AN EVALUATION OF LIFE HISTORY PARAMETERS AND MANAGEMENT OF WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) IN THE RED RIVER VALLEY OF NORTHEASTERN NORTH DAKOTA

BY

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ABSTRACT

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Aside from the central region of North Dakota, North Dakota Game and Fish lacks basic information on seasonal movements, home range sizes, survival rates, and cause-specific mortality factors of white-tailed deer (*Odocoileus virginianus*) in the Red River Valley where climate and landscape–level habitat characteristics differ markedly from those of previous research areas. As a result, the objectives of this study focused on collecting empirical data for those basic parameters along with determining response to seasonal flooding, monitoring disease, and measuring fawn bed site habitat characteristics. I captured and radiocollared 97 (60 adults, 37 neonates) deer in the Red River Valley in northeastern North Dakota. Of the surviving 78, 46 deer were classified as resident animals, 23 as migrators, and 9 deer exhibited late season movements. I calculated 83 individual home ranges and mean 50% and 95% kernel utilization distribution home ranges (HR). The 50% and 95% seasonal home ranges for resident deer (n=46) were 1.0 and 5.3 km^2, respectively. Seasonal 50 and 95% HR estimates were as follows: 0.7 and 3.7 km^2 for summer migrating deer (n=17), 0.7 and 7.0 km^2 for winter migrating deer (n=19) and 1.1 and 4.8 km^2 for deer that exhibited late season movements (n=9). During the flood event of 2013, deer were displaced a mean of 3.2 km from their original home range. Natural causes (e.g., poor nutrition, predation), were the greatest mortality factors influencing adult and neonate survival rates. Annual survival rates in adult deer were 0.75 (SE = 0.05, n=54) in 2012 and 0.74 (SE = 0.05, n=47) in 2013. Neonate summer survival rates were 0.50 (SE=0.11, n=18) in 2012 and 0.64 (SE = 0.12, n=19) in 2013. The majority of radiocollared adult female deer (2012: 84%, 2013: 85%) during the firearm season were located on posted private land and available for harvest by firearm hunters (2012: 81%, 2013: 79%). Overall, 50 (62%) neonatal bed sites were located in forested habitats, 13 (16%) in CRP, 12 (15%) in grass/pasture land, 3 (3.7%) in agricultural fields, and 3 (3.7%) in cattails. Neonates that survived west of Interstate 29 selected for shorter, less dense grass while neonates that survived east of Interstate 29 selected for taller, denser grass for bed sites. This valuable information provides North Dakota Game and Fish with better insight on how to manage their deer populations as well as baseline data to incorporate into an overall deer management plan.

CHAPTER 1: GENERAL INTRODUCTION

White-tailed deer provide high levels of economic value as they are the most sought after big game species in the United States (McCullough 1987). The majority of hunters in North Dakota engage in deer hunting more than any other shooting sport, and they provide up to 3.5 million dollars annually in license sales for the department as well as 60 million dollars from gas, food, lodging, and equipment. North Dakota Game and Fish manages deer populations to balance hunting opportunity and hunter satisfaction with landowner tolerance. With a recent drop in population numbers and hunter success, there is a greater need for statewide population information on white-tailed deer (*Odocoileus virginianus*). Aside from the central region of North Dakota, North Dakota Game and Fish Department (NDGFD) lacks basic information on annual recruitment rates, cause-specific mortality, habitat use, and late winter mortality rates for white-tailed deer in the Red River Valley where climate and landscape–level habitat characteristics differ from those of previous research study areas. This information can help evaluate regional trends among deer populations and aid in deer management decisions.

White-tailed deer are highly adaptable to changing surroundings. Unregulated hunting, advancing settlement, and evolving farm practices nearly eradicated deer to an unprecedented low of about 500,000 white-tailed deer in North America by the start of the 20th century (Cook 1945, Kernohan et al. 2002, Cook and Dagget 1995, Hubbard et al. 2000). As land use practices changed, harvest was regulated, and conservation programs were implemented, key habitats and forage opportunities for white-tailed deer improved and white-tailed deer were able to recover (Cook 1945, Kernohan et al. 2002). In present day North America, over 27 million white-tailed deer now exist and are thriving in the Northern Great Plains (Knapp 2001, Naugle et al. 1996, Burris 2005, Grovenburg et al. 2009).

Prior to European settlement, native prairie covered North Dakota and white-tailed deer mainly resided along riparian areas (Knue 1991). Exploitation of deer populations increased as an influx of Europeans began to colonize the area and establish residence in the 1860s (Petersen 1984). By the early 1900s, white-tailed deer numbers were able to increase with the enactment of wildlife laws and regulated hunting to their current level, becoming a valued natural, recreational, and economic resource to the State of North Dakota (Petersen 1984).

Currently in North Dakota, the NDGFD manages white-tailed deer by hunting units through the use of lottery allocation of licenses. The NDGFD uses a five step process that evaluates past performance of each unit and surrounding units to determine specific hunting unit goals. Population indices, such as deer hunter success rates, winter aerial deer surveys, number of deer sighted by hunters per hour of effort during the opening weekend of rifle season, and deer-vehicle collisions, reveal long-term trends and help determine the number of licenses to allocated for each hunting unit. A management approach of this kind requires the knowledge and understanding of the biological and social factors driving white-tailed deer populations. To help determine the biological factors, the primary objectives of this study were to: 1) document survival rates and cause-specific mortality and 2) determine seasonal movement patterns and home range sizes. Secondary objectives were to 1) conduct neonate bed site analysis, 2) evaluate the movement responses to spring floods, 3) evaluate deer distribution and hunter access during the firearm season and 4) evaluate reliability of winter aerial deer surveys.

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

ABSTRACT Seasonal movements and home ranges of white-tailed deer (*Odocoileus virginianus*) have been well documented in specific regions of the Northern Great Plains, but limited information is available in the agriculture-dominated (83% land cover) region of North Dakota. Thus, the purpose of this study was to document seasonal movements, daily movements, 50 and 95% home ranges, and distribution of white-tailed deer during the firearms season. From February 2012 – February 2013, 60 adult (>1.5 years) female white-tailed deer were captured and radiocollared to monitor movements and survival. A total of 6,697 locations is obtained from these animals. We classified 46 deer as resident animals, 23 as migrators, and 9 deer exhibited late season movements. We calculated 83 individual home ranges and mean 50% and 95% home ranges of resident deer (n = 46) were 1.0 and 5.3 km^2, of summer migrating deer (n = 18), they were 0.7 and 3.7 km^2, of winter migrating deer (n = 10), they were 0.7 and 7.0 km^2, and of deer that exhibited late season movements (n = 9), they were 1.1 and 4.8 km^2. Overall, mean seasonal migration distance was 4.7 km (SE = 0.4, n = 17) and mean late season movement distance was 4.9 km (SE = 1.5, n = 9). During the flood event of 2013, deer were displaced a mean of 3.2 km from their original home range. Movements seem largely driven by habitat availability, weather and environmental conditions, and food availability. In November 2012 and 2013, we located radiocollared deer via aerial telemetry twice throughout each 16.5 day firearms season. During the firearms season,

the majority of adult female deer (2012, 84%, n = 49; 2013, 85%, n = 66) were located on posted private land but were available for harvest by firearms hunters (2012, 81%; 2013, 79%). Even though there was a high level of access to these animals, mortality due to hunter harvest during the firearms season was low (8%).

INTRODUCTION

An understanding of deer movements and migrational patterns helps wildlife managers better focus management efforts and establish measures for controlling diseases. White-tailed deer (*Odocoileus virginianus*) that exhibit long–distance movements risk an exposure to disease and population models may not account for management unit immigration and emigration. White-tailed deer movement patterns and seasonal home ranges are well documented in the Northern Great Plains (Sparrowe and Springer 1970, Kernohan et al. 1994, Jensen 1999, Burris 2005, Grovenburg et al 2009, Robling 2011, Smith 2005, Schaffer 2013). Many of these studies focused on seasonal movements from winter to summer home ranges with mean migration distances of 19.0 km (Jensen 1999), 11.2 km (Smith et al. 2007), and 11.8 km (Schaffer 2013) 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), 10.6 km (Haffley 2013), and 4.8 km (Robling 2011) in South Dakota.

Cold temperatures, depth of snow, photoperiod, and change in vegetation due to environmental factors all influence the length and timing of deer migrations (Nelson 1995, Brinkman et al. 2005, Swanson 2005, Burris 2005, Grovenburg et al. 2009, Robling 2011, Schaffer 2013). In addition, Grovenburg et al. (2009) hypothesized that limited forest cover caused deer to migrate longer distances. In northeastern South

Dakota, forest cover also is limited, but Robling (2011) proposed the limited movements by deer were due to an increased availability of wetlands. In central North Dakota, Schaffer (2013) found agricultural crop availability limited winter movements until forage became limited.

In North Dakota, where climate, landscape, and habitat variation may affect movements and home ranges, information on home range and movements of white-tailed deer is limited to studies of Aalgaard (1973), Martin (1973), Smith (2005), and Schaffer (2013). Documenting seasonal movement patterns and home ranges of white-tailed deer in northeastern North Dakota were the primary objectives of this research project while documenting distribution and hunter access to radiocollared deer during the 16.5 day firearms season and evaluating winter aerial deer surveys were secondary objectives.

STUDY AREA

Throughout 2012-2013, we studied movements and estimated home ranges of adult female white-tailed deer in Walsh and Grand Forks counties in the Red River Valley of northeastern North Dakota (Figure 2-1). The 2,400 km^2 study area is contained within the Lake Agassiz Plain Level III Ecoregion, which is characterized by a lack of topography, lakes, and wetlands and intensive agricultural practices compared to surrounding areas (Bryce et al. 1998). Dominant crops in the valley include potatoes, sugar beets, edible beans, and wheat. Corn, soybeans, sunflowers, and flax also are grown in the area (USDA National Agricultural Statistics Service Cropland Data Layer 2011). Lands converted to agriculture comprised 83% of the study area. Developed area, grasslands, wetlands, and other land uses made up 5.6%, 5.1%, 2.9%, and <1% of the study area, respectively (Jin et al. 2013). In addition, the majority of the study area was privately owned; Wildlife Management Areas, Waterfowl Production Areas, and National Wildlife Refuges made up only 1% of the study area.

The Red River Valley was once considered tallgrass prairie dominated by grasses and forbs such as big bluestem (*Pascopyrum smithii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), slender wheatgrass (*Elymus trachycaulus*), western prairie-fringed orchid (*Platanthera praeclara*), meadow anemone (*Anemone canadensis*), prairie cinquefoil (*Potentilla argute*), prairie blazing star (*Liatris pycnostachya*), and tall goldenrod (*Solidago altissima*). Remnants of the tallgrass prairie in North Dakota are restricted to the Red River Valley and are primarily contained in the Sheyenne National Grasslands, Kelly's Slough National Wildlife Refuge, and Prairie Chicken Wildlife Management Area (Hagen et al. 2005, Seabloom et al. 2011). The Red River Valley is primarily a treeless plain, but trees can be found in riparian areas and shelterbelts. Deciduous riparian forests consist primarily of American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and bur oak (*Quercus macrocarpa*) trees (Hagen et al. 2005).

Free–ranging cervids in the area include white-tailed deer, moose (*Alces americanus*), and occasionally elk (*Cervus elaphus*). The predator base for adult white-tailed deer is limited to coyotes (*Canis latrans*) (Seabloom et al. 2011). However, on rare occasions gray wolf (*Canis lupus*), black bear (*Ursus americanus*), and mountain lion (*Puma concolor*) sightings have occurred in northeastern North Dakota (Seabloom et al. 2011).

The archery hunting seasons occurred 31 August 2012 – 6 January 2013 and 30 August 2013– 5 January 2014. Youth firearms season occurred 14 – 23 September 2012 and 20 – 29 September 2013. Firearms seasons were 9 – 25 November 2012 and 8 – 24 November 2013. Muzzleloader seasons spanned 30 November – 16 December 2012 and 29 November – 15 December 2013. The area consists of mostly private land, but state wildlife management areas, waterfowl production areas, national wildlife refuges, and PLOTS (Private Land Open to Sportsmen) land provide public hunting opportunities.

METHODS

Capture and Handling

In 2012, we captured adult female white-tailed deer (<1.5 year old) by net gun fired from a helicopter. A crew member hobbled, blind folded, aged, and radiocollared each captured deer in northeast North Dakota (Native Range Capture Services, Ventura, California, USA). Vaginal Implant Transmitters (VITs) were inserted in randomly selected females. VITs were inserted through a 0.5" ID PVC pipe. The inserted end of the pipe was cut at a 45 degree angle, and the edges were rounded and polished smoothed.

In winter 2013, we captured white-tailed deer from 21 January-21 February using modified Clover traps (Clover 1954). We pre-baited each trap with a mineral block, sugar beets, alfalfa, corn, and molasses and rebaited set traps with alfalfa and corn. Traps were checked morning and evening, and we physically restrained captured individuals, fitted blind folds, and attached radiocollars (Advanced Telemetry Systems, Isanti, MN, USA) or ear tags (Y-Tex, Cody, WY, USA) depending on age and sex. We radiocollared adult and yearling females (>1.5 year) and ear-tagged adult and yearling males (>1.5

year), male fawns, and female fawns (<1 year). Vaginal Implant Transmitters (VITs) were inserted in randomly selected females. 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

Radiocollared deer were monitored 2-3 times per week from 22 February 2012 – 11 December 2013 using aerial telemetry from a fixed-winged aircraft (North Dakota Game and Fish Department, American Champion Scout, Rochester, WI, USA) and ground telemetry. We used a null-peak antenna system (Brinkman et al. 2002), omnidirectional antennas, and hand-held 4-element Yagi antennas (Advanced Telemetry Systems, Isanti, MN, USA) to visually locate individuals and/or performed ground triangulation. A minimum of three directional bearings were obtained 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. 2009, Schaffer 2013). Locations of radiocollared individuals were not obtained on successive days or at similar times of day during the same week to ensure we accurately characterized home ranges while minimizing autocorrelation.

Home Range Analysis

We imported location data into Program R (R Core Team 2015) and performed k-means cluster analyses to determine migration dates. We then used Program R to calculate 50% and 95% kernel utilization distributions for each radiocollared deer. We used leastsquares cross-validation (LSCV) to estimate the smoothing parameter (Seaman et al. 1999). We classified movement types by year instead of combining years of the study similar to previous studies conducted 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. 2009, 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 (e.g., non-traditional sallies [Schaffer 2013] AKA occasional sallies Burt [1943]) out of their home ranges in late winter. Home ranges and movements were compared relative to year using t-tests (SYSTAT Software, Inc., San Jose, CA, USA).

Distribution and Hunter Access

We located radiocollared deer twice during each 16.5 day firearms season in 2012 and 2013. We obtained locations via aerial telemetry to avoid disturbing both deer and hunters and minimize our effects on movements of radiocollared animals. After locations were obtained, we determined land ownership inhabited by radiocollared deer. We then contacted private landowners and obtained information on hunter access to their property. We classified land type into three classes: private, public lands open to hunting (Wildlife Management Areas, Waterfowl Production Areas), and public lands closed to hunting (National Wildlife Refuges).

Winter Aerial Deer Surveys

We used aerial surveys to assess sightability of deer. We assessed sightability based on the number of deer observed during flights compared to the number of deer observed on the ground within a week of the flight. Radiocollared deer were subsequently located to help determine if any groups were missed.

Deer Winter Severity Indices

We calculated Deer Winter Severity Indices (DWSI; Brinkman et al. 2005) for the 2012-2013 and 2013-2014 winters throughout our study area in northeastern 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 ≥35.0 cm (Brinkman et al. 2005) during the months of November – April (W.F. Jensen, pers. comm., Unpublished NDGF data).

RESULTS

We captured 40 adult female white-tailed deer west of Interstate 29 (I-29) on 20-21 February 2012 with helicopter net guns; VITs were inserted into 20 females. An additional 20 deer were captured using Clover traps east of I-29 from 24 January 2013 – 24 February 2013. From the Clover trapping efforts, we radiocollared 20 adult female deer (>1.0 year old), and ear tagged 5 adult males (>1.0 year old) and 23 fawns (<1 year old) (13 female, 10 male); VITs were inserted into 13 adult female deer. Two capture related mortalities occurred during helicopter net-gunning operations in 2012. These deer were transported to the North Dakota Game and Fish Laboratory in Bismarck, North Dakota for necropsy where both deaths were attributed to capture myopathy. An additional capture related mortality occurred during Clover trapping in 2013.

We collected a total of 6,697 locations of radiocollared individuals throughout the duration of our study. Requiring a minimum of 15 locations to calculate a home range, we calculated 83 individual home ranges using an average of 82 locations per year for resident home ranges and an average of 42 locations for seasonal home ranges.

Seasonal Movements

During 2012, 22 (61%) deer were classified as residents, 11 (31%) as migrators, and 3 (8%) exhibited late season movements. Mean 2012 migration date was 17 April 2012 and the average spring migration distance was 5.6 km (SE = 0.6). Deer that made late season movements in the 2012 winter had a mean migration date of 18 March 2012 and a mean travel distance of 6.2 km (SE = 1.0). Mean 2012 fall migration date was 07 November 2012 and the mean 2012 fall dispersal distance was 4.1 km (SE = 0.7). During 2013, 23 (53%) deer were classified as residents, 12 (28%) as migrators, and 7 (16%) exhibited late season movements. Average migration date in spring 2013 was 13 May 2013 and the mean spring 2013 migration distance was 4.5 km (SE = 0.8) (Table 2-1). We were not able to calculate a mean fall 2013 dispersal distance due to lack of 2013-2014 winter locations. Radiocollared animals that exhibited late season movements had a mean migration date of 16 February 2013 and traveled a mean of 4.9 km (SE = 1.5). The overall mean migration distance throughout the duration of the study was 4.7 km (SE = 0.4, n = 17). Spring migrations did not differ between 2012 and 2013 ($P=0.24$). Late season migration distances did not differ between 2012 and 2013 ($P = 0.32$).

Dispersals and Ear Tags

There were 2 adult dispersal events in 2012 following helicopter capture efforts and 1 adult dispersal event following Clover trapping efforts in 2013. Dispersal distances ranged from 3 km to 44 km with a mean dispersal distance of 21.8 km (*n* =3). After the 2013 winter Clover trapping efforts, 4 deer that were ear tagged were harvested during the 2013 hunting season and 2 ear tagged deer were reported on trail cameras. Ear tagged white-tailed deer movement distances ranged from 1.6 km to 44 km with an average movement distance of 19.7 km (SE = 7.1, *n* = 6).

Home Ranges

We generated 46 resident home ranges, 17 summer home ranges for migrators, 10 winter home ranges for migrators, and 9 home ranges for late season migrators. In 2012, mean 95 and 50% home ranges of resident animals were 4.9 km^2 (SE = 2.8, *n* = 23) and 0.9 km^2 (SE = 0.6, *n* = 23), respectively. Mean 95 and 50% summer home ranges of migrating animals were 4.2 km^2 (SE = 0.5, *n* = 11) and 0.8 km^2 (SE = 0.2, *n* = 11), respectively. The 95 and 50% home ranges for the individuals that exhibited late season movements in 2012 were 7.8 km^2 (SE = 2.5, *n* =2) and 2.0 km^2 (SE = 0.6, *n* =2), respectively. During the 2012-2013 winter, mean 95 and 50% winter home ranges of migrating animals were 7.0 km^2 (SE = 2.0, *n* = 10) and 0.7 km^2 (SE = 0.3, *n* =10), respectively. In 2013, mean 95 and 50% home ranges for resident individuals were 5.1 km^2 (SE = 0.6, *n* = 23) and 0.9 km^2 (SE= 0.1, *n* = 23). Mean 95 and 50% summer home ranges of migrating animals were 3.2 km^2 (SE = 0.6, *n* = 7) and 0.7 km^2 (SE = 0.1, *n* = 7), respectively. The 95 and 50% home ranges for the individuals that exhibited late season movements in 2013 were 3.9 km^2 (SE = 0.4, n =7) and 0.9 km^2 (SE = 0.1, n =7), respectively (Table 2-2).

Overall mean 95 and 50% home ranges for resident animals were 5.3 km^2 (SE = 0.5, n =46) and 1.0 km^2 (SE = 0.1, n = 0.1, n = 46), respectively. Overall mean 95 and 50% summer home ranges for migrating animals were 3.7 km^2 (SE = 0.4, n = 18) and 0.7 km^2 (SE = 0.1, n = 18), respectively. Overall mean 95 and 50% home ranges for animals that exhibited late season movements were 4.8 km^2 (SE = 0.8, n = 9) and 1.1 km^2 (SE = 0.2, n = 9), respectively.

Distribution and Hunter Access

During the 2012 firearms season, 84% of radiocollared deer were located on private posted land and 16% on private land that was not posted. Throughout this season, 81% of radiocollared deer were accessible to hunters, while 19% were located on private land that restricted hunter access. During the 2013 firearms season, 85% of radiocollared deer were located on private, posted land, 14% on private, un-posted land, and 1% on public land. Throughout this season, 79% of radiocollared deer were located on public and private lands accessible to hunters and 21% were located on private land that restricted hunter access.

Winter Aerial Deer Surveys

An aerial deer survey was flown in the Northeastern portion of North Dakota in the 2013-2014 winter. Throughout the winter, deer were closely associated with areas of forested cover and unharvested crops. Areas of dense forested cover and minimal snow cover affected aerial sightability. When comparing aerial counts to intensive ground counts, up to 84% of the deer on the study area were counted by aerial observers.

Deer Winter Severity Indices

For the northeastern portion of North Dakota, the average DWSI for the 2011-2012 winter was 108 and 170 for the 2012- 2013 winter (Figure 2-2).

DISCUSSION

Seasonal Movements

We documented three movement strategies: residents, migrators, and late season movements. Of the three strategies, the majority of deer in the study area were residents (58%). This percentage was higher than most studies conducted across the Northern Great Plains (25-46% Brinkman et al. 2005; 22.5% Burris 2005; 38% Grovenburg et al. 2009), but it was similar to the percentage of resident deer reported in central North Dakota and northeastern South Dakota (67%, Schaffer 2013; 50%, Robling 2011). We classified movements similar to those reported in central North Dakota (Schaffer 2013), and thus, the high number of resident deer relative to other studies conducted in the Northern Great Plains may have resulted from differences in our classification methods. The high number of resident deer also could be due to the frequency of severe winters in northeastern North Dakota and the potential for starvation may have resulted in deer establishing home ranges around known winter food sources.

In central North Dakota, Schaffer (2013) documented deer movements out of their home range later in the winter and returning to their home range prior to parturition. These movements were attributed to diminished forage availability. We also observed these movements in northeastern North Dakota. Many of these movements were from areas that filled with snow to areas of thicker forest cover near food sources (i.e., hay yards, unharvested crops). In our study area, the 2013 deer winter severity index (DWSI)

(170) was higher than in 2012 (108), suggesting that these late winter movements were correlated with winter severity.

We also observed movements in response to flooding that occurred in spring of 2013. Using ArcMap 10.3 and 1/9 arc-second elevation data (United States Geological Survey 2009), analysis showed only a 0.15 meter difference in elevation between Minnesota and North Dakota. This provides insight into the flat topography and how sheet flooding can spread and impact a large area. The official flood stage at the United States Geological Survey (USGS) water gage near Drayton, North Dakota is reached at 32 feet (9.8 m), the moderate flood stage is at 38 feet (11.6 m), and the major flood stage is at 42 feet (12.8 m). In 2012, the Red River crested at 22.3 feet (6.8 m) on 20 March and in 2013, at 39.9 feet (12.2 m) on 06 May (National Weather Service 2015).

Radiocollared deer residing on the North Dakota side of the Red River in 2013 were displaced west approximately 3.2 km into shelterbelts and farmsteads. None of these deer crossed I-29. In contrast, radiocollared deer residing on the Minnesota side of the Red River did not exhibit movements in response to the flood but rather, concentrated their locations to patches of dry land within their home range. Radiocollared deer that resided along the Forest River, a tributary to the Red River, also exhibited flood movements averaging 4.43 km. Aside from these flood movements in spring 2013, these deer were considered residents to the Forest River riparian area in 2012 and 2013. These specific deer were observed again in the winter of 2014 in the same area they traveled to during the flood. Insufficient data inhibited us from determining if the 2014 winter observation was in response to a late season movement or was a secondary winter home range separate from their previously established winter home range along the river.

Mean migration distance (4.7 km) was much less than those reported for deer in other regions of the Northern Great Plains (10.1 km, Brinkman et al 2005; 11.2 km, Smith 2005; 11.8 km, Schaffer 2013; 19.4 km, Grovenburg et al. 2009; 19.0 km, Jensen 1999). However, migration distance was similar to the mean migration distance reported in northeastern South Dakota (4.76 km, Robling 2011). Robling (2011) attributed the shorter migration distance for deer in east-central South Dakota to an abundance of suitable habitat (i.e., wetlands and CRP grasslands); in contrast, Grovenburg et al. (2009) attributed longer migration distances to a lack of suitable habitat (i.e., trees). While our study area is characterized by a lack of tree cover and topography, we speculate that the short migration distances were due to the close proximity of summer habitats (i.e., wetlands, tree belts and farmsteads) and abundance of crops near forested cover used for wintering areas. In this study, the majority of deer captured along the Red River (87%) were classified as resident deer likely because the Red River is one of the main areas in the study area with heavy forest cover, CRP grasslands, water, and food resources in close proximity.

Our reported dispersal rate (5%) was similar to previously reported dispersal rates for yearling and adult female white-tailed deer in the Northern Great Plains (Brinkman 2003, Burris 2005, Smith 2005, Grovenburg et al. 2009, Robling 2011, Schaffer 2013). Because dispersals occurred shortly after capture events, we speculate that the trauma of the capture might have triggered dispersal. Furthermore, our low dispersal rate was the result of focusing our capture efforts on adult female deer, which are less likely to exhibit dispersal behavior. It has been documented that adult female deer will be aggressive towards other deer including their offspring during parturition (Ozoga et al.1982, Grovenburg et al. 2009), which may explain the longer dispersals for yearling ear tagged deer in our study.

Home Ranges

Home range sizes are affected by various factors (i.e., snow depth, deer density, low temperatures, habitat characteristics, age, sex, anthropogenic activities, and crop harvest) and thus, can be difficult to compare (Nelson 1995, Brinkman 2003, Burris 2005, Grovenburg et al. 2009, Robling 2011, Grovenburg 2007, Demaris et al. 2000, Brinkman et al. 2005, Shaffer 2013). Previous studies in the Northern Great Plains documented mean 95% summer home ranges similar to those we documented in northeastern North Dakota (1.7-4.6 km^2, Burris 2005; 2.7 km^2, Brinkman 2003, 3.3 km^2, Swanson 2005). Mean 95% summer home ranges reported by Schaffer (2013) in central North Dakota (6.8 km^2) were higher than in northeast North Dakota (3.7 km^2). Grovenburg et al. (2009) reported 95% summer home ranges varying from 3.6 km^2 to 15.6 km^2 in north-central South Dakota. Both these studies had low percentages of cultivated land (26.73%, Schaffer 2013; 42.4%, Grovenburg et al. 2009) in comparison to northeastern North Dakota (83%). The abundant food sources likely influenced deer fidelity to their summer ranges. Winter 95% home ranges in northeastern North Dakota ranged from 1.8 km^2 to 15.4 km^2. The mean 95% winter home range (6.8 km^2) was similar to the mean 95% winter home ranges reported in east-central South Dakota (3.9 – 9.1 km^2; Grovenburg 2007) and in southwestern Minnesota (5.18 km^2; Brinkman 2003). Deer minimize movements in the winter to conserve their energy (Moen 1976, Parker et al. 1984). Because of this restricted movement, deer are predicted to have smaller winter home ranges than summer home ranges. However, the mean winter 95% home range

(7.0 km) in our study area was almost double the summer 95% home range (3.7 km). Brinkman (2003) observed this trend as well and hypothesized the condensed summer home ranges were due to unlimited cover and food, of which, both were available in the summer in northeastern North Dakota.

Distribution and Hunter Access

Throughout the 16.5 day firearms season in November, the percentage of radiocollared deer located on public and private posted land accessible to hunters was 81% and 79% in 2012 and 2013, respectively. As a result, 19% of radiocollared deer in 2012 and 21% of radiocollared deer in 2013 were located on private posted land not available to firearm hunters. Despite a high percentage of accessibility, hunting mortality was low in northeastern North Dakota. Firearm hunter harvest only accounted for 8% (n = 2) of all mortalities. Similar to our study, Schaffer (2013) also documented a high percentage of accessibility (80%, 2010 and 84%, 2011) and low hunter mortality (24%).

Winter Aerial Deer Surveys

Because aerial deer surveys are flown in late winter, deer exhibiting late winter movements may be missed, which would result in lower population estimates. Sightablity factors, such as snow and forest cover also can affect population estimates. Similar to Schaffer (2013), the majority of missed groups or undercounted groups during aerial flights were associated with towns or farmsteads with heavy forested cover. Conversely, the majority of undercounted deer from the ground was a result of inaccessibility, a problem solved with the use of an aerial system. With these factors taken into consideration, aerial surveys prove to be a reliable index of deer numbers.

MANAGEMENT IMPLICATIONS

The high number of resident white-tailed deer in northeastern North Dakota was likely a result of ideal juxtaposition of food and forested cover. Seasonal migrations and late season movements increased with an increase in winter severity in 2013 and perhaps as a response to an increase in food requirements and demands. Annual flooding also affected deer movements by forcing them into farmsteads, hay yards, and areas away from the rivers with less forested cover.

These late season and flood movements may force deer to travel outside of survey areas along the rivers, thusly, affecting aerial surveys flown along the Red River by North Dakota Game and Fish. An evaluation of the aerial surveys and intensive ground observations revealed 84% of deer were observed from the air. Discrepancies did occur with deer located near towns and farmsteads. Nevertheless, winter aerial deer surveys provide a valuable index to deer populations across the landscape.

This study found a large amount of movement between Minnesota and North Dakota along the Red River and long dispersal movements into Minnesota and towards the site of an outbreak of *Mycobacterium bovis*, or Bovine Tuberculosis in 2005 in free-ranging white-tailed deer. While deer that dispersed into Minnesota did not return to North Dakota, these movements were still important in establishing disease prevention measures if such an event were to occur in the future.

Within the Northern Great Plains, deer movement patterns are affected by various factors, but habitat, food availability, and weather conditions seem to be the most important factors influencing seasonal and dispersal movements. As a result, changes in the landscape (e.g., loss of CRP, tree removal, and wetland conversion) may cause further concentration of deer in the remaining cover and/or result in more seasonal migrations with the potential for exposure to severe winter conditions. Preserving forested habitat combined with establishing food plots may help deer limit their seasonal movements.

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Table 2-1. Mean migration distance and standard error of migration during 3 migratory periods for radiocollared white-tailed deer (*Odocoileus virginianus*) in northeastern North Dakota, USA, 2012-2013.

	Distance (km)	
Migratory Period	Mean	SE
Spring 2012	5.6	0.6
Fall 2012	4.1	0.7
Spring 2013	4.5	0.8
Fall 2013	0[a]	0[a]

[a] Lack of data prevented migration distances to be determined in the fall of 2013.

Mean 95% and 50% home range size (km^2) calculated using kernel utilization distributions in Program R for radiocollared white-tailed deer (*Odocoileus virginianus*) in northeastern North Dakota, USA, 2012-2014.

	2012				**2013**			
	95%		50%		95%		50%	
	$\bar{x}$	**SE**	**$\bar{x}$**	**SE**	**$\bar{x}$**	**SE**	**$\bar{x}$**	**SE**
Resident	4.9	2.8	0.9	0.6	4.9	0.6	0.9	0.1
Migrator	5.6	1.3	0.8	0.3	5.6	0.6	0.8	0.1
LSM[a]	7.8	2.5	2	0.6	7.8	0.4	2	0.1

[a] LSM = Late Season Movement

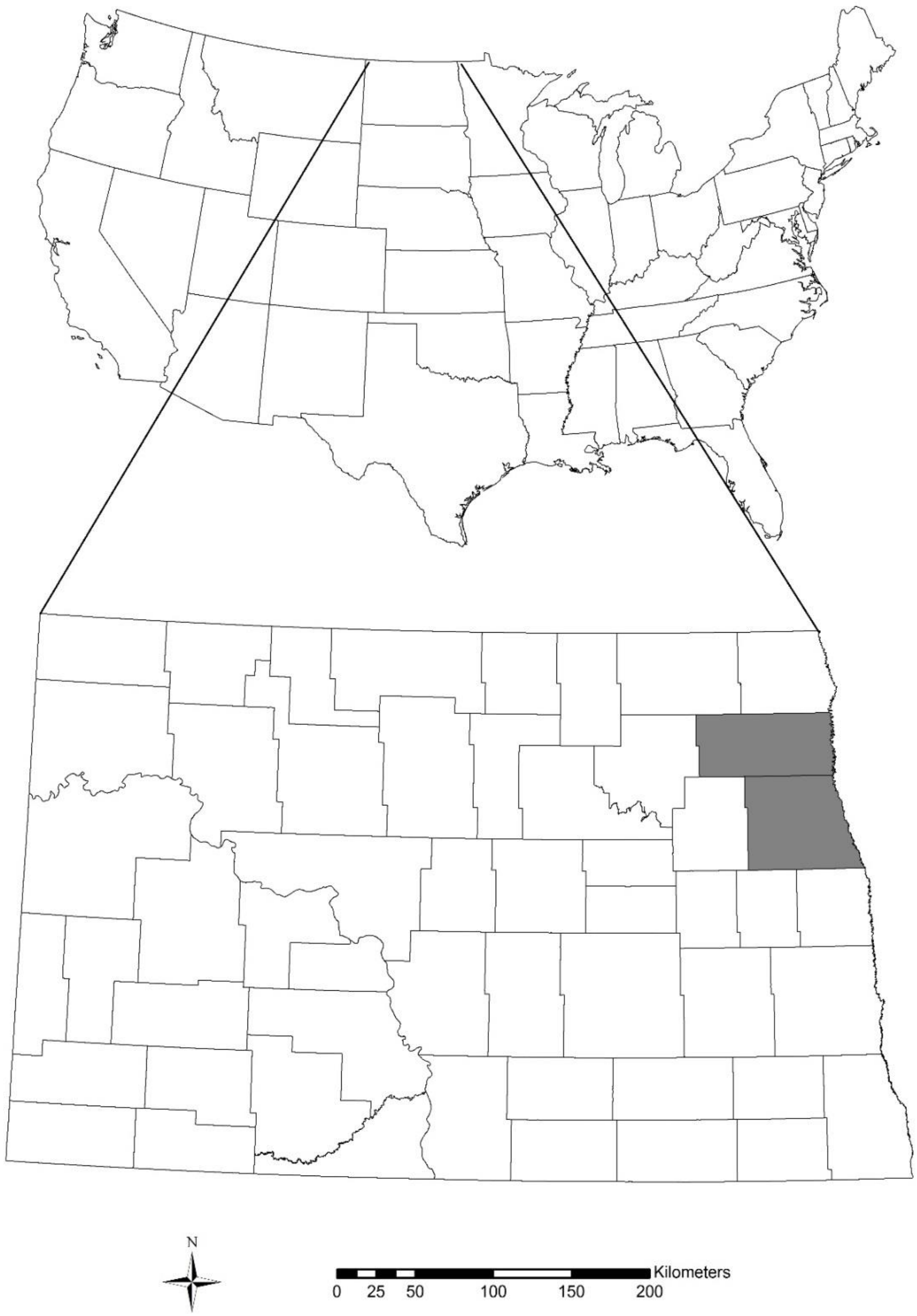

Figure 2-1. Study area where adult female white-tailed deer (*Odocoileus virginianus*) were captured in northeastern North Dakota, USA, 2012-2013. Shaded area is Walsh and Grand Forks counties.

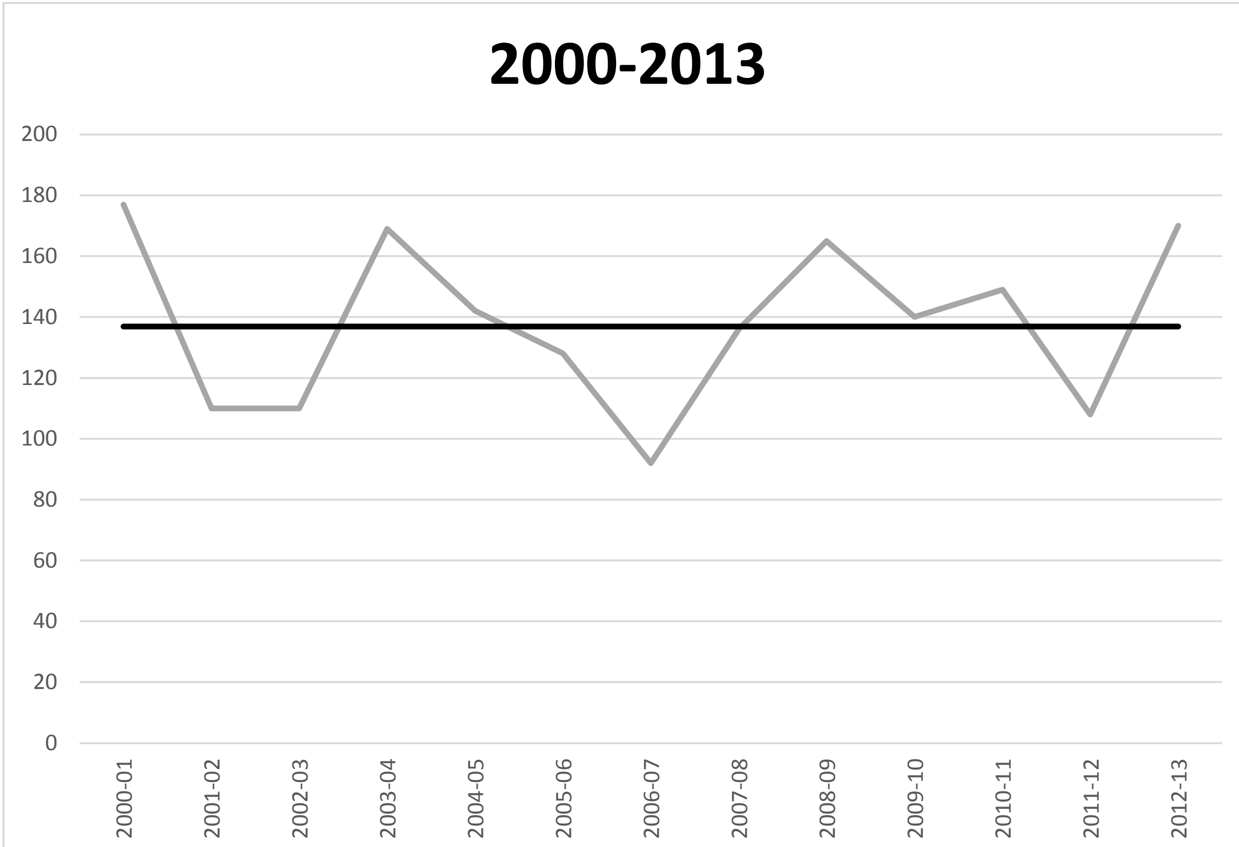

Figure 2-2. Deer winter severity indices (DWSI) plotted against the mean DWSI for in northeastern North Dakota, USA. We assigned one point for each day mean temperature was ≤ - 7° C and an additional point for each day snow depth was ≥35.0 cm; Unpublished Data, W.F.Jensen, North Dakota Game and Fish.

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

ABSTRACT Cause-specific mortality and survival rates of white-tailed deer (*Odocoileus virginianus*) have been well documented in specific regions of the Northern Great Plains, but limited information is available in the agriculture–dominated (83% land cover) region of North Dakota. The objectives of this project were to document cause-specific mortality and survival rates of adult female and neonate white-tailed deer in the Red River Valley of North Dakota. We captured and radiocollared 60 adult female (> 1.5 year) and 37 neonate (20 males and 17 females) white-tailed deer and ear-tagged 5 adult males (>1.5 year) and 24 fawns (< 1.0 year: 10 male, 14 female). Natural causes (e.g., starvation, predation) were attributed to the majority (66.7 %, n=22) of mortalities among adult deer. Annual survival rates during 2012 and 2013 for adult females were 0.75 (SE = 0.05, n=54) and 0.74 (SE = 0.05, n=47), respectively. Seasonal adult female survival rates during summer, fall, and winter 2012 were 0.98 (SE = 0.01), 0.96 (SE = 0.02), and 0.99 (SE = 0.01), respectively; during 2013, rates for summer, fall, and winter were 0.98 (SE = 0.01), 0.98 (SE = 0.01), and 0.96 (SE = 0.01), respectively. Neonate summer survival during 2012 and 2013 was 0.35 (SE = 0.11, n=18) and 0.64 (SE = 0.12, n=19), respectively. The majority of neonate mortalities (47.4%, n=9) were due to predation, primarily by coyotes (*Canis latrans*) and red fox (*Vulpes vulpes*). Approximately 52.6% (n=10) of neonate mortalities occurred at 0–2 weeks of age, 26.3% (n=5) at 2–8 weeks of age, and 21.1% (n=4) at >8 weeks of age. The high amount of natural mortality in adult and neonate white-tailed deer was likely associated with recent changes in the landscape

(i.e., increased amount of CRP expiring and the conversion of wetlands and tree belts to row crops).

INTRODUCTION

Knowledge of cause-specific mortality and survival rates is essential for understanding population dynamics and providing supplementary data for management decisions for white-tailed deer (*Odocoileus virginianus*) (Dusek et al. 1992; DePerno et al. 2000; Brinkman et al. 2004, Grovenburg et al. 2011). Survival rates fluctuate spatially, seasonally, and temporally. Thus, data on survival are essential to modeling region specific deer populations (Grund 2001, Brinkman et al. 2004, Robling 2011).

Numerous white-tailed deer radio-telemetry studies have documented diverse causes of mortality including hunting, vehicle collisions, illegal harvest (Fuller 1990, Dusek et al. 1992, Jensen 1999, Brinkman et al. 2004, Smith et al. 2007, Robling 2011, Grovenburg et al. 2011), severe winter weather (DePerno et al. 2000), predation (Whitlaw et al. 1998, DePerno et al. 2000, Smith et al. 2007), starvation (Lamoureux et al. 2001), and disease (Matschke et al. 1984). In most areas, research has documented hunter harvest as the primary cause of mortality (DelGiudice et al. 2002, Brinkman et al. 2004, Dusek et al., 1992, Nixon et al., 2001). As a result, manipulating hunting mortality rates is a primary tool for managing populations.

Cause-specific mortality and survival rates have been well documented in the Northern Great Plains, but many of these studies were conducted during periods of moderate winter severity and in areas of differing landscape and habitat level characteristics (Jensen 1999, Grassel 2000, Brinkman et al. 2004, Swanson 2005, Burris 2005, Smith et al. 2007, Robling 2011, Grovenburg et al. 2011, Schaffer 2013). As a result, information on cause-specific mortality and survival rates is limited in northeast North Dakota where the climate, landscape, and habitat characteristics vary from surrounding landscape counterparts. The primary objective of this research project was to estimate survival rates (annual, seasonal) and investigate cause-specific mortality for white-tailed deer in an intensely farmed region of northeastern North Dakota.

STUDY AREA

Throughout 2012-2013, we studied survival rates and cause-specific mortality of adult female and neonate white-tailed deer in Walsh and Grand Forks counties in the Red River Valley of northeast North Dakota (Figure 3-1). The Red River Valley, a remnant lake bottom of Lake Agassiz formed after the retreat of glaciers during the Wisconsin glaciation 10,000 to 12,000 years ago, is located along the eastern edge of northeastern North Dakota and northwestern Minnesota (Seabloom et al. 2011).

The 2,400 km^2 study area was contained within the Lake Agassiz Plain Level III Ecoregion (Bryce et al. 1998). The region is characterized by lack of topography, lakes, and wetlands, and intensive agricultural practices. Agriculture comprised 83% of the study area. Dominant crops planted in the Red River Valley include potatoes, sugar beets, edible beans, and wheat as well as corn, soybeans, sunflowers, and flax (USDA National Agricultural Statistics Service Cropland Data Layer 2011). Developed area, grasslands, forested areas, and other uses comprised 5.6%, 5.1%, 2.9%, and <1% of the study area, respectively (Jin et al. 2013).

The Red River Valley was once considered tallgrass prairie dominated by grasses and forbs such as big bluestem (*Pascopyrum smithii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), slender wheatgrass (*Elymus trachycaulus*), western prairie-fringed orchid (*Platanthera praeclara*), meadow anemone (*Anemone canadensis*), prairie cinquefoil (*Potentilla argute*), prairie blazing star (*Liatris pycnostachya*), and tall goldenrod (*Solidago altissima*). The only remnants of the tallgrass prairie in North Dakota that exist in the Red River Valley are primarily contained in the Sheyenne National Grasslands, Kelly's Slough National Wildlife Refuge, and Prairie Chicken Wildlife Management Area (Hagen et al. 2005, Seabloom et al. 2011). The Red River Valley is primarily a treeless plain, but trees can be found in riparian areas and shelterbelts. The deciduous riparian forest consists primarily of American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and bur oak (*Quercus macrocarpa*) trees (Hagen et al. 2005).

White-tailed deer and moose (*Alces americanus*), and the occasional elk (*Cervus elaphus*) are the only free-ranging cervids in the area, and the predators for adult white-tailed deer are limited to primarily coyotes (*Canis lat*rans). Red fox (*Vulpes vulpes*) and badgers (*Taxidea taxus*) present an additional threat to neonates (Seabloom et al. 2011). Rare gray wolf (*Canis lupus*), black bear (*Ursus americanus*), and mountain lion (*Puma concolor*) sightings have occurred in northeast North Dakota (Seabloom et al. 2011).

During this study, archery hunting seasons occurred 31 August 2012 – 6 January 2013 and 30 August 2013– 5 January 2014. Youth firearms season occurred 14 – 23 September 2012 and 20 – 29 September 2013. Firearms seasons were 9 – 25 November 2012 and 8 – 24 November 2013. Muzzleloader seasons spanned 30 November – 16 December 2012 and 29 November – 15 December 2013 (North Dakota Game and Fish Department Deer Hunting Guide 2012, 2013). The area consists of mostly private land, but state wildlife management areas, waterfowl production areas, national wildlife refuges, and PLOTS (Private Land Open to Sportsmen) land provide public hunting opportunities.

METHODS

In 2012, we captured adult female white-tailed deer (<1.5 year old) with helicopter net guns (Native Range Capture Services, Ventura, California, USA) and radiocollared them in northeast North Dakota. We targeted deer west of the Interstate, I-29, in Walsh County, North Dakota. A helicopter crew member hobbled, blind folded, aged, and radiocollared deer. In addition, vaginal implant transmitters (VITs) were inserted in select does. VITs were inserted through a 0.5” ID PVC pipe. The inserted end of the pipe was cut at a 45 degree angle, and the edges were rounded and polished smoothed.

In winter 2013, we captured white-tailed deer with modified Clover traps (Clover 1954). These deer were targeted east of the Interstate, I-29, along the Red River, which formed the eastern boundary of the study area. We pre-baited each trap with a mineral block, sugar beets, alfalfa, corn, and molasses and rebaited traps with alfalfa and corn. Traps were checked morning and evening; we physically restrained captured individuals, fitted blind folds, and attached radiocollars (Advanced Telemetry Systems, Isanti, MN, USA) or ear tags (Y-Tex, Cody, WY, USA). We radiocollared adult and yearling females (>1.5 year) and ear-tagged adult (>1.5 years) and yearling males (1.5 years), and male and female fawns (<1 year). As in 2012, vaginal implant transmitters (VITs) were inserted in select does. Radiocollared deer were monitored for mortality 2-3 times per week, and we censored mortalities from analyses within 26–days post capture regardless of the ultimate cause of death (Beringer et al. 1996). Our animal handling methods were approved by the Institutional Animal Care and Use Committee at South Dakota State University and followed guidelines for care and use of mammals established by the American Society of Mammalogists (Sikes et al. 2011).

We monitored adult females daily and walked in on them <1 hr after detecting a change in signal associated with expulsion of VITS. We intensively searched areas around the VIT and female. After capture, neonates were fitted with expandable collars (Advanced Telemetry Systems, Isanti, MN, USA). To avoid post-capture abandonment, we minimized human scent by placing collars in natural vegetation 4 weeks prior to the capture and wearing latex gloves. After a collar was fitted, sex, weight (gm), and hoof growth (mm) were measured. We used hoof growth measurements and known fawn ages from vitted does to calculate age for randomly caught fawns. We also captured neonates by spotlighting, random searches, and intensively searching areas of observed female postpartum behavior, i.e., isolation and short fleeing distance after disturbance (Grovenburg et.al. 2010, Schaffer 2013). Neonates were monitored daily up to 30–days post capture followed by 2-3 times per week until 1 September. Mortalities were transferred to the North Dakota Game and Fish Wildlife Laboratory in Bismarck, North Dakota for necropsy. Lower incisors, if present, were collected from each carcass, post-mortem, and sent to Matson's Lab (Milltown, MT, USA) for aging.

Annual and seasonal adult survival rates were calculated 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). We assessed study area, year, season, and time within the models. Model averaging was used to account for the variability within models. Seasonal survival rates were calculated for three time periods: Post-hunt (January 2012-April 2012; January 2013-April 2013), Pre-hunt (May 2012-August 2012; May 2013- August 2013), and Hunt (September 2012 – December 2012; September 2013 – December 2013). Summer survival rates for neonates were estimated using the Kaplan-Meier method (Kaplan and Meier 1958) adapted for nonstaggered entry in Program MARK version 6.0 (White and Burnham 1999, Cooch and White 2006). We assessed age interval 1 (0-2 weeks, 2+ weeks), age interval 2 (0-2 weeks, 2-8 weeks, 8+ weeks), study area, year, sex, age, and weight among models.

Deer winter severity indices (DWSI; Brinkman et al. 2005) were calculated for the northeast portion of North Dakota during the 2011-2012 and 2012-2013 winters. Using information collected by the National Center for Environmental Information, one point for each day mean temperature was ≤ -7° C and an additional point for each day the snow depth was ≥ 35.0 cm (Brinkman et al. 2005) were summed for the months of November through March (W. Jensen, NDGF, Bismarck, unpubl. data).

RESULTS

Adults

We captured 40 adult female deer west of I-29 on 20-21 February 2012 with helicopter net guns; VITs were inserted into 20 females. All VITs were retained until parturition (100% success rate). An additional 48 deer were captured using Clover traps east of I-29 from 24 January 2013 – 24 February 2013; we radiocollared 20 adult female deer (>1.0 year old), and ear tagged 5 adult males (>1.0 year old) and 23 fawns (<1 year old; 13 female, 10 male). VITs were inserted into 13 adult female deer. Two of these VITs were retained until parturition a success rate of 23.1%.

Twenty-five adult mortalities occurred throughout the study. We censored three mortalities in the survival analysis due to capture–related events. Eight mortalities were classed as unknown/predation, meaning they were found severely scavenged so the ultimate cause of death could not be determined. Hunting was the cause of death for four deer (2 firearms, 1 archery, and 1 muzzleloader), three died from poor nutrition (1 starvation, 2 rumen acidosis), two died from vehicle collisions, two died of disease (stomach lesions, heart attack), two died from injury, and one died of confirmed coyote predation (Table 3-4). Median age at death was 8.3 years (n=17, range 2.5-12.5). Four male deer ear tagged in 2013 were recovered during the study. The four mortalities were due to hunter harvest and all mortalities occurred in Minnesota. Average distance traveled from capture to harvest was 9.25 km (SE=3.9) (Table 3.6).

Model selection results indicated that {S.} was our best approximating model for estimating adult survival (Table 3-1). Because there were 3 other models within 2 AIC points that had considerable weight, we averaged all the models to account for all variability within the model. As a result, adult annual survival rate was 0.74 (n=57, SE=0.06, 95% CI = 0.57-0.87). Adult seasonal survival rates in 2012 and 2013 for pre-hunt (May - August), hunt (September - December), and post-hunt (January – April) were 0.98 (SE = 0.01), 0.96 (SE = 0.02), and 0.99 (SE = 0.01), and 0.98 (SE = 0.01), 0.98 (SE = 0.01), and 0.96 (SE = 0.01) in 2013, respectively (Table 3-2). Of the 22 documented mortalities, 8 occurred during January-April, 6 during May to August, and 8 occurred during September –December (Table 3-4).

Fawns

From 15 May 2012 – 30 June 2012, we captured and radiocollared 18 neonates (11 males, 7 females). From 11 May 2013 – 30 June 2013, we captured and radiocollared 19 neonates (9 males, 10 females). All neonates in 2012 were captured west of Interstate 29. In 2013, capture efforts were separated between the two study sites, and 10 neonates were captured east of Interstate 29 and 9 neonates were captured west of Interstate 29. In 2012, average weight at capture was 3.68 kg (n=18, SE = 0.26) and average age at capture was 1.5 days (n=18, SE = 0.45). In 2013, average weight at capture was 3.68 kg (n=19, SE = 0.23) and average age at capture was 2.11 days (n=19, SE = 0.32). Comparing the captures among the two study areas, average weight at capture west of Interstate 29 was 3.58 kg (n=28, SE=0.19) and 3.93 kg (n=9, SE=1.23) east of Interstate 29. Average age at capture west and east of Interstate 29 was 1.75 (n=28, SE=0.34) and 1.20 (n=9, SE=0.40), respectively.

Throughout the study, 19 neonate mortalities occurred (12 in 2012, 7 in 2013) including 9 confirmed predation mortalities (8 coyote, 1 red fox), 7 mortalities were due to poor nutrition, and 3 mortalities were classed as unknown/predation. Quadruplets were captured 29 May 2012 from a 13.5 year old female. The female died of heart failure on 1 June 2012, and as a result, the 4 neonates died of starvation.

From our model selection results, we considered {$S_{\text{age interval 1}}$} as the best approximating model. Because 2 other models were within 2 AIC points and had considerable weight, we used model averaging to calculate an overall survival rate of 0.58 (SE=0.12, 95% CI=0.34-0.78). This result did not include the quadruplets. When the quadruplets were included in the analysis, the overall survival rate was 0.47 (SE = 0.09, 95% CI = 0.27-0.69). Neonate survival in 2012 (capture to 1 September) was 0.50

(n=18, SE=0.11, 95% CI=0.17-0.58). With the quadruplets included, the survival rate for 2012 was 0.35 (n=18, SE=0.11, 95% CI=0.17-0.58). Neonate survival in 2013 (capture to 1 September) was 0.64 (n=19, SE=0.11, 95% CI=0.39-0.83).

DISCUSSION

Adults

Model selection indicated that annual survival did not vary yearly, seasonally, or between study areas (east and west of I-29). Instead, adult survival was constant over the duration of the study (74%). This result differs from other studies in the Northern Great Plains where adult survival was highest during pre-hunt periods when human interactions were minimal, and an abundance of quality forage and suitable escape cover existed (0.8-1.0, Brinkman et al. 2004; 0.72-0.99, Grovenburg, 2007; 1.0, Schaffer 2013). Annual survival of adult white-tailed deer was higher than reported in female deer in the Black Hills of South Dakota (50-62%: DePerno et al., 2000), but consistent with other survival rates reported in preceding studies in the Northern Great Plains (77%: Smith et al. 2007; 76%: Grovenburg et al., 2011; 70-78%: Robling 2011; 71-91%: Schaffer 2013).

In the Northern Great Plains, hunter harvest is usually the leading cause of mortality for adult white-tailed deer (86.4%: Simon 1986; 74%: Dusek et al. 1992; 64.7%: Robling 2011; 68%: Burris 2005; 69.9%: Grovenburg et al. 2011). In contrast, hunter harvest accounted for 16.1% of adult mortalities in our study. Schaffer (2013) also documented low hunter harvest mortality in central North Dakota with 28.6% of adult female mortalities due to hunting. The low hunter harvest mortality may have resulted from limited antlerless tags, short firearms seasons, or a hunter bias towards the study. The majority of adult deer mortalities (64%, n=16) were due to natural causes (i.e., predation, malnutrition, sickness, and unknown causes).

We were unable to determine the ultimate cause of death for 8 adult female deer. While predation has been found to be a source of mortality (DePerno et al. 2000, Brinkman et al. 2004, Robling 2011, Schaffer 2013), it is unlikely that all unknown mortalities were the result of predation. We attributed the single known adult predation mortality to coyotes because a necropsy revealed carcass characteristics consistent with injuries received from a predator attack. Rumen acidosis accounted for 8% of known mortalities, and we speculate it may have accounted for a portion of the unknown/predation mortalities due to the prevalence of baiting with agricultural crops in northeast North Dakota and its use during the fall and winter months.

We documented 2 deer-vehicle collisions (8%) during the fall of 2012 on a particular county road. This rate is less than reported in two studies of white-tailed deer in areas with high populations and dense road systems; Haffley (2013) (36.8%) in southeast South Dakota and Brinkman et al. (2004) (21.4%) in southwest Minnesota. Even though a heavy traveled, well-established road network exists in northeast North Dakota, we found that white-tailed deer limited their movement patterns and home ranges to areas with less traveled, local gravel roads and rarely crossed interstates, state highways, and county roads; thus, limiting interaction with vehicles. The flat topography and prevalence of low-growing crops such as edible beans, soybeans, wheat, and sugar beets may aid in visibility along roads as well.

Fawns

Neonate survival (0.58) was similar to that reported in central North Dakota (0.61: Schaffer 2013). Other studies in an intensely farmed areas of Minnesota and eastern South Dakota also had high neonate survival rates, but these studies coincided with a mange epizootic that reduced the predator population (0.84: Brinkman, et al. 2004, 0.87: Grovenburg et al. 2012). It has been well documented that canids have a significant impact on neonate survival and have been reported as the leading cause of neonate mortality in Minnesota (67%; Brinkman et al. 2004), South Dakota (80%, Grovenburg et al. 2011), and North Dakota (100%, Schaffer 2013). We believe, through anecdotal sightings, canid abundance was higher in 2012 than in 2013, which may have been a contributing factor to the slightly lower survival rate in 2012.

Nelson and Woolf (1987) reported that fawns rely on their camouflage and inactivity during the first two weeks of life and are vulnerable to predation and environmental stressors. During our study, 10 of the 19 neonate mortalities occurred within the first two weeks of life (52.6%) which supports the hypothesis that fawns are most vulnerable during the 0-2 week period of life (Rohm et al. 2007, Grovenburg et al. 2011).

Grund (2001) suggested that winter severity may impact fawn survival with survival decreasing with increasing winter severity. Our results contrast this hypothesis as the 2013 (DWSI: 170) neonate survival rate was higher than in 2012 (DWSI: 108). Additionally, there was no significant difference in birth weights between the two years and the winter severity did not affect adult survival. Typically, severe winters result in lower survival (Fuller 1990, DelGiudice et al. 2002, Schaffer 2013). We speculate the severe winters did not have a detectable effect on winter survival because of the prevalence of baiting, unharvested fields, and spent agricultural crops throughout the majority of the winter surrounding areas of rare, but dense cover, thus limiting deer movements (Warner et al. 1989, Nixon et al. 1991, Brinkman et al. 2005). Also, North Dakota experienced a string of severe winters from 2008-2011, potentially eliminating the weakest and most vulnerable deer, or the deer adapted to such harsh conditions during that period, making them less vulnerable to the harsh winter of 2013.

In northeast North Dakota, 83% of the land is cultivated and crop emergence coincides with the peak fawning period leaving 11.4 of the landscape for fawning areas, which were limited to grassy areas within shelterbelts and tree groves, Conservation Reserve Program grasslands, and other small areas dominated by grasses. These reduced, concentrated patches of natural habitat also concentrate predators searching efforts for prey (Brinkman et al. 2004). In an agricultural dominated landscape, many of these areas are being converted to cropland, further fragmenting the available fawning habitat and further reducing the area where predators search to find neonate fawns.

MANAGEMENT IMPLICATIONS

Unlike previous studies in the Northern Great Plains, hunter harvest along the Red River did not influence mortality. In northeastern North Dakota, natural causes of mortality were a major influence on adult and neonate deer survival. As the loss of CRP, grassland conversion, wetland drainage, and tree belt removal continue to change the landscape and reduced patch size for hiding cover; survival rates could be affected by an increase in vulnerability to hunters, predator efficiency, environmental stressors, and a reduction in recruitment. An evaluation of fawn bedding site patch size and cover type may assist land managers seeking to increase fawn survival rates. Hunter harvest was not a significant cause of a mortality, yet North Dakota Game and Fish Department relies heavily on hunting as a primary management tool. The use of winter aerial deer surveys, hunter harvest surveys, hunter observation surveys, and winter severity monitoring provide the North Dakota Game and Fish Department with the best options for determining management goals. The department may be able to better direct future management efforts with an evaluation of the efficiency and accuracy of these populations indices.

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Table 3-1. A *priori* models used to estimate survival of adult female white-tailed deer northeastern North Dakota, 2012–2013.

Model[a]	AIC_c[b]	ΔAIC_c[c]	w_i[d]	K[e]	Deviance
$S_{constant}$	209.60	0.00	0.35	1	207.5908
$S_{study\ area}$[f]	209.80	0.20	0.32	2	205.787
$S_{study\ area + year}$[f]	211.55	1.96	0.13	3	205.527
S_{year}[f]	211.59	2.00	0.13	2	207.5817
S_{season}[f]	213.46	3.87	0.05	3	207.4345
$S_{season + year}$[f]	215.47	5.88	0.02	4	207.4269
$S_{time + year}$[f]	219.93	10.34	0.00	11	197.6399
S_{time}[f]	221.99	12.40	0.00	12	197.6475

[a] Season = pre hunting (June-August), hunting (September-January), and post hunting (February-May).

[b] Akaike's Information Criterion corrected for small sample size (Burnham and Anderson 2002).

[c] Difference in AIC_c relative to minimum AIC.

[d] Akaike weight (Burnham and Anderson 2002).

[e] Number of parameters.

[f] 95% CI for the β estimates of at least 1 parameter contained 0, so these models were not considered when selecting the model with the lowest AIC_c (Barber-Meyer et al. 2008).

Table 3-2. Annual survival rates for radiocollared white-tailed deer (*Odocoileus virginianus*) in northeastern North Dakota, USA, 2012-2014

	2012 - 2013
Number at-risk	60
Number of Deaths	25
Number Censored	3
Seasonal Survival Rates	Post-hunt - 0.98 Pre-Hunt - 0.98, Hunt - 0.97
Survival Rate	0.75
SE	0.05
95% CI Lower	0.65
95% CI Upper	0.83

Table 3-3. Seasonal survival rates for radiocollared adult female white-tailed (*Odocoileus virginianus*) deer in northeastern North Dakota, USA, 2012-2014. Post-hunt: January-April; Pre-hunt: May-August, Hunt: September-December.

Year	Survival Interval	Estimate	Standard Error	95% Confidence Interval	
				Lower	Upper
2012	Post-hunt	0.98	0.01	0.95	0.99
	Pre-hunt	0.98	0.01	0.95	0.99
	Hunt	0.97	0.01	0.93	0.99
2013	Post-hunt	0.98	0.01	0.95	0.99
	Pre-hunt	0.98	0.01	0.95	0.99
	Hunt	0.97	0.01	0.93	0.98

Table 3-4. Seasonal, cause-specific mortality for radiocollared white-tailed deer (*Odocoileus virginianus*) in northeastern North Dakota, 2012–2014.

Cause of Mortality	Pre-hunt	Hunt	Post-hunt	Totals
Harvest	0	4	0	4
Predation	0	0	1	1
Disease	2	0	0	2
Injury	0	0	2	2
Unknown	3	1	4	8
Poor nutrition	1	1	1	3
Vehicle Collision	0	2	0	2

[a]Seasonal intervals = Post-hunt (January 2012 - April 2012), (January 2013 - April 2013), Pre-hunt (May 2012 - August 2012), (May 2013 - August 2013), and Hunt (September 2012 - December 2012), (September 2013 – January 2013).

Table 3-5. A priori models used to estimate survival of neonate white-tailed deer in northeastern North Dakota, 2012-2013.

Model[a]	AICc[b]	ΔAICc[c]	wi[d]	K[e]	Deviance
$S_{\text{age interval 1}}$	154.812	0	0.3092	2	150.806
$S_{\text{age interval 2}}$	156.15	1.34	0.15845	3	150.137
S_{constant}	157.057	2.24	0.10066	1	155.055
S_{age}	157.171	2.36	0.09506	2	153.165
$S_{\text{sex + age + weight}}$	157.25	2.44	0.09138	4	149.229
$S_{\text{age interval 2 + year}}$	157.689	2.88	0.07339	4	149.667
S_{year}	158.508	3.7	0.04872	2	154.502
S_{sex}	159.039	4.23	0.03736	2	155.033
S_{weight}	159.058	4.25	0.03701	2	155.052
$S_{\text{study area + year}}$	160.467	5.66	0.01829	3	154.454
$S_{\text{age + weight}}$	160.787	5.97	0.01559	3	154.774
$S_{\text{age + sex}}$	160.881	6.07	0.01488	3	154.868

[a] Age Interval 1 = 2-stage age interval: 0-2 weeks, >2 weeks. Age Interval 2 = 3 stage age interval: 0-2 weeks, 2-8 weeks, 8+ weeks. Age = age at capture.
[b] Akaike's Information Criterion corrected for small sample size (Burnham and Anderson 2002).

[c] Difference in AICc relative to minimum AIC.

[d] Akaike weight (Burnham and Anderson 2002).

[e] Number of parameters.

Table 3-6. 2013 Firearms harvested white-tailed deer *(Odocoileus virginianus*) that were ear-tagged from 2013 Clover trapping efforts in northeastern North Dakota, 2013.

Age at Capture	**Sex**	**Dispersal Direction/Distance**	**State Harvested**	**Date of Recovery**
Adult	Male	SW 1.6 km	MN	09-Nov-13
Fawn	Male	NE 19.3 km	MN	09-Nov-13
Fawn	Male	N 4.82 km	MN	11-Nov-13
Adult	Male	SE 11.27 km	MN	14-Nov-13

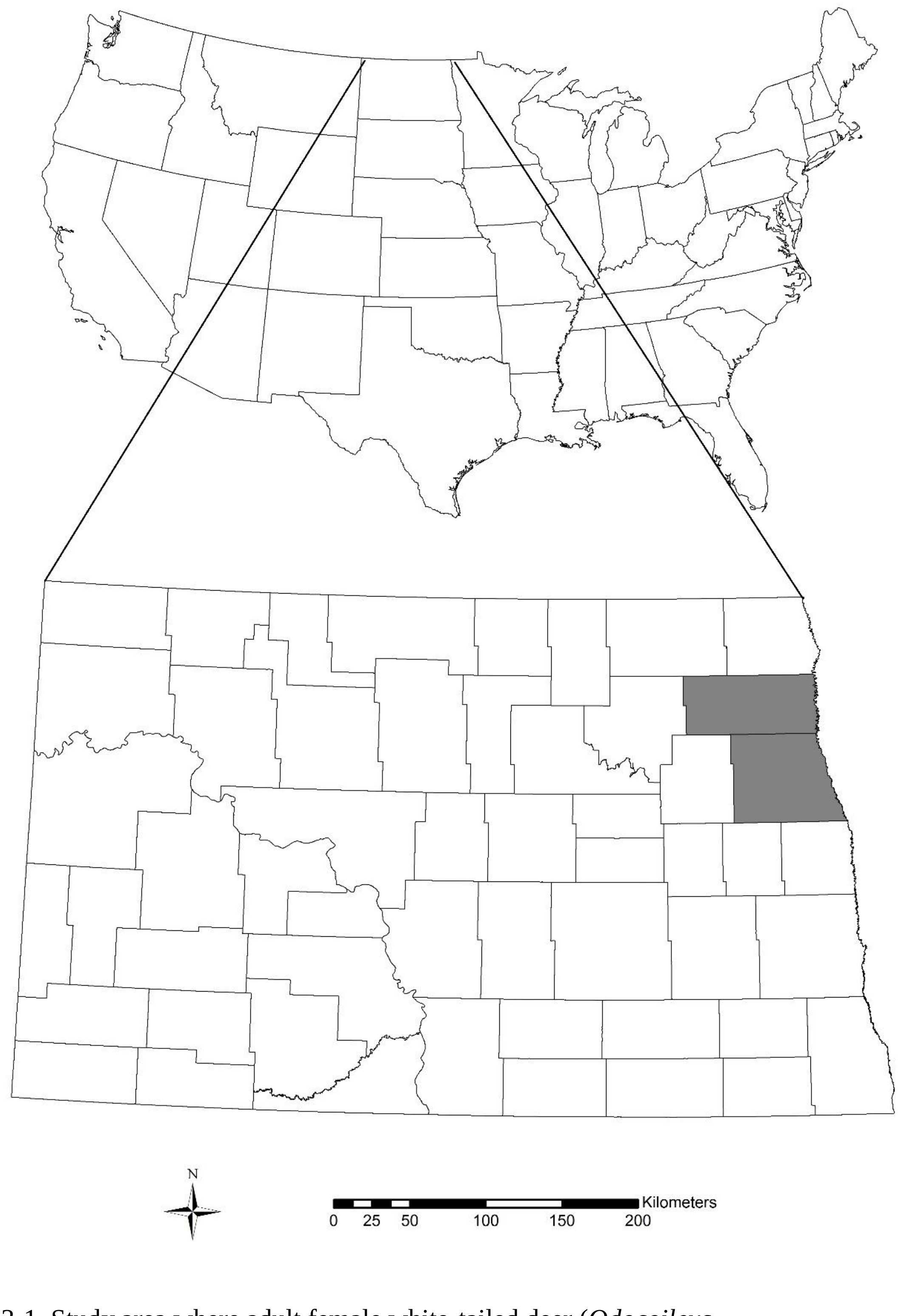

Figure 3-1. Study area where adult female white-tailed deer (*Odocoileus virginianus*) were captured in northeastern North Dakota, USA, 2012-2013. Shaded area is Walsh and Grand Forks counties.

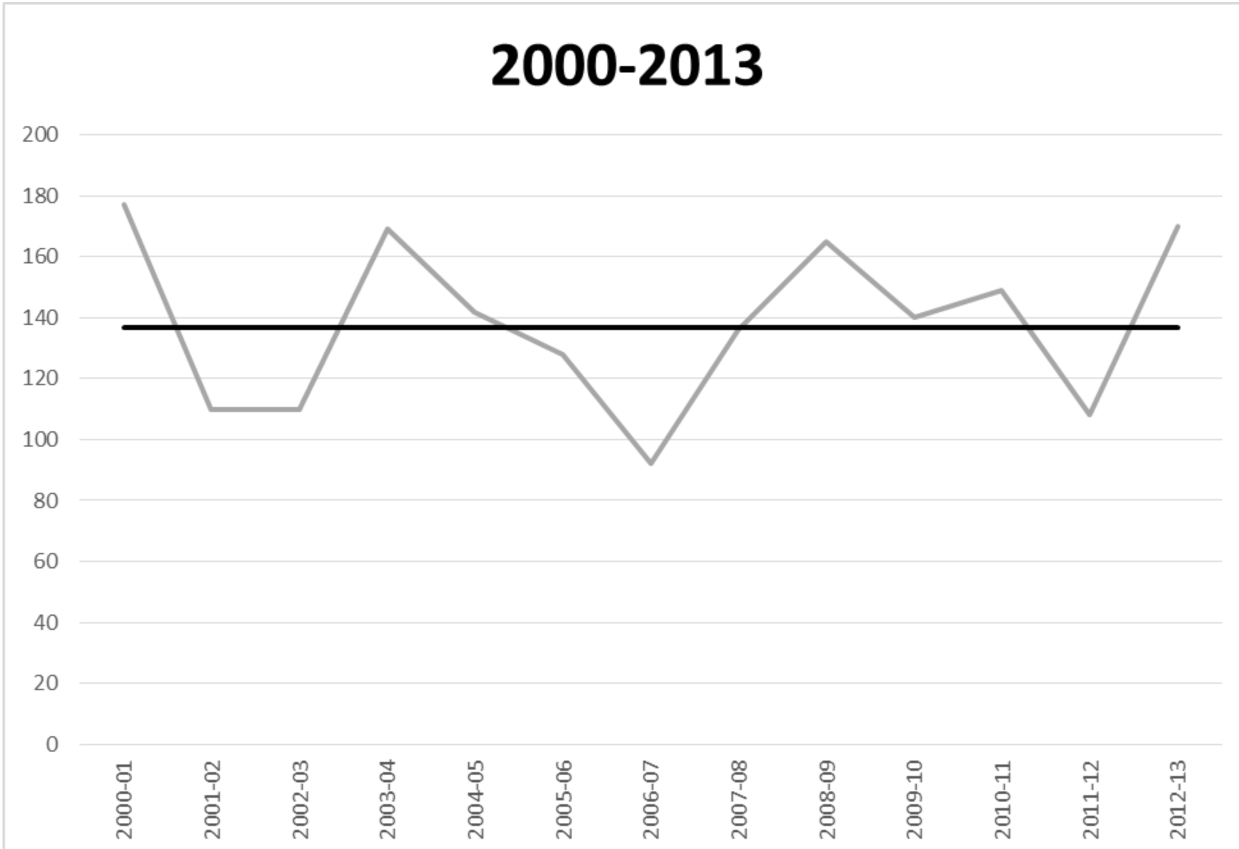

Figure 3-2. Deer winter severity indices (DWSI) plotted against the mean DWSI in northeastern North Dakota, USA. We assigned one point for each day mean temperature was ≤ - 7° C and an additional point for each day snow depth was ≥35.0 cm; Unpublished Data, W.F. Jensen, North Dakota Game and Fish.

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

ABSTRACT The docile bedding behavior of white-tailed deer (*Odocoileus virginianus*) neonates leads to a susceptibility to predation and mortality during the first 60 days of life. Vegetation characteristics play an important role in neonate survival by influencing thermal regulation and providing concealment from predators. Limited bed site habitat information in North Dakota exists, especially in the northeast where climate and habitat characteristics differ from surrounding areas. Throughout 2012 -2013, we measured macro- and microhabitat characteristics of 81 neonate bed sites in northeast North Dakota, USA. At the macrohabitat characteristic level, we located 50 (62%) bed sites in forested areas, 13 (16%) in Conservation Reserve Program (CRP) grasslands, 12 (15%) in Grass/Pasture lands, 3 (3.7%) in cattails (Typha spp.), and 3 (3.7%) in agricultural fields. Even though forested areas harbored the majority of bed sites, forest cover only comprise 2.9% of the study area. We found no differences among the microhabitat characteristics, vertical height, density, canopy cover, tree basal area, and percent cover, between bed sites and random sites (P=0.859). We documented fawns that survived east of the interstate selected taller, denser vegetation and fawns that survived west of the interstate selected shorter, sparser vegetation which provided insight into the habitat differences among the two study areas.

INTRODUCTION

Vulnerability to predation and other natural causes of death affect neonate survival during the first 60 days of life. During this time, understanding the selection of bed site habitat characteristics provides important information on neonate survival (Verme 1977, Huegel et al. 1985*a*, Nelson and Woolf 1987, Grovenburg et al. 2010, Schaffer 2013). Grovenberg et al. (2010) and Schaffer (2014) measured habitat characteristics of neonate bed sites in the Northern Great Plains and found vegetation height to be an important selection factor of a bed site. The northeast region of North Dakota differs from the two previous study areas in that agricultural practices limit the amount of grasslands, Conservation Reserve Program (CRP) grasslands, and forested areas on the landscape. Limited information about neonate bed site habitat selection exists in these intensely farmed areas. Our objectives were to measure the macro- and microhabitat characteristics of bed sites selected by neonate white-tailed deer in the agriculturally dominated area of northeast North Dakota and determine their implications on neonate survival.

STUDY AREA

Throughout 2012-2013, we studied white-tailed deer in Walsh and Grand Forks counties in the Red River Valley of northeast North Dakota (Figure 4-1). The 2,400 km^2 study area is contained within the Lake Agassiz Plain Level III Ecoregion, which is characterized by the lack of topography, lakes, and wetlands and the intensive agricultural practices compared to surrounding areas (Bryce et al. 1998). Dominant crops in the valley include potatoes, sugar beets, edible beans, and wheat. Corn, soybeans, sunflowers, and flax also are grown in the area (USDA National Agricultural Statistics Service Cropland Data Layer 2012). Agriculture makes up 83% of the study area. Developed area, grasslands, forests, and wetlands make up 5.6%, 5.1%, 2.9%, and 1.3% of the study area, respectively (Jin et al. 2013).

In Walsh county, there were 36,041.5 ha and 25,469.2 ha of CRP in 2012 and 2013, respectively. This makes up 10.8% and 7.6% of the total county area, resulting in a decrease of 3.2% from 2012 to 2013 (United States Department of Agriculture, FSA 2012, 2013). In Grand Forks County, there were 37,282.6 ha and 33,371.3 ha of Conservation Reserve Program grasslands in Grand Forks County in 2012 and 2013, respectively (United States Department of Agriculture, FSA 2012, 2013). This makes up 10% and 8.9% of the total county area, resulting in a decrease of 1.1% from 2012 to 2013.

Native vegetation in the Red River Valley included tallgrass prairie grasses and forbs such as big bluestem (*Pascopyrum smithii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), slender wheatgrass (*Elymus trachycaulus*), meadow anemone (*Anemone canadensis*), prairie cinquefoil (*Potentilla argute*), prairie blazing star (*Liatris pycnostachya*), and tall goldenrod (*Solidago altissima*). The Red River Valley is primarily a treeless plain, but trees can be found in riparian areas and shelterbelts. The deciduous riparian forest consist of primarily American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and bur oak (*Quercus macrocarpa*) trees (Hagen et al. 2005).

METHODS

In 2012, we captured adult female white-tailed deer (<1.5 year old) with helicopter net guns (Native Range Capture Services, Ventura, California, USA) and radiocollared them in northeastern North Dakota. We targeted deer west of the Interstate, I-29, in Walsh County, North Dakota. A helicopter crew member hobbled, blind folded, aged, and radiocollared deer. In addition, vaginal implant transmitters (VITs) were inserted in select does. VITs were inserted through a 0.5” ID PVC pipe. The inserted end of the pipe was cut at a 45 degree angle, and the edges were rounded and polished smoothed.

In winter 2013, we captured white-tailed deer with modified Clover traps (Clover 1954). These deer were targeted east of the Interstate, I-29, along the Red River, which formed the eastern boundary of the study area. We pre-baited each trap with a mineral block, sugar beets, alfalfa, corn, and molasses and rebaited traps with alfalfa and corn. Traps were checked morning and evening; we physically restrained captured individuals, fitted blind folds, and attached radiocollars (Advanced Telemetry Systems, Isanti, MN, USA) or ear tags (Y-Tex, Cody, WY, USA). We radiocollared adult and yearling females (>1.5 year) and ear-tagged adult (>1.5 years) and yearling males (1.5 years), and male and female fawns (<1 year). As in 2012, vaginal implant transmitters (VITs) were inserted in select does.

Our neonate capture events occurred from 15 May 2012 to 30 June 2012 and 15 May 2013 to 30 June 2013. We monitored Vaginal Implant Transmitters (VITs) daily and walked in on the indicator signal <1 hr of detecting a mortality signal. We intensively searched areas around the VIT and doe. We also captured neonates by spotlighting, random searches, and intensively searching areas of observed female postpartum behavior, i.e. isolation and short fleeing distance after disturbance (Grovenburg et.al. 2010, Schaffer 2013). After capture, neonates were fitted with expandable collars (Advanced Telemetry Systems, Isanti, MN, USA). To avoid post capture abandonment, we minimized human scent by placing collars in natural vegetation 4 weeks prior to the capture and wearing latex gloves. After fitting the collar, we determined sex, measured hoof growth (mm), and measured weight (gm) using a 4.8-mm mesh bag. We used hoof growth measurements and known fawn ages from vitted does to calculate age for randomly caught fawns. Our animal handling methods were approved by the Institutional Animal Care and Use Committee at South Dakota State University and followed guidelines for care and use of mammals established by the American Society of Mammalogists (Sikes et al. 2011).

We located neonates and their sequential bed sites using omnidirectional antennas and hand-held 4-element Yagi antennas (Advanced Telemetry Systems, Isanti, MN). We marked bed sites at a set distance and direction from the site and returned 1-3 days later to collect vegetation measurements. We recorded and measured 1-3 bed sites per radiocollared neonate.

A secondary site was chosen at random within 250 m and similar cover type of each neonate bed site. Cover types were classified as forest, grasslands, Conservation Reserve Program grasslands (CRP), cattails (Tyhpa spp.), and agricultural fields. A modified Robel pole (Robel et al. 1970) with 10–cm increments was used 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 visually estimated percent cover using 5% increments for forbs, grasses, shrubs, trees, bare ground, woody debris, litter, cattails, and row crops 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 in each cardinal direction of the site center using a spherical densiometer (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).

RESULTS

From 15 May 2012 – 30 June 2012, we captured and radiocollared 18 neonates (11 males, 7 females). From 11 May 2013 – 30 June 2013, we captured and radiocollared 19 neonates (9 males, 10 females). All neonates in 2012 were captured west of the interstate, I-29. In 2013, capture efforts were separated between the two study sites, and 10 neonates were captured east of the interstate and 9 neonates were captured west of the interstate. The average weight at capture west of Interstate 29 was 3.58 kg (n=28, SE=0.19) and 3.93 kg (n=9, SE=1.23) east of Interstate 29. Average age at capture west and east of Interstate 29 was 1.75 (n=28, SE=0.34) and 1.20 (n=9, SE=0.40), respectively.

A total of 81 bed sites and 81 random sites were located and analyzed throughout May and June of 2012 and 2013. We located 61.7% of bed sites in forested areas, 16.1% in CRP, 14.8% in Grass/Pasture lands, 3.7% in cattails, and 3.7% in agricultural fields. Mean forested cover was 7.5% east of the interstate and 2.4% west of the interstate. Habitat-specific selection was not significant (X_5^2=9.41, P=0.051), but does trend towards using forested areas for bed sites.

In microhabitats, grass was the most abundant cover type used with a mean percent cover of 58.94% for bed sites and 59.55% for random sites (Table 4.1). Cover types did not differ between bed sites and random sites ($F_{16,160}$ = 0.32, P = 0.859) nor between years ($F_{1,79}$ = 0.53, P = 0.469). Percent canopy cover and tree basal area at bed sites in 2012 and 2013 was 41.95% (SE=0.44) and 46.14% (SE= 0.47) and 12.19 m^2/ha (SE=0.15) and 12.27 m^2/ha (SE=0.15), respectively. The vertical height (VOH) and density of understory vegetation at bed sites in 2012 and 2013 was 55.44 cm (SE=0.36) and 51.70 cm (SE=0.33) and 12.87 cm (SE=0.19) and 11.82 cm (SE=0.19), respectively. VOH and density of vegetation differed among study areas for surviving neonates. Mean VOH and density were greater for neonates that survived east of Interstate 29 and mean VOH and density were less for fawns that survived west of the Interstate 29 (Table 4.2). Of the fawns that died within the first two weeks of life east of Interstate 29, one of three died due to probable predation. Of the fawns that died within the first two weeks of life west of Interstate 29, three of the seven mortalities were due to predation/probable predation. An additional 7 fawn mortalities occurred from two to eight weeks of life west of Interstate 29. All of these mortalities were classed as probable predation (Table 4.3).

DISCUSSION

In northeast North Dakota, crop emergence occurs around the same time as the fawning period. With 83% cultivated land in northeast North Dakota, the majority of the landscape is bare to minimally covered throughout the start of the fawning period. Fawning habitat is primarily limited to the remaining 11.4% of the landscape comprised of forested areas, CRP, grasslands and pasture, and cattails. There were two occurrences of fawns bedding in wheat fields, and they both occurred in 2012. The winter of 2012 was mild in precipitation allowing for an earlier plant date, 03 April 2012 versus 23 April 2013 (United States Department of Agriculture 2013). This allowed for slightly higher vegetation heights and more mature field crops throughout the time of fawning. Even with the abundance of this cover type and taller grasses and crops in 2012, there was still a strong trend towards neonates utilizing forested areas over other habitat types on the landscape (62%) which accounted for 2.9% of the study area. Huegel et al. (1986) also reported a high percentage, 77%, of bed sites in areas with canopy cover. This is higher than other studies conducted in the Northern Great Plains. Bed sites in forested areas were reported as 23% in north-central South Dakota (Grovenburg et al 2010) and 25% in central North Dakota (Schaffer 2013).

The mean height of vegetation (55.4 cm) was less than that reported in central North Dakota (87.3 cm) (Schaffer 2013) and north-central South Dakota (76.6 cm) (Grovenburg et al. 2010). Differences may arise from climate differences as well as the prevalence of shorter grass species within forested areas. Height of vegetation was found to be an important characteristic in bed site selection in central North Dakota (Schaffer 2013) and north-central South Dakota (Grovenburg et al. 2010). Uresk et al. (1999) reported fawns selecting for bed sites that exhibited a greater vegetation height within forested cover. Encompassing the entire study area, neonates did not select for any microhabitat characteristics within cover types.

We did, however, find a difference in vegetation height and density among surviving neonates within study sites. Surviving neonates west of the interstate selected for lower vegetation height and density than the non-surviving neonates. In contrast, surviving neonates east of the interstate selected for higher vegetation height and density than the non-surviving neonates. Ciuti et al. (2014) noted as oil fragmentation increased in the presence of high predator populations, mule deer (*Odocoileus hemionus*) fawn survival decreased. Rohm et al. (2007) also noted increased white-tailed deer fawn survival in areas of continuous, irregular forest patches, which can affect a predator's ability to locate neonates. Our findings support these statements. East of Interstate 29 (I-29), where fawn survival was highest, there was less fragmentation, greater forest cover, and large, irregular patches of bedding cover along the river corridor. West of I-29 where fawn survival was low, roads and agriculture fragmented bedding cover to smaller and/or narrower patches. Forest cover with a vegetated understory was limited to farmsteads and linear tree belts. This fragmentation could have resulted in does having fawns in smaller areas that allow predators to search more efficiently. Because forested cover is limited west of I-29, and predators can efficiently search it, perhaps it is more advantageous for a neonate to select a bed site in an area where a predator may not typically search, such as areas with less dense, shorter grasses.

MANAGEMENT IMPLICATIONS

In northeastern North Dakota, development and agricultural practices continue to fragment the available habitat and concentrate deer populations and fawning habitat. As a result of this fragmentation, adult females have fawns in smaller areas that predators are able to search more efficiently, thus, resulting in lower neonate survival. Our research supports the importance of forested cover and the shape and size of habitat patches. A management goal of increasing the amount of forested cover may not be possible in an agriculturally dominated landscape, but importance may be placed on preserving the remaining forested cover and improving size, shape, and interspersion of essential habitats. This could be achieved partially through greater promotion of the department's abandoned farmstead protection program and promotion of the importance of shelter belts. By improving these landscape-level habitat characteristics, the effectiveness of coyote predation on fawns may be reduced by reducing the predator's ability to search these small patches of habitat. I suggest that more research be conducted on neonatal bed site habitat selection and predator interactions throughout the Northern Great Plains.

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Table 4-1. Mean (and SE) microhabitat characteristics for neonate bed sites for 37 radiocollared neonate white-tailed deer (*Odocoileus virginianus*) in northeastern North Dakota, 2012–2013

Habitat	Use (n=81)		Random (n=81)	
	$\bar{x}$	SE	$\bar{x}$	SE
Grass (%)	58.94	0.39	59.55	0.40
Forb (%)	6.22	0.15	6.06	0.16
Shrub (%)	0.10	0.01	0.04	0.00
Row crop (%)	3.29	0.17	3.12	0.20
Woody debris (%)	8.50	0.14	7.76	0.13
Rock (%)	1.75	0.06	1.59	0.04
Cattail (%)	4.08	0.21	3.69	0.21
Bare (%)	2.87	0.12	2.61	0.12
Litter (%)	7.76	0.17	9.40	0.18
Vertical height (cm)	55.44	0.36	51.70	0.33
Density (cm)	12.87	0.19	11.82	0.19
Tree canopy cover (%)	41.95	0.44	46.14	0.47
Tree basal area (m2/ha)	12.19	0.15	12.27	0.15

Table 4-2. Comparing mean (and SE) visual obstruction height (VOH) and density values of bed site vegetation for surviving and non-surviving radiocollared neonate white-tailed deer (*Odocoileus virginianus*) west and east of the interstate in northeastern North Dakota, USA, 2012-2014.

	East Interstate			
	Survived[a]	N	$\bar{x}$	SE
VOH (cm)	0	6	24.50	7.07
	1	38	42.28	5.31
DENSITY (cm)	0	6	0.75	0.48
	1	38	8.70	2.37
	West Interstate			
VOH (cm)	0	40	68.63	5.32
	1	78	53.59	1.80
DENSITY (cm)	0	40	19.86	3.09
	1	78	11.16	1.28

[a] 0 = did not survive >2 weeks of life; 1 = survived >2 weeks of life

Table 4-3. Comparison of surviving and non-surviving radiocollared neonate white-tailed deer (*Odocoileus virginianus*) and cause specific mortality west and east of the Interstate, I-29, in northeast North Dakota, USA, 2012-2014.

	East I-29	West I-29
Survived <2 weeks of life	6	21
Died <2 weeks of life	3	7
Predation	1	3
Poor Nutrition/Starvation	2	4
Survived >2 weeks of life	3	7
Died >2 weeks of life	-	7
Predation		7

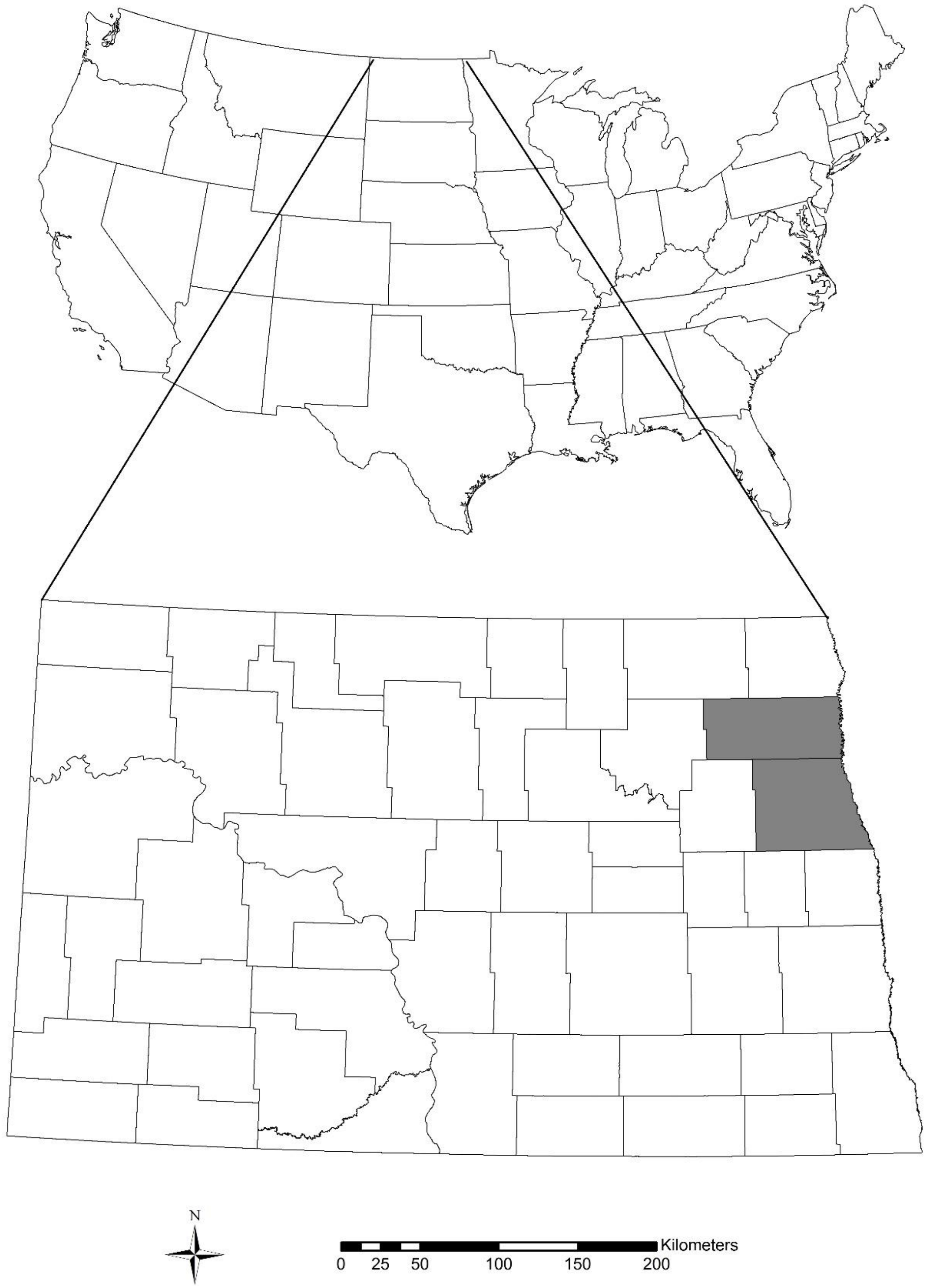

Figure 4-1. Study area where adult female white-tailed deer (*Odocoileus virginianus*) were captured in northeast North Dakota, USA, 2012-2013. Shaded area is Walsh and Grand Forks Counties.

CHAPTER 5: MANAGEMENT IMPLICATIONS

The importance of this research is evident due to the lack of previously documented white-tailed deer research completed in the Red River Valley of North Dakota. Much of the previous research in the Northern Great Plains has been completed in regions that differ in landscape-level habitat and vary in climate, both which are known to affect the several factors that influence white-tailed deer populations.

Because the study area is largely agricultural, high quality food sources are abundant nearly year round. The scarcity of large, dense forested areas interspersed among the agricultural fields may be the reason for the high number of resident deer in northeast North Dakota. Both winters during the study were considered severe based on the Deer Winter Severity Index (DWSI). When snowfall totals start to cover food sources and forested areas, deer were forced to make late season movements into new areas.

These late season movements may affect winter aerial surveys flown by the North Dakota Game and Fish Department. Deer have the potential to move outside of the monitoring block during the same time period the survey flights are completed, which can affect long-term population trends. Also, deer consistently moved between North Dakota and Minnesota across the Red River during winter, so biased population estimates may occur from flights flown near the river. The information collected on deer movement patterns show that they are affected by weather conditions and food and habitat availability, all varying greatly within the Northern Great Plains. During the winter, deer moved into farmsteads, towns and other residential areas, making them unavailable to count during flight. Yet, comparing aerial observations to intensive ground searches revealed 84% of the deer in the aerial survey block were counted by aerial observers. This supports the assumption that aerial surveys provide an adequate index of population numbers.

The winter conditions may also have affected the high rate of natural mortality experienced throughout the study. License allocations may need to be adjusted following successive severe winters to account for natural mortality through decreased body condition, diminished food sources and vulnerability to predation.

Additionally, with advancements in agriculture changing landscape-level habitat, wildlife managers need to account for the potential change in white-tailed deer population dynamics. Tree belt removal and grassland conversion may increase migration probability and distance, predation potential, and reduce survival rates. The majority of deer were concentrated around larger tracts of forested area and neonate bed sites were commonly found within treebelts, farmsteads, and wooded riparian areas. It is difficult to determine if the deer truly selected for these areas or if they were forced to use these areas as a result of few CRP acres in the study area. Nevertheless, suitable habitat continues to decrease with the constant expansion and improvements in agriculture. Programs that increase CRP acres or protect current forested areas should be advertised more or made more lucrative or competitive.

The variables studied during the project are known to vary among years and between regions. This study only provided a snapshot in time and space and managers must consider continuous monitoring efforts to help understand deer in northeastern North Dakota. In the Northern Great Plains, as the loss of CRP, grassland conversion, wetland drainage, and tree belt removal continue to change the landscape and reduce patch size for hiding cover; survival rates could be affected by an increase in vulnerability to hunters, predator efficiency, and environmental stressors, and thus, recruitment may be reduced. Hunter harvest was not the greatest cause of mortality, but manipulating tag allocations remains the primary management tool for the North Dakota Game and Fish Department. With the ever-changing landscape, harvest strategies may need to take a more conservative approach in the future to maintain deer populations. The continuation of winter aerial deer surveys, hunter harvest surveys, hunter observation surveys, winter severity monitoring, and research will allow managers to set appropriate management goals and plans in the future.