AN EVALUATION OF LIFE HISTORY PARAMETERS OF WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) IN NORTH DAKOTA

BY

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AN EVALUATION OF LIFE HISTORY PARAMETERS OF WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) IN NORTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusion of the major department.

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ABSTRACT

AN EVALUATION OF LIFE HISTORY PARAMETERS OF WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) IN NORTH DAKOTA

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Life history characteristics of white-tailed deer (*Odocoileus virginianus*) have been documented in the Northern Great Plains, but limited information is available in regions dominated by grasslands. The objectives of our study were to document movements, cause-specific mortality, survival rates, and habitat selection of white-tailed deer. We captured and radiocollared 75 (62 adult female, 13 neonates) deer in the Wing-Tuttle region of North Dakota; 58 adult deer were residents, 21 were migrators, and 7 exhibited late season movements. We calculated 86 individual seasonal home ranges; mean 50 and 95% home ranges of resident animals (n = 58) were 1.38 and 6.82 km^2 and were similar to those of migrating individuals (n = 21, 1.04 and 4.94 km^2) and those of deer that exhibited late season movements (n = 7, 1.14 km^2 and 5.82 km^2). Natural causes (e.g., starvation, predation) were the greatest factors resulting in mortality of deer. Adult annual survival rates during 2010 and 2011 were 0.91 (SE = 0.04, n = 48) and 0.71 (SE = 0.06, n = 55), respectively. Adult seasonal survival rates were highest during post-hunt 2010 (1.0) and pre-hunt 2010 (1.0) but lowest during hunt 2010 (0.84) and post-hunt 2011 (0.81) periods. The majority of radiocollared adult female deer (2010; 78%, n = 47, 2011; 73%, n = 43) during the firearm season were located on posted private land and available for harvest by firearm hunters (80% in 2010, 84% in 2011). During summer

2011, we documented 13 (46%) neonate bed sites in grasslands, 7 (25%) in Conservation Reserve Program grasslands, 7 (25%) in forested cover, and 1 (4%) in alfalfa. We used our observations to test a previously published grassland bed site model for the Northern Great Plains that stated the probability of neonate bed site selection increased with increase of vertical height of vegetation; model validation resulted in an accuracy of 68.3%. Management for vertical height of grasslands would improve the quality of habitat for neonates during first 60 days of life. With limited movement outside management unit boundaries and natural causes dominating cause-specific mortality, regulating hunter harvest remains the primary tool for maintaining population goals.

CHAPTER 1: GENERAL INTRODUCTION

Regional understanding of white-tailed deer (*Odocoileus virginianus*) life history parameters is important for proper management. With white-tailed deer being the most sought after big game animal in North America, management should not be based off personal opinions and theories (McCullough 1987). In 2011, hunters in North Dakota spent an estimated $73,086,189 pursuing white-tailed deer throughout the state (National Shooting Sports Foundation 2012). Similar to other state wildlife agencies, the North Dakota Game and Fish Department strives to maintain white-tailed deer populations to provide the most opportunity for sportsmen while staying within landowner tolerances. For these reasons, it is crucial to conduct regionally-specific research to obtain estimates of life history parameters of deer in North Dakota. Once information of this nature is obtained, wildlife managers can begin to understand white-tailed deer population trends and improve deer management in North Dakota.

Throughout their existence, white-tailed deer have proven to be highly adaptable survivors. By the end of the 19th century, deer were nearly eradicated from the landscape due to unregulated harvest, advancing settlement, and farm practices (Cook 1945, Kernohan et al. 2002). At the start of the 20th century, deer numbers were at an all-time low with an estimated 500,000 animals. However, by the mid-20th century the change in land use practices, regulated harvest, and the birth of conservation programs allowed for the recovery of white-tailed deer (Cook 1945, Kernohan et al. 2002). Current estimates suggest roughly 27 million white-tailed deer inhabit North America (Knapp 2001) and this species thrives throughout the Northern Great Plains (Naugle et al. 1996, Burris 2005, Grovenburg et al. 2009).

Prior to the arrival of European settlers, North Dakota was comprised of mostly native grasslands and white-tailed deer were restricted to riparian areas along river systems (Knue 1991). The Homestead Acts, transcontinental railways, and the cessation of Indian hostilities in the 1860s and 1870s caused an influx of settlers to the Northern Great Plains (Petersen 1984). White-tailed deer flourished in the highly fragmented agricultural landscape; however, subsistence hunting resulted in deer being exploited to support the growing number of settlers. With the initiation of wildlife laws and regulated hunting in the early1900s, white-tailed deer have returned in great force to the Northern Great Plains. Currently, white-tailed deer are a valuable natural, recreational, and economic resource for the people of North Dakota (Petersen 1984).

White-tailed deer are currently managed on a unit by unit basis through the use of lottery allocation of licenses. The North Dakota Game and Fish Department sets hunting unit goals based on a five step process that evaluated past performance of each unit and surrounding units. Population indices are then used to determine the number of licenses to be allocated for each hunting unit. These indices evaluate long-term trends and include; deer hunter success rates, winter aerial deer surveys, the number of deer sighted by hunters per hour of effort during the opening weekend of rifle season, and deer-vehicle collisions. This management approach emphasizes the importance of understanding unknown biotic and abiotic factors that may influence deer numbers. Primary objectives of this study were to: 1) document survival rates and cause-specific mortality factors and document seasonal movement patterns and home range size. Secondary objectives were to: 1) conduct fawn bed site analysis and evaluate winter aerial deer surveys.

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CHAPTER 2: MOVEMENT, HOME RANGES, AND DISTRIBUTION DURING FIREARMS SEASON OF WHITE-TAILED DEER IN CENTRAL NORTH DAKOTA

ABSTRACT Limited information is available on white-tailed deer (*Odocoileus virginianus*) movements where grasslands dominate the landscape such as in central North Dakota. The purpose of this study was to document seasonal movements, daily movements, 50 and 95% home ranges, and distribution of white-tailed deer during firearm season. From February 2010 – January 2011, 62 adult (>1.5 years) female white-tailed deer were captured and monitored for survival and movements using radio telemetry. A total of 5,603 locations was collected. We performed k-means cluster analyses to estimate date of separation of summer and winter home ranges because of the lack of decisive separation between seasonal home ranges, which was in contrast to previous research on deer conducted throughout the region. We calculated 86 individual seasonal home ranges, of which 58 deer were residents, 21 deer were migrators, and 7 deer exhibited late season movements. Overall, mean 50 and 95% home ranges of resident animals (n = 58) were 1.38 and 6.82 km^2, respectively, and were similar (P = 0.49, 0.32) to those of migrating individuals (n = 21, 1.04 and 4.94 km^2) and those of deer that exhibited late season movements (n = 7, 1.14 km^2 and 5.82 km^2). Mean migration distance was 11.76 km (SE = 0.86, n = 21). Late season movements of deer averaged 20.69 km (SE = 2.94, n = 7) and were likely the result of deer exhausting food resources and traveling to predetermined alternative feeding areas. As a result, during severe winters, winter deer surveys may be affected by deer making late season

movements outside management unit boundaries. We located radiocollared deer via aerial telemetry twice during the 16.5 day firearms season. We determined land ownership and contacted private landowners to obtained information on hunter access to their property. During the 16.5 day November firearm season, the majority of radiocollared adult female deer (2010; 78%, *n* = 47, 2011; 73%, *n* = 43) were located on posted private land but were available for harvest by firearm hunters (80% in 2010, 84% in 2011). As a result, during 2010 and 2011 firearm gun seasons only 20% of radiocollared individuals were located on land that did not permit hunters access. Mortality due to firearm hunter harvest was low despite high access to radiocollared individuals during the 2010 and 2011 firearm seasons. Deer movement in the region seemed to be driven by habitat, weather conditions, and food availability.

INTRODUCTION

Numerous studies throughout the Northern Great Plains have documented movement patterns and home range size of white-tailed deer (Sparrowe and Springer 1970, Kernohan et al. 1994, Jensen 1999, Kernohan et al. 2002, Brinkman et al. 2005, Burris 2005, Swanson 2005, Smith et al.2007, Grovenburg et al. 2009, Robling 2011). Knowledge of movement strategies of deer on a regional basis can be valuable information for wildlife managers for generating population models and evaluating disease control measures. Movements of white-tailed deer in the Northern Great Plains typically have been classified as: short distance, dispersal, and seasonal migration (Kenohan et al. 1994, Brinkman et al. 2005, Grovenburg et al. 2009). Short-distance movements typically occur when mild winter conditions are experienced and food resources are sufficient (Marchinton and Hirth 1984, Grovenburg et al. 2009, Robling 2011).

Dispersal is described as a permanent, long-distance movement from a previously established home-range with development of a new home-range (Kernohan et al. 1994). Dispersal behavior in white-tailed deer has generally been associated with yearling males, and in the Northern Great Plains can be extensive (Kernohan et al. 1994, VerCauteren and Hygnstrom 1998, Jensen 1999, Brinkman 2003, Burris 2005, Smith 2007, Grovenburg et al. 2009). Previous research in North Dakota documented movements that ranged from 0.6 km to 42.2 km (Jensen 1999, Smith et al.2007). However, others have documented extensive dispersals that have exceeded 200 km (Sparrowe and Springer 1970, Kernohan et al. 1994).

Knowledge of emigration and immigration of individuals in a population can improve the understanding of population dynamics (Rosenberry et al. 1999). Individuals that exhibit long-distance dispersals have the potential to cross management unit boundaries, state lines, and can contribute to the spread of disease (Swanson 2005). Although dispersal has been studied in white-tailed deer to great length (Long et al. 2005, 2008), it is difficult to measure and it is generally assumed that immigration and emigration are equivalent in populations (Johnson 1994, Rosenberry et al. 1999).

Seasonal movement from winter to summer home ranges is the most commonly documented movement type of white-tailed deer at the northern limits of their range (Ozoga and Gysel 1972, Nelson 1998, Van Deelen et al. 1998, Swanson 2005, Grovenburg et al. 2009). In the Northern Great Plains, seasonal movements generally were greater than 10 km whereas mean migration distance was 19.0 km (Jensen 1999) and 11.2 km (Smith et al. 2007) in North Dakota, 10.1 km (Brinkman et al. 2005) and 14.6 km (Swanson 2005) in western Minnesota, and 10.1 km (Burris 2005), 19.4 km (Grovenburg et al. 2009), and 4.8 km (Robling 2011) in South Dakota. Long-distance movements present the possibility for movement into different management units, which could influence population models and survey accuracy (Brinkman et al. 2005, Burris 2005, Grovenburg et al. 2009).

White-tailed deer migrations throughout the Northern Great Plains are influenced by cold temperatures, snow depth, photoperiod, and changes to vegetation cover due to snow depth (Nelson 1998, Brinkman et al. 2005, Swanson 2005, Burris 2005, Grovenburg et al. 2009, Robling 2011). Previous research in the Northern Great Plains documented that movements to wintering areas typically occur in November and December with variability due to weather conditions; movement back to summer range was typically the result of rising temperatures, decreasing snow depths, and sprouting spring forage (Sparrowe and Springer 1970, Brinkman 2003, Burris 2005, Swanson 2005, Grovenburg 2007, Robling 2011).

Although white-tailed deer movement patterns and seasonal home ranges have been studied extensively in South Dakota (Sparrowe and Springer 1970, Kernohan et al. 1994, Burris 2005, Grovenburg et al. 2009, Robling 2011) limited information exists in North Dakota where latitudinal variation in climate may influence seasonal movements and home range size. Furthermore, previous research that assessed deer movement and seasonal home ranges in North Dakota (Jensen 1999, Smith et al. 2007) focused on Wildlife Management Areas (WMA's) where food plots were left standing throughout winter.

The primary objectives of this research project were to document seasonal movement patterns and home ranges of white-tailed deer on the Missouri Coteau of central North Dakota where grasslands dominated the landscape (57.7% land cover; United States Department of Agriculture 2011). Secondary objectives were to document distribution and hunter access to radiocollared deer during the 16.5 day firearms season, and an evaluation of winter aerial deer surveys.

STUDY AREA

During 2010 and 2011, we monitored movements and estimated home ranges of adult female white-tailed deer in Burleigh, Kidder, and Sheridan counties (Figure 2-1) in central North Dakota, which comprised an area of 10,558 km^{2}. The study area was located within the Northwestern Glaciated Plains Level III Ecoregion (Bryce et al. 1998). The region is characterized by significant surface irregularity and high concentrations of wetlands (United States Department of Agriculture 2011). Long-term (30 year) summer temperatures ranged from 13.1° C to 27.5° C and mean annual precipitation (30 year average) was 44.9 cm (North Dakota State Climate Office 2012). Nearly all land throughout this region was used for agriculture. Grasslands and croplands were dominant habitats and comprised 57.66% and 26.73%, respectively, of the landscape. Additionally, wetlands and water comprised 11.26%, developed land 4.14%, and other land uses <1% (United States Department of Agriculture 2011). Furthermore, Burleigh, Kidder, and Sheridan counties had 17,599 ha in Wildlife Management Areas, 13,293 ha in National Wildlife Refuges, and 12,821 ha in Waterfowl Production Areas (C. Penner, NDGF, personal communication).

Native vegetation that occurred throughout the study area included western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), needle and thread (*Stipa comata*), green needlegrass (*Stipa viridula*), prairie cordgrass (*Spartina pectinata*), northern reedgrass (*Calamagrostis stricta),* plains muhly (*Muhlenbergia cuspidata),* prairie muhly (*Muhlenbergia cuspidata*), prairie junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*), and saltgrass (*Distichlis spicata*). Cultivated crops in the region included wheat, sunflowers, corn, soybeans, canola, flaxseed, barley, peas, oats, dry beans, potatoes, sorghum, triticale, millet, rye, lentils, mustard, and safflower (United States Department of Agriculture 2011).

Statewide hunting seasons for white-tailed deer were open from 03 September – 02 January 2010-2011 and 02 September – 08 January 2011-2012. Hunting seasons included archery, youth firearm, firearm, and muzzleloader. Youth firearm seasons occurred 17 – 26 September 2010 and 16 – 25 September 2011. Firearm seasons occurred 05 – 21 November 2010 and 04 – 20 November 2011. Muzzleloader seasons occurred from 26 November – 12 December 2010 and 25 November – 11 December 2012. Archery hunting was open throughout the entire length of hunting seasons (North Dakota Game and Fish Department 2010, 2011). Predators of adult white-tailed deer in the region were limited to coyotes (*Canis latrans*; Seabloom et al. 2011).

METHODS

Capture and Handling

Deer captured during helicopter net gunning efforts were hobbled, blind folded, aged, and radiocollared by a crew member of a helicopter capture company (Quicksilver Air Inc., Peyton, CO, USA). In winter 2011, we used modified Clover traps (Clover 1954) to capture white-tailed deer from 12 January-9 February. We baited Clover traps with corn silage, shelled corn, and molasses. Traps were checked at first light and captured individuals were physically restrained, blind folded, and radiocollared or ear-tagged depending on age and sex. Adult females (>1.5 year) were radiocollared (Sirtrack, North Liberty, IA, USA); adult males (>1.5 year), and female and male fawns (<1.5 year) were ear-tagged (Y-Tex, Cody, WY, USA). Our animal handling methods were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval no. 10-006E) and followed guidelines for care and use of mammals established by the American Society of Mammalogists (Sikes et al. 2011).

Monitoring Radiocollared Deer

We monitored radiocollared deer 2-3 times per week from 16 February 2010 - 30 December 2011 through a combination of methods that included aerial telemetry from a fixed-winged aircraft (North Dakota Game and Fish Department, American Champion Scout, Rochester, WI, USA) and ground telemetry. Mortalities within 26 days post-capture were censored from analyses regardless of ultimate cause of death (Beringer et al. 1996).

We used omnidirectional antennas and hand-held 4-element Yagi antennas (Advanced Telemetry Systems, Isanti, MN, USA) to visually locate individuals and perform ground triangulation. Universal Transverse Mercator coordinates were estimated using a geographical positioning system (GPS) unit (Garmin, Olathe, KS, USA) in the aircraft during aerial telemetry flights. Due to lack of roads and significant topography within the study area, we obtained locations by walking in on and visually observing research animals. When topography allowed, we performed ground triangulation using a hand-held 4-element Yagi antenna. We obtained a minimum of three directional bearings using a compass from prerecorded stations. We entered bearings and stations into LOCATE III (Nams 2006) to estimate locations and error polygons. Estimated locations that exhibited 95% error ellipses ≥20 ha were excluded from further analyses (Brinkman et al. 2005, Burris 2005, Grovenburg et al. 2010). Radiocollared individuals were not located on successive days or at the similar times of day during the same week to ensure we accurately characterized home ranges while minimizing autocorrelation. Home ranges and movements were compared relative to year using t-tests (SYSTAT Software, Inc., San Jose, CA, USA).

Distribution and Hunter Access

During both years of the study we located radiocollared deer via aerial telemetry twice during the 16.5 day firearms season. We avoided disturbing both deer and hunters to minimize our effects on movements of radiocollared animals. After locations were obtained, we determined land ownership that radiocollared deer inhabited. We then contacted private land owners and obtained information on hunter access to their property. We classified land type into three classes: private, public (Wildlife Management Areas, Waterfowl Production Areas) lands (open to hunting) and National Wildlife Refuge (closed to hunting).

Home Range Analysis

We imported location data into ArcGIS 9.3 (ESRI, Inc., Redlands, CA, USA) and used the fixed kernel method in the Home Range Extension (HRE; Rodgers and Carr 1988) to calculate 50% and 95% home ranges. We used least-squares cross-validation (LSCV) to estimate the smoothing parameter (Seaman et al. 1999). We classified movement types on an annual basis instead of over both years of the study like previous studies throughout the region (Brinkman et al. 2005). We classified deer as migratory if their summer and winter home ranges did not overlap (Burris 2005, Swanson 2005, Grovenburg et al. 2010, Robling 2011) and deer maintained seasonal residency until the following migratory period (Brinkman et al. 2005, Burris 2005, Grovenburg et al. 2009, Robling 2011). We classified deer as residents if they failed to move between separate seasonal home ranges. We classified deer as late-season migrators if they failed to migrate during a documented migratory period but made late winter movements of short duration.

Winter Aerial Deer Surveys

We used aerial surveys to assess sightability of radiocollared deer. We calculated sightability based on number of marked deer observed during flights.

Deer Winter Severity Indices

During winter 2010-2011 and 2011-2012 we calculated Winter Severity Indices (DWSI; Brinkman et al. 2005) for our study area in central North Dakota. Each day that the mean temperature was ≤ - 7° C received a point and the index received an additional point for each day snow depth was $\geq$35.0 cm during the months of November - May (National Climatic Data Center 2012; Unpublished NDGF data).

RESULTS

On 16 February 2010, we captured 50 adult female (>1.5 year old) white-tailed deer by helicopter net gun (Quicksilver Air Inc., Peyton, CO, USA) and radiocollared them at 14 locations in central North Dakota. From 19 January – 08 February 2011, we captured 32 deer using Clover traps (Clover 1954) and radiocollared 14 adult females (>1.5 year), and ear-tagged 4 adult males (> 1.0 year) and 14 fawns (< 1 year old; 6 male, 8 female). Two capture related mortalities occurred during helicopter net-gunning operations in 2010. Remains of both animals were transported to the North Dakota Game and Fish Laboratory in Bismarck, North Dakota for necropsy where both deaths were attributed to capture myopathy. No capture related mortalities occurred during Clover trapping in 2011.

We collected a total of 5,603 locations of radiocollared individuals throughout the duration of our study. We calculated 86 individual seasonal home ranges using a minimum of 20 locations from which we documented 58 resident deer, 21 migrating deer and 7 deer that exhibited late season movements.

Seasonal Movements

Radiocollared deer with single clusters of locations were classified as residents while animals with two clusters were classified as migratory (i.e., two separate seasonal home ranges). Movements of deer that made non-traditional sallies (e.g., occasional sallies, Burt 1943) out of their home ranges late in the winter were classified as late season movements.

During 2010, 36 (84%) deer were classified as residents (i.e., had overlapping seasonal home ranges). Additionally, 7 (16%) deer migrated (i.e., deer did not have overlapping seasonal home ranges); mean migration distance was 11.6 km (SE = 1.81). No radiocollared deer made late season movements during 2010. During 2011, 22 (51%) deer were classified as residents. Additionally, 14 (33%) deer migrated; mean migration distance was 11.9 km (SE = 0.96). During winter 2011, 7 (16%) radiocollared animals made late season movements with mean distance traveled of 20.7 km (SE = 2.94).

Throughout the duration of this study (2010-2012) overall mean migration distance of deer was 11.8 km (SE = 0.86, n = 21). Deer that exhibited migratory behavior did not travel significantly farther (P = 0.09) in 2010 than in 2011.

Home Ranges

We generated 58 resident home ranges, 21 summer home ranges of migrators, and 7 home ranges of individuals who exhibited late winter movements. Due to inaccessibility during winter months an insufficient number of locations was collected to generate winter home ranges of radiocollared individuals who exhibited traditional seasonal migrations and late season movements. In 2010, mean 50 and 95% home ranges of resident animals were 1.0 km^2 (SE = 0.13, n = 36) and 5.2 km^2 (SE = 0.62, n = 36), respectively. Mean 50 and 95% summer home ranges of migrating individuals in 2010 were 1.1 km^2 (SE = 0.3, n = 7) and 4.8 km^2 (SE = 1.09, n = 7), respectively. In 2011, mean 50 and 95% home ranges of resident animals were 2.0 km^2 (SE = 0.38, n = 22) and 9.5 km^2 (SE = 1.57, n =

22), respectively. In 2011, mean 50 and 95% home ranges of migrating individuals were 1.0 km^2 (SE = 0.17, *n* = 14) and 5.00 km^2 (SE = 0.8, *n* = 14), respectively. During 2011, mean 50 and 95% home ranges of individuals that exhibited late season movements were 1.1 km^2 (SE = 0.12, *n* = 7) and 5.8 km^2 (SE = 0.56, *n* = 7), respectively. For the three observed movement strategies (resident, migratory, late season movement), 50 and 95% home ranges were similar (*P* = 0.490, *P* = 0.317) in size. Overall, mean 50 and 95% home ranges of resident animals were 1.4 (SE = 0.17, *n* = 58) and 6.8 km^2 (SE = 0.75, *n* = 58), respectively. Mean 50 and 95% home ranges of migrating individuals were 1.0 (SE = 0.14, *n* = 21) and 4.9 km^2 (SE = 0.62, *n* = 21), respectively.

Distribution and Hunter Access

During the 2010 firearms season, 78% of radiocollared deer were located on private posted land, 11% on National Wildlife Refuges, 7% on public land, and 4% on private land that was not posted. During the 2011 firearms season, 73% of radiocollared deer were located on private posted land, 3% on National Wildlife Refuges, 12% on Public land, and 12% on private land that was not posted. During the 2010 firearms season, 80% of radiocollared deer were accessible to hunters, while the remaining 20% of locations were on private land or National Wildlife Refuges that restricted hunter access. During the 2011 firearms season, 84% of radiocollared deer were accessible to hunters, while the remaining 16% of the radiocollared deer were on private land or National Wildlife Refuges that restricted hunter access.

Winter Aerial Deer Surveys

During both winters of this study, deer were closely associated with either farmsteads or unharvested crops. Groups of deer near unharvested crops were easily observed and counted; however, individuals associated with farmsteads were unable for use in evaluating aerial sightability. However, when aerial observations were compared to intensive ground surveys, up to 87% of the deer on the study area were counted by aerial observers.

Deer Winter Severity Indices

Average DWSI for the winter of 2009-2010 and 2010-2011 (Figure 2-3) was 166.0 and 215, respectively, for the Wing-Tuttle Study Area.

DISCUSSION

Seasonal Movements

White-tailed deer in central North Dakota exhibited a mixture of movement strategies consisting of residents, migrators, and late season movements; our results indicated that populations in this region were composed largely of residents. Interestingly, the percentage of resident deer (67%) documented during our study was substantially higher than previously reported in the Northern Great Plains (25-46%; Brinkman et al. 2005, 22.5%; Burris 2005, 38%; Grovenburg et al. 2009, 50%; Robling 2011). However, this difference may have been due to our methods of classifying deer movement strategies.

Long et al. (2005) and Grovenburg et al. (2011) observed that deer were likely to travel greater distances during migration periods in landscapes with limited tree cover to occupy forested cover that provides thermal cover, escape shelter, and food resources. We speculate that white-tailed deer in the grassland dominated landscapes of central North Dakota are substituting unharvested crops for forest cover during severe winter weather. Consequently, microsite characteristics that minimize heat loss (i.e., forested habitat; Moen 1976) are not critical to deer survival because deer can maintain core temperature via consumption of high-quality agricultural feedstuffs, such as waste or unharvested sunflower seeds and corn.

We attribute the decrease in resident animals in winter 2011, in part, to the increased number of animals making late season movements. In our study area, winter severity indices (DWSI's) during 2009-2010, and 2010-2011 were higher and thus, winter was more severe, compared to conditions when other studies on deer movements were conducted in the Northern Great Plains. We speculate that deer were forced to make late season movements during winter 2010-2011 in an attempt to find suitable forage. Of the 7 documented late season movements, all resulted in radiocollared individuals leaving a food source or habitat (e.g., unharvested sunflowers/corn) that either had no available food remaining or had become inaccessible because of drifting snow. These individuals made significant late winter movements to a high energy food source (unharvested corn, residential area). We speculate these were pre-planned and direct movements to previously used wintering areas.

Between 6 and 20 April 2010 we observed six radiocollared resident adult female white-tailed deer make non-traditional movements ranging from 12-24 km and returning to their previous summer ranges prior to parturition. Movements of this nature have been documented in other studies as "occasional sallies" (Burt 1943); however, little reasoning has been put forth as to the purpose of these movements. We speculate that these deer were "performing reconnaissance" to locate previously used or known wintering areas for future use. In winter 2009, North Dakota Game and Fish estimated that 28% of deer populations died due to severe weather conditions (Jensen 2009). Reconnaissance sallies might become more prevalent after severe winters such as those that occurred in North Dakota 2009-2011 because of the potential need to travel to and utilize new food resources.

Of deer that made the six post-winter movements (sallies) that we documented in spring 2010, 2 individuals made late season movements in winter 2011 to locations visited during the previous, post-winter movements, 1 individual used a different home range in summer 2011, 2 deer were residents (unharvested sunflower fields were located within home ranges during winter 2011), and 1 deer was killed in a vehicle collision in October 2010. Thus, the sallies documented during our study support, in part, their use as reconnaissance movements to support survival strategies during severe winters and may provide some insight that may help our understanding of deer survival strategies in the Northern Great Plains. For example, cognitive map theory suggests that the hippocampus of animals provides a representation of their environments, specific locations within those environments, and particular information on those locations; this information provides the basis for spatial memory and flexible navigation (Burgess et al. 2002). Considering the temporal change that occurs annually in the Northern Great Plains due to crop rotation patterns, deer occupying sites with subquality food and/or cover resources might make sallies focused around crop planting (i.e., spring) to update spatial memory for potential use in winter.

Migration distance was similar to that reported in eastern South Dakota (10.1 km; Burris 2005), western Minnesota (10.1 km; Brinkman et al. 2005; 14.6 km; Swanson 2005), and North Dakota (11.2 km; Smith 2005). Additional studies in the region have documented mean migration distances greater than that documented in central North Dakota (19.4 km; Grovenburg et al. [2009] in north central South Dakota, 19.0 km; Jensen [1999] in North Dakota) while some resulted in shorter distances (4.76 km; Robling [2011]). We believe the variation exhibited by deer throughout the Northern Great Plains provides evidence that habitat complexity can affect survival strategy that is linked to landscape-level availability of food and cover resources.

In central North Dakota the driving force behind migration seemed to be high quality food sources (unharvested sunflowers, corn). The majority of deer avoided costly migrations if some combination of food and winter cover was present within their home ranges; however, when winter weather became too severe, or a food source was diminished, the number of migrations and late season movements increased. Another reason we suspect food to be the driving force in winter movements in central North Dakota was that of the radiocollared deer we monitored for two winters, 74% did not return to the same wintering area within their home ranges. This low degree of site fidelity in home range placement was likely related to agricultural crop rotations within the matrix of stable cover habitats (i.e., shelter belts and wetlands).

Previous studies reported dispersal rates for yearling and adult female white-tailed deer in the Northern Great Plains that ranged from 0 to 8.3% (Brinkman 2003, Burris 2005, Smith 2005; Grovenburg et al. 2009). Due to abundant quality habitat (wetlands, CRP grasslands) in eastern South Dakota, Robling (2011) did not document any dispersal of adult female white-tailed deer. We also may have observed low dispersal behavior in central North Dakota due to quality habitat (i.e., CRP and unharvested crops) and because we focused are captures on adult female deer, which are less likely to exhibit dispersal behavior. During parturition, adult female white-tailed deer have been documented as being aggressive towards other deer, including their previous offspring (Ozoga et al. 1982, Grovenburg et al. 2009). This behavior may result in offspring dispersing great distances to establish new home ranges (Schwede et al. 1993, Kernohan et al. 1994). Limited information exists on dispersal in white-tailed deer and more research is needed to better understand the patterns of this behavior (Bowman 2003).

Home Ranges

In the north, many factors influence white-tailed deer home range size, including temperature, snow depth, and population density (Ozoga and Gysel 1972, Nelson 1995, 1998, Sabine et al. 2002, Brinkman 2003, Burris 2005, Grovenburg et al. 2009, Robling 2011), hunting pressure (Sparrowe and Springer 1970, Root et al. 1998, Naugle et al. 1997), habitat characteristics (Sparrow and Springer 1970, Grovenburg 2007, Robling 2011), and crop harvest (VerCauteren and Hygnstrom 1998, Brinkman et al. 2005). Furthermore, factors that can significantly influence variation in home range characteristics include age, sex, habitat, season (Demarais et al. 2000), and anthropogenic activities (Robling 2011).

During our study, we documented higher numbers of resident deer compared to other studies conducted in this region of the state. Smith (2005) classified 16 of 24 (67%) of his radio-collared adult females on Lonetree WMA (55 km north of Wing) as migratory; whereas, Jensen (unpublished data) documented that 16 of 18 (88%) adult females that wintered on Dawson WMA (60km southeast of Wing) were migratory. Lonetree WMA provided ample feed plots through the winter and Dawson WMA had a long history of feeding deer throughout the winter.

Previous studies documented 95% home range sizes of white-tailed deer (Brinkman [2003], 2.3-5.2 km^{2}', southwestern Minnesota; Swanson [2005], 2.6-3.3 km^2, southwestern Minnesota; Burris [2005], 1.0-4.6 km^2, western Minnesota and eastern South Dakota; Robling [2011], 1.4-1.6 km^2, east-central South Dakota) varied slightly compared to our study. Grovenburg et al. (2009) reported mean 95% summer home ranges ranging from 3.6-15.6 km^2. Although many factors can contribute to the documented variation in Minnesota, South Dakota, and North Dakota, we believe that landscape level habitat characteristics are the most influential factors in spatial variation of home ranges.

The increased demand for biofuel production has caused increased grassland to cropland conversion (Secchi and Babcock 2007, Searchinger et al. 2008, Farigione et al. 2009). This increased demand for corn production in the United States resulted in 4.9 million ha that has been converted from grasslands to cropland between 2005 and 2008. Wide spread habitat change on this scale has the potential to directly affect wildlife populations (Fargione et al. 2009). We speculate that the rapidly changing landscape (grassland conversion and wetland drainage) within the Northern Great Plains will affect home range size and movement strategies of white-tailed deer occupying the region; requiring white-tailed deer to engage in the potentially more costly strategy of seasonal migration.

Distribution and Hunter Access

Although the majority of radiocollared adult female deer during the 16.5 day November firearm season were located on posted private land, 80% in 2010 and 84% in 2011 were available for harvest by firearm hunters. As a result, during 2010 and 2011 firearm gun seasons only 20% of radiocollared individuals were located on land that did not permit hunter access (National Wildlife Refuges, posted private land). Mortality due to firearm hunter harvest was low despite high access to radiocollared individuals during the 2010 and 2011 firearm seasons. Firearm hunters accounted for 24% (n = 5) of all mortality during the study.

Winter Aerial Deer Surveys

Winter deer surveys flown may be affected by late season movements of deer out of the study area, which may result in long-term population trends being impacted. Information collected through this project indicated that deer behavior varies greatly within the Northern Great Plains and can be affected by many factors. Furthermore, snow conditions improved sightability of deer (i.e., near 100%) when not located near farmsteads. This may support the assumption that aerial surveys can provide a practical index of deer numbers.

MANAGEMENT IMPLICATIONS

The majority of white-tailed deer in central North Dakota were residents. High number of resident deer was likely attributed to high quality food sources located within summer home ranges. Winter migrations and late season movements increased with more severe winter conditions experienced during the winter of 2011. Winter deer surveys flown by the North Dakota Game and Fish Department may be affected by late season movements into or out of the monitoring block as was observed during this project; potential for late season movements should be considered when looking at annual population trends. With this study occurring during two severe winters, food seemed to be the driving force behind deer movements. Information collected through this study indicated that deer movement patterns vary greatly within the Northern Great Plains and can be affected by habitat availability, weather conditions, and food availability.

Loss of winter cover and food sources due to landscape changes (e.g., loss of CRP, wetland drainage, and conversion of grasslands to cropland), may require a larger percentage of white-tailed deer needing to engage in seasonal migration, which may be more costly relative to survival. Providing stable winter cover in association with food plots distributed across the landscape may allow deer to retain their resident home range status during most winters. Development of food plots in association with abandon farmsteads could serve this purpose.

Finally, initial evaluations of intensive ground observations verses aerial winter deer surveys suggest that that these winter aerial deer surveys are able to count up to 87% of what was observed from ground, and up to 100% of the deer not associated with farmsteads. Winter aerial deer surveys seemed to provide a valuable index of actual deer numbers present across the landscape.

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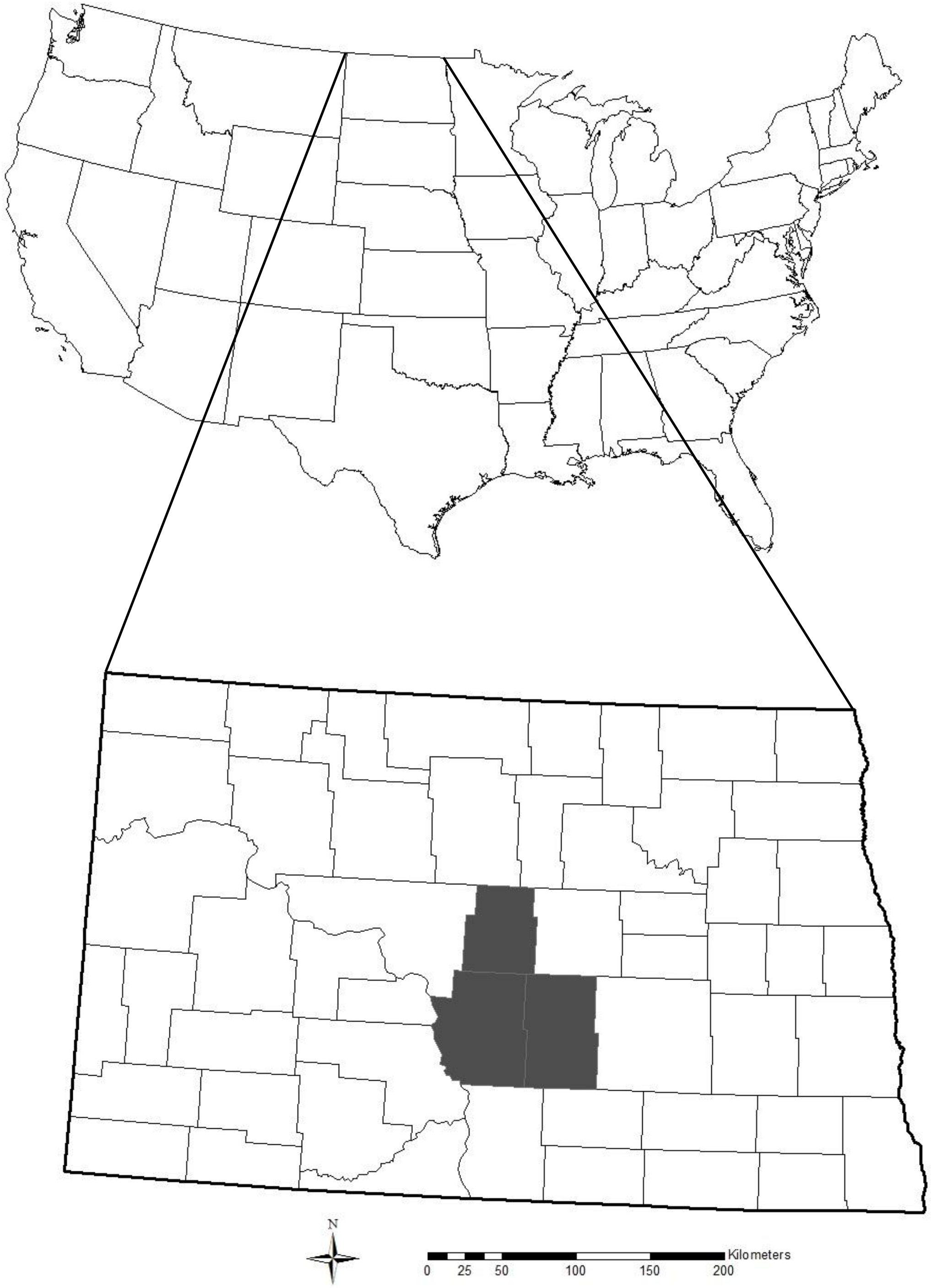

Figure 2-1. Study area where we captured adult female white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2010-2012. Shaded area is Burleigh, Kidder, and Sheridan counties.

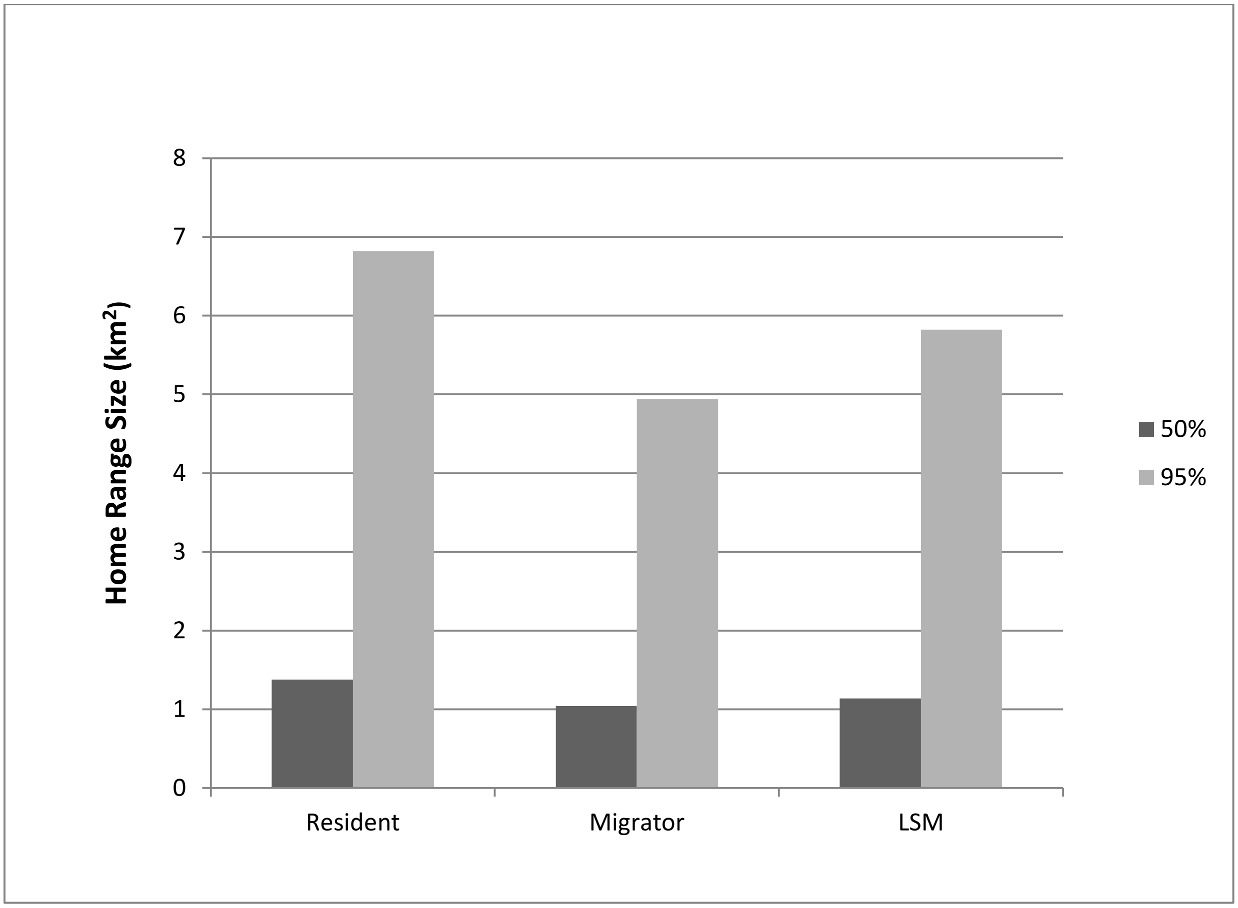

Figure 2-2. Mean 50 and 95% home range size (km^2) for radiocollared white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA 2010-2012. Home ranges calculated using LSCV method.

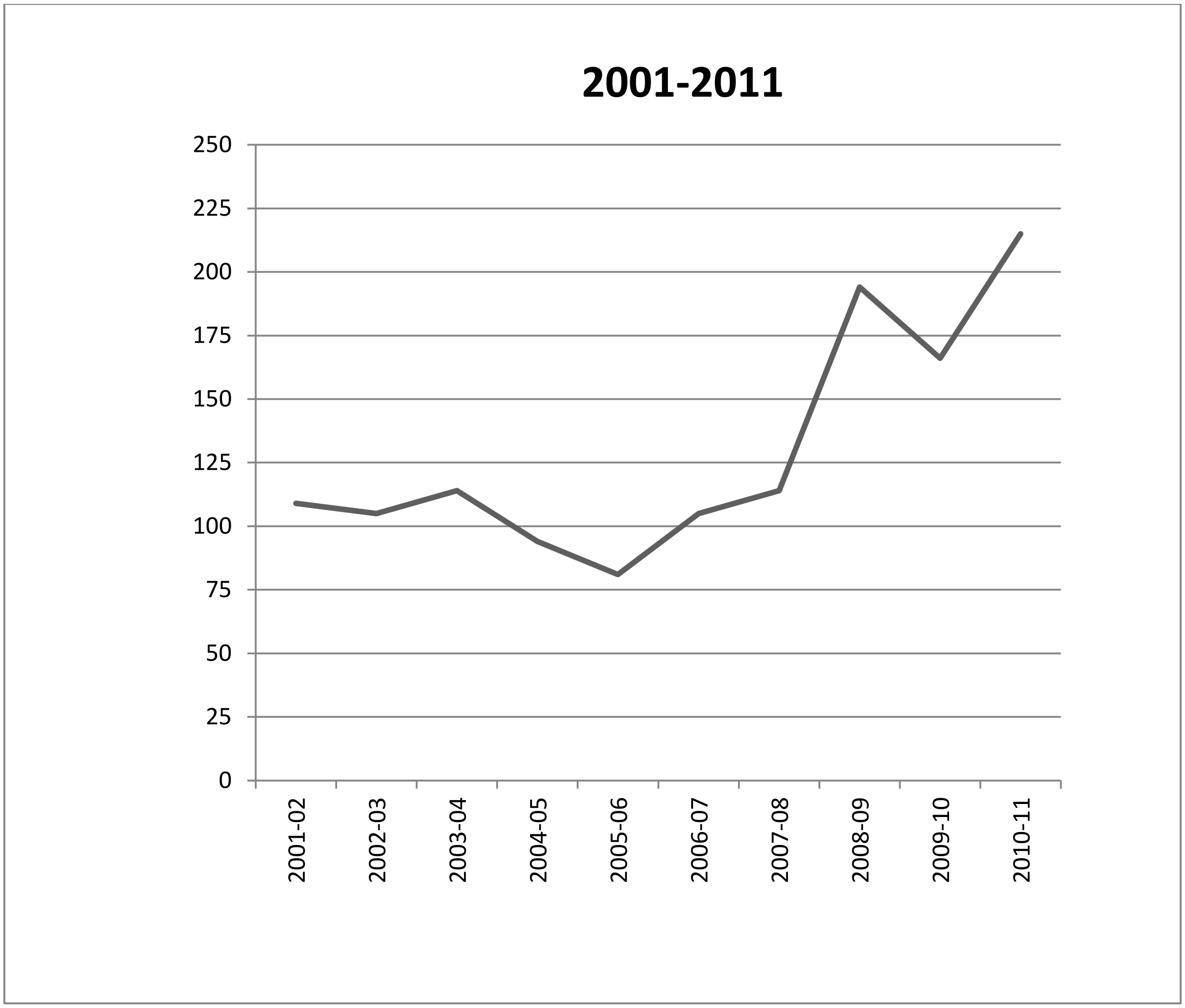

Figure 2-3. Deer winter severity indices (DWSI) for central, North Dakota, USA. We assigned one point for each day mean temperature was ≤ - 7° C and an additional point for each day snow depth was ≥35.0 cm; Unpublished Data, Jensen North Dakota Game and Fish Department.

CHAPTER 3: SURVIVAL OF WHITE-TAILED DEER IN CENTRAL NORTH DAKOTA

ABSTRACT Cause-specific mortality and survival rates of white-tailed deer (*Odocoileus virginianus*) have been well documented in regions of the Northern Great Plains, but limited information is available in areas dominated by grasslands (57% land cover). The objectives of this project were to document cause-specific mortality and survival rates of neonate and adult female white-tailed deer in central North Dakota. We captured and radiocollared 62 adult female (> 1.5 year) and 13 neonate (7 male, 5 female, 1 unknown) white-tailed deer and ear-tagged 4 adult males (>1.5 year) and 14 fawns (< 1.0 year) (6 male, 8 female). Natural causes (e.g., starvation, predation) were the greatest cause of mortality among adult deer, with 42.9 % (n = 21) of all mortalities being attributed to natural causes. Adult female annual survival rates during 2010 and 2011 were 0.91 (SE = 00.4, n = 48) and 0.71 (SE = 0.06, n = 55), respectively. Seasonal adult female survival rates were highest during post-hunt 2010 (1.0) and pre-hunt 2010 (1.0), while being lowest during hunt 2010 (0.84) and post-hunt 2011 (0.81). Unlike other studies in the Northern Great Plains, hunter harvest was not leading source of mortality at 28.6%. During summer 2011, 1 (25%) neonate mortality was confirmed as predation; however, we speculate that 100% could be attributed to predation due to the condition and location of radiocollars post mortality. Neonate summer survival in summer 2011 was 0.61 (SE = 0.15, n = 13) and was lower than was reported in other studies throughout the region. Although natural causes were the leading cause of mortality in adult and neonate white-tailed deer in central North Dakota, regulating hunter harvest remains the primary tool for maintaining population goals.

INTRODUCTION

Knowledge of cause-specific mortality and survival rates is essential for proper management of white-tailed deer (*Odocoileus virginianus*). Multiple radio-telemetry studies conducted throughout the Northern Great Plains suggest that environmental and anthropogenic factors can influence survival rates of white-tailed deer on a regional level (Robling 2011). Models used to predict population fluctuations require regionally-specific data (Grund 2001). If regional data are not available, population models lose their validity and overexploitation is possible (Hoskinson and Mech 1976, Nelson and Mech 1986, Brinkman et al. 2004).

Many studies have documented survival and cause-specific mortality of deer in the Northern Great Plains (Jensen 1999, Grassel 2000, Brinkman et al. 2004, Smith et al. 2007, Robling 2011, Grovenburg et al. 2011). Documented causes of mortality of deer in northern climates include hunting, vehicle collisions, illegal harvest (Fuller 1990, Dusek et al. 1992, Jensen 1999, Brinkman et al. 2004, Porter et al. 2004, Smith et al. 2007, Robling 2011, Grovenburg et al. 2011), severe winter weather conditions (DelGiudice et al. 2002), predation (Mech 1984, Van Deelen et al. 1997, Whitlaw et al. 1998, Smith et al. 2007), starvation (Lamoureux et al. 2001), and disease (Matschke et al. 1984). The majority of studies have shown hunter harvest as the primary cause of mortality, which emphasizes the importance for accurate harvest mortality rates for proper management (DelGiudice et al. 2002). Although, survival rates and cause-specific mortality have been well documented in the Northern Great Plains (Jensen 1999, Grassel 2000, Brinkman et al. 2004, Swanson 2005, Burris 2005, Smith et al. 2007, Grovenburg et al. 2011, Robling

2011), limited information exists in North Dakota, where latitudinal variation in climate and landscape level habitat variance may influence survival rates and causes of mortality.

Previous research that assessed cause-specific mortality and movements of white-tailed deer in North Dakota (Jensen 1999, Smith et al. 2007) focused on state owned and managed Wildlife Management Areas (WMA's) where food plots were left standing throughout the winter. Furthermore, most research conducted on white-tailed deer in North Dakota as well as the Northern Great Plains occurred during periods of moderate winter severity (Jensen 1999, Smith et al.2007, Grovenburg et al. 2011). The primary objective of this research project was to estimate survival rates (annual, seasonal) and investigate cause-specific mortality for white-tailed deer on private lands that characterized central North Dakota.

STUDY AREA

During 2010-2012, we studied survival rates and cause-specific mortality of adult female and neonate white-tailed deer in Burleigh, Kidder, and Sheridan counties (Figure 3-1) in central North Dakota, which comprised an area of 10,558 km^2. The study area was located within the Northwestern Glaciated Plains Level III Ecoregion (Bryce et al. 1998). The Northwestern Glaciated Plains ecoregion has significant surface irregularity and high concentrations of wetlands (United States Department of Agriculture 2011). Mean summer and winter (30 year) temperatures ranged from 13.1° C to 27.5° C and -2° C to -11.5° C, respectively. Long-term (30 year average) annual precipitation was 44.9 cm (North Dakota State Climate Office 2012). Nearly all land throughout this region was used for agriculture. Grasslands and croplands were dominant habitats and comprised

57.7% and 26.7 %, respectively, of the landscape. Additionally, wetlands and water comprised 11.7%, developed land 4.1%, and other land uses <1% (USDA National Agricultural Statistics Service Cropland Data Layer 2011). Burleigh, Kidder, and Sheridan counties had 17,599 ha in Wildlife Management Areas, 13,293 ha in National Wildlife Refuges, and 12,821 ha in Waterfowl Production Areas (C. Penner, NDGF, personal communication)

Native vegetation that occurred throughout the study area included western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), needle and thread (*Stipa comata*), green needlegrass (*Stipa viridula*), prairie cordgrass (*Spartina pectinata*), northern reedgrass (*Calamagrostis stricta)*, plains muhly (*Muhlenbergia cuspidata)*, prairie muhly (*Muhlenbergia cuspidata*), prairie junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*), and saltgrass (*Distichlis spicata*). Cultivated crops in the region included wheat, sunflowers, corn, soybeans, canola, flaxseed, barley, peas, oats, dry beans, potatoes, sorghum, triticale, millet, rye, lentils, mustard, and safflower (United States Department of Agriculture 2011).

Statewide hunting seasons for white-tailed deer were open from 3 September – 2 January 2010-2011 and 2 September –8 January 2011-2012. Hunting seasons included archery, youth firearm, firearm, and muzzleloader. Youth firearm seasons occurred from 17 September – 26 September and 16 September – 25 September in 2010 and 2011, respectively. Firearm seasons occurred from 5 November – 21 November 2010 and 4 November - 20 November 2011. Muzzleloader seasons occurred from 26 November – 12 December 2010 and 25 November – 11 December 2011. Archery hunting was open the entire length of the hunting seasons (North Dakota Game and Fish Department 2010, 2011).

Predators of adult white-tailed deer in the region were limited to coyotes (*Canis latrans*); however, neonates were susceptible to coyotes, badgers (*Taxidea taxus*), and red foxes (*Vulpes vulpes*) (Seabloom et al. 2011).

METHODS

We captured adult female (>1.5 year old) white-tailed deer by helicopter net gun (Quicksilver Air Inc., Peyton, CO, USA) and radiocollared them at 14 locations in central North Dakota. Deer captured during helicopter net gunning efforts were hobbled, blind folded, aged, and radiocollared by a crew member. In winter 2011, we used modified Clover traps (Clover 1954) to capture white-tailed deer. We baited Clover traps with corn silage, shelled corn, and molasses. Traps were checked at first light and captured individuals were physically restrained, blind folded, and radiocollared or ear-tagged depending on age and sex. Adult females (>1.5 year) were radiocollared (Sirtrack, North Liberty, IA, USA) and adult males, and male and female fawns (<1 year) were ear-tagged (Y-Tex, Cody, WY, USA). Post capture, we monitored radiocollared adult deer for mortality 2-3 time per week. Mortalities within 26 days post-capture were censored from analyses regardless of ultimate cause of death (Beringer et al. 1996).

Neonate white-tailed deer were captured by hand by intensively searching areas where we observed females exhibiting distinctive postpartum behavior. These behaviors included adult females exhibiting isolation and only fleeing a short distance after being approached (Grovenburg et al. 2010). Upon capture, we fitted captured neonates with

M4210 expandable breakaway radiocollars (Advanced Telemetry Systems, Isanti, MN, USA). We placed radiocollars in natural vegetation 6 weeks prior to the start of capture and wore latex gloves to minimize transfer of scent. We recorded sex and weight (gm) of captured neonates. Neonates were monitored daily for the first 30 days post capture and then monitored 2-3 times per week until 1 September.

When we encountered mortalities, if cause of death could not be determined in the field, we transported carcasses to the North Dakota Game and Fish Wildlife Laboratory in Bismarck, North Dakota for further investigation. We collected lower incisors from all study animals, post-mortem, and sent them to Matson's Lab (Milltown, MT, USA) for aging. Our animal handling methods were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval no. 10-006E) and followed guidelines for care and use of mammals established by the American Society of Mammalogists (Sikes et al. 2011).

We calculated annual and seasonal survival rates using the Kaplan-Meier method (Kaplan and Meier 1958) adapted for staggered entry (Pollack et al. 1989) in Program MARK version 6.0 (White and Burnham 1999, Cooch and White 2006). Seasonal survival rates were calculated for three time periods; Post-hunt (4 January 2010-16 May 2010), (3 January 2011-14 May 2011), Pre-hunt (17 May 2010-05 September 2010), (15 May 2011 - 3 September 2011), and Hunt (6 September 2010 - 2 January 2011), (4 September 2011 – 9 January 2012).

We calculated deer winter severity indices (DWSI; Brinkman et al. 2005) for the Wing-Tuttle Study Area during the winters of 2010-11 and 2011-12. We assigned one point for each day mean temperature was ≤ - 7° C and an additional point for each day snow depth was ≥35.0 cm (Brinkman et al. 2005) during the months of November through March using information collected by the National Climatic Data Center (2012) (Unpublished NDGF Data Jensen).

RESULTS

On 16 February 2010 we captured and radiocollared 50 deer via helicopter net gun. From 19 January – 8 February 2011, we captured 32 deer using modified Clover traps and radiocollared 14 adult females (>1.0 year), ear-tagged 4 adult males (> 1.0 year) and 14 fawns (< 1 year old) (6 male, 8 female). From 20 May – 30 June 2011, we captured and radiocollared 13 neonates via ground searches and nocturnal spotlighting. Twenty-one adult mortalities occurred during the study; 6 deer were hunter-harvested (5 firearms, 1 archery), 3 deer died from deer vehicle collisions, 3 deer died from coyote predation, 1 deer died from starvation, 6 deer died from unknown winter mortalities, and 1 deer died from unknown summer mortality (Table 3-2). Median age at death was 4.7 years (n = 10, range = 1-12 years). Four (22%) ear-tagged deer were recovered during the study. Three (75%) mortalities were due to starvation while 1 (25%) was attributed to hunter-harvest. Four neonate mortalities occurred, including 1 confirmed predation (coyote or badger) and 3 unknown mortalities, which were suspected predation due to location and condition of radiocollars.

Adult annual survival rates during 2010 and 2011 were 0.91 (SE = 0.04, n = 48; (Table 3-1) and 0.71 (SE = 0.06, n = 55; Table 3-1), respectively. Adult seasonal survival rates were highest during post-hunt 2010 (1.0) and pre-hunt 2010 (1.0) while they were lowest during hunt 2010 (0.84) and post-hunt 2011 (0.81; Table 3-3). Neonate survival for the summer of 2011 (capture - 1 September) was 0.61 (SE = 0.15, *n* = 13).

DISCUSSION

Annual survival rates for adult female white-tailed deer during 2010 and 2011 were similar to previous studies in the Northern Great Plains (77%, Smith et al. [2007], 76%, Grovenburg et al. [2011], 70 - 78%, Robling [2011]). Previous research indicates that in the Northern Great Plains the leading cause of mortality of adult female white-tailed deer is hunter harvest (61%, Smith et al. [2007], 69.9%, Grovenburg [2011], and 64.7%, Robling [2011]). Contrary to other studies, hunter harvest accounted for only 28.6% of all mortality, while natural causes (predation, malnutrition, and unknown causes) were the primary causes of mortality in central North Dakota and collectively represented 42.9% of total mortality (Table 3-2). Limited antlerless tag allocations, short firearm seasons, and quality escape cover (CRP, unharvested crops, wetlands) likely influenced hunter harvest mortality in the region.

Adult seasonal survival documented during this study was highest during the post-hunt 2010 and pre hunt 2010, 2011 periods. High survival rates during both pre-hunt periods of this study were similar to those reported by Brinkman et al. (2004; 0.8 – 1.0) in southwestern Minnesota, Grovenburg (2007; 0.72 – 0.99) in east central South Dakota, and Robling (2011; 0.94 – 0.96) in eastern South Dakota. High pre-hunt survival can be attributed to minimal human interactions, availability of quality forage, and suitable escape cover (Nixon et al. 1991, Brinkman et al. 2004, Robling 2011). In addition to high survival during the pre-hunt period, we documented high survival during the post-hunt period in 2010. In our study area, DWSI's were higher and thus, more severe, compared to previous winter conditions when other studies on deer survival were conducted in the Northern Great Plains. Burris (2005), Grovenburg et al. (2011), and Robling (2011) reported DWSI ranging from 36-168, which resulted in minimal winter mortalities due to natural causes (e.g., starvation, exposure, and predation).

We speculate survival was high during the post-hunt 2010 period because the winter of 2008-2009 was the first severe winter (DWSIs >100) since 2000-2001, which may have caused an increased number of winter mortalities (R. Johnson, NDGF, personal communication). If this occurred, we hypothesize that more fit individuals were left in the population that were able to survive the 2009-2010 winter despite a DWSI of 166, indicating continued severe winter conditions. However, the winter of 2010-2011, which had a DWSI of 215 was again severe, and cumulative winter effects likely led to a decrease in deer condition and subsequent increase in winter mortality.

Neonate survival documented in 2011 (0.61) was similar to that reported in southern Illinois (0.59: Rohm et al. 2007) but higher than reported in Minnesota (0.49: Kunkel and Mech 1994), Maine (0.40: Long et al. 1998), New Brunswick (0.47: Ballard et al. 1999), and Pennsylvania (0.46: Vreeland et al. 2004). Our neonate survival estimates were lower than reported in South Dakota and Minnesota (0.87: Grovenburg et al. 2012) and in southern Illinois (0.70: Nelson and Woolf 1987). Canid predation has been documented as a significant source of neonate mortality throughout the Midwest (Huegel et al. 1985, Benzon 1998). Previous research has documented that canids were the most common cause of neonate mortality in southern Illinois (0.69, Nelson and Woolf 1987; 0.64, Rohm et al. 2007), south-central Iowa (0.77, Huegel et al. 1985a), southwest

Minnesota (0.67, Brinkman et al. 2004), and South Dakota (0.80, Grovenburg et al. 2011). Although we were unable to confirm our four mortalities as canid predation, we suspect that 100% of our neonate mortalities were attributed to predation due to the condition and location of radiocollars post mortality.

Nelson and Woolf (1987) reported that neonate survival can be described by 3-stage age-intervals. In the first interval (<2 weeks), neonates rely on cryptic coloration and inactivity to avoid predation. During the second interval (2-8 weeks of age), neonates become more active, however, they lack the ability to use locomotion to evade predators. Once neonates reach the third interval (>8weeks) they are capable of evading predators through locomotion. Nelson and Woolf (1987) conducted their study in a highly forested landscape and reported neonate mortality was highest when neonates stopped relying on cryptic coloration and inactivity and became more active (second interval). During our study we documented all neonate mortality within the first 2 weeks (first interval) and highest survival during the second and third intervals. Our findings support Rohm et al. (2007) and Grovenburg et al. (2011) who hypothesized that neonates were most vulnerable during the first two weeks of life.

We documented 3 deer-vehicle collisions (14%) throughout this study, which was similar to that reported in North Dakota by Jensen (1999; 21%) and in Minnesota and South Dakota (15%) by Grovenburg et al. (2011). Although our findings were similar, both Smith et al. (2007) and Robling (2011) did not document deer vehicle collisions of radiocollared deer. In the winter of 2011, 11 radiocollared deer routinely crossed paved highways traveling from bedding areas to food sources (hay yards, silage piles, and standing crops) and prior to spring dispersal, (27%) were killed in vehicle collisions. We speculate that during severe winters the location of food sources and bedding areas in relation to highways has more of an effect on survival than road densities.

MANAGEMENT IMPLICATIONS

Unlike previous research in the Northern Great Plains, natural causes accounted for the greatest cause of mortality for both adult and neonate white-tailed deer during our study. High natural mortality was likely exacerbated by the severe winter conditions experienced throughout the duration of this study. As landscape level habitat changes continue in the Northern Great Plains (e.g., loss of CRP, grassland conversion, wetland drainage) survival rates could decrease because of vulnerability to hunter-harvest, reduced recruitment, and winter conditions. Although hunting was not the most significant cause of mortality of white-tailed deer in central North Dakota, it remains the primary management tool for the North Dakota Game and Fish Department. The combination of winter aerial deer surveys, hunter harvest surveys, hunter observation surveys, and monitoring winter severity remain the best option for setting management goals. An evaluation of these population indices may provide insight as how best to direct management resources.

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Table 3-1. Annual survival rates for radiocollared white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2010 and 2011.

	2010	2011
Number at-risk	48	55
Number of Deaths	6	15
Number Censored	1	0
Survival Rate	0.91	0.71
SE	0.04	0.06
CI Lower	0.778	0.578
CI Upper	0.965	0.813

Table 3-2. Seasonal, cause-specific mortality for radiocollared white-tailed deer (*Odocoileus virginianus*) in central North Dakota, 2010–2012.

Cause of Mortality	Pre-hunt[a]	Hunt[a]	Post-Hunt[a]	Totals
Harvest	0	6	0	6
Predation	0	1	2	3
Disease	0	0	0	0
Unknown	1	0	7	8
Starvation	0	0	1	1
Vehicle Collision	0	3	0	3

[a]Seasonal intervals = Post-hunt (4 January 2010-16 May 2010), (3 January 2011-14 May 2011), Pre-hunt (17 May 2010-05 September 2010), (15 May 2011 - 3 September 2011), and Hunt (6 September 2010 - 2 January 2011), (4 September 2011 – 09 January 2012).

Table 3-3. Seasonal survival rates for radiocollared adult female white-tailed (*Odocoileus virginianus*) deer in central North Dakota, USA, 2010-2012.

				95% Confidence Interval	
Year	Survival Interval	Number at-risk	Survival Rate	Upper	Lower
2010	Post-Hunt	48	1.00	1.00	1.00
	Pre-Hunt	48	1.00	1.00	1.00
	Hunt	47	0.84	0.70	0.92
	Annual	48	0.91	0.78	0.96
2011	Post-Hunt	53	0.80	0.68	0.89
	Pre-Hunt	44	0.97	0.83	1.00
	Hunt	43	0.93	0.80	0.98
	Annual	55	0.71	0.58	0.81

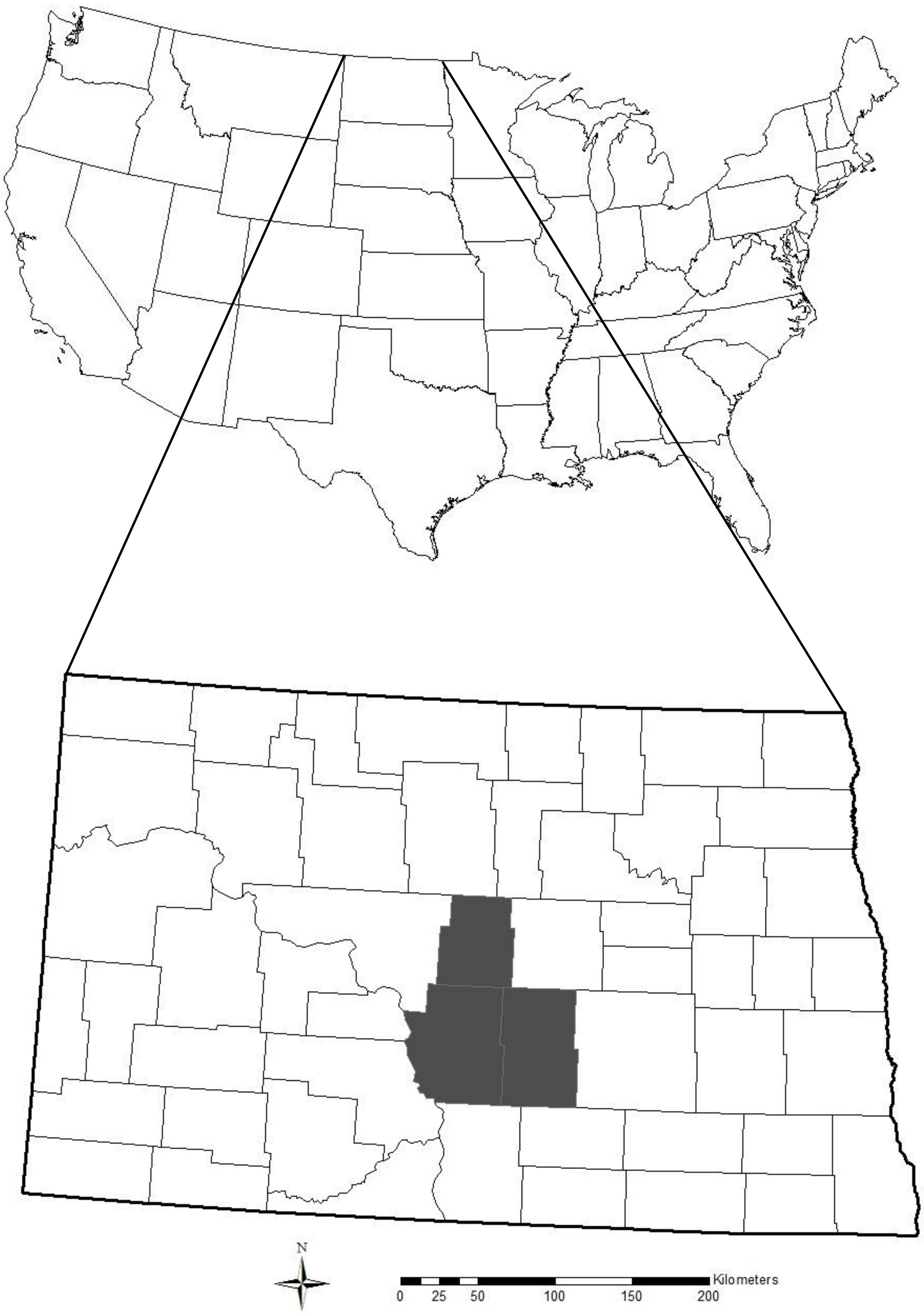

Figure 3-1. Study area where we captured adult female white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2010-2012. Shaded area is Burleigh, Kidder, and Sheridan counties.

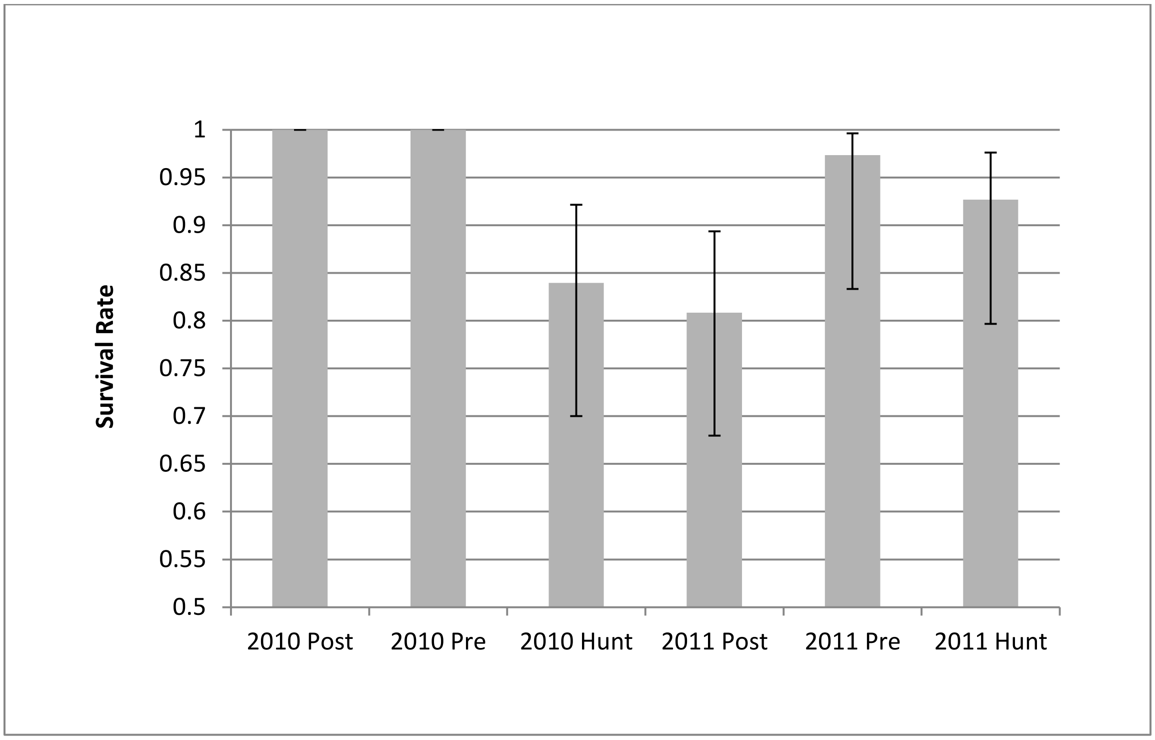

Figure 3-2. Seasonal survival rates for radiocollared adult female white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2010-2012.

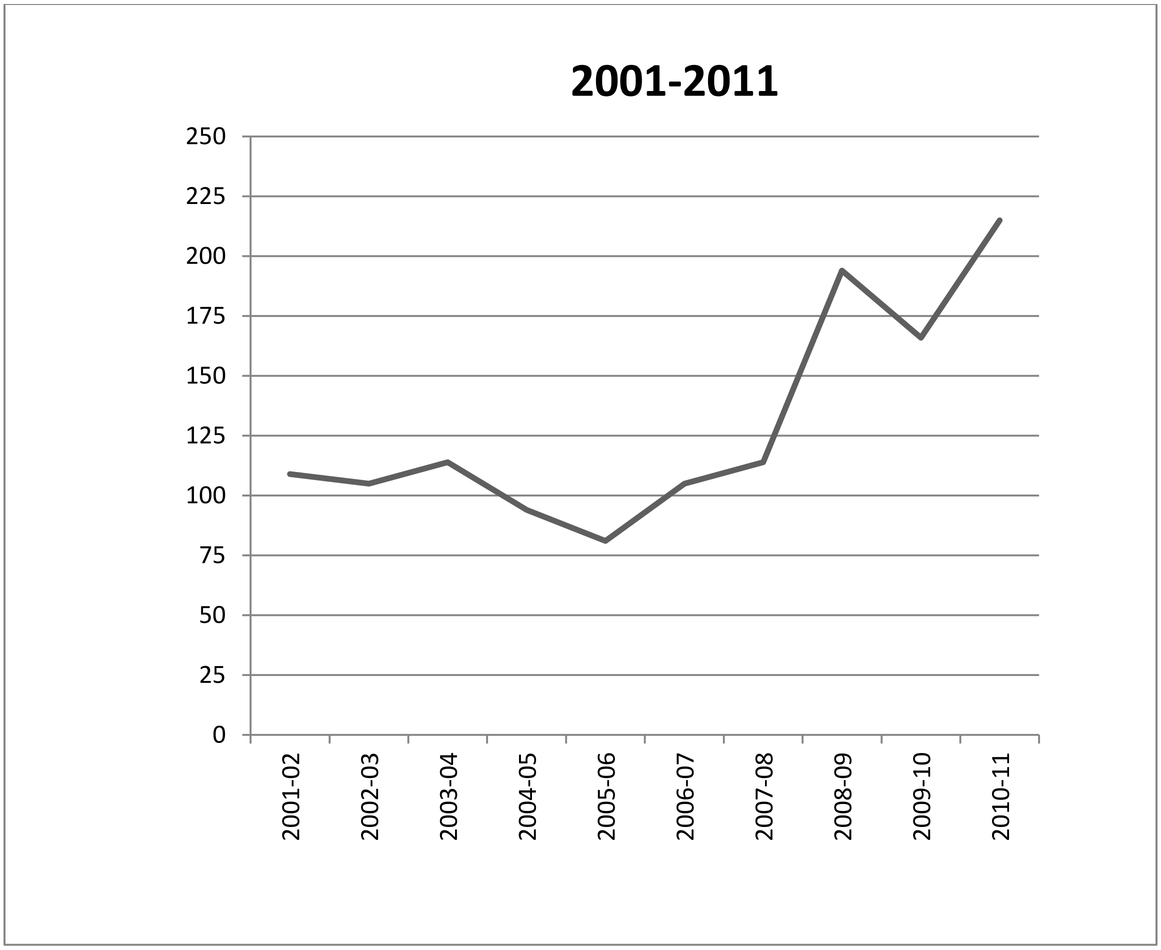

Figure 3-3. Deer winter severity indices (DWSI) for white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA. We assigned one point for each day mean temperature was ≤ - 7° C and an additional point for each day snow depth was ≥35.0 cm; (W.F. Jensen NDGF, Pers. Communication Unpublished Data)

CHAPTER 4: BED SITE SELECTION BY NEONATE WHITE-TAILED DEER IN CENTRAL NORTH DAKOTA

ABSTRACT White-tailed deer (*Odocoileus virginianus*) neonates are most vulnerable during the first 60 days post parturition. During this critical phase, neonates spend the majority of their time bedded except while being fed and groomed by dams. Vegetation characteristics at bed sites influence thermal conditions and provide protection from predators. Neonate bed site selection has been studied in South Dakota; however, no information is available for North Dakota where latitudinal variation in climate could affect bed site selection. During summer 2011, we investigated bed site selection of 13 radiocollared neonate white-tailed deer in central North Dakota, USA. We documented 13 (46%) bed sites in grasslands, 7 (25%) bed sites in enrolled Conservation Reserve Program grasslands, 7 (25%) bed sites in woodland, and 1 (4%) bed site in alfalfa. Micro-habitat factors evaluated to assess habitat selection included vertical height, density, canopy cover, tree basal area, and percent cover. Mean micro-habitat measurements at bed sites did not differ (P = 0.789) between bed sites and random sites. We used our observations to test a previously published grassland bed site model for the Northern Great Plains that indicated the probability of neonate bed site selection increased with increase of vertical height of vegetation; model validation resulted in an accuracy of 68.3%. In areas where grassland habitat is limited, management for vertical height of grasslands could improve the quality of habitat for neonates during the first 60 days of life.

INTRODUCTION

Understanding bed site selection and vegetation characteristics provides valuable information for population management (Verme 1977, Huegel et al. 1985*a*, Nelson and Woolf 1987). Predation and other natural-caused mortalities are most likely to occur within the first 60 days of life; a time period when selected habitat characteristics are vital to survival (Verme 1977, Huegel et al. 1985*a*, Nelson and Woolf 1987, Grovenburg et al. 2010). Prior to the study of Grovenburg et al. (2010), limited research had been completed on bed site selection of neonate white-tailed deer in the Northern Great Plains. In eastern South Dakota, vertical height of understory vegetation was the most important habitat characteristic at bed sites; selection likely pertained directly to protection from predation and thermal insulation (Grovenburg et al. 2010, Grovenburg et al.2012*a*). To our knowledge, no research has been conducted on fawn bed site selection in North Dakota. Our objective was to describe the physical and vegetative characteristics of bed sites selected by neonate white-tailed deer in the grassland dominated landscape of central North Dakota. We hypothesized that vegetation height was selected for at bed sites by neonate white-tailed deer.

STUDY AREA

We studied neonatal white-tailed deer in Burleigh County (Figure 4-1) in central North Dakota, which comprised an area of 2,652 km^2. The study area was located within the Northwestern Glaciated Plains level III ecoregion (Bryce et al. 1998). The region is characterized by significant surface irregularity and high concentrations of wetlands (United States Department of Agriculture 2011). Long-term (30 year) mean summer temperatures ranged from 13.1° C to 27.5° C and mean (30 year) annual precipitation was 44.9 cm (North Dakota State Climate Office 2012). Nearly all land within the region was used for agricultural purposes. Grasslands and croplands dominated the landscape at 66.2% and 21.0%, respectively. Additionally, wetlands and water comprised 7.4%, developed land 5.2%, and other land uses <1% of the landscape (United States Department of Agriculture 2011). Furthermore, Burleigh County had 4,884 ha in Wildlife Management Areas, 6,844 ha in National Wildlife Refuges, and 4,546 ha in Waterfowl Production Areas (North Dakota Game and Fish Department 2012).

Native vegetation occurring on the study area included western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), needle and thread (*Stipa comata*), green needlegrass (*S. viridula*), prairie cordgrass (*Spartina pectinata*), northern reedgrass (*Calamagrostis stricta),* plains muhly (*Muhlenbergia cuspidata),* prairie muhly (*M. cuspidata*), prairie junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*), and saltgrass (*Distichlis spicata*). Cultivated crops in the region included wheat, sunflowers, corn, soybeans, canola, flaxseed, barley, peas, oats, dry beans, potatoes, sorghum, triticale, millet, rye, lentils, mustard, and safflower (United States Department of Agriculture 2011).

METHODS

We captured neonates from 20 May to 30 June 2011, by intensively searching areas where we observed females exhibiting distinctive postpartum behavior. These behaviors included adult females exhibiting isolation and only fleeing short distances after being approached by personnel (Downing and McGinnes 1969, White et al. 1972, Huegel et al. 1985*b*, Grovenburg et al. 2010). Upon capture, we manually restrained neonates, determined sex, and recorded weight to the nearest gram using a 4.8-mm mesh bag suspended from a digital scale. We fitted captured neonates with M4210 expandable breakaway radiocollars (Advanced Telemetry Systems, Isanti, MN, USA). To help minimize stress and reduce capture-related mortality, we minimized handling time, processed fawns at capture sites, wore sterile rubber gloves, stored radiocollars and other equipment for 6 weeks before capture in natural vegetation commonly found in the area, kept noise to a minimum, and rubbed fawns with native vegetation before release (Grovenburg et al. 2012*b*).

We obtained subsequent bed site locations by relocating radiocollared neonates (Grovenburg et al. 2010). We used omnidirectional antennas and hand-held 4-element Yagi antennas (Advanced Telemetry Systems) to locate radiocollared neonates and appropriate bed sites. We took precautions not to disturb bedded neonates; however, if the neonate did leave the area, we collected vegetation measurements. If neonates were located without being disturbed, we marked bed sites a set distance and cardinal direction from the site and returned 1–4 days later to collect vegetation measurements. We located and recorded 1–5 bed site locations for each radiocollared individual. Our animal handling methods were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval no. 10-006E) and followed the recommendations of the American Society of Mammalogists (Sikes et al. 2011).

We collected vegetation data at paired sites: neonate bed sites and randomly selected sites. Random sites were located within the same cover type and less than 250 m from neonate bed sites. Each bed site was classified in one of the following cover types: grasslands, Conservation Reserve Program grasslands (CRP), forest, or alfalfa hay. We followed the methods of Grovenburg et al. (2010) for data collection. We used a modified Robel pole (Robel et al. 1970) with 10–cm increments to measure vertical height and density of understory vegetation at each paired site. Measurements were collected at the center of paired sites and at four locations 2 m from the bed site along transects radiating out from the bed site or random site in the 4 cardinal directions (Robel et al. 1970). We recorded ocular estimation of percent cover using 5% increments for forbs, grasses, shrubs, rock, bare ground, slash, litter, cultivated crops, water, alfalfa, trees, and wheat in 24, 1.0-m^2 Daubenmire plots (Daubenmire 1959) spaced at 1-m intervals along 2 perpendicular transects originating at the center of the bed site or random site. We estimated tree canopy cover at the center of the bed site and random site, and at 6 m north, south, east, and west of sites using a spherical densitometer (Geographic Resource Solutions, Arcata, CA, USA; Uresk et al. 1999). We estimated tree basal area (BA) at the center of bed and random sites using a 10-factor prism (Jim-Gem® Square Prisms, Forestry Suppliers, Inc., Jackson, MS, USA; Sharpe et al. 1976).

We used analysis of variance (ANOVA) to compare mean parameters of bed sites and random sites. We used a Likelihood ratio Chi-square to determine if habitat–specific selection occurred at the landscape level. We used data from locations to test the grassland bed site model developed for neonates in north-central South Dakota (Grovenburg et al. 2010) and we used the SCORE statement to calculate predicted values for presence (*p*_1) and absence (*p*_0) for each observation (SAS Institute 2008).

RESULTS

We captured and radiocollared 13 fawns (7 M, 5 F, 1 unknown) between 28 May and 23 June. At capture, mean weight was 3.84 kg (SE = 0.27, n = 11) and ranged from 2.49 kg to 5.17 kg. Mean weight based on sex (M:F) was 3.67 kg (SE = 0.49, n = 6) and 3.76 kg (SE = 0.31, n = 4), respectively. We collected data at 28 bed sites and 28 random sites used by radiocollared neonates from 28 May to 30 June 2011. We located and analyzed 13 (46.4%) bed sites in grasslands, 7 (25%) in CRP grasslands, 7 (25%) in forest cover, and 1 (3.6%) in alfalfa; habitat-specific selection did not differ (χ_5^2 = 4.46, P = 0.486). Percent cover estimates indicated that the most abundant cover at bed sites and random sites was grass at 69.5% and 66.7%, respectively (Table 4-1). Mean micro-habitat measurements at bed sites were 87.3 cm (SE = 4.93, n = 28) for vertical height, 43.1 cm (SE = 43.07, n = 28) for density, 9.9% (SE = 3.93, n = 28) for tree canopy cover, and 0.1 m^2/ha (SE = 0.08, n = 28) for tree basal area; micro-habitat characteristics did not differ between bed sites and random sites ($F_{16,39}$ = 0.69, P = 0.789). Predicted probability of presence (p_1) and absence (p_0) of North Dakota bed sites using the vertical height of grassland model of Grovenburg et al. (2010) was 0.683 (SE = 0.02) and 0.317 (SE = 0.02), respectively.

DISCUSSION

During summer of 2011, vertical height of vegetation was an important habitat characteristic to neonates in central North Dakota. Micro-habitat analysis of bed sites and random sites were significantly different from that reported by Huegel et al. (1986) in south central Iowa. They reported mean percent of tall grass at bed sites was less than at random sites and 77% of bed sites were in forested cover. Grovenburg et al. (2010) reported similar results to those of Uresk et al. (1999) for fawns in the Black Hills of South Dakota where neonates selected for bed sites that exhibited greater height of vegetation within forested cover. We documented that neonate selection for bed sites increased with greater vertical height of vegetation, which provided greater visual concealment and better thermal protection for neonates in the highly variable temperatures of the Northern Great Plains. Selection of vertical height of vegetation may in part, be attributed to the land cover throughout the study area. During the summer of 2011, 66% of the study area was comprised of grasslands while <1% was comprised of forested cover.

We used our bed site observations to validate the grassland bed site model for north-central South Dakota that indicated the probability of neonate bed site selection increased with increase of vertical height of vegetation while other variables evaluated did not contribute to habitat selection (Figure 4-2; Grovenburg et al. 2010). Although the fit of our data was acceptable, we speculate the difference between our observations and those of Grovenburg et al. (2010) was due to the quality of grasslands available to fawns in North Dakota. Grovenburg et al. (2010) documented fawns selecting for tallgrass-CRP whereas fawns in North Dakota did not select for specific grasslands types. This may be explained, in part, by higher quality (i.e., greater vertical height) in all of the North Dakota grasslands (CRP grasslands, native grasslands). Mean vertical height of bed site vegetation in North Dakota was 87.3 cm whereas Grovenburg et al. (2010) documented mean height of CRP-tallgrass of 76.6 cm. Furthermore, pasture habitat in north-central South Dakota had mean vertical height of 34.8 cm (Grovenburg et al. 2010). If fawns select for vegetation height to enhance thermal cover and concealment from predators as hypothesized (Huegel et al. 1986, Grovenburg et al. 2010, Grovenburg 2012*a*), the greater availability of suitable cover in North Dakota may explain the variation in model results.

In south-central Iowa (Huegel et al. 1986) and Texas (Hyde et al. 1987) density of understory vegetation was an important micro-habitat characteristic of neonate bed sites. Similar to Grovenburg et al. (2010) in north-central South Dakota, our radiocollared neonates did not select bed sites relative to density of understory vegetation. In warmer climates, such as experienced in south-central Iowa and Texas, neonates may select for bed sites with dense understory vegetation for thermal characteristics, which to protects them from overheating and maintains water balance (Ockenfels and Brooks 1994). In cooler climates, such as in north central South Dakota (Grovenburg et al. 2010) in the Black Hills of South Dakota (Uresk et al. 1986), we speculate that neonates exhibit the opposite behavior in an effort to maximize heat gain from solar radiation while providing high visual obstruction from predators.

Many factors have influenced the decrease of enrolled hectares in CRP across the United States (United States Department of Agriculture 2007, Fargione et al. 2009). By 2010, the Food, Conservation, and Energy Act of 2008 reduced CRP to 12.9 million ha. This legislation mandated a maximum number of hectares that can be enrolled, which will stabilize at 12.2 million in 2013 (Fargione et al. 2009, United States Department of Agriculture 2009). The Northern Great Plains is experiencing an increased demand for biofuel production, which has caused grassland habitat to be converted into crop production (Secchi and Babcock 2007, Searchinger et al. 2008, Fargione et al. 2009).

This increased demand for land to produce corn in the United States resulted in 4.9 million ha converted from grassland to cropland from 2005 to 2008. Habitat loss on this scale has the potential to have direct effects on wildlife populations (Fargione et al. 2009). Increased demand for agricultural production in the Northern Great Plains is the leading cause of grassland habitat conversion, which may influence behavioral changes and potentially affect survival of white-tailed deer neonates in central North Dakota.

MANAGEMENT IMPLICATIONS

In central North Dakota, grasslands offer the greatest vertical height of understory vegetation which in turn provides neonates with protection from predators. Abundant quality grassland habitat across the landscape provided options for neonates during our research. Nevertheless, continued loss of CRP and native grasslands due to changes in agricultural practices in the Northern Great Plains will reduce available vegetation for neonate selection during the first 60 days of life. Landscape-level changes may affect bed site selection and decrease the survival of fawns in central North Dakota. We suggest that more research be conducted on neonatal bed site selection throughout the Northern Great Plains.

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Table 4-1. Mean (and SE) microhabitat characteristics for neonate bed sites for 13 radiocollared neonate white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2011.

	Use (*n*=28)		Random (n=*28*)	
Habitat	$\bar{x}$	SE	$\bar{x}$	SE
Grass (%)	69.51	4.00	66.72	4.34
Forb (%)	12.83	2.75	11.07	2.49
Shrub (%)	0.79	0.42	0.37	0.24
Row Crops (%)	0.64	0.64	0.00	0.00
Rock (%)	0.36	0.22	0.00	0.00
Bare ground (%)	0.32	0.17	0.12	0.06
Slash (%)	1.23	0.47	0.86	0.43
Litter (%)	5.35	1.37	9.52	2.28
Water (%)	4.23	2.81	0.86	0.86
Alfalfa (%)	4.69	2.47	4.96	2.53
Trees (%)	0.99	0.81	1.06	0.89
Wheat (%)	0.80	0.80	0.80	0.80
Vertical height (cm)	87.29	4.93	83.88	4.86
Density (cm)	43.07	2.94	38.19	3.35
Tree canopy cover (%)	9.93	3.93	9.93	3.98
Tree basal area (m2/ha)	0.08	0.08	0.00	0.00

There was no statistical significance between use and random bed sites ($P < 0.05$).

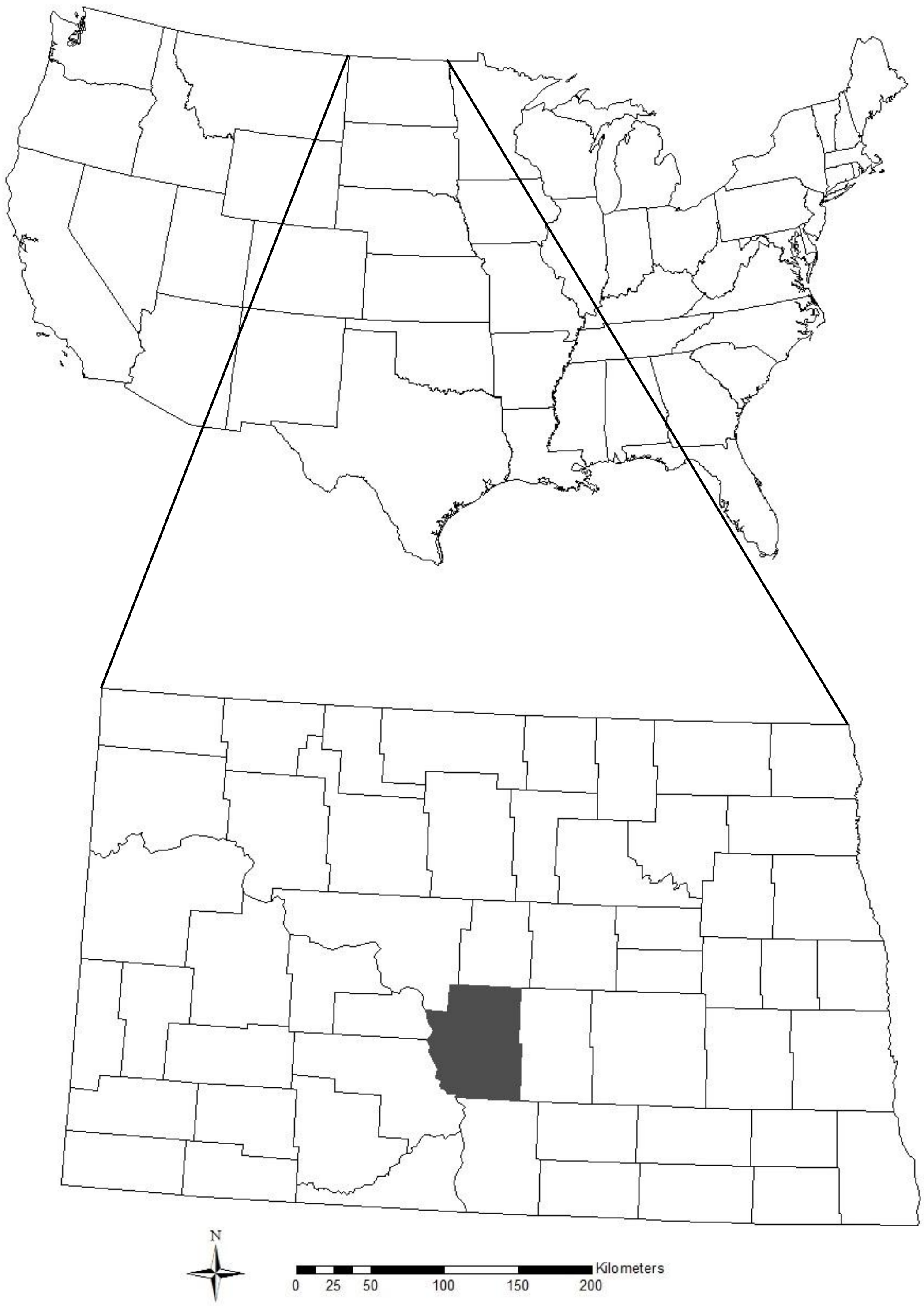

Figure 4-1. Study area where we captured neonate white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2011. Shaded area is Burleigh County.

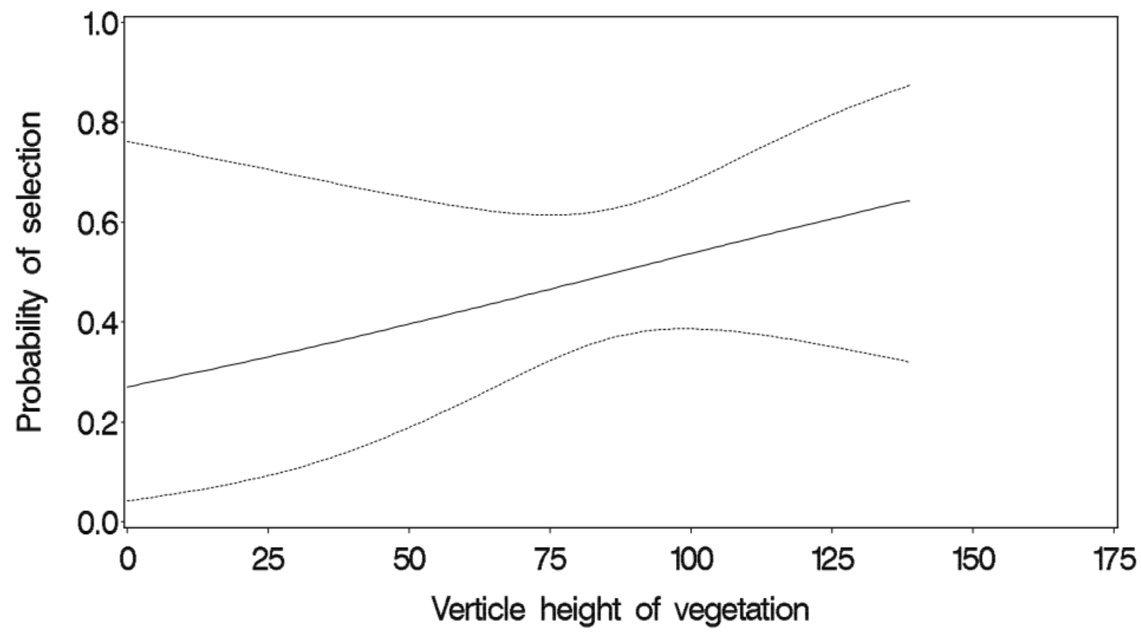

Figure 4- 2. Probability of bed site selection for neonate white-tailed deer (*Odocoileus virginianus*) in central North Dakota, USA, 2011 using the Grovenburg et al. 2010 vertical height of vegetation model.

CHAPTER 5: MANAGEMENT IMPLICATIONS

North Dakota Game and Fish Department biologists should consider several factors when managing white-tailed deer populations. Unlike previous research conducted throughout the Northern Great Plains, both winters during this study were considered extremely severe based on the Deer Winter Severity Index (DWSI) and thus, data collected during this study provided a rare opportunity to document the influence of severe winter weather on white-tailed deer in a grassland-dominated landscape.

The majority of white-tailed deer in central North Dakota were residents. High numbers of resident deer were likely associated with availability of high quality food sources (unharvested corn/sunflowers) located within home ranges during both winters of this study. Nevertheless, the number of deer that migrated, or made late season movements, increased with more severe winter conditions experienced during the winter of 2010-11. Although one radiocollared adult female dispersed during this study, she remained within the same hunting hunt. These finding support the current size of these hunting units and the need to retain rather large hunting units on the Northern Great Plains. Smaller hunting unit may be problematic for meeting management objectives.

Winter deer surveys flown by the North Dakota Game and Fish Department may be affected by late season movements of deer out of the monitoring block; this behavior was observed during this project and could impact long-term population trends. Information collected through this study indicated that deer movement patterns vary greatly within the Northern Great Plains and can be affected by habitat availability, weather conditions, and food availability. During both winters of this study, deer were closely associated with farmsteads and thus, were unavailable for use in evaluating aerial sightability. However, when aerial observations were compared to intensive ground surveys, up to 87% of the deer on the study area were counted by aerial observers. Furthermore, snow conditions improved observability of deer (i.e., near 100% sightability) when not associated with farmsteads. This supports the assumptions that aerial surveys can provide a reasonably good index of deer numbers.

High natural mortality was likely exacerbated by the severe winter conditions experienced during this study and wildlife managers may need to consider license allocation adjustments following a series of severe late season snow storms to compensate for fluctuating rates of natural mortality. Additionally, wildlife managers need to be aware of ongoing landscape-level changes due to agricultural advancements (tree removal, wetland drainage, and grassland conversion), which have the potential to quickly change the population dynamics of white-tailed deer in central North Dakota. Conversion of grasslands to cropland may increase the probability of deer migration and reduce survival rates.

In central North Dakota, grasslands offer the greatest vertical height of understory vegetation, which in turn, provides neonates with protection from predators. Continued loss of CRP and grasslands due to changes in agricultural practices in the Northern Great Plains will reduce available hiding cover for neonate bed site selection during the first 60 days of life. Landscape-level changes that reduce hiding cover could decrease the survival of fawns in central North Dakota.

This project provided North Dakota Game and Fish Department biologists with a unique opportunity to observe the effects that severe winter weather has on white-tailed deer. However, this research is a snap shot of what occurs in the region and wildlife managers need to be aware that these variables have the potential to fluctuate from year to year. Continuous monitoring of factors that affect white-tailed deer life history parameters would allow for a better understanding of white-tailed deer in central North Dakota. As landscape-level habitat changes, such as grassland conversion and wetland drainage, continue in the Northern Great Plains, white-tailed deer recruitment and survival rates also will be impacted. Survival rates will likely decrease because of vulnerability to hunter-harvest and reduced fawn recruitment due to increased vulnerability to predation. Although hunting was not the most significant cause of mortality of white-tailed deer in central North Dakota, it remains the primary management tool for the North Dakota Game and Fish Department. The combination of winter deer surveys, hunter harvest surveys, and future research remain the best option for setting appropriate management goals.