brood sites compared to random sites in North Dakota ($P \leq 0.05$), with the exception of grass height, which was slightly higher at random sites. In South Dakota, vegetative characteristics at brood-rearing sites also had higher values than random sites ($P \leq 0.05$). When the two states were combined, maximum grass height did not differ between brood and random sites ($P = 0.23$). We could not distinguish sites based on brood-rearing age-classes from the cluster analysis, as the best clusters were not associated with brood age-classes.

Our best model of resource selection for sage grouse broods included sagebrush height, total herbaceous cover, and maximum grass height (AIC_c weight = 0.46; Table 12.2). Including variables year and state to the top model did improve model fit. Total cover and grass height were positively associated with brood-rearing site selection (total cover: $\beta = 0.05 \pm 0.01 \pm$ SE, grass height: $\beta = 0.02 \pm 0.01 \pm$ SE). Sagebrush height was negatively associated with brood-rearing site selection ($\beta = -0.02 \pm 0.01 \pm$ SE). The Hosmer–Lemeshow test was acceptable ($P = 0.16$). Although the top model included maximum grass height, Akaike weight for all models was strongest for total cover (0.96) and sagebrush height (0.96), with total cover having a stronger effect (Fig. 12.2).

The second-ranked model (AIC_c weight = 0.21) included total cover, sagebrush height, and forb cover. Similar to the top model, total cover was positively associated with brood-rearing site selection ($\beta = 0.05 \pm 0.01 \pm$ SE) and sagebrush height was negatively associated with brood-rearing site selection ($\beta = -0.02 \pm 0.01 \pm$ SE). Forb cover was positively associated with brood-rearing site selection ($\beta = 0.04 \pm 0.02 \pm$ SE). The Hosmer–Lemeshow goodness-of-fit test was nonsignificant ($P = 0.11$), indicating acceptable model fit.

TABLE 12.2

Top five ranked logistic regression models from 173 models for Greater Sage-Grouse brood-rearing sites (n = 251) and random sites (n = 221) in North Dakota, 2005–2006, and South Dakota, 2006–2007.

Model	$-2\ln(L)$	K[a]	ΔAIC_c[b]	w_i[c]	ΔDev[d]
Sagebrush hgt. + herbaceous cover + max grass hgt.	512.16	5	0.00	0.46	0.00
Sagebrush hgt. + herbaceous cover + forb cover	513.78	5	1.62	0.21	1.62
Sagebrush hgt. + herbaceous cover	516.96	4	2.76	0.12	4.80
Sagebrush hgt. + herbaceous cover + year	515.10	5	2.94	0.11	2.94
Sagebrush hgt. + herbaceous cover + state	516.28	5	4.12	0.06	4.12

[a] Number of parameters in the model including intercept and standard error.
[b] Change in AIC_c value.
[c] Model weight.
[d] Change in model deviance.

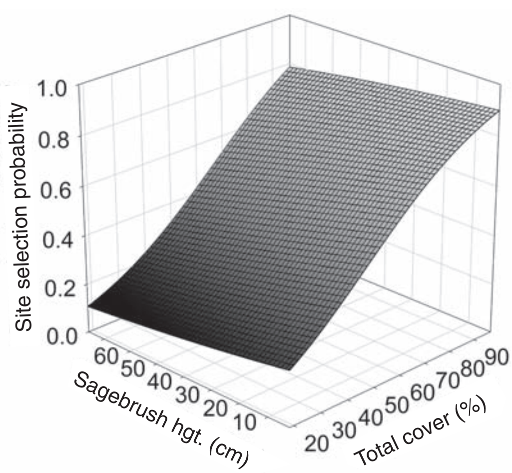

Figure 12.2. Effect of sagebrush height and total herbaceous cover on Greater Sage-Grouse brood-rearing habitat selection in North Dakota, 2005–2006, and South Dakota, 2006–2007. Probability of use derived from parameter estimates in the best approximated model.

DISCUSSION

Herbaceous Cover

Brood-rearing habitats are important for determining sage grouse productivity (Crawford et al. 1992). Our models suggested that increased herbaceous plant matter is a feature of sage grouse brood-rearing habitats in both North and South Dakota. In the Great Basin, females with chicks also selected for areas of increased herbaceous cover (Klebenow 1969, Autenrieth 1981). Although the North Dakota study site had higher values for vegetation components than the South Dakota site, resource selection by female sage grouse with broods was invariant to the habitat conditions represented by geographic range of these two study areas. Sagebrush cover was found to be important to brood site use, but sagebrush height was identified to have a slightly negative or null effect. The apparent discrepancy may be best explained by the timing of our sampling in mid-June to mid-August, when sagebrush is not a major component of sage grouse chicks' diets (Johnson and Boyce 1990, Huwer 2004). In addition, some of the brood sites did not possess any sagebrush component, which helps explain why sagebrush height entered our models with negative coefficients. However, when females with broods did select sites with sagebrush, the sagebrush tended to be of taller stature.

Grass Cover

Taller grass provides concealment from predators and, perhaps more importantly, greater herbaceous biomass is correlated with greater invertebrate abundance (Healy 1985, Rumble and Anderson 1996, Jamison et al. 2002). Female sage grouse typically move their broods from upland nesting areas to more mesic, greener areas later in the summer (Peterson 1970, Dunn and Braun 1986, Sveum et al. 1998). Although we could not differentiate between habitats based on brood age-classes, broods may be selecting areas with higher grass cover for the increased invertebrate abundance and protection from predators that grass-dominated areas tend to provide. Females with broods in the Dakotas selected areas with greater grass cover than values typically reported in the literature for sage grouse (Drut et al. 1994, Sveum et al. 1998, Thompson et al. 2006). Our study area forms a transition zone between the northern wheatgrass–needlegrass prairie that dominates most of the Dakotas and the big sagebrush plains of Wyoming (Johnson and Larson 1999), and possesses a greater grass component compared to the shrubsteppe region (Lewis 2004). In Alberta, brood habitat was located in moist areas and drainages and was suggested to be limiting sage grouse productivity (Aldridge and Brigham 2002). In our study, brood habitat was not limiting for sage grouse populations, but grass structure, which is highly correlated with visual obstruction, provided increased protection from predators and invertebrate abundance.

Forb Cover

Availability of food resources such as forbs and insects can limit sage grouse populations through decreased recruitment of young (Peterson 1970, Wallestad 1975, Autenrieth 1981). The period from 1 to 10 days is when chick mortality is highest (Patterson 1952, Autenrieth 1981) and young need insects in close proximity to escape cover. Invertebrates are also necessary for growth, development, and survival of sage grouse chicks (Johnson and Boyce 1990). Chicks that fed in forb-rich areas gained more weight than when they fed in forb-poor habitats, and areas with greater forb cover may attract higher numbers of invertebrates (Jamison et al. 2002, Huwer 2004). Greater invertebrate abundance may explain why sage grouse tend to select areas with higher forb cover, which our second-ranked model identified as being important to sage grouse broods (Apa 1998, Sveum et al. 1998, Holloran 1999). Other studies have shown that sage grouse broods also use areas of high forb cover; however, forb cover in our study site was much lower than values reported in the literature (Schoenberg 1982, Sveum et al. 1998, Holloran 1999). Forb cover may be more important to sage grouse brood-rearing habitat in the central portion of their range, where conditions are drier, leading to more bare ground than in western North and South Dakota.

Management Implications

With possible listing under the Endangered Species Act, sage grouse conservation and preservation will be a priority for many western land management agencies. Management of sage grouse brood-rearing habitat in the Dakotas could focus on maintaining grass heights of at least 33 cm and herbaceous cover of at least 67%, which provides high visual obstruction for sage grouse broods and abundant insects for food. In addition, managers could promote and protect greener areas during mid- to late summer because these areas typically have higher production and invertebrate abundance. Programs that defer or reduce grazing and haying operations in these areas could be implemented to promote favorable conditions in brood-rearing habitats. Domestic livestock grazing may negatively influence sage grouse productivity by decreasing plant biomass and protective cover. However, light or moderate grazing in dense, grassy meadows can be beneficial to sage grouse, but overgrazing can reduce sage grouse habitats (Klebenow 1982, 1985; Oakleaf 1971).

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