

**SEASONAL MOVEMENTS OF WHITE-TAILED DEER IN EASTERN SOUTH
DAKOTA AND SOUTHWESTERN MINNESOTA RELATIVE TO
TRADITIONAL RANGES AND MANAGEMENT UNIT BOUNDARIES**

BY

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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 conclusions of the major department.

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ABSTRACT**SEASONAL MOVEMENTS OF WHITE-TAILED DEER IN EASTERN SOUTH
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Knowledge of movement patterns, cause-specific mortality, and survival rates is imperative to understanding population dynamics of white-tailed deer (*Odocoileus virginianus*). Deer management requires an understanding of seasonal movements relative to traditional ranges and management unit boundaries. In addition, knowledge of survival and cause-specific mortality of adults and neonates provides vital information pertaining to reproduction, sex-ratio, and age-structure of white-tailed deer. Population dynamics of white-tailed deer in southwestern Minnesota have been extensively studied in recent years; however, little information exists regarding survival and movements of deer in eastern South Dakota. The purpose of this study was to provide accurate, site-specific data regarding white-tailed deer population dynamics in eastern South Dakota and southwestern Minnesota. Primary objectives were to document seasonal movements and survival rates of adult deer in the region. Secondary objectives were to calculate seasonal home ranges and document seasonal movement strategies relative to management unit boundaries. In addition, for fawn (~8-10 months) and adult (≥ 1.5

years) radiocollared deer, objectives were to determine cause-specific mortality and estimate seasonal, annual, and overall survival rates. Furthermore, for radiocollared neonates (<1 month at capture), objectives were to document cause-specific mortality and estimate monthly and summer (May-August) survival rates. From September 2002 to December 2004, radio telemetry was used to monitor the movement and mortality of 65 (49 adult, 16 fawn) white-tailed deer at Lincoln County, Minnesota and Grant and Brookings counties, South Dakota. A total of 6,707 deer locations was collected, with a mean error ellipse (95%) of 1.92 ha. I documented a total of 175 seasonal movements during 5 periods of migration; fall 2002 ($n = 18$), spring 2003 ($n = 41$), fall 2003 ($n = 35$), spring 2004 ($n = 46$), and fall 2004 ($n = 35$). Primary stimuli influencing seasonal migration were temperature and snow depth. Mean migration distance between seasonal home ranges was 10.1 km (SE = 0.6, $n = 120$). During migratory periods, percentages of migrants crossing management unit boundaries en route to subsequent ranges ranged from 31.8 to 48.1%. In addition, 4 (6.2%) deer dispersed a mean distance of 90.8 km (SE = 36.2, range = 143.6 km). A total of 113 individual home ranges was calculated during 4 periods of seasonal range use; winter 2002-03 ($n = 11$), summer 2003 ($n = 36$), winter 2003-04 ($n = 25$), and summer 2004 ($n = 41$). Mean 95% home range sizes during winter and summer ranged from 1.55-4.57 km² and 1.04-3.60 km², respectively. During this study, 25 deer (≥ 0.5 years) died, and the overall (28 month) survival rate was 0.49 (SE = 0.06, $n = 65$). Annual survival rates during 2003 and 2004 were 0.86 (SE = 0.05, $n = 45$) and 0.69 (SE = 0.06, $n = 51$), respectively. Adult survival was predominantly dependant on human-related factors (i.e., hunting, vehicle collisions), which caused

76.0% of all mortalities. Natural causes of death (i.e., predation, disease) only contributed 8.0% to total mortality. Lengthy hunting seasons, lack of escape cover, and a well-established road network in eastern South Dakota and southwestern Minnesota likely influenced susceptibility of white-tailed deer to human-induced mortality. Radio telemetry also was utilized to monitor survival and cause-specific mortality of 41 (26 male, 15 female) white-tailed deer neonates. During this study, *Canid* predation accounted for 100% ($n = 2$) of neonate mortalities. Pooled neonate survival rate was 0.95 (SE = 0.04, $n = 41$) during May-August 2002-03. High neonate survival was likely attributed to low predator densities, quality vegetation at neonatal bedding areas, and superior nutritional condition of reproductive females. This study provided extensive, empirical data regarding survival and movements of white-tailed deer in eastern South Dakota and southwestern Minnesota. These data will be used to refine deer population models and assist wildlife agencies with management decisions. However, continuous monitoring is required to further understand population dynamics of white-tailed deer, which will enhance adaptive management strategies.

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CHAPTER 1

INTRODUCTION AND STUDY AREA

BACKGROUND

Throughout history, white-tailed deer (*Odocoileus virginianus*) populations in eastern South Dakota and southwestern Minnesota have fluctuated similarly to other deer populations in the Northern Great Plains (Cook 1945, Sparrowe and Springer 1970). By the late 1800's, deer were nearly eradicated as a result of advancing settlement and unregulated hunting, which restricted deer to remaining riparian habitats in the region (Cook 1945, Kernohan et al. 2002). During the mid 1900's, land use practices (i.e., planting of cultivated crops, timber management) provided white-tailed deer with suitable habitat and various sources of high-quality forage, allowing proliferation of the species (Cook 1945, Kernohan et al. 2002). Deer have readily adapted to the checkerboard mosaic of habitats that characterize the Midwest and Northern Great Plains (Nixon et al. 2001, Brinkman et al. 2004), and high deer densities commonly occur in this intensively farmed region (Naugle et al. 1996), despite limited patches of permanent cover. Thriving white-tailed deer populations must be actively managed to maintain levels that are acceptable to the various stakeholders (i.e., hunters, landowners) interested in this important resource.

Currently, white-tailed deer in this region of the Northern Great Plains are managed through the use of political boundaries. Harvest quotas in eastern South Dakota and southwestern Minnesota are based on management units (counties) and permit areas, respectively. State agencies (i.e., South Dakota Department of Game, Fish, and Parks, Minnesota Department of Natural Resources) utilize population models to determine the number of deer that can be harvested to maintain populations within management goals.

In addition, models assist managers in assigning specific numbers of male and female (antlerless) deer tags to each management unit or permit area. Population models incorporate several variables, including population size, age-structure, sex-ratio, harvest data, survival rates, reproductive data, registration rate, illegal harvest rate, and wounding loss (Brinkman 2003, South Dakota Department of Game, Fish, and Parks 2003). Models then generate output based on these variables, which aids managers in implementing management strategies.

In South Dakota and Minnesota, existing population models do not incorporate movement patterns of white-tailed deer, even though deer exhibit several movement strategies in this region. Seasonal migration of northern white-tailed deer, primarily in response to temperature and snow depth, has been well documented (Nelson 1995, 1998, Sabine et al. 2002, Brinkman et al. 2005, Swanson 2005). In northern regions, variable winter weather causes inconsistent patterns of migration. In addition, migration distances of white-tailed deer in this region typically exceed 10 km (Sparrowe and Springer 1970, Kernohan et al. 1994, Brinkman et al. 2005, Swanson 2005), potentially representing a significant seasonal exchange of deer across management units (Rosenberry et al. 1999, Brinkman et al. 2005). Hence, deer may have seasonal (i.e., summer, winter) home ranges in different management units (Swanson 2005). Knowledge of underlying causes and effects of seasonal migration would allow managers to incorporate predicted patterns of movement into population models, thus enhancing white-tailed deer management.

White-tailed deer dispersal also is common in the Northern Great Plains, and movements exceeding 200 km have been documented (Kernohan et al. 1994, Brinkman

et al. 2005), likely due to limited permanent cover in the region (Long et al. 2005). These long-distance movements generally transcend both management unit and state boundaries and have the potential to significantly affect white-tailed deer population dynamics. However, dispersal is difficult to accurately measure; hence, managers typically assume immigration and emigration are equivalent (Johnson 1994, Rosenberry et al. 1999). Knowledge of deer dispersal rates and distances would allow managers to further understand genetics, population dynamics, transfer of invasive species, and establishment of endangered species (Long et al. 2005). In addition, the spread of chronic wasting disease (CWD), a biologically dangerous transmissible spongiform encephalopathy, has concerned wildlife managers in recent years (Williams et al. 2002). Understanding dispersal patterns permits management agencies to monitor and prepare for the spread of such diseases (Swanson 2005).

Knowledge of survival rates and cause-specific mortality is imperative to understanding population dynamics of white-tailed deer (Nelson and Mech 1986, Dusek et al. 1992, DePerno et al. 2000, DelGiudice et al. 2002, Brinkman et al. 2004). Adult and neonate survival is generally high in this region and primarily depends on human-induced factors (i.e., hunting, vehicle collisions) and predator densities (Brinkman et al. 2004, Swanson 2005). Survival rates are currently included in population models; however, rates are usually based on theoretical estimates, rather than precise spatial and temporal data. Survival research provides vital information regarding reproduction, sex-ratios, and mortality of white-tailed deer (Downing and McGinnes 1969). Excluding this information from management strategies could lead to overexploitation of heavily

hunted populations (Nelson and Mech 1986). Thus, this type of research improves the predictive proficiency of wildlife managers and is essential for continued enhancement of population models (Ballard et al. 1999).

Due to social pressures, wildlife agencies in South Dakota and Minnesota are forced to manage for high-density white-tailed deer populations, while minimizing depredation to agricultural crops (Dusek et al. 1992). In this region, Naugle et al. (1994) determined that landowners' perceptions of deer populations are mainly influenced by deer densities. Thus, managers require accurate spatial and temporal data to maintain deer populations within management goals.

Primary objectives of this research were to document seasonal movements and survival rates of adult white-tailed deer in eastern South Dakota and southwestern Minnesota. Secondary objectives were to calculate seasonal home ranges and determine seasonal movement strategies (i.e., migration, dispersal) relative to management unit and permit area boundaries. In addition, for fawn (~8-10 months) and adult (≥ 1.5 years) radiocollared deer, objectives were to determine cause-specific mortality and estimate seasonal, annual, and overall survival rates. Furthermore, for radiocollared neonates (<1-4 months old), objectives were to document cause-specific mortality and estimate monthly and summer (May-August) survival rates.

STUDY AREA

This study was conducted from September 2002 to December 2004 in the highly fragmented landscape of eastern South Dakota and southwestern Minnesota (44° 11' N to 45° 20' N - 96° 5' W to 97° 13' W). More specifically, study areas and capture locations

included Brookings and Grant counties, South Dakota and Lincoln County, Minnesota (Fig. 1). These study sites were selected, because they serve as traditional winter ranges for deer in the region. Lincoln, Grant, and Brookings counties lie in the Prairie Coteau region, which was formed by the Wisconsin Glaciation (Westin et al. 1959). The Coteau is a large, “dead-ice moraine”, which historically contained numerous wetlands (Johnson and Larson 1999). Soils that developed on the Coteau are fertile, resulting in high agricultural productivity; thus, nearly all of the land in this region, including wetlands, has been converted to farmland.

Due to the close proximity of selected counties, major land use/cover types were relatively similar between study sites (Table 1). This region is dominated by agricultural activities, with cultivated land and pasture/grassland constituting 56.6 and 34.9% (91.5% combined), respectively, of total land use (Table 1; National Landcover Data Set, Vogelmann et al. 2001). In 2002, the number of farms operating in Lincoln, Grant, and Brookings counties were 761, 548, and 962, respectively (Minnesota Agriculture Statistics Service 2002, South Dakota Agriculture Statistics Service 2002). Primary harvested crops include soybeans (*Glycine max*), corn (*Zea mays*), wheat (*Triticum aestivum*), and alfalfa (*Medicago sativa*). Grasslands in this region are dominated by tall and mixed-prairie grasses, including Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), smooth brome grass (*Bromus inermis*), tall dropseed (*Sporobolus asper*), prairie dropseed (*Sporobolus heterolepis*), sideoats grama (*Bouteloua curtipendula*),

porcupine grass (*Stipa spartea*), and western wheatgrass (*Elymus smithii*; Johnson and Larson 1999).

Remaining land use/cover types are wetlands (4.0%), woodlands (2.0%), open water (1.8%), residential areas (0.8%), rocky areas (<0.5%; i.e., gravel pits), and transitional land (<0.5%, Table 1; Vogelmann et al. 2001). Common wetland plants include prairie cordgrass (*Spartina pectinata*), reed canarygrass (*Phalaris arundinacea*), common reed (*Phragmites australis*), cattails (*Typha* spp.), rushes (*Juncus* spp.), and sedges (*Carex* spp.; Johnson and Larson 1999). Woodlands are dominated by American elm (*Ulmus americana*), bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), and eastern cottonwood (*Populus deltoides*; Johnson and Larson 1999).

This research was conducted near the towns of Lake Benton in Lincoln County, Stockholm in Grant County, and Astoria in Brookings County (Fig. 1). This region has a continental climate type, consisting of hot, wet summers and long, cold winters (Westin et al. 1959, Hokanson et al. 1970, Miller 1979). Lincoln County is characterized by flat to steeply rolling topography, with elevation ranging between 579 and 610 m above mean sea level (Hokanson et al. 1970). Average temperatures during winter (i.e., December-February) and summer (i.e., June-August) are -8.9 and 21.7°C, respectively. Average annual snowfall and precipitation are approximately 86.4 and 62.2 cm, respectively, with 78% of total precipitation occurring between April and September (Hokanson et al. 1970).

Grant County lies at the transition of the Prairie Coteau and Minnesota-Red River Lowlands and is characterized by a slightly undulating to hilly relief (Miller 1979).

Elevation ranges between 298 and 610 m above mean sea level, and this region is drained by the Big Sioux River. Average winter and summer temperatures are -8.9 and 21.7°C , respectively. Average annual snowfall is approximately 91.9 cm. Mean annual precipitation is 55.7 cm, with 80% occurring between the months of April and September (Miller 1979).

Brookings County is located entirely on the Prairie Coteau and is characterized by flat to gently sloping topography (Westin et al. 1959). Elevation ranges from 488 to 579 m above mean sea level, and this area is drained by the Big Sioux River, along with its tributaries. Average temperatures are -8.6°C during winter months and 21.0°C during summer months. Average annual precipitation is approximately 54.9 cm, with 78% occurring between April and September (Westin et al. 1959).

Although Lincoln, Grant, and Brookings counties lie in close proximity to one another, harvest management differs between these areas. In southwestern Minnesota, regular firearms seasons are divided into 2 (i.e., 2 day, 4 day) periods. In eastern South Dakota, firearms seasons differ between northern and southern zones (counties). Grant County is located in the northern zone, whereas Brookings County lies in the southern zone. Firearms seasons in southwestern Minnesota during fall 2002, 2003, and 2004 were 9-10 and 16-19 November, 8-9 and 15-18 November, and 6-7 and 13-16 November, respectively. During fall 2003 and 2004, regular firearms seasons for northern/southern zones in eastern South Dakota were 15-30/22-30 November and 20 November-5 December/27 November-5 December, respectively. Furthermore, lengthy archery and muzzleloader hunting seasons occurred annually in all study areas.

CHAPTER 2

**SEASONAL MOVEMENTS OF WHITE-TAILED DEER IN EASTERN SOUTH
DAKOTA AND SOUTHWESTERN MINNESOTA**

INTRODUCTION

Movements of white-tailed deer have been documented in several localities of varying environmental conditions, such as Texas (Michael 1965), Minnesota (Rongstad and Tester 1969, Nelson 1995, Brinkman et al. 2005, Swanson 2005), South Dakota (Sparrowe and Springer 1970, Kernohan et al. 1994), New Brunswick (Drolet 1976, Sabine et al. 2002), Wisconsin (Larson et al. 1978), New York (Tierson et al. 1985), Missouri (Root et al. 1990), Michigan (Van Deelen et al. 1998), and Nebraska (VerCauteren and Hygnstrom 1998). White-tailed deer exhibit three primary movement patterns, which were described by Kernohan et al. (1994) as short distance, dispersal, and migratory. Short distance movements generally occur in southern regions where winter weather is less severe (Michael 1965, Alexander 1968, Marchinton and Hirth 1984, Gaudette and Stauffer 1988, Nelson 1998, Sabine et al. 2002). Dispersal movements are permanent long-distance shifts from previous home ranges to new home ranges, and these typically occur throughout the range of white-tailed deer (Hawkins et al. 1971, Kammermeyer and Marchinton 1976, Nelson and Mech 1992, Kernohan et al. 1994). In eastern South Dakota and southwestern Minnesota, deer demonstrate an annual pattern of seasonal migration between summer and winter ranges, which is a common behavior occurring in northern latitudes (Carlsen and Farnes 1957, Nelson and Mech 1981, Kernohan et al. 1994, Nelson 1995, 1998, Van Deelen et al. 1998), where winter weather is potentially severe. However, during periods of less severe winter weather, northern white-tailed deer may inhabit the same range throughout the year (Sparrowe and Springer 1970, Nelson 1995, Brinkman et al. 2005, Swanson 2005).

In the Northern Great Plains, migration from summer to winter range commonly occurs in November and December (Sparrowe and Springer 1970) and is presumably initiated by the combination of snowfall and low temperatures (Nelson 1995, 1998). White-tailed deer generally depart winter range during March and April in this region (Sparrowe and Springer 1970), and the onset of spring migration apparently coincides with increasing temperatures and the loss of snow cover (Nelson 1995).

Research indicates that the distance and direction of migration are unrelated to sex and age-class (Kernohan et al. 1994, Van Deelen et al. 1998). Nelson (1998) suggested that migratory behavior is inherited through association with matrilineal groups. Thus, successful movement patterns learned by juvenile deer ultimately determine the distance and direction of seasonal migration. Migration between summer and winter ranges in eastern South Dakota is generally directed upon physiographic features of the landscape (Sparrowe and Springer 1970, Kernohan et al. 1994).

Currently, harvest quotas in South Dakota and Minnesota are based on political boundaries. Potential problems encountered with this management system are that pre-harvest counts of white-tailed deer may not coincide with actual populations within each region during harvest, due to migration of deer from summer to winter ranges. Sparrowe and Springer (1970) suggested that deer management units might be more effective as a management tool if they were based on physiographic features rather than county boundaries, because deer movement in this region of the Northern Great Plains generally follows stream systems that are not associated with political boundaries.

However, eastern South Dakota and southwestern Minnesota have few physiographic features that differ to the extent that they impact deer populations.

Movement of white-tailed deer in the region has been documented (Sparrowe and Springer 1970, Kernohan et al. 1994, 2002, Brinkman et al. 2005, Swanson 2005).

However, little information exists on timing and extent of deer movement relative to management unit boundaries. Therefore, the objectives of this research were to

(1) document seasonal movement patterns of white-tailed deer in eastern South Dakota and southwestern Minnesota relative to traditional ranges and existing management unit boundaries, and (2) calculate seasonal home ranges for deer in the region. Information gained in this study will establish movement patterns of deer populations occupying political boundaries during harvest and other seasons.

METHODS

White-tailed deer were captured using modified clover traps (Clover 1956) in Brookings and Grant counties, South Dakota from January-March 2003 and 2004.

Trapping efforts were directed towards adult female deer, because mature females, along with their offspring, dominate harvested white-tailed deer populations (VerCauteren and Hygnstrom 1998). Trapping sites were baited with a combination of shelled corn, pelleted soy hulls, apples, and molasses. To address the concerns of animal welfare, traps were checked daily to minimize stress and incidence of injury to captured individuals. In the event of injury, captured deer were sedated and treated on site. Upon capture, deer were manually restrained and blindfolded to reduce stress. Captured deer were sexed and aged as fawn (~8-10 months) or adult (≥ 1.5 years) based on tooth replacement and wear

criteria (Severinghaus 1949, Severinghaus and Cheatum 1956) and body size. Fawns were classified as yearlings upon reaching approximately 12 months of age. Chest girth measurements were taken to estimate live body weight of adults ($\hat{Y} = -15.97 + 0.08X$) and fawns ($\hat{Y} = -19.12 + 0.07X$) during the winter trapping season (Weckerly et al. 1987). Female deer were ear-tagged and fitted with radiocollars (Advanced Telemetry Systems, Inc., Isanti, MN) to assess seasonal movement patterns. Radiocollars were equipped with mortality sensors, which were activated after the collar had remained stationary for 8 hours. Captured male and additional female white-tailed deer were ear-tagged to document dispersal behavior and movements relative to hunter harvest. After processing, blindfolds were removed, and captured deer were released. Total handling time and physical condition were recorded for each individual. In addition, I continued to monitor 24 adult female white-tailed that were previously captured and radiocollared in Lincoln County, Minnesota (Brinkman 2003). All methods described in this study were approved by the Institutional Animal Care and Use Committee (IACUC; Approval No. 02-A037) at South Dakota State University (SDSU).

Radiocollared individuals were monitored 2-3 times weekly for survival and located 1-3 times weekly by ground triangulation at ≥ 20 hour intervals (Kernohan et al. 1998). Mortalities occurring < 26 days post-capture were assumed to be capture-related (Beringer et al. 1996). Deer locations were assigned Universal Transverse Mercator (UTM) coordinates. If a radiocollared individual could not be located from the ground, a fixed-wing airplane was used to locate the animal. To obtain locations for each individual, 3-5 directional bearings were taken from established telemetry stations using a

collapsible, vehicle-mounted “null-peak” antenna system (Brinkman et al. 2002) attached to an electronic compass (C100 Compass Engine; KVH Industries, Inc., Middletown, RI). This telemetry system was accurate to $\pm 1^\circ$. Locations were estimated using the LOCATE II computer program (Nams 2001), and those with 95% error ellipses ≥ 20 ha were excluded from seasonal movement and home range analyses (Giuliano et al. 1999). Estimated locations were imported into ArcView (ESRI, Inc., Redlands, CA) and overlaid onto landcover maps with management unit boundaries (Smith et al. 2002) to calculate seasonal home ranges and assess seasonal movement patterns (Kernohan et al. 1998). The fixed kernel method, a component of the Home Range Extension (HRE) for ArcView (Rodgers and Carr 1998), was used to calculate 50% (core area) and 95% seasonal home ranges. In addition, least-squares cross-validation was utilized to estimate the smoothing parameter (Seaman et al. 1999).

Deer were considered migratory if no overlap existed between seasonal home ranges. Migration date was calculated as the mean date between consecutive locations, where migration had occurred (Nelson 1995). Seasonal movement was determined by calculating the straight-line distance between centers of seasonal home ranges (Brinkman 2003). Dispersal was documented by deer movement from initial home ranges to newly established home ranges, without return to previous ranges (Lidicker 1982, Etter et al. 2002). Deer were considered obligate migrators if they migrated annually between summer and winter home ranges and remained on these respective ranges until the following migratory period (Sabine et al. 2002, Brinkman et al. 2005). Deer were considered conditional, or facultative migrators (Nelson 1995) if they failed to migrate

during all migratory periods, remained on winter range for a decreased amount of time (<1 month), or made several migrations between seasonal home ranges during a single period of winter range use (Brinkman et al. 2005). Deer were considered residents if they failed to migrate and had overlapping seasonal home ranges. Individual radiocollared deer that were monitored through at least 2 consecutive migration periods were classified as dispersers, obligate migrators, conditional migrators, or residents (Brinkman et al. 2005). Migration from summer to winter range was classified as fall migration, and migration from winter to summer range was classified as spring migration, regardless of migration date (Sabine et al. 2002).

Annual deer winter severity index (DWSI) was calculated for each study area using methods described by Brinkman (2003). Annual DWSI assigned 1 point for each day mean temperature was $\leq -7^{\circ}\text{C}$ and an additional point for each day snow depth was ≥ 35.0 cm (Brinkman 2003) during the months of October-April (Midwest Regional Climate Center 2005, South Dakota Office of Climatology 2005). Thus, daily DWSI values were 0, 1, or 2.

SYSTAT (Wilkinson 1990) was used to conduct basic statistical analyses. Analysis of variance (ANOVA) and pairwise comparisons were used to compare home range sizes and migration distances between years, seasons, and study sites (Sokal and Rohlf 1995).

RESULTS

I captured and radiocollared 41 white-tailed deer (25 adult females, 15 female fawns, 1 male fawn) during January-March 2003 ($n = 25$; Table 2, Appendix A) and

January-February 2004 ($n = 16$; Table 3, Appendix B) at two study sites in eastern South Dakota. I radiocollared 23 deer at the Brookings County study site and 18 deer at the Grant County study site. Furthermore, I ear-tagged 21 additional deer (16 male fawns, 5 female fawns; Table 4, 5, Appendix A, B) in Grant ($n = 13$) and Brookings ($n = 8$) counties.

Overall capture success was 11.8 trap-nights/radiocollared individual and 7.8 trap-nights/marked individual. Mean processing time was 5.7 minutes (Table 2, 3) for radiocollared deer and ranged from 4.0-15.0 minutes. Mean handling time for ear-tagged deer was 2.8 minutes (Table 4, 5) and varied between 1.0 and 6.0 minutes. Mean chest girth measurements for fawns and adults were 75.7 and 98.9 cm, respectively, and ranged from 67.0 to 110.0 cm (Table 2, 3, 4, 5). Average estimated body weights of captured adults and fawns were 63.1 and 33.8 kg, respectively. Three radiocollared deer (1 adult, 2 fawns) died <26 days post-capture, and mortality was assumed to be capture-related (Beringer et al. 1996). Lastly, I monitored 24 adult female white-tailed deer that were previously captured and radiocollared at the Lincoln County study site in southwestern Minnesota (Appendix C; Brinkman 2003).

I monitored deer at two study sites in eastern South Dakota and the Lincoln County study site from January 2003-January 2005 and September 2002-December 2004, respectively. I collected a total of 6,707 deer locations with a mean 95% error ellipse of 1.92 ha. I documented a total of 175 seasonal movements (Appendix D, E, F) during five periods of migration; fall 2002, spring 2003, fall 2003, spring 2004, and fall 2004. I

calculated 113 individual home ranges (Appendix E, F) during 4 periods of seasonal range use; winter 2002-03, summer 2003, winter 2003-04, and summer 2004.

Fall Migration 2002

During fall 2002, 15 (83.3%) radiocollared individuals migrated a mean distance of 9.5 km (SE = 1.4, range = 16.2 km; Table 6). Three (16.7%) deer did not migrate and had overlapping summer and winter home ranges. Median migration date from summer to winter range for migratory individuals was 28 November and ranged from 12 October to 5 December. During this period, 5 (33.3%) migratory deer crossed permit area boundaries while moving from summer to winter ranges. Median migration date for these individuals was 24 November and ranged from 3 November to 4 December.

Spring Migration 2003

During spring 2003, 27 (65.9%) deer migrated a mean distance of 8.7 km (SE = 1.0, range = 17.4 km; Table 6). Fourteen (34.1%) deer did not migrate during this period. Median migration date for 27 migrating individuals was 25 March and ranged from 7 December 2002 to 20 April 2003. In addition, three deer dispersed a mean distance of 64.3 km (SE = 34.9, range = 107.2 km; Appendix E). Median dispersal date was 12 June and ranged from 13 April to 20 June. Mean migration distances in Lincoln, Grant, and Brookings counties were 10.3 (SE = 1.4, $n = 16$), 7.4 (SE = 1.9, $n = 6$), and 5.5 km (SE = 2.0, $n = 5$), respectively (Table 6). Percentages of migratory deer in Lincoln, Grant, and Brookings counties were 84.2, 85.7, and 33.3%, respectively. One dispersal movement was documented at each of the three study sites.

During this period, 13 (48.1%) of the migratory and dispersing deer moved across management unit or permit area boundaries in transit to summer ranges. Median migration, or dispersal date, for these individuals was 27 March and ranged from 16 March to 20 June. In addition, 7 (50.0%) nonmigratory deer had home ranges that overlapped unit boundaries.

Fall Migration 2003

During fall 2003, 24 (68.6%) deer migrated a mean distance of 8.7 km (SE = 1.1, range = 18.6 km; Table 6). Eleven (31.4%) deer did not exhibit migratory behavior. Median departure date for 24 migratory individuals was 29 November and ranged from 22 October 2003 to 4 January 2004. Mean migration distances of deer in Lincoln, Grant, and Brookings counties were 10.2 (SE = 1.6, $n = 14$), 6.5 (SE = 0.9, $n = 4$), and 6.5 km (SE = 2.3, $n = 6$), respectively (Table 6). In Lincoln, Grant, and Brookings counties, percentages of migratory deer were 87.5, 80.0, and 42.9%, respectively.

During this period, 9 (37.5%) migratory deer crossed management unit boundaries in route to winter ranges. Median departure date for these deer was 30 November and ranged from 11 November to 27 December. Also, 5 (45.5%) nonmigratory deer had home ranges that extended into multiple management units.

Spring Migration 2004

During spring 2004, 32 (69.6%) radiocollared deer migrated a mean distance of 10.7 km (SE = 1.3, range = 34.5 km; Table 6). Fourteen (30.4%) deer did not migrate. Median migration date for 32 migratory deer was 24 March and ranged from 16 February to 25 July. In addition, one Grant County deer initially migrated from winter to summer

range, but later dispersed 170.4 km on 17 June (Appendix F). Mean migration distances of deer in Lincoln, Grant, and Brookings counties were 10.2 (SE = 1.6, $n = 14$), 12.5 (SE = 3.0, $n = 10$), and 9.4 km (SE = 2.9, $n = 8$), respectively (Table 6). Percentages of migratory deer in Lincoln, Grant, and Brookings counties were 93.3, 71.4, and 47.1%, respectively.

Thirteen (40.6%) of the 32 migratory or dispersing deer moved across unit boundaries while traveling from winter to summer ranges. Median movement date for these individuals was 23 March and ranged from 16 February to 15 July. Furthermore, 6 (42.9%) nonmigratory deer had home ranges that were encompassed by multiple unit boundaries during this period.

Fall Migration 2004

During fall 2004, 22 (62.9%) deer migrated a mean distance of 12.7 km (SE = 1.9, range = 35.2 km; Table 6). Thirteen (37.1%) deer did not migrate. Median movement date for migratory deer was 26 November and ranged from 1 November 2004 to 7 January 2005. Mean migration distances of deer in Lincoln, Grant, and Brookings counties were 11.2 (SE = 1.8, $n = 11$), 13.0 (SE = 4.5, $n = 7$), and 16.2 km (SE = 5.6, $n = 4$), respectively (Table 6). In Lincoln, Grant, and Brookings counties, percentages of migratory deer were 91.7, 70.0, and 30.8%, respectively.

Seven (31.8%) migratory deer crossed management unit boundaries during migration. Median departure date for these individuals was 28 November and ranged from 9 November to 15 December. Additionally, home ranges of 5 (38.5%) nonmigratory deer extended into several management units.

Comparison of Migration Distances

Overall (2002-04) mean migration distance (10.1 km; SE = 0.6, $n = 120$; Table 6) of all deer was similar between years ($F_{2,117} = 2.290$, $P = 0.106$), seasons ($F_{1,118} = 0.176$, $P = 0.675$), and study sites ($F_{2,117} = 0.381$, $P = 0.684$). Deer in Lincoln, Grant, and Brookings counties migrated mean distances of 10.2 (SE = 0.7, $n = 70$), 10.6 (SE = 1.7, $n = 27$), and 9.0 km (SE = 1.7, $n = 23$), respectively, during this study (Table 6).

Deer Winter Severity Index

Average DWSIs during winter 2002-03 and winter 2003-04 were 68.7 and 59.0, respectively (Fig. 2). During winter 2002-03, DWSI values in Lincoln, Grant, and Brookings counties were 71, 67, and 68, respectively (Fig. 2). Annual DWSIs during winter 2003-04 were 57 in Lincoln County, 61 in Grant County, and 59 in Brookings County. Seasonal migration was compared to temperature ($^{\circ}\text{C}$) and snow depth (cm) during fall 2002 (Fig. 3), fall 2003 (Fig. 4), fall 2004 (Fig. 5), spring 2003 (Fig. 6), and spring 2004 (Fig. 7).

Home Ranges

Individual home ranges were calculated using a minimum of 25 and a mean of 43.6 (SE = 1.2, $n = 113$) locations. Due to lengthy capture operations, an insufficient number of locations was collected on radiocollared deer in Grant County during winter 2002-03 to calculate seasonal home ranges. During winter 2002-03, mean 50 and 95% home ranges (Table 7) in Lincoln County were 1.0 (SE = 0.4, $n = 10$) and 4.6 km^2 (SE = 1.5, $n = 10$), respectively. Mean 50 and 95% home ranges in Brookings County were 0.3 (SE = 0.0, $n = 1$) and 1.7 km^2 (SE = 0.0, $n = 1$), respectively.

During summer 2003, mean 50 and 95% home ranges (Table 7) in Lincoln County were 0.5 (SE = 0.1, $n = 16$) and 2.1 km² (SE = 0.4, $n = 16$), respectively. Mean 50 and 95% home ranges in Grant County were 0.7 (SE = 0.2, $n = 5$) and 3.6 km² (SE = 1.2, $n = 6$), respectively. Brookings County deer had mean 50 and 95% home range sizes of 0.3 (SE = 0.0, $n = 14$) and 1.4 km² (SE = 0.2, $n = 13$), respectively, during this period.

During winter 2003-04, Lincoln County deer had mean 50 and 95% home ranges of 0.6 (SE = 0.1, $n = 13$) and 2.9 km² (SE = 0.5, $n = 13$), respectively (Table 7). Mean 50 and 95% home ranges of deer in Grant County were 0.9 (SE = 0.5, $n = 3$) and 3.8 km² (SE = 2.2, $n = 3$), respectively. During this time, mean 50 and 95% home range sizes of Brookings County deer were 0.3 (SE = 0.1, $n = 9$) and 1.5 km² (SE = 0.2, $n = 9$), respectively.

During summer 2004, mean 50 and 95% home ranges (Table 7) in Lincoln County were 0.4 (SE = 0.1, $n = 15$) and 1.8 km² (SE = 0.3, $n = 15$), respectively. Grant County deer had mean 50 and 95% home ranges of 0.4 (SE = 0.1, $n = 11$) and 1.8 km² (SE = 0.3, $n = 11$), respectively. Mean 50 and 95% home range sizes of deer in Brookings County were 0.2 (SE = 0.0, $n = 15$) and 1.0 km² (SE = 0.1, $n = 15$), respectively, during this period.

Mean 50% home range sizes (Table 7) differed among study sites ($F_{2,92} = 8.036$, $P = 0.001$) and between seasons ($F_{2,92} = 4.549$, $P = 0.013$). Mean 50% home ranges of Brookings County deer differed from those in Lincoln ($P = 0.013$) and Grant ($P = 0.001$) counties. However, 50% core areas were similar ($P = 0.347$) for deer in Lincoln and

Grant counties. Mean 50% home ranges also differed ($P = 0.014$) between winter 2003-04 and summer 2004, but were similar during other periods of seasonal range use (Table 7).

Mean 95% home ranges (Table 7) differed among study sites ($F_{2,92} = 8.282$, $P < 0.001$) and between seasons ($F_{2,92} = 5.495$, $P = 0.006$). Home ranges of deer in Brookings County differed from those in Lincoln ($P = 0.018$) and Grant ($P = 0.001$) counties; however, ranges were similar ($P = 0.226$) between Lincoln and Grant county deer. Summer 2004 95% home ranges differed from summer 2003 home ranges ($P = 0.049$) and winter 2003-04 home ranges ($P = 0.012$); however, summer 2003 and winter 2003-04 95% mean home range sizes were similar (Table 7). During this study, 95% home ranges were similar ($F_{1,110} = 0.002$, $P = 0.964$) between adults (220.9 ha; SE = 22.6, $n = 98$) and juveniles (218.0 ha; SE = 49.8, $n = 14$).

Ear-Tagged Deer

Eight (38.1%) ear-tagged deer were recovered throughout this study. Mean distance between capture site and recovery location was 16.8 km (SE = 4.2, range = 35.4 km). Two (25.0%) ear-tagged deer were recovered in management units other than where they were captured. Median recovery date for ear-tagged individuals was 20 November 2004 and ranged from 31 March to 21 November 2004.

DISCUSSION

Capture

Clover trapping was a relatively safe and effective method for capturing white-tailed deer in eastern South Dakota. Three radiocollared deer died <26 days

post-capture, and necropsies revealed hemorrhaging and degeneration of skeletal and caudal muscle tissue, which are indicative of capture myopathy (Beringer et al. 1996). Mean handling time (6.2 minutes) for these individuals was slightly longer than average processing time (5.7 minutes; Table 2, 3) for all radiocollared deer. Beringer et al. (1996) suggested that handling time should be reduced to minimize stress levels of captured deer, as stress increases the likelihood of myopathy. Rate of capture myopathy (7.3%) in this study was comparable to previously documented rates (<1.0-23.5%; Palmer et al. 1980, Connor et al. 1987, Sullivan et al. 1991, Beringer et al. 1996) using various capture methods.

Overall winter trapping success (12.8%) for all captured individuals was lower than success rates of 35.9 and 41.0%, documented by Naugle et al. (1995) and Morgan and Dusek (1992), respectively. I postulate that the lower rate of capture success in this study was attributed to mild winter weather (i.e., average DWSIs = 68.7, 59.0). During the winter trapping season, deer had access to various food sources, which reduced interest in bait. Chest girth measurements were used to estimate live body weight of captured deer (Weckerly et al. 1987). Average estimated body weight at capture was 63.1 kg for adult females and 33.8 kg for fawns, which were slightly lower than those reported for adults (69.3 kg) and fawns (41.7 kg) in southwestern Minnesota (Brinkman 2003). However, Weckerly et al. (1987) stated that the relationship between chest girth and body weight may differ between areas. In addition, some error in chest girth measurements can be attributed to researchers collecting these data.

Seasonal Movement

Overall mean migration distance (10.1 km; Table 6) between winter and summer ranges in eastern South Dakota and southwestern Minnesota was comparable to previously documented white-tailed deer movements in northern regions (15.6 km, Carlsen and Farnes [1957]; 23.2 km, Sparrowe and Springer [1970]; 13.8 km, Verme [1973]; 17.0 km, Nelson and Mech [1981]; 23.8 km, Kernohan et al. [1994]; 15.3 km, Lewis and Rongstad [1998]; 1.7-9.2 km, Van Deelen et al. [1998]; 10.1 km, Brinkman [2003]; 14.6 km, Swanson [2005]). Time spent in transit between seasonal home ranges was minimal (<1 week), and few locations were obtained on migrating individuals en route to subsequent ranges. Rapid movement of deer between seasonal ranges in this study is consistent with previous research in northern regions (Rongstad and Tester 1969, Verme 1973, Sabine et al. 2002, Brinkman 2003).

Mixed movement strategies of white-tailed deer have been well documented (Rongstad and Tester 1969, Sparrowe and Springer 1970, Drolet 1976, Nelson 1995, Van Deelen et al. 1998, VerCauteren and Hygnstrom 1998, Sabine et al. 2002, Porter et al. 2004, Brinkman et al. 2005). White-tailed deer in eastern South Dakota and southwestern Minnesota demonstrated a variety of movement strategies (i.e., obligate migrators, conditional migrators, residents, dispersers). Of 49 radiocollared individuals monitored ≥ 2 consecutive migratory periods, 18 (36.7%) were obligate migrators, 16 (32.7%) conditional migrators, 11 (22.5%) residents, and 4 (8.2%) dispersers.

Primary factors influencing seasonal movements of white-tailed deer in northern regions are temperature and snow depth (Verme 1968, Ozoga and Gysel 1972, Verme

1973, Drolet 1976, Tierson et al. 1985, Nelson 1995, 1998, Sabine et al. 2002, Brinkman et al. 2005). Therefore, Brinkman (2003) created a white-tailed deer specific DWSI to ascertain whether or not the effects of temperature and snow depth on movement applied to deer in southwestern Minnesota. I applied this index, with respective components, to document the effects of temperature and snow depth on seasonal deer movement in eastern South Dakota and southwestern Minnesota.

Average DWSIs (Fig. 2) during winter 2002-03 (68.7) and winter 2003-04 (59.0) were similar, and indicated relatively mild winters during this study. Verme (1968) concluded that WSI values >100 are indicative of “severe” winters. Mild winter weather potentially explains the high percentage (32.7%) of conditional migrators during this study. Several individuals migrated to winter range, but remained there for a limited amount of time, and other deer made several migrations between seasonal home ranges during a single winter. An increase in the proportion of migratory individuals remaining on summer ranges during mild winters has been well documented in northern white-tailed deer (Rongstad and Tester 1969, Sparrowe and Springer 1970, Drolet 1976, Nelson 1995, Van Deelen et al. 1998, Sabine et al. 2002) and mule deer (*Odocoileus hemionus*; Brown 1992). Traditional winter ranges provide thermal cover (Verme 1965, Rongstad and Tester 1969, Ozoga and Gysel 1972, Verme 1973, Nelson 1995), forage (Nelson 1995), communal trail systems (Verme 1973, Nelson 1995, Sabine et al. 2002), and antipredator benefits (Nelson and Mech 1981, 1991) to white-tailed deer concentrations during severe winters. Therefore, conditional migratory behavior allows for reduced deer density and

competition for resources on traditional winter ranges during a series of mild winters (Brown 1992).

Temperature and snow depth influenced seasonal deer movement in eastern South Dakota and southwestern Minnesota. However, I speculate that the effect of snow depth on movement was minimal, because depths rarely exceeded 35.0 cm (i.e., 5 days) during this study. Fall migration in eastern South Dakota and southwestern Minnesota primarily corresponded to decreasing temperatures. During fall 2002, 66.7% of migratory deer moved to winter range during a brief period (24 November – 5 December), when mean daily temperatures ranged from 0 to -15°C (Fig. 3). During fall 2003, widely fluctuating temperatures caused a less pronounced migration from summer to winter range (Fig. 4). Most (91.7%) deer migrated when mean daily temperatures were $\leq 0^{\circ}\text{C}$ for an extended period of time (i.e., several days). During fall 2004, fluctuating temperatures again caused a wide range in migration dates (1 November 2004 – 7 January 2005; Fig. 5). The majority (90.9%) of Lincoln County deer migrated between 15 November and 19 December, when mean daily temperatures averaged -1°C. Six (85.7%) Grant County deer migrated between 21 November 2004 and 1 January 2005, when mean daily temperatures averaged -5°C. Similarly, all Brookings County deer ($n = 4$) migrated between 4 December 2004 and 7 January 2005, when mean daily temperatures averaged -8°C. Highly variable timing of fall migration observed in this study is consistent with previous research (Nelson 1995). Despite the lack of substantial snow depth, many deer initiated migration following a series of cold days (i.e., 0 to -15°C). Thus, decreasing temperature was the primary stimulus for fall movement. Similarly, the majority of

white-tailed deer in northern Minnesota moved to winter ranges after temperatures dropped to -7°C (Nelson and Mech 1981).

During this study, regular firearms hunting had little impact on deer movement and apparently did not initiate seasonal migration from summer to winter range. Median migration dates during fall 2002 (28 November; $n = 15$), 2003 (29 November; $n = 24$), and 2004 (26 November; $n = 22$) were after the onset of regular firearms seasons in both eastern South Dakota and southwestern Minnesota. Hunters frequented areas used by deer and may have caused short-term movements; however, deer returned to normal ranges within a short period of time (i.e., 1-2 days). The minimal effect of hunting on deer movement supports previous research by Kilpatrick and Lima (1999). Conversely, Sparrowe and Springer (1970), Root et al. (1988), and Naugle et al. (1997) documented increased deer movement during hunting seasons.

Temperature and snow depth also influenced spring migration of deer in eastern South Dakota and southwestern Minnesota. Median migration dates during spring 2003 and 2004 were 25 March ($n = 27$) and 24 March ($n = 32$), respectively. During spring 2003, 75.0% of Lincoln County deer departed winter range between 6 March and 2 April, when mean daily temperatures averaged 1°C and snow depth was absent (Fig. 6). All Grant County deer migrated between 24 March and 20 April, when daily temperatures averaged 6°C and all snow had melted. Similarly, all Brookings County deer migrated between 16 March and 14 April, when daily temperatures averaged 5°C and the snow pack had diminished.

During spring 2004, the majority (71.4%) of Lincoln County deer departed winter range between 20 March and 7 April, when mean daily temperatures averaged 6°C and a maximum snow depth of 33.0 cm had diminished (Fig. 7). Nine (90%) Grant County deer migrated to summer range between 23 March and 4 April, when mean temperature was 6°C and after a snow depth of 41.0 cm had melted. The majority (62.5%) of Brookings County deer migrated between 16 February and 23 March, when mean daily temperatures averaged -1°C and the snow pack (15.0 cm) had dissipated. During this study, initiation of spring migration corresponded to mean daily temperatures $\geq 1^\circ\text{C}$ and loss of snow cover. Verme (1973), Drolet (1976), Nelson and Mech (1981), Nelson (1995), and Sabine et al. (2002) reported similar spring migratory behavior in response to increasing temperatures and melting of snow. Median fall and spring migration dates during this study were similar to those documented in eastern South Dakota (Sparrowe and Springer 1970), northeastern Minnesota (Nelson 1995), northern Wisconsin (Lewis and Rongstad 1998), and northern Michigan (Van Deelen et al. 1998).

Percentages of migratory deer crossing management unit boundaries en route to subsequent seasonal ranges during 5 migratory periods (i.e., fall 2002, spring 2003, fall 2003, spring 2004, and fall 2004) ranged from 31.8 to 48.1%. Median departure dates for these individuals were comparable to other migratory deer during respective periods. Hence, deer crossing management unit boundaries generally departed summer range after the onset of regular firearms seasons. Therefore, the majority of deer was utilizing summer ranges during the hunting season and was available for hunter harvest in these areas. However, because temperature and snow depth are the primary factors influencing

seasonal deer movement in northern regions, the advent of an early, “severe” winter could potentially cause earlier migration and an increased percentage of migrants. Brown (1992), Nelson (1995), Sabine et al. (2002), and Brinkman et al. (2005) documented proportionate increases in migratory deer during severe winters. Given this scenario, deer movement to winter range could create a discrepancy between harvest quotas and numbers of deer occupying management units during hunting seasons. In addition, the percentage of nonmigratory deer occupying home ranges that extended into several management units during the 5 previously mentioned migratory periods ranged from 0.0 to 50.0%, which further impacted movement relative to unit boundaries. These resident deer frequently crossed unit boundaries, potentially affecting the number of deer available for hunter harvest in certain management units.

Dispersal

White-tailed deer dispersal is common and has been well documented in the Midwest and Northern Great Plains (Sparrowe and Springer 1970, Nelson and Mech 1992, Kernohan et al. 1994, VerCauteren and Hygnstrom 1998, Brinkman 2003). During this study, 4 deer (1 adult female, 2 yearling females, 1 yearling male) dispersed a mean distance of 90.8 km (SE = 36.2, range = 143.6 km; Appendix E, F). All dispersal movements occurred shortly after spring migration, and annual dispersal rates in 2003 and 2004 were 7.3 and 2.2%, respectively. In 2003, dispersal rates for adult females, yearling females, and yearling males were 3.0, 14.3, and 100.0%, respectively. In 2004, 20% of yearling females dispersed. Dispersal rates in this study were similar to those previously documented in eastcentral Illinois (21.0% of yearling females; Nixon et al.

1991), northeastern Minnesota (64.0% of yearling males, 20.0% of yearling females; Nelson 1993), southwestern Minnesota (5.0% of adult females; Brinkman 2003), and New York (14.3% of yearling females, 8.3% of adult females; Porter et al. 2004). However, low sample sizes of dispersing deer limit the precision of these values.

Although female white-tailed deer are predominantly philopatric, female dispersal does occur (Nelson and Mech 1992). Yearling females F145 and F502 departed winter ranges and moved to pre-dispersal summer home ranges, similar to other migratory deer. Grant County female 145 departed winter range on 28 March 2003 and migrated 15.4 km southwest to her initial summer range. She remained on summer range until 12 June, when she began dispersing in a northwest direction. I aeri ally located F145 on 30 June near Waubay, South Dakota, approximately 39.5 km from her last known location. Female 145 exhibited ever-increasing northward movements, until I was unable to locate her on 8 July. I relocated F145 on 14 August near Milnor, North Dakota, which was 87.1 km from her previous location. She remained in this general area until she was harvested on 10 November 2004. Straight-line distances from F145's newly established home range to her initial winter and summer ranges were 130.1 and 134.0 km, respectively.

Grant County female 502 exhibited similar dispersal behavior to F145. Female 502 departed winter range on 4 April 2004 and migrated 9.9 km southwest to her original summer range. On 17 June, F502 was located 12.5 km northwest of her preliminary summer range. Thereafter, I was unable to locate F502, despite several aerial telemetry attempts. Remains of F502 were discovered on 18 November near Lake Vermillion,

South Dakota, approximately 166.5 km from her last known location. There was no evidence of foul play in her death or the placement of her carcass. Straight-line distances from F502's location of death to her initial winter and summer ranges were 170.4 and 166.0 km, respectively.

Timing of dispersal for F145 and F502 closely coincided with the fawning period (i.e., late May-mid June). Females 145 and 502 likely migrated to summer ranges with their mother and siblings (i.e., social group). Individuals in social groups generally migrate together (Nelson and Mech 1981) and have similar seasonal movements throughout the first year (Tierson et al. 1985). However, during the fawning season, pregnant females display aggression towards other deer, including previous offspring (Ozoga et al. 1982, Schwede et al. 1993, Jones et al. 1997). Dispersing females F145 and F502 likely established new permanent ranges to avoid confrontation with aggressive, more dominant females (Brinkman 2003). Long-distance dispersal (mean = 152.2 km) of F145 and F502 was potentially due to limited forest cover (1.6%; Table 1) in Grant County. Long et al. (2005) determined that dispersal distance of yearling male white-tailed deer was inversely related to percentage of forest cover, and I speculate that limited forest habitat available in the fragmented landscape of the Northern Great Plains contributed to the long-distance dispersal of yearling females documented during this study.

The dispersal of adult female F771 is more difficult to explain. Female 771 departed previously established seasonal ranges in Lincoln County, Minnesota and dispersed 31.9 km southwest into Moody County, South Dakota on 13 April 2003, and

she was harvested in this same area on 25 November. Dispersal of adult female white-tailed deer has been documented in eastern South Dakota (Sparrowe and Springer 1970), New York (Tierson et al. 1985, Porter et al 2004), Illinois (Etter et al. 2002), and southwestern Minnesota (Brinkman et al. 2005). Female 771 potentially dispersed to seek solitude and suitable habitat for the impending fawning season.

Brookings County yearling male M341 remained on 2002-03 winter range until 20 June 2003, when he dispersed 26.8 km southeast into Lincoln County, Minnesota. Here, M341 established new summer and winter ranges and remained in this area until his death on 24 March 2004. Dispersal of yearling male white-tailed deer is quite common, with dispersal rates regularly exceeding 50% (Hawkins et al. 1971, Nelson and Mech 1984, Nixon et al. 1991, Nelson 1993, Rosenberry et al. 1999). Male white-tailed deer disperse more frequently than females. Purdue et al. (2000) suggested that males are responsible for the maintenance of genetic variability within subpopulations of white-tailed deer.

Home Ranges

In northern regions, white-tailed deer movement, and consequently home range size, is influenced by temperature and snow depth (Verme 1968, Ozoga and Gysel 1972, Verme 1973, Tierson et al. 1985, Drolet 1976, Nelson 1995, 1998, Sabine et al. 2002), hunting pressure (Sparrowe and Springer 1970, Root et al. 1988, Naugle et al. 1997), crop harvest (VerCauteren and Hygnstrom 1998), and habitat characteristics (Michael 1965, Sanderson 1966, Sparrowe and Springer 1970). In addition, extreme variation exists among home ranges of individual deer (Michael 1965). Previously documented

annual and seasonal home range sizes of white-tailed deer in northern regions include 1.62-4.86 km² (Rongstad and Tester 1969), 2.59-6.99 km² (Sparrowe and Springer 1970), 0.88-9.49 km² (Drolet 1976), 0.77-1.78 km² (Larson et al. 1978), 0.44-3.19 km² (Nelson and Mech 1981), 1.32-2.33 km² (Tierson et al. 1985), 0.43-0.69 km² (Mooty et al. 1987), 7.30-30.37 km² (Van Deelen et al. 1998), 1.70 km² (VerCauteren and Hygnstrom 1998), 0.32-0.51 km² (Etter et al. 2002), 0.50-0.85 km² (Grund et al. 2002), 4.37 km² (Kernohan et al. 2002), 2.27-5.18 km² (Brinkman 2003), and 2.57-3.31 km² (Swanson 2005).

During this study, mean summer home ranges in Lincoln, Grant, and Brookings counties ranged from 1.76-2.14 km², 1.76-3.60 km², and 1.04-1.44 km², respectively (Table 7). Mean winter home ranges were 2.94-4.57 km² in Lincoln County, 3.84 km² in Grant County, and 1.55-1.68 km² in Brookings County (Table 7). Mean seasonal home ranges of Brookings County deer were significantly smaller than those in Lincoln and Grant counties. Although habitat composition was relatively similar among study sites (Table 1), Brookings County deer utilized several wetland complexes throughout this study. These wetlands, consisting of large expanses of escape cover, were in close proximity to water, forage, and other essential requirements of white-tailed deer, potentially resulting in smaller home ranges. Kernohan et al. (2002) suggested that the basic needs of deer in the Northern Great Plains can be obtained in a relatively small area. In addition, natural selection may favor northern white-tailed deer that utilize their habitat as a means to maximize energy conservation over those that deplete energy reserves by searching for higher quality, more nutritious sources of forage (Dusek 1987).

Summer 2004 home ranges were significantly smaller than those calculated in previous periods of range use. During this time, yearlings accounted for 4.9% of all radiocollared deer, which was proportionally less than the percentage of juvenile deer during winter 2002-03 (9.1%), summer 2003 (19.4%), and winter 2003-04 (16.0%). Initially, I suspected that reduced home ranges during summer 2004 were due to a small percentage of radiocollared juvenile deer during this period. In northeastern Minnesota, home ranges of yearling females were three times larger than those of adult females (Nelson and Mech 1981). However, during this study, average 95% home ranges were similar between adults (220.9 ha) and juveniles (218.0 ha). Similarly, Larson et al. (1978) and VerCauteren and Hygnstrom (1998) failed to detect a significant difference in home range sizes of adult and juvenile female white-tailed deer in southcentral Wisconsin and Nebraska, respectively. Smaller home ranges during summer 2004 were likely due to a combination of factors, because habitat composition, season, and sex and age-class of deer have been reported to influence home range sizes (Demarais et al. 2000, Brinkman et al. 2005).

CHAPTER 3

**SURVIVAL OF ADULT AND NEONATE WHITE-TAILED DEER IN EASTERN
SOUTH DAKOTA AND SOUTHWESTERN MINNESOTA**

INTRODUCTION

Knowledge of survival rates and cause-specific mortality is imperative to understanding population dynamics of white-tailed deer (Nelson and Mech 1986, DePerno et al. 2000, Dusek et al. 1992, DelGiudice et al. 2002, Brinkman et al. 2004). Furthermore, accurate survival information provides insight regarding reproduction and sex-ratios of deer (Downing and McGinnes 1969); thus, enabling implementation of successful management strategies (Whitlaw et al. 1998). Although precise measurements of survival and cause-specific mortality of wild ungulates are difficult to obtain (Nelson and Mech 1986), radio telemetry provides a more accurate estimation than previous methods (Heisey and Fuller 1985, Fuller 1990, Van Deelen et al. 1997).

Previous research indicates that survival and mortality rates of white-tailed deer differ regionally and seasonally with respect to sex, age-class, and density of deer (Gavin et al. 1984, Dusek et al. 1992, Whitlaw et al. 1998, DelGiudice et al. 2002, Brinkman et al. 2004). General sources of mortality include both natural and human-related factors (DePerno et al. 2000, DelGiudice et al. 2002, Brinkman et al. 2004). Primary causes of mortality for adult white-tailed deer are hunting (Dusek et al. 1992, Brinkman et al. 2004), starvation (Lamoureux et al. 2001), vehicle-collisions (Etter et al. 2002, Porter et al. 2004), and predation by gray wolves (*Canis lupus*; Nelson and Mech 1986, DelGiudice et al. 2002) and coyotes (*Canis latrans*; Messier et al. 1986, Van Deelen et al. 1997). Major sources of mortality for white-tailed deer neonates include starvation (Carroll and Brown 1977, Pojar and Bowden 2004), disease (Cook et al. 1971), and predation by gray wolves (Kunkel and Mech 1994), black bears (*Ursus americanus*;

Kunkel and Mech 1994, Ballard et al. 1999), domestic dogs (*Canis familiaris*; Nelson and Woolf 1987, Ballard et al. 1999) and coyotes (Cook et al. 1971, Huegel et al. 1985a). Additional factors influencing susceptibility of neonates to mortality include body mass (Kunkel and Mech 1994), date of birth (Whittaker and Lindzey 1999), maternal age (Ozoga and Verme 1986b, Kunkel and Mech 1994), habitat quality (Huegel et al. 1985a, Nelson and Woolf 1987), climate (Carroll and Brown 1977), presence of alternative prey (Hamlin et al. 1984), mother-offspring behavior (White et al. 1972, Ozoga et al. 1982), and predator density (Beasom 1974, Stout 1982). Because multiple variables continuously impact population dynamics of white-tailed deer in eastern South Dakota and southwestern Minnesota, accurate estimates of survival and mortality rates are required to enhance management of deer in the region.

Survival and cause-specific mortality of adult and neonate white-tailed deer has been well documented in farmland Minnesota (Brinkman et al. 2004, Swanson 2005) and the central Black Hills of South Dakota (Benzon 1998, DePerno et al. 2000); however, no direct spatial and temporal survival information exists for white-tailed deer in eastern South Dakota. Therefore, the objectives of this study were to (1) document seasonal, annual, and overall survival rates of adult white-tailed deer in eastern South Dakota and southwestern Minnesota, (2) document summer survival rates of white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, and (3) document cause-specific mortality of adult and neonate white-tailed deer in eastern South Dakota and southwestern Minnesota.

METHODS

Adults

White-tailed deer were captured and radiocollared on traditional winter ranges in Grant and Brookings counties, South Dakota during January-March 2003 and 2004 (see Chapter 2 for capture methodology). In addition, I continued to monitor 24 adult female white-tailed deer that were previously radiocollared during January 2001 and 2002 in Lincoln County, Minnesota (Brinkman 2003). Radiocollars were equipped with mortality sensors, which were activated after the collar had remained stationary for 8 hours. Individual radiocollared deer were monitored 2-3 times weekly for survival using a collapsible, vehicle-mounted “null-peak” antenna system (Brinkman et al. 2002). Mortalities were located with a hand-held “H-style” antenna attached to a receiver (Advanced Telemetry Systems, Inc., Isanti, MN) and were assessed immediately to determine cause of death. Cause of death was established by evidence at the kill-site and carcass characteristics (White et al. 1987). If cause of death was unknown, carcasses were transported to the Animal Disease Research Diagnostic Laboratory (ADRDL) at SDSU for further examination. To determine approximate age at death, lower jaws were removed (Bigalke et al. 2003) to obtain lower incisors, which were aged using cementum annuli analysis (Gilbert 1966). Mortalities occurring <26 days post-capture were assumed to be capture-related (Beringer et al. 1996) and were censored from survival analyses. All methods described were approved by the IACUC at SDSU.

Seasonal, annual, and overall survival rates were calculated for white-tailed deer in eastern South Dakota and southwestern Minnesota. Seasonal survival rates were

separated into three time intervals; pre-hunt (1 May - 31 August), hunting (1 September - 31 December), and post-hunt (1 January - 30 April) (Brinkman 2003). Furthermore, the hunting interval was separated into two additional periods (i.e., hunting and hunting-all; Brinkman 2003). Hunting included only harvest-related mortalities, while hunting-all included all mortalities occurring during the specified time interval. Survival rates were estimated using the Kaplan-Meier method (Kaplan and Meier 1958) adapted for staggered entry (Pollock et al. 1989). Annual and overall survival rates were calculated by age, season, and study site, and compared using the computer program CONTRAST (Hines and Sauer 1989). Alpha was set at $P \leq 0.05$, and a Bonferroni correction factor was utilized to maintain experiment-wide error rates. Basic statistical analyses were conducted using SYSTAT (Wilkinson 1990).

Neonates

White-tailed deer neonates were captured in 2002 and 2003 during the peak fawning period (i.e., mid May-mid June) in Brookings County, South Dakota and Lincoln County, Minnesota. Neonates were located using daytime and nighttime vehicle searches, following methods described by Downing and McGinnes (1969). Postpartum behavior of reproductive females was the primary indicator of fawn presence (White et al. 1972, Huegel et al. 1985*b*). After a neonate was sighted, a loud and rapid approach was used to flush the dam, which invoked the neonate to “drop” (Downing and McGinnes 1969). Neonates were then captured by hand and manually restrained.

Captured neonates were radiocollared, sexed, aged, and weighed. Expandable breakaway radiocollars (Advanced Telemetry Systems, Inc., Isanti, MN or Telonics, Inc.,

Mesa, AZ) were fitted to captured individuals. Collars were outfitted with mortality sensors, which were activated after the transmitter had remained stationary for 4 hours. Neonate age was determined using a hoof growth measurement ($\hat{Y} = 0.66 + 2.2X$), along with other physical characteristics (i.e., umbilicus condition; Haugen and Speake 1958). Neonates were gently placed in a 4.8-mm-mesh drawstring bag and weighed using a digital scale (Extech Instruments, Melrose, MA). To minimize the transfer of human scent to neonates, latex gloves were worn by all neonate capture assistants. In addition, radiocollars were placed in a plastic bag containing natural vegetation approximately 1-2 weeks prior to neonate capture. Capture location was determined using a Global Positioning System (GPS). Radiocollared neonates were then released, and total handling time was recorded for each individual. All methods described were approved by the IACUC at SDSU.

During the first 2 months after birth, neonates are vulnerable to a variety of factors (i.e., predation, starvation, disease), and mortality is often substantial (White et al. 1972). Therefore, radiocollared neonates were monitored 1-2 times daily until approximately 9 weeks post-capture, and thereafter, 2-3 times weekly. Neonate survival was monitored using a collapsible, vehicle-mounted “null-peak” antenna system (Brinkman et al. 2002) and a hand-held “H-style” antenna. Mortalities were assessed immediately to determine the cause of death, which was established by evidence at the kill-site and carcass characteristics (White et al. 1987). If cause of death was not determined in the field, carcasses were taken to the ADRDL at SDSU for further

examination. If cause of death was capture-related or radiocollars prematurely “broke-away”, neonates were censored from survival analyses.

Survival rates were estimated using the Kaplan-Meier method (Kaplan and Meier 1958) adapted for staggered entry (Pollock et al. 1989). Neonate survival was calculated monthly from May through August. Program CONTRAST (Hines and Sauer 1989) was used to compare neonate survival rates between months, years, and sexes. Alpha was set at $P \leq 0.05$, and a Bonferroni correction factor was utilized to maintain experiment-wide error rates. Basic statistical analyses were performed using SYSTAT (Wilkinson 1990).

RESULTS

Adults

Forty-one deer (25 adults, 16 fawns) were captured and radiocollared during January-March 2003 ($n = 25$; Table 2, Appendix A) and January-February 2004 ($n = 16$; Table 3, Appendix B) at two study sites (i.e., Grant and Brookings counties) in eastern South Dakota. Twenty-three deer were radiocollared at the Brookings County study site and 18 in Grant County. In addition, I ear-tagged 21 deer (16 male fawns, 5 female fawns) during this study (Table 4, 5, Appendix A, B). Furthermore, I continued to monitor 24 previously radiocollared adult female white-tailed deer at the Lincoln County study site in southwestern Minnesota (Appendix C; Brinkman 2003).

Twenty-eight deer died during the 28-month study (September 2002-December 2004), and 25 were included in survival analyses (Table 8, Appendix G). Nineteen (76.0%) mortalities were due to human-related factors, and only 2 (8.0%) were attributed to natural causes. Firearms hunting was the primary cause of mortality, accounting for 17

(68.0%) deaths (Fig. 8, Appendix G). In addition, 2 (8.0%) deer were killed by vehicle collisions, 1 (4.0%) by predators, 1 (4.0%) by disease, and 4 (16.0%) deaths were attributed to unknown causes. Median age at death was 3.5 years (range = 11.0 years, $n = 25$; Appendix G). Ten (40.0%) deer died at the Lincoln County study site, 8 (32.0%) at Grant County, and 7 (28.0%) at Brookings County. Furthermore, 8 (38.1%) ear-tagged deer were recovered during this study (Appendix H). Four (50.0%) deaths were attributed to firearms harvest, 3 (37.5%) to vehicle collisions, and 1 (12.5%) to archery harvest. Median age at death for ear-tagged deer was 2.0 years (range = 1.5 years, $n = 8$; Appendix H).

A 3.0 year-old female white-tailed deer died on 1 May 2003. No visible evidence of mortality was apparent, and the carcass was transported to the ADRDL at SDSU. Necropsy revealed an old, infected wound in the abdominal region of this deer. The infection had gradually progressed into the chest cavity, eventually encompassing the vital organs. Thus, cause of death for this individual was classified as disease.

On 20 July 2004, predators killed a 1.0 year-old female white-tailed deer in Brookings County. Remains of this deer were scattered throughout a small portion of a wetland complex. The area surrounding the carcass and kill-site was completely trampled, indicating a chase/struggle. In addition, several bite marks were visible on the leather strap and battery-pack of the radiocollar. Tracks and fecal evidence found near the remains were indicative of *Canid* presence.

Throughout this study, four deaths were attributed to unknown causes. Dispersing male M341 died on 24 March 2004 near Lake Benton, Minnesota. The deer

appeared healthy, and the carcass was untouched by predators. A yearling female died on 17 June 2004 at the Grant County study site. The carcass was nearly decomposed and had been completely consumed by predators; however, cause of death could not be determined. Dispersing yearling female F502 died on 18 November 2004 near Lake Vermillion, South Dakota. The carcass was almost completely consumed by predators. A 9.5 year-old female white-tailed deer died on 19 December 2004 at the Grant County study site. The carcass was mainly intact, however, predators had eaten a portion of the abdominal region. Evidence near the carcasses of these individuals revealed little information as to the cause of death. Although 3 (75.0%) of the unknown mortalities were consumed by predators, it was undetermined whether or not predation was the cause of death.

During this study, 7 deer were censored from survival analyses. Three deer (1 adult, 2 fawns) died <26 days post-capture (Appendix G), and consequently were censored, because mortality may have been capture-related (Beringer et al. 1996). Four additional deer were censored at different times during this study due to radiocollar malfunction. These individuals were censored at the time of radiocollar failure.

Annual survival rates of all radiocollared deer differed ($\chi^2_1 = 4.118$, $P = 0.042$) between years and were 0.86 (SE = 0.05, $n = 45$; Table 9) in 2003 and 0.69 (SE = 0.06, $n = 51$; Table 10) in 2004. Annual survival was similar among study sites in 2003 ($\chi^2_2 = 1.812$, $P = 0.404$) and 2004 ($\chi^2_2 = 4.981$, $P = 0.083$). During 2003, annual survival rates of deer in Lincoln, Grant, and Brookings counties were 0.79 (SE = 0.09, $n = 20$), 0.86 (SE = 0.13, $n = 7$), and 0.94 (SE = 0.06, $n = 18$), respectively (Table 9). In 2004,

annual survival was 0.86 (SE = 0.09, $n = 15$) in Lincoln County, 0.53 (SE = 0.12, $n = 17$) in Grant County, and 0.67 (SE = 0.10, $n = 19$) in Brookings County (Table 10). Overall survival for all deer was 0.49 (SE = 0.06, $n = 65$; Table 11) and was similar ($\chi^2_2 = 1.373$, $P = 0.503$) across study sites. Overall survival rates in Lincoln, Grant, and Brookings counties were 0.57 (SE = 0.11, $n = 24$), 0.46 (SE = 0.11, $n = 18$), and 0.63 (SE = 0.10, $n = 23$), respectively (Table 11).

In 2002, seasonal survival during hunting and hunting-all periods was 0.83 (SE = 0.07, $n = 24$; Table 12). In 2003, survival was similar ($\chi^2_3 = 2.179$, $P = 0.536$) during post-hunt (0.98; SE = 0.02, $n = 45$), pre-hunt (0.95; SE = 0.03, $n = 42$), hunting (0.92; SE = 0.04, $n = 39$), and hunting-all (0.92; SE = 0.04, $n = 39$) periods. Seasonal survival rates differed ($\chi^2_3 = 15.040$, $P = 0.002$) in 2004 during post-hunt (0.96; SE = 0.03, $n = 51$), pre-hunt (0.96; SE = 0.03, $n = 47$), hunting (0.79; SE = 0.06, $n = 45$), and hunting-all (0.75; SE = 0.06, $n = 45$) intervals. Seasonal survival was similar between years during post-hunt ($\chi^2_1 = 0.304$, $P = 0.581$), pre-hunt ($\chi^2_1 = 0.058$, $P = 0.900$), hunting ($\chi^2_2 = 3.326$, $P = 0.190$), and hunting-all ($\chi^2_2 = 5.353$, $P = 0.069$) seasons (Table 12).

Annual survival rates were compared between fawns/yearlings (8-18 months) and adults (≥ 1.5 years). During 2003, annual survival differed ($\chi^2_1 = 7.477$, $P = 0.006$) between fawns (1.00; SE = 0.00, $n = 9$; Table 13) and adults (0.83; SE = 0.06, $n = 36$). In 2004, annual survival was similar ($\chi^2_1 = 1.947$, $P = 0.163$) between fawns (0.40; SE = 0.22, $n = 7$) and adults (0.72; SE = 0.07, $n = 44$; Table 13). Annual survival rate

differed ($\chi^2_1 = 7.499$, $P = 0.006$) between years for fawns but was similar ($\chi^2_1 = 1.335$, $P = 0.248$) for adults.

Neonates

A total of 41 (26 male, 15 female) white-tailed deer neonates was captured and radiocollared at the Brookings and Lincoln county study sites during 2002 (Table 14, Appendix I) and 2003 (Table 14, Appendix J). In 2002, 6 (5 male, 1 female) neonates were captured at the Brookings County study site. During 2003, 16 (12 male, 4 female) and 19 (9 male, 10 female) neonates were captured and radiocollared in Brookings and Lincoln counties, respectively. Neonates were captured between 18 May and 15 June. Ten (24.4%) neonates required a short chase prior to capture, while 31 (75.6%) remained motionless when approached. Twenty-five (61.0%) neonates struggled during processing; 16 (39.0%) remained passive. Five (33.3%) females and 5 (19.2%) males required a short chase, and 9 (60.0%) females and 16 (61.5%) males struggled during handling. Mean age at capture was 4.9 days (SE = 0.5, $n = 37$; Table 14), and mean birth date was 25 May (29 May in 2002, 24 May in 2003) based on estimated ages at capture. Average weight at capture was 4.4 kg (SE = 0.2, $n = 33$). Mean processing time was 4.0 minutes (SE = 0.3, $n = 41$; Table 14).

All neonates were captured using daytime ($n = 18$) and nighttime ($n = 23$) vehicle searches. During 2002, no record of search-hours or man-hours required to capture 6 neonates was kept. During 2003, 35 neonates were captured after a total of 183 search-hours and 396 man-hours. An average of 5.2 search-hours and 11.3 man-hours were conducted per captured neonate.

Five neonate mortalities (Table 15, Appendix K) were documented from May through August 2002 and 2003. Three deaths occurred ≤ 6 days post-capture and may have been capture-related. No evidence regarding the cause of mortality was observed near carcasses; however, further examination conducted at the ADRDL revealed that starvation was the cause of death. Hence, these neonates were likely abandoned by their mothers. Because mortality occurred shortly after capture and I could not determine whether death was capture-related or natural, these individuals were censored from survival analyses at the time of death. Two neonate mortalities (100%) were attributed to *Canid* predation. Tracks and fecal evidence located near the kill-sites indicated that coyotes were responsible for mortality. Seven additional neonates (1 in 2002, 6 in 2003) were censored from survival analyses due to faulty radiocollars or collars prematurely “breaking-away” from neonates. These neonates were censored at the time of radiocollar failure.

During May-August 2002, neonate survival was 1.00 (SE = 0.00, $n = 6$; Table 16). During 2003, survival rates in Brookings and Lincoln counties were respectively 1.00 (SE = 0.00, $n = 16$) and 0.88 (SE = 0.10, $n = 19$), and pooled 2003 survival was 0.94 (SE = 0.05, $n = 35$; Table 16). Overall neonate survival rate was 0.95 (SE = 0.04, $n = 41$) for May-August 2002-03. Neonate survival was similar between study sites ($\chi^2_1 = 1.504$, $P = 0.220$) and years ($\chi^2_1 = 1.695$, $P = 0.193$). Although all mortalities ($n = 2$) occurred during the month of June, neonate survival was similar ($\chi^2_3 = 1.594$, $P = 0.661$) between months. Estimated monthly survival rates during May, June, July, and August were 1.00 (SE = 0.00, $n = 28$), 0.95 (SE = 0.03, $n = 38$), 1.00 (SE = 0.00, $n = 32$), and 1.00

(SE = 0.00, $n = 29$), respectively (Table 17). Also, neonate survival was similar ($\chi^2_1 = 1.558$, $P = 0.212$) between males (1.00; SE = 0.00, $n = 26$; Table 18) and females (0.86; SE = 0.11, $n = 15$).

DISCUSSION

Adults

Annual survival rates of white-tailed deer in eastern South Dakota and southwestern Minnesota during 2003 (86%; Table 9) and 2004 (69%; Table 10) were similar to previously documented rates in Illinois (56-92%; Nixon et al. 2001), New Brunswick (66-85%; Whitlaw et al. 1998), northern New York (75-88%; Jones et al. 1997), northern Michigan (77%; Van Deelen et al. 1997), southwestern Minnesota (77%; Brinkman et al. 2004), northeastern Minnesota (79%; Nelson and Mech 1986), and the central Black Hills of South Dakota (50-62%; DePerno et al. 2000).

Survival of white-tailed deer in eastern South Dakota and southwestern Minnesota was predominantly dependant on human-induced factors (i.e., hunting, vehicle collisions), rather than natural causes (i.e., predation, starvation, disease). Human-related factors accounted for 76% of all mortalities, whereas only 8% of deaths were due to natural causes. Firearms hunting was the main cause of mortality (68%; Fig. 8) for white-tailed deer in this study. Similarly, hunting was the largest source of mortality (74%) for adult female white-tailed deer in eastern Montana (Dusek et al. 1992). Hunting also accounted for 63% of all deaths in northern Wisconsin (Lewis and Rongstad 1998). In southern New Brunswick, Whitlaw et al. (1998) documented an annual hunting-induced mortality rate of 0.13 for adult white-tailed deer. Hunters caused 43%

of all female white-tailed deer mortalities in north-central Minnesota (DelGiudice et al. 2002) and southwestern Minnesota (Brinkman et al. 2004). In eastern South Dakota and southwestern Minnesota, susceptibility of white-tailed deer to hunting-related mortality was potentially influenced by a lack of escape cover in the highly fragmented landscape (Nixon et al. 1991) and a “well-established road network” (Brinkman et al. 2004). In addition, lengthy (>14 day) firearms seasons in eastern South Dakota likely contributed to high rates of hunting-related mortality.

Mean seasonal survival rates during post-hunt (1 January – 30 April), pre-hunt (1 May – 31 August), hunting (1 September – 31 December), and hunting-all (1 September – 31 December) periods were 0.97, 0.95, 0.85, and 0.84, respectively (Table 12). Because hunting was the primary cause of mortality, seasonal survival was consequently lower during hunting and hunting-all periods. Seasonal survival was highest during post-hunt and pre-hunt intervals. High seasonal survival of northern white-tailed deer during the pre-hunt (i.e., summer) season has been well documented (Nelson and Mech 1986, Van Deelen et al. 1997, Etter et al. 2002, Brinkman et al. 2004) and is potentially attributed to increased forage and cover (i.e., corn fields), minimal impact of human-related activities, and small summer home ranges (Nixon et al. 1991, Brinkman et al. 2004) associated with parturition and fawn-rearing (Hawkins and Klimstra 1970).

During 2003, annual fawn survival (1.00; Table 13) was higher than adult survival (0.83); however, the small sample size ($n = 9$) of radiocollared fawns likely overestimated survival. Previous research indicates that annual survival of fawns is

generally lower than adults (Nelson and Mech 1986, Lamoureux et al. 2001). DelGiudice et al. (2002) suggested that juvenile female white-tailed deer are more susceptible to hunter harvest. In addition, fawns and yearlings are more likely to disperse than mature females (Nixon et al. 1991, Nelson 1993, Porter et al. 2004), which may increase vulnerability to mortality. Nixon et al. (1991, 2001) reported lower survival for dispersing deer compared to sedentary deer in Illinois. Deer that remain on natal ranges may have an advantage in avoiding danger (i.e., predators, hunters, roads), as a result of associating with social groups and mature females (Ozoga and Verme 1986a, Nixon et al. 2001).

Winter severity (i.e., cold temperatures, snowpack) can substantially impact survival of white-tailed deer in northern regions (Fuller 1990, DelGiudice et al. 2002). Reproductive females have only a brief period between lactation and the winter season to accumulate adequate fat reserves necessary for winter survival (Nelson and Mech 1986). Severe winter weather may cause starvation (White et al. 1987, Lamoureux et al. 2001), which directly decreases survival. In addition, deep snow impedes deer mobility (Nelson 1998), consequently increasing vulnerability to predators, such as coyotes (Whitlaw et al. 1998) and wolves (Nelson and Mech 1986, DelGiudice et al. 2002). The risk of mortality was positively correlated with WSI values for white-tailed deer in north-central Minnesota (DelGiudice et al. 2002), and substantial overwinter losses occurred in northern Michigan when WSI exceeded a value of 100 (Verme 1968). In eastern South Dakota and southwestern Minnesota, average DWSIs during 2002-03 (68.7) and 2003-04 (59.0) were indicative of mild winter weather during this study (Fig. 2). Therefore, the

effect of winter severity on deer survival was minimal throughout this research.

Nevertheless, a series of harsh winters could have a significant impact on survival of white-tailed deer in the region.

Neonates

Knowledge of survival rates and cause-specific mortality of neonates from birth through recruitment into the adult population is an integral component of white-tailed deer management (Huegel et al. 1985a). Deer are more susceptible to mortality during the first year of life than in any other age-class (DelGiudice et al. 2002). Annual survival of fawns (<1 year old) is generally low (22-50%) for white-tailed deer (Nelson and Mech 1986, Benzon 1998, Ballard et al. 1999) and mule deer (White et al. 1987, Pojar and Bowden 2004). Thus, determining underlying factors influencing neonatal survival can provide vital information to wildlife biologists regarding management decisions.

Pooled (2002-03) summer (i.e., May-August) survival was 95% for white-tailed deer neonates in eastern South Dakota and southwestern Minnesota (Table 16). However, approximate survival may have been overestimated, because mean age at capture was 4.9 days (Table 14). Ozoga and Clute (1988) determined that substantial neonate mortality occurs <2 days postpartum. As most (70.3%) neonates were captured ≥ 3 days after birth (Appendix I, J), I potentially missed some early neonate mortality.

Summer neonate mortality (5%) was much lower than previously reported rates in the Midwest and Northern Great Plains. In southwestern Minnesota, Brinkman et al. (2004) and Swanson (2005) documented summer mortality rates of 16 and 28%, respectively. Huegel et al. (1985a) reported 27% neonate mortality from birth to 5

months postpartum in south-central Iowa. In southern Illinois, summer mortality rate was 30% (Nelson and Woolf 1987). Kunkel and Mech (1994) reported a May-October mortality rate of 51% for white-tailed deer neonates in northeastern Minnesota.

All neonate mortalities ($n = 2$) observed during this study occurred <14 days postpartum and were attributed to *Canid* (coyote) predation. Neonates are an important food source for predators, constituting 40-70% of a coyote's diet during June and July (White et al. 1972, Messier et al. 1986). Thus, coyote predation can have a detrimental effect on neonate survival in certain regions (Messier et al. 1986). *Canid* predation was attributed to 50-53% of white-tailed deer neonate mortalities in southern Texas (Cook et al. 1971, Carroll and Brown 1977), 69% in southern Illinois (Nelson and Woolf 1987), 77% in south-central Iowa (Huegel et al. 1985a), and 67-100% in southwestern Minnesota (Brinkman et al. 2004, Swanson 2005). In addition, coyotes caused 90% of all mule deer neonate mortality in north-central Montana (Hamlin et al. 1984) and 79% in sympatric mule and white-tailed deer in Colorado (Whittaker and Lindzey 1999). Newborn neonates are feeble and relatively immobile, making them extremely vulnerable to predators (Cook et al. 1971). Neonates with more body mass tend to have higher survival rates than their smaller counterparts (Kunkel and Mech 1994). Mean weight at capture for predator-killed neonates (3.87 kg) in this study was slightly lower than average capture weight (4.14 kg) of surviving neonates, potentially increasing susceptibility to predation.

In southwestern Minnesota, Brinkman et al. (2004) attributed high summer survival (84%) of white-tailed deer neonates to low predator densities, quality vegetation

at neonatal bedding areas, and superior nutritional condition of reproductive females. These same factors likely contributed to the high rate of neonate survival (95%) observed in eastern South Dakota and southwestern Minnesota during 2002-03. Although no direct estimate of predator density was calculated during this study, few (<5) coyotes were observed during neonate capture operations in 2002-03, including nighttime spotlight searches. Because predators, specifically coyotes, substantially impact neonate survival in the region, high neonate survival was likely a result of low predator densities. In addition, dense, quality vegetation at bedding areas provided adequate hiding cover, reducing the capability of coyotes to locate and kill neonates (Huegel et al. 1985a).

Winter severity can have a profound effect on survival and nutritional condition of reproductive female white-tailed deer (DelGiudice et al. 2002), and consequently, fetal development (Verme 1977). Following a series of severe winters, neonate survival may be reduced during subsequent fawning seasons. This study was conducted during a series of mild winters, which allowed gestating females to maintain superior nutritional condition throughout the year. The high nutritional plane maintained by reproductive females during this study potentially increased neonate survival. Monitoring survival of white-tailed deer neonates provides useful information regarding reproduction, sex-ratios, mortality, movements, and behavior (Downing and McGinnes 1969). With this vital information, wildlife biologists can continually refine population models (Ballard et al. 1999), thus enhancing management strategies.

CHAPTER 4

MANAGEMENT IMPLICATIONS

Knowledge of spatial and temporal survival rates and movement patterns (i.e., seasonal migration, dispersal) of white-tailed deer is necessary for enhancement of management strategies. Currently, harvest quotas in eastern South Dakota and southwestern Minnesota are determined via manipulation of population models, which incorporate several fluctuating variables that continuously affect population dynamics of white-tailed deer. Survival rates and movements of deer in southwestern Minnesota have been well documented in recent years (Brinkman et al. 2004, 2005, Swanson 2005). However, little information exists pertaining to survival and movements of white-tailed deer in eastern South Dakota. The primary objective of this study was to provide accurate, site-specific data regarding survival rates and movement patterns of white-tailed deer in the region.

Migration between seasonal home ranges is common for northern white-tailed deer, and primary stimuli initiating seasonal migration are temperature and snow depth (Nelson 1995, 1998, Brinkman et al. 2005, Swanson 2005). In addition, dispersal movements, although poorly understood, occur throughout the range of white-tailed deer. Brinkman et al. (2005) suggested that dispersal is a result of social pressures. Furthermore, long-distance dispersal is common in this region due to limited patches of suitable habitat available in the fragmented landscape of eastern South Dakota and southwestern Minnesota. Regardless of the reasons for white-tailed deer migration and dispersal, these movements commonly occur in the region and must be evaluated to successfully manage this species.

Occurrence of both short (i.e., seasonal migration) and long-distance (i.e., dispersal) movements presents several problems for wildlife managers attempting to understand population dynamics of white-tailed deer. Movement patterns are difficult to accurately measure, and this type of research generally imposes a large financial burden on management agencies. In addition, deer movement may have a substantial impact on numbers of deer occupying specific management units or permit areas throughout the year. Most agencies typically assume that emigration and immigration are equivalent (Johnson 1994, Rosenberry et al. 1999); however, this assumption likely is not valid for many populations. Hence, factors influencing deer movement must be assessed and understood, so managers can improve population models based on these fluctuating variables.

In eastern South Dakota and southwestern Minnesota, temperature and snow depth were the main factors influencing deer movement, which is consistent with previous northern white-tailed deer studies. Annual DWSIs indicated that during this study (2002-04), winter weather was relatively mild. Thus, many deer remained in the same general ranges throughout the entire study, and several (32.7%) deer were considered conditional migrators. These deer exhibited brief winter range visits or made several migrations during a single period of range use. Many (31.8-48.1%) migratory individuals possessed summer and winter ranges in different management units. All (100.0%) dispersing deer crossed at least one, and in many cases several, unit boundaries before establishing permanent ranges. Furthermore, a large proportion (0.0-50.0%) of resident deer frequently moved across unit boundaries during this study. Therefore,

substantial movement across management unit and permit area boundaries was documented, even during mild winter conditions.

Mild winter weather also caused delayed fall migration, with most migration occurring during or after the onset of regular firearms hunting seasons. Thus, during this time, the majority of deer was utilizing summer ranges and was available to hunter harvest in these areas. However, winter weather is extremely variable and can substantially impact both movements and survival of northern white-tailed deer. Severe winters generally cause earlier migration and increased percentages of migratory deer in the region (Sparrowe and Springer 1970, Brinkman et al. 2005). Hence, during severe winters, deer will likely depart summer ranges before the onset of regular firearms seasons, forming large congregations in traditional wintering areas. Results from this study indicate that 30-50% of deer wintering in one management unit had summer home ranges in a different management unit. In this instance, there may be a discrepancy between tag numbers and available numbers of deer occupying certain management units, specifically those serving primarily as summer or winter habitats. Consequently, other aspects such as hunter success, sex-ratios, and population size may be altered. In extreme cases, overexploitation or underexploitation of deer populations is possible.

Given the impact weather has on deer movement in this region, managers should incorporate these variables (i.e., temperature, snow depth), along with predicted patterns of movement (i.e., migration, dispersal), into population models. In addition, traditional wintering habitats should be actively managed (Sabine et al. 2002) to support moderate densities of deer during severe winters. Furthermore, during harsh winters, managers

should consider issuing increased numbers of depredation permits near traditional winter ranges, when large concentrations of deer are present.

Currently, management units in eastern South Dakota and permit areas in southwestern Minnesota are based on arbitrary, political boundaries (i.e., counties, roads). However, deer movement in the region is generally directed on physiographic features of the landscape (Sparrowe and Springer 1970, Kernohan et al. 1994, this study). During this study, migrating and dispersing deer seemed to travel through the limited patches of suitable habitat available in the fragmented landscape. Management units and permit areas do not depict “natural units of deer range” (Sparrowe and Springer 1970). Therefore, I concur with Sparrowe and Springer (1970), who suggested that management units might be more effective if based on physiographic features or regions, rather than political boundaries. Results from this study indicate that physiographic regions (i.e., Missouri Coteau, James River Lowlands, Prairie Coteau, Minnesota-Red River Lowlands) in eastern South Dakota and southwestern Minnesota could potentially function as biologically-based management units.

Several other proposed management strategies also may be applicable to this region. In southern New Brunswick, Drolet (1976) suggested that management units should be based on winter ranges and their respective regions of influence (i.e., summer ranges). Similarly, Van Deelen et al. (1998) stated that paired summer and winter ranges united by seasonal migration should be assessed to create natural, meaningful management units in northern Michigan. In southeastern Idaho, Brown (1992) recommended using natural breaks in the landscape to define management units for mule

deer. Regardless of the management unit delineation chosen, managers should identify traditional seasonal ranges of white-tailed deer and consider movements between these areas when making management decisions.

Annual survival (69-86%) of adult white-tailed deer in eastern South Dakota and southwestern Minnesota was relatively high during this study. Only 8% of total mortalities were attributed to natural causes. Low predator densities and mild winters experienced during 2002-04 potentially influenced the low rate of natural mortality observed. Throughout this study, deer were able to access various sources of high-quality forage; thus, conserving fat reserves. These factors allowed them to maintain superior nutritional condition throughout the year. However, the onset of a harsh winter could significantly impact white-tailed deer survival in the region. Winter severity can cause starvation and impede mobility, making deer susceptible to predators. Thus, managers should expect higher rates of natural mortality during a series of severe winters, and adjust population models accordingly.

During this study, survival of adult white-tailed deer was dependant on human-related factors. Firearms hunters caused 68% of all documented mortalities. In the highly fragmented landscape of eastern South Dakota and southwestern Minnesota, deer are susceptible to hunting-related mortality due to lengthy firearms seasons, lack of escape cover (Nixon et al. 1991), and a “well established road network” (Brinkman et al. 2004). With current management practices, biologists should expect to observe continued high rates of white-tailed deer mortality due to human-related causes, specifically hunting. Furthermore, because hunting is the primary cause of death for deer

in the region, managers should consider reducing tag numbers following a series of severe winters, to compensate for increased rates of natural mortality. Regulation of harvest quotas and hunting season framework is the primary tool for maintaining desirable populations of white-tailed deer in this region.

During this research, white-tailed deer neonates also had a high rate (95%) of summer survival, likely a result of low predator densities, quality vegetation at neonatal bedding areas, and superior nutritional condition of reproductive females (Brinkman et al. 2004). In this region, the major source of mortality for neonates is *Canid* predation. Predator populations generally fluctuate on a year-to-year basis. Therefore, an increase in predators could dramatically reduce neonatal survival. To dampen the effect of predation on newborn survival, managers can implement predator-control programs. In addition, during dry years, vegetation will likely be sparse and short, offering neonates little protection from predators and natural elements (i.e., wind, rain). Managers should attempt to maintain patches of permanent cover in and surrounding traditional fawn-rearing grounds. Permanent cover provides neonates with high-quality bedding sites and adequate escape cover. Winter severity also can directly and indirectly affect neonatal survival. Severe winters may stunt fetal development and leave gestating females in poor nutritional condition. Therefore, in subsequent fawning seasons, neonatal survival will potentially be reduced. To compensate, managers could reduce tag numbers, specifically antlerless deer tags, during subsequent hunting seasons.

Knowledge of movement patterns and survival rates is fundamental to white-tailed deer management. In northern regions, winter severity dramatically impacts

deer survival and movement patterns. Survival research provides useful information regarding reproduction, sex-ratio, age-structure, and cause-specific mortality of white-tailed deer. In addition, movement studies assist managers in defining biologically sound management units and estimating rates of immigration and emigration. Knowledge of dispersal rates also allows managers to prepare for the potential spread of transmissible diseases, such as CWD. Understanding these aspects is an integral component of deer management. This study provided extensive, empirical data for white-tailed deer in eastern South Dakota and southwestern Minnesota. However, these data are both time and site-specific and should only be applied to deer management in this region. Furthermore, variables affecting population dynamics of white-tailed deer fluctuate widely. Therefore, continuous monitoring of these variables would allow adaptive management of this species. Doing so, wildlife managers will be able to continually refine population models and accurately predict outcomes based on these models. Consequently, they can implement strategies to manage for desirable populations of white-tailed deer, which will be accepted by various groups interested in this species.

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Table 1. Percentages of major land-cover types of selected study sites in eastern South Dakota and southwestern Minnesota (adapted from National Landcover Data Set; Vogelmann et al. 2001).

Study Site	Cultivated	Pasture/Grassland	Wetland	Forest	Water	Residential	Rocky	Transitional
Lincoln County	59.65	31.28	4.01	2.04	2.30	0.69	0.02	0.01
Grant County	51.72	41.80	3.49	1.56	0.78	0.62	0.02	0.00
Brookings County	58.29	31.49	4.36	2.46	2.26	1.10	0.04	0.00
Average	56.55	34.86	3.95	2.02	1.78	0.80	0.03	0.00

Table 2. Capture data by study site for radiocollared white-tailed deer in eastern South Dakota, January-March 2003.

	Grant County			Brookings County			All Sites		
Age	Adult	Fawn	Total	Adult	Fawn	Total	Adult	Fawn	Total
Adult (≥ 1.5 years)									
Fawn (~8-10 months)									
Number of Deer Captured	3	4	7	13	5	18	16	9	25
Mean (SE) handling time (minutes)	5.7 (0.4)	4.7 (0.7)	5.2 (0.4)	6.7 (1.0)	5.1 (0.4)	6.1 (0.7)	6.4 (0.8)	4.9 (0.3)	5.9 (0.5)
Mean (SE) chest circumference (cm)	99.3 (2.6)	74.7 (3.2)	87.0 (5.8)	99.3 (1.8)	78.8 (1.8)	93.2 (2.7)	99.3 (1.5)	77.3 (1.7)	91.6 (2.5)

Table 3. Capture data by study site for radiocollared white-tailed deer in eastern South Dakota, January-February 2004.

	Grant County			Brookings County			All Sites		
Age	Adult	Fawn	Total	Adult	Fawn	Total	Adult	Fawn	Total
Adult (≥ 1.5 years)									
Fawn (~8-10 months)									
Number of Deer Captured	6	5	11	3	2	5	9	7	16
Mean (SE) handling time (minutes)	5.4 (0.4)	4.6 (0.4)	5.0 (0.3)	7.3 (0.9)	5.8 (1.8)	6.7 (0.8)	6.1 (0.5)	4.9 (0.5)	5.6 (0.4)
Mean (SE) chest circumference (cm)	101.0 (2.6)	78.3 (1.4)	91.9 (4.0)	92.7 (0.9)	70.0 (1.0)	83.6 (5.6)	98.2 (2.2)	75.5 (2.0)	89.1 (3.3)

Table 4. Capture data by study site for ear-tagged white-tailed deer in eastern South Dakota, January-March 2003.

	Grant County			Brookings County			All Sites		
	Adult	Fawn	Total	Adult	Fawn	Total	Adult	Fawn	Total
Age									
Adult (≥ 1.5 years)									
Fawn (~8-10 months)									
Number of Deer Captured	0	6	6	0	5	5	0	11	11
Mean (SE) handling time (minutes)		3.3 (0.1)	3.3 (0.1)		4.0 (0.5)	4.0 (0.5)		3.7 (0.3)	3.7 (0.3)
Mean (SE) chest circumference (cm)									

Blank cells represent “no data”.

Table 5. Capture data by study site for ear-tagged white-tailed deer in eastern South Dakota, January-February 2004.

	Grant County			Brookings County			All Sites		
	Adult	Fawn	Total	Adult	Fawn	Total	Adult	Fawn	Total
Age									
Adult (≥ 1.5 years)									
Fawn (~8-10 months)									
Number of Deer Captured	0	7	7	0	3	3	0	10	10
Mean (SE) handling time (minutes)		1.6 (0.1)	1.6 (0.1)		2.8 (0.7)	2.8 (0.7)		2.0 (0.3)	2.0 (0.3)
Mean (SE) chest circumference (cm)		69.0 (2.0)	69.0 (2.0)		77.0 (0.0)	77.0 (0.0)		71.7 (2.9)	71.7 (2.9)

Blank cells represent “no data”.

Table 6. Mean seasonal migration distance (km) by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

	Lincoln County	Grant County	Brookings County	All Deer
2002 Fall Migration (<i>n</i> , SE)	9.5 (15, 1.4)			9.5 (15, 1.4)
2003 Spring Migration (<i>n</i> , SE)	10.3 (16, 1.4)	7.4 (6, 1.9)	5.5 (5, 2.0)	8.7 (27, 1.0)
2003 Fall Migration (<i>n</i> , SE)	10.2 (14, 1.6)	6.5 (4, 0.9)	6.5 (6, 2.3)	8.7 (24, 1.1)
2004 Spring Migration (<i>n</i> , SE)	10.2 (14, 1.6)	12.5 (10, 3.0)	9.4 (8, 2.9)	10.7 (32, 1.3)
2004 Fall Migration (<i>n</i> , SE)	11.2 (11, 1.8)	13.0 (7, 4.5)	16.2 (4, 5.6)	12.7 (22, 1.9)
Pooled Migration (<i>n</i> , SE)	10.2 (70, 0.7)	10.6 (27, 1.7)	9.0 (23, 1.7)	10.1 (120, 0.6)

Blank cells represent “no data”.

Table 7. Mean seasonal home range size (km²) by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

	Lincoln County	Grant County	Brookings County
2002-03 Winter 50% (<i>n</i> , SE)	1.0 (10, 0.4)		0.3 (1, 0.0)
2002-03 Winter 95% (<i>n</i> , SE)	4.6 (10, 1.5)		1.7 (1, 0.0)
2003 Summer 50% (<i>n</i> , SE)	0.5 (16, 0.1)	0.7 (5, 0.2)	0.3 (14, 0.0)
2003 Summer 95% (<i>n</i> , SE)	2.1 (16, 0.4)	3.6 (6, 1.2)	1.4 (13, 0.2)
2003-04 Winter 50% (<i>n</i> , SE)	0.6 (13, 0.1)	0.9 (3, 0.5)	0.3 (9, 0.1)
2003-04 Winter 95% (<i>n</i> , SE)	2.9 (13, 0.5)	3.8 (3, 2.2)	1.5 (9, 0.2)
2004 Summer 50% (<i>n</i> , SE)	0.4 (15, 0.1)	0.4 (11, 0.1)	0.2 (15, 0.0)
2004 Summer 95% (<i>n</i> , SE)	1.8 (15, 0.3)	1.8 (11, 0.3)	1.0 (15, 0.1)

Blank cells represent “no data”.

Table 8. Seasonal, cause-specific mortality for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

Cause of Mortality	Pre-hunt ^a	Hunting-all ^a	Post-hunt ^a	Totals
Harvest	0	16	1	17
Vehicle-collision	1	0	1	2
Predation	1	0	0	1
Disease	1	0	0	1
Unknown	1	2	1	4
Totals	4	18	3	25

^a Seasonal intervals = Post-hunt (January 1 – April 30), Pre-hunt (May 1 – August 31), Hunting (September 1 – December 31), and Hunting-all (September 1 – December 31).

Table 9. Annual survival rates by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2003.

	Lincoln County	Grant County	Brookings County	All Sites
Number at-risk	20	7	18	45
Number of Deaths	4	1	1	6
Number Censored	1	0	3	4
Survival Rate	0.7917	0.8571	0.9375	0.8569
Confidence Interval (95%)	± 0.1771	± 0.2592	± 0.1228	± 0.1060
Variance	0.0082	0.0175	0.0039	0.0029

Table 10. Annual survival rates by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2004.

	Lincoln County	Grant County	Brookings County	All Sites
Number at-risk	15	17	19	51
Number of Deaths	2	7	6	15
Number Censored	1	2	0	3
Survival Rate	0.8571	0.5333	0.6706	0.6871
Confidence Interval (95%)	±0.1833	±0.2258	±0.2016	±0.1256
Variance	0.0087	0.0133	0.0106	0.0041

Table 11. Overall survival rates by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

	Lincoln County	Grant County	Brookings County	All Sites
Number at-risk	24	18	23	65
Number of Deaths	10	8	7	25
Number Censored	2	2	3	7
Survival Rate	0.5655	0.4571	0.6287	0.4906
Confidence Interval (95%)	± 0.2109	± 0.2087	± 0.2007	± 0.1144
Variance	0.0116	0.0113	0.0105	0.0034

Table 12. Seasonal survival rates for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

Season ^a	2002		2003				2004			
	Hunting	Hunting -all	Post- hunt	Pre-hunt	Hunting	Hunting -all	Post- hunt	Pre-hunt	Hunting	Hunting -all
Number at-risk	24	24	45	42	39	39	51	47	45	45
Number of Deaths	4	4	1	2	3	3	2	2	9	11
Number Censored	0	0	2	1	1	1	2	0	3	1
Survival Rate	0.8333	0.8333	0.9767	0.9518	0.9217	0.9217	0.9568	0.9574	0.7942	0.7500
Confidence Interval (95%)	±0.1455	±0.1455	±0.0450	±0.0656	±0.0843	±0.0843	±0.0568	±0.0577	±0.1177	±0.1225
Variance	0.0055	0.0055	0.0005	0.0011	0.0018	0.0018	0.0008	0.0009	0.0036	0.0039

^aSeasons = Post-hunt (January 1 – April 30), Pre-hunt (May 1 – August 31), Hunting (September 1 – December 31), and Hunting-all (September 1 – December 31).

Table 13. Annual survival rates by age for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2003-04.

Age	2003		2004 ^a	
	Fawn (~8-10 months)	Adult (≥1.5 years)	Fawn (~8-10 months)	Adult ^b (≥1.5 years)
Number at-risk	9	36	7	44
Number of Deaths	0	6	3	12
Number Censored	2	2	2	1
Survival Rate	1.0000	0.8250	0.4000	0.7191
Confidence Interval (95%)	±0.0000	±0.1256	±0.4294	±0.1281
Variance	0.0000	0.0041	0.0480	0.0043

^aSeven fawns and nine adults were added during 2004 capture operations.

^bRemaining 2003 fawns were recruited into the adult age-class in 2004.

Table 14. Capture data for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, mid May-mid June 2002-03.

Study Site	2002			2003			Pooled 2002-03					
	Brookings County			Brookings County			Lincoln County			All		
Sex	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All
Number captured	5	1	6	12	4	16	9	10	19	26	15	41
Mean (<i>n</i> , SE) handling time (minutes)	4.0 (5, 0.8)	3.0 (1, 0.0)	3.8 (6, 0.7)	3.6 (12, 0.3)	3.8 (4, 1.1)	3.6 (16, 0.3)	4.1 (9, 0.5)	4.7 (10, 0.8)	4.4 (19, 0.5)	3.8 (26, 0.3)	4.3 (15, 0.6)	4.0 (41, 0.3)
Mean (<i>n</i> , SE) age at capture (\pm 3 days)	4.8 (4, 0.9)	1.0 (1, 0.0)	4.0 (5, 1.0)	7.0 (11, 0.5)	6.7 (3, 1.2)	6.9 (14, 0.5)	3.6 (9, 1.1)	3.4 (9, 1.2)	3.5 (18, 0.8)	5.3 (24, 0.6)	4.0 (13, 1.0)	4.9 (37, 0.5)

Table 15. Monthly cause-specific mortality for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, May-August 2002-03.

Cause of Mortality	May	June	July	August	Totals
Predation	0	2	0	0	2
Starvation ^a	2	1	0	0	3
Totals	2	3	0	0	5

^aMortality may have been capture-related, thus, these neonates were censored from survival analyses.

Table 16. Survival rates by study site for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, May-August 2002-03.

	2002	2003		2002-2003
Study Site	Brookings County	Brookings County	Lincoln County	Pooled
Number at-risk	6	16	19	41
Number of Deaths	0	0	2	2
Number Censored	1	2	7	10
Survival Rate	1.0000	1.0000	0.8824	0.9474
Confidence Interval (95%)	±0.0000	±0.0000	±0.1876	±0.0791
Variance	0.0000	0.0000	0.0092	0.0016

Table 17. Monthly survival rates for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, 2002-03.

	2002				2003				Pooled 2002-2003			
Month	May	June	July	August	May	June	July	August	May	June	July	August
Number at-risk	2	6	5	5	26	32	27	24	28	38	32	29
Number of Deaths	0	0	0	0	0	2	0	0	0	2	0	0
Number Censored	0	1	0	0	3	3	3	0	3	4	3	0
Survival Rate	1.0000	1.0000	1.0000	1.0000	1.0000	0.9375	1.0000	1.0000	1.0000	0.9474	1.0000	1.0000
Confidence Interval (95%)	±0.0000	±0.0000	±0.0000	±0.0000	±0.0000	±0.0812	±0.0000	±0.0000	±0.0000	±0.0691	±0.0000	±0.0000
Variance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000

Table 18. Monthly survival rates by sex for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, 2002-03.

Sex	May		June		July		August	
	Male	Female	Male	Female	Male	Female	Male	Female
Number at-risk	15	13	24	14	22	10	21	8
Number of Deaths	0	0	0	2	0	0	0	0
Number Censored	2	1	2	2	1	2	0	0
Survival Rate	1.0000	1.0000	1.0000	0.8571	1.0000	1.0000	1.0000	1.0000
Confidence Interval (95%)	±0.0000	±0.0000	±0.0000	±0.1697	±0.0000	±0.0000	±0.0000	±0.0000
Variance	0.0000	0.0000	0.0000	0.0075	0.0000	0.0000	0.0000	0.0000

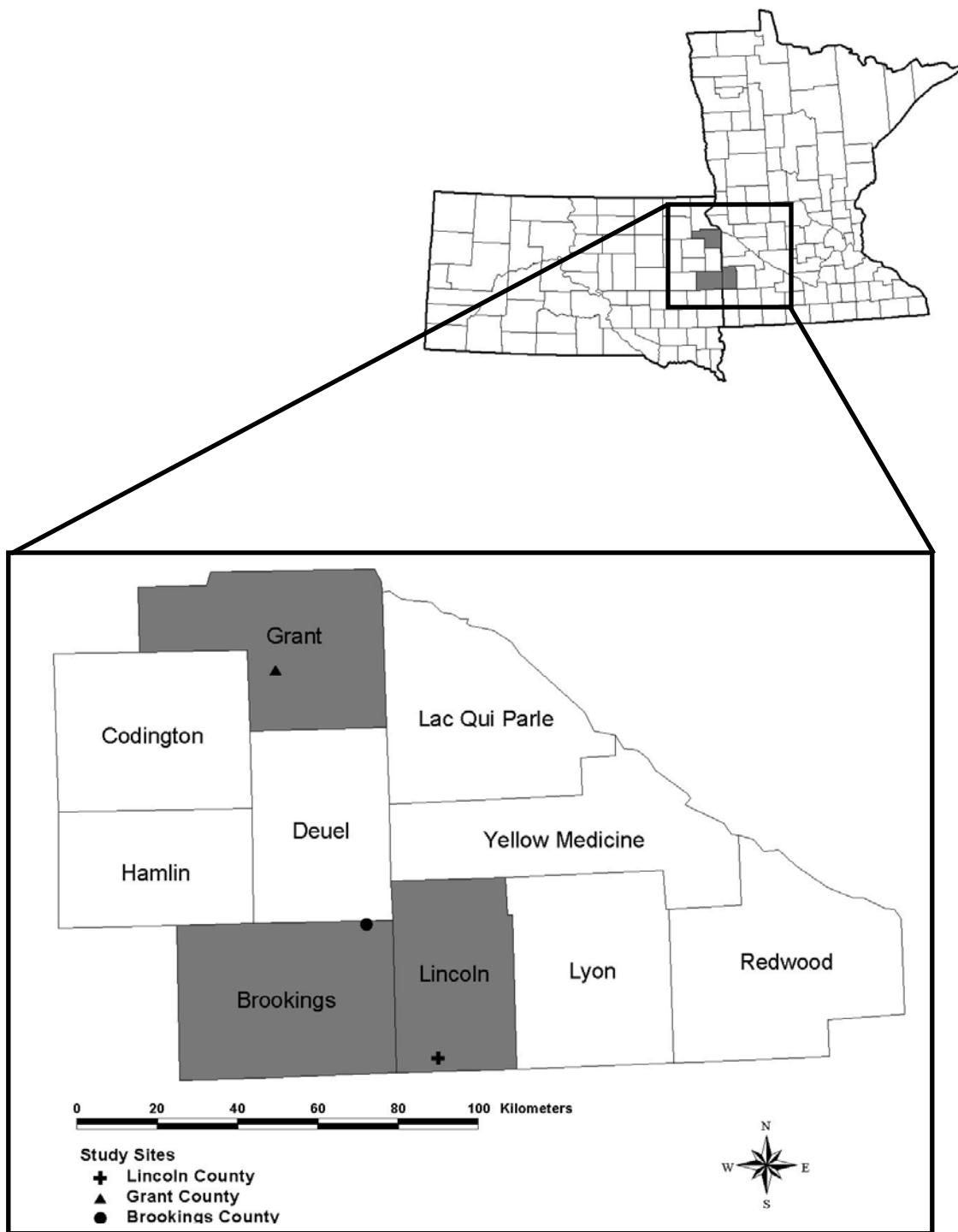


Figure 1. Study areas and capture locations for white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

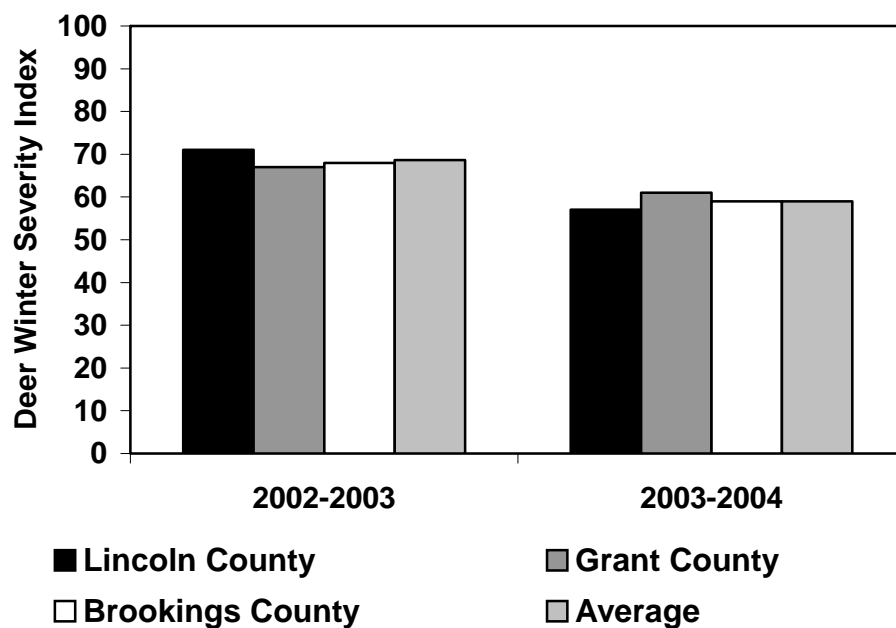


Figure 2. Annual deer winter severity index (DWSI) for individual study sites in eastern South Dakota and southwestern Minnesota, 2002-04. One point assigned for each day between October and April with a mean temperature $\leq -7^{\circ}\text{C}$, and an additional point assigned for each day with snow depths ≥ 35 cm (Brinkman 2003); (Midwest Regional Climate Center 2005, South Dakota Office of Climatology 2005).

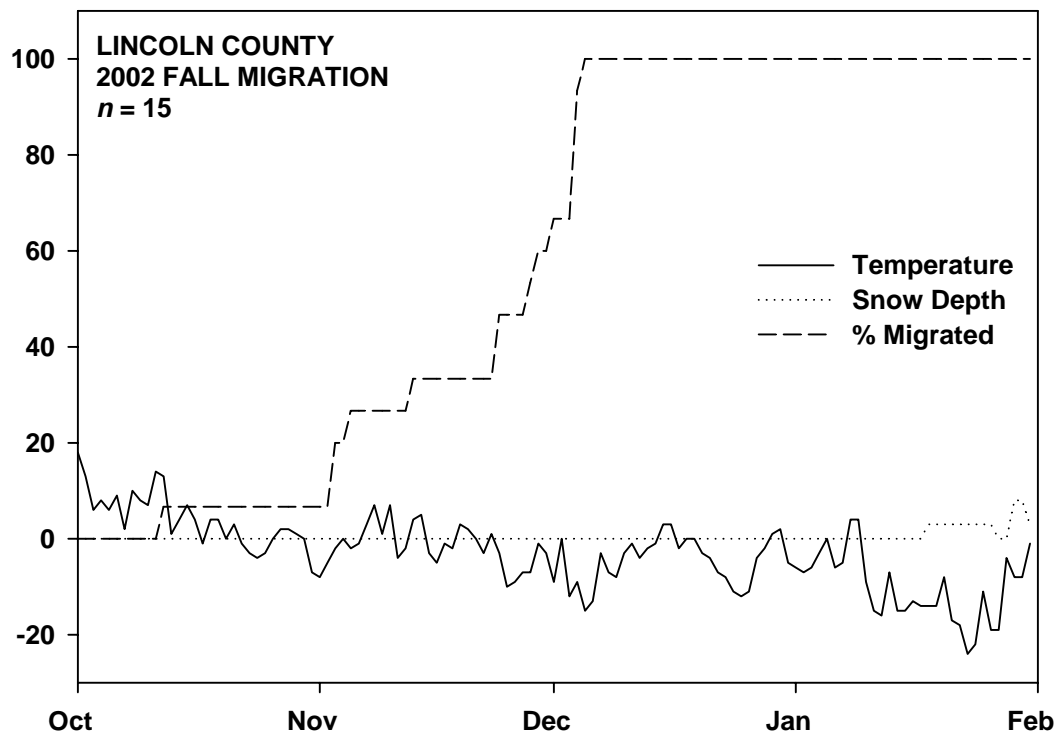


Figure 3. Fall 2002 migration for radiocollared female white-tailed deer in southwestern Minnesota. Three variables [temperature (°C), snow depth (cm), and migrating (%)] compose the Y-axis.

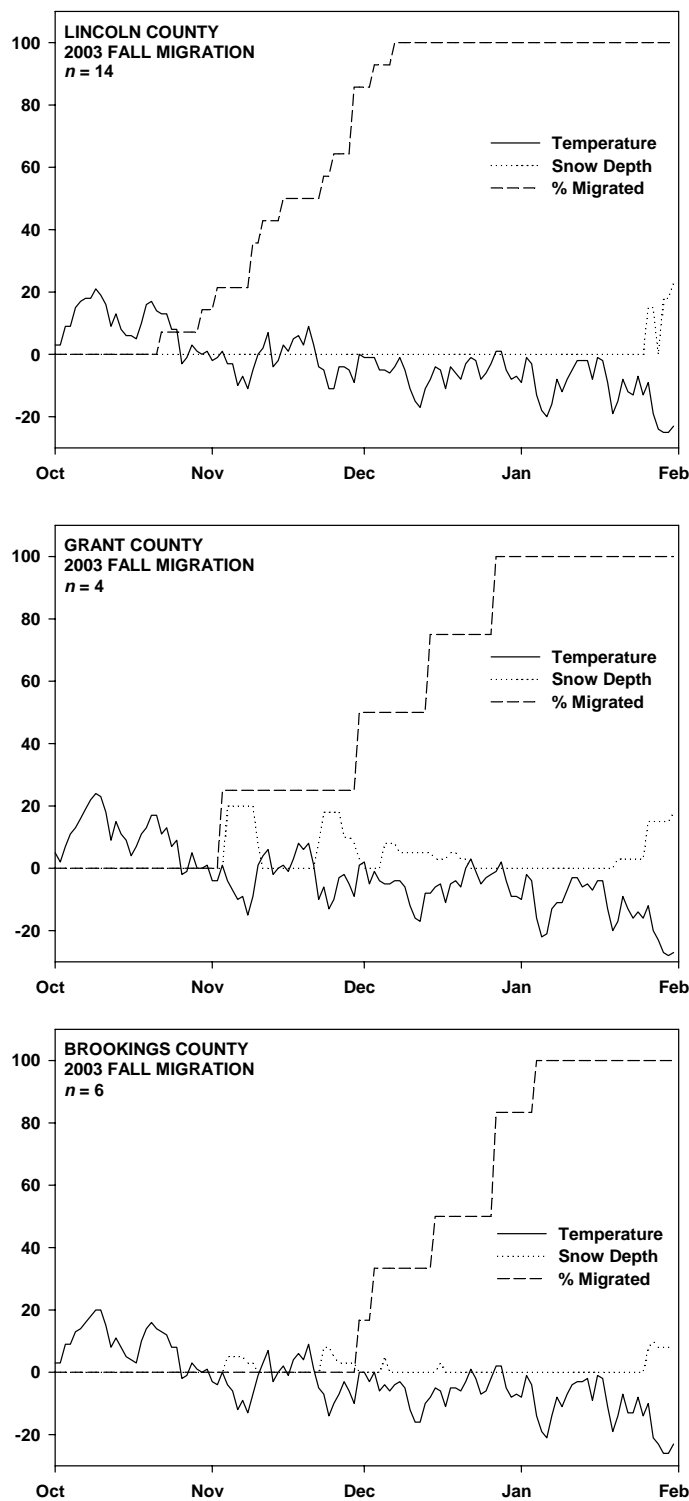


Figure 4. Fall 2003 migration by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota. Three variables [temperature ($^{\circ}\text{C}$), snow depth (cm), and migrating (%)] compose the Y-axis.

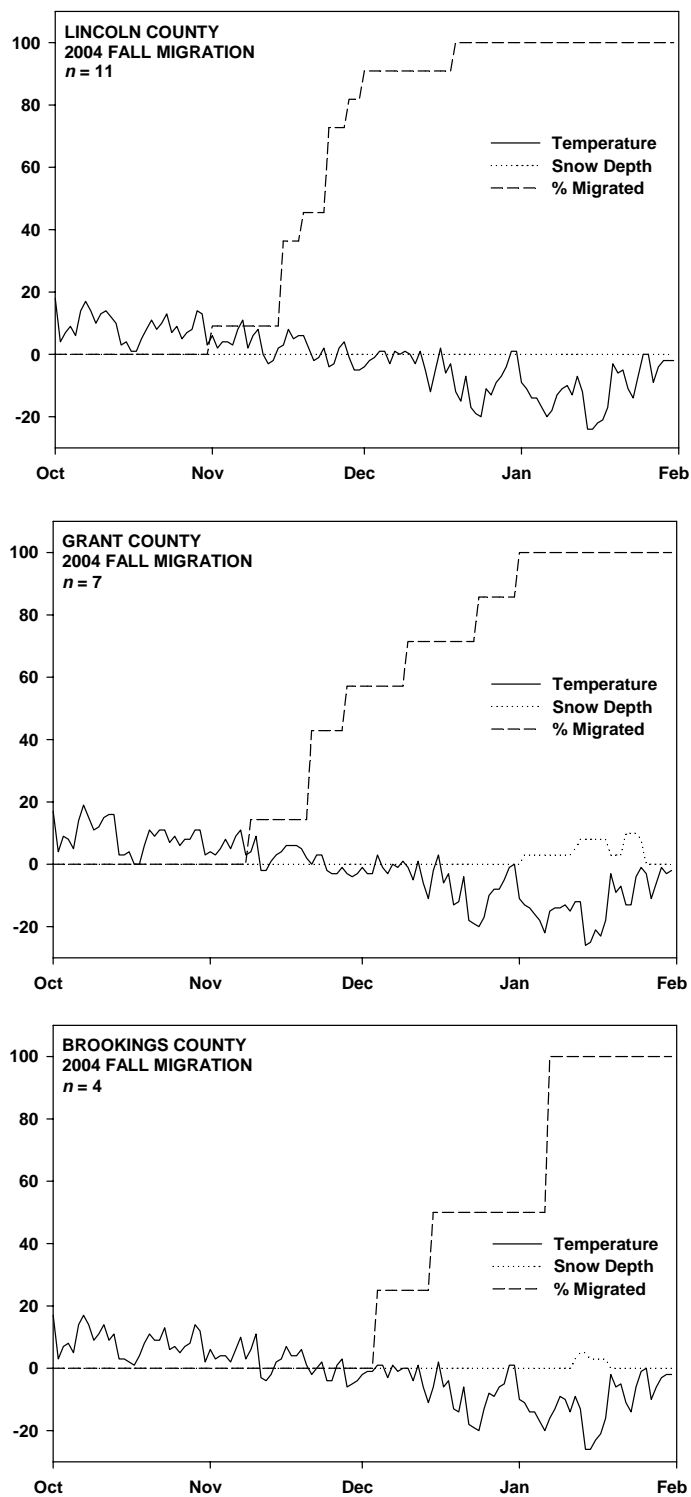


Figure 5. Fall 2004 migration by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota. Three variables [temperature (°C), snow depth (cm), and migrating (%)] compose the Y-axis.

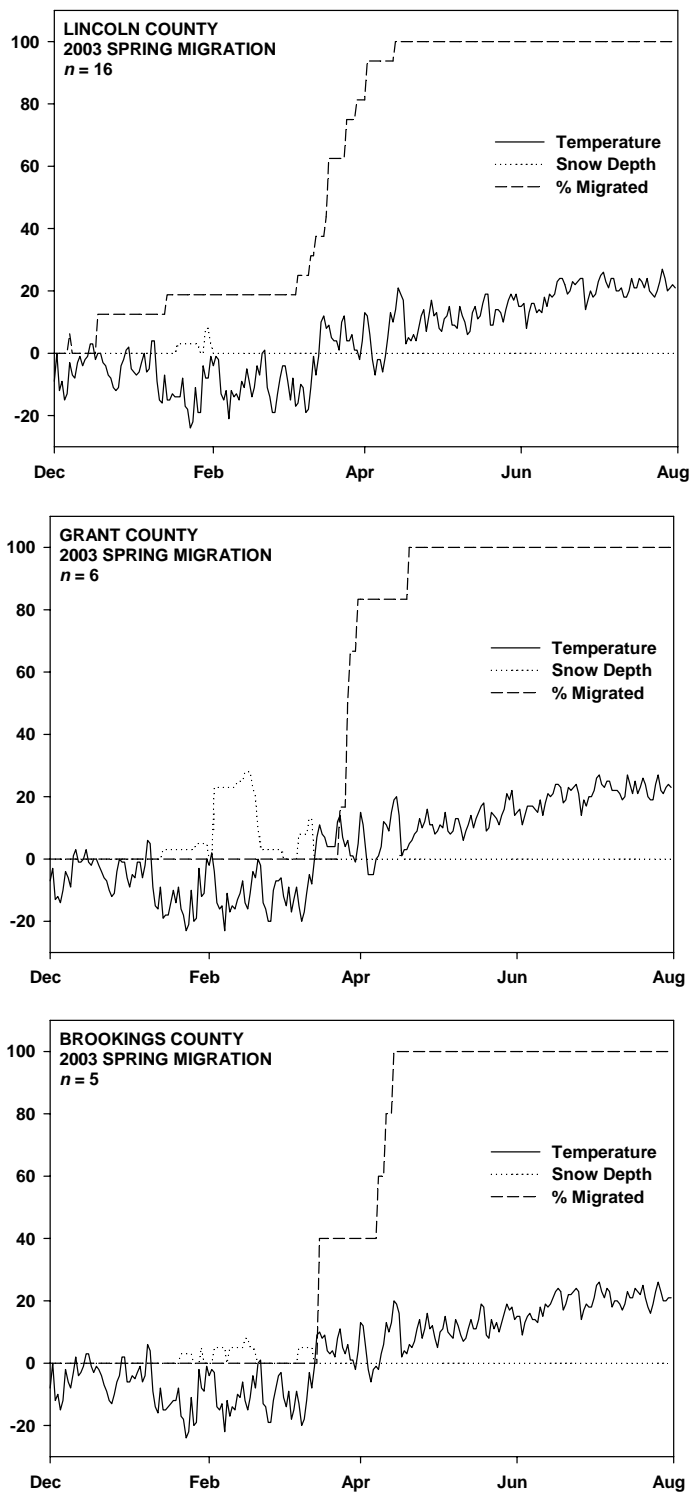


Figure 6. Spring 2003 migration by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota. Three variables [temperature ($^{\circ}\text{C}$), snow depth (cm), and migrating (%)] compose the Y-axis.

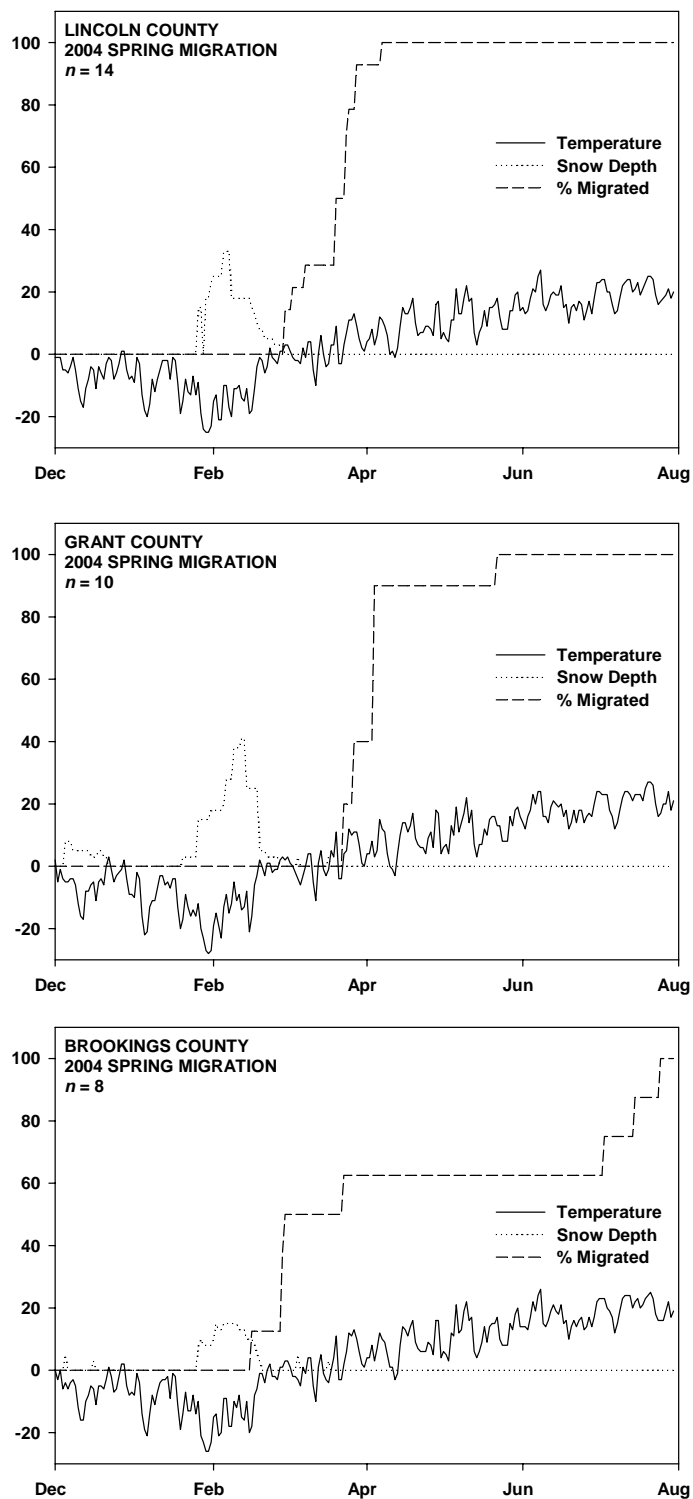


Figure 7. Spring 2004 migration by study site for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota. Three variables [temperature ($^{\circ}\text{C}$), snow depth (cm), and migrating (%)] compose the Y-axis.

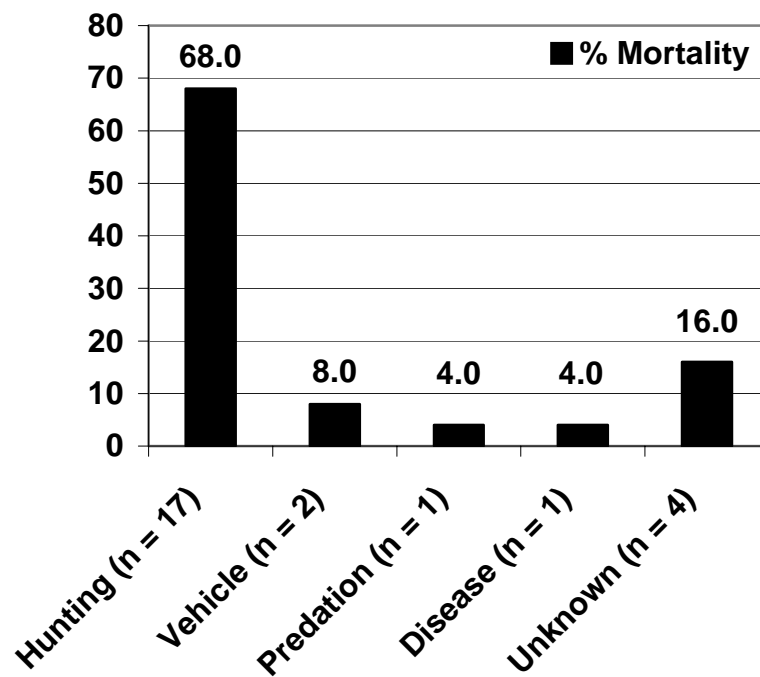


Figure 8. Cause-specific mortality ($n = 25$) of radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

Appendix A. Capture data for white-tailed deer in eastern South Dakota, January-March 2003.

Capture Date	Study Site	Age at Capture (fawn, adult)	Sex (male, female)	Collar Frequency	Processing Time	Chest Girth (cm)	Left Ear Tag #	Right Ear Tag #
1/21/03	Brookings County	A	F	014	15.00	102	51	751
1/21/03	Brookings County	A	F	103	6.00	88	52	752
1/22/03	Brookings County	F	F	N/A	6.00	No Data	53	753
1/22/03	Brookings County	F	F	N/A	4.00	No Data	55	755
1/23/03	Brookings County	F	M	N/A	4.00	No Data	56	756
1/26/03	Brookings County	A	F	431	5.50	104	57	757
1/26/03	Brookings County	A	F	482	8.00	94	58	758
1/28/03	Brookings County	F	F	163	6.00	76	59	759
1/28/03	Brookings County	A	F	522	5.00	103	60	760
1/29/03	Brookings County	F	M	N/A	3.00	No Data	61	761
1/29/03	Brookings County	A	F	583	6.00	91	62	762
1/29/03	Brookings County	A	F	621	5.50	94	63	763
1/31/03	Brookings County	F	F	222	4.00	84	64	764
2/5/03	Brookings County	A	F	662	5.50	No Data	No Data	No Data
2/7/03	Brookings County	A	F	743	No Data	107	65	765
2/7/03	Brookings County	A	F	802	No Data	98	66	766
2/8/03	Brookings County	A	F	863	5.00	104	67	767
2/9/03	Brookings County	F	M	N/A	3.00	No Data	68	768
2/10/03	Brookings County	F	F	282	5.50	79	69	769
2/11/03	Brookings County	F	M	341	5.50	81	70	770
2/11/03	Brookings County	A	F	912	6.50	102	71	771
2/17/03	Brookings County	F	F	382	4.50	74	72	772
2/17/03	Brookings County	A	F	951	4.00	104	73	773
2/28/03	Grant County	F	M	N/A	3.50	No Data	74	774
2/28/03	Grant County	F	F	063	5.50	No Data	75	775
3/1/03	Grant County	F	M	N/A	3.00	No Data	76	776
3/2/03	Grant County	F	M	N/A	No Data	No Data	77	777
3/2/03	Grant County	F	M	N/A	No Data	No Data	78	778

Appendix A. Continued.

3/3/03	Grant County	F	M	N/A	3.00	No Data	79	779
3/4/03	Grant County	A	F	365	6.50	104	80	780
3/4/03	Grant County	F	M	N/A	3.50	No Data	81	781
3/7/03	Grant County	A	F	423	5.50	95	82	782
3/12/03	Grant County	F	F	145	4.00	75	83	783
3/20/03	Grant County	A	F	462	5.00	99	84	784
3/25/03	Grant County	F	F	183	4.00	69	85	785
3/28/03	Grant County	F	F	262	6.00	80	86	786

Appendix B. Capture data for white-tailed deer in eastern South Dakota, January-February 2004.

Capture Date	Study Site	Age at Capture (fawn, adult)	Sex (male, female)	Collar Frequency	Processing Time	Chest Girth (cm)	Left Ear Tag #	Right Ear Tag #
1/18/04	Grant County	F	F	323	6.00	No Data	87	No Data
1/18/04	Grant County	F	F	502	4.50	79	88	No Data
1/20/04	Grant County	F	M	N/A	1.50	No Data	89	789
1/21/04	Grant County	F	M	N/A	2.00	No Data	90	790
1/22/04	Grant County	F	F	544	4.00	80	91	791
1/22/04	Grant County	A	F	602	5.00	99	92	792
1/25/04	Grant County	F	F	642	4.50	74	93	793
1/28/04	Grant County	F	M	N/A	2.00	No Data	94	794
1/28/04	Grant County	A	F	763	4.50	98	95	795
1/29/04	Grant County	A	F	843	6.00	93	96	No Data
1/29/04	Grant County	F	F	692	4.00	80	97	797
1/30/04	Grant County	F	F	N/A	1.00	No Data	98	798
2/2/04	Grant County	F	M	N/A	1.50	No Data	99	799
2/3/04	Grant County	F	F	N/A	1.50	67	100	800
2/3/04	Grant County	F	F	N/A	2.00	71	476	676
2/5/04	Grant County	A	F	882	5.50	110	477	677
2/6/04	Grant County	A	F	932	7.00	99	478	678
2/11/04	Grant County	A	F	423B	4.50	107	479	679
2/16/04	Brookings County	F	F	323B	7.50	69	480	680
2/16/04	Brookings County	A	F	1254	7.00	94	481	681
2/16/04	Brookings County	F	M	N/A	3.50	No Data	482	682
2/18/04	Brookings County	F	M	N/A	1.50	No Data	483	683
2/18/04	Brookings County	F	F	382B	4.00	71	484	684
2/18/04	Brookings County	A	F	1334	6.00	91	485	685
2/19/04	Brookings County	A	F	1311	9.00	93	486	686
2/23/04	Brookings County	F	M	N/A	3.50	77	487	687

Appendix C. Capture data for radiocollared female white-tailed deer in southwestern Minnesota, January 2001-02 (Brinkman 2003).

Capture Date	Study Site	Age at capture (fawn, adult)	Collar Frequency	Processing Time	Rectal Temp. C°	Neck Girth (cm)	Chest Girth (cm)	Left Ear Tag #	Right Ear Tag #	Transport Distance (km)
1/22/01	Lincoln County	A	731	11.00	40.0	48	105	1025	1026	1.43
1/22/01	Lincoln County	F	761	11.00	40.4	40	95	1123	1124	1.09
1/22/01	Lincoln County	A	131	8.00	39.9	41	111	1127	1128	2.95
1/22/01	Lincoln County	A	372	9.00	40.6	42	113	1129	1130	1.05
1/22/01	Lincoln County	A	672	12.00	41.1	49	108	1131	1132	1.24
1/22/01	Lincoln County	A	072	9.00	41.8	38	101	1235	1234	2.11
1/22/01	Lincoln County	A	011	6.00	39.9	41	107	1136	1135	1.50
1/22/01	Lincoln County	F	853	13.00	40.4	35	87	1238	1239	0.23
1/22/01	Lincoln County	F	881	15.00	41.0	31	83	1243	1242	0.80
1/22/01	Lincoln County	F	821	8.00	40.6	33	83	1137	1138	0.23
1/22/01	Lincoln County	A	309	11.00	39.9	40	114	1139	1140	1.19
1/22/01	Lincoln County	A	250	9.00	40.5	39	112	1233	1232	0.35
1/22/01	Lincoln County	A	491	9.00	40.5	42	108	1025	1026	1.09
1/22/01	Lincoln County	A	611	7.00	41.0	45	101	1237	1236	1.42
1/22/01	Lincoln County	A	643	7.00	40.0	46	115	1226	1227	1.46
1/22/01	Lincoln County	A	430	8.00	40.9	44	109	1229	1228	2.08
1/26/02	Lincoln County	A	032B	7.00	40.5	52	107	1301	1302	1.28
1/26/02	Lincoln County	A	352B	9.00	40.6	48	100	1337	1336	2.04
1/26/02	Lincoln County	A	551B	9.00	39.9	44	104	1335	1334	1.18
1/26/02	Lincoln County	A	771B	5.00	40.8	45	101	1303	1304	1.67
1/26/02	Lincoln County	A	803B	6.00	40.2	41	99	1333	1332	2.11
1/26/02	Lincoln County	A	832B	5.00	41.5	42	101	1331	1330	0.85
1/26/02	Lincoln County	A	868B	7.00	40.8	52	103	1327	1326	1.70
1/26/02	Lincoln County	A	901B	7.00	41.1	42	104	1329	1328	1.06

Appendix D. Seasonal movement for individual radiocollared female white-tailed deer in southwestern Minnesota, 2002.

Deer ID	Study Site ^a	Fall Movement (km)	Fall Migration (km)
011	LC		
032B	LC	17.6	17.6
072	LC	11.7	11.7
131	LC	10.1	10.1
250	LC	7.2	7.2
309	LC		
352B	LC		
372	LC	5.7	5.7
430	LC	0.0	
491	LC		
551B	LC	3.5	3.5
611	LC	9.7	9.7
643	LC	4.2	4.2
672	LC		
731	LC	7.6	7.6
761	LC	7.2	7.2
771B	LC		
803B	LC	6.3	6.3
821	LC	0.0	
832B	LC	2.9	2.9
853	LC	11.3	11.3
868B	LC	19.1	19.1
881	LC	0.0	
901B	LC	19.0	19.0

^aLC = Lincoln County

-Blank cells represent "no data".

Appendix E. Seasonal movement for individual radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2003.

Deer ID	Study Site ^a	Winter 50% Home Range (ha)	Winter 95% Home Range (ha)	Summer 50% Home Range (ha)	Summer 95% Home Range (ha)	Spring Movement (km)	Spring Dispersal (km)	Spring Migration (km)	Fall Movement (km)	Fall Migration (km)
032B	LC			58.8	286.0	17.9		17.9	17.5	17.5
072	LC			19.5	117.2	12.8		12.8	13.7	13.7
131	LC					10.1		10.1		
250	LC			12.0	73.7	7.1		7.1	7.2	7.2
352B	LC	39.7	143.7			16.4		16.4		
372	LC	384.3	1675.4	53.9	248.8	6.2		6.2	6.4	6.4
430	LC			44.4	199.5	0.0			4.9	4.9
551B	LC			8.2	50.2	4.0		4.0	3.6	3.6
611	LC			13.2	72.3	10.2		10.2	10.1	10.1
643	LC	81.7	385.7	66.3	288.5	4.1		4.1	4.0	4.0
731	LC	139.0	562.1	14.1	74.2	7.4		7.4	7.3	7.3
761	LC	180.3	827.2	16.5	104.0	7.3		7.3	7.1	7.1
771B	LC					31.9	31.9			
803B	LC	44.6	216.0	69.4	376.3	6.7		6.7	6.7	6.7
821	LC			112.6	438.9	0.0			0.0	
832B	LC					3.0		3.0		
853	LC	36.7	199.3	19.4	135.0	11.2		11.2	14.6	14.6
868B	LC	25.5	121.6	182.7	702.4	19.3		19.3	19.5	19.5
881	LC	14.8	102.7	16.0	78.5	0.0			0.0	
901B	LC	75.6	338.9	29.7	180.8	20.4		20.4	20.7	20.7
063	GC			36.4	258.8	3.4		3.4	4.9	4.9
145	GC					134.0	134.0	15.4		
183	GC				115.3	4.2		4.2	5.3	5.3
262	GC			37.5	188.6	7.8		7.8	8.6	8.6
365	GC			52.3	244.4	0.0			0.0	
423	GC			50.9	448.3	3.5		3.5		
462	GC			155.8	901.9	10.0		10.0	7.2	7.2
014	BC			41.5	163.7	0.0			0.0	
103	BC			17.9	83.4	0.0			2.6	2.6
163	BC			32.7	167.5	0.0			0.0	
222	BC			20.1	112.1	0.0				
282	BC			25.8	131.1	3.2		3.2	2.0	2.0
341	BC	29.9	168.5	55.9	372.9	26.8	26.8		3.1	3.1
382	BC									
431	BC			21.9	105.0	0.0			0.0	
482	BC									
522	BC			18.2	102.8	0.0			0.0	
583	BC			40.2	182.0	0.0			0.0	
621	BC					0.0				
662	BC								13.6	13.6
743	BC			61.8	244.4	3.9		3.9	4.0	4.0
802	BC			14.3	62.6	3.7		3.7	0.0	
863	BC			11.5	53.3	0.0			0.0	
912	BC			12.2		13.6		13.6	13.9	13.9
951	BC			17.1	91.3	3.2		3.2	0.0	

^aLC = Lincoln County, GC = Grant County, BC = Brookings County
 -Blank cells represent “no data”.

Appendix F. Seasonal movement for individual radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2004.

Deer ID	Study Site ^a	Winter 50% Home Range (ha)	Winter 95% Home Range (ha)	Summer 50% Home Range (ha)	Summer 95% Home Range (ha)	Spring Movement (km)	Spring Dispersal (km)	Spring Migration (km)	Fall Movement (km)	Fall Migration (km)
032B	LC	35.1	159.6	64.8	285.9	17.5		17.5	17.6	17.6
072	LC	94.3	532.2	11.0	116.0	13.8		13.8	13.9	13.9
250	LC	116.1	483.9	7.3	32.8	7.6		7.6		
372	LC	84.3	411.3	32.4	196.5	5.5		5.5	5.5	5.5
430	LC			19.0	84.8	3.7		3.7		
551B	LC	40.5	181.5	53.7	242.7	3.6		3.6	2.7	2.7
611	LC			13.7	71.6	9.8		9.8	10.2	10.2
643	LC	18.5	99.9	61.8	219.5	4.1		4.1		
731	LC	47.3	246.0	24.8	101.4	7.5		7.5	7.6	7.6
761	LC	48.8	231.5	23.9	104.8	7.2		7.2	7.1	7.1
803B	LC	33.4	175.4	19.4	97.8	7.1		7.1	6.6	6.6
821	LC	83.0	370.5	74.4	331.6	0.0			0.0	
853	LC	144.4	634.4	23.1	128.4	15.0		15.0	11.6	11.6
868B	LC	24.5	120.1	91.9	428.0	19.9		19.9	19.9	19.9
901B	LC	26.5	172.8	46.7	196.1	20.1		20.1	20.3	20.3
063	GC			53.7	242.5	5.2		5.2	5.3	5.3
145	GC									
183	GC	186.5	806.6	24.2	151.9	5.2		5.2	3.6	3.6
262	GC	21.0	91.8	35.6	145.9	8.3		8.3	7.5	7.5
323	GC									
365	GC	55.9	252.2	34.6	175.7	0.0			0.0	
423B	GC			24.5	100.7	0.0			0.0	
462	GC			49.6	221.8	7.7		7.7		
502	GC					170.4	170.4	9.9		
544	GC									
602	GC			10.2	50.9	19.0		19.0	16.7	16.7
642	GC					0.0				
692	GC			39.3	186.4	0.0			0.0	
763	GC			98.0	465.1	12.7		12.7		
843	GC					36.6		36.6	37.9	37.9
882	GC			42.3	151.8	8.1		8.1	7.8	7.8
932	GC			9.4	47.3	12.7		12.7	12.0	12.0
014	BC	46.1	182.8	18.4	82.0	0.0			0.0	
103	BC			23.6	132.4	2.6		2.6	0.0	
163	BC	56.6	238.0	29.4	125.8	0.0			0.0	
282	BC	26.2	144.4	7.4	38.4	2.4		2.4		
323B	BC					0.0				
341	BC									
382B	BC			14.5	70.5	2.1		2.1	8.4	8.4
431	BC	20.3	92.1	23.9	112.7	0.0			8.3	8.3
522	BC	24.4	144.2	13.2	67.7	0.0			0.0	
583	BC	31.3	189.3	16.1	103.5	0.0				
662	BC			38.7	199.0	13.9		13.9	16.0	16.0
743	BC			32.9	158.8	4.0		4.0	0.0	
802	BC	18.1	115.9	13.3	64.6	0.0			0.0	
863	BC									
912	BC			18.0	83.7	14.0		14.0	0.0	
951	BC	10.9	54.4	9.6	44.2	0.0			0.0	
1254	BC	44.1	230.1	50.3	224.2	11.1		11.1	32.2	32.2
1311	BC			11.1	53.6	0.0			0.0	
1334	BC					24.9		24.9		

^aLC = Lincoln County, GC = Grant County, BC = Brookings County
 -Blank cells represent "no data".

Appendix G. Mortality for radiocollared white-tailed deer in eastern South Dakota and southwestern Minnesota, 2002-04.

Capture Location	Age at Capture	Capture Date	Cause of Death	Age at Death (years)	Date of Death
Lincoln County	Adult	1/22/01	Hunting	Unknown	11/9/02
Lincoln County	Adult	1/22/01	Hunting	9.5	11/9/02
Lincoln County	Adult	1/22/01	Hunting	10.5	11/9/02
Lincoln County	Adult	1/22/01	Hunting	6.5	12/9/02
Brookings County	Adult	1/26/03	Capture related ^a	1.5	2/12/03
Brookings County	Fawn	2/17/03	Capture related ^a	0.5	2/21/03
Lincoln County	Adult	1/22/01	Vehicle collision	11.5	3/2/03
Brookings County	Adult	1/29/03	Disease	3.0	5/1/03
Lincoln County	Adult	1/26/02	Vehicle collision	4.0	6/28/03
Grant County	Adult	3/7/03	Hunting	7.5	9/17/03
Lincoln County	Adult	1/26/02	Hunting	Unknown	11/25/03
Lincoln County	Fawn	1/22/01	Hunting	3.5	12/13/03
Brookings County	Adult	2/8/03	Hunting	3.5	1/31/04
Grant County	Fawn	1/18/04	Capture related ^a	0.5	2/4/04
Brookings County	Fawn	2/11/03	Unknown	1.5	3/24/04
Grant County	Fawn	1/25/04	Unknown	1.0	6/17/04
Brookings County	Fawn	2/16/04	Predation	1.0	7/20/04
Lincoln County	Adult	1/22/01	Hunting	8.5	11/6/04
Brookings County	Fawn	2/10/03	Hunting	2.5	11/6/04
Brookings County	Adult	1/29/03	Hunting	3.5	11/7/04
Grant County	Fawn	3/12/03	Hunting	2.5	11/10/04
Grant County	Fawn	1/18/04	Unknown	1.5	11/18/04
Grant County	Adult	1/28/04	Hunting	Unknown	11/20/04
Grant County	Adult	1/29/04	Hunting	2.5	11/20/04
Lincoln County	Adult	1/22/01	Hunting	6.5	11/27/04
Grant County	Adult	2/11/04	Hunting	6.5	12/1/04
Brookings County	Adult	2/18/04	Hunting	2.5	12/11/04
Grant County	Adult	3/20/03	Unknown	9.5	12/19/04

^aMortality occurred <26 days post-capture and may have been capture-related, therefore, these individuals were censored from survival analyses.

Appendix H. Mortality for ear-tagged white-tailed deer in eastern South Dakota, 2003-04.

Capture Location	Age at Capture	Sex	Capture Date	Cause of Death	Age at Death (years)	Date of Death
Grant County	Fawn	F	1/30/04	Vehicle Collision	1.0	3/31/04
Grant County	Fawn	F	2/3/04	Vehicle Collision	1.0	6/5/04
Brookings County	Fawn	M	2/9/03	Vehicle Collision	2.5	11/10/04
Grant County	Fawn	M	2/2/04	Archery Hunting	1.5	11/19/04
Brookings County	Fawn	M	1/23/03	Firearms Hunting	2.5	11/20/04
Grant County	Fawn	M	3/2/03	Firearms Hunting	2.5	11/20/04
Grant County	Fawn	M	1/21/04	Firearms Hunting	1.5	11/20/04
Grant County	Fawn	M	3/1/03	Firearms Hunting	2.5	11/21/04

Appendix I. Capture data for white-tailed deer neonates in eastern South Dakota, mid May-mid June 2002.

Study Site	Frequency	Capture Date	Sex	Handling Time (min.)	Estimated Age (± 3 days)
Brookings County	124	5/27/2002	F	3	1
Brookings County	103	5/30/2002	M	6	3
Brookings County	164	6/2/2002	M	5	7
Brookings County	144	6/4/2002	M	1	Unknown
Brookings County	083	6/6/2002	M	4	4
Brookings County	173	6/9/2002	M	4	5

Appendix J. Capture data for white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, mid May-mid June 2003.

Study Site	Frequency	Capture Date	Sex	Handling Time (min.)	Estimated Age (± 3 days)
Brookings County	001	5/22/2003	M	3	8
Brookings County	014	5/22/2003	F	6	9
Brookings County	024	5/23/2003	M	5	5
Brookings County	035	5/23/2003	M	5	5
Brookings County	043	5/29/2003	M	3	5
Brookings County	053	5/29/2003	M	4	6
Brookings County	063	5/30/2003	F	5	5
Brookings County	073	5/30/2003	M	4	5
Brookings County	133	6/2/2003	F	1	Unknown
Brookings County	093	6/3/2003	M	4	6
Brookings County	114	6/3/2003	M	4	8
Brookings County	152	6/4/2003	M	3	8
Brookings County	214	6/4/2003	F	3	6
Brookings County	294	6/5/2003	M	4	7
Brookings County	182	6/11/2003	M	1	Unknown
Brookings County	194	6/15/2003	M	4	9
Lincoln County	240	5/18/2003	M	7	1
Lincoln County	030	5/23/2003	F	4	<1
Lincoln County	170	5/23/2003	M	6	<1
Lincoln County	280	5/23/2003	M	3	<1
Lincoln County	290	5/24/2003	F	4	1
Lincoln County	340	5/26/2003	F	3	3
Lincoln County	220	5/28/2003	M	3	2
Lincoln County	230	5/28/2003	F	5	12
Lincoln County	260	5/28/2003	F	5	2
Lincoln County	120	5/28/2003	M	4	5
Lincoln County	100	5/29/2003	M	3	6
Lincoln County	080	5/29/2003	M	4	<1
Lincoln County	060	5/29/2003	F	6	<1
Lincoln County	310	5/30/2003	M	5	5
Lincoln County	140	5/31/2003	F	11	6
Lincoln County	300	5/31/2003	F	3	4
Lincoln County	190	5/31/2003	F	4	1
Lincoln County	340b ^a	5/31/2003	F	2	Unknown
Lincoln County	280b ^a	6/7/2003	M	2	10

^aRadiocollars were fitted on additional neonates due to collar prematurely dropping or mortality of initially collared neonates.

Appendix K. Mortality for radiocollared white-tailed deer neonates in eastern South Dakota and southwestern Minnesota, May-August 2002-03.

Study Site	Year	Sex	Capture Date	Mortality Date	Cause of Mortality
Brookings County	2003	Male	5/22/03	5/23/03	Starvation ^a
Lincoln County	2003	Female	5/23/03	6/5/03	Predation
Lincoln County	2003	Female	5/26/03	5/30/03	Starvation ^a
Lincoln County	2003	Male	5/30/03	6/5/03	Starvation ^a
Lincoln County	2003	Female	5/31/03	6/5/03	Predation

^aMortality may have been capture-related, thus, these neonates were censored from survival analyses.