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RESOURCE SELECTION FOR FORAGING BY FEMALE MERRIAM'S WILD TURKEYS WITH POULTS IN THE SOUTHERN BLACK HILLS, SOUTH DAKOTA

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Abstract: Knowledge of Merriam's wild turkey (*Meleagris gallopavo merriami*) resource selection in the context of landscape attributes is an important asset for managing resources on multiple-use public lands. We investigated resource selection for foraging by Merriam's wild turkey broods in the southern Black Hills, South Dakota. We collected macro- and microhabitat data from 48 radiotagged female wild turkeys during brood-rearing from 2001 to 2003. Broods selected meadows for macrohabitat resource selection, whereas dense stands of mature ponderosa pine (*Pinus ponderosa*) and wildfire-burned habitats were avoided. Within all ponderosa pine structural stages, or pooled classes of stands composed of varying tree density and size, brood foraging sites were predicted best by greater total herbaceous understory cover, greater diameter at breast height (dbh) of large trees, and closer to vegetation association edges. In open pine stands with $\leq$40% canopy cover, broods selected resources with greater total herbaceous cover and closer to vegetation association edges. Within the meadow vegetation community, broods selected resources that were closer to vegetation association edges, usually meadow–ponderosa-pine forest ecotones. We recommend that managers maintain a range of 1,170–1,306 kg/ha herbaceous biomass through August. Silviculture practices that promote or maintain pine savannas with larger dbh trees are recommended. Because broods selected meadows with fewer small ponderosa pine trees and, given the importance of understory herbaceous cover, we recommend management that limits pine encroachment into meadows.

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Recent changes in policy for U.S. Forest Service and Bureau of Land Management agencies have led to adoption of land management practices that emphasize conservation of biodiversity and compatibility with sustained use by humans (Thomas and Dombeck 1996, Lugo et al. 2006). National forest plans have included prioritizing focus species of local concern. Merriam's wild turkey (*Meleagris gallopavo merriami*) fits this prioritization in the Black Hills because of its high social and economic value (Griebel et al. 2007). Knowledge of wild turkey resource selection in the context of landscape attributes is an important asset for managing wild turkey populations and

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their habitats on multiple-use public lands. Although resource needs of Merriam's wild turkeys have been described during the brood-rearing period (Jonas 1966; Scott and Boeker 1975; Hengel 1990; Rumble and Anderson 1993, 1996*a*, 1996*b*; Rumble et al. 2003), specific information on selection of resources in open to moderately forested ponderosa pine (*Pinus ponderosa*) ecosystems is limited.

During brood-rearing, female Merriam's wild turkeys select resources where poults can find resources necessary for rapid growth and development, while also providing safety from predation (Scott and Boeker 1975, Rumble et al. 2003). Growth and development of poults are linked to invertebrate abundance, and studies have demonstrated a correlation between invertebrate abundance and greater herbaceous vegetation in open-canopied forests or meadow vegetation communities (Healy 1985; Rumble and Anderson 1996*a*, 1996*b*).

Management of vegetation through moderate herbivory can stimulate herbaceous growth; however, continuous intensive grazing can deplete vegetation resources (Hoffman et al. 1993). Annually, the Black Hills National Forest has 129 active cattle grazing allotments and livestock grazing has been 128,000 animal unit months (Black Hills National Forest Land and Resource Management Plan 2006). Additionally, foraging by native ungulates such as deer (*Odocoileus virginianus*, *O. hemionus*) and elk (*Cervus elaphus*) removes herbaceous biomass that could be used by other species. Guidelines for standing herbaceous biomass required for wild turkey broods have not been quantified for the southern Black Hills. General guidelines indicate at least 714 kg/ha of standing herbaceous biomass should be maintained as brood-rearing areas for Merriam's wild turkeys, but research determining a minimum threshold of herbaceous biomass is needed throughout their range (Hoffman et al. 1993, Rumble et al. 2003). Previous research in the central Black Hills indicated open-canopied forests with understory vegetation that provided greater visual obstruction was important for females with broods (Rumble and Anderson 1996*b*); however, this region of the Black Hills is more densely forested than the southern Black Hills and only 16% of this region was comprised of meadows (Rumble and Anderson 1993). Meadows are an important vegetation community during brood rearing; however, specific information on selection of resources for foraging in open to moderately forested ponderosa pine ecosystems is limited and would be useful for managers in semiarid western landscapes. Our objectives were to: (1) identify Merriam's wild turkey brood resource selection patterns at macro- (third-order) and microhabitat levels (fourth-order; Johnson 1980), and (2) ascertain resource selection at the microhabitat level specific to pine structural stages and the meadow vegetation community.

STUDY AREA

The study area (1,213 km^2) was located in Custer and Fall River counties in the southern portion of the Black Hills physiographic region of South Dakota (Johnson et al. 1995). The area consisted of interspersed public and private land; the majority of public land was administered by the U.S. Forest Service. The southern Black Hills ranges in elevation from 930 m to 1,627 m above mean sea level with a varied topography of rocky ridges, drainages, canyon walls, and mountain valleys (Kalvels 1982). The study area has a continental climate, with mean annual precipitation of 44.0 cm and mean annual temperature of 7.8°C (National Climatic Data Center 1971–2000). During this study, mean annual precipitation was 43.7 cm (National Climatic Data Center 2001–2003). Land cover types were ponderosa pine forest (48%) and meadows (23%). Twenty-nine percent of the study area was burned by catastrophic wildfires in 2000 and 2001, increasing the amount of open pine or meadow vegetation communities within the study area. Much of the wildfire was stand-replacing where 75% of the area was burned with moderate- to high-intensity fire with 52–100% tree mortality (Lentile et al. 2005). Rare stands of Rocky Mountain juniper (*Juniperus scopulorum*) and deciduous draws (<1%) occurred on the area. Western snowberry (*Symphoricarpos occidentalis*) and common juniper (*J. communis*) were common shrubs in the understory, while serviceberry (*Amelanchier alnifolia*), bearberry (*Arctostaphylos uva-ursi*), and chokecherry (*Prunus virginiana*) occurred less frequently (Hoffman and Alexander 1987). Common native grasses included needle and thread grass (*Stipa comata*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*; Larson and Johnson 1999).

METHODS

Capture and Radiotelemetry

We captured female Merriam's wild turkeys during 3 winters (2001–2003) using cannon nets (Dill and Thornsberry 1950, Austin et al. 1972), rocket nets (Thompson and Delong 1967, Wunz 1984), and drop nets (Glazener et al. 1964). We determined the age of captured females as either adult (>=1 yr old) or yearling (<1 yr old) based on feathers (Williams 1961). We fitted each female with a 98-g backpack-mounted radiotransmitter equipped with activity, loafing or non-active, and mortality signals (Advanced Telemetry Systems, Isanti, Minnesota, USA [Use of company name does not imply an endorsement by the U.S. Forest Service.]) These transmitters had a ball switch that had a "varying" pulse rate if the bird was active, and a "standard" pulse rate when not active. Additionally, there was a mortality switch in which the transmitter's "standard" pulse rate would double after 8 hr of inactivity. We located radiomarked females and their broods by direct observation during the months of May through August. We were careful not to disturb broods during visual observations. We used only observations of hens and poults where it appeared they were moving and feeding through the vegetation, and did not include loafing, or non-moving observations in our analyses. We only used observations where females and poults did not appear to change their behavior because of the investigators being in the area. We located all radiomarked wild turkeys systematically and locations for individuals were distributed evenly across the sampling period. To avoid temporal bias, we systematically located female wild turkeys during 3 time periods; sunrise to 1000 hrs, 1001–1400 hrs, and 1401 hrs to sunset.

Resource Selection

Macrohabitats

Availability of vegetation communities was determined at the third-order (macrohabitat) scale of resolution (Johnson 1980) by creating a 100% minimum convex polygon of all female wild turkey locations using the Home Range Extension (Rodgers and Carr 1998) within ArcView 3.3 geographic information system (GIS; Environmental Systems Research Institute, Redlands, California, USA). We overlaid this polygon with the Black Hills National Forest Resource Information System (RIS) GIS coverage (Black Hills National Forest Vegetation Database, USDA Supervisors Office, Custer, South Dakota, 2000). We delineated polygons of vegetation on private land within the area and assigned vegetation type and structural stages by comparing these polygons with classified polygons from adjacent Forest Service land using 1:24,000 aerial photographs and digital ortho-photographs to aid our interpretation. Vegetation descriptions of these macrohabitat polygons by the Black Hills National Forest were based on 5 sample plots systematically located in each polygon as part of the established RIS inventory protocol. The sample plots provide attributes of vegetation structural stage in the GIS framework.

Polygons in the RIS coverage were described using a hierarchical classification based on vegetation types and structural stages (Buttery and Gillam 1983). Vegetation structural stages of macrohabitats included grass or forb (meadow), shrub or sapling, pole stands (2.54–22.9 cm dbh), and mature or saw-timber stands (>22.9 cm dbh) with overstory canopy-cover categories in pole and mature or saw-timber forest of 0–40%, 41–70%, and >70%. Rare vegetation communities that comprised <1% of the area included deciduous draws and shrubs. Fires in August of 2000 and July of 2001 burned 35,170 ha (29%) of our study area. The areas within the perimeter of these wild fires were reclassified to recently burned wildfire in our GIS coverage. This reclassification resulted in 10 vegetation structural stage categories (Table 1).

Microhabitats

We used stratified random sampling (Cochran 1977) to determine estimates of available microhabitats. Strata for random sampling were the vegetation structural stages of non-burned macrohabitats described above. We randomly selected 15 polygons of each vegetation structural stage without replacement and selected one random point in each of these from a 30-m grid.

Vegetation characteristics were quantified along a 60-m transect centered where wild turkeys were observed and at random points. Observations of wild turkey broods were made at feeding sites along the feeding path of broods; the sites were evaluated 1–2 days after the locations were identified. Data collected along transects were averaged for each observation. We estimated overstory canopy cover from 50 points at 1-m intervals along each transect using a Geographic Resource Solutions densitometer (Stumpf 1993; Arcata, California, USA). Understory visual obstruction (VOR) was measured at 5-m intervals ($n = 12$) along each transect using a modified Robel pole (Robel et al. 1970) marked with alternating colors at 2.54-cm increments (Benkobi et al. 2000). Additionally, vegetation was clipped and dried within a 0.5-m^2 area and herbaceous biomass was estimated using VOR estimates (Benkobi et al. 2000). We measured the tallest height of vegetation (i.e., tallest plant of any grass, forb, or shrub next to the pole) with a ruler from the 4 cardinal directions while recording VOR measurements. We estimated percent understory canopy cover (Daubenmire 1959) of total cover, grass, forbs, shrubs, and dominant plant species at 2-m intervals ($n = 30$) along transects in a 0.1-m^2 quadrat. Tree characteristics were measured in 3 plots with one at the midpoint of each

Table 1. Selection of vegetation communities (macrohabitats) by Merriam's wild turkey broods foraging in the southern Black Hills, South Dakota, USA, 2001–2003.

Vegetation community categories[a]			Available proportion[b]	Use counts	Selection ratio (CI)	Utilization[c]
Macrohabitat class	Dbh class	Overstory canopy				
Meadow			23%	84	1.66 (1.09–2.24)	+
Ponderosa pine	Shrub or sapling		1%	6	1.96 (−0.26–4.17)	0
Ponderosa pine	2.54–22.9 cm	0–40	6%	24	1.83 (0.76–2.89)	0
Ponderosa pine	2.54–22.9 cm	41–70	8%	24	1.46 (0.55–2.38)	0
Ponderosa pine	2.54–22.9 cm	71–100	4%	10	1.31 (−0.22–2.83)	0
Ponderosa pine	>22.9 cm	0–40	14%	41	1.37 (0.60–2.13)	0
Ponderosa pine	>22.9 cm	41–70	12%	25	0.93 (0.32–1.54)	0
Ponderosa pine	>22.9 cm	71–100	3%	1	0.18 (−0.28–0.63)	–
Recently burned wildfire			29%	4	0.06 (−0.05–0.18)	–
Rare[d]			<1%	0	0.00 (0.00–0.00)	0

[a] Vegetation structural stages were described based on dominant vegetation species, dbh, and overstory canopy cover (Buttery and Gillam 1983). The category recently burned wildfire was added as a macrohabitat.

[b] The study area included 121,274.4 ha and the approximate area for each category can be calculated using the available proportions.

[c] Use of resources by wild turkeys were categorized as: selected (used more than available, +), random (equal use, 0), and avoided (used less than available, –).

[d] Rare category included deciduous draws and shrubs. All of these categories were small in sample size (<1%) and, therefore, pooled for analysis.

transect and one at each end 30 m away. We recorded species and dbh of trees $\geq$15.24 cm dbh in a variable-radius plot using a 10-factor prism (Sharpe et al. 1976) and used a 5.03-m fixed-radius plot for trees <15.24 cm dbh. Aspect was recorded using a compass as the prevailing downhill direction and slope was estimated along this same gradient using a clinometer. Downed woody debris (metric tons/ha) was interpolated from a pictorial guide (Simmons 1982). We also paced the distance from the brood location to the nearest vegetation association edge (m). The edge of 2 vegetation associations was distinct and the vegetation changed abruptly such as either a meadow–ponderosa pine forest interface, or a meadow–shrub-patch ecotone. The distance was truncated at 100 m.

Analyses and Model Development

Macrohabitat Analysis

We used the Design II goodness-of-fit test (Manly et al. 1993) to estimate selection of macrohabitat categories for foraging by female Merriam's wild turkeys during brood-rearing. We pooled rare vegetation communities that comprised <1% of the area for these analyses. Significance was determined at $\alpha = 0.10$, and *P*-values for selection of macrohabitats were adjusted to maintain experiment-wise error rates at the predetermined α using the Bonferroni inequality (Miller 1981). Our research was conducted in an effort to provide information on how resource management such as logging and herbivore grazing might affect Merriam's wild turkeys. Committing a Type II error would be equivalent to incorrectly suggesting wild turkeys use vegetation communities randomly; thus, we selected a more liberal α-level so as to not preclude management beneficial to Merriam's wild turkeys.

Microhabitat Analysis

Microhabitats or fourth-order scale vegetation communities (Johnson 1980) selected by broods of Merriam's wild turkeys were compared with available microhabitats. We summarized microhabitat characteristics for random sites and sites where females and their poults were observed feeding during brood-rearing. For analyses of resource selection by broods while foraging, we included a weight factor to accommodate deviations from proportional sampling among random strata (Cochran 1977). Each random site was assigned a weight $= P_i N_t / N_i$, where P_i was the proportion of the entire study area comprised of a particular stratum (*i*; vegetation structural stage), N_t was the total number of random samples, and N_i was the number of random samples in a particular stratum (*i*). Sites where we observed broods received a weight of 1.0.

We evaluated continuous variables using quantile–quantile plots and conducted a Kolmogorov–Smirnov (K–S) 2-sample distribution test (SAS Version 9.01; SAS Institute Inc., Cary, North Carolina, USA) to assess differences between random and use sites for all vegetation community categories combined, and for analysis of pine structural stages. We used a multiple-response permutation procedure (MRPP; Mielke and Berry 2001) and quantile–quantile plots to compare vegetation characteristics for the meadow vegetation community. Multiple-response permutation procedure tests relax the parametric structure requirement of a test statistic and are less affected by an extreme measurement of a single object. A chi-square contingency table was used to compare the categories of aspect (SAS Version 9.01).

Because broods often use meadow and open pine vegetation communities (Rumble and Anderson 1993, 1996*b*; Mollohan et al. 1995), we further examined selection exclusively within each of those categories. To estimate selection of resources from those available, we used the information–theoretic approach (Burnham and Anderson 1998, 2002). We used K–S and MRPP test results, as well as previous research information, to create reduced data sets for pine and meadow resource selection (Hosmer and Lemeshow 2000, Steidl 2006). Significance level was set at $\alpha = 0.10$ for all comparisons because the 0.05 level can fail to identify variables known to be important (Hosmer and Lemeshow 2000). We also evaluated variables in data sets for correlations ($r > 0.7$) and only one variable from a correlated set was included in the final set of candidate models. The global model was included as a candidate in the final set of models because of the restrictive model screening process (Guthery et al. 2005). A final parsimonious set of models was ranked and compared for meadow ($n = 15$ models) and pine vegetation communities ($n = 15$ models for all pine structural stages and $n = 15$ models for open pine models). Logistic regression functions more like a logistic discriminant model when the availability function is not clearly defined relative to unused vegetation communities (Keating and Cherry 2004).

Variables used in plausible models were based on a priori information (e.g., Jonas 1966, Scott and Boeker 1975, Crawford and Lutz 1984, Mollohan et al. 1995, Rumble and Anderson 1996*b*). Variables considered in model development included: large-tree basal area (trees $\geq$ 15.24 cm dbh/m^2/ha), small tree density (trees < 15.24 cm dbh/ha), distance to vegetation association edge (m), total herbaceous understory cover (%), understory forb cover (%), understory shrub cover (%), and herbaceous biomass (kg/ha). Broods may feed close to understory shrubs due to their escape-cover value (Jonas 1966, Rumble and Anderson 1996*a*). Also, the amount of herbaceous biomass and understory vegetation cover may influence the selection of sites by Merriam's wild turkeys (Crawford and Lutz 1984, Healy 1985, Mollohan et al. 1995, Rumble and Anderson 1996*b*). Distance to escape cover edge also may influence selection of vegetation communities (Scott and Boeker 1975, Rumble and Anderson 1996*b*). We hypothesized that wild turkeys would select foraging sites closer to meadow–forest edges and sites with greater density of herbaceous biomass.

Logistic models were compared using Akaike's information criterion ($QAIC_c$; Burnham and Anderson 2002). $QAIC_c$ was computed using the log likelihood, number of parameters (*K*), and modified for overdispersed count data with a variance inflation factor ($\hat{c}$). Competing models with $\Delta_I \leq 3$ were considered to have substantial support in explaining variation in the data (Burnham and Anderson 2002). We calculated unit odds ratios and 90% confidence intervals to further evaluate importance of variables (Hosmer and Lemeshow 2000). To assess goodness-of-fit, a Hosmer–Lemeshow test was generated for each model (Hosmer and Lemeshow 2000). We used Receiver Operating Characteristic (ROC) curves (SAS Version 9.01, 2005) as a diagnostic to discriminate between use and random sites in logistic models (Hosmer and Lemeshow 2000).

RESULTS

Resource Selection

Capture and Radiotelemetry

We collected data from 48 female wild turkeys ($n = 46$ adults, $n = 2$ yearlings) and their broods ($n = 688$ poults), resulting in 219 macrohabitat and 144 microhabitat brood sites during foraging. For distribution of macrohabitat observations, we collected a mean of 4.08 (SE = 0.59) visual observations/bird; 34% were collected sunrise to 1000 hr, 37% from 1001 hr to 1400 hr, and 29% from 1401 hrs to sunset. For microhabitat observations, we collected a mean of 3.43 (SE = 0.39) visual observations/bird; 37% were collected sunrise to 1000 hr, 37% from 1001 hr to 1400 hr, and 26% from 1401 hr to sunset. Age of poults monitored varied from 1 day to 38 days of age, with most (77%) of the observations occurring when poults were from 1 day to 20 days of age. Number of poults in broods monitored ranged from 1 to 11.

Macrohabitat

The study area included 9,159 macrohabitat units accounting for 121,274 ha. The study area was comprised of 119,603 ha of public land and 1,671 ha of private land. There were no differences ($\chi^2 = 357.50$, df = 423, $P = 0.99$) in use of macrohabitat vegetation communities among individual broods during feeding and movement activity. Resource use was not proportional to availability ($\chi^2 = 141.91$, df = 9, $P < 0.001$) at the macrohabitat level. The meadow category ($n = 84$) was selected, whereas the pine category >22.9 cm dbh with >70% canopy cover ($n = 1$) and recently burned wildfire ($n = 4$) were avoided (Table 1); selection of other categories was random. Deciduous draw and shrub communities, or rare vegetation communities, were not used ($n = 0$); however, little of this category was available to wild turkeys (<1%).

Microhabitat Comparisons of Use and Random Sites (All Categories)

We compared 144 feeding sites with 170 stratified random sites. Brood foraging sites differed from random sites in most characteristics (Table 2). Brood sites had less overstory canopy coverage of ponderosa pine and fewer trees. Sites were lower in slope gradient and greater in total ground vegetation cover than random sites. Clipped vegetation and biomass estimates were correlated ($r^2 = 0.81$) with VOR estimates (Fig. 1) and biomass was greater at brood feeding sites than random sites. Brood sites were closer to vegetation association edges compared to random

Table 2. Microhabitat metrics for brood feeding areas of Merriam's wild turkeys and random sites for all vegetation community categories combined. Means (±SE), test statistics, and probability levels (*P*-value) comparing brood and random sites in the southern Black Hills, South Dakota, USA, 2001–2003.

Variable	Microhabitats				Test statistic	*P*-value[a]
	Brood sites	SE	Random sites	SE		
Canopy cover (%)	9.82	1.21	27.82	1.85	2.49	0.00
Slope (%)	5.81	0.41	9.16	0.99	2.09	0.00
Aspect[b]			Overall χ^2 test for aspect =		3.95	0.27
North	23		36			
East	40		38			
South	51		48			
West	30		48			
Woody debris (metric tons/ha)	5.32	0.54	7.79	0.51	1.62	0.01
Distance to edge (m)	23.26	2.20	60.39	2.87	3.61	0.00
Large-tree basal area (m^2/ha)[c]	5.72	0.57	12.66	0.79	2.21	0.00
Large-tree dbh (cm)	29.50	1.15	24.02	0.76	2.88	0.00
Visual obstruction (cm)	7.96	0.49	5.83	0.35	1.89	0.00
Herbaceous biomass (kg/ha)	1,237.64	52.88	1,009.29	37.94	1.89	0.00
Vegetation ht (cm)	29.97	1.02	17.32	1.02	3.51	0.00
Small-tree density (ha)[d]	101.73	17.88	396.21	72.97	2.69	0.00
Small-tree dbh (cm)	3.50	0.36	5.98	0.35	2.33	0.00
Total ground cover (%)	84.11	1.03	50.00	2.36	4.28	0.00
Grass cover (%)	74.44	1.66	40.13	2.69	3.60	0.00
Forb cover (%)	21.77	1.40	10.46	1.28	3.32	0.00
Shrub cover (%)	13.75	1.50	8.55	0.95	1.43	0.03

[a] Sites compared with either a chi-square test or Kolmogorov–Smirnov test.
[b] Aspect was a categorical variable (North, South, East, and West) and the no. of sites at each aspect is given in table.
[c] Basal area of trees ≥15.24 cm dbh were estimated in a variable-radius plot using a 10-factor prism (Sharpe et al. 1976).
[d] Density of small trees (<15.24 cm dbh) was estimated in a 5.03-m-radius fixed plot.

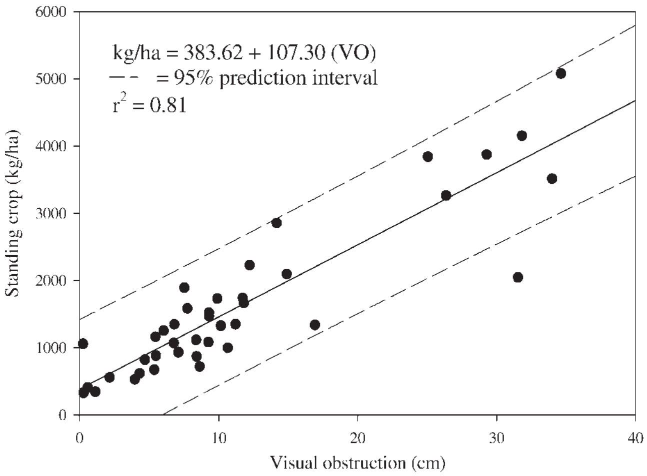

Figure 1. Scatter plot of standing crop (kg/ha) of dry weight herbaceous biomass in relation to Robel pole visual obstruction readings (cm) with associated regression model and 95% prediction intervals from the southern Black Hills, South Dakota, USA, 2001–2003.

sites. Vegetation height was greater at feeding sites than random sites (Table 2).

Microhabitat Evaluating Pine Forest Resource Selection (All Pine Structural Stage Categories)

We compared 42 feeding sites with 104 stratified random sites. Brood foraging sites differed from random sites in several characteristics (Table 3). Sites had less overstory canopy coverage of ponderosa pine and fewer trees. Brood sites were greater in large-tree dbh. Brood sites were closer to vegetation association edges and greater in total herbaceous cover compared to random sites (Table 3).

Four models predicted brood foraging sites in pine forest ($\Delta QAIC_c$ range = 0.00–1.95; Table 4). The remaining models were less effective in predicting pine foraging sites ($\Delta QAIC_c \geq 3.0$). The best model included greater total herbaceous cover and greater large-tree dbh. The best model was at least 1.25 times more likely to predict brood use than the remaining models. Classification accuracy and discrimination between use and random sites for the top 4 models was excellent with ROC values $\geq$0.92.

Odds ratios indicated that greater total herbaceous cover and greater dbh of large trees were associated positively with brood sites. Greater distance to vegetation association edge was associated negatively with resource selection. Forb cover was in one of the top models, but had lower association than total herbaceous cover, dbh of large trees, and distance to edge in predicting brood foraging within all pine structural stages (Table 4).

Microhabitat Evaluating Open Pine Forest Resource Selection (Pine Categories ≤40% Canopy Cover)

We compared 42 feeding sites with 30 pine random sites. Further evaluation within the open pine structural stage indicated resource selection. Five models predicted brood foraging sites in open pine forest ($\Delta QAIC_c$ range = 0.00–2.52; Table 5). The remaining models were less

Table 3. Microhabitat metrics for brood feeding areas of Merriam's wild turkeys and random sites within all ponderosa pine structural stage categories. Means (±SE), test statistic, and probability level (*P*-value) for comparisons in the southern Black Hills, South Dakota, USA, 2001–2003.

	Microhabitats					
Variable	Brood sites	SE	Random sites	SE	Test statistic	*P*-value[a]
Canopy cover (%)	23.05	2.61	39.60	1.90	1.39	0.04
Slope (%)	7.90	0.99	10.61	0.68	1.04	0.23
Aspect[b]			Overall χ^2 test for aspect =		6.06	0.11
North	8		23			
East	13		27			
South	15		22			
West	6		32			
Woody debris (metric tons/ha)	9.07	1.12	10.06	0.58	1.21	0.11
Distance to edge (m)	35.10	5.67	68.51	3.57	1.98	0.00
Large-tree basal area (m^2/ha)[c]	10.95	0.94	17.80	0.95	1.73	0.01
Large-tree dbh (cm)	31.53	0.96	25.20	0.52	2.26	0.00
Visual obstruction (cm)	6.73	0.87	5.39	0.37	0.92	0.37
Herbaceous biomass (kg/ha)	1,105.39	92.90	961.49	39.77	0.92	0.37
Vegetation ht (cm)	27.45	1.96	11.39	0.80	2.88	0.00
Small-tree density (ha)[d]	198.16	41.86	534.16	110.02	1.32	0.06
Small-tree dbh (cm)	5.33	0.66	7.21	0.36	1.30	0.07
Total ground cover (%)	78.61	2.15	34.12	2.38	3.77	0.00
Grass cover (%)	65.82	3.18	21.32	2.22	3.59	0.00
Forb cover (%)	19.20	2.55	4.55	0.63	2.55	0.00
Shrub cover (%)	15.33	2.83	8.64	1.16	1.14	0.15

[a] Sites compared with either a chi-square test or Kolmogorov–Smirnov test.
[b] Aspect was a categorical variable (North, South, East, and West) and the no. of sites at each aspect is given in table.
[c] Basal area of trees ≥ 15.24 cm dbh were estimated in a variable-radius plot using a 10-factor prism (Sharpe et al. 1976).
[d] Density of small trees (<15.24 cm dbh) was estimated in a 5.03-m-radius fixed plot.

Table 4. Best set of logistic models predicting selection of resources within ponderosa pine structural stages for Merriam's wild turkeys in the southern Black Hills, South Dakota, USA, 2001–2003. Odds ratios (90% CIs) were calculated for the covariates distance to vegetation association edge (edge), total understory herbaceous cover (total cover), large-tree (trees $\geq$ 15.24 cm) diameter at breast height (large-tree dbh), and understory forb cover (forb cover) in models with evidence ratios $\leq$4.

Pine resource selection diagnostics

Logistic models	K	Log[L(θ)][a]	$QAIC_c$[b]	$\Delta(QAIC_c)$[c]	w_i[d]	ER[e]
$u = -8.41 + 0.08$ (total cover [%]) $+ 0.10$ (large-tree dbh [cm])	4	74.71	82.99	0.00	0.30	1.00
$u = -5.00 + 0.09$ (total cover [%]) $- 0.01$ (edge [m])	4	75.11	83.39	0.40	0.24	1.69
$u = -7.22 + 0.07$ (total cover [%]) $+ 0.10$ (large tree dbh [cm]) $+ 0.02$ (forb cover [%]) $- 0.01$ (edge [m])	6	70.81	83.41	0.42	0.24	1.71
$u = -5.99 + 0.09$ (total cover [%])	3	78.77	84.94	1.95	0.11	3.66

Unit odds ratios[f]

Covariate	Odds ratio	CI	P-value
Total cover (%)[g]	1.09	1.06–1.12	<0.001
Large tree DBH (cm)[g]	1.11	1.01–1.22	0.06
Edge (m)[h]	0.99	0.97–1.00	0.06
Forb cover (%)[i]	1.02	0.96–1.08	0.58

[a] Fisher's max. likelihood estimates (–2log-likelihood).
[b] Akaike's information criterion (AIC) modified for a variance inflation factor ($\hat{c} = 1.94$) when count data are overdispersed ($QAIC_c$).
[c] Kullback–Leibler distances rescaled as simple differences: $\Delta_I = AIC_i - \text{minAIC}$.
[d] Strength of evidence for models or model wt (w_i) computed as a ratio: $\exp(-0.5\Delta_I)/\Sigma \exp(-0.5\Delta_I)$.
[e] Evidence ratios (best model w_i/w_j competing models) used to compare models.
[f] Unit odds ratios >1 indicate a positive relationship and <1 indicate a negative relationship with the response variable.
[g] Odds ratios (90% CIs) taken from best pine resource selection model (total cover, large-tree dbh [cm]).
[h] Odds ratios (90% CIs) taken from second-best pine resource selection model (total cover, edge).
[i] Odds ratios (90% CIs) taken from third-best pine resource selection model (total cover, large-tree dbh, forb cover, edge).

effective in predicting foraging within open pines ($\Delta QAIC_c \geq 17.0$). The best model included greater total herbaceous cover and less distance to vegetation association edge. The best model was at least 1.5 times more likely to predict brood use than the remaining models. Classification accuracy and discrimination between use and random sites for the top 5 models was excellent with ROC values $\geq$0.89.

Odds ratios indicated that greater total herbaceous cover was positively associated with brood sites; greater distance to vegetation association edge was negatively

Table 5. Best set of logistic models predicting selection of resources within open ponderosa pine structural stages ($\leq$40% canopy cover) for Merriam's wild turkeys in the southern Black Hills, South Dakota, USA, 2001–2003. Odds ratios (90% CIs) were calculated for the covariates distance to vegetation association edge (edge), total understory herbaceous cover (total cover), large-tree (trees $\geq$ 15.24 cm) diameter at breast height (large-tree dbh), and understory forb cover (forb cover) in models with evidence ratios $\leq$4.

Open pine resource selection diagnostics

Logistic models	K	Log[L(θ)][a]	$QAIC_c$[b]	$\Delta(QAIC_c)$[c]	w_i[d]	ER[e]
$u = -4.23 + 0.08$ (total cover [%]) $- 0.02$ (edge [m])	4	61.99	58.59	0.00	0.35	1.00
$u = -5.08 + 0.08$ (total cover [%])	3	65.81	59.43	0.84	0.23	1.52
$u = -6.34 + 0.07$ (total cover [%]) $+ 0.07$ (large-tree dbh [cm]) $+ 0.02$ (forb cover [%])	5	60.70	59.86	1.27	0.18	1.89
$u = -6.65 + 0.07$ (total cover [%]) $+ 0.07$ (large-tree dbh [cm])	4	64.24	60.40	1.81	0.14	2.48
$u = -4.87 + 0.07$ (total cover [%]) $+ 0.03$ (forb cover [%])	4	65.12	61.11	2.52	0.10	3.53

Unit odds ratios[f]

Covariate	Odds ratio	CI	P-value
Total cover (%)[g]	1.08	1.05–1.12	<0.001
Large-tree dbh (cm)[h]	1.07	0.95–1.20	0.26
Edge (m)[g]	0.99	0.97–1.00	0.06
Forb cover (%)[h]	1.02	0.96–1.09	0.53

[a] Fisher's max. likelihood estimates (–2log-likelihood).
[b] Akaike's information criterion (AIC) modified for a variance inflation factor ($\hat{c} = 1.94$) when count data are over-dispersed ($QAIC_c$).
[c] Kullback–Leibler distances rescaled as simple differences: $\Delta_I = AIC_i - \text{minAIC}$.
[d] Strength of evidence for models or model wt (w_i) computed as a ratio: $\exp(-0.5\Delta_I)/\Sigma \exp(-0.5\Delta_I)$.
[e] Evidence ratios (best model w_i/w_j competing models) used to compare models.
[f] Unit odds ratios >1 indicate a positive relationship and <1 indicate a negative relationship with the response variable.
[g] Odds ratios (90% CIs) taken from best open pine resource selection model (total cover, edge).
[h] Odds ratios (90% CIs) taken from third-best open pine resource selection model (total cover, forb cover, large-tree dbh).

Table 6. Microhabitat metrics for brood feeding areas of Merriam's wild turkeys and random sites within the meadow vegetation community category. Means (±SE), test statistic, and probability level (*P*-value) for meadow sites in the southern Black Hills, South Dakota, USA, 2001–2003.

Variable	Meadow site microhabitats				Test statistic	*P*-value[a]
	Brood sites	SE	Random Sites	SE		
Canopy cover (%)	4.37	0.88	3.93	1.13	0.86	1.00
Slope (%)	4.94	0.39	6.18	0.70	−0.53	0.21
Aspect[b]			Overall χ^2 test for aspect =		3.09	0.38
North	15		9			
East	27		9			
South	36		23			
West	24		14			
Woody debris (metric tons/ha)	3.78	0.55	3.18	0.76	0.05	0.38
Distance to edge (m)	18.38	1.87	44.07	4.63	−19.50	0.00
Large-tree basal area (m^2/ha)[c]	3.56	0.37	2.28	0.39	−2.88	0.02
Large-tree dbh (cm)	28.66	1.57	21.57	2.26	−4.30	0.01
Visual obstruction (cm)	8.47	0.59	6.65	0.78	−1.62	0.07
Herbaceous biomass (kg/ha)	1,292.09	63.61	1,097.08	84.10	−1.62	0.07
Vegetation height (cm)	31.03	1.18	29.28	1.83	0.21	0.43
Small-tree density (ha)[d]	62.03	17.11	114.26	37.66	−1.55	0.08
Small-tree dbh (cm)	2.75	0.41	3.48	0.59	−0.06	0.31
Total ground cover (%)	86.38	1.08	82.58	2.82	−3.70	0.01
Grass cover (%)	77.99	1.84	78.77	3.07	−0.38	0.23
Forb cover (%)	22.83	1.67	23.15	3.18	−1.91	0.05
Shrub cover (%)	13.10	1.77	8.18	1.79	−1.51	0.08

[a] Sites compared with either a χ^2 or MRPP test.
[b] Aspect was a categorical variable (North, South, East, and West) and the no. of sites at each aspect is given in table.
[c] Basal area of trees ≥15.24 cm dbh were estimated in a variable-radius plot using a 10-factor prism (Sharpe et al. 1976).
[d] Density of small trees (<15.24 cm dbh) was estimated in a 5.03-m-radius fixed plot.

associated with brood sites. Large-tree dbh and forb cover were in the top models, but had lower association than total herbaceous cover and distance to edge in predicting brood foraging within open pine structural stages (Table 5).

Microhabitat Evaluating Meadow Resource Selection

Metrics were compared between 102 poult feeding sites in meadows and 55 random meadow sites. Of the 102 meadow sites used by wild turkeys, 61 were detectable at the macrohabitat level and 41 were too small to be detected with the imagery. Meadows from which poults were observed differed from random sites in several characteristics (Table 6). Brood sites were closer to vegetation association edges compared to random sites. Broods were found primarily along meadow–ponderosa pine forest ecotones ($n = 63$ sites), and secondarily, along meadow–shrub ecotones ($n = 39$ sites). Visual obstruction and herbaceous biomass were greater at feeding sites. Also, there were fewer small ponderosa pine trees within the meadows selected by broods. Total ground cover, particularly the shrub component, was greater at brood feeding sites compared to random meadow sites (Table 6).

Four models predicted brood foraging sites in meadows ($\Delta QAIC_c$ range = 0.00–2.15; Table 7). The remaining models were less effective in predicting meadow foraging sites ($\Delta QAIC_c \geq 7.43$). The best model included less distance to vegetation association edge. The best model was at least 1.36 times more likely to predict brood use than the remaining models. Discrimination between use and random sites for the top 4 models was adequate with ROC values ≥ 0.72. Primary shrub species found at meadow foraging sites were western snowberry (9.35%, SE = 1.51), poison ivy (*Toxicodendron rydbergii*; 1.15%, SE = 0.52), and rose (*Rosa acicularis*; 1.10%, SE = 0.30).

Odds ratios indicated that greater distance to vegetation association edge was associated negatively with brood sites (odds ratio = 0.97). Greater shrub cover and herbaceous biomass were included in the best models, but these covariates had lower association than distance to edge in predicting brood sites (Table 7).

DISCUSSION

Selection of resources during brood rearing provides poults optimal forage for fast growth and development while, at the same time, affording cover for avoiding predation (Scott and Boeker 1975, Rumble et al. 2003). In the southern Black Hills, female Merriam's wild turkeys with poults selected for meadows at the macrohabitat scale. Dense ponderosa pine stands (>22.9 cm dbh) with high canopy cover (>70%) were avoided by broods in our study and in the central Black Hills (Rumble and Anderson 1993).

Recently burned forest from wildfire was avoided in our analysis; however, it should be noted that some broods used resources in the wildfire areas, but these birds were observed actively foraging along the edges of burned and unburned vegetation communities. Extensive portions of wildfire areas within our study area were burned severely by stand-replacing fires and lacked live trees (Lentile et al.

Table 7. Best set of logistic models predicting selection of resources within meadows for Merriam's wild turkeys in the southern Black Hills, South Dakota, USA, 2001–2003. Odds ratios (90% CIs) were calculated for the covariates distance to vegetation association edge (edge), understory shrub cover (shrub cover), and herbaceous biomass (biomass) in models with evidence ratios ≤ 4.

Meadow resource selection diagnostics						
Logistic models	K	Log[L(θ)][a]	$QAIC_c$[b]	$\Delta(QAIC_c)$[c]	w_i[d]	ER[e]
$u = 1.63 - 0.04$ (edge [m])	3	173.18	148.11	0.00	0.34	1.00
$u = 1.45 - 0.03$ (edge [m]) + 0.02 (shrub cover [%])	4	171.33	148.70	0.59	0.25	1.34
$u = 1.13 - 0.04$ (edge [m]) + 0.01 (biomass [kg/ha])	4	171.33	148.70	0.59	0.25	1.34
$u = 1.15 - 0.03$ (edge [m]) + 0.01 (shrub cover [%]) + 0.01 (biomass [kg/ha])	5	170.63	150.26	2.15	0.12	2.93
Unit odds ratios[f]						

Covariate	Odds ratio	CI	P-value
Edge (m)[g]	0.97	0.95–0.98	<0.001
Shrub cover (%)[h]	1.02	1.00–1.04	0.20
Biomass (kg/ha)[i]	1.00	1.00–1.02	0.18

[a] Fisher's max. likelihood estimates (–2log-likelihood).
[b] Akaike's information criterion (AIC) modified for a variance inflation factor ($\hat{c} = 1.94$) when count data are overdispersed ($QAIC_c$).
[c] Kullback–Leibler distances rescaled as simple differences: $\Delta_I = AIC_i - \text{minAIC}$.
[d] Strength of evidence for models or model wt (w_i) computed as a ratio: $\exp(-0.5\Delta_I)/\Sigma \exp(-0.5\Delta_I)$.
[e] Evidence ratios (best model w_i/w_j competing models) used to compare models.
[f] Unit odds ratios >1 indicate a positive relationship and <1 indicate a negative relationship with the response variable.
[g] Odds ratios (90% CIs) taken from best meadow resource selection model (edge).
[h] Odds ratios (90% CIs) taken from second-best (tied with edge + biomass model) meadow resource selection model (edge + shrub).
[i] Odds ratios (90% CIs) taken from second-best (tied with edge + shrub model) meadow resource selection model (edge + biomass).

2005). Live overstory trees may be important as protective cover, particularly for protection from aerial predators, which may explain why broods avoided wildfire-burned habitats in our study. Thompson (1993) also noted avoidance of severely burned habitats by Merriam's wild turkeys during summer and that birds used the edges of burned and non-burned areas more readily. Following the wildfires in summers of 2002 and 2003, forb and grass growth was robust, and provided adequate ground-level cover for females with poults. These areas also appeared to have adequate invertebrate abundance for poult development (Lehman 2005); it is evident that more research is needed on brood resource selection and the effects of recently burned forest for Merriam's wild turkeys.

Similar to our findings in the southern Black Hills, other researchers have found non-random use of resources by Merriam's wild turkeys during brood-rearing (Crawford and Lutz 1984, Mollohan et al. 1995, Rumble and Anderson 1996*b*). Research that evaluates resource selection exclusively within the pine vegetation community is limited and our findings indicate females with poults selected open pine stands with greater herbaceous cover, larger diameter trees, and were closer to vegetation association edges than found at random. Selection for larger diameter trees was due to broods feeding in older open pine savannas found in the southern Black Hills (Bolt and Deusen 1974). Typically, younger ponderosa pine stands are stocked densely and provide less herbaceous biomass (Bolt and Deusen 1974). Further evaluation within the open pine community indicated broods in our study would seek out areas with greater understory herbaceous cover, which most likely was associated with greater invertebrate abundance, for foraging (Healy 1985; Rumble and Anderson 1996*a*, 1996*b*).

Further analysis comparing variables from meadows used by broods with metrics from random meadows may be useful for resource managers. Merriam's wild turkeys in the southern Black Hills primarily selected for the edges of meadow–ponderosa pine forest vegetation associations. We observed poults flying into adjacent cover of ponderosa pine branches when disturbed by investigators or predators. Selection of feeding sites near meadow edges appears to be a survival tactic due to the proximity of predator-escape cover (Rumble and Anderson 1996*b*). Similar to our study, Merriam's wild turkeys in Arizona and Oregon also selected sites with greater herbaceous biomass (Crawford and Lutz 1984, Mollohan et al. 1995). Total ground cover, particularly the shrub component, was greater at brood sites compared to random meadow sites in the southern Black Hills. Western snowberry was more abundant at brood sites compared to random sites in the southern Black Hills (Lehman 2005) and in other studies (Jonas 1966, Rumble and Anderson 1996*b*). Although odds ratios did not indicate shrubs were associated significantly with foraging-site selection, we observed poults feeding along the edges of snowberry patches and using the patches as hiding cover when predators approached. Escape cover, primarily in the form of herbaceous vegetation and shrubs, was not lacking in brood-rearing areas.

Wild turkeys appear to select brooding areas at least partly based on the amount of herbaceous biomass needed at poult feeding sites. Healy (1985) recommended a large range of herbaceous biomass (400–3,000 kg/ha) as suitable for eastern wild turkey poults. Hoffman et al. (1993) recommends at least 714 kg/ha of standing herbaceous for Merriam's wild turkeys. In the southern Black Hills, we estimate that wild turkeys selected a narrower range (1,170–1,306 kg/ha; 80% CI) of herbaceous vegetation at brood foraging sites, which is similar to the 1,260 kg/ha average reported for the central Black Hills (Rumble and Anderson 1996*b*). Greater herbaceous biomass was correlated with greater biomass of invertebrates in the central

Black Hills (Rumble and Anderson 1996*a*, 1996*b*). Grasshoppers (Orthoptera), beetles (Coleoptera), and other invertebrates associated with herbaceous cover are important for providing protein for poult growth and development in the Black Hills (Rumble and Anderson 1996*a*, Lehman 2005).

MANAGEMENT IMPLICATIONS

We suggest management goals for brood foraging resources take into account understory herbaceous metrics such as total herbaceous cover, herbaceous biomass, and vegetation height during the brood-rearing period; we suggest managing for 1,170–1,306 kg/ha herbaceous biomass through August in the southern Black Hills, South Dakota. Some meadows available to broods within the study area had less biomass due to overgrazing by native ungulates and cattle; these activities can compromise the quality of brood foraging habitat. Meadows with inadequate herbaceous cover for broods usually were adjacent to water sources. Management that disperses grazing pressure, such as increasing allocation of water resources, may alleviate some deficiencies in herbaceous biomass if animal unit months for cattle grazing are kept constant or reduced. Because fewer small (<15.24 cm dbh) ponderosa pine trees were observed within meadows where poults were foraging, we recommend management activities that prevent encroachment of pine trees on range soils where meadows occur. Furthermore, forestry practices that promote or maintain open pine savannas with larger dbh trees at 8–12 m^2/ha basal are recommended.

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