



*Management and Conservation Article*

# Bed Site Selection by Neonate Deer in Grassland Habitats on the Northern Great Plains

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**ABSTRACT** Bed site selection is an important behavioral trait influencing neonate survival. Vegetation characteristics of bed sites influence thermal protection of neonates and concealment from predators. Although previous studies describe bed site selection of neonatal white-tailed deer (*Odocoileus virginianus*) in regions of forested cover, none determined microhabitat effects on neonate bed site selection in the Northern Great Plains, an area of limited forest cover. During summers 2007–2009, we investigated bed site selection ( $n = 152$ ) by 81 radiocollared neonate white-tailed deer in north-central South Dakota, USA. We documented 80 (52.6%) bed sites in tallgrass–Conservation Reserve Program lands, 35 (23.0%) bed sites in forested cover, and 37 (24.3%) in other habitats (e.g., pasture, alfalfa, wheat). Bed site selection varied with age and sex of neonate. Tree canopy cover ( $P < 0.001$ ) and tree basal area ( $P < 0.001$ ) decreased with age of neonates, with no bed sites observed in forested cover after 18 days of age. Male neonates selected sites with less grass cover ( $P < 0.001$ ), vertical height of understory vegetation ( $P < 0.001$ ), and density of understory vegetation ( $P < 0.001$ ) but greater bare ground ( $P = 0.047$ ), litter ( $P = 0.028$ ), and wheat ( $P = 0.044$ ) than did females. Odds of bed site selection increased 3.5% (odds ratio = 1.035, 95% CI = 1.008–1.062) for every 1-cm increase in vertical height of understory vegetation. Management for habitat throughout the grasslands of South Dakota that maximizes vertical height of understory vegetation would enhance cover characteristics selected by neonates.

**KEY WORDS** bed site, habitat use, neonate, Northern Great Plains, *Odocoileus virginianus*, South Dakota, white-tailed deer.

Previous research documented variable behavior of adult female white-tailed deer (*Odocoileus virginianus*; hereafter deer) at parturition. White et al. (1972) and Ozoga et al. (1982) reported that dams sought isolation at parturition, whereas Hirth (1977) and Grovenburg et al. (2009) observed dams remaining in social groups during and after parturition. Differences in parturition behavior may represent adaptive strategies unique to habitat and region (Hirth 1977). Following parturition, neonatal behavior is shaped by predation (Lent 1974, Schwede et al. 1994). Neonates either follow the dam or hide, although most ungulates exhibit hiding behavior during the first month of life (Lent 1974, Hiller et al. 2008). White-tailed deer are considered hider-types, relying on cover and cryptic coloration for protection from predation (Lent 1974, Huegel et al. 1986).

Bed site selection is critical to neonate survival; neonates spend most of their time resting at bed sites often at considerable distance from dams (Huegel et al. 1986, Schwede et al. 1994). Vegetation at bed sites may enhance thermal cover and hide neonates from predators, such as coyotes (*Canis latrans*), which locate prey using visual and olfactory cues (Wells and Lehner 1978, Huegel et al. 1986, Hyde et al. 1987). Neonates remain inactive and hidden until the dam returns to groom and nurse (Huegel et al. 1986). Choice of bed site is typically limited to the general area (macrohabitat) chosen by the dam; however, the actual bed site is selected by the neonate (Marchinton and Hirth 1984, Huegel et al. 1986). Neonates rarely use the same bed

site on consecutive days, instead moving (100–130 m) from one area to another (Ozoga et al. 1982).

In southwestern Oklahoma, USA, neonates selected bed sites with greater vertical height of vegetation and higher percentage of grass (48–85%) than at random sites (Garner et al. 1979). In south Texas, USA, percent canopy cover of grasses and forbs was greater at bed sites than at random sites. Additionally, woody cover was selected by neonates; 50% of bed sites were near or under a woody plant (Hyde et al. 1987). Huegel et al. (1986) documented that bed sites contained a greater percentage of woody cover and less short and medium herbaceous cover than random sites. Density of vegetation was an important component of bed sites in South Texas and Iowa, USA (Huegel et al. 1986, Hyde et al. 1987). In the Black Hills of South Dakota, USA, neonates selected bed sites in open stands of ponderosa pine (*Pinus ponderosa*) with greater vertical height of understory vegetation; density of understory vegetation at bed sites did not differ from random sites (Uresk et al. 1999). However, in the Northern Great Plains, forested cover is limited and often fragmented (Smith et al. 2002).

Higgins et al. (1987) hypothesized that Conservation Reserve Program (CRP) grasslands provided a missing habitat component in intensively managed, agricultural areas characterized by limited cover, and thus, potentially enhanced landscapes for wildlife species such as white-tailed deer. Conservation Reserve Program fields were selected by adult deer seasonally and diurnally for bedding or active periods, with increased usage corresponding to rapid vegetative growth in spring and early summer (Gould and Jenkins 1993). During a mild winter in the Northern

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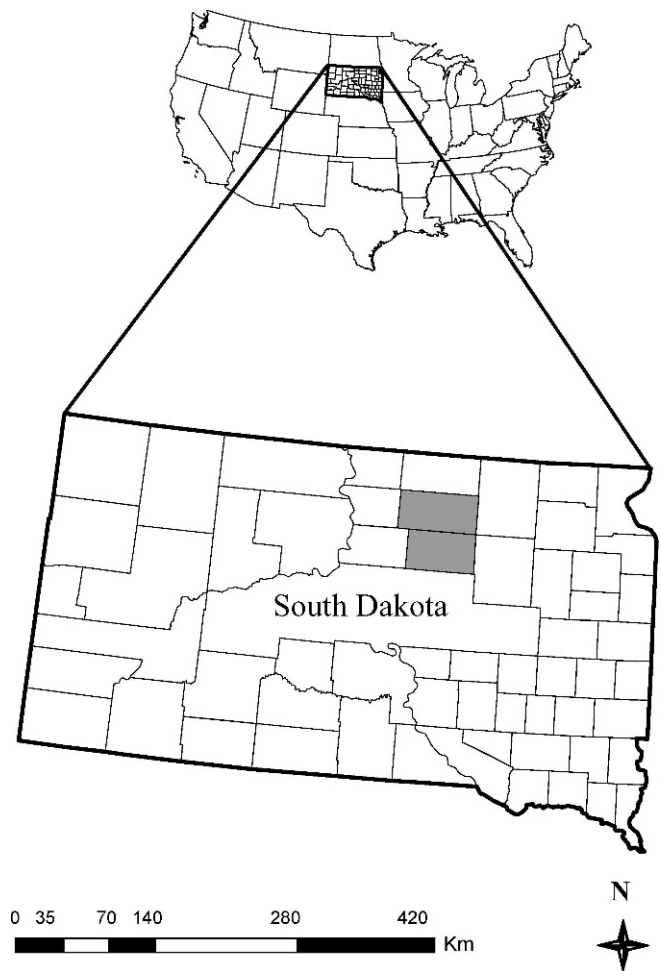
Great Plains, adult female deer selected for CRP grasslands (Grovenburg et al. 2010). However, land enrolled in the CRP peaked at 14.9 million ha in September 2007 and by October 2007, CRP enrollment declined by 931,000 ha, of which 850,000 ha were grasslands (Fargione et al. 2009, United States Department of Agriculture 2009b). Conservation Reserve Program enrollment as of spring 2009 was 13.6 million ha with an additional 1.8 million due to expire on 30 September 2009 (United States Department of Agriculture 2009a).

Because neonates are most vulnerable to predation and death by natural causes during the first 60 days of life, information on habitat characteristics at neonate bed sites in this landscape could be especially important for deer population management (Verme 1977, Huegel et al. 1985a, Nelson and Woolf 1987). However, to our knowledge limited information documents neonate white-tailed deer bed-site selection in grasslands on the Northern Great Plains. Additionally, reductions in CRP enrollments during our study provided an opportunity to evaluate bed site selection by neonates during a period of changing availability of cover characteristics in the region. Our primary objective was to determine vegetation characteristics of neonate white-tailed deer bed sites during a period of CRP decline. Our secondary objectives were to determine effects of age and sex of neonate on bed site selection of white-tailed deer in the Northern Great Plains.

## STUDY AREA

We studied neonatal white-tailed deer in Edmunds and Faulk counties (Fig. 1) in north-central South Dakota, which comprised an area of 5,558 km<sup>2</sup>. Mean annual (30-yr) precipitation was 49.5 cm and mean summer (30-yr) temperature ranged from 18.2° C to 21.3° C (South Dakota Office of Climatology 2009). The study area was located within the Northwestern Glaciated Plains and the Northern Glaciated Plains level III ecoregions (Bryce et al. 1998). The landscape was flat to gently rolling terrain intermixed with numerous pothole wetlands and mounds of glacial till (Bryce et al. 1998). Agriculture was the predominant land use in the region. Cultivated land and pasture–grassland comprised 40.4% and 45.7% of total land use, respectively. Forests, mainly woodland plantings and shelterbelts, covered 2.3% of the area (Smith et al. 2002). Additionally, the 2-county area had 1,711 ha in Game Production Area lands (South Dakota Department of Game, Fish and Parks 2009). South Dakota had 631,704 ha enrolled in the 2006 CRP with 14,975 ha in the 2-county area (South Dakota Agriculture Statistics Service 2009). Summer deer densities within the study area were estimated at 2.3–3.3 deer/km<sup>2</sup> (Grovenburg et al. 2009).

Native mixed-grass vegetation on CRP-enrolled grasslands was dominated by western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), porcupine grass (*Heterostipa spartea*), and little bluestem (*Schizachyrium scoparium*). Dominant tree species were green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), boxelder (*Acer negundo*), hackberry (*Celtis* spp.), and eastern cotton-



**Figure 1.** Study area where we captured neonate white-tailed deer in north-central South Dakota, USA, 2007–2009. Shaded areas are Edmunds and Faulk counties.

wood (*Populus deltoides*; Petersen 1984, Johnson and Larson 1999). Common wetland vegetation included prairie cordgrass (*Spartina pectinata*), reed canarygrass (*Phalaris arundinacea*), common reed (*Phragmites australis*), cattails (*Typha* spp.), rushes (*Juncus* spp.), and sedges (*Carex* spp.; Johnson and Larson 1999). Cultivated crops included corn, soybeans, wheat, and alfalfa (South Dakota Agriculture Statistics Service 2009).

## METHODS

We captured white-tailed deer neonates by hand from 15 May to 10 June 2007–2009, by intensively searching areas where we observed females exhibiting distinctive postpartum behavior such as isolation, females attempting to hide by lowering themselves to the ground, and females fleeing only a short distance as vehicles approached (Downing and McGinnes 1969, White et al. 1972, Huegel et al. 1985b). We fitted captured neonates with model M4210 expandable breakaway radiocollars (Advanced Telemetry Systems, Isanti, MN). We determined age of neonate (days) using hoof growth measurement and umbilicus condition (Brinkman et al. 2004). We recorded bed site locations at time of capture and obtained subsequent bed site locations by

**Table 1.** Land cover availability (%) for neonate white-tailed deer in north-central South Dakota, USA, study area, summer 2007–2009.

Habitat	2007	2008	2009
Forested	1.9	1.9	1.9
CRP <sup>a</sup>	5.7	4.3	3.4
Wetland	1.0	1.2	1.5
Wheat	19.8	22.4	25.6
Cultivated	37.8	36.0	33.1
Pasture	29.7	30.1	30.4
Development	4.1	4.1	4.1

<sup>a</sup> CRP = Conservation Reserve Program grasslands.

relocating radiocollared neonates (Jacques et al. 2007). We analyzed bed sites used by neonates up to 30 days of age because after 4 weeks neonates are mobile and rely less on hiding to escape predation (Huegel 1985). We used a truck-mounted null-peak antenna system (Brinkman et al. 2002) and hand-held 4-element Yagi antennas (Advanced Telemetry Systems, Isanti, MN) to locate bedded neonates. If neonates did not attempt to escape capture when approached on foot, we marked the bed site and collected measurements 1–5 days later. If neonates flushed when approached, we marked and analyzed the bed site. We measured vegetation characteristics at 1–3 bed sites for each radiocollared neonate. Our animal handling methods followed guidelines approved by the American Society of Mammalogists (Gannon et al. 2007) and were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval no. 04-A009).

We collected vegetation measurements at paired bed sites and randomly selected sites <250 m from the bed site. We selected random locations in similar habitat as bed sites (i.e., bed site located in tallgrass-CRP, random site located in tallgrass-CRP). We visually estimated percent cover of grasses, forbs, shrubs, row crops (corn, soybeans), wheat, bare ground, slash, and litter in 24 1.0-m<sup>2</sup> quadrats spaced at 1-m intervals along 2 perpendicular transects originating at the bed site or center of the random site. We used a modified Robel pole to estimate vertical height and density of understory vegetation at bed sites or the center of random sites and at 4 locations 2 m from center along each transect (Robel et al. 1970). We used a 10-factor prism (Jim-Gem<sup>®</sup> Square Prisms; Forestry Suppliers, Inc., Jackson, MS) to estimate tree basal area (BA) at each bed and random site center (Sharpe et al. 1976). We estimated tree canopy cover using a spherical densitometer (Geographic Resource Solutions, Arcata, CA) at bed and random site centers and from 4 plots, each 6 m from the plot center (Uresk et al. 1999). To determine available habitats, we used ArcGIS 9.2 and 2001 National Land Cover Data (Homer et al. 2007). We ground-verified individual habitats and annual land use changes (i.e., CRP-grasslands converted to agriculture) using a Global Positioning System and updated a unique map for each summer.

We classified each bed site according to general habitat type (i.e., tallgrass-CRP, pasture, alfalfa, wheat, and forested) and used chi-square analysis to determine differences between years. We used one-way multivariate

**Table 2.** Habitat type of bed sites ( $n = 152$ ) of white-tailed deer neonates in north-central South Dakota, USA, 2007–2009.

Habitat	2007	2008	2009
CRP <sup>a</sup>	34	28	18
Forested	14	9	12
Pasture	1	1	3
Alfalfa	2	0	1
Wheat	0	6	23

<sup>a</sup> CRP = Conservation Reserve Program grasslands.

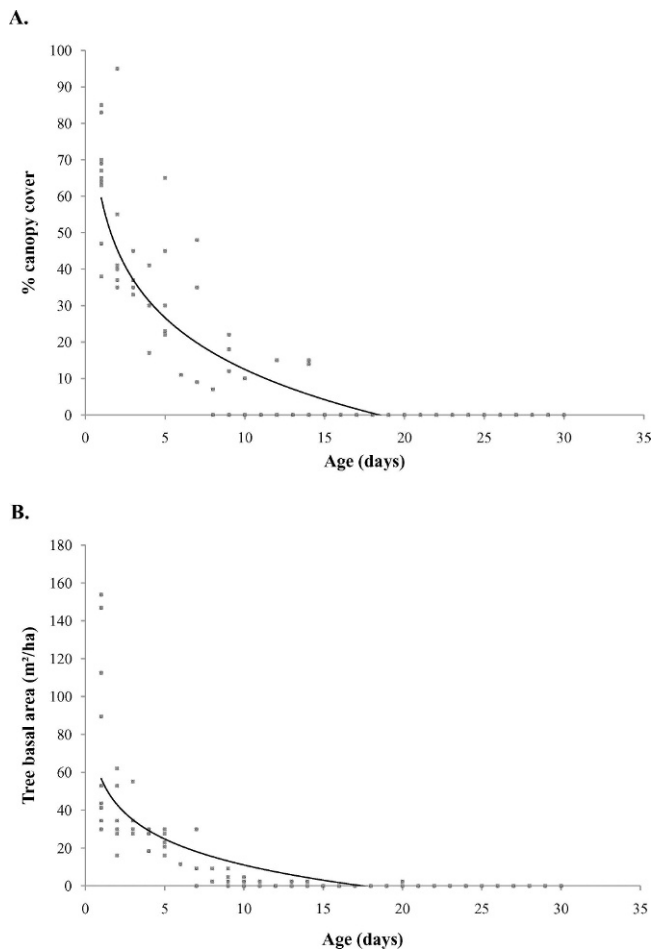
analysis of variance to test for relationships between both sex and age of neonate and vegetation characteristics. We used logistic regression to determine effects of microhabitat variables on bed site selection. Prior to modeling, we tested for collinearity between predictor variables using variance inflation (Allison 1999) and posited 14 models of how neonatal bed sites might be influenced by vertical height of understory vegetation, density of understory vegetation, percent grass cover, tree canopy cover, and tree BA in the Northern Great Plains. We selected model parameters based on biological importance to neonates in published literature. We used Akaike's Information Criterion (AIC) to select the most parsimonious model and considered models differing by  $\leq 2$   $\Delta$ AIC from the selected model as potential alternatives (Burnham and Anderson 2002). We used Akaike weights ( $w_i$ ) as an indication of support for each model and used multimodel inference to average parameters across potential models. We used the Hosmer–Lemeshow goodness-of-fit test to determine model fit ( $P > 0.05$  indicated appropriate model fit; Hosmer and Lemeshow 2000). We used analysis of variance to test for differences between habitat type and meaningful model covariates. We conducted statistical tests using SAS version 9.1 (SAS Institute, Cary, NC) with an experiment-wide error rate of 0.05.

## RESULTS

We examined 152 bed sites (51 in 2007, 44 in 2008, and 57 in 2009) used by 81 radiocollared neonates (capture ratio: 51 F:30 M) from 15 May to 30 June. All bed sites were <300 m from neonate capture locations, indicating minimal effect of capture on subsequent bed site location. Additionally, we analyzed 152 random sites (51 in 2007, 44 in 2008, and 57 in 2009) throughout the study area. We located and analyzed 80 (52.6%) bed sites in tallgrass-CRP, 35 (23.0%) in forested cover, 5 (3.3%) in pasture, 3 (2.0%) in alfalfa, and 29 (19.1%) in wheat; habitat type differed among years ( $\chi^2_8 = 35.01$ ,  $P < 0.001$ ; Table 1). Land cover changed from 2007 to 2009 (Table 1) and bed sites located in CRP decreased each year, whereas bed sites located in wheat increased each year (Table 2).

Microhabitat characteristics of bed sites varied with age of neonates ( $F_{348,1272} = 2.25$ ,  $P < 0.001$ ). Tree canopy cover ( $F_{29,122} = 29.44$ ,  $P < 0.001$ ) and tree BA ( $F_{29,122} = 9.63$ ,  $P < 0.001$ ) at bed sites decreased with age of neonate until approximately 18 days of age (Fig. 2). Microhabitat characteristics of bed sites also differed by sex of neonate ( $F_{12,139} = 9.93$ ,  $P < 0.001$ ). Percent grass ( $F_{1,150} = 12.80$ ,





**Figure 2.** Estimated tree canopy cover (A) and basal area (B) at bed sites ( $n = 152$ ) of neonatal white-tailed deer with age of neonate during 2007–2009 in north-central South Dakota, USA. Canopy cover (A) regression ( $y = -20(\ln x) + 59.557$ ,  $R^2 = 0.79$ ) indicated no use of canopy cover at bed sites after approximately 18 days of age. Tree basal area (B) regression ( $y = -19.81(\ln x) + 56.640$ ,  $R^2 = 0.62$ ) indicated limited use of forested cover at bed sites after approximately 17 days of age.

$P < 0.001$ ), vertical height of understory vegetation ( $F_{1,150} = 115.24$ ,  $P < 0.001$ ), and density of understory vegetation ( $F_{1,150} = 79.25$ ,  $P < 0.001$ ) were lower at bed sites of male than female neonates. In contrast, wheat ( $F_{1,150} = 4.12$ ,  $P = 0.044$ ), bare ground ( $F_{1,150} = 4.00$ ,  $P = 0.047$ ), and litter ( $F_{1,150} = 4.92$ ,  $P = 0.028$ ) were greater at bed sites of male than female neonates (Table 3).

Prior to model development, variance inflation analysis revealed collinearity between percent wheat and grass cover. Thus, we used only one variable (grass cover) in model development. Vertical height of understory vegetation was the optimal model ( $w_i = 0.847$ ; Table 4) for predicting neonate bed sites. Results of the Hosmer–Lemeshow goodness-of-fit ( $P = 0.765$ ) indicated predictive capability of the model was acceptable. Odds-ratio point estimates (Odds ratio = 1.035, 95% CI = 1.008–1.062) indicated that vertical height of understory vegetation had an effect on bed site selection; although the relationship was not perfectly linear, odds of neonate bed site selection increased by 3.5% for every 1-cm increase in vertical height of understory

**Table 3.** Mean (and SE) microhabitat characteristics for male and female neonate bed sites for 81 neonate white-tailed deer in north-central South Dakota, USA, 2007–2009.

Habitat <sup>a</sup>	M ( $n = 56$ )		F ( $n = 96$ )	
	$\bar{x}$	SE	$\bar{x}$	SE
Grass (%) <sup>b</sup>	47.4	4.7	65.8	2.8
Forb (%)	7.1	1.5	7.6	0.8
Shrub (%)	2.1	1.4	1.0	0.5
Wheat (%) <sup>b</sup>	25.4	5.4	13.0	3.4
Row crops (%)	0.0	0.0	0.0	0.0
Rock (%)	0.3	0.2	0.1	0.1
Bare ground (%) <sup>b</sup>	1.5	0.4	0.6	0.2
Slash (%)	1.4	0.6	0.7	0.4
Litter (%) <sup>b</sup>	14.8	1.7	11.2	0.7
Vertical ht (cm) <sup>b</sup>	56.1	1.6	80.1	1.5
Density (cm) <sup>b</sup>	32.7	1.8	55.4	1.7
Tree canopy cover (%)	12.3	3.1	10.5	2.1
Tree basal area (m <sup>2</sup> /ha)	10.1	3.1	9.6	2.5

<sup>a</sup> Vertical ht = vertical ht of understory vegetation (cm); Density = density of understory vegetation (cm).

<sup>b</sup> Indicates differences between M and F neonate bed site selection ( $P < 0.05$ ).

vegetation. Parameter and standard error estimates were consistent among models where the vertical height of understory vegetation ( $\beta = 0.022$ ,  $SE = 0.009$ ) covariate occurred and 95% confidence intervals never overlapped zero, indicating this variable influenced neonate bed site selection. Additionally, odds ratio estimates were consistent among models where the vertical height of understory vegetation covariate occurred and 95% confidence intervals never overlapped one. All remaining variables were inconsistent; 95% confidence intervals overlapped zero for parameter estimates and one for odds ratio estimates. Mean height of understory vegetation was greater ( $F_{4,147} = 11.74$ ,  $P < 0.001$ ) for tallgrass-CRP habitat ( $\bar{x} = 76.58$  cm,  $SE = 1.90$ ,  $n = 80$ ) than for alfalfa ( $\bar{x} = 46.67$  cm,  $SE = 13.02$ ,  $n = 3$ ), pasture ( $\bar{x} = 34.80$  cm,  $SE = 3.1$ ,  $n = 5$ ), forested cover ( $\bar{x} = 74.8$  cm,  $SE = 2.45$ ,  $n = 35$ ), and wheat ( $\bar{x} = 62.60$  cm,  $SE = 2.86$ ,  $n = 29$ ).

## DISCUSSION

Neonates selected bed sites with greater vertical height of understory vegetation than in surrounding areas, which provided greater visual concealment and better thermal insulation. Composition of vertical structure differed greatly between our study area and south-central Iowa where Huegel et al. (1986) reported mean percent of tallgrass at bed sites was less than at random sites and 77% of all bed sites were in forested cover. During our study, vertical structure selected by neonates was composed primarily of tallgrass-CRP bed sites (52.6%), whereas only 23% of bed sites were in forested cover. Similar to Uresk et al. (1999), neonates selected bed site locations with taller grasses. Selection of tallgrass-CRP habitat as vertical cover might be explained, in part, by land cover in the study area. Forested cover comprised a small percentage (2.3%) of total land cover (Smith et al. 2002), whereas available CRP comprised 5.7% of land cover in our study area and was greater at the beginning of the study than when field work ended. Greater

**Table 4.** Akaike's Information Criterion (AIC) model selection of a priori logistic regression models for neonatal white-tailed deer bed sites in north-central South Dakota, USA, 2007–2009.

Model covariates <sup>a</sup>	K <sup>b</sup>	Log-likelihood	AIC <sup>c</sup>	ΔAIC <sup>d</sup>	w <sub>i</sub> <sup>e</sup>
VH	3	406.951	410.951	0.000	0.847
VH + C	4	410.207	416.207	5.256	0.061
C	3	414.436	418.436	7.485	0.020
VH + D + C + TB + G	6	407.090	419.090	8.139	0.014
VH + D + TB	5	411.111	419.111	8.160	0.014
C + D	4	413.605	419.605	8.654	0.011
VH + D	4	413.828	419.828	8.877	0.010
TB + C	4	414.204	420.204	9.253	0.008
VH + TB	4	414.605	420.605	9.654	0.007
TB	3	418.599	422.599	11.648	0.003
G + VH	4	416.941	422.941	11.990	0.002
G	3	420.446	424.446	13.495	0.001
D	3	420.781	424.781	13.830	0.001
G + D	4	420.222	426.222	15.271	0.000

<sup>a</sup> VH = vertical ht of vegetation, C = canopy cover, D = density of vegetation, TB = tree basal area, G = grass cover.

<sup>b</sup> No. of parameters.

<sup>c</sup> Akaike's Information Criterion (Burnham and Anderson 2002).

<sup>d</sup> Difference in AIC relative to min. AIC.

<sup>e</sup> Akaike wt (Burnham and Anderson 2002).

availability of CRP corresponded to increased bed site selection in CRP than in forested cover during 2007. However, during 2007–2009, CRP grassland was reduced by 41% in our study area (Table 1) as contracts expired and were not extended (United States Department of Agriculture 2009b). Consequently, decline in percentage of bed sites in CRP habitat (66.7% to 31.6%) and subsequent increased use of wheat from 2007 to 2009 was directly related to loss of CRP habitat. Additional use of other habitats for bed sites can be expected in future years as contracts totaling 416,921 ha (86.2% of remaining enrolled land) of CRP are due to expire in South Dakota (United States Department of Agriculture 2009a). In addition, we documented a significant decrease in summer survival corresponding to loss of tallgrass-CRP. During 2007–2009, summer mortality was 1, 5, and 12 neonates, respectively; predation ( $n = 10$ ) and hypothermia ( $n = 5$ ) were proximate causes of death. During summer 2009, 5 predation and all hypothermia ( $n = 5$ ) mortalities occurred in wheat. Because vertical height of understory vegetation was approximately 20% greater in tallgrass-CRP than in wheat and neonates select vertical structure for concealment cover and thermal insulation (Huegel et al. 1986), we speculate that the shift from tallgrass-CRP to wheat for selection of bed sites will likely lead to greater neonate mortality in grassland habitats throughout the Northern Great Plains.

Density of understory vegetation has been reported as an important component in habitat selection of neonates because of cooler ambient temperatures that characterize bed sites (Huegel et al. 1986, Hyde et al. 1987). Neonates did not select for bed sites with greater density of understory vegetation. Differences in density of understory vegetation between our study and south-central Iowa (Huegel et al. 1986) and South Texas (Hyde et al. 1987) might be explained by differences in ambient temperatures among the study areas. On warm days ( $>29.5^{\circ}\text{C}$ ) in south-central

Iowa, neonates selected bed sites with denser understory vegetation than on average ( $>24^{\circ}\text{C}$  but  $<29.5^{\circ}\text{C}$ ) or cool days ( $<24^{\circ}\text{C}$ ; Huegel et al. 1986). Temperatures during our study never reached  $29.5^{\circ}\text{C}$ ; 96.5% of mean daily temperatures were categorized as cool and 3.5% as average days (South Dakota Office of Climatology 2009). In warmer climates, density of understory vegetation may be necessary for thermal cover to reduce heat loading and maintain water balance (Ockenfels and Brooks 1994). Our results were similar to those documented in the forested landscape of the Black Hills of South Dakota (Uresk et al. 1999). However, mean monthly temperatures in the Black Hills during the warmest month (Aug) ranged from  $16.1^{\circ}\text{C}$  to  $21.9^{\circ}\text{C}$  (Uresk et al. 1999), substantially below the warm threshold documented by Huegel et al. (1986). In Iowa, bed site temperatures on cool days were cooler than the surrounding area, which was characterized by increased density of understory vegetation (Huegel et al. 1986). Consequently, cooler temperatures may minimize the need for increased density of understory vegetation as a mechanism to minimize heat gain from direct solar radiation. Our results suggested quite the opposite, decreased density of understory vegetation may maximize heat gain in regions with cooler temperatures.

Contrary to previous findings (Huegel et al. 1986), we observed that bed site selection in forested cover declined with age of neonate. Neonates develop locomotion skills and the ability to flee rapidly after 10 days of age (Downing and McGinnes 1969, Cook et al. 1971, Huegel et al. 1985b, Grovenburg et al. 2009). Neonates up to 12 weeks of age spent up to 80% of their time  $\geq 100$  m away from dams while at bed sites, were sedentary, and associated infrequently with their dam (Huegel et al. 1986, Schwede et al. 1994, Hiller et al. 2008). Additionally, neonate deer bed sites in heavily forested regions were used as late as  $>90$  days of age (Uresk et al. 1999). Unlike traditional hider-type behavior typical of neonates in habitats providing cover

(Lent 1974, Schwede et al. 1994, Fisher et al. 2002, Torriani et al. 2006), we rarely located neonates >25 days of age not following dams. One explanation for this behavior is that neonates in this region may transition to follower behavior earlier than in other regions. Many neonate ungulates exhibit follower behavior at an early age and the behavior evolved in species that occupy open habitats (Lent 1974, Schwede et al. 1994, Fisher et al. 2002, Torriani et al. 2006). With limited permanent cover available in this region, neonates may have adapted earlier use of follower behavior as an anti-predation mechanism.

We documented significant differences ( $P < 0.001$ ) in bed-site microhabitat characteristics relative to sex of neonate. Structure afforded greater visual concealment and cooler temperatures at bed sites (Huegel et al. 1986). However, we observed male neonates selecting for less vertical structure (ht and density of understory vegetation) and more open (bare ground, litter) bed sites. Sex-specific variation in weaning age and duration of mother-young bond has been documented for many ungulates (Schwede et al. 1994). Additionally, male black-tailed deer (*O. hemionus*) fawns exhibited greater curiosity, increased activity, and earlier independence from their dam than females, which subsequently resulted in greater mortality (Taber and Dasmann 1954). Moreover, male white-tailed neonates became independent (greater activity) from their dams earlier than females (Schwede et al. 1991, 1994) and exhibited greater mobility and activity. Neonates using bed sites characterized by low vertical height of understory vegetation and greater percentage of bare ground were potentially at greater risk from predators, possibly influencing male-biased defensive behavior by the dam documented during capture (Grovenburg et al. 2009).

Several factors have contributed to the decline in enrolled hectares of CRP (United States Department of Agriculture 2007, Fargione et al. 2009). First, the Food, Conservation, and Energy Act of 2008 reduced the total hectares that may be enrolled in the CRP to 12.9 million ha by 2010, ensuring that the trend of expiring CRP area and decreased enrollment will continue. This legislation mandates a reduced total of allowable hectares with no established minimum enrolled hectares, and the United States Department of Agriculture projects that CRP-enrolled land will stabilize at 12.2 million ha in 2013 (Fargione et al. 2009, United States Department of Agriculture 2009b). Second, increased demand for biofuel production has potentially large land-use implications; greater demand for biofuels has caused and may continue to cause idle croplands to be put back into crop production (Secchi and Babcock 2007, Searchinger et al. 2008, Fargione et al. 2009). Current United States law mandates production of 136 billion L of biofuel by 2022, a 740% increase over 2006 production levels (Fargione et al. 2009). Demand for agricultural land to grow corn for biofuels increased by 4.9 million ha between 2005 and 2008 in the United States, with potentially wide-ranging effects on wildlife due to loss of habitat (Fargione et al. 2009). Continued losses of CRP in the Northern Great Plains will reduce the already limited cover available to deer,

contribute to even greater fragmentation of habitats, and potentially lead to behavioral changes and reduced survival.

## MANAGEMENT IMPLICATIONS

Management of habitat throughout the grasslands of the Northern Great Plains that maximizes vertical height of understory vegetation would provide neonates with adequate cover for protection from predators. However, continued CRP losses in the Northern Great Plains will likely lead to increased changes in bed site selection and potentially greater neonate mortality. We suggest that further research on neonate habitat selection be conducted during summer months to document potential relationships between habitats and survival of neonates occupying the Northern Great Plains.

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