POPULATION ECOLOGY OF WHITE-TAILED DEER IN THE DRIFT PRAIRIE-COTEAU OF NORTH DAKOTA

by

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This thesis, submitted by Jason R. Smith in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

Chairperson

This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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ABSTRACT

Although widespread changes in natural ecosystems associated with agricultural and urban development have negatively affected many organisms, white-tailed deer (*Odocoileus virginianus*) have greatly benefited from these human-induced changes by increased populations and range expansion. Current management of white-tailed deer in North Dakota involves balancing the popularity of the species as a big game mammal with the concerns of private landowners over increasing depredation damage. Further, the North Dakota Game and Fish Department oversees numerous Wildlife Management Areas (WMAs) where a variety of grains and other crops are grown to provide quality habitat and hunting opportunities. These WMAs are often surrounded by intensively farmed agricultural fields and associated farmsteads, which deer regularly visit in their normal movements in search of shelter and food.

My primary objectives in this study were to (1) assess seasonal patterns of habitat use and movements of white-tailed deer in relation to forage availability in food plots on Lonetree Wildlife Management Area (WMA) and in adjacent agricultural fields, and (2) evaluate survival in relation to different major mortality factors (hunting, deer-vehicle collisions, predation, etc.).

I used a combination of radiotelemetry locations and 100m x 2m fecal pellet belt transects to assess habitat use by deer. Winter and summer home range sizes (95%, 50% minimum convex polygon (MCP), and 95%, 50% adaptive kernel (ADK) home ranges) were also estimated for a subset of adult females. Diets of deer were estimated from microhistological analyses of fecal pellets, based on bimonthly composite samples collected monthly from January 2002 to December 2003. Seasonal movements of deer were assessed using a combination of systematic locations of radiocollared deer, and biweekly spotlight surveys. I also estimated survival from the fates of radiocollared female deer using the staggered-entry Kaplan-Meier method.

Results indicated that radiocollared deer selected for food plots, trees and shrubs, and dense nesting cover while avoiding grassland habitats (Log-ratio Chi-square = 137.5, df = 3, $P < 0.001$). Similar to data from radiolocations, fecal transect information indicated that deer selected for food plots and trees and shrubs. Unlike data from radiocollared deer, however, fecal transect data did not identify a preference for dense nesting cover. Dietary analyses also revealed variation in diets among seasons (Log-ratio Chi-square = 138.1, df = 10, $P < 0.0001$). Analyses of home range sizes for adult females at Lonetree WMA indicated that estimated 95% MCP ($t_{0.05\,(1),\,11} = 4.87$, $P < 0.001$) and 50% MCP ($t_{0.05\,(1),\,11} = 2.17$, $P = 0.03$) winter home range sizes were significantly greater than summer home range sizes (95%, 50% MCP).

The overall average movement exhibited by deer at Lonetree WMA was 22.4 km (SE $\pm$ 3.8). Maximum movements observed were 32.2 km for an adult female, 132.7 km for a fawn female and 120.4 km for a fawn male. Spotlight surveys indicated deer numbers gradually declined on Lonetree March to May, were low June to December, and then increased after late December to a peak of 6.5 deer/km in February. Overall adult and fawn female survivorship from March 2002 through December 2003 was 60% and 67%, respectively. Estimated annual survival rates were 77% for adult females and 78% for fawn females in 2002 and 83% for adult females and 89% for fawn females in 2003.

CHAPTER 1

INTRODUCTION AND DESCRIPTION OF STUDY

Background and History

Although widespread changes in natural ecosystems associated with agricultural and urban development have negatively affected many organisms, white-tailed deer (*Odocoileus virginianus*) have greatly benefited from these changes by increased populations and range expansion (U.S. Dept. Agric. For. Serv. 1970, Waller and Alverson 1997). Over the past 100 years in the northern Great Plains for example, white-tailed deer have greatly expanded in number related to the extirpation of large predators, such as wolves (*Canis lupus*), and the conversion of land to agriculture, which has provided forage in the form of crops and cover via the planting of shelterbelts (Oehler et al. 1995, Demarais et al. 2000).

Prior to the arrival of Europeans, North Dakota was largely an expanse of native prairie, and white-tailed deer populations were mainly restricted to riparian areas along the river systems (Figure 1). The influx of settlers due to the enactment of the Homestead Act resulted in the conversion of prairie into a highly fragmented agricultural landscape. This habitat change would have been beneficial to white-tailed deer had it not coincided with a period when conservation of wildlife was not a high priority. Unregulated subsistence hunting caused a decline in deer numbers in the late 1800s to a point that by the early 1900s observations of white-tailed deer were rare in North Dakota

(Bailey 1926). However, during the 1920s white-tailed deer populations began to rebound due to the enactment of wildlife-related legislation at the federal and state levels,

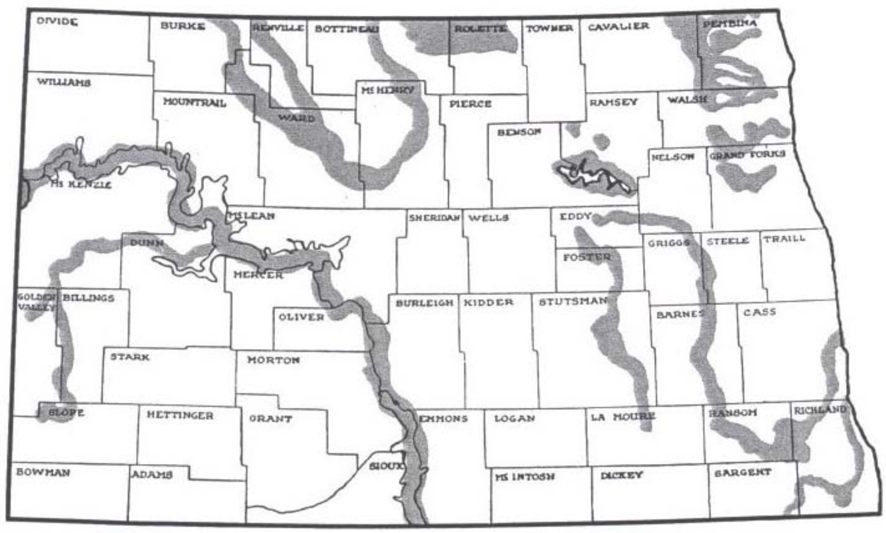

Figure 1. Historical distribution of white-tailed deer in North Dakota (North Dakota Outdoors, June 1941 *in* Big Game in North Dakota: A Short History, Knue 1991)

including closed and increasingly regulated hunting seasons (Knue 1991). In 1937 the Federal Aid in Wildlife Restoration Act, also known as the Pittman-Robertson Act, was passed and in 1939 North Dakota received its first funding. This event marked a major turning point for white-tailed deer and other wildlife in the state. During this period the concept of “game management” as proposed by Aldo Leopold (Leopold 1933) was also gaining in popularity, and funding provided by the Pittman-Robertson Act allowed the North Dakota Game and Fish Department to implement wildlife research, and to buy, develop, and manage habitat for wildlife.

The development of the Missouri River under the Pick-Sloan Missouri River Development Plan during the late 1940s and early 1950s would have an increasing impact on wildlife with projects like the Garrison Dam (Knue 1991). The effect that the

Garrison Dam had on North Dakota's white-tailed deer herd cannot be underestimated (Knue 1991). The land lost due to the filling of the Lake Sakakawea reservoir, over 40,469 hectares of trees and timber were inundated, represented a considerable percentage of North Dakota's white-tailed deer habitat (Hanson 1950). By the time that the Garrison Dam was completed in 1953, deer had begun to shift from their traditional riparian habitat and were becoming increasingly abundant in nontraditional prairie habitat. Critical to the success of white-tailed deer in this transition, was the passage of the Soil Bank Act in 1956, which during its duration removed nearly 1,214,057 hectares of land from agricultural production in North Dakota (Knue 1991).

In addition, because there were no provisions for wildlife under the Army Corps of Engineers original plans and proposals, in 1945 the North Dakota Game and Fish Department initiated a survey to examine possible effects of the Missouri Basin Development upon wildlife in North Dakota (Miller and Bach 1945). One important recommendation made by the Game and Fish Department was that, "destroyed habitat including timber, brush, and grasslands should be replaced in other favorable areas that will produce an equal amount of wildlife" (Miller and Bach 1945). This clearly indicated that the Game and Fish Department was committed to ensuring that quality wildlife habitat lost to projects such as the Missouri Basin Development would need to be replaced. State-based land purchase for developing Wildlife Management Areas (WMAs) in the 1930s were the result, and as of 2004 there were approximately 171 WMAs totaling roughly 73,894 hectares distributed across the state. These WMAs are either owned or leased to the North Dakota Game and Fish Department for management (North Dakota Game and Fish Department 2003a). The creation of multiple WMAs combined with regulated hunting seasons and ecosystem change caused by agriculture contributed to a steady increase of deer from the 1940s to the present. Currently, white-tailed deer numbers in North Dakota are at all time highs, and although this situation is popular among hunters, deer in many areas are using agricultural fields and shelterbelts around farmsteads for forage and cover and depredation damage to crops is a growing concern among farmers and ranchers.

Current management of white-tailed deer in North Dakota involves balancing the popularity of the species as a big game mammal while taking into account the concerns of private landowners over increasing depredation damage. Further, the North Dakota Game and Fish Department oversees numerous WMAs where a variety of grains and other crops are grown to provide quality habitat and hunting opportunities. These WMAs are often surrounded by intensively farmed agricultural fields and associated farmsteads, which deer regularly visit in their normal movements in search of shelter and food. Very little quantitative information is available on habitat use, seasonal movements, and productivity of white-tailed deer within North Dakota's WMAs useful for improving management and mitigating problems associated with burgeoning populations of white-tailed deer. My research was designed to provide quantitative data on the population ecology of white-tailed deer at Lonetree WMA in central North Dakota.

Objectives of Study

1) Assess seasonal patterns of habitat use and movements of white-tailed deer in relation to forage availability in food plots on Lonetree WMA and in adjacent agricultural fields.

2) Evaluate survival in relation to different major mortality factors (hunting, deer-vehicle collisions, predation, etc.) for white-tailed deer in the Drift Prairie-Coteau region of North Dakota.

Study Area

History and Description

The study was conducted at the Lonetree Wildlife Management Area (WMA) in Sheridan and Wells counties in central North Dakota. This 13,404-hectare WMA skirts the Missouri Coteau and encompasses the Sheyenne River Headwaters. Tall and mixed-grass prairie, seasonal wetlands, and prairie potholes dominate the area. The development of Lonetree WMA was directly related to the Missouri Basin Development in that it was originally intended to be a regulatory reservoir for the Garrison Diversion Project connecting the McClusky Canal with the New Rockford Canal, and linking the Missouri River with the James River, Souris River, and Sheyenne River Watersheds (North Dakota Game and Fish Dept. 2001). Specifically, the Garrison Diversion Unit Project (GDU) was authorized by Congress as part of the Flood Control Act of 1944, and the initial stage of GDU was authorized in 1965. It was to be an irrigation, municipal, industrial, and recreational water project for the State of North Dakota to compensate for the loss of river bottomland when Garrison Dam was built in the early 1950s. Due to environmental and international concerns about the Garrison Diversion Project, Congress established the Garrison Diversion Unit Commission in 1984 to address these concerns and to define current water needs of North Dakota in relation to GDU. The Commission's recommendations became the foundation of the Garrison Diversion Unit Reformulation Act of 1986. Under this act it was recommended that land purchased in fee title for the Lonetree Reservoir be retained by the Department of the Interior with the Bureau of Reclamation as the administering agency. Lonetree WMA was turned over to the State of North Dakota for the purpose of managing it for wildlife on January 7, 1997 making it the states largest WMA. The Lonetree Reservoir was deauthorized under the Dakota Water Resources Act of 2000 (North Dakota Game and Fish Dept. 2001).

All land previously in agricultural production on Lonetree WMA has been seeded into permanent cover (Appendix I) with the exception of approximately 283 hectares, which was converted into seasonal wildlife food plots. Food plots were planted to provide winter food and cover for resident wildlife and to alleviate any potential depredation problems that might occur on private lands adjacent to the management area (North Dakota Game and Fish Dept. 2001). Currently there are approximately 40 food plots ranging in size from 6 to 31 hectares, distributed throughout the 13,404-hectare area, with most situated adjacent to large block plantings of trees that provide cover for wildlife (Appendix I). Food plots on the southern border of the management area appear to attract higher numbers of deer, most likely because they are adjacent to woody draws on private land that provide additional cover, forage, and security. Cover habitat in these woody draws is American elm (*Ulmus americana),* Boxelder (*Acer negundo),* Chokecherry (*Prunus virginiana),* Common buckthorn (*Rhamnus cathartica),* Green ash (*Fraxinus pennsylvanica)*, Roundleaved hawthorn (*Crataegus rotundifolia),* Serviceberry (*Amelanchier alnifolia),* Silverberry (*Elaeagnus commutata),* and Western snowberry (*Symphoricarpos occidentalis).*

White-tailed Deer Populations in the Lonetree WMA Region

Lonetree WMA is located in the Drift Prairie-Coteau area of central North

Dakota. The Drift Prairie-Coteau region of the state encompasses about 63,999 km^2 where approximately 21,850 deer were harvested in 2003 (North Dakota Game and Fish Department, W. Jensen, unpublished data). In 1941, annual or periodic winter aerial surveys were implemented to monitor white-tailed deer and have become one of the primary tools used by the North Dakota Game and Fish Department to assess the status of deer populations in the state. Winter aerial surveys in the Drift Prairie-Coteau region are currently conducted on five large monitoring blocks that together encompass 16,653 km^2 in total area (Table 1, Figure 2). The five winter aerial survey monitoring blocks are the Anamoose, Cando, Dawson, Wing-Tuttle, and Zahl areas delineated in Figure 2. Although it has not been quantitatively assessed, it is assumed that the placement of these monitoring blocks is representative of the Drift Prairie-Coteau region of the state. During the 2004 winter aerial surveys a total of 20,997 white-tailed deer were counted in the Drift Prairie-Coteau region for an approximate density of 1.3 deer/km^2 (Table 1).

Table 1. Winter white-tailed deer aerial survey units for the Drift Prairie-Coteau region of North Dakota indicating monitoring block area and observed deer density for 2004.

Monitoring Block	Survey Area	Estimated Deer Density
Anamoose	3341 km^2	2.0 deer/km^2
Cando	3108 km^2	1.6 deer/km^2
Dawson	3833 km^2	0.8 deer/km^2
Wing-Tuttle	3108 km^2	1.5 deer/km^2
Zahl	3263 km^2	0.5 deer/km^2
Total/Average	**16653 km^2**	**1.3 deer/km^2**

While there has been some variation observed between these monitoring blocks, trend data suggest deer numbers have been increasing from year to year in most areas of

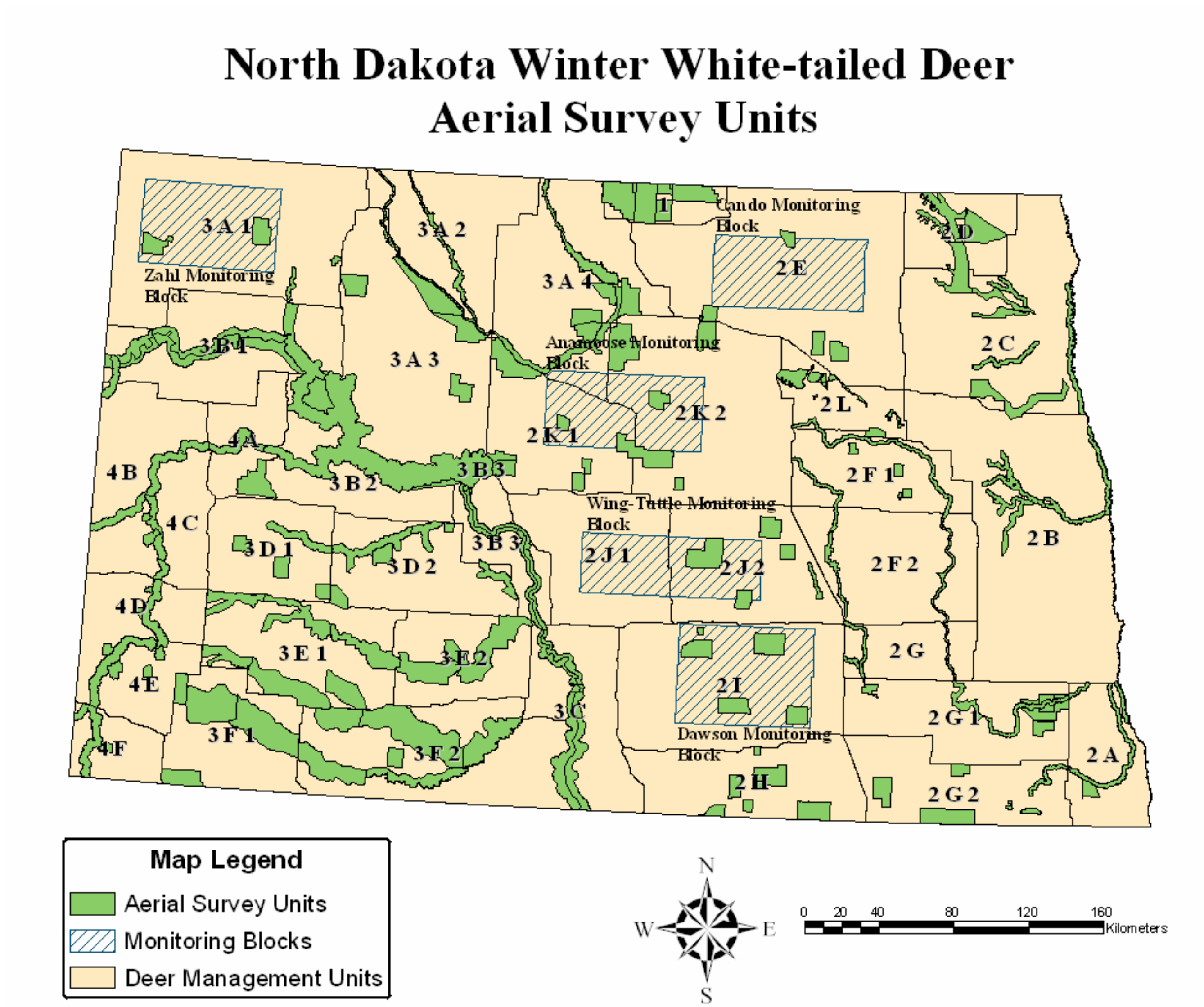

Figure 2. North Dakota Game and Fish Department winter white-tailed deer aerial survey units (Anamoose, Cando, Dawson, Wing-Tuttle, and Zahl) for the Coteau region.

the Drift Prairie-Coteau (Figure 3). The only monitoring block showing a trend for recent population decrease was the Zahl block, where local landowners requested an increase in deer licenses to reduce deer abundance (North Dakota Game and Fish Department, W. Jensen, personal communication).

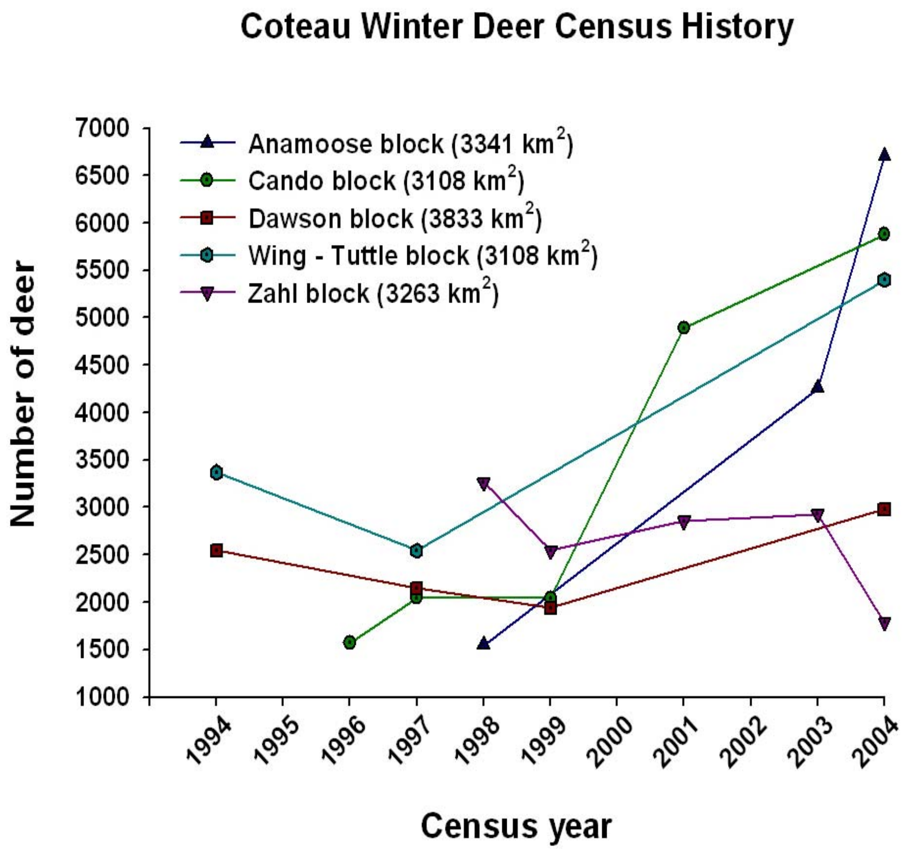

Figure 3. Winter deer census history for the five major monitoring blocks in the Drift Prairie-Coteau region of North Dakota indicating number of deer counted during surveys from 1994 through 2004.

Lonetree WMA, which is in close proximity to the Anamoose monitoring block, has been surveyed separately since 1995. The Lonetree WMA monitoring block encompasses approximately 282 km^2, where many hundreds of white-tailed deer typically congregate during winter. Past censuses indicate that the number of white-tailed deer using the Lonetree WMA during the winter months has been steadily increasing. During the 2004 winter aerial survey 3021 animals were observed on the management area (estimated density = 10.7 deer/km^2, Figure 4).

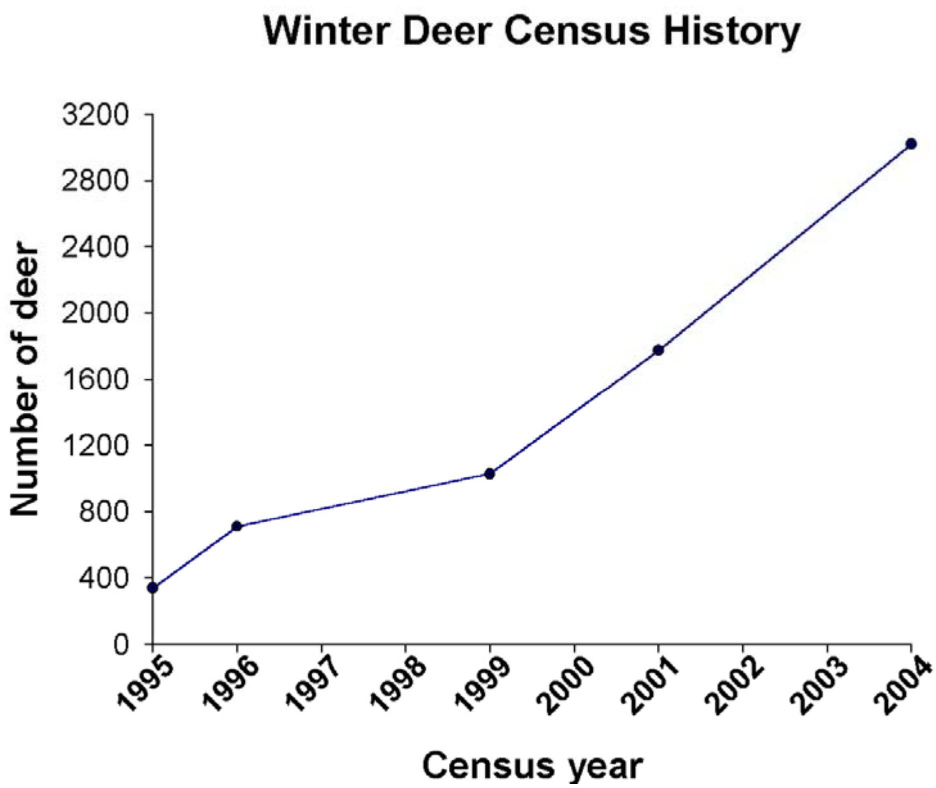

Figure 4. North Dakota winter white-tailed deer aerial census counts for Lonetree WMA, indicating steady population increase from 1995 to 2004.

CHAPTER 2

CAPTURE AND MARKING OF WHITE-TAILED DEER AT LONETREE WILDLIFE MANAGEMENT AREA

Introduction

Investigations of movement patterns, habitat use, population dynamics, and behavior often require the capture and marking of free-ranging animals (Nietfeld et al. 1996). There are a variety of methods that have been used successfully for live capturing white-tailed deer including wooden box traps, net-covered traps, rocket nets, drop nets, drive nets, and tranquilizer guns (Rongstad and McCabe 1984, Haulton et al. 2001). The success of most animal trapping operations depends on a suitable bait or scent to attract animals into traps. While there are a variety of baits available, domestic livestock foods are probably the most common lure for big game (Schemnitz 1996).

Animals captured for study are commonly marked to facilitate identification at a distance. There are several different marking techniques available for wild ungulates including tags, reflective neck collars, bands, transponders, branding, tattoos, tissue removal, dyes and paints, and chemical markers. Natural markings are also sometimes used to facilitate individual identification (Nietfeld et al. 1996). Color-coded numbered ear tags are commonly used to mark deer (Nietfeld et al. 1996), often in association with VHF or GPS telemetry radiocollars. Radiotelemetry has greatly enhanced the ability of wildlife ecologists to locate animals at will, observe behavior, and detect and determine proximate causes of mortality (Samuel and Fuller 1996).

Methods

White-tailed deer were captured for radiocollaring and tagging at Lonetree WMA during the period from mid to late March 2001, mid-December 2001 to mid-March 2002 and January to mid-February 2003. I used portable clover traps (Clover 1954) as the primary capture method, and chemical immobilizations via dart rifles as a secondary capture technique. Methods for capturing and handling white-tailed deer were reviewed and approved by the University of North Dakota Institutional Animal Care and Use Committee (# A3917-01). My initial capture/trapping protocol included attaching radiocollars (Wildlife Materials International, Inc. Murphysboro, Illinois) to juvenile and adult female deer, and juvenile male deer. Radiocollared juvenile male deer were tagged with numbered orange cattle tags (Y-Tex Corporation, Cody, Wyoming) in the right ear and metal strap tags (Hasco Tag Corporation, Dayton, Kentucky) in left ear, whereas radiocollared females were fitted with numbered orange tags in left ear and metal strap tags in right ear. I also captured yearling and older-aged male deer, and these animals were fitted with numbered orange livestock tags in the right ear and metal strap tags in the left ear and released without radiocollars. I did not fit yearling and older-aged males with radiocollars due to problems associated with collar retention related to growth and changes in neck size.

Intensive efforts to capture and radiocollar white-tailed deer for the research project were initiated in late December 2001 after preliminary surveys in late November-early December to locate appropriate locations for clover traps. Fourteen different trapping sites were established in December 2001 when clover traps were transported to the sites, staked down, and pre-baited with alfalfa in preparation for initiation of trapping in late December. Trap sites were selected based on information on areas of concentrated deer habitat use provided by area wildlife managers, and observations of deer activities and movements from pilot research in early spring 2001. In general, most clover traps were positioned in tree rows adjacent to food plots, or along obvious corridors for deer movement from upland habitats and woody draws south of the WMA onto the management area itself. Clover traps were initially baited with third cutting alfalfa and a fruit-based scent lure, but bait was later augmented with a grain mixture of corn, barley and sunflower seeds.

Related to unusually warm weather conditions and very little snow from November 2001 through early February 2002, deer capture success in clover traps was very low. Subsequently, efforts were initiated to capture deer for radiocollaring by chemical immobilization with darts in mid-January 2002. Darting was conducted during the early evening and early morning hours when deer were actively foraging or moving from foraging areas to daytime bedding areas. Blinds were used to conceal a two-person darting team from deer that were either traveling along heavily used game trails or foraging at bait piles provisioned with mixtures of alfalfa, oats, corn, and sunflower seeds established in relatively open areas within 20 meters of blinds. A CO_2 powered dart rifle (Dan-Inject, Børkop, Denmark) was used to administer intramuscular injections of a combination of Rompun (Xylazine Hydrochloride, Bayer Corporation, Shawnee Mission, Kansas) (dosage = 0.5 mg/kg) and Telazol (Tiletamine Hydrochloride and Zolazepam Hydrochloride, Fort Dodge Animal Health, Fort Dodge, Iowa) (dosage = 3.0 mg/kg). Post-injection induction time for this drug combination was approximately 5 minutes (Kreeger 1996), and specially designed, lightweight radio transmitters fitted to the barbed darts (Pneu-Dart Inc., Williamsport, Pennsylvania) were used to locate animals that moved away from blind areas before induction. All anesthetized animals were blindfolded after a mild ophthalmic ointment was applied to eyes to prevent drying, hobbled as necessary depending upon the degree of immobilization, and placed in a left-lateral or sternal recumbency position. Subsequently, immobilized deer were examined to estimate age, and then were fitted with ear tags and radiocollars as previously described. Any obvious darting-related cuts or abrasions were cleaned with a liquid betadine solution and then treated with a topical antibiotic ointment. Upon completion of processing, immobilized deer were visually monitored until they recovered and were able to stand and walk in a coordinated fashion (45 minutes to 2.5 hours).

Based on results from 2002, the capture/trapping protocol for 2003 was revised such that radiocollars were attached to juvenile female and adult female deer only. Very few of the juvenile male deer that were collared in 2002 retained their collars for more than three months. All female deer that were captured in 2003 for attaching radiocollars were marked as previously described. Adult males and juvenile males were fitted with numbered white or yellow livestock tags (Allflex Tag Corporation, Dallas, Texas) in the right ear and metal strap tags (Hasco Tag Corporation, Dayton, Kentucky) in the left ear. Nineteen different trap locations were used to capture deer in 2003, including most of the sites from 2002 and several additional locations. Trapping success was higher in winter 2003 than 2002 due to colder temperatures and increased snow cover compared to the previous year. Because of the higher trap success in 2003, I did not attempt to capture deer using dart rifles.

Results

Initial attempts to capture white-tailed deer for the study began in late February 2001 when three adult females and one yearling male were captured in clover traps and fitted with radiocollars (Table 2). One adult-aged male was captured and tagged only. No deer were captured in late winter-early spring 2001 using dart rifles. Between mid-December 2001 and late March 2002, a total of 40 individual deer were captured; 34 deer were captured in clover traps and six were captured using dart rifles. In winter 2003, 67 individual white-tailed deer were captured, all in clover traps (Table 2). Capture mortalities were limited to two animals in winter 2003; both occurred when the animals injured themselves inside clover traps as they were being approached by the capture team.

Trapping effort and capture success (captures for a period/number of functional traps X trap days for the same period) was 82 trap nights and 6% trap success in March 2001, 705 trap nights and 6% trap success for the period from mid-December to mid-March 2002, and 354 trap nights and 24% trap success for January to mid-February 2003. Among the adult-aged deer captures, proportionally more females (75.6%) were captured than males (24.4%), whereas proportionally similar numbers of fawn females (46.4%) were captured as fawn males (53.6%; Table 2). Limited data were available on recaptures in March 2001, but proportionally more deer were recaptured in 2003 (24.6%) than during the winter 2001-02 period (7.5%). No adult-aged males were recaptured, whereas similar proportions of the recaptures were adult females (30%), fawn females (30%) and fawn males (40%; Table 2).

Darting efforts were limited to the period of January 17, 2002 through March 4, 2002. During this period there were a combined 35 morning or evening darting sessions when six deer were successfully darted including one adult female, three fawn females, and two fawn males. Also during this period three deer were hit by darts but did not become fully immobilized and consequently were not recovered.

Of the overall total 114 individual white-tailed deer that were captured, 68 deer were radiocollared and tagged, and 41 were tagged only (Table 2). A total of three animals was captured and released without tags (Table 2).

Table 2. Demographic information for all white-tailed deer captured at Lonetree WMA from March 2001 to February 2003, indicating age, sex, and type of marking.

	Adult Female	Adult Male	Fawn Female	Fawn Male	Total
March 2001					
Radiocollared	3 (75%)	0 (0%)	0 (0%)	1 (25%)	4
Ear Tags Only	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1
Released unmarked	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Recaptures	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Trap Mortality	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
2001/2002 Season					
Radiocollared	12 (36.4%)	0 (0%)	10 (30.3%)	11 (33.3%)	33
Ear Tags Only	0 (0%)	3 (50%)	1 (17%)	2 (33%)	6
Released unmarked	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1
Recaptures	0 (0%)	0 (0%)	1 (33%)	2 (66%)	3
Trap Mortality	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
2003 Season					
Radiocollared	13 (42%)	0 (0%)	18 (58%)	0 (0%)	31
Ear Tags Only	4 (11.8%)	6 (17.6%)	1 (3%)	23 (67.6%)	34
Released unmarked	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2
Recaptures	6 (35%)	0 (0%)	5 (29%)	6 (35%)	17
Trap Mortality	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2

Discussion

White-tailed deer were captured in this study predominantly by clover traps, which worked best when winter snow cover was present and temperatures were relatively cold. Warm weather terminates efforts to capture white-tailed deer in clover traps when natural forage becomes available and the animals are no longer effectively drawn to baited traps. In winter 2002 for example, temperatures were relatively warm and there was very little snow cover at Lonetree WMA prior to mid-February. Deer had access to abundant food in the many food plots at the study site, and very few animals entered the baited clover traps. Shortly after the occurrence of several winter storms associated with significant cooling of ambient temperatures (late February through mid-March), capture success increased related to the combination of complete snow cover and depleted forage in and around food plots. Also, in winter 2003 there was significant snow cover and cold temperatures from mid-December to early March, and overall capture success rate was much higher compared to during the 2001/2002 trapping season (Table 2). Also, related to more severe weather conditions, it appeared that deer were depleting food plot resources near trap locations at an earlier period than the previous year and were therefore more inclined to risk entering traps to consume bait.

Captures of fawn females and fawn males using clover traps were fairly equal, but the number of adult females captured in clover traps was much higher than the number of adult-aged males. The higher ratio of adult females to adult-aged males captured in clover traps could be related to 1) a behavioral response where adult-aged males are more cautious and therefore are less inclined to enter traps, or 2) it may represent the post harvest sex ratio of the white-tailed deer population at Lonetree WMA during trapping periods. Recaptures of adult females and fawn female and fawn male white-tailed deer at Lonetree WMA were similar proportionally, while no adult-aged males were recaptured. Excluding adult-aged male white-tailed deer, the equal proportion of recaptures for adult female and fawn female and fawn male white-tailed deer indicated that capture using clover traps was not overly traumatic to the animal and did not cause avoidance of trap areas after release.

Because trap success was low during the 2001/2002 trapping season, I decided to implement chemical immobilization as a secondary capture method. The advantage of using chemical immobilization is that it allows for age selection or selection of sex-specific cohorts (Kock et al. 1987) and also minimizes recaptures (Hawkins et al. 1967). Capture-induced stress is also potentially reduced with darting equipment compared to methods using physical restraints such as clover traps (DelGiudice et al. 1990). While darting of white-tailed deer at Lonetree WMA was not as labor intensive as capturing deer using clover traps, it proved to be more time intensive. Only six deer were successfully captured using this method; three animals that were hit with darts were not immobilized related to dart malfunctions. Because darting was done during cold winter periods, I attributed dart malfunctions to drugs freezing inside the aluminum darts that thereby prevented complete administration of drugs. Attempts were made to keep loaded darts as warm as possible, but when the darts were loaded into a cold rifle barrel they sometimes were exposed to very cold temperatures. Although I initially attempted to dart deer during the early morning and the early evening periods, early morning darting efforts were not nearly as productive as evening periods for deer activity at bait piles. Eventually, all darting efforts were scheduled for early evening periods when deer movements from bedding sites to feeding areas were more predictable.

CHAPTER 3

HABITAT USE BY WHITE-TAILED DEER AT LONETREE WILDLIFE MANAGEMENT AREA

Introduction

Habitat selection analysis for wildlife involves comparisons of the proportions of different cover types and forage used by animals to the proportions of cover and forage that are available (Potvin et al. 2003). While there are several different techniques to assess habitat selection, data on individual animal locations obtained by radiotelemetry are commonly combined to assess habitat use relative to habitat availability (Pietz and Tester 1983, Alldredge and Ratti 1986, Kenward 1987). A classical approach involves computing habitat use at the individual location sites or inside fixed circle buffers applied to the sites (Potvin et al. 2003). Other approaches used to estimate habitat use include visual observations, captures, track counts, fecal pellet counts and browsed twig counts (Litvaitis et al. 1996).

Insight into movement behavior is also important for effectively managing white-tailed deer populations (Grassel 2000). Home range is defined as the area traversed on an annual or seasonal basis by individual animals during activities associated with foraging and reproduction (Burt 1943). The home range area used by an animal must be large enough for maintenance and reproduction but small enough to allow the animal to gain survival advantage by becoming familiar with the area in which it lives (Marchinton and Hirth 1984). Multiple factors interact to influence the size of a home range including annual and seasonal climate, habitat composition, population density, and the sex and age of individuals (Marchinton and Hirth 1984). White-tailed deer in northern climates tend to traverse larger home ranges that are less stable over time than white-tailed deer in southern climates (Severinghaus and Cheatum 1956). Also, deer in northern climates tend to be migratory with distinct seasonal home ranges compared to deer in southern climates that are more sedentary (Larson et al. 1978, Messier and Barrette 1985, Lincoln 1992, Loudon and Brinklow 1992, Nelson 1995, Van Deelen et al. 1998).

In this study I used data from radiotelemetry, fecal pellet belt transects, and microhistological diet analysis to assess habitat use by white-tailed deer at Lonetree WMA. I also determined the area utilized by white-tailed deer on Lonetree WMA during winter and summer periods by estimated home range sizes for adult females.

Methods

Radiotelemetry

The most common method for estimating animal locations by radiotelemetry is triangulation (White and Garrott 1986). Based on preliminary research results from March 2001, it was determined that an antenna tower system would be more efficient for effective triangulation to positions of radiocollared deer than ground-based telemetry using hand-held antennas. The quality of radiolocations determined by triangulation is a function of tower locations, the animal's location relative to the towers, and precision of the bearings from the tower to the animal (White 1985). In the period between September and November 2001 four stationary radiotelemetry antenna towers were established and calibrated in the Lonetree WMA area. Sites for antenna towers were selected based on (1) relatively high elevation with line of site coverage of relatively large areas, (2) proximity to areas of potential habitat use by deer, and (3) geographic position relative to other tower posts for appropriate configuration for radiotelemetry and triangulation. Each radiotelemetry antenna tower was a null peak system composed of two five-element Yagi antennas (Telonics, Mesa, Arizona). Each tower was initially calibrated for operation using a single radiocollar placed in a known location established with a portable real-time differential correction global positioning unit. Subsequently, antenna towers were tested for signal bias and additional fine-scale calibration based on estimated azimuths to a minimum of 30 different collars placed in multiple surveyed (using the differential GPS unit described above) locations around each individual tower (Biggins et al. 1999). Average tower error was calculated using the location of a signal (LOAS) computer program (Ecological Software Solutions, Switzerland), which integrates information on known locations of radiocollars and estimated azimuths to formulate the approximate azimuth angle errors for each tower. Average azimuth angle errors were then calculated for each tower and they were recalibrated appropriately. Antenna towers were periodically checked to make sure they remained properly calibrated with respect to variable and occasional severe wind and weather events.

Radiocollared deer were periodically radiolocated from mid-March 2002 through December 2003 using the antenna tower system and by fixed-wing aerial telemetry. If the deer were residing on Lonetree WMA, three or four azimuths or bearings were taken using the tower systems. Positioning technicians at two different towers minimized the time between locations whereupon hand-held radios were used to coordinate collection of near simultaneous bearings on individual animals in the region of the towers. Deer were located 1 - 4 times per week on a rotational schedule. Generally, days were divided into four 6-hour blocks and locations were rotated through this schedule. The blocks were 0600-1200, 1200-1800, 1800-2400, and 2400-0600. This rotational schedule allowed for locations at varying times of the day to obtain a better understanding of deer daily movements and habitat use. Deer locations as Universal Transverse Mercator (UTM) coordinates were subsequently determined from azimuths by triangulation using LOAS software (Ecological Software Solutions, Switzerland).

Aerial radiotelemetry by fixed-wing aircraft was used to periodically locate individual collared deer that moved beyond the range of the tower systems at the Lonetree WMA study site. Deer positions collected by aerial radiotelemetry were Universal Transverse Mercator coordinates from a global geographical positioning system (GPS) unit in the aircraft. Information regarding land cover/crop type was also recorded when animals were relocated by aircraft away from the Lonetree WMA to determine the types of areas/habitat deer were migrating/dispersing towards. Attempts were made to locate radiocollared deer residing on private land off the study area approximately bimonthly. Ultimately, however, the majority of collared deer that moved away from the Lonetree WMA study area were located approximately once a month related to constraints on pilot availability and funding.

Habitat types and habitat availability for the Lonetree WMA area were determined from geographic information systems (GIS) habitat map maintained by the USDA Bureau of Reclamation in Bismarck, North Dakota. Geographic information system software (ArcView GIS 3.2; Environmental Systems Research Institute, Inc. 1992-1999) was used to estimate the area of six different habitat types across the Lonetree WMA (Table 3). Because capture efforts were focused entirely on the eastern end of Lonetree WMA and all locations for collared deer were east of Highway 14, habitat that was west of Highway 14 was not included in habitat use/selection analyses. Adjusted habitat availability was determined by subtracting the amount of habitat west of Highway 14 from the overall total available habitat (Table 3). The amount of adjusted available habitat excluding gravel pits, roads, trails, barren land, and the dam construction area was approximately 9149 hectares. ArcView 3.2 was used to plot deer locations onto vegetation layers for Lonetree WMA.

Table 3. Total habitat availability (TH) and adjusted habitat (AH) availability for Lonetree Wildlife Management Area classified by habitat type.

Habitat type	TH	AH
Wetlands/River/Canal	2093 ha	1303 ha
Trees/Shrubs/Woodland	596 ha	492 ha
Native/Planted/Tame grasses	7960 ha	5223 ha
Dense nesting cover/Alfalfa	2395 ha	1914 ha
Food plots	256 ha	217 ha
Totals	**13300 ha**	**9149 ha**

When an animal is observed to be in a certain habitat, it may actually be elsewhere due to potential triangulation error (Nams 1988). Because of this potential error, the telemetry location is not an exact point, but rather lies somewhere within an error area (Heezen and Tester 1967). When the error area overlaps more than one habitat type, there is a problem in determining which habitat the animal is actually located in (Nams 1988). To account for this I calculated an average error polygon size for all deer locations with three or more azimuths that were within the boundary of the Lonetree WMA covered by the GIS habitat map. The average error polygon size was generated using LOAS software with an Andrew's estimator, and bearings with no intersections were ignored. LOAS parameters were set at an accuracy of 0.000001, and a Hubers/Andrews constant of 1.5 and 60 total iterations. Confidence distributions for error ellipses were determined using a Chi-square analysis with a 95% confidence interval. If the Andrews estimator failed to determine an estimated location no further steps were taken with that group of bearings and it was determined to be a failed estimate. According to White (1990), when signal bounce is expected (trees, ravines, rolling topography) the Andrews estimator (Lenth 1981) is preferred because erroneous signals can be detected and given less weight in determining the estimate of the transmitter locations. The Andrews estimator also provides "safety" with its estimates, providing no estimated locations, as opposed to inadvertent erroneous estimates when there are wayward bearings.

Out of 1167 estimated locations, only 432 (37%) were located on the management area and from these the mean ellipse area was 42.2 hectares (SE $\pm$ 2.9). The mean error ellipse was considered as a circle, and half of the radius of this circle (183 meters) was used to generate a buffer, defined by GIS as a zone of a specified distance around coverage features (estimated locations). The 432 estimated deer locations were plotted over the GIS habitat map with buffer circles created for each. The proportions of each of the four major habitat types (Food plots, Trees/Shrubs, Dense nesting cover, and Grasslands) making up greater than 10% of the buffer area were visually estimated. If trees/shrubs or food plots constituted less than 10% of the buffer area their presence was also noted. Chi-squared tests (Zar 1999) were used to identify habitats used significantly more often than expected relative to availability.

Fecal Pellet Belt Transects

Fecal pellet group belt transects (100m X 2m) conducted during summer 2002 and summers 2003 were used to obtain an overall estimate of deer habitat use at Lonetree WMA (Litvaitis et al. 1996). A grid consisting of 500m x 500m cells was layered over Lonetree WMA using GIS software, and within each grid cell four random Universal Transverse Mercator (UTM) coordinate points were assigned and randomly ordered. These UTM coordinates were then extracted and used as potential starting points for fecal pellet belt transects. In the event that a random starting position was located in a marsh or lake or was on a parcel of private land, the next starting position in the order was used for the belt transect in the grid cell. After navigating to an appropriate UTM coordinate start position a random direction from north for each belt transect was determined by looking at a wristwatch and multiplying the second position by six. A 100m tape was then run out in the assigned direction and walked by two observers; all deer fecal pellet groups within 1m of either side of the transect line were noted. In association with each fecal pellet group belt transect I recorded the number of fecal pellet groups encountered (classified by age as “old” or “fresh”), habitat type, and variations or transitions across habitat types including a measurement of where the transition occurred. In 2002 a single fecal pellet group transect was done within each of the 500m X 500m grid cells whereas in 2003 two fecal pellet group transects were done in each grid cell. A total of 453 fecal pellet group belt transects was completed in August and September 2002, and 829 pellet group transects were done between May and June 2003.

For analyses of fecal belt transects I considered four major habitat types, food plots; trees and shrubs; dense nesting cover; and native, planted, and tame grasslands.

Chi-squared tests (Zar 1999) were used to assess patterns of habitat use relative to availability based on the GIS habitat map, where habitat availability was the total habitat of each category encompassed along the belt transects conducted each year and use was based on the number of pellet groups found in each habitat category (Table 4).

Table 4. Total available habitat (TAH) in hectares for four major habitat types as well as the number of fecal pellet groups (FPG) found in each habitat type for 2002 and 2003.

Habitat type	2002 TAH	2002 FPG	2003 TAH	2003 FPG
Food plots	0.26 ha	0	0.22 ha	40
Trees and shrubs	0.63 ha	184	0.86 ha	139
Dense nesting cover	1.70 ha	63	4.11 ha	68
Native/planted/tame grasslands	6.06 ha	107	11.39 ha	146

Microhistological Diet Analysis

In addition to examining habitat use, I assessed white-tailed deer diets from microhistological analysis of fecal pellets. Microhistological analysis is a technique that uses plant cell fragments in ungulate fecal samples to determine the relative frequency of individual plant samples consumed (Sparks and Malechek 1968, Reynolds et al. 1978, Van Vuren 1984). For all months from January 2002 to December 2003 except May and June 2002, I collected a minimum of 20 fecal samples per month from various locations around the WMA. Fecal samples were later pooled to create 11 bimonthly “composite” samples for microhistological analyses. Frozen samples were shipped to the Diet Analysis Laboratory at Washington State University in Pullman, Washington. One hundred and fifty microscope fields (25 views on each of 6 slides) were examined for epidermal fragments of forage plants for determination of plant tissue fragments to the level of genus and species (Davitt, personal communication). From examination of microscope fields and views of slides, the percent contribution of each plant was estimated for each bimonthly composite diet.

Diets of white-tailed deer on Lonetree WMA for 2002 and 2003 were analyzed using a log-linear model (LLM; Systat 8.0, SPSS Inc.) to assess potential differences by year, season, and class. Seasons were grouped as winter to early spring (January through April), summer (May through August), and fall to early winter (September through December), and class categories were organized as crops, trees and shrubs, forbs, grasses, sedges, and fruits.

Home Range Analysis

Winter (January to April) and summer (May to October) home ranges were estimated for white-tailed deer monitored during 2003. As a starting point for home range analyses, I eliminated all deer locations with relatively large error ellipses (> 200 hectares) from consideration. Next, I plotted estimated 100% minimum convex polygon (MCP) (Mohr 1947) and 100% adaptive kernel (ADK) (Worton 1989) summer and winter home range areas determined using program CALHOME (Kie et al. 1994) against number of locations in order to determine the number of locations required to achieve stable estimates of home range area (Lesage 2000). Results indicated that white-tailed deer home range areas in the Lonetree WMA area approached an asymptote at around 22 locations, and I therefore estimated 95% ADK home ranges for all individual deer for which a minimum of 22 locations were available within a season. Because Boulanger and White (1990) noted that MCP methods can provide reliable estimates of home range areas when number of locations is limited, I also estimated 95% MCP home ranges for individual white-tailed deer for which ≥ 15 locations were available during a season. The “core” region of individual home ranges (area of intensive use including bed/den sites and other resources necessary for survival) was defined and estimated as the MCP and ADK home range area which included 50% of an animal’s positions (i.e., 50% MCP and 50% ADK home range area). Significant autocorrelation can occur if an animal moves either less or more between sequential locations than between nonsequential locations related to an individual’s past experience and knowledge of resources within home ranges (Sweitzer 2003). To avoid serial autocorrelation, consecutive locations used for home range analyses were separated by at least 24 hours.

Results

Radiotelemetry

Data for 1167 radiolocations of white-tailed deer collected from January 2002 through December 2003 included 432 (37%) positions falling within the boundary of the management area, and 735 (63%) on private land on the southern edge of Lonetree WMA. Deer locations on private land to the south of Lonetree WMA were primarily focused in or around naturally occurring woody draws. Data for locations within the boundary of the management area indicated that white-tailed deer preferred certain habitat types to others based on availability and usage (Figure 5; Log-ratio Chi-square = 137.5, df = 3, $P < 0.001$). Examination of the data indicated that white-tailed deer positively selected for food plots, trees and shrubs, and dense nesting cover, and avoided or selected against grasslands (Figure 5).

Fecal Pellet Belt Transects

Of the 1282 fecal pellet transects conducted during 2002 and 2003 there were 663 positive fecal pellet belt transects where at least one fecal pellet group was observed.

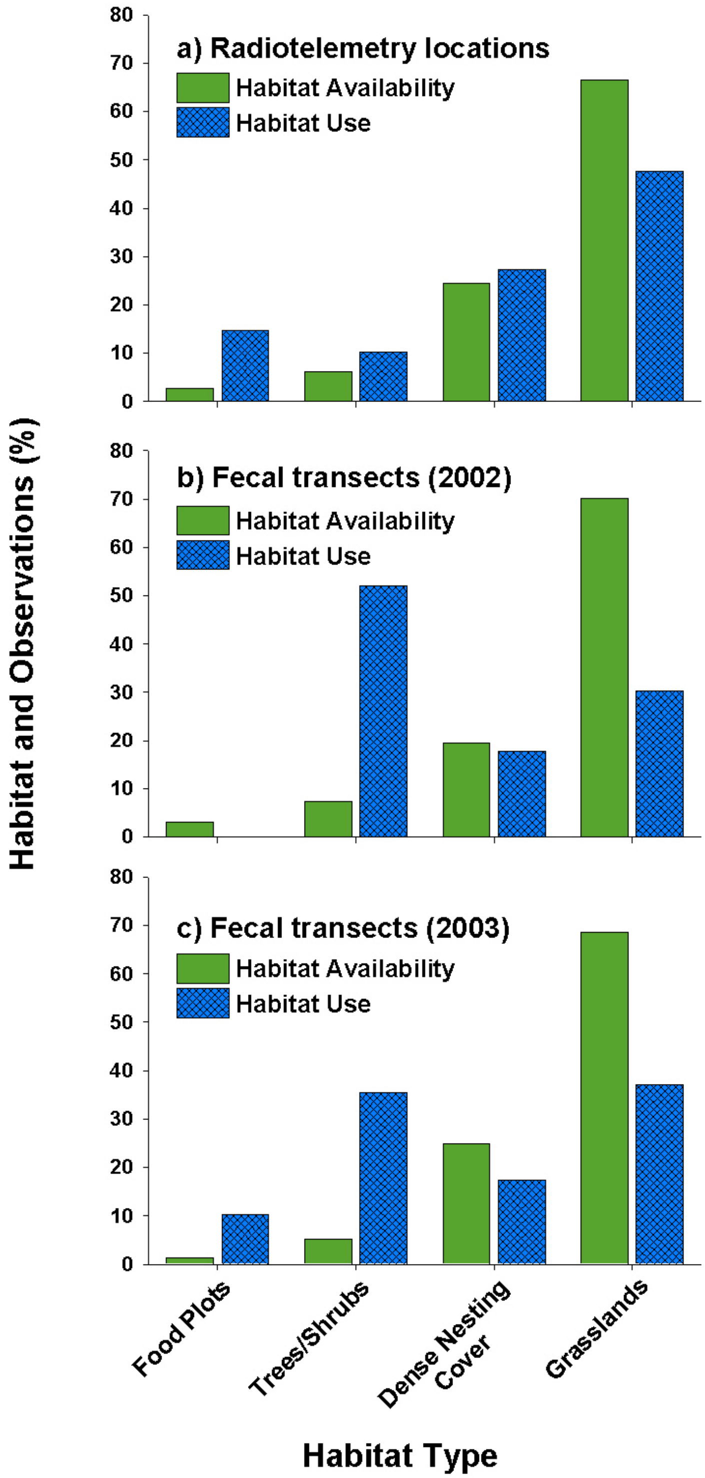

Figure 5. Habitat availability versus use related to a) radiotelemetry locations, b) fecal pellet belt transects performed during 2002, and c) fecal pellet belt transect performed during 2003 indicating proportions of habitat availability and observations of white-tailed deer use of food plots, trees/shrubs, dense nesting cover, and grasslands.

Although data on habitat use from pellet groups were similar for 2002 and 2003, I analyzed each year separately because fecal pellet transects were performed in different seasons in each year (2002 = fall, 2003 = spring/early summer), which, in association with the timing of annual habitat management activities by North Dakota Game and Fish at Lonetree WMA, altered pellet group sightability. Analysis of data for 2002 revealed that white-tailed deer selected for trees and shrubs, but there was no selection for food plots, dense nesting cover, or grasslands (Figure 5; Log-ratio Chi-square = 10.3, df = 3, P = 0.016). In 2003 deer exhibited a preference for trees and shrubs, and food plots, but no preference for grasslands or dense nesting cover (Figure 5; Log-ratio Chi-square = 137.5, df = 3, $P < 0.001$).

Microhistological Diet Analysis

Estimated diets were similar for 2002 and 2003, so data were pooled for more detailed analyses. Results indicated variation in diets of deer among seasons (Log-ratio

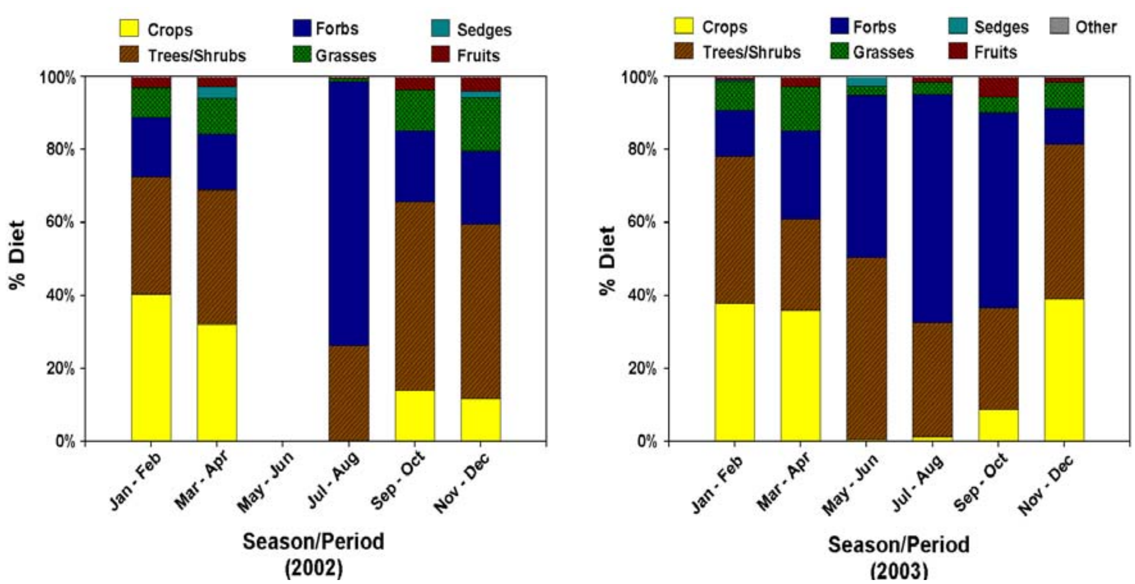

Figure 6. Proportions of different types of plants consumed by white-tailed deer on Lonetree WMA based on microhistological analysis of bimonthly composite fecal samples collected from January to December 2002 and 2003 (excluding May and June 2002).

Chi-square = 138.1, df = 10, $P < 0.0001$; Figure 6). The dominant dietary items consumed by white-tailed deer on Lonetree WMA for January to April were crops (≥ 32%), and trees and shrubs (≥ 25%). During the May to August period deer consumed mostly forbs (≥ 44%), and trees and shrubs (≥ 26%). In the September to December period dominant dietary items were trees and shrubs (≥ 28%), forbs (≥ 10%), and crops (≥ 9%) (Appendix II, III).

Home Range Analysis

Winter 95% MCP home ranges for nine adult female white-tailed deer averaged 635.4 ha (SE ± 71.6), and the average 50% MCP core use area was 113.7 ha (SE ± 39.8) (Table 5). Winter 95% ADK home ranges for five adult female white-tailed deer averaged 1041.3 ha (SE ± 161.4), and the average 50% ADK core use area for the same

Table 5. Winter and summer home range sizes (ha), estimated using the minimum convex polygon method (MCP, 95%, 50%) and adaptive kernel method (ADK, 95%, 50%) for adult female white-tailed deer (*Odocoileus virginianus)* at Lonetree WMA.

Animal	Nloc	MCP 95%	MCP 50%	ADK 95%	ADK 50%
Winter					
W1095	15	845.1	87.9		
W704	18	744.2	31.3		
W711	19	789.8	193.6		
W836	21	935.3	396.1		
W935	22	549.4	55.3	1545.0	142.8
W855	24	676.6	137.4	1302.0	224.0
W755	26	453.4	32.8	828.2	71.4
W815	26	297.6	48.9	797.9	100.2
W844	28	427.4	39.8	733.5	78.4
Mean (± SE)		635.4± 71.6	113.7± 39.8	1041.3± 161.4	123.4± 28.1
Summer					
S896	15	150.2	19.4		
S855	16	160.0	7.9		
S711	18	335.6	14.8		
S985	18	259.3	55.9		
Mean (± SE)		226.3± 43.9	24.5± 10.7		

animals was 123.4 ha (SE ± 28.1) (Table 5). Summer 95% MCP home range for four adult female white-tailed deer averaged 226.3 ha (SE ± 43.9), and their average 50% MCP core use area was 24.5 ha (SE ± 10.7) (Table 5). Because I did not have 22 or more locations for any individual deer for summer 2003, I was unable to estimate a 95% ADK summer home range. Overlays of the 95% MCP home ranges and composite home range of adult female white-tailed deer on a digital ortho quadrangle (DOQ), and associated GIS vegetation layers of Lonetree WMA (Figures 7 and 8) visually illustrate the pattern of white-tailed deer movements in relation to wooded ravines on private land on the southern edge of the management area as well as habitat use during both winter and summer periods.

Discussion

Data on habitat use from radiotelemetry locations, fecal pellet belt transects, microhistological analyses, and home range analyses indicated that deer at Lonetree WMA selected for certain habitat types over others. Food plots were highly utilized during the November to April period, and observations supported that food plots located along the southern edge of Lonetree WMA were depleted first, after which deer gradually moved northward to forage in other food plots as winter progressed. Food plots are generally harvested in March or April depending on weather, and are usually replanted soon thereafter. Trees and shrubs are also important for browse throughout the year, and forbs (dense nesting cover) consisting mainly of alfalfa (*Medicago sativa*) and clover (*Melilotus spp*.), are highly utilized from May through October. It should be noted that low positives for food plots, dense nesting cover, and wetlands associated with fecal pellet belt transects may be an underestimate of use due to land management practices

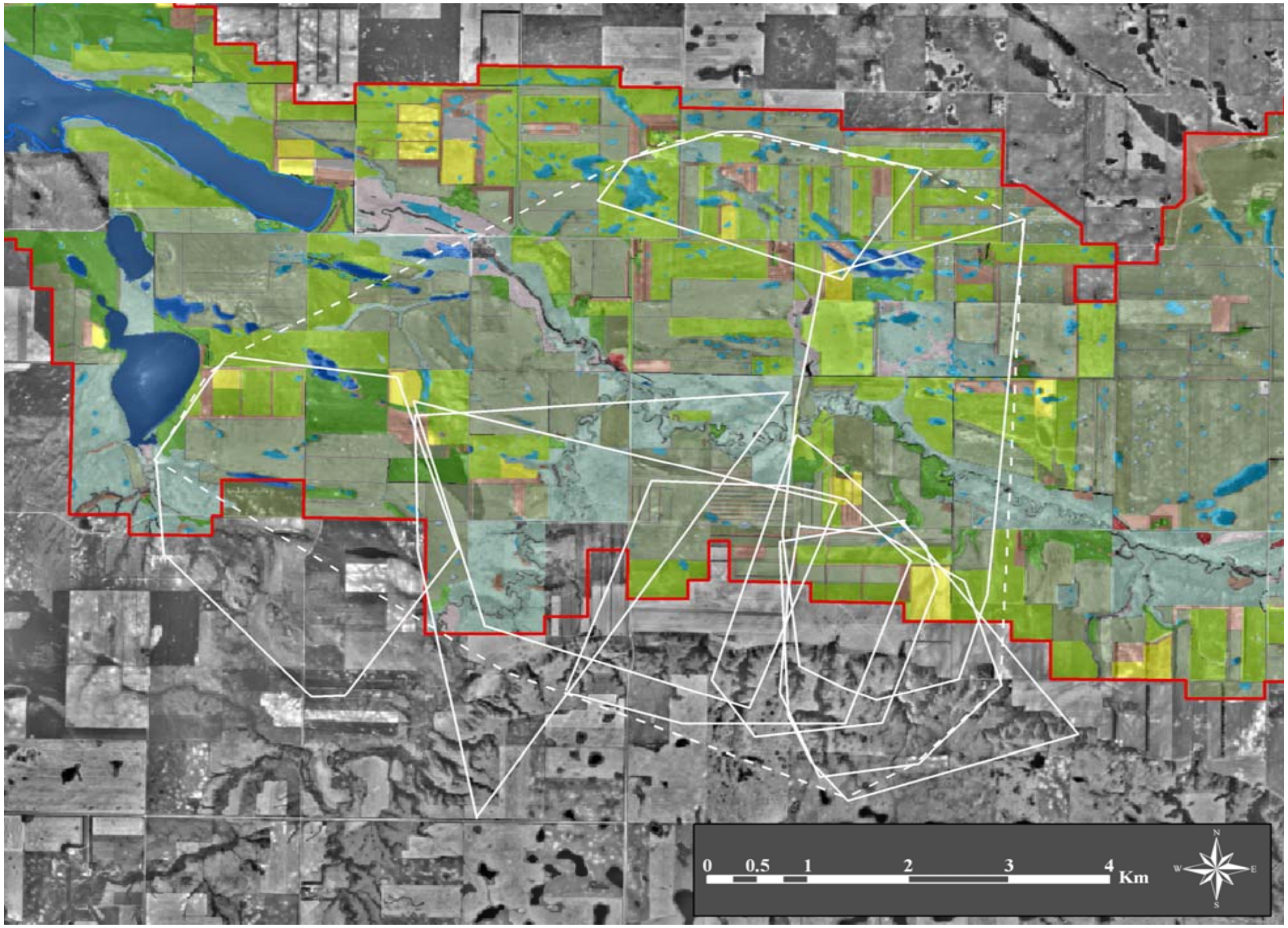

Figure 7. Plots of 95% minimum convex polygon home ranges (solid line) and a composite 95% MCP home range (dashed line) for radio-collared adult female white-tailed deer ($n = 9$) at Lonetree WMA during the winter period 2003. Home range outlines were overlaid on a DOQ map with GIS vegetation layers of Lonetree WMA to illustrate patterns of habitat use in relation to different habitat features (woody draws, food plots, trees/shrubs, dense nesting cover, and grasslands).

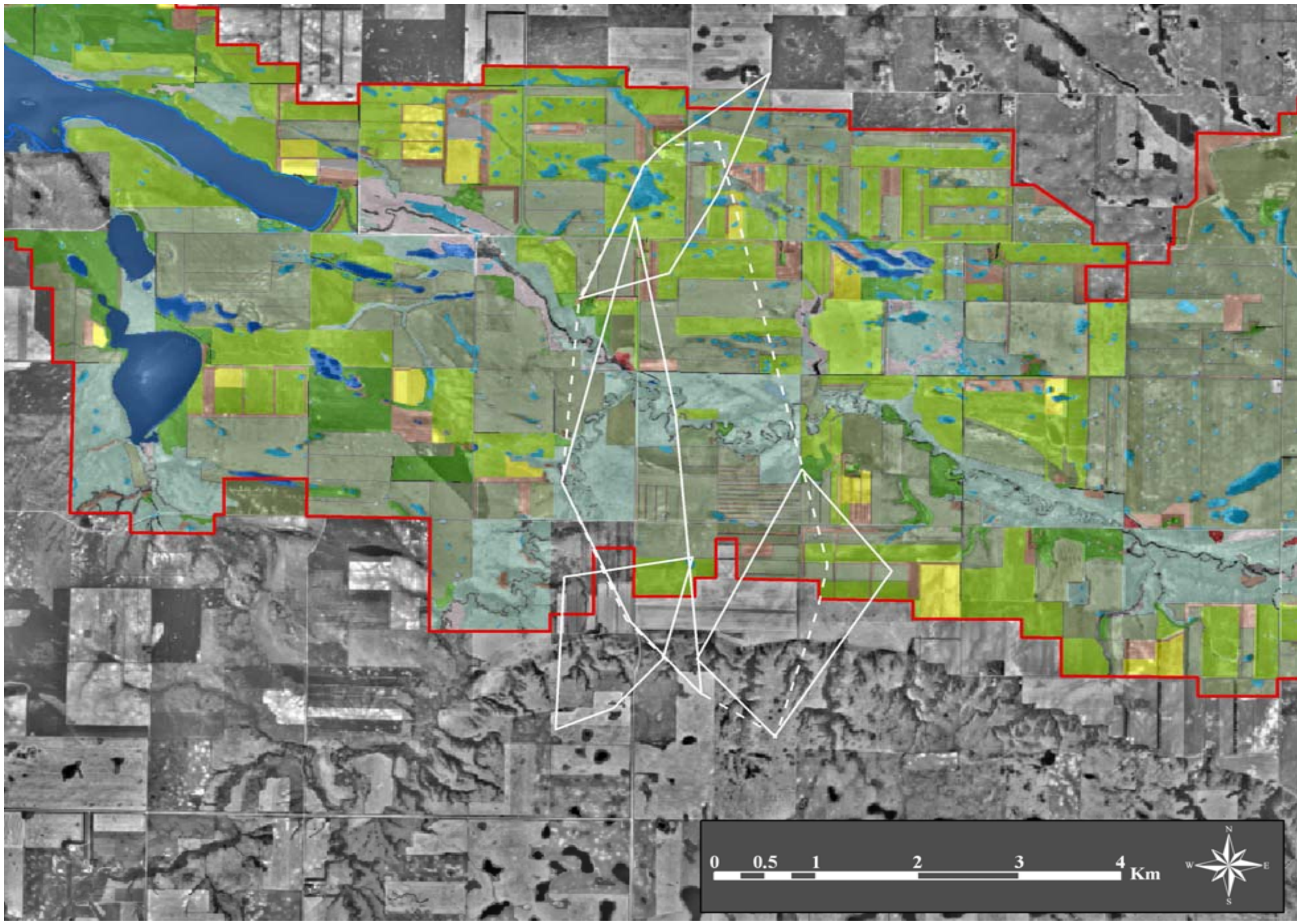

Figure 8. Plots of 95% minimum convex polygon home ranges (solid line) and a composite 95% MCP home range (dashed line) for radio-collared adult female white-tailed deer (n = 4) at Lonetree WMA during the summer period 2003. Home range outlines were overlaid on a DOQ map with GIS vegetation layers of Lonetree WMA to illustrate patterns of habitat use in relation to different habitat features (woody draws, food plots, trees/shrubs, dense nesting cover, and grasslands).

related to harvest and cultivation, haying and prescribed burning, and sightability of fecal pellet groups related to high water or dense vegetation during those periods of the year where low numbers of fecal pellet groups were observed.

Information from radiotelemetry indicated that woody draws on the southern edge of the management area were important for white-tailed deer throughout the year. On a daily basis many deer moved north from these woody draws to the management area around dusk and returned back south to the draws around dawn. White-tailed deer that left the Lonetree WMA area in the spring were often located around vacant or abandoned farmsteads during the May to November period. Habitats they were observed in or near included block plantings or tree rows, cattail sloughs, agricultural fields, and fields enrolled in the Conservation Reserve Program planted with tame and native grasses and forbs. Agricultural crops that deer were either directly observed in or that were in the immediate area were alfalfa (*Medicago sativa*), barley (*Hordeum vulgare*), beans (*Phaseolus vulgaris*), canola (*Brassica rapa*), flax (*Linum usitatissimum*), oats (*Avena byzantina*), sunflowers (*Helianthus spp.*), and wheat (*Triticum spp*.). In general, radiocollared deer that moved away from the study area during the summer occupied areas with similar habitats as at Lonetree WMA.

The average winter 95% MCP home range for female white-tailed deer at Lonetree WMA ($\bar{x}$ = 635.4 ha, SE $\pm$ 71.6) was substantially larger than the 95% MCP home ranges for adult females reported by Griffin et al. (1999) (127.5 ha), and Lesage et al. (2000) (102 ha and 112 ha). The average 95% MCP summer home range for female white-tailed deer at Lonetree WMA ($\bar{x}$ = 226.3 ha, SE $\pm$ 43.9) was also substantially larger than the 95% MCP home range for female white-tailed deer reported by Griffin et al. (1999) (76.5 ha), but smaller than the 95% MCP home ranges for adult females reported by Lesage et al. (2000) (910 ha, 2812 ha). For comparative purposes, the average winter home range size for female white-tailed deer at Lonetree WMA estimated using the ADK method ($\bar{x}$ = 1041.3 ha, SE $\pm$ 161.4, 95% ADK) was also larger than other reported winter home ranges of adult female white-tailed deer. These include estimates (95% ADK) of 47 ha (Dusek 1987), 684 and 774 ha (Naugle 1994), 328 ha (Oliver 1997), 203 ha (Griffin et al. 1999), and 616 ha (Grassel 2000) for female white-tailed deer.

A two sample t-test assuming unequal variance was used to evaluate whether mean winter home range size was greater than mean summer home range size as calculated by the 95% and 50% MCP methods. Results indicated that estimated 95% MCP ($t_{0.05\,(1),\,11} = 4.87$, $P < 0.001$) and 50% MCP ($t_{0.05\,(1),\,11} = 2.17$, $P = 0.03$) winter home range sizes were significantly greater than summer home ranges for female white-tailed deer at Lonetree WMA. Adult female deer summer home ranges usually include the location where they reproduce and care for their young, whereas their winter ranges encompass habitats and forage that will allow them to survive winter weather conditions. The large size of winter ranges for female white-tailed deer at Lonetree WMA could be related to distances moved between cover and forage. Related to these movements, deer highly utilize the woody ravines on the southern boundary of the management area and also depend heavily on food plots during the winter period. My observations indicated that as the winter period progressed and food plots near the southern boundary of Lonetree WMA were depleted, deer moved farther north to forage in other food plots. Because many of the deer continued to move south into the woody draws for cover during the day, the sizes of their winter home ranges gradually increased until spring snow melt. In contrast, during the summer period females at Lonetree WMA used relatively small areas (mean 95% MCP home range = 226.3 ha, SE ± 43.9), likely because forage was abundant and habitat needs were well met during these periods. It has also been reported that female white-tailed deer reduce the size of home ranges after parturition to minimize energy expenditures during lactation (Sparrowe and Springer 1970, Nelson and Mech 1981, Beier and McCullough 1990).

Visual observations of plotted home range polygons on a DOQ map with GIS vegetation layers of Lonetree WMA support findings of habitat use similar to other methods used in this study. Results from radiotelemetry locations indicated that white-tailed deer at Lonetree WMA are highly dependent on the wooded ravines near the southern boundary (63% of the radiolocations were around these woody draws). Analyses of diets presented earlier indicated that white-tailed deer at Lonetree WMA relied heavily on the food plots (> 30%) during the January to April period. Also, during the May to August period the use of forbs in the form of alfalfa (*Medicago sativa*) and clover (*Melilotus spp.*) are also heavily utilized (> 40%). Observations of habitat use by white-tailed deer on Lonetree WMA made while conducting spotlight surveys indicated that white-tailed deer highly utilized food plots during the winter period and also highly utilized forage available from dense nesting cover plantings during the spring, summer and early fall periods.

In the northern Great Plains draws, swales, lowlands, and river floodplains provide important habitat for white-tailed deer (Peterson 1984). Marshes and sloughs are also important for forage and they often afford the only good cover free from human disturbance for fawning females in the agriculturally fragmented Drift Prairie-Coteau (Harmoning 1976). Tracts of conservation reserve program (CRP) also serve as important cover for white-tailed deer on a seasonal basis (Gould and Jenkins 1993, Oliver 1997).

The advent of agricultural practices in the form of tree plantings for shelterbelts and agricultural crops in North Dakota made it possible for the highly adaptable white-tailed deer to expand their range onto the prairie. Windbreaks or tree rows are often the only cover that is available to deer in intensively farmed areas, particularly in central and east central North Dakota. Intensively farmed areas in the northern Great Plains support white-tailed deer in significant numbers wherever there is ample winter cover (Peterson 1984). The Lonetree WMA provides white-tailed deer with important winter cover in the form of both narrow windbreak style tree plantings, and larger block type plantings. The availability of forage in the form of food plots and dense nesting cover also enhances the quality of habitat for white-tailed deer on Lonetree WMA, as is evident from increasing populations.

CHAPTER 4

MIGRATION AND DISPERSAL MOVEMENTS OF WHITE-TAILED DEER IN THE DRIFT PRAIRIE-COTEAU REGION OF NORTH DAKOTA

Introduction

White-tailed deer have been able to adapt to the highly fragmented agrarian prairie areas throughout much of the Midwest and the eastern Great Plains where food resources are abundant (Sparrowe and Springer 1970, Nixon et al. 1991). Movements and migrations by deer in these areas are often caused by extrinsic forces such as changes in weather and availability of food (VerCauteren and Hyngstrom 1994), and migration between summer and winter ranges is most pronounced where there are marked seasonal differences in weather (Siglin 1965). Autumn or early winter migrations largely are responses to cold weather and a sharp drop in temperature (Verme and Ozoga 1971, Hoskinson and Mech 1976). The spring movement back to summer range appears to be a release from a restricted food supply, with the animals moving to newly available spring forage (Severinghaus and Cheatum 1956). Migrational patterns may vary between sexes and according to weather conditions, and white-tailed deer sometimes leave and return to their winter range several times before the final move to their summer range (Marchinton and Hirth 1984). Deer will generally occupy the same summer range year after year, but winter range locations may be less consistent related to climatic conditions and food availability. Dispersal events are most common during the spring fawning seasons and the fall breeding season (Nixon et al. 1994, Rosenberry et al. 1999), but many dispersal characteristics are known to vary among regions. White-tailed deer typically disperse 8 to 12 km, but movements of greater than 200 km have been reported (Kernohan et al. 1994). Some studies have shown that deer movements are directional and associated with watersheds (Sparrowe and Springer 1970, Kernohan et al. 1994, Nixon et al. 1994), while other studies have indicated no relation to physiographic features (Verme 1973, Kilgo et al. 1996).

White-tailed deer are defined as migratory if seasonal home ranges are completely separate with no overlap, and non-migratory or philopatric if they occupy the same home range area seasonally (Marchinton and Hirth 1984). Dispersal is considered to be individual movement beyond the limits of a home range that exhibits no predicted return. Home range can be described as the area traversed on an annual basis by an individual in its normal activities of food gathering, mating, and caring for young (Marchinton and Hirth 1984). In northern climates, home range sizes tend to be larger and less stable than in southern climates (Severinghaus and Cheatum 1956). Instances have been reported in which deer have starved to death rather than leave a depleted range even though food was available in adjacent areas (Severinghaus and Cheatum 1956). An awareness of distant food sources may determine the extent that deer will move away from their normal ranges to meet their needs (Byford 1970, Kammermeyer and Marchinton 1976).

Methods

Seasonal Movements and Dispersal Distances

White-tailed deer that were radiocollared at Lonetree WMA were periodically relocated from mid-March 2002 through December 2003 to assess seasonal and migratory movement behaviors. If I was unable to relocate individual collared deer with the tower systems (usually because they had moved off/away from the WMA), then aerial radiotelemetry by fixed-wing aircraft was used to attempt to locate the missing animals. Universal Transverse Mercator coordinates were estimated using a geographical positioning system (GPS) unit in the aircraft. The maximum distance traveled was calculated as a straight-line distance using UTM coordinates from the capture site and UTM coordinates at the farthest distance where the animal was observed.

Prior research on white-tailed deer in North Dakota focusing on movements and habitat use by white-tailed deer was conducted on or around Dawson WMA, in Kidder County, North Dakota in the 1970s (Aalgaard 1973, Martin 1973, Harmoning 1976, Johnson 1977). Also, in January 1999 North Dakota Game and Fish Department biologist Dr. William Jensen initiated a study of white-tailed deer at Dawson WMA for assessing movements and survival. The North Dakota Game and Fish Department was also interested in obtaining baseline information about the relative importance of various mortality factors influencing deer in this region of the state. As part of his study, Jensen captured and fit 69 white-tailed deer with ear tags, of which twenty adult females and five fawn females were radiocollared. Jensen captured white-tailed deer on the Dawson WMA with clover traps in January 1999, January 2000, and January 2001. Radiocollared deer were subsequently relocated approximately monthly from fixed-wing aircraft. Location information for deer that were tagged at Dawson WMA was also obtained from reports from the public and from hunter harvested deer. Data on movements and mortality factors of white-tailed deer from Jensen's Dawson WMA study were integrated with my data from Lonetree WMA to assess movements and survival across a larger portion of the Drift Prairie-Coteau region of North Dakota.

Reliable estimates of population density, demographics (i.e., age and sex ratios), and trends are important for proper management of white-tailed deer (Whipple et al. 1994). It is difficult to make direct observations of deer during daylight hours due to their cryptic coloration and crepuscular habits, however, because of eye reflection from the tapetum, deer are readily observed at night with a spotlight (McCullough 1982). Spotlighting has been widely used to study the abundance, sex and age structure, movements and migratory patterns, activity rhythms, distribution, habitat use, and social ecology of deer (Carbaugh et al. 1975, McCullough 1982, Fafarman and DeYoung 1986).

For this study biweekly spotlight surveys were used to assess seasonal patterns of movement and changes in relative abundance of white-tailed deer at Lonetree WMA. The spotlight survey perimeter followed the Lonetree WMA boundary within approximately 1.6 km and consisted of two sections, survey unit 1 and survey unit 2. The Goodrich/Martin road divided the survey units (Figure 9). Survey unit 1 began just east of the Goodrich/Martin line, extended to the eastern boundary of Lonetree WMA (total survey route distance = 37 km), whereas survey unit 2 began just west of the Goodrich/Martin line and extended approximately 3.2 km past Highway 14 (total survey route distance = 39 km) (Figure 9). Spotlight surveys were conducted on two consecutive nights starting with survey unit 1 the first night and finishing with survey unit 2 on the second night as weather allowed. Surveys were initiated at least one hour after sunset at first full darkness and continued for 2 to 3 hours depending on the number of deer observed. Routes were driven at 16 to 24 km/hr. Weather information (estimated cloud cover, temperature, relative humidity, precipitation, and wind direction and speed) was collected at the start of each survey using a hand-held Kestrel 3000 weather system

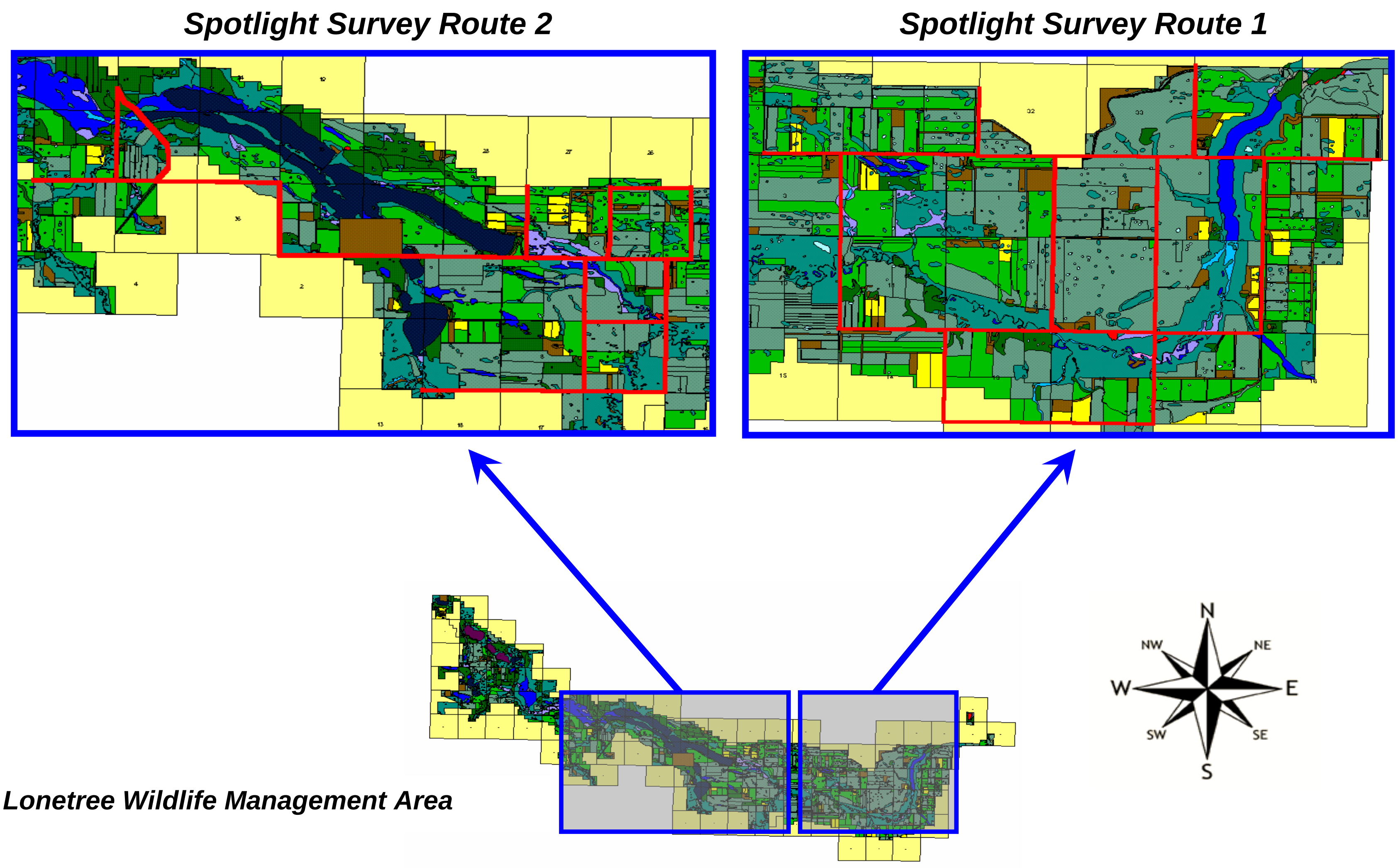

Figure 9. Expanded view of Lonetree WMA detailing routes driven (red lines) during biweekly spotlight surveys.

(Nielsen – Kellerman, Boothwyn, PA), and later hourly data were obtained from the North Dakota Agricultural Weather Network database (NDAWN, North Dakota State University, Fargo, ND). During spotlight surveys each of the two observers scanned either side of the road for deer using 530,000 candlepower spotlights (170 mm Striker, Lightforce USA, Orofino, Idaho) mounted to the hood of the vehicle. To minimize the risk of missing animals on the centerline, each observer surveyed their respective side of the transect, but frequently scanned the fields ahead to detect deer running away from the approaching vehicle (Ruette et al. 2003). When deer were spotted the vehicle was stopped and data on group size, numbers of tagged and untagged individuals, activity, and habitat type were recorded. Observers also had available a pair of 10 x 42 mm binoculars and a 20-60 x 80 mm spotting scope to aid in identification of marked individuals. Hand-held tally meters were used to enumerate large groups of animals; for large groups each observer estimated the size of the group and the group size was taken as the mean of the two counts. Total numbers of deer observed and distances covered for both survey units (76 km) were combined to determine the number of deer/km observed for each biweekly spotlight survey.

Daily Movements

Knowledge of daily movements is useful for positioning of food plots, developing census techniques, and determining the optimum size of harvest units (Marchinton and Hirth 1984). One approach to measuring daily movements is to locate radiocollared deer every two hours throughout a 24-hour period calculating the greatest distance between extreme radiolocations (DBE) and the sum of distances between sequential locations (MTD) (Marchinton and Jeter 1967, Marchinton 1969). While average extreme locations are generally less than 1.6 km, distances moved by individual deer can vary greatly related to sex, age, season, habitat, weather, and physical condition (Marchinton and Hirth 1984).

In early August and late October 2003, 24-hour telemetry monitoring sessions were done for adult female deer residing on the management area to assess daily movements. Three technicians assisted during each of the 24-hour monitoring periods when one person was positioned at each of three antennae towers with hand-held radios to coordinate simultaneous bearings on individual animals for triangulation. Using this method, thirteen locations were obtained for each animal in the area over a 24-hour period. Estimated Universal Transverse Mercator (UTM) coordinates were generated using LOAS software (Ecological Software Solutions, Switzerland), and Geographic Information System (GIS) software (ArcView GIS 3.2; Environmental Systems Research Institute, Inc. 1992-1999) was used to plot locations onto a layer of Lonetree WMA from which movement measurements were obtained. The greatest distance between extreme radiolocations (DBE) and the sum of distances between sequential locations (MTD) were calculated for each individual (Marchinton and Jeter 1967, Marchinton 1969).

Results

Seasonal Movements and Dispersal Distances

During the winter months of December through April, the majority of deer were being tracked using the tower system. By spring 2002, however, many of the radiocollared deer were moving away from Lonetree WMA where they were then periodically relocated from fixed-wing aircraft. Movements for collared deer were classified as being migratory or dispersive. Information on movements of deer that were tagged only was obtained from reports from the public, North Dakota Game and Fish staff, and hunter tag returns.

Movement distances for radiocollared and tagged adult female white-tailed deer at Lonetree WMA ranged from a minimum of 0.6 km to a maximum of 32.2 km ($\bar{x}$ = 11.2, SE ± 1.9) (Figure 10, Appendix IV). Movement distances for radiocollared and tagged fawn females ranged from a minimum of 3.3 km to a maximum of 132.7 km for a fawn female that was harvested just south of Belcourt, North Dakota ($\bar{x}$ = 25.6, SE ± 6.3) (Figure 10, Appendix V). Distances recorded for fawn males ranged from a minimum of 2.6 km to a maximum of 120.4 km for a fawn male whose tag was discovered near a grain bin by a farmer near Upham, North Dakota ($\bar{x}$ = 47.1, SE ± 15.3) (Figure 10, Appendix VI).

Movement distances for adult radiocollared females at Dawson WMA recorded from 1999 through 2003 ranged from a minimum of 7.4 km to a maximum of 42.2 km ($\bar{x}$ = 19.0, SE ± 2.1) (Appendix VII). Distances for radiocollared and tagged fawn females ranged from a minimum of 6.3 km to a maximum of 57.5 km ($\bar{x}$ = 25.7, SE ± 7.2) (Appendix VIII). Tags were returned for three fawn males harvested during the rifle season, and distances traveled were 9.9 km, 16 km, and an extreme movement of 90 km for a fawn male that was harvested near Hosmer, Edmunds County, South Dakota on November 25, 2000.

From July 2002 to December 2003, 22 different biweekly spotlight surveys were conducted at Lonetree WMA, excluding the deer rifle seasons (November 2002, and November 2003). The number of observed white-tailed deer on Lonetree WMA during

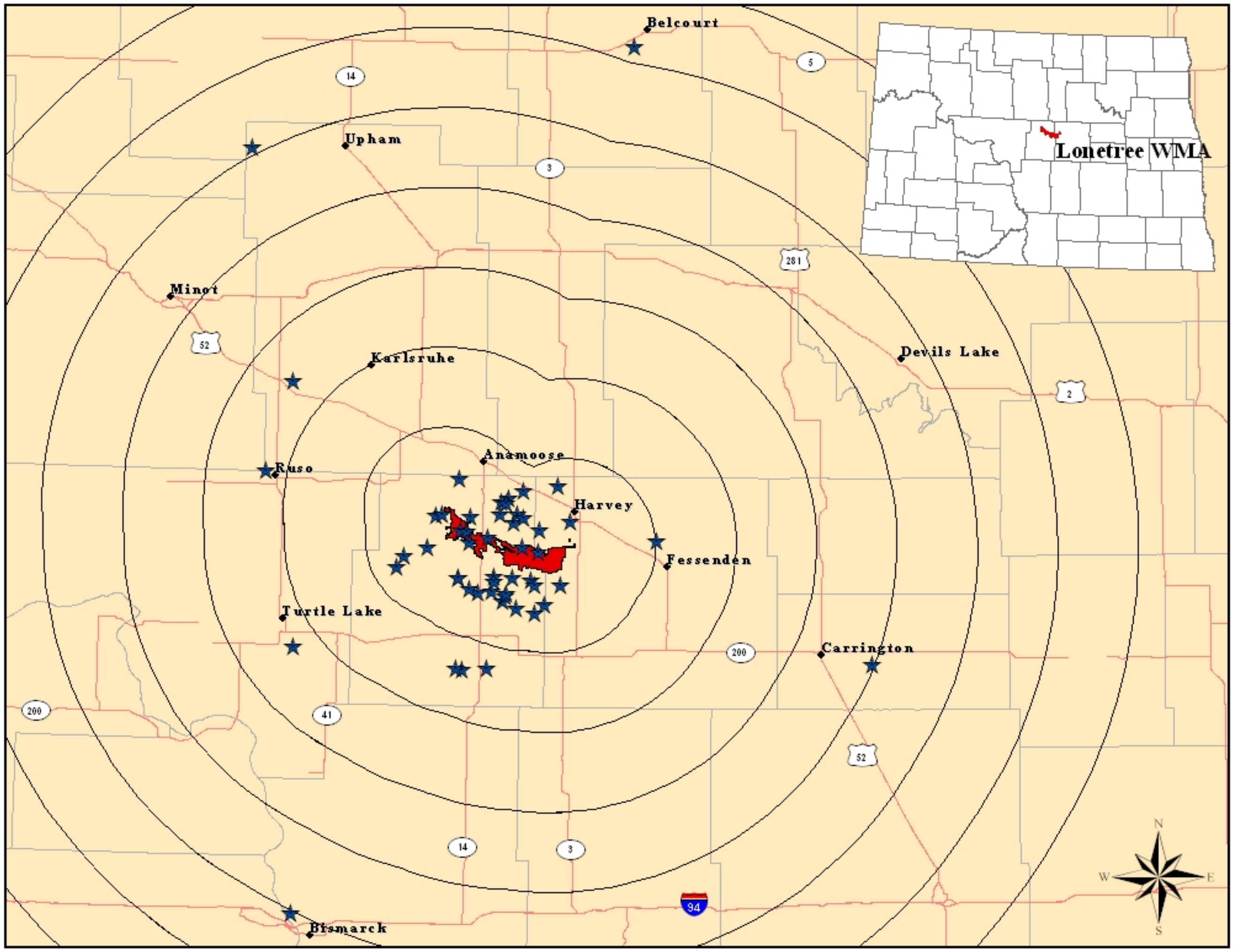

Figure 10. Blue stars represent the locations of maximum movements of white-tailed deer from capture sites within Lonetree Wildlife Management Area. Concentric polygons denote 20 km intervals from the management area boundary.

spotlight surveys from June to mid-December was generally low (≤ 1.5 deer/km), with numbers gradually increasing by late December and peaking in February (≤ 6.5 deer/km) (Figure 11). The number of deer/km gradually declined from March to May (Figure 11).

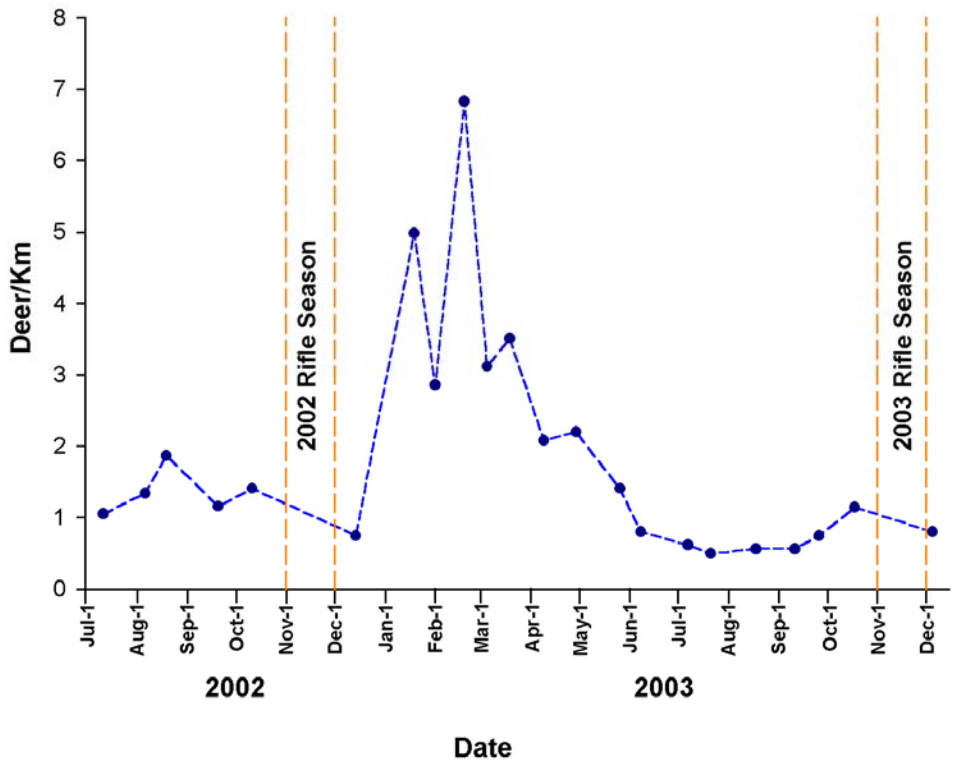

Figure 11. Results from biweekly spotlight surveys indicating trends in seasonal abundance of deer on Lonetree WMA (deer/km) for 2002 and 2003. NOTE: no surveys were conducted during the 2002 or 2003 rifle seasons.

Daily Movements

Locations were recorded over a 24-hour period on August 3, beginning at 2000 hours, and were completed on August 4, 2003 at 2000 hours. A second 24-hour rotation was completed on October 25, beginning at 1100 hours and was completed on October 26, 2003 at 0900 hours. All locations recorded during these periods were combined to calculate an average extreme movement and greatest distance traveled in 24 hours (Table 6). The greatest distance between extreme radiolocations for an individual animal at

Lonetree WMA was 1.75 km ($\bar{x}$ = 1.18, SE ± 0.11) in a 24-hour period (October), and the greatest distance traveled in a 24-hour period (August) was 6.67 km ($\bar{x}$ = 4.41, SE ± 0.44).

Table 6. Average distances (km) traveled by radiolocated white-tailed deer during 24-hour periods.

Location	Number of Deer	Mean DBE[a]	Mean MTD[b]	Source
Lonetree WMA, ND	6	1.18	4.41	This study
Florida	3	1.74	4.70	Bridges (1968)
Alabama	6	1.06	3.11	Byford (1970)
Georgia	7	1.06	2.93	Kammermeyer (1975)
South Carolina	2	1.13	3.38	Sweeney (1970)
Iowa	9	n/a	1.45	Zagata and Haugen (1973)

[a]Greatest distance between extreme radiolocations.
[b]Sum of distances between sequential locations.

Of the 6 deer that were monitored over 24-hour periods, two remained entirely on the management area, one made a brief transition to the management area but was primarily located on private land around wooded draws to the south (150.855, Figure 12), one moved to and from the management area out of the wooded draws on the southern edge of Lonetree WMA, and two remained entirely on private land. The adult female (150.985, Figure 12) that transitioned from the management area to private land was primarily located on Lonetree WMA from 2000 – 0600 hours, on private land from 0800 – 1000 hours, and back on the management area from 1200 – 1800 hours.

Discussion

The overall average maximum movement exhibited by white-tailed deer at Lonetree WMA was 22.4 km (SE ± 3.8) which was less than average maximum movements documented by other studies of the species in the Missouri Coteau of North Dakota during the early 1970s, but were within the range of average maximum

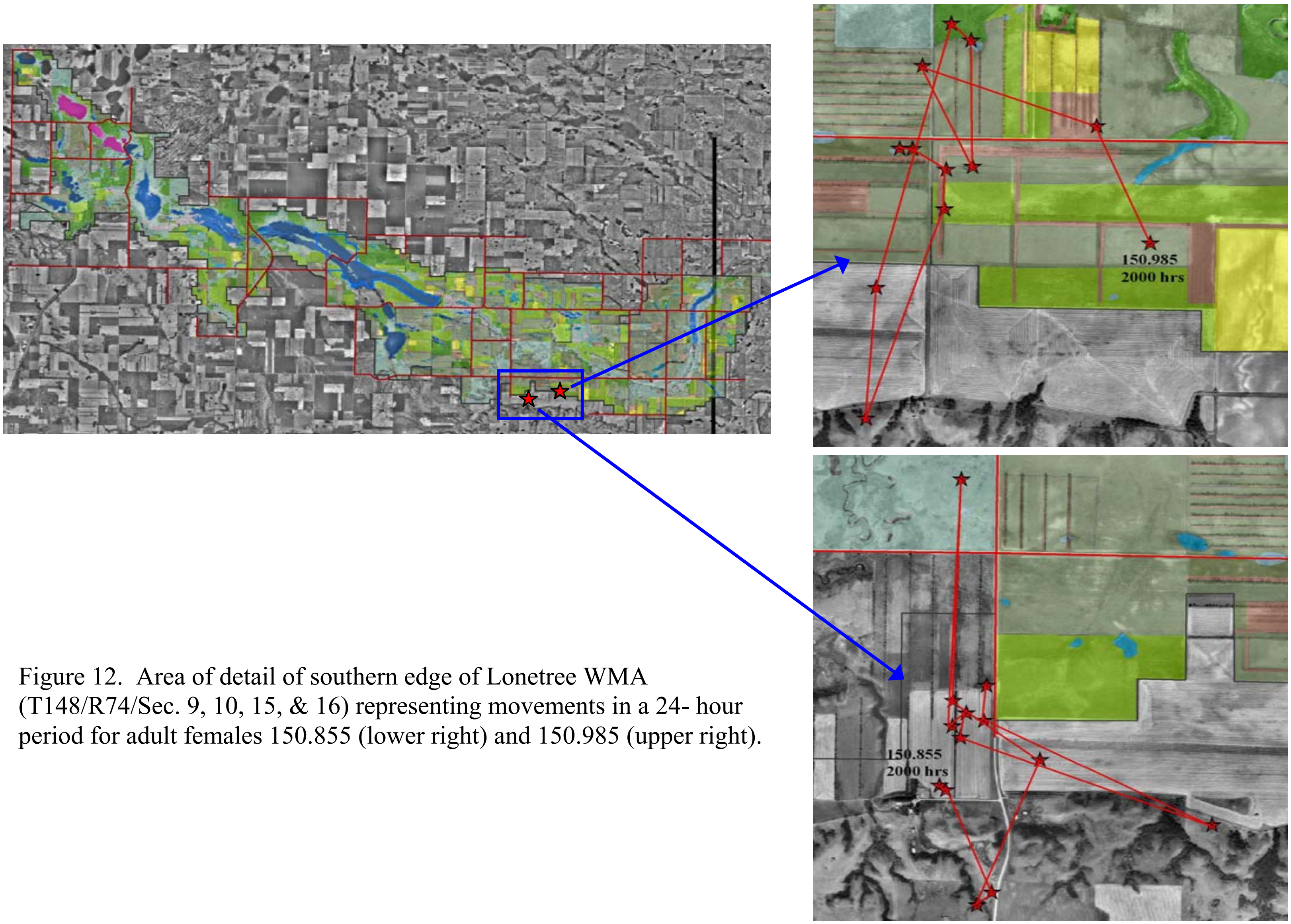

Figure 12. Area of detail of southern edge of Lonetree WMA (T148/R74/Sec. 9, 10, 15, & 16) representing movements in a 24- hour period for adult females 150.855 (lower right) and 150.985 (upper right).

movements reported by other studies conducted in surrounding states. Martin (1973) reported an average maximum movement of 32.9 km (SE ± 11.8) for white-tailed deer at Dawson WMA. Martin's minimum recorded movement was 0.8 km whereas his maximum recorded individual movement was by a fawn male that moved 216 km prior to being harvested near Ashton, South Dakota. Aalgaard (1973) also reported movement data for white-tailed deer for the Dawson WMA area including an average maximum movement of 44.5 km (SE ± 19.2), a minimum individual movement of 1.0 km and a maximum individual movement of 273.6 km by a fawn female harvested near Stanley, North Dakota. Other data on movements for white-tailed deer in the region are reported in Table 7 for comparison.

Table 7. Average and maximum movement distances reported for white-tailed deer in North Dakota and surrounding states.

Location	Average movements (km)	Maximum movements (km)	Source
Lonetree WMA, ND [a,b]	22.4	132.7 [d]	This study
Dawson WMA, ND [b]	32.9	216.0 [c]	Martin (1973)
Dawson WMA, ND [a,b]	44.5	273.6 [d]	Aalgaard (1973)
Northwest Minnesota [a]	15.6	88.5 [d]	Carlsen and Farmes (1957)
Eastcentral Minnesota [a,b]	22.0	104.6 [c]	Rongstad and Tester (1969)
Northeastern Minnesota [a]	20.0	38.0 [d]	Hoskinson and Mech (1976)
Northeastern Minnesota [a]	17.0	40.0 [d]	Nelson and Mech (1981)
Eastcentral South Dakota [a,b]	23.2	160.9 [d]	Sparrowe and Springer (1970)
Northeastern South Dakota [a,b]	14.6	212.6 [c]	Kernohan et al. (1994)
Southwestern South Dakota [a,b]	31.8	56.6 [d]	Griffin et al. (1999)
Upper Peninsula Michigan [b]	13.8	51.5 [c]	Verme (1973)
Wisconsin [b]	9.6	19.3 [d]	Dahlberg and Guettinger (1956)
Eastcentral Illinois [a,b]	13.0	n/a	Nixon et al. (1991)
Montana [a,b]	3.6 - 13.2 (Range)	n/a	Wood et al. (1989)

[a]Estimates based on radiolocations

[b]Estimates based on tag returns or direct observations

[c]Reported for male white-tailed deer

[d]Reported for female white-tailed deer

The significant regional variations in movements by white-tailed deer based on this literature review (Table 7) are the result of extensive habitat differences among the areas where the studies were conducted (Verme 1973).

Based on data from radiolocations deer began to move away from Lonetree WMA during the months of April and May as temperatures warmed and snow melt exposed forage. The pattern I observed was that whenever weather conditions began to deteriorate, deer that had began to move off of the management area would return until weather conditions improved. While spring movements to summer range were related to newly available spring forage, pregnant females were also moving back to traditional fawning areas. White-tailed deer are not generally gregarious during this period of the year, and moving away from a highly populated winter range to a summer range facilitates imprinting and raising young.

Radiocollared deer generally began to return to the management area during November, with the majority of deer back on the management area by late December. The autumn migration back to the management area is likely due to responses to cold weather and sharp drops in temperature associated with snow cover. Also during this period of the year, the majority of most agricultural crops have been harvested on private land, resulting in a decrease in available forage. To some extent, hunting seasons also were important for fall movements, as the majority of radiocollared deer were located in the wooded draws on the southern edge of the management area where hunting pressure was less intense during this period.

Deer that migrated or dispersed away from Lonetree WMA moved in all directions, although there was a westerly movement trend. Based on data from Jensen's recent study, white-tailed deer at Dawson WMA tend to exhibit southward movements, although both Martin (1973) and Aalgaard (1973) noted an eastward trend for deer movements for the same area in the early 1970s.

Movements by white-tailed deer at Lonetree and elsewhere may be influenced by natural or man-made boundaries. The McClusky canal near the western boundary of Lonetree WMA appeared to limit westward movements because few radiocollared deer were relocated west of this structure. In relation to natural boundaries, the only limiting factor for white-tailed deer at Lonetree WMA appeared to be the Missouri River; deer were located just east of the river but none were relocated to the west. The major limiting factor of movements for deer at Dawson WMA appears to be Interstate 94 (Martin 1973, Aalgaard 1973) as Martin (1973) and Aalgaard (1973) reported very few marked deer captured at Dawson WMA north of Interstate 94.

CHAPTER 5

MORTALITY CAUSES FOR WHITE-TAILED DEER IN THE DRIFT PRAIRIE-COTEAU REGION OF NORTH DAKOTA

Introduction

Radiotelemetry is used widely in wildlife ecology to study use of habitat, movement, and survival (White and Garrott 1990). Once marked, collared animals are released and searches are made within a study area to obtain locations and determine status as alive or dead. In studies emphasizing survival estimation, searches and radiolocations of radio-tagged animals are often made at regular and nearly continual intervals so as to determine the time of death, and to identify sources of mortality (Bunck et al. 1995). Common causes of mortality for white-tailed deer include hunter harvest, poaching, deer vehicle collisions (Fuller 1990, Nixon et al. 1991, Brinkman et al. 2004), severe weather conditions (DelGiudice et al. 2002), predation (Mech 1984), and disease (Matschke et al. 1984, Heisey and Fuller 1985).

Mortality rate (or survival rate = 1.0 – mortality rate) can be defined as the proportion of animals dying within a specified time period (i.e. the number of animals that died during a period divided by the number alive at the beginning of that period). An important problem in assessing mortality rates is determining when an animal dies. Unless marked deer are harvested the fate of most animals remains unknown. Even when dead animals are located determining the time or cause of death can be difficult or impossible (Lancia et al. 2000).

The two direct methods to evaluate survival that are most applicable to large mammals are (1) marking and recapturing animals when they die such as during a hunting season and (2) following the fate of radiomarked individuals. Survival rate of radiomarked animals can be estimated with the staggered entry, Kaplan-Meier estimator (Lancia et al. 2000). The Kaplan-Meier survival estimation technique is flexible in that it allows for censorship of animals removed from the population due to radio failure, collar loss, or emigration, and because large mammals are difficult to trap and collar in large numbers at one time, it also allows new animals to be added after initiating the study (Bertram and Vivion 2002). The Kaplan-Meier method assumes the following: *(i)* random sampling of individuals, *(ii)* independent fates for all animals, *(iii)* no influence of the radio tag on survival, *(iv)* censoring unrelated to an animal's fate, *(v)* homogenous survival rates (newly tagged animals have the same survival function as previously tagged animals), and *(vi)* animals present are located with probability 1 (Pollock et al. 1989). Using the staggered entry approach, survival is calculated sequentially at each time interval, based on whether individual animals die. Survival over subsequent periods is the product of previous interval survivals. The Kaplan-Meier survival estimator yields a stair step pattern of survival over time. If no animals die in several time intervals, survival is a flat line. However, if a number of animals die in a period, survival drops dramatically in a stair step fashion. This graphical display of survival through time reveals how mortality patterns vary annually and seasonally (Lancia et al. 2000).

Methods

I used data obtained from adult and juvenile females radiomarked at Lonetree WMA and Dawson WMA to estimate survival of white-tailed deer within the Drift

Prairie-Coteau region of North Dakota. Deer residing off the management area were relocated a minimum of once per month by fixed-wing aerial telemetry, whereas deer residing on Lonetree WMA were relocated three to four times a week using the antennae tower system. The VHF radiocollars I used in the study were equipped with mortality sensors for detecting a lack of movement after approximately 4 hours (when on mortality the normal pulse rate of 60 bpm doubles to 120 bpm). Note also that a mortality pulse rate will be emitted when collars fall off animals. Upon detection of a mortality pulse, the animal was located by homing to the signal with a hand-held antenna. Alternatively, if a mortality pulse was encountered during aerial radiotelemetry, I attempted to obtain a visual of the animal and directed the pilot to land in close proximity for recovering the collar and to attempt to determine cause of death. If a carcass was recovered, it was examined for broken bones, bullet holes, or bite marks depending on the extent to which the animal had been scavenged. Lower jaws were collected for aging (Severinghaus 1949), and animal location in relation to roads was also noted.

To estimate survival I used the nonparametric staggered-entry Kaplan-Meier method to calculate survival rates for white-tailed deer captured at Lonetree WMA and Dawson WMA. For this method a time origin at which survival analysis would begin as well as a time interval at which survival would be assessed was required. The time origin for Lonetree WMA was set at March 15, 2002 and the time origin for Dawson WMA was set at January 15, 1999. The interval selected for survival assessment at Lonetree WMA was bimonthly for periods when deer were being actively located with the antennae tower system (November through April), and monthly when the majority of collared deer were located away from the management area (May through October). The interval selected for survival assessment for white-tailed deer radiocollared at Dawson WMA was monthly because most deer from that study were located a minimum of once per month by fixed-wing aircraft. I also separated fawn females (< 1.5 years of age) and adult females (>1.5 years of age) into separate groups to estimate survival. Lonetree WMA and Dawson WMA were also separated for analyses due to potential differences between study sites and time lags between the collaring of animals at Dawson and collaring of animals at Lonetree WMA. Survival was calculated separately for Lonetree WMA adult females, Lonetree WMA fawn females, Dawson WMA adult females, and Dawson WMA fawn females. The time interval used to evaluate survivorship between the two management areas was monthly, and survival was compared using a log-rank test to assess whether survivorship within age groups followed the same survivorship curve (Cox and Oakes 1984).

In addition to survival estimates of radiocollared females, hunter check stations and targeted road surveys were used to assess mortality for non-collared deer residing on or near Lonetree WMA. Hunter check stations were operated at the Lonetree WMA office headquarters during the November 2002 and November 2003 rifle seasons. Data gathered from deer brought to check stations included sex, age, body weight, neck and chest circumference, and hind leg length. Lower jaws were also collected or examined for age according to molar wear and eruption (Severinghaus 1949). If a marked deer was harvested, information on the location of harvest was also collected. Targeted road surveys were conducted approximately weekly on Highway #3 and Highway #14, which run north and south along the eastern border and through the WMA on the western edge, respectively. Area covered for road survey routes consisted of approximately 12.8 km for each highway with the major portion of the route falling within or running parallel to the management area boundary. The surveys involved looking for marked or unmarked deer mortalities due to deer vehicle collisions (DVCs). DVCs that were reported by the public or North Dakota Game and Fish staff located within the interior of Lonetree WMA were also investigated. When DVCs were located and when possible depending on the condition of the carcass, necropsy reports were completed to record information on age, sex, and body weight. Various other body measurements were recorded, as well as the location of the mortality, and whether the animal was marked or unmarked.

Results

The overall adult female and fawn female survivorship at Lonetree WMA during the period from March 2002 through December 2003 was 60% and 67%, respectively (Figure 13). I also estimated the annual survival rates for collared deer at Lonetree, which were 77% and 78% for adult and fawn females respectively in 2002 (March through December) and 83% and 89% for adult and fawn females respectively in 2003 (January through December; Figure 13).

During 2002, one adult female was killed by coyotes (*Canis latrans*) in late March, one was found dead of unknown causes in early June, and one was harvested during the November rifle season. In 2003, one adult female was killed by coyotes in late May, one died of unknown causes and one shed its collar in early September, two died in November as the result of hunter harvest or crippling loss, while another died in mid-December as the result of crippling loss (Table 8). In 2002, one fawn female shed its collar in late March, one was harvested during the rifle season in November, and one died of unknown causes in mid-December. During 2003, one fawn female shed its collar in early February, one left the area in early April, one died in late April from unknown causes, two more left the area in late May and mid-July, and two were harvested during the rifle season in November (Table 8).

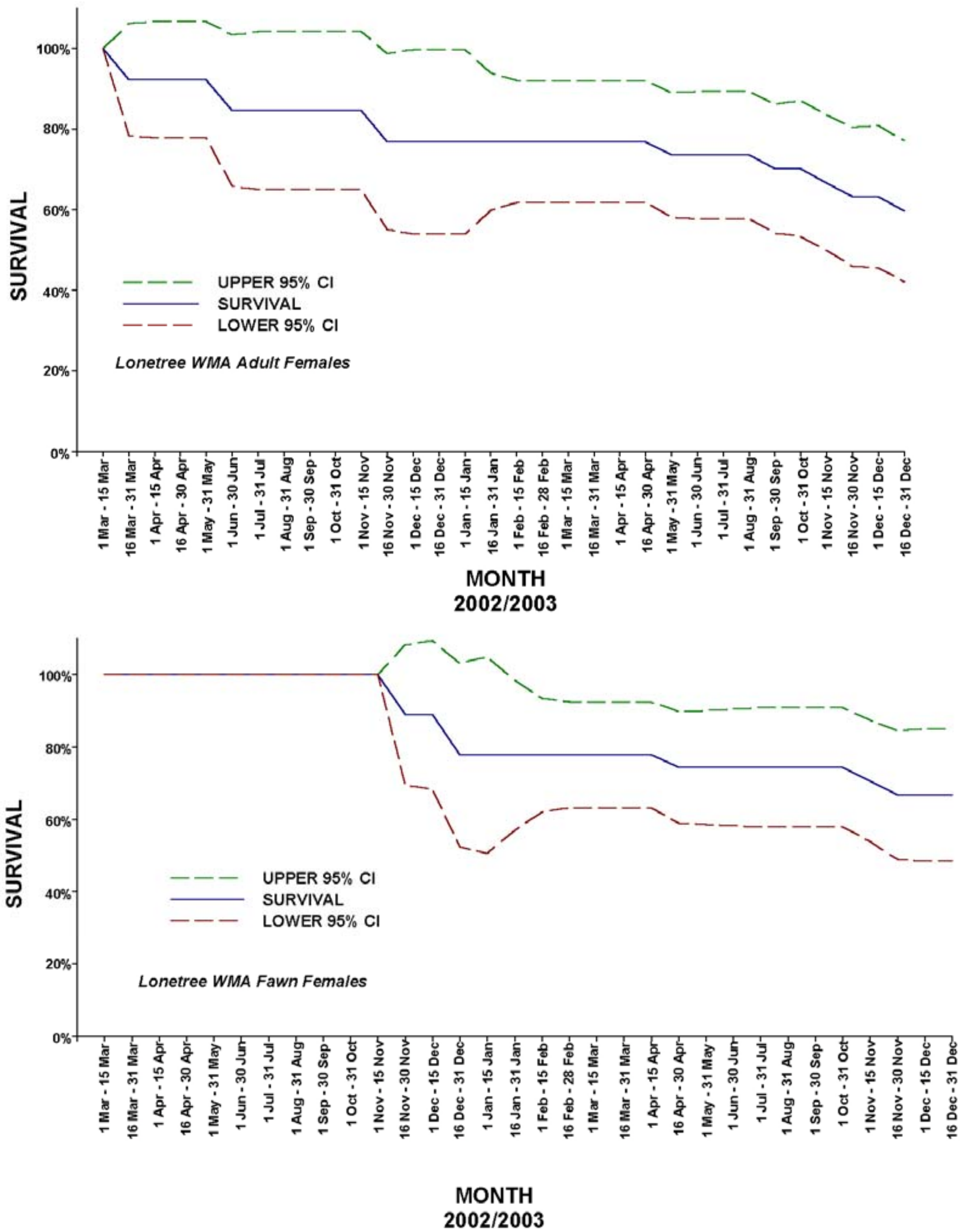

Figure 13. Survival estimates for adult and fawn female deer at Lonetree WMA, 2002 to 2003, using Kaplan-Meier method with staggered entry design.

Table 8. Causes of mortality for deer at Lonetree WMA based on age, gender, and whether animals were marked. Unmarked individuals represent deer that were reported by the public, observed during road surveys, or discovered during other field research.

		Causation of Mortality						
Age/Sex/Category	N	Hunting	Crippling Loss	Predation	Starvation	DVC's	Capture Mortality	Unknown
Adult Female								
Collared	12	3	2	4				3
Tagged	1	1						
Unmarked	13			3		6		4
Fawn Female								
Collared	5	3		1				1
Tagged	1	1						
Unmarked	6					3	2	1
Adult Male								
Collared								
Tagged	2	2						
Unmarked	7					4		3
Fawn Male								
Collared	4	2		1		1		
Tagged	3	2	1					
Unmarked	1							1

The estimated overall survival rate for adult females at Dawson WMA from January 1999 through December 2001 was 30% (Figure 14). Data on radiocollared fawn females at Dawson WMA were not available until 2001, which were used to estimate an overall fawn female survival rate of 60% for the period between January 2001 and December 2003. Because of the relatively small sample sizes for radiocollared deer at Dawson WMA I did not attempt to estimate annual survival rates for that study area.

In 1999 one adult female died as a result of starvation in early February, and one was harvested during the November rifle season. In 2000, two died as the result of deer vehicle collisions in May, one died from unknown causes in September, and one died from unknown causes and two were harvested during the rifle season in November. During 2001 one female deer died in mid-March as the result of a deer-vehicle collision; two were harvested during the November rifle season; and there were two deaths in

December, one crippling loss, and the other due to unknown causes (Table 9). The only deaths recorded for fawn females at Dawson WMA were two fawn females that starved in early February 2001 (Table 9).

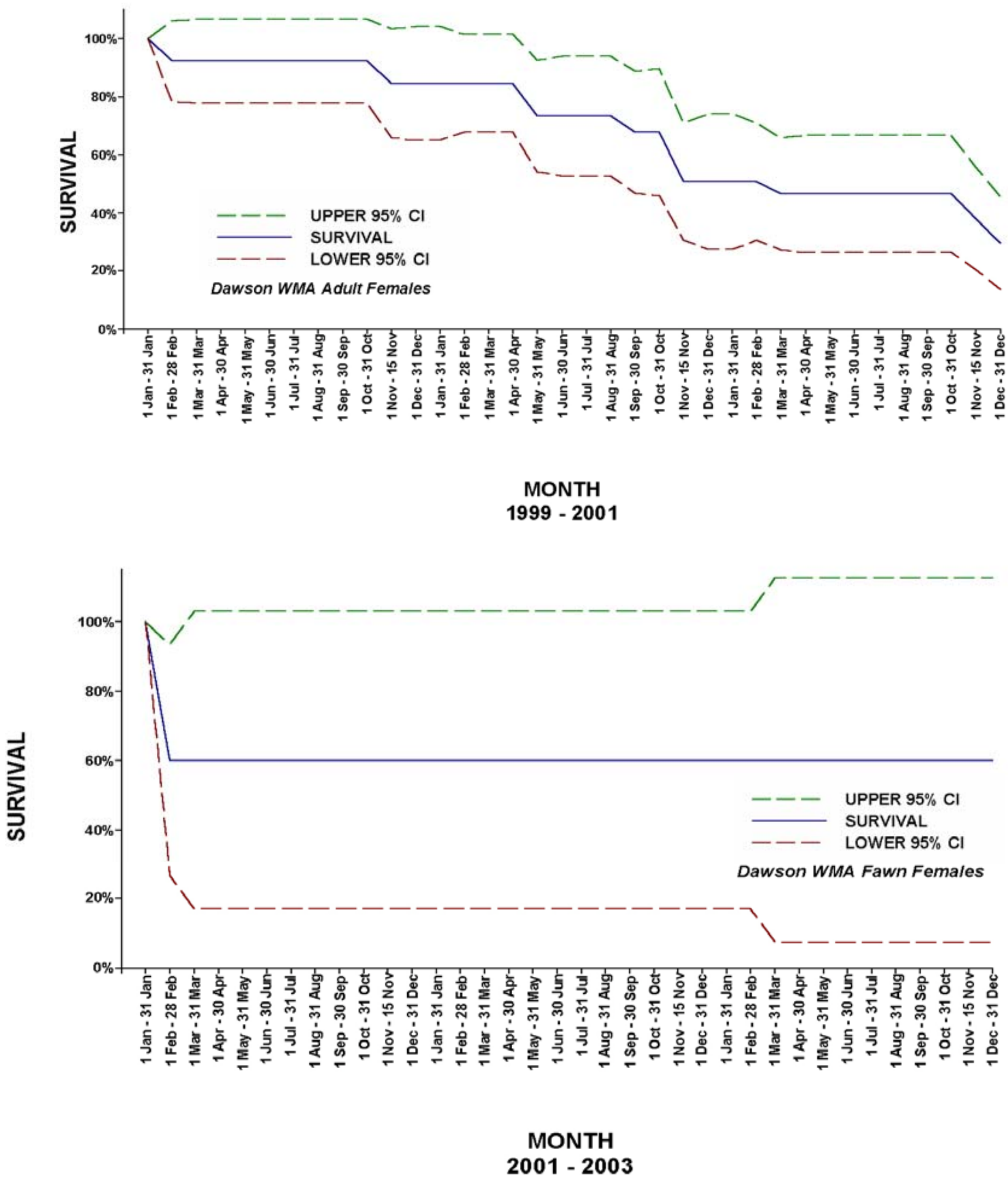

Figure 14. Survival estimates for adult female deer (1999 to 2001) and fawn female deer (2001 to 2003) at Dawson WMA using Kaplan-Meier method with staggered entry design.

Table 9. Causes of mortality for deer at Dawson WMA based on age and gender. Information on tagged individuals was provided by hunters who harvested animals or by the public.

		Causation of Mortality						
Age/Sex/Category	N	Hunting	Crippling Loss	Predation	Starvation	DVC's	Capture Mortality	Unknown
Adult Female								
Collared	14	6	1		1	3		3
Tagged	0							
Fawn Female								
Collared	2				2			
Tagged	2	1					1	
Adult Male								
Collared	0							
Tagged	2	2						
Fawn Male								
Collared	0							
Tagged	6	2				1	1	2

Results from analyses indicated that there was no significant difference in survival between adult females and fawn females at Lonetree WMA (Log-ratio Chi-square = 0.21, df = 1, $P = 0.65$), adult females and fawn females at Dawson WMA (Log-ratio Chi-square = 1.85, df = 1, $P = 0.17$), or adult females at Lonetree WMA and adult females at Dawson WMA (Log-ratio Chi-square = 0.40, df = 1, $P = 0.53$).

A total of 46 (29 males, 17 females) deer were checked during the 2002 hunter check station. Five animals (3 females, 2 males) brought to the 2002 hunter check station were marked deer. A total of 41 (24 males, 17 females) deer were checked during the 2003 hunter check station, including nine marked deer (5 females, 4 males).

Observations during targeted road surveys or reports of mortalities related to DVCs on or near Lonetree WMA were low ($n = 15$). Demographics of observed DVCs consisted of 6 adult females (unmarked), 4 fawn females (unmarked), and 5 yearling or adult males (1 marked, 4 unmarked). Two DVCs mortalities occurred on Highway #14, while the rest occurred within the boundary of the management area. The periods during which the majority of DVCs were observed ranged from late May through early July which is a period where deer are typically exhibiting more movement as they transition from winter to summer ranges.

Discussion

Based on Kaplan-Meier survival estimates and investigations of mortalities of radiocollared deer during this study, the major source of deer mortality in the Drift Prairie-Coteau region of North Dakota is hunter harvest. Annual survival of adult (77%) and fawn (78%) female deer at Lonetree WMA was similar to survival rates reported elsewhere for female white-tailed deer (65%-80%, Gavin et al. 1984, Fuller 1990, Nixon et al. 1991, Whitlaw et al. 1998, DePerno et al. 2000, Brinkman et al. 2004) where hunter harvest was the greatest cause of mortality. Other observed sources of mortality for white-tailed deer at Lonetree WMA were deer vehicle collisions and predation by coyotes. Most of the unknown mortalities had been severely scavenged, preventing unambiguous determination of the cause of mortality.

Most of the mortalities by coyote predation occurred during the period of late March through early June. Additionally, several unmarked deer were found on the Lonetree WMA area that had been killed by coyotes during late March and early April. It was possible that the apparent focus of coyote predation during the late winter period was because deer had been become weakened by food limitation. However, visual assessments of food plots suggested ample forage remained available well into March. To evaluate whether or not white-tailed deer at Lonetree WMA were in a deteriorated physical state due to a starvation diet, a small sample of femurs was collected from deer carcasses when coyote predation was suspected. The femur marrow is considered to be the last site of depletion of stored fat, and thus a low femur-marrow fat content indicates serious malnutrition (Verme and Ullrey 1984). Collected femurs were cut or broken open to visually assess femur fat levels (Cheatum 1949). In other studies of deer, mortalities were attributed to starvation when marrow fat content appeared to be < 25%, while predation was considered likely when there were signs of chase, the carcass was widely scattered, and/or biting wounds were visible (Dumont et al. 2000). Femur fat levels exceeded 70% for all dead deer that were located and sampled at Lonetree WMA during the study.

Climate and disease could also contribute to mortality in this region. To some extent climate may be a limiting factor depending on available cover and forage and the length of winter and duration of snow cover. Epizootic hemorrhagic disease annually affects white-tailed deer in the section southwest of the Missouri River in North Dakota (Hoff et al. 1973), but it has not been reported in the Coteau region other than Williams, Mountrail, and Divide counties. Other diseases related to white-tailed deer are currently of little consequence in the region.

CHAPTER 6

MANAGEMENT RECOMMENDATIONS FOR WHITE-TAILED DEER AT LONETREE WILDLIFE MANAGEMENT AREA

It is a common assumption that white-tailed deer populations in North America are overabundant and may be more numerous now than they were at the turn of the twentieth century (McShea et al. 1997). Currently in North Dakota, white-tailed deer populations are at all time highs related to abundant forage provided by agricultural crops and several consecutive mild winters. Results of this study indicate that Lonetree WMA is meeting the objectives set forth by its management plan in managing nonnative habitats to maximize white-tailed deer abundance (North Dakota Game and Fish Dept. 2001). Lonetree WMA is currently supporting a large population of white-tailed deer during winter periods. Data from radiocollared individuals suggest that these deer are being drawn to Lonetree WMA from a large area of the Drift Prairie-Coteau region. The importance of Lonetree WMA as a wintering area for white-tailed deer that supports an increasing white-tailed deer population during winter periods is largely related to the abundance of cover and winter forage. Planting of shelterbelts, tree block plantings, and native grasses are important for cover on Lonetree WMA, and woody draws located on private land on the southern boundary of the management area are also providing important winter cover. Data on deer movements and diets indicate that food plots provide important preferred forage for white-tailed deer during winter periods at Lonetree WMA. During other seasons of the year, observations made while conducting spotlight surveys and other field related techniques indicate that white-tailed deer also prefer alfalfa and clover present in dense nesting cover plantings, especially after it has been hayed.

Overpopulation of ungulates is a recent problem for wildlife managers (Jewell and Holt 1981). White-tailed deer in particular are known to be irruptive, and several factors that contribute to irruptive population behavior include sudden creation of suitable habitat, production of agricultural crops and artificial feeding, and reduced natural mortality by elimination of natural predators or altered hunting regulations (McCullough 1997). Deer in agricultural areas of the northern Great Plains are taking advantage of the nutritious and abundant foods provided by agriculture and carrying capacities in these areas often far exceed current population levels (Hansen et al. 1997). Landowner tolerance is the most important factor driving deer management programs in these areas, and deer numbers are currently managed near a "cultural carrying capacity" based on landowner attitudes (Naugle et al. 1994, Hansen et al. 1997, Irby et al. 1997).

To assess whether the white-tailed deer population at Lonetree WMA is overabundant several factors need to be considered. The term overabundance when referring to animal populations can be defined as (1) when the animals threaten human life or livelihood, (2) when the animals depress the densities of favored species, (3) when the animals are too numerous for their own good, or (4) when their numbers cause ecosystem dysfunction (Caughley 1981). Based on these definitions, the deer population at Lonetree WMA will likely be considered overabundant if or when they begin to threaten human livelihoods by increased crop depredation, damage to livestock food stores, or by increased property damage such as by deer vehicle collisions. White-tailed deer populations may also be considered overabundant if high densities lead to increased spread of disease. The number of deer that Lonetree WMA can support is more than likely related to the number of deer that private landowners in the surrounding area will tolerate rather than the actual carrying capacity of the management area based on habitat and forage availability.

The original purpose of food plot plantings at Lonetree WMA was to alleviate potential depredation problems on adjacent private lands caused by increasing wildlife populations (North Dakota Game and Fish Dept. 2001). Plantings of food plots at Lonetree WMA may have in fact facilitated increasing white-tailed deer populations by providing a source of agricultural forage during fall and winter when access to this type of food is limited by harvest on private lands. Because food plots are heavily used during winter months when white-tailed deer congregate on the management area, it may be possible to control the burgeoning deer population at Lonetree WMA by removing or limiting the number of planted food plots. However, it is also possible that removal or limited food plots would do little to reduce winter congregations of white-tailed deer at the management area because of the abundant cover provided by tree plantings. Also, removing or limiting food plots at the management area would reduce winter forage and likely cause immediate problems for landowners in the area by increased deer depredation. Currently, with the number of food plots now available on the management area, there are few complaints of white-tailed deer depredation on private lands adjacent to Lonetree WMA. As populations of white-tailed deer continue to increase on and around the management area, however, problems with depredation may arise. The current policy of the North Dakota Game and Fish Department regarding wildlife depredation is to (1) avoid big game feeding programs during the winter, (2) continue to develop predictive capabilities for big game population trends, (3) emphasize habitat programs that provide wildlife with adequate winter habitat and natural forage during severe winters, and (4) establish appropriate fall harvest levels for these species (North Dakota Game and Fish Dept. 2003b). Responses to problems caused by overabundant deer, such as those that may eventually occur at Lonetree WMA, are constrained to the framework of this policy.

Because natural predators such as wolves (*Canis lupus*) have long been extirpated from their historic range in North Dakota, the best tool for controlling deer numbers is regulated hunter harvest (Smith and Coggin 1984, Ellingwood and Caturano 1988, McCullough 1997), and is currently the best method for controlling white-tailed deer populations at Lonetree WMA. Increases in available licenses for antlerless deer, which include adult females and young of the year, would be the most beneficial in maintaining or decreasing the white-tailed deer population in the area. Numbers of white-tailed deer licenses issued in North Dakota have been increasing steadily, with more than 100,000 being issued statewide annually since the late 1990s (Jensen 1999). There were 6000 antlerless deer permits available for deer management unit 2K2 (2004 rifle season), which encompasses a major portion of Lonetree WMA, and an additional statewide supplemental antlerless season, with the exception of several Badland units (4A, 4B, 4C, 4D, and 4E), was conducted in December 2004. Efficacy of hunter harvest may be limited by accessibility, especially in areas where public land is limited and private land is abundant as is the case in North Dakota. Also, a saturation point may be reached where only a certain number of licenses can or will be sold related to the willingness of hunters to purchase antlerless permits and/or harvest relatively large numbers of white-tailed deer. To assess effects of increases in antlerless hunting licenses or supplemental seasons on white-tailed deer populations at Lonetree WMA from year to year the North Dakota Game and Fish Department should continue to monitor white-tailed deer populations in the area via fixed-wing winter aerial surveys.

Currently disease issues for white-tailed deer are of little consequence in the state, however with occurrences of large congregations of deer, problems associated with disease may become a reality. It has been documented that large congregations of deer caused by supplemental feeding can facilitate transmission of disease (Miller et al. 2003). Because of recent issues with chronic wasting disease (CWD), nearly all states in the continental United States have implemented some type of surveillance sampling to assess whether CWD exists in a state (Diefenbach et al. 2004). The North Dakota Game and Fish Department is currently monitoring white-tailed deer populations for CWD across the state and has regulations in place banning the importation of cervids or parts of cervids from areas where CWD is known to occur (Colorado, Illinois, Kansas, Montana, Nebraska, New Mexico, Oklahoma, South Dakota, Utah, Wisconsin, Wyoming and Saskatchewan, Canada). As the North Dakota Game and Fish Department continues to monitor white-tailed deer in the state for CWD, distances of dispersal and migrational movements exhibited by white-tailed deer in this study and the large congregations of deer that currently occur at Lonetree WMA during winter periods should be considered. These large white-tailed deer congregations associated with natural wintering areas or other wildlife management areas similar to Lonetree WMA may potentially serve as “hot spots” in facilitating disease transmission should CWD be detected in the state.

It is important to note that while the majority of white-tailed deer leave Lonetree WMA in the spring, habitat components of their summer ranges essentially mirror cover and forage available on the management area. Related to this similarity in habitat preference, the development of areas such as block plantings around abandoned farmsteads could potentially hold deer on their summer range for longer periods, which could extend the amount of available forage on Lonetree WMA during severe winters. As movements of white-tailed deer appear to be related to the availability of preferred forage in the form of food plots and dense nesting cover, deer movements could be directed based on the placement and timing of harvest of these plantings. Potential future increases in deer depredation complaints may require relocating or adding additional food plots within the interior of Lonetree WMA to direct deer movements away from private land.

In summary, the major findings of this study important for management of white-tailed deer at Lonetree WMA are as follows. The white-tailed deer population in the Drift Prairie-Coteau region of North Dakota is increasing steadily, including at Lonetree WMA where the population is now at an all time high. Notably, the estimated 2004 winter deer density at Lonetree WMA was 10.7 deer/km^2 across an area of 282 km^2, which was over 5X as high as the 2 deer/km^2 winter deer density at the nearby and much larger Anamoose monitoring block (the Anamoose area encompasses 3341 km^2). Multiple types of data from this study indicated that food plots, trees and shrubs, and dense nesting cover are important for white-tailed deer at Lonetree WMA at different times of the year. Radiotelemetry and spotlight surveys together revealed that the Lonetree WMA is attracting white-tailed deer from a large area of the Drift Prairie-

Coteau region of the state during fall and winter periods. Related to limited mortality from native predators, hunter harvest was identified as the most important source of mortality for white-tailed deer in the region. Nevertheless, survival was high for both adult and fawn females, and this relatively high survival coupled with several consecutive mild winters has facilitated the continual increase in the white-tailed deer population at Lonetree WMA.

APPENDICES

APPENDIX I

Vascular plant species planted (PLA) or observed occurring naturally (NAT) at Lonetree Wildlife Management Area in Sheridan and Wells Counties, North Dakota (Plants classified as being native or non-native to the state).

Species	PLA	NAT
DICOTYLEDONS		
Aceraceae		
Acer ginnala Maxim.	X	
Amur maple. Non-native tree		
Acer negundo L.		X
Boxelder. Native tree		
Acer saccharinum L.	X	
Silver maple. Non-native tree		
Amaranthaceae		
Amaranthus retroflexus L.		X
Rough pigweed. Non-native annual		
Anacardiaceae		
Rhus glabra L.	X	
Smooth sumac. Native shrub		
Asclepiadaceae		
Asclepias syriaca L.		X
Common milkweed. Native perennial		
Asteraceae		
Artemisia absinthium L.		X
Wormwood. Non-native perennial		
Chrysopsis villosa (Pursh) Nutt. ex DC.		X
Goldenaster. Native perennial		
Cirsium arvense (L.) Scop.		X
Canada thistle. Non-native perennial		
Cirsium undulatum (Nutt.) Spreng.		X
Wavyleaf thistle. Native perennial		
Conyza canadensis (L.) Cronq.		X
Horseweed. Native annual		
Echinacea angustifolia DC.		X
Purple coneflower. Native perennial		
Grindelia squarrosa (Pursh) Dunal		X
Curley-top gumweed. Native biennial/perennial		
Helianthus annuus L.	X	
Sunflowers. Non-native annual		
Iva xanthifolia Nutt.		X
Marsh elder. Native annual		

Species	PLA	NAT
Lactuca oblongifolia Nutt.		X
Blue lettuce. Native perennial		
Ratibida columnifera (Nutt.) Woot. & Standl.		X
Prairie coneflower. Native perennial		
Sonchus arvensis L.		X
Field sow thistle. Native perennial		
Sonchus oleraceus L.		X
Common sow thistle. Native annual		
Tragopogon dubius Scop.		X
Goatsbeard. Non-native biennial/perennial		
Xanthium strumarium L.		X
Cocklebur. Native annual		
Betulaceae		
Corylus americana L.	X	
American hazelnut. Native shrub		
Brassicaceae		
Descurainia sophia (L.) Webb ex Prantl		X
Flixweed. Non-native annual		
Cactaceae		
Coryphantha vivipara (Nutt.) Britt. & Rose		X
Common pincushion cactus. Native perennial		
Caprifoliaceae		
Lonicera tatarica L.	X	
Tatarian honeysuckle. Non-native shrub		
Symphoricarpos occidentalis Hook	X	X
Western snowberry. Native shrub		
Chenopodicaceae		
Chenopodium album L.		X
Lamb's quarter. Non-native annual		
Kochia scoparia (L.) Schrad.		X
Kochia. Non-native annual		
Salsola iberica (Sennen & Pau) Botsch. ex Czerepanov		X
Russian thistle. Non-native annual		
Convolvulaceae		
Convolvulus arvensis L.		X
Field bindweed. Non-native perennial		
Cornaceae		
Cornus stolonifera Michx.	X	X
Red Osier dogwood. Native shrub		
Elaeagnaceae		
Elaeagnus angustifolia L.	X	
Russian olive. Non-native shrub		
Elaeagnus commutata Bernh. ex Rydb.	X	X
Silverberry. Native shrub		
Shepherdia argentea (Pursh) Nutt.		X
Silver buffaloberry. Native shrub		

Species	PLA	NAT
Euphorbiaceae		
Euphorbia esula L.		X
Leafy spurge. Non-native perennial		
Fabaceae		
Astragalus missouriensis Nutt.		X
Missouri milkvetch. Native perennial		
Caragana arborescens Lam.	X	
Siberian peashrub. Non-native shrub		
Medicago sativa L.	X	
Alfalfa. Non-native perennial		
Melilotus alba Medikus	X	
White sweet clover. Non-native biennial/annual		
Melilotus officinalis (L.) Lam.	X	
Yellow sweet clover. Non-native biennial/annual		
Robinia pseudoacacia L.	X	
Black locust. Non-native tree		
Fagaceae		
Quercus macrocarpa Michx.	X	
Bur oak. Native tree		
Quercus rubra L.	X	
Red oak. Non-native tree		
Grossulariaceae		
Ribes odoratum Wendl.	X	
Golden currant. Native shrub		
Hippocastanaceae		
Aesculus glabra Willd.	X	
Ohio buckeye. Non-native tree		
Juglandaceae		
Juglans nigra L.	X	
Black walnut. Non-native tree		
Oleaceae		
Fraxinus pennsylvanica Marsh.	X	X
Green ash. Native tree		
Syringa vulgaris L.	X	
Common lilac. Non-native shrub		
Polygonaceae		
Rumex occidentalis S. Wats.		X
Western dock. Native perennial		
Ranunculaceae		
Anemone patens L.		X
Pasque flower. Native perennial		
Rhamnaceae		
Rhamnus cathartica L.		X
Common buckthorn. Non-native shrub		

Species	PLA	NAT
Rosaceae		
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer Western serviceberry. Native shrub	X	X
Cotoneaster bullatus Boiss. Cotoneaster. Non-native shrub	X	
Crataegus rotundifolia Moench. Roundleaved hawthorn. Native shrub	X	X
Geum triflorum Pursh Prairie smoke. Native perennial		X
Malus baccata (L.) Borkh. Siberian crabapple. Non-native tree	X	
Malus pumila P. Mill. Domestic apple. Non-native tree	X	
Prunus americana Marsh. Wild plum. Native tree	X	X
Prunus padus L. Mayday. Non-native tree	X	
Prunus pumila L. Sand cherry. Native shrub	X	
Prunus tomentosa Thunb. Nanking cherry. Non-native shrub	X	
Prunus virginiana L. Chokecherry. Native shrub	X	X
Pyrus ussuriensis Maxim. Ussurian pear. Non-native tree	X	
Rosa arkansana Porter Prairie rose. Native shrub		X
Rosa gallica L. Hedge rose. Non-native shrub	X	
Salicaceae		
Populus deltoides Bartr. ex Marsh Cottonwood. Native tree	X	X
Populus tremuloides Michx. Quaking aspen. Native tree	X	
Salix acutifolia auct. non Hook. Sharpleaf willow. Non-native tree	X	
Salix alba L. Golden willow. Non-native tree	X	
Salix pentandra L. Laurel willow. Non-native tree	X	
Ulmaceae		
Celtis occidentalis L. Hackberry. Native tree/shrub	X	X
Ulmus americana L. American elm. Native tree		X

Species	PLA	NAT
Ulmus pumila L.	X	
Siberian elm. Non-native tree		
MONOCOTYLEDONS		
Poacea		
Agropyron cristatum (Linnaeus) Gaertn.		X
Crested wheatgrass. Non-native perennial		
Agropyron elongatum (Host) Beauv.	X	
Tall wheatgrass. Non-native perennial		
Agropyron intermedium (Host) Beauv.	X	
Intermediate wheatgrass. Non-native perennial		
Agropyron smithii Rydb	X	X
Western wheatgrass. Native perennial		
Agropyron trachycaulum (Link) Malte ex. H.F. Lewis	X	X
Slender wheatgrass. Native perennial		
Andropogon gerardi Vitman	X	X
Big bluestem. Native perennial		
Avena fatua L.		X
Wild oats. Non-native annual		
Bouteloua curtipendula (Michx.) Torr	X	
Sideoats grama. Native perennial		
Bouteloua gracilis (Vasey) A.S. Hitchc.	X	X
Blue grama. Native perennial		
Bromus inermis Leyss		X
Smooth brome. Non-native perennial		
Buchloe dactyloides (Nutt.) Engelm.		X
Buffalo grass. Native perennial		
Calamovilfa longifolia (Hook) Scribn.	X	X
Prairie sandreed. Native perennial		
Elymus canadensis L.		X
Canada wild rye. Native perennial		
Elymus repens (L.) Gould		X
Quackgrass. Non-native perennial		
Hesperostipa comata (Trin. & Rupr.) Barkworth		X
Needle and Thread grass. Native perennial		
Hordeum jubatum L.		X
Foxtail barley. Native perennial		
Koeleria macrantha (Ledeb.) J.A. Schultes		X
Junegrass. Native perennial		
Panicum virgatum L.	X	
Switchgrass. Native perennial		
Poa pratensis L.		X
Kentucky bluegrass. Non-native perennial		
Schizachyrium scoparium (Michx.) Nash	X	X
Little bluestem. Native perennial		
Setaria glauca sensu Vickery		X
Yellow foxtail. Non-native annual		

Species	**PLA**	**NAT**
Setaria viridis L. Beauv.		X
Green foxtail. Non-native annual		
Sorghastrum nutans (L.) Nash	X	
Indian grass. Native perennial		
Sporobolus cryptandrus (Torr.) Gray	X	
Sand dropseed. Native perennial		
Stipa viridula Trin	X	
Green needlegrass. Native perennial		
Triticum aestivum L.	X	
Wheat. Non-native annual		
Zea mays L.	X	
Corn. Non-native annual		
Typhaceae		
Typha angustifolia L.		X
Narrowleaf cattail. Non-native perennial		
Typha latifolia L.		X
Broadleaf cattail. Native perennial		
FERNS and ALLIES		
Equisetaceae		
Equisetum fluviatile L.		X
Water horsetail. Native annual		
JUNIPERS, PINES, and SPRUCES		
Cupressaceae		
Juniperus scopulorum Sarg.	X	
Rocky Mountain juniper. Native tree		
Pinaceae		
Picea abies (L.) Karst.	X	
Norway spruce. Non-native tree		
Picea glauca (Moench) Voss	X	
Black Hills spruce. Non-native tree		
Picea pungens Engelm.	X	
Blue spruce. Non-native tree		
Pinus ponderosa P.& C. Lawson	X	
Ponderosa pine. Native tree		
Pinus sylvestris L.	X	
Scotch pine. Non-native tree		

APPENDIX II

Plant species and percentages of different plant species identified as part of the diets of white-tailed deer on Lonetree Wildlife Management Area in 2002. Estimates of monthly diets were by microhistological analyses of composite fecal samples collected from January to December 2002 excluding the months of May and June 2002. For composite fecal samples, a minimum of 20 samples from various areas around the WMA were collected each month and combined into bimonthly samples for analyses.

	Months (2002)				
Plant type/species	Jan/Feb	Mar/Apr	Jul/Aug	Sep/Oct	Nov/Dec
Crops	40.2	32.1	0.0	14.0	11.8
Zea mays	18.7	27.5		10.7	5.2
Helianthus spp.	5.4				4.8
Triticum spp.	16.1			3.3	
Other crops		4.6			1.8
Trees/Shrubs	32.2	36.7	26.1	51.7	47.7
Acer spp.		3.0			
Celtis occidentalis	3.1	5.0	8.6		11.7
Crataegus spp.					4.0
Populus spp.		3.4		7.9	
Prunus spp.		3.0			
Salix spp.		5.4			6.3
Shepherdia/Elaeagnus spp.	18.4	5.3	9.4	27.2	11.7
Other Trees/Shrubs	10.7	11.6	8.1	16.6	14.0
Forbs	16.2	15.2	72.5	19.4	20.1
Artemisia spp.	3.2				
Cirsium spp.			4.7		4.5
Kochia scoparia					3.1
Medicago/Melilotus		5.8	56.5		
Other Forbs	13.0	9.4	11.3	19.4	12.5
Grasses	8.2	9.9	0.8	11.2	14.6
Bromus inermis					4.2
Poa pratensis					3.0
Other Grasses	8.2	9.9	0.8	11.2	7.4
Sedges	0.0	3.2	0.0	0.0	1.8
Carex spp.		3.2			1.8
Fruits	3.2	2.9	0.6	3.7	4.0
Seed/Nut	3.2	2.9	0.6	3.1	4.0
Berry				0.6	

APPENDIX III

Plant species and percentages of different plant species identified as part of the diets of white-tailed deer on Lonetree Wildlife Management Area in 2003. Estimates of monthly diets were by microhistological analyses of composite fecal samples collected from January to December 2003. For composite fecal samples, a minimum of 20 samples from various areas around the WMA were collected each month and combined into bimonthly samples for analyses.

	Months (2003)					
Plant type/species	Jan/Feb	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec
Crops	37.8	35.9	0.4	1.3	8.6	38.9
Zea mays	28.4	29.6			7.0	37.2
Helianthus spp.	4.4	3.3				
Triticum spp.	5.0	3.0				
Other crops			0.4	1.3	1.6	1.7
Trees/Shrubs	40.1	24.9	50.0	31.2	27.9	42.6
Amelanchier alnifolia	3.5					
Celtis occidentalis					3.5	
Salix spp.		3.0				7.8
Shepherdia/Elaeagnus spp.	16.4	14.1	38.8	20.1	12.5	21.9
Other Trees/Shrubs	20.2	7.8	11.2	11.1	11.9	12.9
Forbs	12.7	24.2	44.3	62.5	53.5	9.6
Artemisia spp.	6.0	11.5			5.1	
Cirsium spp.				3.2		
Equistem fluviatile				3.2		
Medicago/Melilotus		4.4	35.8	39.9	31.1	
Typha latifolia				5.9		
Other Forbs	6.7	8.3	8.5	10.3	17.3	9.6
Grasses	7.9	12.0	2.6	3.4	4.4	7.3
Agropyron spp.		4.4				
Other Grasses	7.9	7.6	2.6	3.4	4.4	7.3
Sedges	0.4	0.0	2.7	0.0	0.0	0.0
Carex spp.	0.4		2.7			
Fruits	1.1	3.0	0.0	1.6	5.6	1.1
Seed/Nut	1.1	1.9		1.6	3.9	1.1
Berry		1.1			1.7	
Other	0.0	0.0	0.0	0.0	0.0	0.5
Lichens						0.5

APPENDIX IV

Movements of adult female white-tailed deer at Lonetree WMA described as migratory (M), dispersal (D), or philopatric (P) based on radiolocations and tag returns from harvest. Distance (km) is maximum straight-line movement from capture site. Movement type marked by "--" indicates lack of information for proper movement classification.

Category/Identification	Movement type	Distance (km)
Adult Female		
Collared		
150.7040	M	12.4
150.7110	P	2.0
150.7550	P	4.4
150.7660	M	9.4
150.7860	P	4.6
150.8060	P	3.2
150.8150	P	0.6
150.8360	M	4.5
150.8440	M	17.7
150.8550	M	3.4
150.8752	M	7.6
150.8850	M	21.5
150.8960	P	0.8
150.9150	M	10.5
150.9350	M	17.5
150.9552	M	10.1
150.9750	M	32.2
150.9850	M	8.5
151.0140	P	3.8
151.0340	M	19.2
151.1550	P	0.7
151.1760	M	29.1
151.1950	M	18.5
151.2050	M	11.4
Tagged		
202/2	--	27.0
Min (km)		0.6
Mean (km)		11.2
Max (km)		32.2

APPENDIX V

Movements of fawn female white-tailed deer at Lonetree WMA described as migratory, dispersal, or philopatric based on radiolocations and tag returns from harvest. Distance (km) is maximum straight-line movement from capture site. Movement type marked by “--“ indicates lack of information for proper movement classification.

Category/Identification	Movement type	Distance (km)
Fawn Female		
Collared		
150.7272	D	132.7
150.7862	D	71.6
150.8870	--	12.8
150.9250	M	12.1
150.7460	M	14.2
151.0050	--	6.6
150.9660	M	18.3
151.1460	D	28.2
151.0260	--	13.6
151.1852	D	19.4
151.2550	--	11.6
151.2350	--	32.1
151.2690	M	24.5
151.0070	--	13.9
151.1320	M	8.1
151.1652	D	104.5
151.2230	M	13.4
151.0452	M	11.6
151.1030	M	12.8
151.1252	D	63.2
151.0560	P	4.2
150.6970	P	3.4
150.9970	M	12.1
151.0750	D	13.5
151.2820	P	3.7
Tagged		
6/706	P	3.3
Min (km)		3.3
Mean (km)		25.6
Max (km)		132.7

APPENDIX VI

Movements of fawn male white-tailed deer at Lonetree WMA described as migratory (M), dispersal (D), or philopatric (P) based on radiolocations and tag returns from harvest. Distance (km) is maximum straight-line movement from capture site. Movement type marked by "--" indicates lack of information for proper movement classification.

Category/Identification	Movement type	Distance (km)
Fawn Male		
Collared		
151.0860	D	15.9
150.9620	P	8.7
151.0450	D	75.3
151.1250	D	120.4
150.8680	D	30.2
Tagged		
795-95	--	31.8
255-14W	--	91.9
257-35Y	P	2.6
Min (km)		2.6
Mean (km)		47.1
Max (km)		120.4

APPENDIX VII

Distances recorded for adult female white-tailed deer at Dawson WMA based on radiolocations and tag returns. Distance (km) is maximum straight-line movement from capture site.

Category/Identification	Distance (km)
Adult Female	
Collared	
150.7060	13.5
150.7850	8.6
150.8860	21.8
150.8360	19.1
150.9360	15.3
150.9780	21.9
151.0180	15.3
151.0560	11.1
150.0940	22.6
150.7660	12.7
150.9580	25.6
150.9970	12.2
150.9070	25.9
150.7260	28.9
151.1180	12.5
151.0360	42.2
150.8550	7.4
151.0770	25.9
Min (km)	7.4
Mean (km)	19.0
Max (km)	42.2

APPENDIX VIII

Distances recorded for fawn female white-tailed deer at Dawson WMA based on radiolocations and tag returns. Distance (km) is maximum straight-line movement from capture site.

Category/Identification	Distance (km)
Fawn Female	
Collared	
150.7860	21.5
150.8260	20.5
150.8460	6.3
Tagged	
712/12Y	57.5
734/34Y	32.1
752/52Y	16.5
Min (km)	6.3
Mean (km)	25.7
Max (km)	57.5

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