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ABSTRACT Habitat use of sympatric greater prairie-chicken (*Tympanuchus cupido*) and sharp-tailed grouse (*T. phasianellus*) broods during the brood-rearing season has not been quantified for stable prairie grouse populations in large contiguous grassland landscapes in the Northern Great Plains. Characteristics of habitats used by prairie grouse broods were described based on data collected from 35 broods (18 greater prairie-chicken and 17 sharp-tailed grouse) during the breeding seasons of 2004 and 2005. Greater prairie-chicken and sharp-tailed grouse broods used vegetation with visual obstruction heights ≥26 cm and 37 cm, respectively. Greater prairie-chicken broods selected western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*) and Japanese brome (*Bromus japonicus*) dominated habitats. Sharp-tailed grouse broods selected sweet clover (*Melilotus spp.*), mixed forb-dominated vegetation, and green needlegrass dominated habitats. Both grouse species avoided habitats dominated by smooth brome (*B. inermis*). Knowledge of brood habitat use will provide information on suitable brood habitat resources needed to sustain prairie grouse populations in South Dakota.

KEY WORDS brood resource selection, Fort Pierre National Grassland, greater prairie-chicken, prairie grouse, sharp-tailed grouse, South Dakota, *Tympanuchus cupido, Tympanuchus phasianellus*

Greater prairie-chickens (GPC; *Tympanuchus cupido*) and sharp-tailed grouse (STG; *T. phasianellus*) populations have been declining since the early 1900s (Hillman and Jackson 1973, Houston 2002); habitat loss is the primary reason for these population declines. To better understand what resource requirements are needed to sustain and grow prairie grouse populations, we studied one of the last remaining (and possibly the most productive) sympatric prairie grouse populations in North America.

Vegetation characteristics can limit brood survival and is considered to be one of the most important factors related to prairie grouse population levels (Hamerstrom et al. 1957, Kirsch 1974, Svedarsky et al. 1999). Vegetation characteristics must accommodate chick movement at ground level, provide adequate abundance and diversity of insects, concealment from predators, protection from weather elements, openings for sun exposure and dusting, and be accessible from nest sites (Svedarsky et al. 2003). Fredrickson (1996) recommended that vegetation height be 25 to 51 cm for nesting, brood-rearing and escape cover for greater prairie-chickens (*T. cupido*). Newell et al. (1988) found that during summer months (June–August), GPC broods primarily used vegetation that was 26 to 50 cm in height on the Sheyenne National Grassland in North Dakota. Resource selection by GPCs and STG broods varies spatially throughout their current geographic ranges. However, previous studies of habitat use have documented the importance of grassland, savannah, and grassland-low shrub transition zones to GPC and STG broods (Hamerstrom 1963, Moyles 1981, Rice and Carter 1982, Horak 1985, Manske and Barker 1988). Although previous studies have provided general descriptions of the types of grasslands used by prairie grouse, to our knowledge no studies have quantified vegetation at the species-specific level. Further, most previous research on prairie grouse has been conducted on declining populations in fragmented landscapes where grassland habitats were not the dominant vegetation cover type. Thus, our objective was to quantify and compare resource selection by GPC and STG broods in grassland dominated habitats in central South Dakota.

STUDY AREA

Our study occurred during summer (June–August) 2004–2005 on a 19,500 ha portion of the Fort Pierre National Grassland (FPNG) west of US highway 83 in central South Dakota (44° 14′ N, 100° 39′ W), centered approximately 27 km south of Pierre, South Dakota. The FPNG is a restored mixed-grass prairie and is currently managed for wildlife production and outdoor recreation by

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the United States Forest Service (USFS; Nebraska National Forest 1998). Rotational cattle grazing occurred throughout FPNG whereby a maximum of 33% was stocked with cattle at any one time; cattle stocking rates ranged from 0.44–2.63 animal unit months (AUM)/ha. An AUM is defined as the amount of forage (800 lbs of air-dried forage) that an animal weighing 1,000 lbs will eat in one month (Gum et al. 1993).

Western wheatgrass (*Pascopyrum smithii*) and green needlegrass (*Nassella viridula*) were the dominant grass species on the flats and ridges, whereas big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and side oats grama (*Bouteloua curtipendula*) were predominant species on the slopes (Faulkner 1999). Overstory vegetation was sparse and included plains cottonwoods (*Populus deltoides*) found near stock ponds. Private land primarily composed of pasture land and limited cultivated fields of alfalfa, sunflower, and wheat were interspersed throughout the FPNG. Long term average annual precipitation on FPNG was 43.2 cm and occurred mainly from April through June (U.S. Forest Service 2001). Daytime high temperatures in July and August often exceeded 38° C, while summer and winter temperatures average 24.2° C and –7.9° C, respectively (National Weather Service 2003).

METHODS

We captured GPC and STG hens on display grounds (leks) using walk-in traps (Schroeder and Braun 1991) during April 2004–2005. We also used nest dragging and bow nets to capture hens using methods previously described by Higgins et al. (1969). Upon locating incubating hens, we flushed them from their nests and subsequently placed a bow net with a 15 m trigger rope (Slayer 1962) within 40 cm of the nest. We placed a flag at the end of the rope and returned to the flag the following day to deploy bow nets.

We aged (immature or adult), weighed, radio-marked and released all GPC and STG females on leks where they were captured. We marked each female with a necklace-mounted transmitter (Holohil Systems Ltd., Carp, Ontario, Canada) and leg banded each male captured. We determined sex of prairie grouse using field criteria previously developed by Bihrle (1993).

Two to three weeks post hatch, we flushed each radio-marked hen to determine presence or absence of chicks. If chicks were present or hens moved short distances (< 0.8 km) from their nests, we captured broods that night between 2300 and 0500 hours. We approached marked hens on foot using standard radiotelemetry techniques, circled each hen's position, and marked the position with 3 to 5 Garrity fun-tastick glow sticks; the mean area marked was approximately 175 m^2. We used and subsequently dropped a 2.4 cm mesh net (15 m × 15 m) over radio-marked hens and their broods. We used spotlights to capture and suture small (<2 g) radio transmitters to the dorsal surface of each chick (Burkpile et al. 2002); radio-marked broods were released within 25 m of the capture site. All animal handling protocols used during our study were approved by the South Dakota State University Institutional Animal Care and Use Committee (Approval 00-A039).

We determined resource selection of broods by sampling vegetation around 2-day-old triangulated locations from radio-marked females that had radio-marked chicks. We located radio-marked females with radio-marked chicks a minimum of 3 times per week from the time chicks were marked at 2 to 3 weeks of age through the end of August by triangulation of directional signals using a truck-mounted null-peak radio telemetry system. We did not sample vegetation around a location if radio-marked chicks were not located with radio-marked hens. We equipped our pickup truck with a Global Positioning System (Garmin GPSMAP® 76S) and a laptop computer for subsequent use in triangulating brood positions.

We established 2, 50-m perpendicular line-transects in each of the 4 cardinal directions, with the estimated location used as the center point for both transects. We collected plant species composition data at 1 m intervals along established transects. We used a Robel pole (Robel et al. 1970) at 10 m intervals along each transect to measure horizontal visual obstruction from the 4 cardinal directions. At 4 m to each side of the point where the visual obstruction was measured we used 2, 0.5 × 0.25 m modified Daubenmire plots (Daubenmire 1959) to estimate vegetation canopy cover. We ocularly estimated percent vegetation canopy coverage for grasses, forbs, and shrubs within each plot using the following cover categories. 0 = none, 1 = 1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–95%, and 6 = 96–100%. We used midpoint values of the cover categories to estimate average cover. We sampled randomly selected points in the same manner to measure resource availability. We quantified resource availability using 37 and 86 random locations during 2004 and 2005, respectively. We sampled the same number of brood locations and random locations each day and selected the closest random points to the brood location for sampling. Plant nomenclature followed the United States Department of Agriculture plants website (USDA, Natural Resource Conservation Service 2005). We clipped United States Geological Survey Digital elevation model 10 m data to 21 GPC brood home ranges and 16 STG brood home ranges to determine percent of each species home range that was composed of 3 slope categories: 0–0.50%, 0.51–1.0%, and > 1.01%. We compared differences in mean composition percentages between species using program CONTRAST (Sauer and Williams 1989).

We determined home range size of hens with broods (Gabbert et. al. 1999) during the breeding season (1-day post-hatch through August) using a minimum of 20 locations for each hen and brood. Additionally, we buffered radiolocations by 200 m and overlaid buffered locations in a GIS to generate home range polygons. We determined the

200 m buffer by looking at average daily movements and adjusting for days during this same period by multiplying the average daily movement by the number of days between radiolocations. This allowed us to encompass the average area that a hen and brood would have used while moving between locations taken on different days.

We analyzed brood resource selection using compositional analysis (Aebischer et al. 1993), which generates resource use scores based on the difference between use and availability. For instance, selection for a habitat category was indicated if the confidence interval for the selection ratio did not contain the value 1 and the lower limit was >1. A habitat category was avoided if the confidence interval for w_i did not contain the value 1 and the upper limit was <1. Use in proportion to availability was indicated if the confidence interval for w_i contained the value 1 (Manly et al. 2002, Grovenburg et al. 2010). We compared use scores using ANOVA and Bonferroni multiple pair-wise comparisons in SYSTAT (SPSS 2000). We compared visual obstruction heights and canopy cover estimates using ANOVA and Bonferroni pair-wise comparisons in SYSTAT; we determined significance using an α value < 0.05.

Table 1. Mean vegetation visual obstruction heights with standard error (SE) at locations used by greater prairie-chicken (GPC) and sharp-tailed grouse (STG) broods in relation to mean vegetation heights with standard error (SE) at random locations on the Fort Pierre National Grassland, South Dakota, USA, summer 2004–2005.

		Habitat Use					Habitat Availability				
Year	Species	Mean height (cm)	SE	LCL[a]	UCL[b]	*n*[c]	Mean height (cm)	SE	LCL[a]	UCL[b]	*n*[c]
2004	GPC	32.1	2.8	26.6	37.5	8	29.4	1.7	26.1	32.7	37
	STG	43.1	2.6	37.9	48.2	8					
2005	GPC	37.9	2.1	33.8	41.9	10	35	1.4	32.3	37.7	86
	STG	42.8	2.3	38.3	47.4	9					

[a] 95% lower confidence limit; [b] 95% upper confidence limit; [c] sample size. Blank cells represent no data.

RESULTS

We determined habitat use by prairie grouse during the brood-rearing season using habitat data collected from 16 broods (8 GPC and 8 STG) in 2004 and 19 broods (10 GPC and 9 STG) in 2005. During 2004 and 2005, we marked a mean of 4 and 3 chicks per brood, respectively. The average polygon size of triangulated locations was 952 m^2 and ranged from 0.1 m^2 to 2000 m^2. Greater prairie-chicken brood locations were sampled for brood habitat use a mean of 1.9 (SD = 1.0) times/brood and STG brood locations were sampled a mean of 2.0 (SD = 0.8) times/brood in 2004. In 2005, GPC brood locations were sampled a mean of 3.5 (SD = 0.7) samples/brood and STG brood locations were sampled a mean of 3.9 (SD =1.7) times/brood.

Visual obstruction of habitats used by GPC broods ranged from 19–53 cm (Table 1). Habitats used by GPC broods were comprised of 9–24% grasses and 1–33% forbs (Table 2). Sharp-tailed grouse broods used vegetation with visual obstruction heights that ranged from 31–55 cm, which in 2004 averaged 9 cm taller than vegetation used by GPC broods ($F_{1,14}$ = 8.9, P < 0.01) and 14 cm taller than the mean available vegetation on the FPNG ($F_{1,37}$ = 12.9, P < 0.01; Table 1). Areas used by STG had canopy cover comprised of 5–24% grasses and 2–32% forbs (Table 2). Forb canopy coverage was 15% less in 2005 than in 2004 on sites used by STG broods ($F_{1,15}$ = 47.0, P < 0.01). Vegetation height ranged from 5–77 cm and grasses and forbs covered 3–74% and 0.1–28% of the ground, respectively.

Available resources were similar (P > 0.05) in 2004 and 2005 except for sweet clover ($F_{1,37}$ = 11.3, P < 0.01), porcupine grass ($F_{1,37}$= 13.4, P < 0.01), Kentucky bluegrass ($F_{1,37}$ = 8.2, P < 0.01), and bare ground categories ($F_{1,37}$ = 10.4, P < 0.01; Fig. 1). During 2004 and 2005, sweet clover comprised 16.1 and 2.5% of the study area, respectively. Larger portions of the FPNG were comprised of porcupine grass, Kentucky bluegrass, and bare ground in 2005 than in 2004 (Fig. 1). We documented 53 different species of vascular plants and bare ground while sampling prairie grouse brood use locations, of which 8 plant species and bare ground accounted for an average of 87% of the use areas (Fig. 1).

Brood habitat use scores differed ($F_{8,145}$ = 7.2, P < 0.01) among different habitats for both GPCs and STG. Sweet clover ranked highest and was significantly higher than bare ground (P < 0.04), smooth brome (P < 0.03), and Japanese brome (P < 0.01) on locations selected by STG broods (Table 3). Mixed forb-dominated vegetation habitat and green needlegrass habitats ranked significantly higher (P < 0.02) than Japanese brome for STG broods.

Table 2. Mean estimated vegetation canopy cover and standard error (SE) for grasses, forbs, and shrubs at locations used by greater prairie-chicken (GPC) and sharp-tailed grouse (STG) broods in relation to mean estimated canopy cover and standard error (SE) at random locations on the Fort Pierre National Grassland, South Dakota, USA, summer 2004–2005.

		Habitat Use					Habitat Availability				
Year	Species	Grass (%)	SE	LCL[a]	UCL[b]	*n*[c]	Grass (%)	SE	LCL[a]	UCL[b]	*n*[c]
2004	GPC	17.9	0.9	16.1	19.8	8	17.4	0.9	15.6	19.1	37
	STG	13.8	1.9	10.0	17.6	8					
2005	GPC	17.8	1.4	15.2	20.5	10	19.3	0.4	16.9	21.8	86
	STG	17.2	1.2	14.8	19.6	9					
Year	Species	Forb (%)	SE	LCL[a]	UCL[b]	*n*[c]	Forb (%)	SE	LCL[a]	UCL[b]	*n*[c]
2004	GPC	10	3.5	3.1	16.8	8	7.7	1.1	5.6	9.8	37
	STG	19.3	2.7	13.9	24.6	8					
2005	GPC	4.6	0.9	2.9	6.3	10	3.9	1.3	3.2	4.6	86
	STG	4.4	0.8	2.7	6.0	9					

[a] 95% lower confidence limit; [b] 95% upper confidence limit; [c] sample size. Blank cells represent no data.

Brood habitat use differed ($F_{16,137}$ = 5.9, P < 0.01) between 2004 and 2005 for GPC broods. During 2004, western wheatgrass ranked highest and was significantly higher ($F_{7,56}$ = 2.9, P < 0.02) than Kentucky bluegrass (Table 4). Smooth brome, bare ground, and Kentucky bluegrass were avoided by GPC broods during 2004. In 2005, GPC broods selected (in order of most to least important) green needlegrass, western wheatgrass, Japanese brome, and mixed forb-dominated vegetation, which all ranked significantly higher (P < 0.03) than smooth brome, sweet clover, and porcupine grass (Table 4).

Sweet clover ($F_{1,33}$ = 11.8, P < 0.01) and porcupine grass ($F_{1,17}$ = 13.4, P < 0.01) habitat use scores for STG broods were higher than the scores for GPC broods (Table 3). The GPC brood use scores for western wheatgrass ($F_{1,33}$ = 7.0, P < 0.02) and Japanese brome ($F_{1,33}$ = 15.3, P < 0.01) communities were higher than for STG broods (Table 3). Greater prairie-chicken ($F_{1,16}$ = 5.3, P < 0.04) and STG ($F_{1,15}$ = 7.1, P < 0.02) brood use of sweet clover habitats were higher in 2004 than in 2005 (Fig. 2). Use of sweet clover by STG broods was higher than GPC brood use during 2004 ($F_{1,14}$ = 3.7, P < 0.08) and 2005 ($F_{1,17}$ = 14.5, P < 0.01; Fig. 2).

Topography of areas used by GPCs and STG broods differed by slope category (Fig. 3). A greater percentage of GPC brood home ranges were composed of slopes < 0.5% (χ^2_1 = 12.8, P > 0.01) than home ranges of STG broods (Fig. 3). Conversely, a greater percentage of STG brood home ranges were composed of slopes > 1.01% (χ^2_1 = 20.06, P > 0.01). We documented no differences (χ^2_1 = 1.13, P = 0.29) in prairie grouse home range use composed of slopes between 0.51 and 1.0 % (Fig. 3).

Table 3. Mean scores (Aebischer et al. 1993), standard error (SE), and confidence intervals for vegetation communities selected by sharp-tailed grouse and differently ($P < 0.05$) by greater prairie-chicken broods in relation to habitats available during summer 2004–2005 on the Fort Pierre National Grassland, South Dakota, USA.

	Sharp-tailed Grouse				Greater Prairie Chicken			
Habitat	Mean score	SE	LCL[a]	UCL[b]	Mean score	SE	LCL[a]	UCL[b]
Sweet Clover	1.74	0.43	1.71	1.76	−0.77	0.58	−0.80	−0.73
Other[c]	0.90	0.43	0.87	0.93				
Green Needlegrass	0.80	0.41	0.78	0.83				
Western Wheatgrass	0.42	0.55	0.39	0.46	1.53	0.25	1.52	1.55
Porcupine Grass	−0.33	0.24	−0.34	−0.31	−3.24	0.34	−3.29	−3.20
Kentucky Bluegrass	−0.34	0.59	−0.38	−0.31				
Bare Ground	−0.60	0.29	−0.63	−0.57				
Smooth Brome	−0.66	0.54	−0.69	−0.62				
Japanese Brome	−1.53	0.75	−1.58	−1.48	1.08	0.28	1.07	1.10

[a] 95% lower confidence limit; [b] 95% upper confidence limit; [c] forb-dominated vegetation . Blank cells represent no differences.

Table 4. Mean scores (Aebischer et al. 1993), standard error (SE), and confident intervals for vegetation communities selected by greater prairie-chicken (GPC) broods during summer 2004–2005 in relation to availability during the breeding season on the Fort Pierre National Grassland, South Dakota, USA.

	2004				2005			
Habitat	Mean score	SE	LCL[a]	UCL[b]	Mean score	SE	LCL[a]	UCL[b]
Western Wheatgrass	1.82	0.42	1.79	1.85	1.31	0.30	1.29	1.32
Japanese Brome	0.92	0.52	0.89	0.95	1.21	0.31	1.19	1.23
Other[c]	0.65	0.86	0.59	0.70	1.07	0.25	1.05	1.08
Sweet Clover	0.57	0.94	0.51	0.63	−1.84	0.57	−1.88	−1.80
Green Needlegrass	0.57	0.28	0.55	0.59	1.38	0.18	1.35	1.37
Smooth Brome	−0.45	1.20	−0.52	−0.37	−1.24	0.81	−1.29	−1.19
Bare Ground	−1.55	0.58	−1.59	−1.51	0.50	0.31	0.48	0.52
Kentucky Bluegrass	−2.53	1.06	−2.60	−2.47	0.88	0.75	0.83	0.93
Porcupine Grass					−3.24	0.72	−3.29	−3.20

[a] 95% lower confidence limit; [b] 95% upper confidence limit; [c] forb-dominated vegetation . Blank cells represent no data.

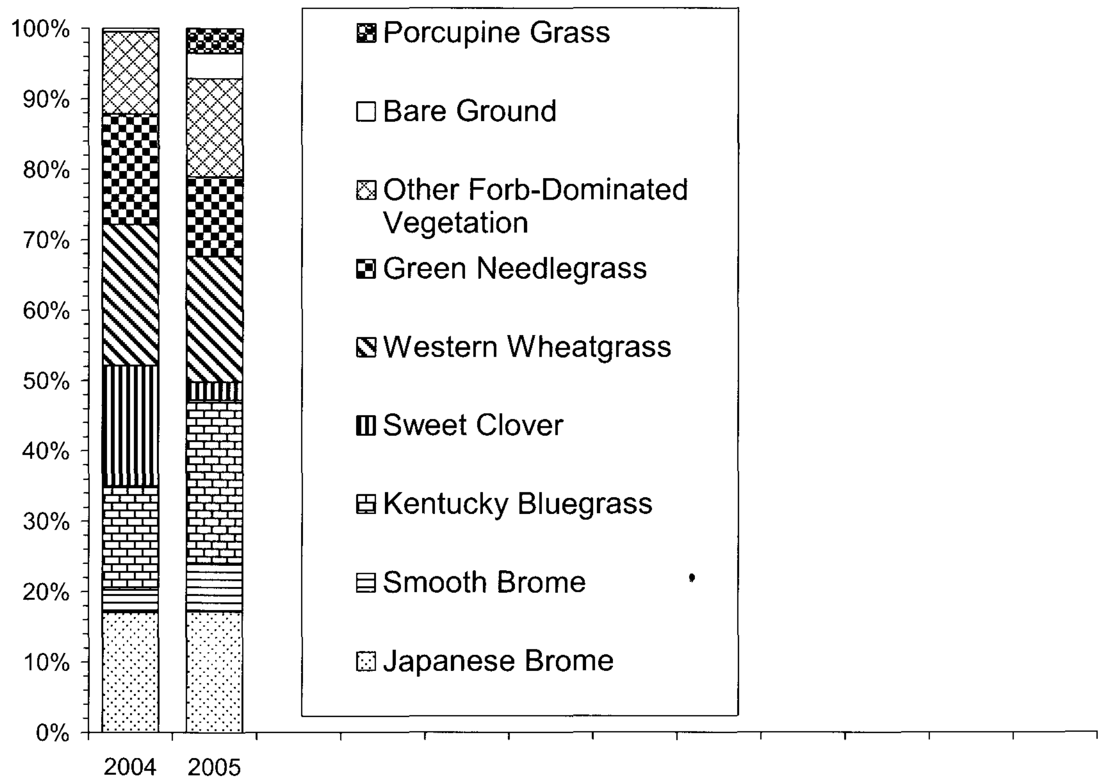

Figure 1. Resource availability for prairie grouse broods on the Fort Pierre National Grassland, South Dakota, USA, summer 2004–2005.

DISCUSSION

Sharp-tailed grouse broods selected vegetation communities primarily composed of sweet clover, mixed forb-dominated vegetation, and green needlegrass. These habitats contained taller vegetation than was randomly found on the FPNG. Greater prairie-chicken and STG broods used areas with abundant forbs, which often contain more insects than other habitats (Jones 1963, Manske and Barker 1988). Sweet clover and mixed forb-dominated vegetation communities likely produced more invertebrates than other habitats and also provided protective cover.

Greater prairie-chicken broods selected vegetation communities primarily composed of western wheatgrass, Japanese brome, green needlegrass and mixed forb-dominated vegetation. Western wheatgrass and green needlegrass often were interspersed with the mixed forb-dominated vegetation community. We hypothesize that mixed forb communities provided more abundant food for broods (invertebrates) whereas adjacent grassy cover with open understory provided easy travel routes. Use of sweet clover, green needlegrass and western wheatgrass by broods of both species of prairie grouse supports the findings of Rice and Carter (1982). However, we did not find any support for use of snowberry, prairie cordgrass, and bulrushes by broods of either prairie grouse species. Drought conditions during 2004 may have resulted in greater use of sweet clover by STG broods, presumably because it provided the most effective hiding cover compared to other herbaceous vegetation. With more abundant moisture in 2005, overhead cover from other vegetation was more abundant and grouse made less use of sweet clover.

Greater prairie-chicken broods selected Japanese brome vegetation communities whereas STG broods selected sweet clover. Sweet clover was primarily located on the tops and sides of hills while Japanese brome was primarily located on flat areas. Western wheatgrass also was used more (P = 0.01) by GPC broods than STG broods, and also occurred primarily in swales and on flat areas. Observed differences in habitat use and landscape position suggested that GPC and STG broods partially segregated by landscape features. For instance, GPC broods used flat areas (< 0.5 % slope) more ($P < 0.01$) than STG broods. Newell et al. (1988) also found that GPC broods spent most of their time in lowland communities. Moreover, sweet clover and porcupine grass grew taller than other vegetation on the FPNG, which likely accounted for observed differences in mean visual obstruction height of vegetation used by STG and GPC broods.

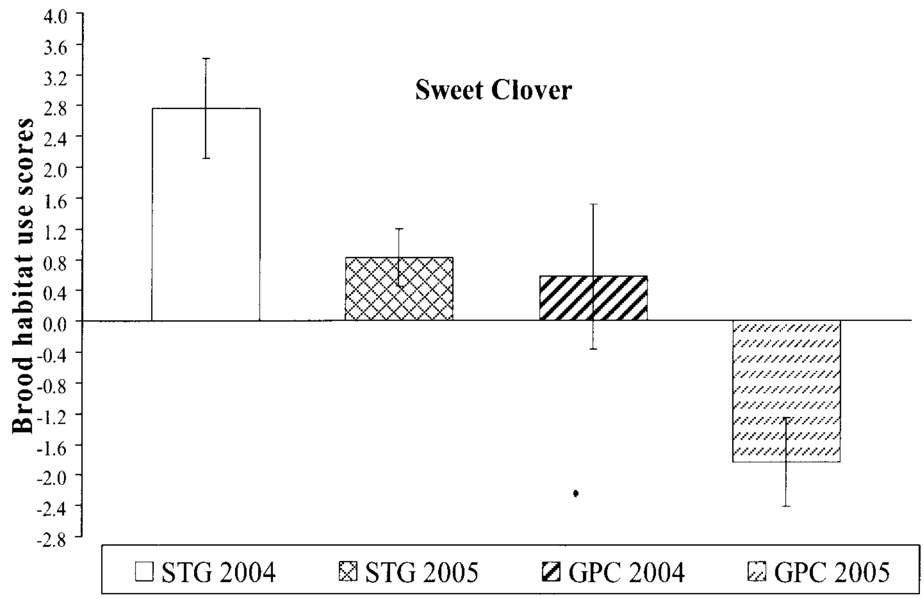

Figure 2. Mean scores (Aebischer et al. 1993) and standard errors for sweet clover habitat use by sharp-tailed grouse (STG) and greater prairie-chicken (GPC) broods in relation to availability on the Fort Pierre National Grassland, South Dakota, USA, summer 2004–2005.

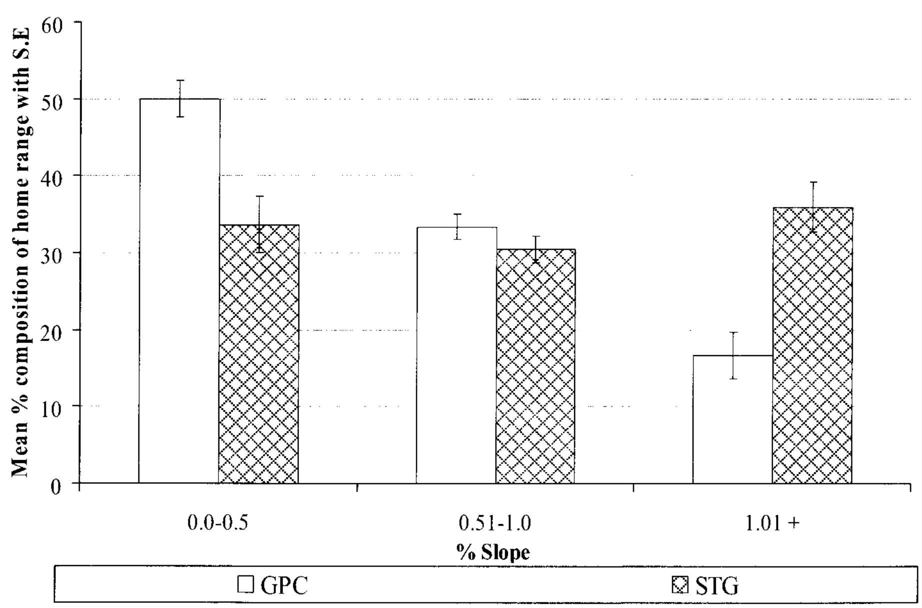

Figure 3. Home range topography of greater prairie-chicken (GPC) and sharp-tailed grouse (STG) hens with broods during the breeding seasons of 2004 and 2005 on the Fort Pierre National Grassland, South Dakota, USA.

Prairie grouse broods of both species exhibited avoidance of smooth brome. Smooth brome occurred in dense monotypic stands on the FPNG. A single species stand of vegetation may not provide as diverse or abundant invertebrate community as plant communities with multiple species (Koricheva et al. 2000). Smooth brome often provided little overhead protective cover from avian predators, especially if it was in an allotment that was actively grazed by cattle, as cattle often graze smooth brome patches before grazing other species of vegetation (A. J. Smart, South Dakota State University, personal communication). Consequently, prairie grouse broods may have avoided smooth brome patches of grassland dominated habitats.

Sharp-tailed grouse broods used taller vegetation than GPC broods during our study. Sweet clover accounted for approximately 95% of the taller vegetation in 2004 on STG brood locations, but the mean vegetation visual obstruction height was only 1 cm shorter in 2005 when sweet clover availability was significantly less ($P < 0.01$) on the landscape. Sharp-tailed grouse broods used habitats that provided adequate protective cover. Greater prairie-chicken broods did not use habitats with vegetation as tall as those used by STG broods (> 37 cm), but used habitats with vegetative visual obstruction height > 26 cm. Newell et al. (1988) and Fredrickson (1996) similarly reported minimum vegetation height in habitats used by GPC broods to be 26 cm and 25 cm, respectively.

MANAGEMENT IMPLICATIONS

In restored grassland across the Northern Great Plains, exclusive planting of sweet clover to improve STG habitat or Japanese brome to improve GPC habitat is not recommended. Segregation of the two prairie grouse species suggested that habitat managers could manage slopes for taller vegetation species, like sweet clover, porcupine grass, and green needlegrass for STG broods, and valleys and flats for shorter vegetation like western wheatgrass for GPC broods. Habitats that provide a diverse community of forbs were important to both species of prairie grouse in this study. Managers should incorporate a diverse herbaceous component into both upland and lowland settings of grasslands managed for prairie grouse broods. These habitats provide an open understory for ease of movement by chicks and overhead cover from avian predators and prolonged exposure to solar radiation.

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