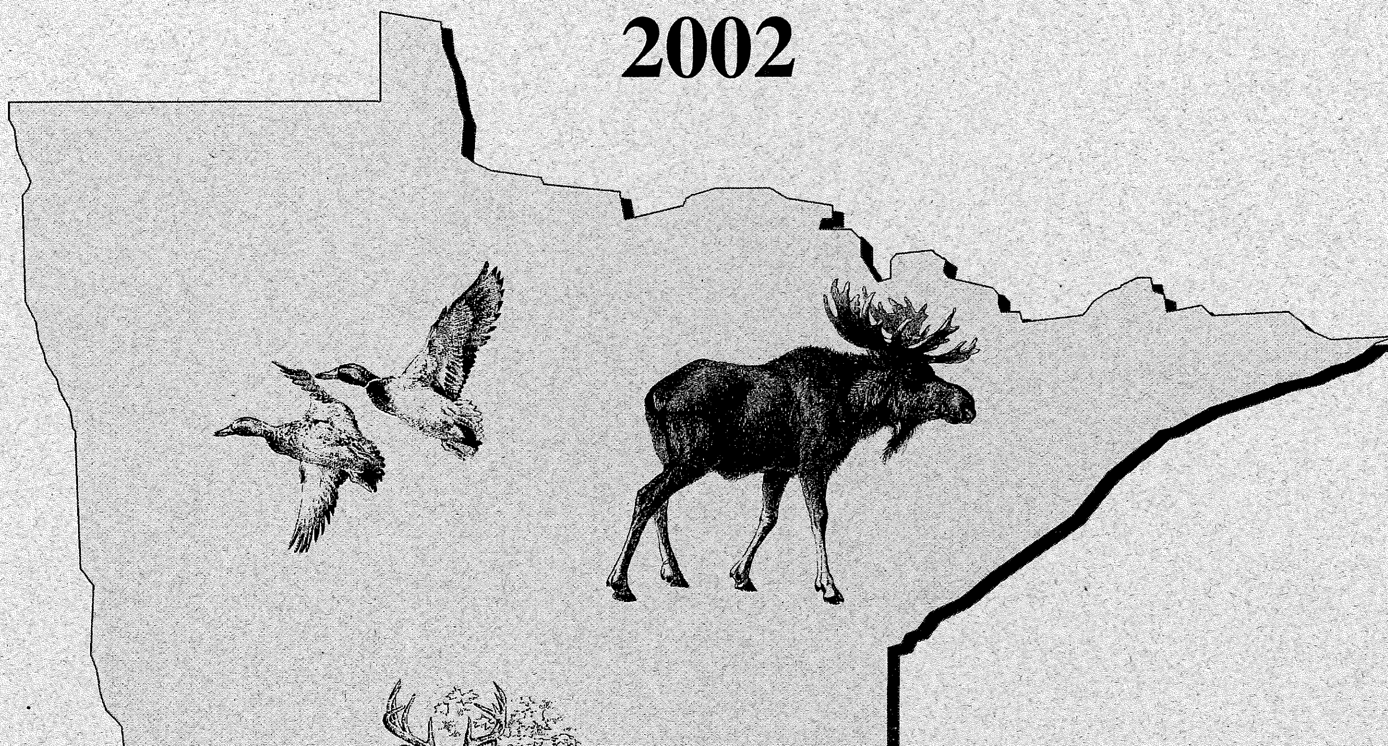
MARIES OF WILDLIFE RESEARCH FINDINGS 2002



Minnesota Department of Natural Resources
Section of Wildlife
Wildlife Populations and Research Unit

SUMMARIES OF WILDLIFE RESEARCH FINDINGS 2002

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This volume contains interim results of wildlife research projects. Some of the data and interpretations may change as a result of additional findings or future, more comprehensive analysis of the data. Authors should be contacted regarding use of any of their data.

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SURVIVAL RATES, CAUSES OF MORTALITY AND MOVEMENTS OF COYOTES IN SOUTHERN MINNESOTA

Christopher S. DePerno, Benjamin J. Bigalke, Isabelle L. Lajoie, Jonathan A. Jenks, Brian S. Haroldson, John D. Erb, and Robert G. Osborn

INTRODUCTION

Coyotes (*Canis latrans*) are the largest predator in farmland Minnesota and a natural predator of white-tailed deer (*Odocoileus virginianus*) in this region. Coyotes can impact adult and neonate white-tailed deer survival (Kie et al. 1979, Ballard et al. 1999, Whittaker and Lindzey 1999, Patterson and Messier 2000) and have been implicated as a major contributor to the decline of deer throughout eastern Canada, Maine, and the Black Hills (Lavigne 1992, Patterson 1994, Parker 1995, Crête and Lemieux 1996, Benzon 1998, DePerno et al. 2000). Research has been conducted on coyotes in the forested region of Minnesota (Chesness and Bremicker 1974, Berg 1977, Preece 1978, Haroldson 1981, Smith 1985, Mech et al. 1985), but little information has been gathered on coyotes for farmland Minnesota. Specifically, data are lacking on coyote survival, causes of mortality, seasonal search patterns, seasonal diet composition, and the impacts coyotes may have on adult and neonate white-tailed deer.

Coyotes are unprotected in Minnesota and hunters are allowed to harvest coyotes throughout the year using virtually any method. In 2001-2002, it was estimated that Minnesota had approximately 11,000 hunters and 1,000 trappers pursuing coyotes (Dexter 2002). As part of an on-going study examining survival rates and cause-specific mortality of white-tailed deer, a pilot study was initiated to determine the habitat searched by coyotes during the pre-fawning, fawning, and post fawning periods, survival, causes of mortality, and seasonal diet composition of coyotes in southeast Minnesota.

STUDY AREA

The study was conducted in southeast Minnesota near the town of Dumfries. Topography of the area was comprised of rolling uplands with deep, stream-cut valleys and wooded hillsides (Minnesota Department of Natural Resources 1979) with land use dominated by forest and row crop agriculture.

METHODS

During October 2001 through May 2003, coyotes were captured and radiocollared using baited, Duke No. 1.75 unpadded coil-spring traps. Trapped animals were restrained with a noose pole, measured (chest and crown to rump), aged (juvenile or adult) fitted with a radiocollar (Advanced Telemetry Systems, Isanti, Minnesota), and released. Directional bearings (3-5) of radiocollared coyotes were obtained using a vehicle mounted "null-peak" antenna system (Brinkman et al. 2002) connected to an electronic compass (C100 Compass Engine, KVH Industries, Inc., Middletown, RI.). Coyotes were randomly selected and located at 30-minute intervals during randomly selected 6-hour evening time periods, following the sequential method described by Laundre and Keller (1984). Hence, individual coyotes were located 12 times over a 6-hour tracking session. Tracking sessions occurred between sunset and sunrise, when coyote activity peaked (Smith et al. 1981, Andelt et al. 1979). Tracking sessions were conducted 1-2 times per week annually. To evaluate coyote movements, locations were plotted on aerial photos, the distance between the two farthest outlying locations measured, and the distances between consecutive locations calculated. Additionally, coyote survival rates were calculated and cause of mortality determined.

An Institutional Animal Care and Use Committee at South Dakota State University approved all methods used in this research (02-A043). Traps used to capture coyotes met the specifications set forth by the International Association of Fish and Wildlife Agencies (2003).

PROGRESS AND SUMMARY OF RESULTS

During 2001, 8 coyotes were captured and radiocollared; however, 1 day after capture, 1 individual dropped the collar. In 2002, 13 additional coyotes were captured and radiocollared. In 2003, 5 additional coyotes were captured and radiocollared. Catch rates averaged 22.7 trap-nights/coyote (22 traps set for 1 night = 22 trap nights) and average handling time was 3.5 minutes/coyote. Since November 2001, 50 night-tracking sessions have been analyzed

Thirteen coyotes have died (Table 1). Causes of mortality included: predator hunters (62%), vehicle collisions (23%), firearm deer hunter (8%), and unknown (8%). Annual survival for all coyotes was 0.27 and since October 2001, the overall survival rate for coyotes was 0.15.

Movements during nocturnal tracking sessions indicated coyotes searched a relatively small area but moved a significant distance within that area. After analyzing all tracking sessions, the 2 farthest outlying locations of all search areas averaged 1.8 km (range = 0.6 - 2.9 km) and total distance traveled within the search area averaged 5.8 km (range = 3.5 - 9.7 km) per tracking session.

DISCUSSION

During this study, nocturnal tracking sessions indicated search distances of coyotes averaged 1.8 km and total distance traveled averaged 5.8 km. Using similar techniques, Grinder and Krausman (2001) determined that urban coyotes moved 1.3-6.2 km at night and were most active from 2200 to 2400 hours. Similarly, other studies have noted that coyotes are most active during the sunset and sunrise hours (Gipson and Sealander 1972, Andelt and Gipson 1979, Laundré and Keller 1981, Woodruff and Keller 1982, Andelt 1985, Shargo 1988). Survival rates of coyotes in southeast Minnesota (27%) were low compared to other studies (0.39-0.87; Roy and Dorrance 1985, Windberg et al. 1985, Harrison 1986, Gese et al. 1989, Holzman et al. 1992, Grinder and Krausman 2001). Vehicle collisions and hunting accounted for 92% of the coyote mortalities in southeast Minnesota, which is high compared to human-caused factors reported in other studies (38-93%; Tzilowski 1980, Roy and Dorrance 1985, Windberg et al. 1985, Harrison 1986, Holzman et al. 1992).

FUTURE PLANS

Coyotes will continue to be checked for mortality weekly and individuals will be tracked at night, 1-2 times/week until May. In May, to coincide with deer fawning, coyote nocturnal tracking will increase to 4-5 times weekly. Coyote scat will continue to be collected in southern Minnesota and scat analysis conducted. Coyote habitat use, search patterns, diet, and movements during white-tailed deer fawning and non-fawning seasons will be compared.

ACKNOWLEDGMENTS

Funding for this study is provided by the Minnesota Department of Natural Resources, South Dakota State University, Bend of the River Chapter of Minnesota Deer Hunters Association, Bluffland Whitetails Association, Cottonwood County Game & Fish League, Des Moines Valley Chapter of Minnesota Deer Hunters Association, Minnesota Bowhunters, Inc., Minnesota Deer Hunters Association, Minnesota State Archery Association I, NorthCountry Bowhunters Chapter of Safari Club International, Rum River Chapter of Minnesota Deer Hunters Association, South Metro Chapter of Minnesota Deer Hunters Association, and Whitetail Institute of North America. We especially thank all landowners that allowed access to their property during capture and tracking. We acknowledge A. Anderson for her hard work and S. Gappa for capturing the coyotes and his invaluable contributions to this study.

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Table 1. Causes of mortality of radiocollared coyotes in southeast Minnesota, 2001-2002.

Capture date	Age	Sex	Mortality date	Cause of mortality
10/30/01	Adult	Male	11/23/01	Incidental-deer hunter
10/27/01	Adult	Female	12/20/01	Vehicle Collision
11/7/01	Adult	Male	3/4/02	Predator Hunter
11/7/01	Adult	Female	3/4/02	Predator Hunter
10/31/01	Adult	Male	5/29/02	Vehicle Collision
4/15/02	Adult	Female	6/27/02	Vehicle Collision
4/13/02	Adult	Female	10/20/02	Predator Hunter
7/12/02	Unknown [a]	Male	12/22/02	Predator Hunter
11/7/01	Juvenile	Male	1/13/03	Predator Hunter
11/2/02	Unknown [a]	Female	1/31/03	Predator Hunter
2/23/02	Adult	Female	2/1/03	Unknown
7/12/02	Unknown [a]	Male	2/15/03	Predator Hunter
10/29/01	Adult	Male	3/11/03	Predator Hunter

[a] Teeth were obtained from these dead coyotes, however, age has not yet been determined.

HUNTER INTERFERENCE AND EASE OF ACCESS FOR SPRING WILD TURKEY HUNTING IN MINNESOTA

Kari L. Dingman, Richard O. Kimmel, John D. Krenz, Brock R. McMillan

Minnesota is at the northern boundary of the ancestral wild turkey range (McMahon and Johnson 1980). Translocation efforts by the Minnesota Department of Natural Resources (MDNR) have expanded the wild turkey range and hunting opportunities north of historic limits. The first wild turkey hunting season in Minnesota was in 1978; 420 permits were available in 2 permit areas (MDNR, unpublished report). For the spring 2002 season, 24,136 permits were available in 50 permit areas. Demand for turkey hunting permits in Minnesota exceeds permit availability (Kimmel et al. 2000), but expanding hunting opportunities through further turkey range expansion is limited.

Minnesota uses a permit system to distribute wild turkey hunters across time and space. Hunters for spring 2002 applied for 1 of 8 seasons, each 5 days in length, within 1 of 50 permit areas. MDNR uses a model to determine permit numbers to allocate for each permit area (Kimmel 2001). Model inputs include turkey population and hunter interference factors. Permit allocations for each permit area are adjusted inversely for hunter interference in an attempt to maintain hunt quality and safety. The objective of this investigation is to determine the relationship between indices of hunter crowding (i.e., hunter interference, access to land for hunting) and hunt quality for spring turkey hunting seasons in Minnesota.

A mail survey was sent to 1,839 spring turkey hunters in 8 permits areas in southern Minnesota immediately following the close of the spring 2002 hunting season. Permit areas were selected based on landownership (% of private vs. public land) and previously estimated interference rates. The selected permit areas were 235 (Carlos Avery Wildlife Management Area), 344 (includes Whitewater Wildlife Management Area), 349, 440, 442, 450, 457, and 459. Permit area 235 is all public land and permit area 344 is comprised of mostly public land. The other permit areas are primarily private land.

Survey questions pertained to number of turkeys seen while hunting, number of turkeys shot at, ease of access to huntable land, feeling of danger while in the field, interference from other hunters, and overall hunt quality (Figure 1). After 3 mailings the response rate was 88.6%.

Results were compared to a similar turkey hunter survey from the 1999 spring season in Minnesota (Kimmel et al. 2000). Hunter interference rates decreased between 1999 and 2002 for all 8 permit areas that we surveyed (Table 1). Hunter interference may have decreased due to hunters establishing hunting patterns over time and restricting movements between hunting areas. High hunter interference could be expected to occur in permit areas newly opened to turkey hunting because hunters would be moving while looking for hunting spots and areas with birds.

Interference was not related to the hunt quality rating (e.g., Question 15, Fig. 1) in 6 of the 8 permit areas (Table 2). Hunter interference was negatively correlated with hunt quality rating in only the permit area that is entirely in public ownership (Permit Area 235) ($r^2 = -0.271$, $P = 0.01$). No correlation could be calculated in permit area 450 because no hunter interference was reported (Table 2). MDNR manages permit numbers to reduce hunter interference. Preliminary results show hunter interference was not a significant factor in determining hunt quality, possibly because hunter interference rates we observed are acceptable to hunters in the areas surveyed. We suggest the relationship between hunter interference and hunt quality would be negatively correlated, if turkey hunters in Minnesota experienced higher interference rates.

The percent of hunters denied access to huntable land decreased between the 1999 and 2002 surveys ($P = 0.009$) (Table 3). Increased ease of access could be due to hunters establishing contacts with landowners and returning to these same areas to hunt. Another explanation could be that landowners are seeing more turkeys on their property and are more likely to allow turkey hunter access.

Hunters were asked to rate access on a 4-point scale of "Very Easy," "Somewhat Easy," "Somewhat Difficult," and "Very Difficult" (Fig. 1). Access was positively correlated with hunt quality rating in 4 of 8 permit areas ($0.268 < r^2 < 0.470$, $P < 0.01$). In the other 4 permit areas, access was not significantly correlated with hunt quality (Table 4).

Successful hunters reported a higher hunt quality ($P < 0.001$). Although success is not the only factor that defines a quality hunt (Hazel et al. 1990), it is important (Stankey et al. 1973, Hendee 1974). Hawn et al. (1987) found that although success may be a predictor of hunt quality, it may not be causally related. Stankey et al. (1973) concluded that hunt quality ratings were not significantly different between successful and unsuccessful hunters.

The average rating for hunt quality ranged from 6.00 to 7.24, on a scale of 0 (poor) to 10 (excellent) (Fig. 2). As the number of wild turkey hunters increases and the amount of huntable turkey habitat remains the same or declines, hunter interference and ease of access should be periodically monitored to maximize permit numbers while providing a quality hunting experience.

Forward regression was used to determine factors that best described a quality hunt. "Success" described 19% of the variation, "Ease of Access" described an additional 6%, "Number of Birds Seen" described 5%, and "Number of Birds Shot At" added 0.7% (Table 5). However, "Success" and "Number of Birds Shot At" are highly correlated. "Hunter Interference" did not describe additional variation when added to the model. The factors that best defined a quality spring turkey hunt for Minnesota in 2002 were "Success," "Access," and "Number of Birds Seen."

This survey is being repeated in spring 2003 using the same 8 permit areas. Final analysis will be completed by January 2004.

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Table 1. Interference rates by permit area in 1999 and 2002 from surveys of spring wild turkey hunters in Minnesota.

Permit Area	1999 Interference Rate	2002 Interference Rate
235	25.6	18.7
344	26.1	22.6
349	25.2	16.5
440	24.7	11.0
442	19.8	11.3
450	10.0	0.0
457	16.7	5.9
459	33.3	7.7

Table 2. Correlation coefficients of hunt quality and hunter interference from surveys of spring 2002 wild turkey hunters in Minnesota.

Permit Area	Correlation Coefficient	Significance
235	-0.271	0.01
344	-0.108	0.051
349	-0.08	0.085
440	-0.078	0.265
442	-0.08	0.111
450	NA*	NA*
457	0.352	0.165
459	0.015	0.899

* - No interference was reported

Table 3. Percent of hunters denied access by permit area for 1999 and 2002 from surveys of spring wild turkey hunters in Minnesota.

	% Denied Access	
Permit Area	1999	2002
235	3.0	0.0
344	13.3	5.7
349	38.5	28.4
440	32.5	18.7
442	31.2	24.2
450	30.0	18.8
457	83.3	67.0
459	43.8	20.8

Table 4. Correlation coefficients of hunt quality and access from surveys of spring 2002 wild turkey hunters in Minnesota.

Permit Area	Correlation Coefficient	Significance
235	0.470	0.000
344	0.315	0.000
349	0.268	0.000
440	0.124	0.077
442	0.293	0.000
450	0.451	0.105
457	0.133	0.612
459	0.184	0.119

Table 5. Forward regression table with factors defining a quality spring 2002 turkey hunt in Minnesota.

Model	R^2	ΔR^2	$P(\Delta R^2)$
Success	0.189	0.189	< 0.001
Success + Access	0.248	0.059	< 0.001
Success + Access + Birds Seen	0.298	0.051	< 0.001
Success + Access + Birds Seen + Birds Shot At	0.304	0.007	< 0.001
Success + Access + Birds Seen + Birds Shot At + Interference	0.304	0.000	0.449

Minnesota Spring Turkey Hunter Survey

*Please respond to all questions based on the **SPRING 2002 TURKEY SEASON**.

1. Did you hunt turkeys in Minnesota during the spring 2002 season? Yes____ No____ If no, you do not need to continue but please return survey.

2. Which wild turkey permit area did you hunt in? _______

3. Did you have a landowner permit or a regular lottery permit? Landowner____ Regular Lottery____

4. Which season did you hunt?

April 17-21___ April 22-26___ April 27-May 1___ May 2-6___ May 7-11___ May 12-16___ May 17-21___ May 22-26____

5. How many days did you hunt turkeys during spring 2002? __________

6. How many turkeys did you see while turkey hunting in 2002? _______

7. How many turkeys did you shoot at? ______

8. Were you successful in bagging a turkey? Yes____ No____

   If yes, was it killed in the morning or afternoon? AM______ PM_______

9. How difficult was it for you to find a place to hunt during the spring 2002 wild turkey hunting season? (check one answer)

   Very easy____ Somewhat easy____ Somewhat difficult____ Very difficult____

10. Did you hunt on public land or private land during the spring 2002 season? Public_____ Private_____ Both_____

    If you hunted on private land, how many landowners turned down your request for permission? _______

11. Did you at any time feel you were put in danger by other hunters while turkey hunting? Yes____ No____

12. On average, how many hunters, other than members of your own party, did you see each day while you were actually in the field hunting during spring 2002? ______

13. How many times did hunters, other than members of your own party, interfere with your hunting during spring 2002?

    ______

14. How many times did people **other than hunters** interfere with your hunting during spring 2002? _____

15. Rate the quality of your turkey hunting experience during spring 2002 on a scale of 1-10 (check one number):

    Poor Quality　　Average Quality　　Excellent Quality

    0____ 1____ 2____ 3____ 4____ 5____ 6____ 7____ 8____ 9____ 10____

Additional comments can be written on the back.

Figure 1. Survey form sent to spring turkey hunters in Minnesota, 2002.

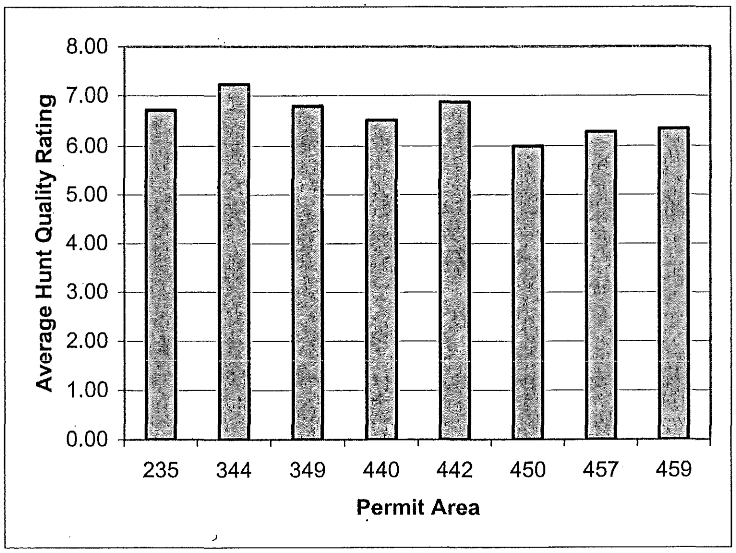

Figure. 2. Average hunt quality rating by survey respondents during spring 2002 wild turkey season in Minnesota.

WINTER SURVIVAL OF EASTERN WILD TURKEYS *(Meleagris gallopavo silvestris)* TRANSLOCATED NORTH OF THEIR ANCESTRAL RANGE IN MINNESOTA

Dale F. Kane, Richard O. Kimmel, Gary C. Nelson, William E. Faber

The northern ancestral range of eastern wild turkeys is presumed to include southern Minnesota (Leopold 1931, Aldrich and Duvall 1955, Mosby 1959). Over the past several decades, Minnesota Department of Natural Resources (MNDNR) has expanded the range of wild turkeys north of the ancestral range through translocations of wild birds (Nelson 2003). There is public interest, particularly from the National Wild Turkey Federation (NWTF), to continue extending the range northward in Minnesota, the northern tier states, and southern Canada. However, little information exists on the ecology and survival of wild turkeys at northern latitudes.

Haroldson (1996) and Haroldson et al. (1998) suggest that physiologically, wild turkeys should be capable of surviving northern Minnesota winters, provided that food is available and accessible. Thus, plots of standing corn could potentially enhance turkey survival during severe winters (Porter et al. 1980). However, turkey movements become limited with powder snow cover, which could limit access to food. Austin and DeGraff (1975) found that powder snow depths of 15-20 cm limit movements and at depths >30 cm, movements virtually stop.

The objectives of this study were to determine winter survival of wild turkeys north of their ancestral range in east-central Minnesota and to investigate the value of corn food plots and supplemental feeding to enhance turkey survival. We monitored radio-tagged wild turkey hens on 1 study area with food during winter (Jan 1 - Apr 1) 2001 (25 hens) and on 4 study areas during winters 2002 (82 hens) and 2003 (73 hens). Two study areas had standing corn food plots and supplemental winter feeding, and 2 study areas had only natural foods.

Winter severity in 2001 was near record with snow depths >30 cm (to ≈70 cm) and minimum temperatures were low. During winter 2002, average snow depth remained ≤20 cm until early March, when it reached ≈ 40 cm. Minimum temperatures averaged warmer than 2001. In winter 2003 snow depths remained at ≤20 cm with periods of patchy bare ground and minimum temperatures were similar to 2001 (MNDNR 2003) (Fig.1).

We used an extension of Kaplan and Meier (1958) with a Pollock et al. (1989) modification to analyze the data and estimate cumulative survival probability (CSP). We censored hens not surviving 7 days beyond release (Kurzejeski et al. 1987, Vangilder 1996) to reduce potential effects of capture, handling, and transport.

In winter 2001, CSP for 2001 was 0.085 (Table 1). In winters 2002 and 2003, CSPs for study areas with supplemental food were significantly higher than for study areas with natural foods only (Table 1). This same trend was seen when data for 2002 and 2003 were combined.
Each winter, turkeys were released over a 5-8 week period. In 2001 releases occurred Jan-Mar on 1 study area with 42 ha of corn food plots located within 8 km of the release site (D. Pauly, MNDNR, personal communication). The CSP of <0.1 (Table 1) implies that if all hens had been

released early in the winter, none would have survived. Results suggest that survival of turkeys translocated during early winter may be limited if deep powder snow conditions occur even if food is provided. Deep snow may limit turkey movements, limiting access to food. However, 5 hens from late winter 2001 releases survived and produced offspring during the following spring.

During 2002 and 2003, turkeys in study areas with supplemental food had higher CSPs than in study areas with natural foods (Table 1). This suggests food plots can enhance turkey survival, especially during milder years. Further research should compare CSP during severe winters for turkeys on study areas with and without food plots. Also, it is unknown whether turkey winter survival and food plot use would differ between recent transplants and turkeys residing on an area before winter.

We found it difficult to determine cause-specific mortality in all cases. However, during 2001 we did record mortalities due to starvation (n=8).

We collected post-winter survival data during 2002. By late summer, the difference in CSP was no longer significant (SD = 0.118, P = 0.171) between study areas with and without supplemental food. However, more hens survived into the spring reproductive period on the supplemental food areas.

NWTF recently awarded a grant to continue this research under the direction of Marco Restani of St. Cloud State University (SCSU) in cooperation with MNDNR. We plan to continue collecting data during both winter and post-winter 2003-2005.

ACKNOWLEDGMENTS

This study was funded by MNDNR, SCSU, NWTF (Minnesota Chapter and Rum River Longbeards Chapter), Mille Lacs Band of the Ojibwe, and the Montgomery Sportsmen's Club. We thank D. Pauly and a long list of MNDNR staff, T. Glines and D. Potter (NWTF, Minnesota Chapter), and J. Otten/NWTF-Rum River Longbeards for assistance with the study. Thanks to SCSU faculty (especially N. Voelz, S. Turner, C. Rose, D. Robinson, and M. Restani) and staff. Field volunteers/interns, particularly S. Anderson, B. Brooks, A. Hoving, C. Thomas, and J. Worms, deserve recognition. Finally, landowners in the study areas were very cordial and generous with allowing access onto their properties and releases of wild turkeys.

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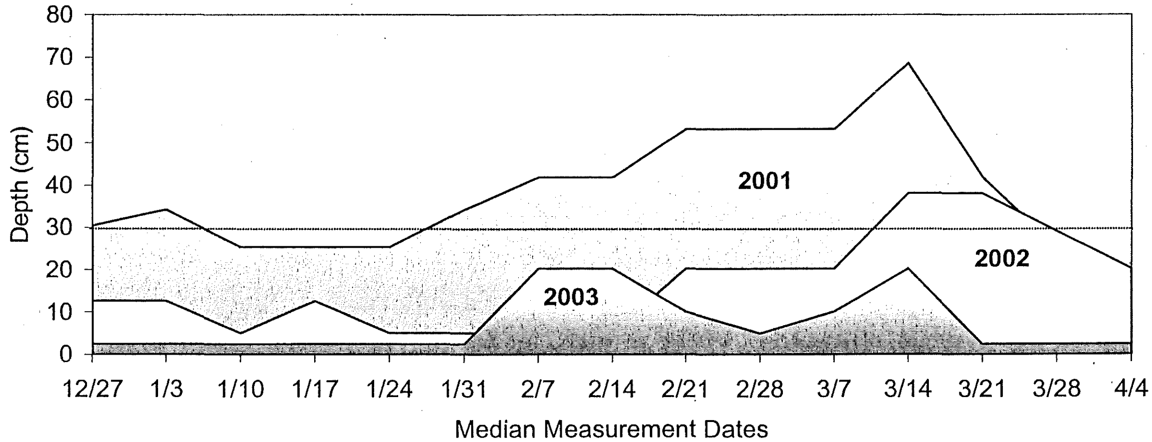

Figure 1. Snow depth by year with 30cm depth line, east-central Minnesota, 2001-2003.

Year	Treatment	# Hens	CSP	Standard Deviation	Compared SD	P-value
2001	Food provided	25	0.085	0.052		
2002	Food provided	43	0.758	0.084		
	Natural foods only	39	0.365	0.095		
					0.126	<0.001
2003	Food provided	38	0.682	0.094		
	Natural foods only	36	0.383	0.088		
					0.129	0.010
2002 & 2003	Food provided	80	0.718	0.090		
	Natural foods only	75	0.347	0.088		
					0.126	0.002

Table 1. Cumulative survival probability (CSP) for radio-marked wild turkey hens on study areas with supplemental food/corn food plots or only natural foods during winters 2001, 2002, 2003, east-central Minnesota.

SURVEY PROPOSAL: MINNESOTA PRAIRIE-CHICKEN MANAGEMENT SURVEY

Prairie-chicken survey committee; John H. Giudice, chair

PREFACE

The Minnesota Department of Natural Resources (MNDNR) is currently soliciting comments on the proposed prairie-chicken management survey. Thus, the proposed survey design is subject to modification. The following is a summary of the draft proposal. Contact John Giudice (507-642-8478 ext. 23, john.giudice@dnr.state.mn.us) for a copy of the complete proposal. This proposal was developed by a prairie-chicken survey committee: John Giudice (MNDNR, chair), Doug Hedtke (MNDNR), Earl Johnson (MNDNR), Brian Winter (TNC), Doug Wells (USFWS), and Terry Wolfe (MNDNR). Additional input was provided by Ross Hier (MNDNR), Mark Chase (USFWS), John Toepfer (Society of Tympanuchus Cupido Pinnatus), Rob Naplin (MNDNR), and Dave Trauba (MNDNR). J. Kobriger (North Dakota Game and Fish), S. Taylor (Nebraska Game and Parks Commission), R. Applegate (Kansas Department of Wildlife and Parks), T. Leif (South Dakota Game, Fish, & Parks), and K. Reese (University of Idaho) provided information on survey methodology used in other states.

BACKGROUND AND JUSTIFICATION

The greater prairie-chicken (*Tympanuchus cupido*) is presently listed as a species of "special concern" in Minnesota; it is not currently threatened with extinction but is a "watch closely" species, dependent on a habitat that could change rapidly (Svedarsky et al. 1997). Minnesota has not had a prairie-chicken hunting season since 1942, but many biologists believe that the population could support a conservative hunting season. A conservative hunting season could create more interest in the species and increase support for prairie and grassland conservation, restoration, and connection efforts. Recent legislation (M.S. 2002:97A.434) authorized the Commissioner of the MNDNR to establish a "limited entry" hunt for prairie-chickens. However, population and harvest information should be gathered and analyzed annually to properly manage prairie-chicken populations, ensure population welfare, and allow maximum public utilization of the species.

Annual booming-ground surveys of prairie-chickens began in Minnesota in 1974 in the northwest and 1977 in the north-central range. Surveys are presently coordinated by the Minnesota Prairie Chicken Society (MPCS). Cooperators include the MNDNR, U.S. Fish and Wildlife Service (USFWS), The Nature Conservancy (TNC), university researchers, students, and bird-watchers who attempt to count males on booming grounds twice during March-May. Survey data reflect yearly variations in access conditions, weather, and turnover of personnel, but the annual counts provide reasonable estimates of minimum numbers and general population trends (Svedarsky et al. 1997). However, the current survey design does not adequately document spatial connectivity and range changes (i.e., the focus is on counting leks in core-census blocks).

Survey design could be improved by standardizing survey protocols (including survey effort) and periodically sampling peripheral areas to document spatial connectivity and range changes. Successfully implementing the new survey and maintaining consistency in data collection will require an active, long-term commitment by the MNDNR. The prairie-chicken survey should be classified as a "formal survey", which would allow MNDNR personnel (including seasonal staff) to participate in the survey as an official activity. Further, MNDNR research should take a more active role in the survey by providing the following services: statewide coordination (similar to the MNDNR August Roadside Survey), data depository (raw data and electronic database), data entry and proofing, data analysis and summarization (with input from MPCS), dissemination of results (via MPCS and annual MNDNR status reports), and harvest recommendations (with input from MPCS and MNDNR managers).

OBJECTIVES

The prairie-chicken survey committee, during a meeting at the Lake Sallie MNDNR office, 28 June 2002, recommended the following objectives for the prairie-chicken monitoring program and annual survey, listed in order of priority:

(1) *Monitor range-wide population trends with a level of precision that is realistic given personnel and funding constraints.* Note: there was some discussion of documenting the response of prairie-chicken populations to a 5-10% harvest rate. However, this is not a realistic objective given the annual variation in counts of leks and total males (e.g., CV = 18.1% for annual counts of total males during 1997-2001). We would not be able to separate hunting effects from other sources of variation, especially at low harvest levels. An experimental approach (with controls, replication, and randomization) would be necessary to provide conclusive evidence of a harvest effect. Likewise, it is difficult to define what constitutes a "realistic level of precision" because a single census of purposively selected blocks (nonrandom sampling units) does not provide estimates of sampling error (variation due to measurement error and among-unit differences). Furthermore, previous survey results were summarized by county (vs. census block). However, if we use among-county variation to approximate among-block variation, use estimates of temporal variation (1997-2001) to approximate total variation within each census block, and let trend variation = 0.83 (based on the CV of the slope of the linear regression line through population estimates for each county during 1997-2001), then the probability of detecting a population change of 10% over 5 years would be $\leq$64% at P = 0.10 (program MONITOR). Alternatively, given that CV of counts = 0.181, Gibbs (2000: Table 7.3) suggested the monitoring program would require 20 plots (census blocks) to detect a 25% change over 10 years at $P = 0.05$ with a likelihood (power) of >0.95 given 1 annual count/block/year. Thus, true population changes of $\leq$20% (over 5-10 years) have a relatively low probability of being detected with the proposed survey design.

(2) *Monitor spatial connectivity of population core areas and potential range changes in peripheral areas.*

(3) *Provide conservative season-setting information for each permit zone, i.e., minimum number of males in spring.* Note: permit zones are delineated in Fig. 3

POPULATION STATUS

Prior to European settlement, the most common gallinaceous bird in Minnesota's prairie region was the sharp-tailed grouse (*Tympanuchus phasianus*). In the mid-1800's, immigrant farmers arrived in large numbers and began to convert the prairies and wetlands to cropland. The resulting mosaic of grasslands, small grains, and wetlands provided ideal habitat for greater prairie-chickens. By 1880, Minnesota's prairie-chicken range had expanded from the southern edge of the state to the extreme northwest and also occupied forested portions of the northeast that had been converted to grasslands via logging, land clearing, and recurrent fires (Svedarsky et al. 1997). Prairie-chicken populations in Minnesota flourished during the late 1800's and early 1900's, but numbers declined steadily after 1900 due to intensified agriculture and fire suppression (Svedarsky et al. 1997).

The primary management response to the prairie-chicken decline was to shorten seasons and reduce bag limits until ultimately the season was closed in 1943. Because the decline was primarily a function of habitat loss and succession, the hunting-season closure did not reverse population declines and range contraction. Prairie-chickens are now found primarily in northwest Minnesota along the beach ridges of glacial Lake Agassiz, although a small remnant population also persists in the largely forested northcentral part of the state where a combination of factors maintains scattered grasslands (Fig. 1). Prairie-chickens have also been reintroduced to the Upper Minnesota River Valley (Lac Qui Parle, Big Stone, and Traverse counties; Fig. 1) with the long-term goal of linking prairie-chicken populations in Minnesota (northwest and Upper MN River Valley), South Dakota, and North Dakota (Winter 2001).

The greater prairie-chicken has been extirpated, or is in danger of extirpation, in 15 states and provinces, but numerous enough to be legally hunted in 4 states (Schroeder and Robb 1993). In contrast, prairie-chicken population indices (total leks and males) in northwest Minnesota have been stable to slightly increasing since 1990 (Fig. 2), largely due to the beneficial effects of grassland establishment under state and federal farm and land-retirement programs such as CRP and RIM. Also, prairie protection and restoration efforts have helped stem the loss of remaining native prairie. Based on Minnesota's annual lek survey, the spring population in 2001 was at least 2,700 birds (total males counted on booming grounds x 2). If average spring-to-fall survival was 0.70 and average recruitment rate was 1.77 juveniles/adult (J. S. Taylor, Nebraska Game and Parks Commission, unpub. data), then the fall population in 2001 was about 4,700 birds. Hypothesized minimum viable population (MVP) sizes for prairie-chickens range from 100 to 250 males in the spring (Toepfer et al. 1990, Westemeier and Gough 1999). Based on lek counts, there were at least 1,350 males in northwest Minnesota in the spring of 2001, which is 5 times more birds than the most conservative MVP estimate

Hamerstrom et al. (1957) recommended that harvest be limited to 25-30% of the fall population. However, Hamerstrom and Hamerstrom (1973) and Bergerud (1988) reported that hunting mortality in prairie-chickens is at least partly additive to natural mortality. Under the proposed hunting season, harvest in Minnesota would be limited to no more than 10% of the spring population and would be dispersed over 7 permit areas that contain hunting refugia. In contrast, Nebraska restricts harvest to no more than 15% of the fall population. Thus, Minnesota's proposed hunting season would be very conservative. Nevertheless, a carefully designed monitoring program is needed to help guide prairie-chicken management, including harvest management.

SURVEY DESIGN

Target Populations

The *target population* represents all animals within some defined space and time interval, and it could contain any part, or all of, one or more biological populations (Thompson et al. 1998:7). Three distinct populations were defined for the monitoring plan: Northwest, Northcentral, and Restoration (Fig. 1). The primary population of interest was the northwest population, whose approximate range was delineated using the intersection of documented leks (1964-1999, 2001) and land-type associations (ecological land-classification units). The following description of survey design and sampling protocols applies only to the northwest population. (Monitoring efforts for other populations are briefly described and discussed in Restoration and North-central populations, below. Note: assuming continued success of the restoration project in the Upper MN River Valley, the proposed survey design should be expanded to include the restoration population, with emphasis on monitoring connectivity between the restoration population, the northwest population, and, possibly, populations in eastern South Dakota.)

Sampled Population (Northwest only)

The *sampled population* refers to only those elements (leks) contained in the sampling frame, i.e., that part of the target population that has a chance of being surveyed (Thompson et al. 1998:10). Any inferences drawn from the count data are applicable only to the sampled population. Because the proposed monitoring program includes both random and nonrandom sampling (*purposive sample*), delineation of the sampled population is problematic. However, based on the total sample area (random + nonrandom), we defined the sampled population as those portions of the target population located within the 7 permit zones plus portions of the target population located within 5 miles of Mahnomen and Becker County census blocks (Fig. 3).

Census Blocks (annual nonrandom sample)

In 1991, a census committee (R. Hier, T. Kucera, D. Wells, and B. Winter) of the MPCS proposed a survey design that included an annual census (complete count) of 5 core-area blocks and a periodic (every 3-5 yrs) intensive survey. The intensive survey consisted of hiring additional personnel to survey most of the northwest range in order to get an overall picture of the status of prairie-chickens in Minnesota, including range extensions and contractions (R. Hier, MPCS Newsletter 1992). The last intensive survey was completed in 1991. Annual surveys since 1992 have focused on complete counts within 5 core-area blocks (Fig. 4), although reported population indices (total leks, total males, and males/lek) included leks observed outside the census blocks. In order to standardize annual-survey effort and provide population data for each permit zone and potentially important peripheral areas (Mahnomen and Becker counties), we recommend the following modifications to census blocks:

(1) Establish 1 census block in permit zone 407N (north Norman County),
(2) Establish 2 census blocks in Mahnomen-Becker counties,
(3) Divide the Wilkin-County census block into 2 blocks (1 each for permit zone 420S and 421), and
(4) Modify boundaries so that each census block is approximately township size.

The proposed modifications would result in 7 township-size census blocks within the core area and 2 census blocks in Mahnomen-Becker counties (Fig. 3; also see Appendix A). Obtaining a complete count of leks and males/lek within the 7 census blocks will be the first priority each year (see Data Collection, below). Leks located outside census blocks will also be documented each year (i.e., via incidental observations or, if feasible, systematic surveys), but population indices and trend estimates will include only leks within designated census blocks. Note: a "census" is defined as a complete count (i.e., detection rate = 1). We acknowledge that some leks are likely missed within census blocks each year (i.e., detection rate < 1.0), but detection bias probably is small. Therefore, in order to maintain consistency with previous reports, we have elected to use the term "census" to describe counts conducted within survey blocks.

Peripheral Areas (periodic random sample)

Annual counts within census blocks will not provide sufficient data to monitor range changes or population connectivity (objective #2). Thus, we recommend a periodic (every 3-5 years) *random* survey of peripheral areas (defined as the potential population range within permit zones but outside census blocks), plus the potential population range within 5 miles of Mahnomen and Becker County census blocks (Fig. 3; also see Sampled Population, above). A random survey of peripheral areas will provide data to (1) document spatial connectivity and range changes, (2) calibrate harvest recommendations based on core-census blocks, and (3) compare population indices and trends (i.e., peripheral areas vs. census blocks). We further recommend a presence-absence survey rather than attempting to count total leks and males. A presence-absence survey will provide sufficient data to document spatial connectivity between core-census blocks and will minimize survey effort and related expenses. Furthermore, if survey results are combined with data from core-census blocks (e.g., mean lek size and density), one can still derive estimates of total abundance (leks and total males) and density for peripheral areas.

We suggest using either a simple random or stratified random sampling design (Scheaffer et al. 1996, Thompson et al. 1998:339) to estimate the proportion of sampling units containing ≥1 lek. A stratified design, where strata are based on the presence-absence of historic leks (from previous survey data), would ensure our sample included sampling units that are likely to contain leks. An adaptive sampling design (Thompson et al. 1998:68) also warrants consideration. An adaptive sampling design would allow for increased counting effort adjacent to sampling units that contained ≥1 lek and would provide more precise estimates if leks are rare and clustered. However, an adaptive design would be difficult to administer in this case because it would require close supervision and daily communication between observers and survey cooperators, which is already problematic due to the large number of observers and cooperators.

We recommend using *sections* as the sampling unit because (1) most detection distances will be ≤0.5 mi and, thus, detection probability should be near 1; (2) very few sections will contain >1 lek, which means the estimator for the proportion of sampling units that contain leks can also be used to estimate total lek abundance; (3) sections are readily identifiable, provide a simple sampling frame, and are small enough that permit-zone boundaries can be approximated using section boundaries. Sample size (number of sections) will depend on size of the sampling frame (N), the proportion of sampling units that contain leks within each stratum (p_i), and the desired level of precision (usually stated as a bound on the population proportion [p_{st}]). Based on historic data for permit zone 407S (Clay County), optimum sample size needed to minimize cost for a given standard error would range from 27 to 106 sections (22 to 84% of the sampling frame).

p_{st}	Bound on p_{st}	Relative error (%)	Stratum 1 (present)			Stratum 2 (absent)			ALL	
			p_1	n	%	p_2	n	%	n	%
0.071	0.010	14	0.348	23	100	0.010	44	43	67	53
0.071	0.050	70	0.348	14	62	0.010	13	13	27	22
0.087	0.010	12	0.348	23	100	0.029	71	69	94	74
0.087	0.050	57	0.348	17	75	0.029	27	26	44	35
0.103	0.010	10	0.348	23	100	0.049	83	80	106	84
0.103	0.050	49	0.348	18	79	0.049	37	36	55	44

Given that $p_{st} = 0.071$ and $p_2 \leq 0.010$ (realistic scenario for permit zone 407S), we would need to sample 22% of the sampling frame (62% of sections that contained leks in the past and 13% of sections with no historic record of leks) to be reasonably certain that our estimate is within ±70% of the true population proportion. For example, if we estimated that $p_{st} = 0.065$ (6.5% of all sections contained ≥1 lek), then the 95% CI for our estimate would be approximately 0.065 ± 0.050 (1.5 to 11.5%). Precision could be improved by increasing the sampling effort (e.g., relative error = 14% with a 53% sampling effort), but surveying ≥50 sections/permit zone may not be feasible given time, budget, and labor constraints. Thus, bounds on population estimates may be relatively large (e.g., 2 to 15 leks in permit zone 407S), but this level of precision may suffice given the primary objective is to monitor spatial connectivity.

Note 1: a suggested alternative approach is to census nonrandom peripheral blocks (areas adjacent to core-census blocks) on a rotating schedule, i.e., a different peripheral block would be censused every year. This approach would provide information on lek abundance and distribution in a particular block in a given year, but the data would have limited utility for addressing objectives #1 and 3. The primary problem with using nonrandom sampling is an inferential one. Population estimates based on counts from nonrandom plots (blocks) cannot be expanded to a larger area (i.e., unsampled plots) unless the plots are representative, which can only be assessed by comparing the results to the "truth" (which is unknown) or some type of random sample (Thompson et al. 1998). Random sampling usually is the preferred approach because on average it yields unbiased results and allows us to assign a known level of uncertainty to population estimates. Uncertainty is a result of spatial and temporal variation in the parameter of interest, as well as variation due to sampling and measurement error. These sources of variation ultimately determine the reliability of population estimates and, hence, acknowledging and estimating uncertainty is better than ignoring it.

Note 2: it has also been suggested that a rangewide census be conducted for 3-5 years to establish baseline estimates of lek abundance and distribution. Although the resulting data would be valuable, there is insufficient staff and funding to conduct a complete census of the entire range. Furthermore, such a "census" provides only a snapshot in time and would need to be repeated at regular intervals to document population trends, range changes, and spatial connectivity. Finally, very few animal populations can be completely enumerated; thus, well-designed sampling strategies are critically important in most wildlife studies (Thompson et al. 1998, Krebs 1999, Morrison et al. 2001).

Limitations and Assumptions

(1) Population estimates and trends based on a nonrandom sample (census blocks) cannot be expanded to the entire population unless the selected plots are truly representative of the whole sampling frame (i.e., in terms of habitat, population density, management activities, etc.). Svedarsky et al. (1997) reported that statewide counts were positively correlated (r = 0.92) with intensive counts in a Polk County study area, and B. Winter (unpubl. data) found a positive correlation between population trends on census blocks and peripheral areas in Clay County during 1990-2002. Thus, core-census blocks (nonrandom sample) likely provided reasonable estimates of minimum numbers and general population trends in the past (Svedarsky et al. 1997) and ***may*** do so in the future **if** census blocks continue to be representative of population and habitat changes occurring in nonsampled areas. Unfortunately, representativeness is not something that can be assessed subjectively (Thompson et al. 1998).

Gibbs (2000) suggested a 2-step solution to the problem: (1) populations at selected sites (e.g., core-census blocks) that are presumably representative of particular habitat strata in a region are rigorously monitored (*our current approach*), and (2) an independent program is established that explicitly monitors changes in distribution and abundance of habitats in the region. Trends in habitats can then be linked to trends in populations at the specific sites to extrapolate regional population trends, i.e., a model-based approach (Verner et al. 1986, Morrison et al. 2001). A model-based approach for prairie-chickens in Minnesota will become more feasible in the near future as remote-sensing data continue to improve (e.g., the ability to differentiate among grassland types and to quantify grassland quality) and acquisition cost declines. <u>When feasible, a habitat-monitoring program should be established that periodically measures changes in the distribution, abundance, and quality (e.g., patch size, isolation, stand type, proximity to trees) of grassland habitats within the prairie-chicken range</u>. At the very least, these data will help biologists understand and quantify factors influencing population trends.

(2) All wildlife surveys should be evaluated at regular intervals to (a) re-examine the objectives (e.g., are they still meaningful and realistic), (b) determine if the survey has been successful (relative to its objectives and cost), and (c) explore potential modifications (e.g., are there new sampling or analytical techniques available that would improve the survey). As noted above, the proposed survey design has important limitations regarding inference space and precision (e.g., low probability of detecting population changes of less than ±20% over 5-10 years). If these limitations are deemed unacceptable, then the survey must be redesigned (e.g., increased sampling effort) or alternative approaches considered (e.g., emphasis on habitat vs. population monitoring). A qualified statistician should be consulted regarding the survey design and any modifications, and the design should be re-evaluated after 2-3 years of data collection (i.e., re-calculate sample size and power estimates).

(3) Applegate (2000) cautioned against using lek surveys as absolute estimates of population size because (a) most lek surveys use nonrandom sampling methods such as roadside surveys; (b) sampling error may be large but often is not quantified (i.e., it is assumed to average out over space and time); (c) no attempt is made to estimate and correct for detection bias (imperfect detection); and (d) distances over which individual prairie-chickens travel to a lek are unknown but can be considerable (important for density estimation and potential problems of double counting). Thus, lek counts based on nonrandom sampling should be viewed as a population index, i.e., a measurement that relates proportionally to the true population density or abundance.

Population indices may still be useful for estimating population trends and relative abundance and can provide a statistic that is more precise than a true population estimate ***if*** the proportion of the population detected is constant across space, time, and density (Lancia et al. 1994). Unfortunately, we know that some leks are missed (e.g., due to factors such as wind speed and direction, detection distance, lek size and stability, observer experience, etc.). Given the many variables that affect detection rates, the assumption of constant detection bias probably is not valid in most cases (Anderson 2001, Rosenstock et al. 2002, Thompson 2002). The magnitude of the bias is assumed to be small, but detection probabilities in lek surveys have not been quantified (note: it could be estimated with distance sampling, double sampling, or sighting-probability models). Finally, we know that counts of males on leks include enumeration error (Cannon and Knopf 1981, Schroeder and Braun 1992). Again, the magnitude of the error is assumed to be small or average out over space and time, but the error has not been properly measured for the proposed survey design (e.g., via replicate counts of males on selected leks). These are important limitations that reduce inference space and certainty of conclusions (Ratti and Garton 1994, Morrison et al. 2001). As suggested by Anderson (2001) and Thompson (2002), empirical models of detectability and well-designed sampling frameworks are needed to improve reliability of wildlife surveys, including prairie-chicken surveys.

Comparison With Other States

Roadside transects, block censuses (complete counts within township-size blocks), and historic lek counts are common methods used to survey prairie-grouse populations. Roadside surveys are popular because they are relatively inexpensive (a primary consideration given budget, personnel, and time constraints of most agencies) and are easy to establish and administer over large geographic areas. Routes are 10-20 miles long (with 1 listening stop/mi) and typically are analyzed as a strip census based on the assumption that (1) all leks within 1 mi of each side of the road are detected and (2) there is no movement of leks in or out of the census area between years (e.g., due to annual changes in land-use practices or other anthropogenic disturbances) or the error is bi-directional and averages out over a large sample. To my knowledge, these assumptions have never been critically evaluated. Furthermore, roadside surveys do not provide random samples of the potentially occupied habitat of a species, and edges often are modified substantially, which may influence a species use of surrounding habitats (Applegate 2000). Roadside surveys *may* be useful for detecting long-term population trends and monitoring changes in population distribution (Applegate 2000), but their legitimacy for estimating population size, population density, or absolute change is questionable.

Block censuses are another popular survey method. Census blocks typically are township-size areas that were initially selected based on the distribution of known leks (i.e., from previous survey efforts and fortuitous observations). Survey methodology usually consists of a listening survey to locate leks, followed by 2-3 replicate counts of total males on each lek. Data are usually summarized by block and region and expressed as total leks and males. Block censuses generally are a good technique for monitoring population trends, but problems with imperfect detection (not all leks are detected, especially smaller satellite leks located >0.5 mi from listening/glassing stops) and observer effects (e.g., due to turnover in personnel) make estimates of population size and absolute change questionable (J. Kobriger, N.D. Game and Fish, pers. comm.). Furthermore, block surveys have limited ability to detect changes in lek distribution (e.g., range expansion) and typically do not provide estimates of precision (i.e., results are simply presented as total leks and total males). Finally, extrapolation of results from non-random census blocks is valid only if the blocks are representative of unsampled areas.

Survey methodology and protocols vary by state, as do response variables and population indices. For example, results are reported as males/route, leks/route, total males, total leks, leks/mi^2, males/mi^2, and birds/mi^2. Cannon and Knopf (1981) suggested that total leks or leks/mi^2 provide the best indication of population status (compared to average lek size), but Schroeder and Braun (1992) cautioned that lek densities may be difficult to estimate accurately and estimates are rarely, if ever, obtained with a corresponding estimate of precision. Schroeder and Braun (1992) suggested that estimates of males/lek may be relatively easy to obtain and justify with precision, but cautioned the methodology for estimating numbers of males could be of critical importance if counts of males are used to estimate population size. However, given potential problems with imperfect detection and non-random sampling, the response variable (regardless of type) in most lek surveys should be treated as a population index and results should not be extrapolated to provide absolute estimates of population size or density (Applegate 2000; also see Limitations, above).

North-Central and Restoration Populations

Only 2-3 prairie-chicken leks and 7-9 males were observed in the north-central population during 1997-2001. Although peripheral populations can be ecologically important (from an evolutionary perspective), the extremely low densities of prairie-chickens in the north-central region are primarily due to natural successional changes (Svedarsky et al. 1997). Soils and climate in this region favor forest vegetation. Consequently, the scattered grasslands must be maintained by prescribed burning (wild hay fields) and wild fires (jack-pine savannas) (Svedarsky et al. 1982). Considering the importance of disturbance and other successional processes in this region, a habitat-monitoring program may provide more useful data than an extensive population survey. However, we recommend that historically used leks (active in the last 4-5 years) and all habitats within 3 mi of these leks continue to be surveyed annually using similar protocols to those described below.

In an effort to re-establish a greater prairie-chicken population in southwestern Minnesota, 205 birds (134 adult cocks, 65 adult hens, and 6 young of the year) were translocated from northwestern Minnesota during 1999-2002 (Winter 2001; D. Trauba, MNDNR, pers. comm.). The goal was to establish 5 booming grounds throughout the Upper Minnesota River Valley. All birds were radio-marked to document general movements, survival, and mortality factors. Two booming grounds were located in 2000 and 2001 and 4 booming grounds were located in 2002. Radio-marked birds are currently present at 5 different locations. Populations in some locations still need augmentation, but successes so far suggest the project is nearly ready to enter the next phase, i.e., large-scale spring releases (D. Trauba, MNDNR, pers. comm.). As mentioned earlier, long-term success will depend on connecting birds here with those in northwest Minnesota or eastern South Dakota (Winter 2001). At this point, we recommend that survey methodology in the restoration population continue to focus on (1) intensive surveys of release sites and established leks, (2) casual observations of birds in or near release sites, and (3) location data on radio-marked birds. However, if large-scale releases are successful, a sampling approach may eventually be necessary to monitor population trends and connectivity (e.g., between the northwest and restoration population). In addition, a monitoring program should be established that documents changes in proportional abundance, distribution, and quality of grassland habitats in the northwest and restoration populations.

DATA COLLECTION, ANALYSIS, AND STORAGE (*see complete proposal for details*)

ANNUAL WORK SCHEDULE

Activity	Feb	Mar	Apr	May	Jun
Preparation (maps, data forms, cooperators...)[a]					
Locating booming grounds[b]					
Counting males on leks[b]					
Data entry, proofing, and analysis (data due May 15)[ac]					
Pop'n data for ELS worksheet (due May 20)					
Draft report (due June 01)					
Review comments and input (due June 15)[d]					
Final report (due July 01)					

[a]MNDNR wildlife research (40-80 hrs).

[b]MNDNR wildlife managers, other agency personnel (e.g., from TNC and USFWS), and volunteers from MPCS and general public (~400-600 hrs, including volunteers and non-MNDNR staff).

[c]In order to meet ELS (Electronic License Sales) deadlines, **<u>all survey data</u>** must be **<u>delivered</u>** to the MNDNR Wildlife Populations and Research Group no later than **<u>May 15</u>**. Data collected or delivered after 15 May will not be used in the season-setting process and will not appear in the final report.

[d]A draft copy of the annual report will be distributed to census-block coordinators and other key personnel for review and comment. Comments must be returned no later than **June 15**. The final copy of the report will be completed no later than **July 01**.

DISSEMINATION OF RESULTS

The draft and final report will be distributed to survey coordinators, the MPCS (president), MNDNR's Division of Wildlife Management Team, and other key personnel. Summary data (tables and figures) will be disseminated to the general public and other interested parties via the MPCS newsletter and MNDNR Status of Wildlife Populations Report. General information on the status and distribution of prairie-chickens in Minnesota should also be posted on the MNDNR web site to generate public interest as well as provide information for individuals interested in hunting opportunities.

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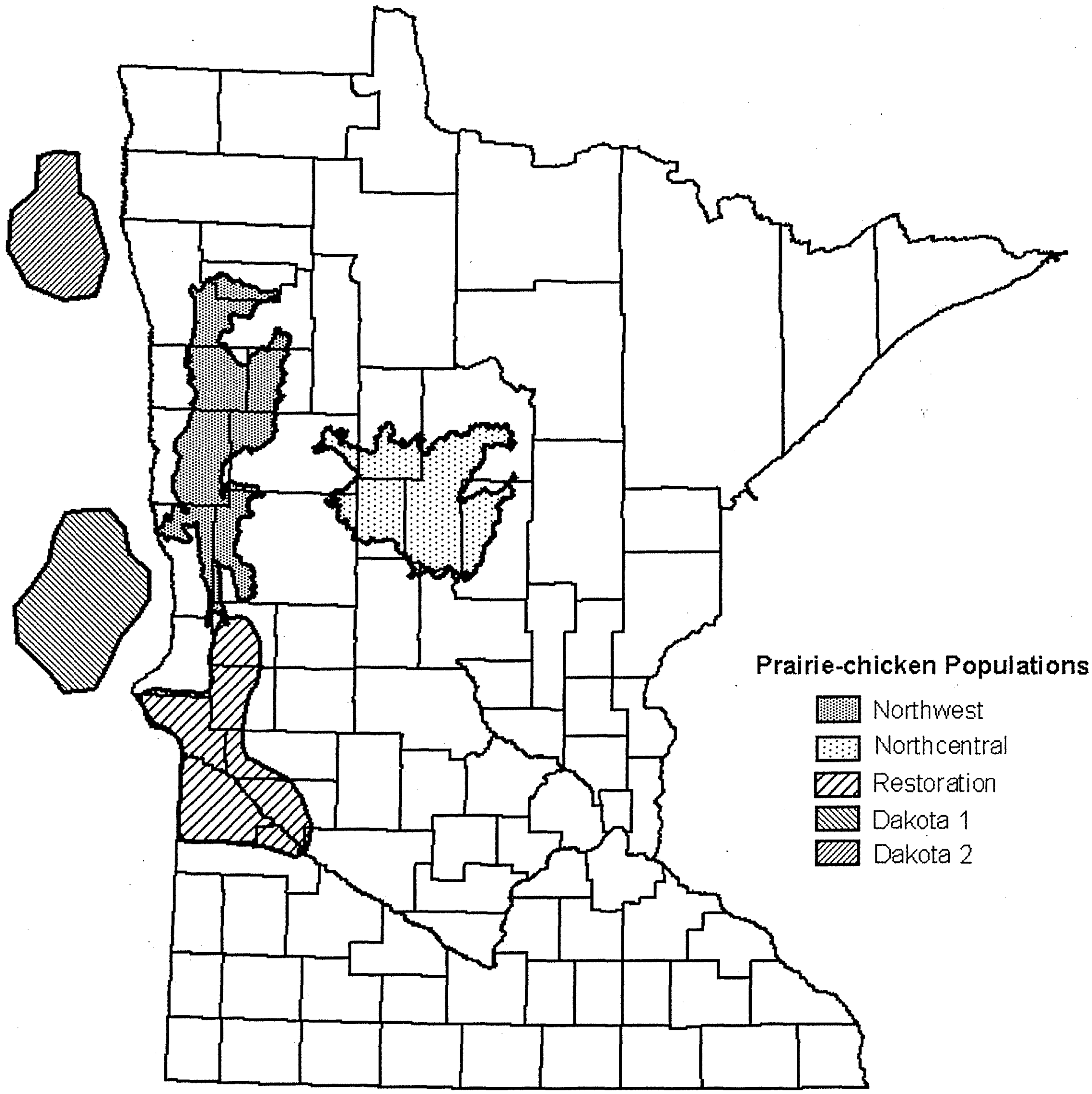

Figure 1. Distribution of greater prairie-chicken populations in Minnesota and adjacent populations in North and South Dakota. Note: boundary delineations for the Northwest and Northcentral populations were based on ecological Land Type Associations and historic lek locations (1964-1999); delineations of other populations were based on an unpublished map.

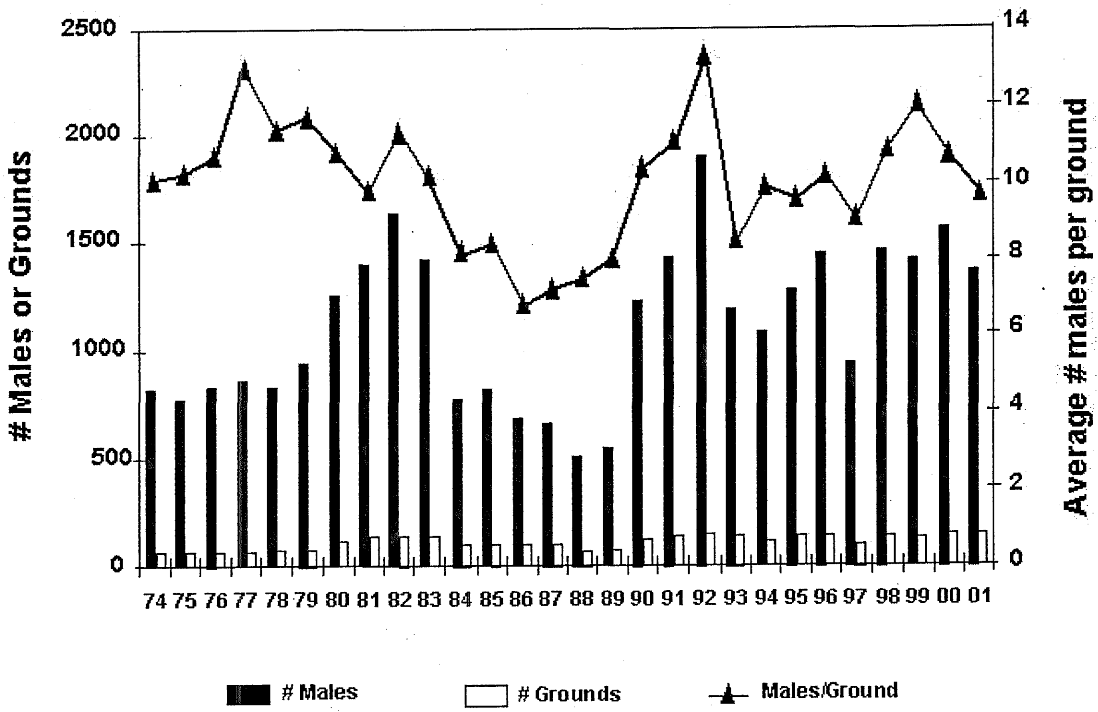

Figure 2. MPCS prairie-chicken census results (1974-2001). Includes leks in Wadena County (Northcentral population) and leks located outside core-census blocks.

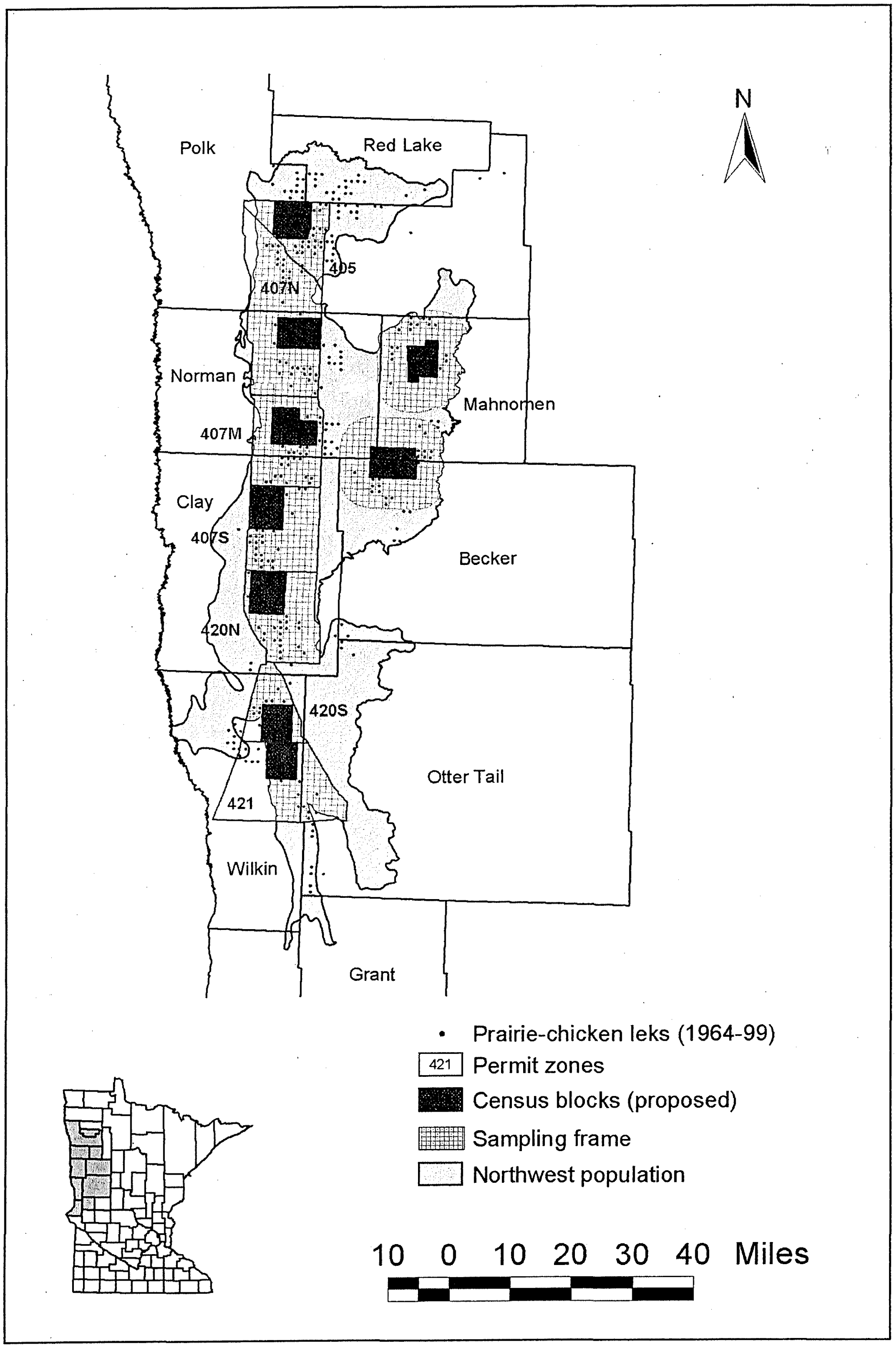

Figure 3. Proposed permit zones, census blocks, and sampling frames (peripheral areas) for the Northwest prairie-chicken population.

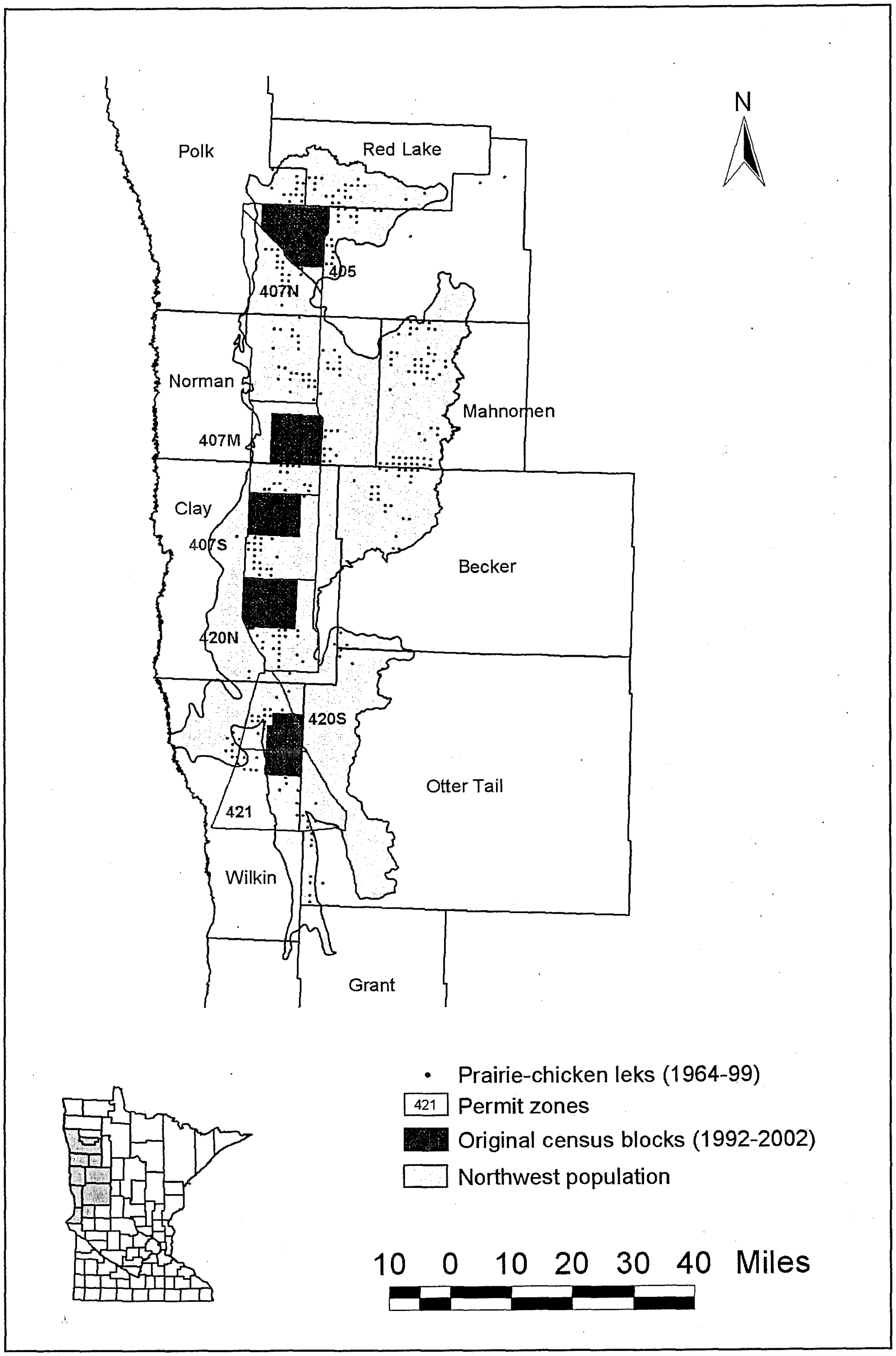

Figure 4. Original census blocks established in 1992.

SURVIVAL AND HOME RANGES OF WHITE-TAILED DEER IN SOUTHERN MINNESOTA

Christopher S. DePerno, Brian S. Haroldson, Todd J. Brinkman, Benjamin J. Bigalke, Christopher C. Swanson, Isabelle L. Lajoie, Jonathan A. Jenks, John D. Erb, and Robert G. Osborn

INTRODUCTION

In 1974, the Minnesota legislature and the Minnesota Department of Natural Resources (MN DNR) adopted a policy for white-tailed deer (*Odocoileus virginianus*) management to: maintain the deer population at the highest level the habitat and landowners would tolerate; provide maximum recreational opportunities, while minimizing landowner/hunter conflicts; and have consistent season frameworks. These guidelines provided a challenge for resource managers to determine the balance between harvest opportunities and minimizing human/deer conflicts. Identifying and maintaining this delicate balance is difficult without reliable empirical data specific for white-tailed deer.

DePerno et al. (1999) indicated that knowledge of survival rates, cause-specific mortality and home range information, critical information to the decision-making process and essential for deer population management in Minnesota, was lacking. Furthermore, when managing a harvestable population, region specific data are necessary to avoid overexploitation (Nelson and Mech, 1986, Van Deelen et al. 1997) and to develop management strategies that will satisfy the needs of hunters, landowners, and the general public (Nixon et al. 2001). The increased use of regional population models (Fuller 1990), designed to predict temporal changes in deer populations, has stressed the importance of sound empirical data (Grund 2001). Hence, without accurate information on deer population dynamics, it is difficult to predict harvest necessary to manage deer populations in Minnesota.

In Minnesota, white-tailed deer are managed through allocation of antlerless deer permits within 129 individual permit areas (PAs). Population goals for each PA are based on landowner tolerance and a balance of biological and cultural carrying capacity (Lenarz and McAninch 1994). Number of antlerless permits allocated to each PA is determined using a computer model and input from wildlife managers. The farmland deer model incorporates many population parameters including initial population size, age/sex ratios, harvest data, seasonal survival rates, reproduction data/hunter kill data, hunter registration compliance, illegal kills, and crippling loss. Although harvest and reproduction data are collected annually, direct information on survival, home range, and non-hunting mortality of white-tailed deer in intensively farmed areas of Minnesota is lacking.

Primary objectives for this on-going project were to gather information on seasonal survival rates, seasonal home ranges, and cause-specific mortality for adult female, fawn, and neonate white-tailed deer in Big Woods Southeast (BWSE) deer management subunit (DMSU) and Prairie deer management unit (DMU). Secondary objectives were to estimate seasonal home range size and determine variables affecting the duration of home range use throughout the year. Data from this study are being used to improve the farmland deer population model and to assist wildlife managers with their decision-making process concerning white-tailed deer population management.

STUDY AREA

Big Woods Southeast DMSU contained 9 PAs in extreme southeast Minnesota. Capture sites were selected near Zumbro Falls, Dumfries, Rushford, and Pleasant Grove (Fig. 1). Topography of the area was comprised of rolling uplands with deep, stream-cut valleys and wooded hillsides; elevations ranged from 30 to 150 m from valley floor to ridge-top with slopes exceeding 70% (Porter 1976 Minnesota Department of Natural Resources 1979). Deciduous forests predominated the valleys and sloped hillsides. Row crops and pastures were generally associated with ridge tops and level areas. Study sites were selected to maximize habitat variation.

Prairie DMU contained 36 PA's across southern and western Minnesota. Capture sites were selected near Lake Benton, Walnut Grove, and Redwood Falls (Fig. 2). Topography of the region was flat to rolling with land use dominated by intensive row crop agriculture consisting mainly of corn and soybeans (Brinkman 2003), with less than 10% of the area established as permanent cover (e.g., grassland, forest). We used GIS to calculate the percentage of cultivated land, grassland, and forest in each PA. Cluster analysis (Boulanger et al. 2002) grouped PAs into 3 similar land use/land cover types (Brinkman 2003) and a capture site was selected from each cluster to maximize habitat variation.

METHODS

Capture and Marking

During January 2000-2003, white-tailed deer were captured using helicopter net-guns (Barrett et al. 1982). Deer were transported to a processing site, where physical condition of deer was assessed and blood samples were collected for disease evaluation. Rectal temperature was continuously monitored as an indicator of stress. Captured deer were aged as an adult (>1 year) or a fawn (~8 months), measured (chest and neck circumference), ear-tagged, and administered a broad-spectrum antibiotic. Radiocollars (Advanced Telemetry System, Isanti, Minnesota, USA) equipped with activity and mortality sensors were placed around the neck of each deer. During 2003, captured deer were injected intramuscularly with 5 mg/kg Ketamine and 1 mg/kg Xylazine prior to transport (Mech et al. 1985, Kreeger et al. 2002). To test for chronic wasting disease, a sample of tonsillar sinus tissue was collected from adult deer using a mouth gag and 30-cm Jackson rectal forceps (Sontec Instruments, Englewood, Colorado, USA). Tonsil tissue was preserved in 10% neutral buffered formalin (Wolfe et. al 2002). Additionally, to determine when does were fawning, we inserted vaginal-implant transmitters (Advanced Telemetry System, Isanti, Minnesota, USA) equipped with a temperature-activated sensor into vaginal canals of adult does (Bowman and Jacobson 1998). Xylazine was reversed by intravenous injection of 0.125 mg/kg of Yohimbine (Mech et al. 1985).

During May and June, neonate white-tailed deer were captured by hand using ground and vehicle searches during diurnal and nocturnal time periods. Searches were conducted in areas where does exhibited postpartum behavioral changes (Huegel et al. 1985a) and in areas with well established road networks (Downing and McGinnes 1969). Captured neonates were sexed, aged (days) by hoof growth (Haugen and Speake 1957, Whittaker and Lindzey 1999, Brinkman et al. 2003), and fitted with expandable radiocollars (Telonics Inc., Mesa, Arizona) equipped with mortality sensors. An Institutional Animal Care and Use Committee at South Dakota State University approved all methods used in this research (02-A043).

Survival and Home Range

Adult and fawn radiocollared deer were located by ground triangulation 2-3 times per week (Brinkman et al. 2000, Brinkman 2003). Collared neonates were monitored daily until approximately 9 weeks of age, and 2-3 times weekly thereafter. From established telemetry stations, 3-5 directional bearings were obtained using a vehicle mounted null-peak antenna system (Brinkman et al. 2002). Deer locations were calculated using Locate II (Nams 2001) and plotted on USGS 3-meter Digital Orthophoto Quadrangles using ArcView (ESRI, Redlands, CA). Cause of death was determined from field necropsy and ancillary evidence at site of mortality (White et al. 1987). If cause of death could not be determined in the field, carcasses were transported to the South Dakota State University Animal Disease Research Diagnostic Laboratory for further investigation. The calendar year was divided into 4 seasons: posthunt (January - April), prehunt (May - August), and hunt (September - December). For data analysis, we also included a "hunt-all" season (September - December; Brinkman 2003); the hunt-all season included all mortalities, whereas the hunt season included only hunting mortality. Survival rates were calculated using the Kaplan-Meier procedure (Kaplan and Meier 1958) modified for a staggered entry design (Pollock et al 1989). The Fixed Kernel method was used to calculate seasonal home ranges using the spatial movement analysis extension in ArcView. Seasonal movement was calculated by measuring the distance between the center points of seasonal home ranges.

PROGRESS AND SUMMARY OF RESULTS

Capture and Marking

During January (2000 - 2003) in Big Woods Southeast DMSU, 90 adult females, 14 fawn females, and 1 fawn male were captured and radiocollared. During January (2001 - 2003) in Prairie DMU, 76 adult females and 18 fawn females were captured and radiocollared. Additionally, 39 neonates (22 females, 17 males) were captured during May - June (2001 - 2002) (Fig. 3) and mean age at capture was 4.8 days (range = 1 - 13 days, SE = 0.6, n = 34,) and mean date of birth was 28 May (range = 22 May - 11 June). One adult and 5 neonates were censored from analysis because of death within 30 days of capture (Beringer et al. 1996) or slipped radiocollars.

Survival and Home Range / Big Woods Southeast DMSU

Forty-three adult and fawn deer died in the first three years of the study (January 2000 - May 2003). Overall, causes of mortality included firearms hunting (42%), archery hunting (16%), wounding loss (firearm, 16%), vehicle collision (14%), predation (5%), accidental (2%), poaching (2%), and unknown (2%). Annual survival rates for all deer equaled 0.72, 0.73, and 0.80 during 2000-2002, respectively (Table 1). Seasonal survival rates ranged from 0.75 to 0.98 during 2000-2002 (Table 2).

Deer in southeast Minnesota occupied two seasonal home ranges; winter ranges from mid-December through late-March, and summer ranges from late-March through mid-December. Mean 95% home ranges and 50% core use areas were 2.7 km^2 ($n = 20$) and 0.5 km^2 ($n = 20$), respectively during winter and 1.4 km^2 ($n = 20$) and 0.2 km^2 ($n = 20$), respectively during summer. Mean seasonal movement was 2.3 km (range = 0 - 27.4 km, $n = 20$).

Prairie DMU

Twenty-five deer died in the first two years of the study (January 2001 - May 2003). Overall, causes of mortality included firearms hunting (44%), vehicle collision (12%), predation (8%), unknown (8%), archery hunting (4%), wounding loss (firearm, 4%), clostridium infection (4%), and train (4%). Annual survival rates for all deer equaled 0.76 and 0.84 during 2001 and 2002, respectively (Table 3). Seasonal survival rates varied from 0.80 to 1.0 (Table 4).

As of December 31, 2002, 8016 deer locations were collected with a mean 95% error ellipse of 4.5 ha. Deer in southwest Minnesota also occupied two seasonal home ranges. Radiocollared deer began moving to their summer range in April, and returned to their winter range in November. Seasonal home ranges of individual deer were calculated using a minimum of 25 and a mean of 37.3 (SE = 0.8, $n = 130$) locations. Mean 95% home range and 50% core use areas during winter were 5.2 km^2 (range = 0.4 - 18.7 km^2; $n = 37$), and 0.8 km^2 (range = 0.1 - 3.4 km^2; $n = 37$), respectively (Table 5). Summer 2001 home ranges were not significantly different ($t = 1.553$; $P = 0.124$) than summer 2002, and were pooled for analysis. Mean 95% home range and 50% core use areas were 2.3 km^2 (range = 0.4 - 12.8 km^2; $n = 93$) and 0.3 km^2 (range = 0.04 - 2.0 km^2; $n = 93$), respectively. Mean seasonal movement, pooled for four migration seasons (i.e., 2001 spring, 2001 fall, 2002 spring, and 2002 fall; Table 6), was 10.5 km (SE = 0.7, $n = 118$).

Neonate Survival

Six neonates died during summers 2001-2002. Causes of mortality included predators (67%), vehicle collision (17%), and disease (17%; *coccidia* and *coronavirus* (Brinkman 2003). In 3 of 4 predator kills, neonate carcasses were not recovered from the kill site; only hair, blood, and pieces of digestive tract were found. Bite marks were present on all 4 radiocollars. We believe two of the predator mortalities were coyote (*Canis latrans*) kills based on tracks and scat located near the recovered collar.

During 2001, the neonate survival rate was 1.0 ($n = 21$) after 4 weeks and 0.95 ($n = 18$) after 12 weeks (Table 7). In 2002, survival rate was 0.78 ($n = 18$) after 4 weeks and 0.72 ($n = 13$) after 12 weeks. Pooled survival rate was 0.84 ($n = 39$) for June-August 2001-02.

DISCUSSION

Survival

Annual survival rates of adult female white-tailed deer in southeast (72 – 78%; Table 1) and southwest (76 – 84%; Table 3) Minnesota were similar to survival rates reported for female white-tailed deer (65%-80%, Gavin et al. 1984, Fuller 1990, Nixon et al. 1991, Whitlaw et al. 1998), but higher than reported for a declining white-tailed deer population in the Black Hills of South Dakota (50 – 62%, DePerno et al. 2000). Also, our seasonal survival rates (Tables 2, 4) were similar to rates observed by others (90–100%; Dusek et al. 1989, Van Deelen et al. 1997, Whitlaw et al. 1998, Grassel 2000). Similar to the conclusions of Dusek et al. (1992), mortality of adult female deer in southern Minnesota was most influenced by human factors. Hunting accounted for 58% and 44% of total mortality in southeast and southwest Minnesota, respectively. Additionally, wounding losses contributed another 16% in southeast and 4% in southwest Minnesota. Overall, deer survivorship was high with minimal vulnerability to death by natural causes (Brinkman 2003). Furthermore, high pre-hunt survival (0.98-1.0) was likely due to condensed home ranges, abundant food and cover, and minimal human activities (Nixon et al. 1991).

Summer neonate survival during 2001 was high compared to other free ranging white-tailed deer neonate studies. For a confined deer herd in Virginia, Downing and McGinnes (1969) reported 92% neonate survival. During the first 30 days postpartum, the time period when most neonate mortalities have been reported (Cook et al. 1971, Schultz 1982, Huegel et al. 1985b, Ballard 1999), neonate survival in 2001 was 100%. Pooled (2001-02) neonate mortality (16%) in southwest Minnesota was similar to that reported in southeast Minnesota (15%; Schulz 1982), but lower than reported in Iowa (21%; Huegel et al. 1985b), Illinois (30%; Nelson and Woolf 1987), and Missouri (33%; Bryan 1980). Heavy neonate losses have been reported in Texas (72% Cook et al. 1971), Colorado (66% Whittaker and Lindzey 1999) and New Brunswick, Canada (53% Ballard et al. 1999). Our high neonate survival may be associated with the nutritional condition of the dams (Brinkman 2003). In intensive agricultural areas, does maintain a high nutritional plane because of access to an abundant and nutritious diet (Gladfelter 1984, Nixon et al. 1991).

Given the high fecundity of white-tailed deer (1.66 fawns/adult doe and 0.34 fawns/fawn doe; R. G. Osborn, Minnesota Department of Natural Resources, unpub. data) in southwest Minnesota, non-hunting fawn mortality alone was not enough to control the deer population. Several studies have shown predation to be the primary cause of mortality among neonates (Cook et al. 1971, Hamlin et al. 1984, Messier et al. 1986, Nelson and Woolf 1987, Whittaker and Lindzey 1999), and overall losses are highest when opportunistic predators, such as coyotes, are present (White et al. 1972). Using our trapping efforts as an indicator of predator numbers, high neonate survival may be due to low predator densities in southwest Minnesota. However, local fluctuations in neonate survival rates have been attributed to changes in predator density (Beasom 1974, Stout 1982). Therefore, an increase in predator density (i.e., coyotes) may decrease survival rates of neonate white-tailed deer.

Home range

Summer home ranges observed in this study were smaller than winter home ranges (Table 5), which is similar to results from other studies conducted in similar habitats (4.35-6.99 km^2, Sparrowe and Springer 1970, Kernohan et al. 1994, Filipiak 1998). Furthermore, deer shifted or expanded home ranges, similar to the description of Filipiak (1998) during a mild winter at the Mille Lacs Wildlife Management Area in central Minnesota. Differences in home range size and seasonal movements between areas were likely the result of habitat composition. Southeast Minnesota is composed largely of wooded hillsides (MNDNR 1979) with approximately 40% of the landscape forested, whereas southwest Minnesota is composed of <10% permanent cover (Brinkman 2003). Many winter and summer home ranges observed in both study areas were overlapping, indicating that major seasonal migrations were not necessary to obtain winter cover or food resources.

Summary

Although a tremendous amount of information has been gathered about white-tailed deer in the last few decades (e.g., Halls 1984, Warren 1997), very little empirical data exists on deer populations across the Midwest and Northeast Regions of the United States. Furthermore, in agricultural landscapes throughout the country, abundance of white-tailed deer has changed dramatically (McShea et al. 1997). Baseline information on white-tailed deer demographics, landscape use patterns, and predator interactions was lacking in farmland Minnesota and agricultural states throughout the Midwest. Therefore, this research was initiated to gather empirical data necessary to improve the capability of wildlife managers to refine population models used for setting harvest quotas and to assist with additional management decisions in farmland Minnesota.

To date, this on-going study has documented that adult and neonate white-tailed deer have high survival and minimal vulnerability to death by natural causes (Brinkman 2003). Human-caused mortalities are the primary factors impacting deer. Furthermore, abundant food provided by intensive agriculture has maintained deer populations at high levels. These data may be extrapolated to white-tailed deer in other highly fragmented regions with intensive agriculture, limited permanent cover, and high hunter and road density (Brinkman 2003). Nevertheless, to determine landscape level thresholds, a landscape level approach and long-term data, especially encompassing varying weather conditions, are crucial to understand seasonal survival and movements of white-tailed deer in farmland Minnesota.

FUTURE PLANS

Adult deer will continue to be monitored ≥3 times per week. During May and June 2003, we will attempt to capture 20 neonate deer in Lake Benton, Redwood Falls, and Dumfries. Radiocollared does carrying vaginal implants will be intensively monitored during the fawning period to aid in neonate retrieval.

Following the suggestions by Fuller (1990) on the importance of regional population models, the seasonal survival rates gathered during this study have been incorporated into the farmland deer model. In the future, a southern Minnesota winter severity index (Brinkman 2003) will be included in the farmland deer model.

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Table 1. Annual survival rates of radiocollared adult and fawn white-tailed deer in southeast Minnesota, 2000-2002.

Year	Study site	Number at-risk	Number of Deaths	Number Censored	Survival Rate	Confidence Interval (95%)	Variance
2000	Zumbro Falls	14	4	2	0.71	± 0.24	0.0146
	Dumfries	12	4	1	0.67	± 0.27	0.0185
	Pleasant Grove	15	6	0	0.60	± 0.10	0.0026
	Rushford	17	2	0	0.88	± 0.15	0.0061
	All sites	58	16	3	0.72	± 0.12	0.0034
2001	Zumbro Falls	17	3	1	0.82	± 0.18	0.0085
	Dumfries	8	4	0	0.50	± 0.35	0.0313
	Pleasant Grove	17	4	2	0.77	± 0.20	0.0106
	Rushford	15	4	0	0.73	± 0.22	0.0130
	All sites	57	15	3	0.74	± 0.11	0.0034
2002	Zumbro Falls	22	7	1	0.68	± 0.20	0.0099
	Dumfries	13	2	0	0.85	± 0.20	0.1000
	Pleasant Grove	13	1	0	0.92	± 0.15	0.0055
	Rushford	11	2	0	0.82	±0.23	0.0135
	All sites	59	12	1	0.80	±0.11	0.0027
Overall 2000-02	Zumbro Falls	29	14	4	0.52	± 0.18	0.0086
	Dumfries	21	10	1	0.52	± 0.21	0.0119
	Pleasant Grove	23	11	2	0.52	±0.20	0.0108
	Rushford	17	8	0	0.53	± 0.24	0.0147
	All sites	90	43	7	0.42	± 0.10	0.0907

Table 2. Seasonal survival rates of radiocollared adult and fawn white-tailed deer in southeast Minnesota, 2000-2002.

Year	Season	Number at-risk	Number of deaths	Number censored	Survival rate	Confidence interval (95%)	Variance
2000	Posthunt [a]	58	1	1	0.98	±0.00	0.0003
	Prehunt [b]	57	1	2	0.98	± 0.00	0.0003
	Hunt [c]	56	8	0	0.86	± 0.09	0.0022
	Hunt-all [d]	56	14	0	0.75	± 0.11	0.0033
2001	Posthunt [a]	57	2	2	0.97	± 0.04	0.0006
	Prehunt [b]	55	1	1	0.98	± 0.03	0.0003
	Hunt [c]	54	9	0	0.83	± 0.09	0.0026
	Hunt-all [d]	54	12	0	0.78	± 0.11	0.0032
2002	Posthunt [a]	59	1	0	0.98	± 0.03	0.0003
	Prehunt [b]	58	1	1	0.98	± 0.00	0.0003
	Hunt [c]	57	8	0	0.86	± 0.09	0.0021
	Hunt-all [d]	57	10	0	0.83	± 0.09	0.0025

[a] January – April
[b] May – Aug
[c] September – December; includes hunter-killed deer only
[d] September – December; includes all mortalities

Table 3. Annual survival rates of radiocollared adult and fawn white-tailed deer in southwest Minnesota, 2001-2002.

Year	Study site	Number at-risk	Number of Deaths	Number Censored	Survival rate	Confidence Interval (95%)	Variance
2001	Lake Benton	20	2	2	0.89	± 0.15	0.0055
	Walnut Grove	19	5	1	0.73	± 0.21	0.0111
	Redwood Falls	19	6	2	0.67	± 0.22	0.0123
	All sites	58	13	5	0.76	± 0.11	0.0034
2002	Lake Benton	24	4	1	0.83	± 0.15	0.0059
	Walnut Grove	13	2	1	0.83	± 0.21	0.0116
	Redwood Falls	23	3	2	0.86	± 0.15	0.0058
	All sites	60	9	4	0.84	± 0.09	0.0023
Overall 2001-02	Lake Benton	28	6	3	0.73	± 0.17	0.0072
	Walnut Grove	19	7	2	0.61	± 0.24	0.0145
	Redwood Falls	30	9	3	0.57	± 0.17	0.0078
	All sites	77	22	9	0.64	± 0.11	0.0030

Table 4. Seasonal survival rates of radiocollared white-tailed deer in southwest Minnesota, 2001-2002.

Year	Season	Number at-risk	Number of deaths	Number censored	Survival rate	Confidence interval (95%)	Variance
2001	Posthunt [a]	58	3	2	0.95	± 0.06	0.0008
	Prehunt [b]	53	0	2	1.00	± 0.00	0.0000
	Hunt [c]	51	6	0	0.88	± 0.08	0.0020
	Hunt-all [d]	51	10	0	0.80	± 0.10	0.0025
2002	Posthunt [a]	60	1	3	0.98	± 0.03	0.0003
	Prehunt [b]	56	0	1	1.00	± 0.00	0.0000
	Hunt [c]	55	6	0	0.89	± 0.08	0.0016
	Hunt-all [d]	55	8	0	0.86	± 0.09	0.0019

[a] January – April
[b] May – Aug
[c] September – December; includes hunter-killed deer only
[d] September – December; includes all mortalities

Table 5. Seasonal home range size of white-tailed deer in southwest Minnesota, 2001-2002.

Study Area	Season	50% Core Area (km^2)		95% Home Range (km^2)	
		n	$\bar{x}$	n	$\bar{x}$
Big Woods Southeast DMSU					
	Winter [a]	20	0.5	20	2.7
	Summer [b]	20	0.2	20	1.4
Prairie DMU					
	Winter [c]	37	0.8	52	5.2
	Summer [d]	93	0.3	23	2.3

[a] December - March
[b] March - December
[c] April – November
[d] November – April

Table 6. Mean seasonal migration of white-tailed deer in southwest Minnesota, 2001-2002.

Study site	Spring 2001 (km) (*n*, SE)	Fall 2001 (km) (*n*, SE)	Spring 2002 (km) (*n*, SE)	Fall 2002 (km) (*n*, SE)	Pooled (km) (*n*, SE)
Lake Benton	8.5 (16, 1.2)	9.3 (10, 1.0)	9.4 (18, 1.2)	9.4 (12,1.6)	9.1 (56, 0.6))
Walnut Grove	7.8 (14, 2.2)	13.6 (8, 4.0)	13.8 (5, 4.8)	13.4 (4, 6.4)	11.0 (31, 1.8))
Redwood Falls	11.6 (12, 2.4)	11.2 (5, 4.0)	11.2 (8, 2.5)	16.7 (6, 1.8)	12.4 (31, 1.3)
All deer	8.8 (40, 1.1)	11.2 (23, 1.7)	10.8 (32, 1.20)	12.0 (18, 1.8)	10.5 (118, 0.7)

Table 7. Monthly survival rates of white-tailed deer neonates in southwest Minnesota, 2001-2002.

Year	Month	Number At-risk	Number of Mortalities	Number Censored	Survival Rate	Confidence Interval 95%)	Variance
2001	June	21	0	2	1.00	± 0.00	0.0000
	July	19	1	0	0.95	± 0.10	0.0025
	August	18	0	2	0.95	± 0.10	0.0026
2002	June	18	4	1	0.78	± 0.17	0.0075
	July	13	0	0	0.78	± 0.20	0.0103
	August	13	1	0	0.72	± 0.21	0.0112
Pooled 2001-2002	June	39	4	3	0.90	± 0.09	0.0021
	July	32	1	0	0.87	± 0.11	0.0031
	August	31	1	2	0.84	± 0.12	0.0036

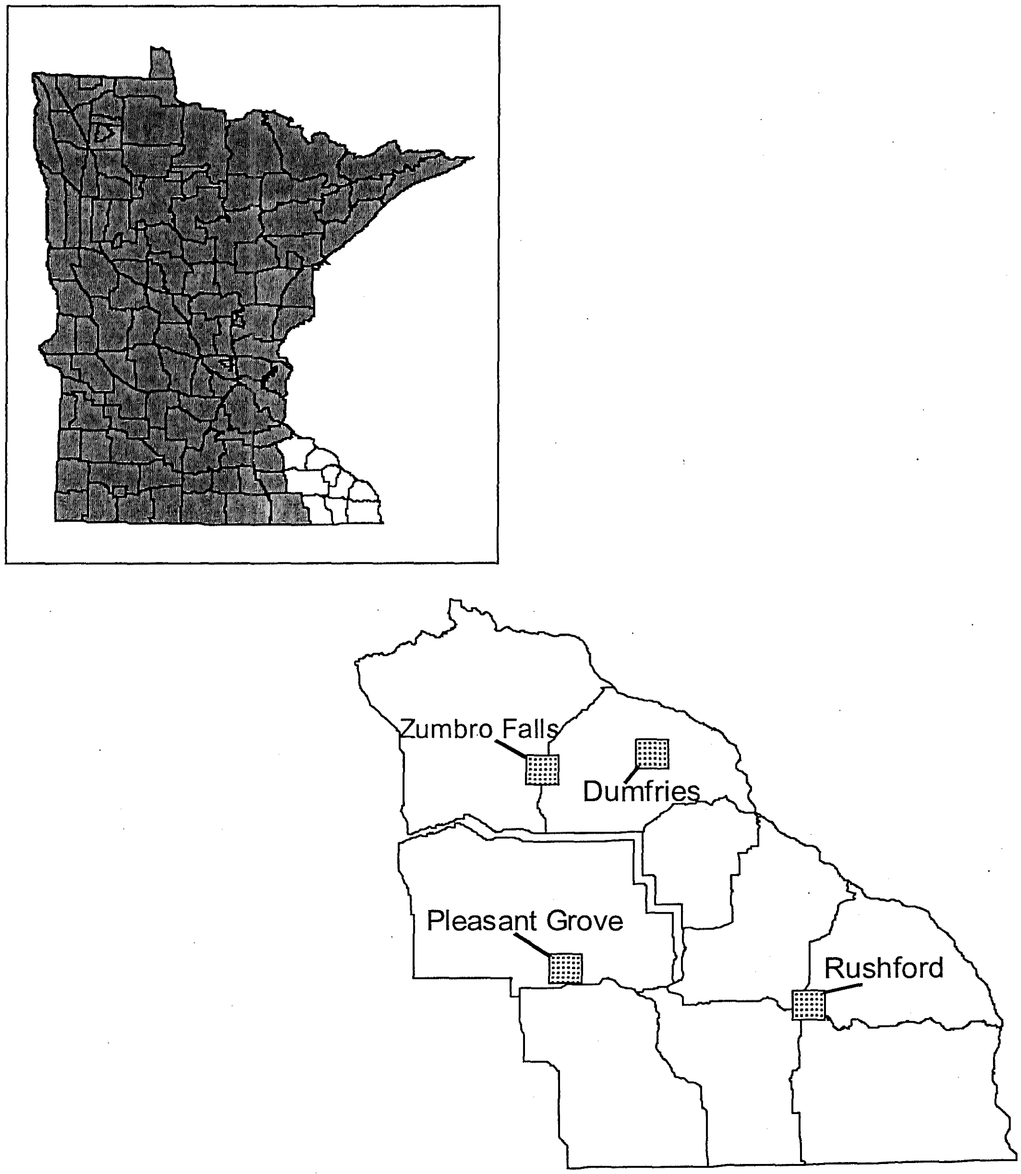
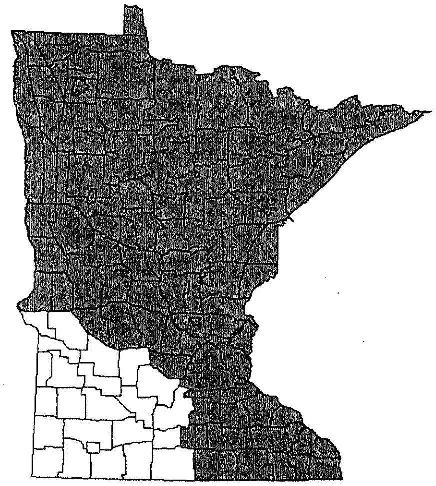


Figure 1. Southeast Minnesota Permit Areas and study sites, 2000-2003.



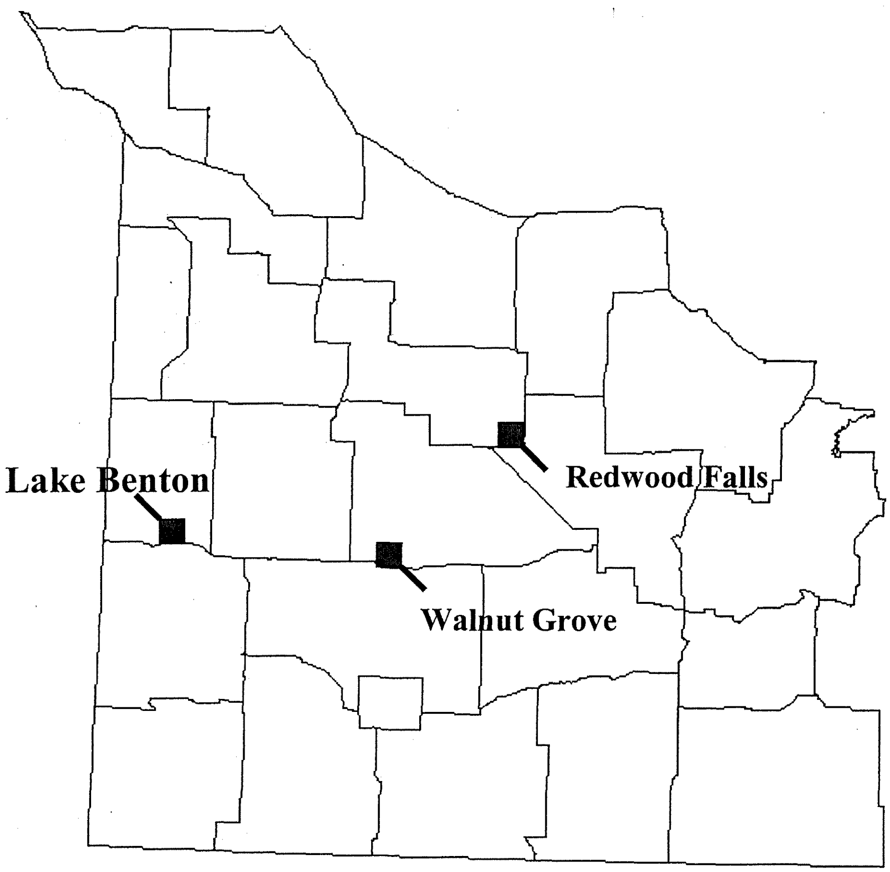


Figure 2. Southwest Minnesota Permit Areas and study sites, 2001-2003.

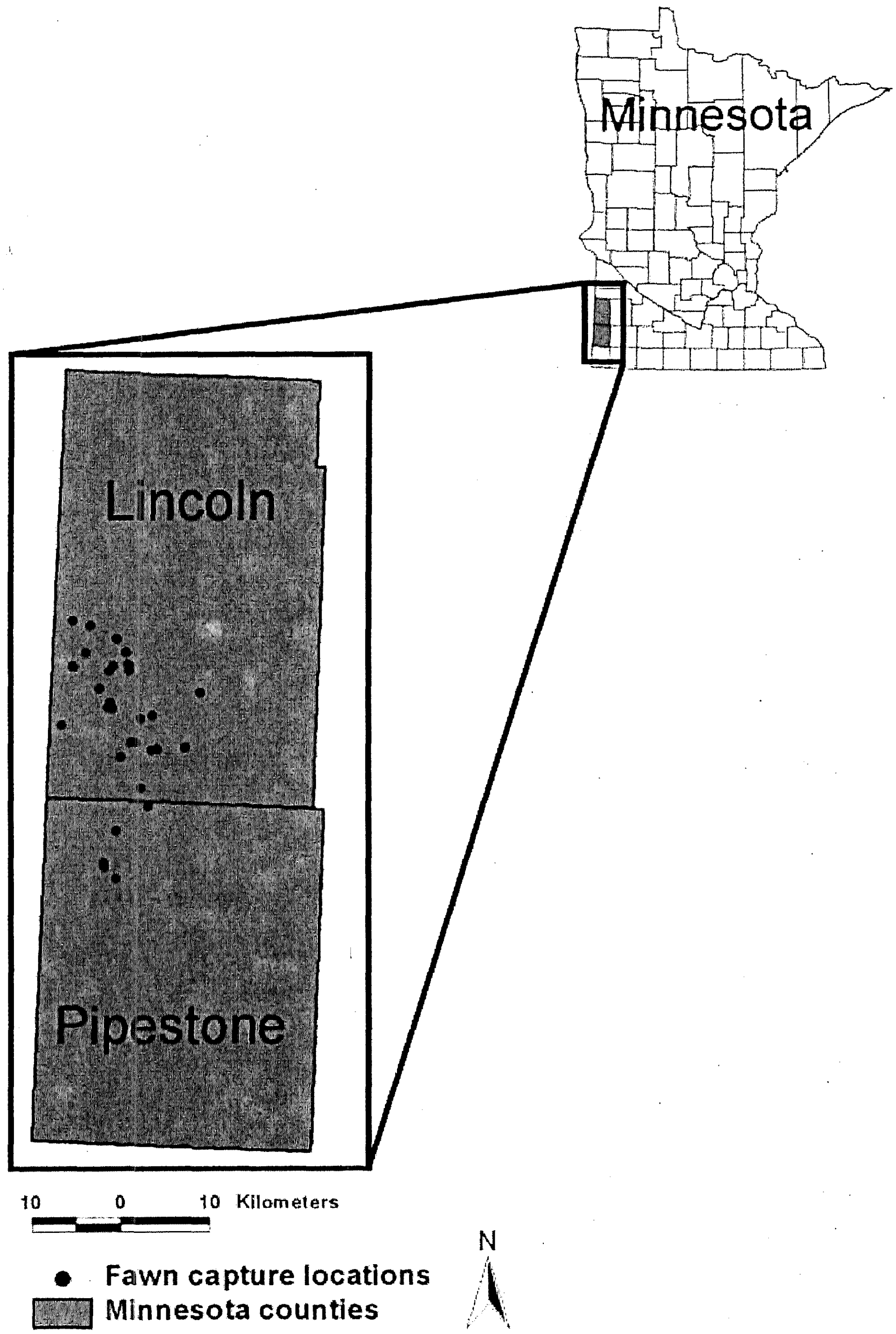


Figure 3. White-tailed deer neonate study area and capture locations in southwest Minnesota, 2001-2003.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES CWD SURVEILLANCE PROGRAM

Jeannine Tardiff, Christopher S. DePerno, Michael DonCarlos, Gary Hart, and John Fieberg

INTRODUCTION

Chronic Wasting Disease (CWD) is a transmissible spongiform encephalopathy (TSE) that affects elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*Odocoileus virginianus*) (Spraker et al. 1997, Miller et al. 2000). TSEs are infectious diseases that alter the morphology of the central nervous system, resulting in a "sponge-like" appearance of this tissue (Williams and Young 1993). An infectious protein or "prion" is believed to be the etiological agent of CWD. A healthy animal exposed to these prions may develop CWD (Miller et al. 1998); however, precise mechanisms and rates of CWD transmission are poorly understood.

CWD was first recognized in 1967 by researchers studying captive mule deer and in 1978 in captive white-tailed deer and elk (Williams and Young 1980). CWD has been diagnosed in captive cervid populations from Nebraska, Oklahoma, Kansas, Montana, Colorado, Wyoming, South Dakota, Wisconsin, and Minnesota, USA, and Alberta and Saskatchewan, Canada (United States Animal Health Association 2001, Canadian Food Inspection Agency 2002). Within wild populations, CWD was historically confined to free-ranging deer and elk in the endemic area of northeast Colorado and southeast Wyoming (Miller et al. 2000, Williams et al. 2002). However, recently CWD has been detected west of the continental divide in Colorado and within wild deer populations of Nebraska, Wisconsin, Illinois, South Dakota, Utah, and New Mexico. (Chronic Wasting Disease Alliance, www.cwd-info.org, 2003.) Generally, wild cervid CWD occurrences outside the endemic area have been located in close proximity to captive cervid facilities with past or present infected animals except for four positive deer located at White Sands Missile Base, New Mexico. (Chronic Wasting Disease Alliance, www.cwd-info.org, 2003.)

Incubation time of the disease, from infection to clinical signs, is a few months to approximately 3 years; clinical signs may include a loss of body condition and weight, excessive salivation, ataxia, and behavioral changes; and there is no known cure for the disease. (Williams and Young 1980, Spraker et al. 1997, Miller et al. 1998).

Public health officials and the Center for Disease Control in Atlanta, Georgia, have found no link between CWD and any neurological disease in humans. (Chronic Wasting Disease Alliance, www.cwd-info.org, 2003.) Furthermore, there are no reports of CWD natural transmissions to animals other than deer and elk. Experimental and circumstantial evidence suggests that transmission of the disease is primarily through direct contact with infected animals (Miller et al. 1998). However, because of the possibility of persistence of the prion in the environment, transmission from a contaminated environment may be possible.

Wildlife disease control strategies must be based on an understanding of specific disease etiology and epidemiology, and most infectious diseases are extremely difficult to eliminate from wild populations once established. Because the epidemiological attributes of CWD remain nebulous, Minnesota Department of Natural Resources (MN DNR) is attempting to acquire all available information about CWD and effective control strategies primarily by assessing the progress of the disease in other states and observing the outcomes of selected management alternatives. Given the extended incubation period associated with CWD, the apparent capacity for horizontal and vertical transmission, and the unknown contributions from environmental contamination, it is imperative that CWD be identified, isolated, and controlled as rapidly as possible following detection within a population.

In response to the discovery of CWD in wild Wisconsin deer and a Minnesota captive elk herd in 2002, MN DNR developed a comprehensive wild deer CWD monitoring program that included surveillance of targeted animals (e.g., suspect or potentially sick deer exhibiting clinical signs or symptoms consistent with CWD), opportunistic surveillance (e.g., vehicle-killed deer), and surveillance of hunter-killed deer.

HUNTER-KILLED DEER SURVEILLANCE METHODS

Sampling Areas

During the 2002 Minnesota deer hunting seasons, 16 sampling areas consisting of 17 Deer Management Areas (DMA) were selected for CWD monitoring of hunter-killed deer (Fig. 1). Sampling areas were selected based on the following criteria: 1) proximity to cervid farms with known or suspected CWD positive animals, 2) proximity to CWD infected states, and 3) a statewide distribution. Due to the extended incubation period of CWD, deer ≥ 1.5 years of age were selected, and because there are no apparent differences in susceptibility to CWD between the sexes, an attempt was made to collect samples equally across sex classes. To optimize time spent collecting samples, collections occurred primarily during the Minnesota firearms deer season. All samples were voluntarily submitted by hunters.

Sample Size and Distribution

Using power analysis, sample sizes for each sampling area were determined to ensure a ≥ 95% probability of detecting the disease, given a 1% infection rate (assuming a random distribution of the disease among individuals within each sampling area). Approximately 300 deer were needed in each sampling area to detect an infection rate of 1% with 95% confidence (Table 1). All sample locations were mapped.

Deer Head Collection

During the 2002 Minnesota firearms deer season, 100 registration stations within selected DMAs were staffed for sample collection. Staff were trained and provided equipment to collect hunter data and to remove deer heads. Hunters were interviewed and data collected, including the DMA where the deer was harvested, the specific harvest location, hunter contact information, and MN DNR number. Additionally, the age of the deer was estimated. Deer heads were removed 6-8" below the base of the skull using scalpels. All heads were given a ID number, individually bagged, and transported with data sheet to "extraction" sites.

Brain Sample Extraction

Eleven "extraction" sites were established to collect brain samples from deer heads. Fifty-seven DNR Wildlife research staff and veterinary/graduate students were trained to extract the brain stem and obex. The process entailed cutting between the occipital condyles and the atlas of the vertebral column. Once removed, the brain stem was trimmed and the obex was fixed in a 10% buffered formalin solution. Adjacent brain stem material was frozen and stored in whirl-pak bags. All samples were labeled with the same ID number previously assigned to the deer head.

CWD Testing

All samples were transported to the Farmland Wildlife Population and Research Station in Madelia where they were inventoried, entered into a database, and shipped to the University of Minnesota Veterinary Diagnostic Laboratory for immunohistochemical (IHC) testing of the obex tissue for the presence of the abnormal prion protein.

RESULTS

CWD Surveillance

No positive results were detected in the 4533 usable samples collected from the selected sampling areas (Table 2). Females and males comprised 40% and 60% of the samples. Five percent (200) of the total samples (4733) were unusable. Assuming that the samples were randomly collected from each DMA (see FUTURE OBJECTIVES, Spatial Analysis, below), preliminary results indicate that CWD infection rates ≥ 1% would have been detected in 7 of 16 sampling areas with ≥ 95% confidence, in 4 areas with 92-95% confidence, and in 5 areas with 70-89% confidence.

Spatial Analysis

Distribution maps for every sampling area (Fig. 2) will be analyzed according to the quadrat-based method (see Future Objectives).

FUTURE OBJECTIVES

Spatial Analysis of 2002 Surveillance Samples

Preliminary calculations of confidences of CWD detection at the 1% infection rate presumed that samples were randomly collected from each DMA and that deer density was uniform within each DMA. Both of these assumptions were likely false to some extent. To assess the degree to which the collected samples were representative of the white-tailed deer populations in each DMA, the distribution of samples will be analyzed to determine the degree of spatial clustering among samples and to look for habitat characteristics associated with clusters. Landscape data will be derived from GAP (Gap Analysis Program, USGS) data.

Two quadrat-based methods will be used to assess the degree at which hunter-harvested CWD surveillance sampling departs from "complete spatial randomness" (csr), where csr is defined by a uniform probability distribution over the entire sampling area. The methods will be applied separately to data collected at the following spatial scales: sections (1 square mile), quarter-sections, and 40-acre parcels (Cressie 1993).

2003 Surveillance

For 2003, the MN DNR plans to expand surveillance to cover 41 sampling units across the state. The plan is based upon a blocking protocol that will enable greater utilization of personnel and result in a more efficient approach to surveillance testing. The plan calls for 5 regional blocks within the state (Fig. 3). Sampling areas, modeled deer population size, and the number of samples necessary to detect CWD at an infection rate of 1% with 95% confidence were determined similar to 2002 (Table 3). Sampling units are prioritized in a hierarchical manner, based upon disease and exposure risk assessment. Medial retropharyngeal lymph nodes will be sent for CWD testing. ELISA testing of medial retropharyngeal lymph node tissue will replace immunohistochemical (IHC) testing of obex tissue. This will enable greater testing capacity, as well as lower per sample costs, without adverse effect upon sensitivity or specificity of the testing procedure.

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Table 1. 2002 CWD Sampling Areas sampled and the sample size required to detect an infection rate of 1% with 95% confidence.

Sampling Area (DMA)[1]	Modeled Pre-Fawn Population Size	CWD Sample Size
154	14459	295
175	15192	295
181/199	13117	295
221	6034	291
227	7504	292
247	13740	295
284	32151	297
341	6354	291
342	5209	290
345	4238	288
346	5997	291
410	9794	294
415	5335	290
417	6948	292
427	2343	280
451	2198	279

[1]Deer Management Area

Table 2. Summary of samples collected by CWD sampling area. Sample numbers include all sample types (i.e., hunter killed, suspect, opportunistic).

Sampling Area (DMA)	Total # of Samples Collected	Total # of Usable Samples	CWD Not Detected	Positive	Unusable	Total # Usable Samples Female	% Usable Female	Total # Usable Samples Male	% Usable Male	Total % Unusable	Confidence Interval 1% Infection Rate
154	663	648	648	0	15	327	50.46%	321	49.54%	2.26%	99.80
175	325	311	311	0	14	78	25.08%	233	74.92%	4.31%	95.50
181/199	336	321	321	0	15	86	26.79%	235	73.21%	4.46%	96.00
221	308	303	303	0	5	131	43.23%	172	56.77%	1.62%	95.50
227	284	268	268	0	16	96	35.82%	172	64.18%	5.63%	93.50
247	305	288	288	0	17	141	48.96%	147	51.04%	5.57%	94.50
284	341	334	334	0	7	154	46.11%	180	53.89%	2.05%	96.50
341	234	218	218	0	16	86	39.45%	131	60.09%	6.84%	89.00
342	194	182	182	0	12	89	48.90%	93	51.10%	6.19%	85.00
345	131	128	128	0	3	55	42.97%	73	57.03%	2.29%	75.00
346	260	252	252	0	8	113	44.84%	139	55.16%	3.08%	92.50
410	375	367	367	0	8	145	39.51%	223	60.76%	2.13%	97.50
415	294	283	283	0	11	117	41.34%	166	58.66%	3.74%	94.50
417	326	313	313	0	13	124	39.62%	189	60.38%	3.99%	96.00
427	142	126	126	0	16	37	29.37%	89	70.63%	11.27%	70.00
451	215	191	191	0	24	57	29.84%	134	70.16%	11.16%	86.00
TOTAL	**4733**	**4533**	**4533**	**0**	**200**		**39.52%**		**60.47%**	**4.79%**	

Table 3. Proposed 2003 CWD sampling areas and sample size required to detect an infection rate of 1% with 95% confidence (98% confidence in combined Deer Management Areas)

Sampling Area (DMA)	Modeled Pre-Fawn Population Size	CWD Sample Size
Block 1		
115	29952	297
116/122/126/127	10440	382
178	13904	295
180	10590	294
Block 2		
201/204	5523	376
206	2920	283
202/203/208	4443	373
207/404	3726	370
209/210/285	5010	374
401/403	3666	369
405	2289	279
406	2478	281
Block 3		
248	4260	288
411	7960	293
412	9296	293
413	6955	292
414	6071	291
416	3264	285
422/423	3770	370
424/431	3751	370
433/446/447	7882	380
425/435	4382	372
Block 4		
223/224	5440	376
228	3555	286
235/236	8718	381
337/338/339	5442	376
418	5548	290
419/429	4083	371
426	2087	278
427	2343	280
428	2640	282
Block 5		
341	6354	291
342	5209	290
343/465	9461	381
344	3250	285
345	4238	288
346	5997	291
347/467	8501	380
348	5478	290
349	7773	292
462	3036	284

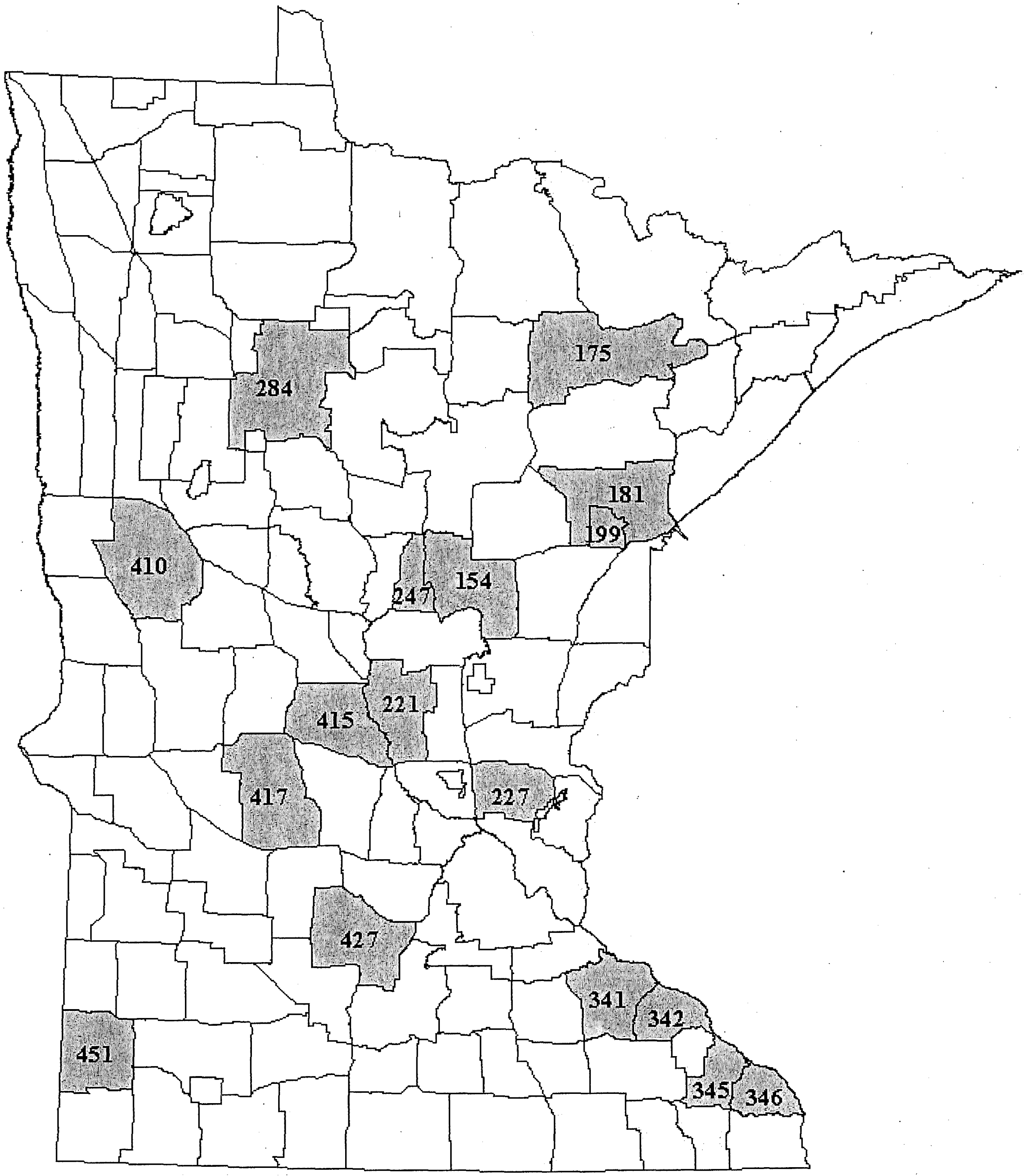

Figure 1. 2002 Chronic Wasting Disease sampling areas denoted by Deer Management Area.

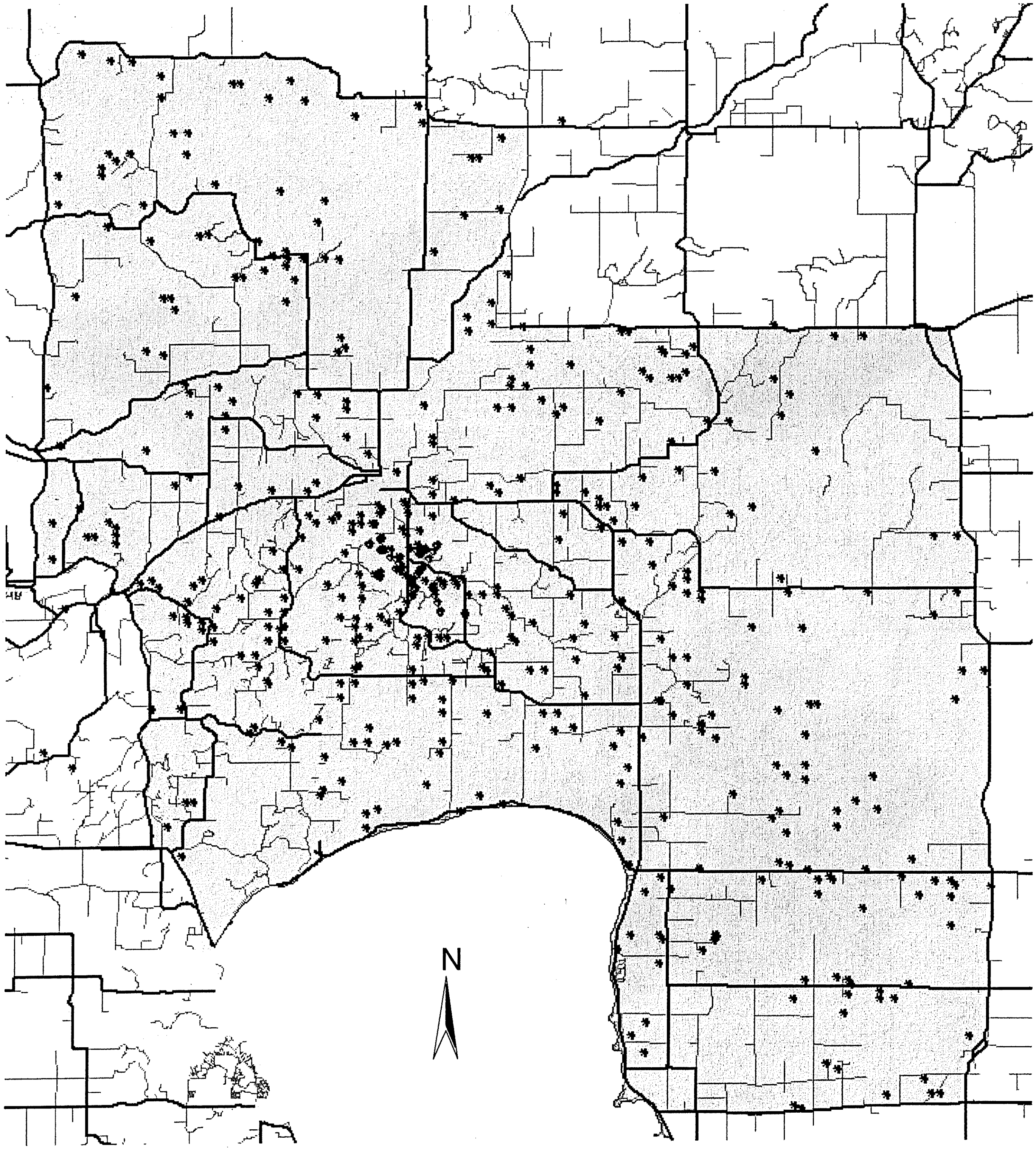

Figure 2. CWD Sampling Area 154. Points denote harvest locations of deer tested for CWD.

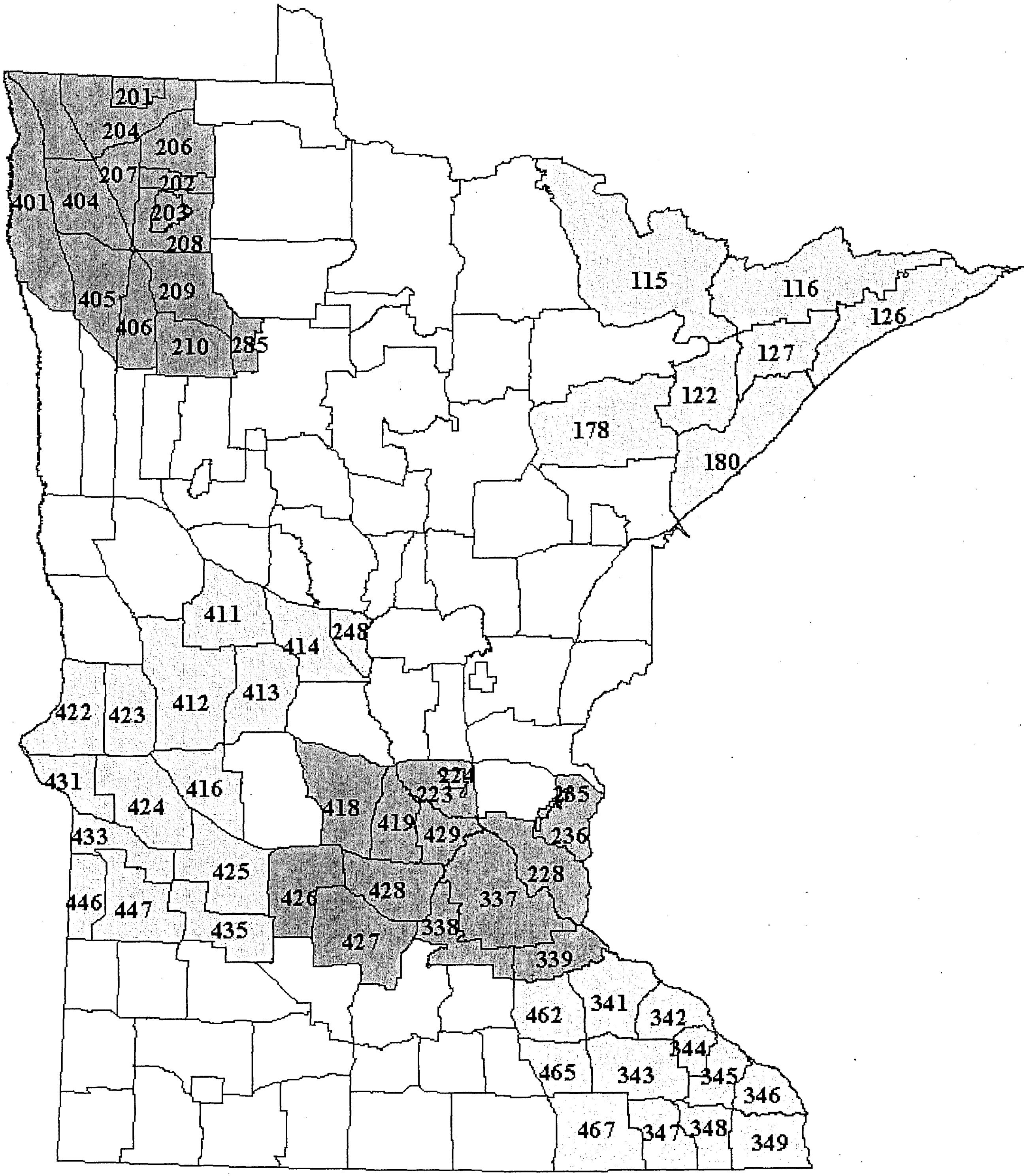

Figure 3. Proposed CWD sampling areas for 2003. Areas are divided into blocks for collection and mapping purposes

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SURVEYING WHITE-TAILED DEER FAWN SURVIVAL AND ITS RELATIONSHIP TO WINTER SEVERITY AND NUTRITIONAL CONDITION OF THEIR DOES

Michelle Carstensen and Glenn D. DelGiudice

The primary objective of this study is to survey survival of free ranging, white-tailed deer (*Odocoileus virginianus*) fawns and examine its relationship to winter severity, nutritional restriction (i.e., dietary), and condition (i.e., body composition) of the does during the prior winter. A principal question concerns how variable fawn survival is among years and whether their survival rate is predictable relative to severity of the winter previous to their birth. A secondary objective is to examine physiological responses of deer to natural, winter nutritional restriction and deteriorating body condition through *in vivo* body composition techniques, as well as by blood and urine analysis, relating patterns of winter nutritional restriction and condition to subsequent reproductive success.

BACKGROUND

Winter Nutritional Condition of Does and Survival of Fawns

Winter in northern Minnesota (Nov-Apr) is the most nutritionally challenging season for white-tailed deer, which can strongly impact their population dynamics through altered survival and reproductive success. The study of seasonal changes in nutrition and physical condition of deer and other cervids has received increasing effort involving both captive and free-ranging animals. Investigators have studied numerous indices of nutritional status, but there is almost no information on the specific changes of complete body composition of *free-ranging* animals relative to nutritional restriction.

Previous studies have addressed the general relationship between nutritional restriction and reproductive success of deer and other cervids. However, the majority of these data have been collected on captive animals, thus excluding, and possibly overlooking, the critical influences of *natural* energy and activity budgets and *natural* diets on assessed responses. Researchers have attempted to elucidate the relationship between fat reserves (and range quality) and fertility of free-ranging cervids, but information relating body composition to reproductive success is scant. According to studies on captive white-tailed deer, does fed a low plane of nutrition (similar to what might be expected during a severe northern winter) had fewer incidences of twinning, lower fawn birth weights, and longer gestational periods. There is evidence that a critical minimum weight and/or fat content of the mother at parturition is vital to the survival of offspring. Less is known about the effect body protein depletion may have on the reproductive success of deer.

Further, little research has included examination of the potential effects of environmental variation, particularly winter severity, on body composition and reproductive success of does, as well as the subsequent survival of their fawns. Such studies of reproductive performance and survival provide insights concerning the influence of individual characteristics (age, condition) and extrinsic factors (resource availability, weather) on reproductive success of individuals and on explaining variation of productivity of populations. In this study, we closely examine the relationship between winter severity, nutritional restriction, body composition and reproductive success of free-ranging female white-tailed deer, and survival of their fawns.

STUDY AREA

The study area for this research consists of 4 trapping sites (located between 46°52' and 47°15'N latitude and 93°45' and 94°07' W longitude) along the eastern and southern boundaries of the Chippewa National Forest in north central Minnesota. The sites range in size from 10 to 19 km^2. The physiography and habitat of these sites are very similar. Topography is undulant with elevations of 400-475 m. Deciduous and mixed coniferous-deciduous stands are associated primarily with the uplands, and conifer swamps predominate in the lowlands.

METHODS

Weather Data Collection

As part of a larger deer/winter thermal cover study (see DelGiudice, this Research Summary), winter severity is being assessed by daily measurements of minimum and maximum ambient temperatures in openings (i.e., forest clearings) and dense conifer stands on the study area. Snow depth and penetration (index of snow density) are being measured to the nearest centimeter in 27 locations (3 measurements along each of 3 transects in openings, mixed hardwood and dense [≥70% canopy closure] conifer stands) on the study area.

Deer Capture, Handling, and Body Composition Determination

During each of 5 winters (1998-99 to 2002-2003), adult (≥1.5 years old) female white-tailed deer and fawns (male and female) were captured by Clover traps (55) and rocket net on 4 study sites. These deer were injected intramuscularly with 1.4 mg xylazine HCl and 4.3 mg ketamine HCl per kg body mass, and handling included ear-tagging, extracting a last incisor for aging by cementum annuli, radiocollaring (primarily standard VHF collars, but some global positioning system [GPS] collars as well), weighing, blood and urine-sampling, monitoring of body temperature, and morphological measurements. During winter 1999-00, we began determining body composition (i.e., water) of does and fawns *in vivo* by intravenous injection of deuterium following a baseline blood sample; serial blood samples were collected out to 120 minutes post-injection to permit assessment of isotope equilibration. Predictive equations were employed to estimate body fat, protein, and ash. Pregnancy status of captured deer was determined in the field by portable dop-tone (Pocket-Dop II, Imex Medical Systems, Inc., Golden, CO) or visual ultrasound (Sonovet 600, Universal Medical Systems, Inc., Bedford Hills, N. Y.), and was confirmed in the laboratory by serum progesterone concentrations ≥1.8 ng/ml.

During winter 1999-00, vaginal transmitter implants (Advanced Telemetry Systems, Inc., Isanti, MN) were inserted into 3 pregnant does to evaluate their usefulness in determining when does are fawning. These implants are expelled during fawning, and the pulse rate increases from 40 to 80 beats per minute (bpm) when the transmitter is exposed to an ambient temperature < 95°F.)

Because we had successful outcomes with 2 of the 3 does (1 implant malfunctioned and was expelled prematurely), during winters 2000-01 and 2001-02, we inserted vaginal transmitter implants into 50 pregnant does. All immobilizations were reversed by intravenous injections of 0.2 mg/kg yohimbine HCl.

Analytical Procedures

Blood samples are being analyzed in the laboratory for deuterium concentration. Extensive profiles of blood (hematology; serum chemistries, electrolytes, metabolic and reproductive hormones) and urine (urea nitrogen, creatinine, potassium, sodium) specimens were determined to assess each animal's overall health and metabolic status. Additionally, urine samples are being analyzed for 3-methylhistidine and allantoin as indicators of muscle protein catabolism and digestible energy intake, respectively.

Survival and Reproductive Success

Constriction of spring-early summer home ranges (1999-2002) or change in pulse rate of the vaginal transmitter implants (from 40 to 80 bmp) of does was used to determine if they had fawned. Neonates were captured, aged (in days) by hoof growth, weighed, blood-sampled, radiocollared, and released. Survival of all radiocollared fawns was monitored daily during the summer and 2-3 times per week throughout the following year via mortality switches built into the radio collars (Advanced Telemetry Systems, Inc., Isanti, MN). All deer mortalities were investigated immediately by a field crew to determine cause of death.

STUDY PROGRESS

Newborn Fawn Capture (1997-2002) and Mortality

During springs 1997, 1999, and 2000, a total of 28 neonates were captured and radiocollared. The overall fawn mortality rate was 19% by 4 weeks and 31% by 8 weeks of age. Forty-six percent of all captured fawns survived beyond 6 months of age. Predation was the proximate cause of all neonate mortality (excluding 2 stillborns). Wolves (*Canis lupus*) and black bears (*Ursus americanus*) accounted for at least 3 neonate deaths in this study; however, this may be underestimated, because a specific species of predator could not be identified for the majority of predator-related kills (4 of 7). Because there is minimal carcass evidence remaining by the time a fawn mortality is investigated, and the site evidence is less obvious compared to kills made during months with snow cover, determination of the cause of death or the species of predator can be difficult.

In early May 2001and 2002, a total of 38 of 50 does (76%) with vaginal implant transmitters fitted during the previous winter were monitored daily for a change in pulse rate (from 40 to 80 bpm) indicating the implants were expelled during parturition. We were unable to monitor 12 implanted does by fawning season due to premature expulsion of the implant (2 does in 2001) or predation of the doe (3 and 7 does in 2001 and 2002). Seventy-four percent of the 38 implants active and monitored beginning in early May led to the capture of 41 neonates (20 and 21 in 2001 and 2002). In addition to the capture of neonates, 31 birth-sites were discovered (17 in

2001 and 14 in 2002). With a technical advancement built into the implant, we were able to document the exact time of parturition for 13 does in 2002; the majority of births (70%) occurred during 1200-1800 hours. We found that the use of vaginal implant transmitters markedly increased our ability to efficiently and successfully locate and capture neonates; however, we also discovered that the implants could be problematic (i.e., including battery failure, fluctuating signals, and monitoring schedules).

Using doe behavior as an indicator of parturition, 25 additional neonates were captured during springs 2001 and 2002. The mean date of birth was 26 May (± 1.6 [SE] days, range = 16 May-19 June) for neonates captured in 2001 and 2002. Overall mean birth weight of the neonates was 2.8 kg ± 0.1 kg in 2001 and 2.9 kg ± 0.1 kg in 2002. Neonate mortality ranged from 16-20% by 2 weeks, 19-26% by 4 weeks and 33-39% by 12 weeks of age. Causes of mortality were predator-kills (24) and unknown causes (3). Predators were responsible for 86% of the neonate mortality, which included kills by black bears (9), bobcats (9), wolves (1), red foxes (1), and unknown predators (4). The mean age of neonates killed by black bears and bobcats was 25 ± 7.0 and 32 ± 5.6 days respectively.

During spring 2001, we began investigating the importance of fawning site characteristics (e.g., vegetative cover, predator pressure) and spatial relationships between does and their newborns to overall fawn survival. Little is known about birth-site selection by does in northern Minnesota. Location of birth-sites may affect neonatal mortality, particularly relative to the risk of predation. Frequency and duration of contact between does and their fawns may be related to the fawn's vulnerability to predators, and the level of predator pressure could influence doe-fawn spatial relationships. To gain a better understanding of doe-fawn behavior and ultimately fawn survival, we began to characterize birth-site habitats and assess the spatial relationships between doe-fawn pairs from parturition to 2-3 weeks after their birth, which is typically how long it takes for fawns to be moving together with their does. Aerial photographs were taken to allow macro-habitat characterization of the 31 birth-sites identified. Additionally, 8 doe-fawn pairs were intensively located from parturition to at least 2 weeks after birth.

Deer Capture and Determination of Body Composition (January-March 2001 and 2002)

Winter 1999-00 was mild with a winter severity index of only 45. Consequently, mean total body fat of does was 77% higher ($P < 0.01$) during mid-winter 2000 (19.7 $\pm$ 3.1%) compared to mid-winter 1997 (11.1 $\pm$ 2.3%), which was historically severe (WSI = 160). Weather conditions during winter 2000-01 were also severe (WSI = 153). We had about 200 deer captures during this winter of relatively high deer densities on the study sites. Body composition of 52 deer (25 adult females, 17 male fawns, 10 female fawns) was determined using the deuterium-oxide dilution technique. Subsequent laboratory analyses of the serial blood samples collected will allow determination of total body water, fat, protein (mostly muscle), and mineral contents.

Additionally, 5 deer (2 adult females, 1 female fawn, 2 male fawns) were euthanized following completion of the deuterium-dilution protocol to allow for direct chemical analysis of body composition. In October 2001, both carcass and noncarcass components were ground and homogenized. Subsamples of the homogenized mixtures will be analyzed for dry matter (water derived), crude protein (macro-Kjeldahl N x 6.25), ash (combustion at 600°C for 12 hours), and fat (ether extract). Predictive equations derived from this chemical analysis will be used to validate the accuracy of deuterium-derived determinations of body composition.

In late February 2001, 2 additional techniques for estimating body condition efficiently were incorporated into the study. Rump fat was measured with a portable real-time ultrasound device (Sonovet 600, Universal Medical Systems, Bedford Hills, NY). Previous studies using this technique to estimate body fat on cervids have reported encouraging results. This study will be the first to use ultrasonography on white-tailed deer. Secondly, a body condition scoring (BCS) system was implemented. This involves palpation of the withers, rib and rump areas to assess deer condition. The value of both ultrasonography and BCS will be evaluated as this study progresses.

During winter 2001-02, body composition of 31 deer (17 adult females, 5 male fawns, 9 female fawns) was determined using the deuterium-oxide dilution technique. Additionally, 24 deer (14 adult females, 3 male fawns, 7 female fawns) were scored with the BCS technique, and rump fat was measured by visual ultrasound on 13 deer (6 adult females, 2 male fawns, 5 female fawns). Eight deer (3 adult females, 2 male fawns, 3 female fawns) were euthanized following completion of the deuterium-dilution protocol and assessments by BSC and ultrasound to allow direct chemical analysis of body composition.

Two additional deer (2 adult females) were euthanized following completion of the deuterium-dilution protocol, BCS and ultrasound measurements during winter 2002-03. These deer were added to the study to improve the sample size of adult females for chemical analyses of body composition ((n = 7 adult females and 8 fawns). Presently, laboratory analyses of the carcass tissues have been completed for 13 of the 15 euthanized deer.

UNDERSTANDING CHRONIC WASTING DISEASE (CWD)

AND

CWD MANAGEMENT PLANNING BACKGROUND:

AN UPDATE

December 9, 2002

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EXECUTIVE SUMMARY

The primary purposes of this document are:

1) to provide a thorough understanding of chronic wasting disease (CWD), its distribution nationwide, and circumstances in Minnesota that make the state vulnerable to the threat of CWD infection; and

2) to *outline* the Minnesota Department of Natural Resources' (MNDNR) comprehensive management approach to reduce the threat to free-ranging and game farm captive cervids (elk and deer) and to effectively manage against CWD should it emerge within the state.

This document outlines the MNDNR's CWD management programs for free-ranging deer and elk. It also discusses potential approaches for improving regulation of captive cervid facilities, including correcting current weaknesses in the statutes or rules regulating elk and deer game farms registered with the MNDNR. A more detailed CWD Contingency Management Plan has been prepared and is reported separately.

As background and to further facilitate a thorough understanding of CWD and the complicated management challenges it poses, the following appendices are included:

Appendix A. Brief review of what is currently known and unknown about CWD;
Appendix B. Current status reports that describe aspects of other states' regulation and management of captive cervids and CWD monitoring and management;
Appendix C. Description of the Minnesota Board of Animal Health's (BAH) CWD Surveillance Program, initially designed primarily for captive elk;
Appendix D. Description of a proposed National CWD Surveillance Program;
Appendix E. Documents addressing the position of the Minnesota Pollution Control Agency on deer and elk carcass disposal relative to CWD.
Appendix F. Evolution of cervid import requirements for Minnesota (BAH) relative to CWD.

Chronic wasting disease is an infectious neurological disease that naturally occurs in North American deer and Rocky Mountain elk and belongs to the group of infectious diseases known as transmissible spongiform encephalopathies (TSEs). Chronic wasting disease is a progressively fatal disease with no known immunity, vaccine, or treatment. There is no evidence linking CWD to neurological disorders of humans. The first cases of CWD were detected in captive deer and elk in the late 1960s-1970s, but it was not until the mid 1980s to early 1990s that additional infections drew the attention of the scientific and management communities.

Chronic wasting disease has been detected in both captive and free-ranging deer and elk in other states. During August 2002, CWD was diagnosed in 1 captive elk in Minnesota, but it has not been detected in either captive deer or free-ranging deer or elk in the state.

Management of CWD is complicated by a number of factors. Much about CWD remains unknown or poorly understood. Clinical signs of the disease may not become apparent for 18-36 months (*incubation period*), during which time the animal is potentially infectious to other cervids. And, until recently, there has been no live-animal test for detecting the disease. Research has been demonstrating the potential of CWD-testing of biopsied tonsils and certain lymph nodes (e.g., retropharyngeal) of deer, which would find its most practical application with captive animals.

Management has been further complicated by the fact that legal responsibilities for managing captive deer and elk have either been unclear, or divided between government agencies. Frequently, regulation and enforcement capacities and abilities vary between agencies. The numbers of captive cervid operations and animals, financial investments, and the intra- and interstate movement of captive elk and deer also vary markedly between states.

There are 229 captive elk herds and 16 combination elk/deer operations registered with the Minnesota BAH, accounting for approximately 11,690 elk. This is more captive elk than in any other state, with the possible exception of Colorado. There are also 43 captive deer and 10 "other" cervid herds registered with BAH. Since 1998, there has been at least a 45% increase in cervid herds registered with the Minnesota BAH. In addition, 43 elk herds (total of 600-650 elk) and 345-360 white-tailed deer herds (total of 4,000-4,500 deer) are present on MNDNR-licensed game farms.

In 1999, the BAH developed a *voluntary* state CWD Surveillance Program, primarily for elk. Currently, 213 captive cervid herds (71.5%) of 298 operations registered with the BAH are enrolled in the program, which includes 9,926 elk (84.9%), 1,028 deer (66.1%), and 202 other cervids (67.1%). This program requires that all cervids older than 16 months of age that die or are destroyed must be tested for CWD. Further, rigorous annual inventories must be conducted, operations must comply with importation restrictions, and advanced herd status is achieved with the number of years participating operations remain CWD-free. (The BAH would prefer that the program be *mandatory* for all captive cervid operations, but currently, funds and personnel are insufficient to operate the program at that scale.)

Captive elk and deer operators in Minnesota, whether registered with the BAH or MNDNR, must request an importation permit from the BAH (see Appendix E). On 17 December 2001, the BAH approved specific restrictions on the importation of *elk only* due to the health threat posed by CWD to Minnesota livestock. In early March 2002, shortly after the report of 3 CWD-infected free-ranging deer in Wisconsin, the Minnesota BAH approved new restrictions on *all cervid* importation. *No deer or elk* originating from an area considered to be endemic for CWD would be allowed into Minnesota, and none can be imported from a herd that is infected or exposed to CWD, until that herd has been cleared to the satisfaction of the Board. *All imported elk* had to be from a herd that has been participating in a state-recognized CWD Surveillance Program for at least one year. As of May 2002, *all imported cervids* require an import permit issued by the BAH, a Certificate of Inspection, and individual identification. Related to CWD, *all cervids*, including animals imported for slaughter purposes, must be from herds under a state approved CWD surveillance program for *at least 3 years*. Further, no import is permitted if it is from a location that occurs on an expanded list of CWD endemic areas.

For more than a year, the MNDNR has been conducting targeted surveillance, wherein brain stems of about 43 "suspect" deer (those exhibiting clinical signs that may be consistent with CWD or that died of unknown causes) were collected and CWD-tested. Additionally, during the fall 2001 season, brain stems were collected from 43 hunter-harvested deer in southern Minnesota and tested for CWD. The results of all tests were negative. During September 2002, the MNDNR established a surveillance area surrounding the captive elk facility where a CWD(+) bull was reported on 29 August 2002. The purpose of this area was to test free-ranging deer to determine if any had been infected by CWD. Primarily within this area, 111 killed deer culled primarily by MNDNR sharpshooters, were tested for CWD. Presently, IHC-test results have been received for 69 brain stems, and all were negative.

The MNDNR has developed a CWD Monitoring Program based on geographically-focused surveillance, which involves more generalized collection and testing of brain stems from pre-determined sample sizes of deer harvested by hunters. This program began during the Fall 2002 Deer Firearm Season and will include testing of 5,000-6,000 brain stems --- 300-500 samples randomly distributed over each of 16 pre-selected Permit Areas of the state's 130 Permit Areas, allowing detection of a 1% prevalence of CWD with 95% confidence.

The MNDNR identified a number of weaknesses in procedures, statutes and rules regulating cervids on game farms licensed by the agency. They include: (1) game farm registration records and associated data (e.g., animal inventory, annual additions to and losses from herds) were not computerized, and consequently, were not readily available for effective monitoring; (2) fencing regulations are inadequate for preventing contact between captive and free-ranging cervids; (3) escapes of captive deer or elk from game farms were *not* required to be reported; (4) there was no statutory language prohibiting the release of captive deer or elk into the wild; and (5) there are no surveillance or testing requirements for CWD.

Since identifying the above needs, the MNDNR has computerized all registration data for captive cervid operations registered with the agency. The MNDNR is working with other agencies and organizations in an attempt to comprehensively address the management of captive cervids under one uniform system. This will require a legislative initiative in the 2003 session. In the meantime, the MNDNR, in cooperation with the BAH, has begun to strengthen importation and release provisions, and to secure a source of funding for long-term CWD management through existing rule-making authorities. **Adopted in April 2002, the following outlines approved Senate and House Floor Amendments:**

1) Farmed cervidae may not be released or allowed to run at large. Cervidae that have escaped must be reported to the MNDNR within 24 hours.

2) Wild cervidae that have entered the confinement area of a farmed cervidae facility must be destroyed by the owner and be reported to the MNDNR within 24 hours of being destroyed.

3) Cervidae may not be imported into the state from a herd that is infected or has been exposed to CWD or from a known CWD endemic area, as determined by the Board. Further, the cervidae may be imported into the state only from a herd that is not in a known CWD endemic area, as determined by the Board, and from a herd subject to a state or provincial approved CWD surveillance/monitoring program for at least 3 years.

4) Fifty cents from each deer license is appropriated for emergency deer feeding and management of CWD, and this money is available until expended.

5) The MNDNR, BAH, and other interested parties shall study and make recommendations on management actions designed to protect captive and free-ranging cervidae from CWD, specifically addressing cervidae fencing requirements, disease infection prevention, criteria for quarantining or depopulating infected herds, methods of harvest, identification of cervidae, and other issues.

More stringent regulation of cervid game farms will reduce the risk of CWD infection occurring in Minnesota's captive and free-ranging cervid populations; however, some level of risk will persist. That risk, and the difficulties associated with CWD already discussed, dictated that a comprehensive management program for free-ranging cervids be formulated with expediency before emergence of the disease in Minnesota.

MNDNR's CWD management plans for free-ranging cervids include 5 essential components or objectives:

1) ongoing targeted surveillance statewide (i.e., collecting and CWD-testing deer/elk exhibiting signs which may be consistent with CWD);

2) continued implementation of the geographically-focused CWD Monitoring Program;

3) implementation of the MNDNR's Contingency Management Plan for rapidly responding to CWD should it be detected in the state;

4) conduct research on the epizootiology (i.e., population effects) and effective management of CWD; and

5) education and information-sharing with the public, constituents, MNDNR and other government agency personnel concerning CWD.

INTRODUCTION

Chronic wasting disease (CWD) is an infectious neurological disease that naturally occurs in North American deer and Rocky Mountain elk and belongs to the group of infectious diseases known as transmissible spongiform encephalopathies (TSEs). Other TSEs include bovine spongiform encephalopathy (BSE) or "mad cow disease" in cattle, scrapie in domestic sheep, Creutzfeldt-Jakob disease (CJD) and new variant CJD in humans, among others. Chronic wasting disease is a progressively fatal disease with no known immunity, vaccine, or treatment.

Chronic wasting disease infection has been detected in captive elk in Colorado, Wyoming, Nebraska, Kansas, Oklahoma, Montana, South Dakota, Saskatchewan, Alberta, and most recently in Minnesota. Further, CWD was diagnosed in captive white-tailed deer in Wisconsin during October 2002. Infections of free-ranging mule deer, white-tailed deer, and/or elk have been documented in Colorado, Wyoming, Nebraska, South Dakota, Wisconsin, New Mexico, Illinois, and Saskatchewan.

Several aspects of CWD (e.g., long incubation period) and the human market for captive elk and deer (involving intra- and interstate movement of these animals) have contributed to the high potential risk of introducing and spreading this disease and to the difficulties associated with managing it. Strict safeguards are the most effective means of preventing the establishment of this disease in Minnesota.

Management guidelines and strategies currently employed by various state and federal natural resource and agricultural agencies vary widely and are changing rapidly. Management of CWD is complicated by a number of factors. Much about CWD remains unknown or poorly understood. Clinical signs of the disease may not become apparent in a deer or elk for 18-36 months (incubation period), during which time the animal is potentially infectious to other cervids. Until recently, there has been only a post-mortem test for detecting CWD in cervids; presently, biopsy and testing of tissue from the tonsils is showing greatest potential as a live-animal test in deer, but not in elk.

Although the first cases of CWD were detected in captive deer and elk at research facilities in the late 1960s, it was not until the mid-1980s to early 1990s that additional infections drew the attention of the scientific and management communities. Management has been further complicated by the fact that legal responsibilities for regulating captive deer and elk operations have been either unclear (e.g., until about 1993 in South Dakota) or divided between agencies (e.g., Departments of Agriculture, Boards of Animal Health, and Departments of Natural Resources). Frequently, different statutes and rules apply and enforcement capacities and abilities vary across agencies. The number of captive cervid operations and animals, financial investments, and the intra- and interstate movement of elk and deer also vary markedly among states.

PURPOSE AND BACKGROUND

The primary purpose of this document is to:

1) provide a thorough understanding of chronic wasting disease (CWD), its distribution nationwide, and circumstances in Minnesota that make the state vulnerable to the threat of CWD infection; and

2) provide an outline of the Minnesota Department of Natural Resources'(MNDNR) comprehensive management approach to reduce the threat to free-ranging and game-farm captive cervids (elk and deer) and to effectively manage against CWD should it emerge within the state. It also discusses potential approaches for improving regulation of captive cervid facilities, including correcting current weaknesses in the statutes or rules regulating elk and deer game farms registered with the MNDNR. A more detailed CWD Contingency Management Plan has been prepared and is reported separately.

As background and to further facilitate a thorough understanding of CWD and the complicated management challenge it poses, the following appendices are included:

Appendix A. Brief review of what is currently known and unknown about CWD;

Appendix B. Current status reports that describe aspects of other states' regulation and management of captive cervids and CWD monitoring and management efforts;

Appendix C. Description of the Minnesota Board of Animal Health's (BAH) CWD Surveillance Program, applied primarily to captive elk;

Appendix D. Description of a proposed National CWD Surveillance Program;

Appendix E. Documents addressing the position of the Minnesota Pollution Control Agency on deer and elk carcass disposal relative to CWD; and

Appendix F. Evolution of cervid import requirements for Minnesota (BAH) relative to CWD.

MINNESOTA CAPTIVE ELK AND DEER

The scale of captive elk and deer farming, the reported incidence of CWD infection (in captive and free-ranging cervids), and state agency regulatory jurisdictions vary markedly among states (see Appendix B). While it is clear from documents and discussions with numerous government biologists, veterinarians, and administrators that states share certain management concerns and considerations relative to CWD infection, official responses have varied.

Minnesota cervid farmers have the option of registering with the state BAH or obtaining a game farm license from MNDNR. The following is a status report (as of October 28, 2002) for

Minnesota:

BAH-Registered Herds. Currently, 298 captive cervid herds are registered with the BAH, including 229 elk herds, 43 white-tailed deer herds, 16 combination elk and white-tailed deer herds, and 10 "other" cervid herds. Collectively, these herds account for 11,690 elk, 1,555 white-tailed deer, and 301 "other" cervids. There are more captive elk in Minnesota than in any other state, except possibly Colorado. Average herd size is 39 elk. Since 1998, there has been a 45% increase in cervid herds registered with the BAH.

MNDNR Game Farm Cervids. Forty-three elk herds (total of 600-650 elk) are registered with MNDNR; average herd size is 15 elk. Further, 345-360 white-tailed deer game farms that include approximately 4,000-4,500 deer, are registered with MNDNR. About 15-20 mule deer occur on these game farms.

MINNESOTA CWD STATUS

CWD-Monitoring of Captive Cervid Herds

There has been one reported (29 August 2002) case of CWD in Minnesota. It was a captive bull elk at an elk operation in Aitkin. The remaining 48 elk in the herd have since been depopulated and CWD-tested, and *all* were negative. Two additional captive elk operations (1 in Sauk Center and 1 in Sauk Rapids), where the CWD-positive bull had previously spent time, have been quarantined. Consequently, importing and exporting of elk are prohibited indefinitely while an epidemiological investigation is being conducted. Some elk from CWD-positive herds were imported into the state from Colorado in the fall of 2001, but follow-up testing of imported animals was negative. In 1999, the BAH developed a *voluntary* state Chronic Wasting Disease Surveillance Program, primarily for elk. Currently, 213 of the BAH's 298 (71.5%) cervid operations are enrolled in the BAH's CWD Surveillance Program. These operations include 9,926 elk, 1,028 deer, and 202 other cervids, which means 84.9%, 66.1%, and 67.1% of these animals are being monitored by the BAH for CWD. Importantly, the BAH would prefer that the program be *mandatory* for at least all captive elk operations; however, currently, funds and personnel are insufficient to operate the program at that scale. Presently, there is no formal surveillance program for cervids kept on game farms licensed by MNDNR, although game farms may voluntarily participate in the BAH's CWD Surveillance Program. (for more details on the Minnesota BAH and National CWD Surveillance Programs, see Appendices C and D).

CWD-Monitoring of Free-Ranging (Wild) Deer

MNDNR has been conducting *targeted surveillance* of white-tailed deer over the past year. Targeted surveillance is considered to be an effective primary initial approach to determining presence or absence of CWD statewide. Targeted surveillance involves collection and CWD-testing of "*suspect*" cervids that are exhibiting signs or symptoms of disease, particularly when consistent with CWD (e.g., emaciation, excessive salivation, tremors, lack of coordination). Those not dead when investigations were initiated were euthanized, and all had a specific portion of the brain stem (obex of the medulla oblongata) extracted for CWD-testing at the National Veterinary Services Laboratory in Ames, Iowa. Presently, 43 brain stems have been collected from suspect deer or deer that have died under unknown circumstances; all tested negative. An additional 43 brain stems were collected from deer harvested by hunters during the fall 2001 season as part of a *pilot* effort aimed at intensifying surveillance in the future. Again, all results were negative for CWD. Targeted surveillance could be expanded to include deer recently killed by vehicular collision (i.e., opportunistic surveillance).

Targeted surveillance can be augmented by *geographically-focused surveillance*, which involves more generalized collection and testing of brain stems from pre-determined sample sizes of deer harvested by hunters during the annual season. The MNDNR's new *CWD Monitoring Program*, to begin during the Fall 2002 Deer Firearm Hunting Season, will rely on this type of surveillance. A *pilot* effort was conducted during the fall of 2001, where 43 brain stem samples collected from hunter-harvested deer were tested for CWD. About half of these were from southeastern Minnesota and half were from southwestern Minnesota; all were negative for CWD. This season's (fall 2002) monitoring efforts involved collection and CWD-testing of 5,000-6,000 brain stems --- 300-500 samples randomly distributed over each of 16 pre-selected Permit Areas of the state's 130 Permit Areas. Statistically, this level of sampling should permit detection of a 1% or higher prevalence of CWD (1 or more infected deer per 100 tested) with 95% confidence. Considerations for selection of the Permit Areas monitored this year included, (1) proximity to Wisconsin and South Dakota borders and location of CWD-positive animals in those states, (2) local density of captive deer and elk operations, (3) occurrence of a CWD-positive captive elk in an Aitkin captive operation and potential exposure of other captive herds to that infected elk, (4) allowing for sampling of deer in the more northern parts of the states, (5) agency personnel and funding requirements of the monitoring effort related to statewide distribution of the actual sampling, and (6) logistical and other factors. The MNDNR's CWD Monitoring Program will be conducted as far into the future as required to thoroughly sample deer in all 130 Permit Areas of the state and determine the presence or absence of the disease, and if present, its spatial distribution and prevalence. The CWD Monitoring Program was designed with inherent flexibility to allow for contingency modifications related to CWD-test findings of the ongoing program.

During September 2002, a surveillance area was established by the MNDNR, which included approximately 9 square miles immediately surrounding the captive elk facility where a CWD(+) bull was reported on 29 August 2002. The purpose of this area was to test free-ranging deer to determine if any had been infected by CWD. Primarily within this area, 111 deer were killed by MNDNR sharpshooters, archery hunters, area landowners, and traffic accidents and tested for CWD. As of this writing, IHC-test results were received for 69 brain stems, and all were negative.

Carcass Disposal

The MNDNR is disposing of deer and elk carcasses by incineration in an air-flow incinerator and by landfilling. During September 2002, the MNDNR purchased an air-flow incinerator capable of burning carcasses at temperatures up to 2,800° F, which exceeds what is required (1,100° F) to denature the infectious abnormal prion proteins associated with CWD. Presently, the MNDNR recommends that hunters dispose of bones and other remains through rendering, burial, incineration, or landfilling. In November 2002, the Minnesota Pollution Control Agency (MPCA) recommended incineration (above 1,100°F), disposal at Lined Mixed Municipal Solid Waste and Ash Landfills, or at the SKB Rosemount Industrial Landfill as acceptable, safe, and practical alternatives for carcass disposal of CWD(+) carcasses of deer and elk. This was based on careful review of a thorough assessment of risks associated with landfilling of deer infected with CWD completed by the Wisconsin Department of Natural Resources (see the assessment at www.dnr.state.wi.us). The MPCA stated that "direct burial of deer that test positive for CWD is not appropriate." Details of the MPCA's position can be viewed in documents in Appendix E.

Also in November 2002, the federal Food and Drug Administration announced "the agency will not permit material from CWD(+) animals, or animals at high risk for CWD, to be used as an ingredient in feed for any animal species." High risk animals would include those from CWD(+) captive herds, free-ranging deer from the endemic area of Colorado and Wyoming or the eradication zone of Wisconsin, and deer or elk "from any areas designated around any new foci of CWD infection that might be identified through surveillance or hunter harvest testing."

Importation of all cervids

Captive elk and deer operators in Minnesota, whether registered with the BAH or licensed by MNDNR, must obtain an importation permit from the BAH. Importation of elk and deer requires health certificates and specific tests and clearance for tuberculosis and brucellosis. Elk must also be imported only from a herd monitored for CWD for a specified minimum length of time and may not come from a CWD endemic area for free-ranging deer and elk (as discussed below). With the increased detection of CWD across North America, requirements for cervid importation have become increasingly restrictive.

On **17 December 2001**, the BAH approved the following restrictions on importation of elk due to the health threat posed by CWD to Minnesota livestock (quoted from a BAH document, 2001):

No elk will be permitted entry into Minnesota if they originate in herds:

- located in the area of the United States where CWD is endemic in the free-ranging deer and elk,
- that have purchased elk from CWD-infected herds unless these herds are cleared to the satisfaction of the BAH,
- infected with CWD,
- that have not been in a state recognized CWD Surveillance Program for at least one year.

Further, in **early March 2002**, shortly after the report of 3 CWD-infected, free-ranging male white-tailed deer in Wisconsin, the BAH approved a new motion to strengthen restrictions on cervid importation as follows (see Appendix F):

No cervid (includes deer) originating from an area considered to be endemic for CWD will be allowed entry into Minnesota. This area includes the following states and counties:

Wyoming:	Albany, Carbon, Converse, Laramie, Platte, Niobrara, Goshen
Nebraska:	Kimball, Sioux, Banner, Scotts Bluff, Cheyenne, Deuel, Keith, Perkins, Chase
Colorado:	Boulder, Gilpin, Larimer, Weld, Logan, Morgan, Phillips, Sedgwick, Washington
South Dakota:	Fall River
Wisconsin:	Dane, Iowa, Sauk, Columbia, Juneau, Jefferson, Rock, Green, Lafayette

No cervid can be imported that is from a herd that is infected or has been exposed to CWD, or that has purchased a cervid from an infected herd, unless the herd has been cleared to the satisfaction of the Board.
All elk imported must be from a herd that has been participating in a state recognized CWD Surveillance Program for at least one year. The CWD herd number and numbers of years in the program must be written on the Certificate of Veterinary Inspection.

Effective **17 May 2002,** a*ll imported cervids* require an import permit issued by the BAH, a Certificate of Veterinary Inspection, and individual identification. Related to CWD, *all cervids*, including animals imported for slaughter purposes, must be from herds under state-approved CWD surveillance for *at least 3 years*. Cervids imported in violation of this section may be seized and destroyed by the Commissioner of the Department of Natural Resources.

Further no importation is allowed from infected or exposed herds or from the following expanded list of endemic areas:

Wyoming:	Albany, Carbon, Converse, Laramie, Platte, Niobrara, Goshen, Platte
Nebraska:	Kimball, Sioux, Banner, Scotts Bluff, Cheyenne, Deuel, Keith, Perkins, Chase
Colorado:	Boulder, Gilpin, Larimer, Weld, Logan, Morgan, Phillips, Sedgwick, Washington
South Dakota:	Fall River
Wisconsin:	Dane, Iowa, Sauk, Columbia, Juneau, Jefferson, Rock, Green, Lafayette
Saskatchewan:	Must have approval from a BAH veterinarian

Effective **14 November 2002,** the counties of Eagle, Garfield, Grand, Jackson, Larimer, Moffit, Rio Blanco, Routt, and Summitt (Colorado); Boone, Stephenson, and Winnebago (Illinois); Crawford, Grant, Richland, and Walworth (Wisconsin) were added to the endemic areas listed above from which importation of cervids is banned.

MNDNR's CWD MANAGEMENT PLAN: AN OUTLINE

Diseases such as CWD tend to be most effectively managed when efforts are applied before or as the disease emerges, rather than after it becomes established. Chronic wasting disease is an emerging disease. The current number of known infections among captive elk varies markedly among states (and Canada) and is increasing steadily with continued surveillance and investigations. Even more disturbing is the increased prevalence and geographic spread of CWD in free-ranging mule deer, white-tailed deer, and elk. Most disturbing of all is the recent discovery of CWD in free-ranging white-tailed deer in Wisconsin, approximately 700 miles east of any previously known infection. Further, the first cases of CWD in captive white-tailed deer in private/commercial operations were reported during September-October 2002.

Further, in some local areas prevalence appears to be increasing at a more rapid rate than in the past, although it is not clear whether or not this is because of increased incidence or increased surveillance, reporting, and testing. Minnesota's cervid management (MNDNR and BAH) and health agencies can learn a great deal from the knowledge gained by states with previous direct experience managing CWD and those states are being consulted in the development of Minnesota's plans.

While CWD has not been detected in free-ranging deer in Minnesota, it has been reported in bordering states to the west and east (i.e., South Dakota and Wisconsin), and as discussed above, it was recently diagnosed in a captive elk in Minnesota. Consequently, the MNDNR has developed more intensive targeted and geographically-focused surveillance plans to monitor free-ranging deer for presence of the disease and a contingency plan to guide MNDNR's response if CWD is detected here. Also, the MNDNR has been evaluating *cervid management laws, rules, regulations, and policies* for those captive and free-ranging cervids that are under MNDNR authority, to identify and assess issues and weaknesses that may be related to disease vulnerability and management. In these efforts, the MNDNR will work with other agencies and organizations (e.g., BAH, Minnesota Departments of Agriculture and Health, Minnesota Deer Hunters Association) responsible for or concerned about free-ranging and captive cervid disease management in an attempt to assure comprehensive approaches to effective management of CWD risks.

Free-Ranging Cervids

Comprehensive management plans for CWD detection in free-ranging cervids (i.e., CWD Monitoring Program) and response (i.e., CWD Contingency Management Plan) have been developed. Review of CWD management plans of other state natural resource management agencies (e.g., Colorado, Nebraska) with experience with CWD were of value in formulating these plans, and consultation with other states will continue as details are developed further. A general outline for the Contingency Plan is described below.

The MNDNR CWD management plans for free-ranging cervids include at least 5 essential components or objectives:

1) ongoing targeted surveillance statewide (i.e., collecting and CWD-testing of deer/elk exhibiting signs which may be consistent with CWD);

2) continued development and implementation of the state's geographically-focused CWD Monitoring Program involving the sampling and CWD-testing of hunter-harvested deer;

3) implementation and further development of the CWD Contingency Management Plan for rapidly responding to CWD should it be detected in the state;

4) conduct research on the epizootiology (i.e., population effects) and effectiveness of management strategies focused on CWD; and

5) education and information-sharing with the public, constituents, MNDNR and other government agency personnel concerning CWD.

Each of these general objectives is discussed in more detail below.

1) Continued Targeted Surveillance of Free-Ranging Deer Statewide

For about a year MNDNR has been collecting brain stems for CWD-testing from "suspect" free-ranging deer (i.e., deer exhibiting signs that may be consistent with CWD or that died recently under questionable or unknown circumstances). This practice has been reported by researchers in other states to be particularly useful for detecting the presence/absence of CWD in local areas statewide. MNDNR will continue testing "suspect" free-ranging deer for CWD.

2) Continued Development and Implementation of a Geographically-Focused CWD Monitoring Program for Free-Ranging Deer

A geographically-focused CWD Monitoring Program for free-ranging deer was initiated during the Fall 2002 Deer Hunting Firearm Season. It's objective involved collection and CWD-testing of brain stems from 5,000-6,000 deer harvested by hunters in 16 Permit Areas distributed around the state. Areas are selected based on a variety of criteria, which may include proximity of captive elk/deer operations, deer density, number of check stations and availability of samples, and proximity to areas where CWD has been detected (e.g., 40 CWD-infected deer recently found in Wisconsin). This type of Monitoring Program will augment the targeted surveillance in detecting presence or absence of CWD, and in determining prevalence should the disease be detected.

3) Implementation and Further Development of a Contingency Plan for Responding Rapidly and Aggressively to CWD Should It be Detected

A) Preventing the Transmission of CWD Between Captive and Free-Ranging Cervids
The potential for transmission of CWD between captive and wild cervids may be minimized by limiting private possession of deer and elk in local areas where CWD has occurred; by minimizing or eliminating the potential for physical contact between captive and wild cervids (e.g., by more stringent fencing requirements, such as double-fencing and frequent fence inspections); by immediate reporting of captive animals that have escaped or wild animals that have entered a captive facility; and by requiring captive animal CWD surveillance and reporting.

B) Limiting the Distribution of CWD in Free-ranging Deer and Elk
Chronic wasting disease may spread naturally (i.e., infectious contacts between deer), as well as by the inadvertent influence of humans (e.g., inadvertent movement of CWD-infected animals). The distribution of CWD among free-ranging cervids may be limited by: (1) preventing inadvertent movements of CWD-infected free-ranging animals, (2) reducing factors that allow increased physical contact between free-ranging and captive cervids, (3) limiting potential sources of CWD infection (e.g., hunter-harvested carcasses from CWD endemic areas), and (4) use of ongoing targeted surveillance and field investigations to detect CWD and monitor changes in prevalence and distribution

C) Reducing the Occurrence of CWD in Free-Ranging Deer and Elk
Chronic wasting disease transmission may be reduced by: (1) encouraging public reporting of suspect animals and promptly culling (killing) and testing wild deer exhibiting symptoms consistent with CWD statewide; (2) prohibiting feeding of wild cervids (include education of public on the adverse effects of feeding); (3) reducing high deer densities through increased hunting or by culling in areas where CWD has occurred; and (4) other alternative strategies developed through cooperative research and management. Alternative strategies could include integrated field and modeling efforts examining methods for monitoring population size, disease prevalence, disease and system responses to population reduction by hunting and culling.

4) Research on the Epidemiology, Epizootiology, and Management of CWD

Research of the numerous aspects of CWD that remain unknown or poorly understood is essential to assuring improved effective management of CWD in captive cervid herds and free-ranging populations. Some of the most important CWD-related topics and issues that require immediate and continued study include: determination of transmission routes, causative agent(s), and the potential of infection from environmental contamination (versus lateral animal to animal) in natural areas and captive facilities; potential for transmission to livestock, other wildlife, and humans; development of treatments and a live-test for CWD; and the potential for reclaiming captive facilities and natural areas where CWD infection has occurred.

Knowledge gained from study of the relationships between deer densities, migration and dispersal, winter severity and nutritional condition to susceptibility of animals to CWD infection, transmission rates, and disease distribution will be critical to future management. Increased understanding of the influence of CWD prevalence on deer and elk mortality rates from other sources (e.g., wolf and bobcat predation, starvation, hunter-harvest), reproductive success, and on population growth rates will assist management in decision-making and planning optimum strategies over time. Ultimately, integrated field and modeling efforts will be necessary to determine the effectiveness of management intervention (e.g., intense surveillance, population reduction by hunter-harvest and culling) on prevalence and distribution of CWD among free-ranging populations.

5) Education and Information-Sharing

The MNDNR will continue to help educate and share current information with the general public, constituent groups, and other agency personnel. Information-sharing and education are accomplished by website updates, distribution of brochures and fact sheets, periodic news releases, public meetings, televised informational programs, and agency communications and reports. This information includes: basic history and understanding of CWD, its nationwide distribution, and status of knowledge of the disease (e.g., epidemiology, transmission, clinical signs, population effects); other CWD-related issues and concerns (e.g., carcass handling, meat processing and consumption, transmission to humans and livestock, deer feeding); and management and research actions being taken by the MNDNR and the BAH. Information products will be designed to focus on specific issues of importance to hunters, meat-processors, taxidermists, deer feeders, and operators of captive deer and elk facilities.

Further, publication of technical findings of research in peer-reviewed journals and agency reports will be strongly encouraged. Chronic wasting disease is a management issue that will likely become more serious with time. The more informed all agencies and the public become, the more effectively CWD risks will be managed in the future.

Captive Cervids on MNDNR-Licensed Game Farms

MNDNR has regulatory jurisdiction over approximately 1,100 licensed game farms, 345-360 of which have cervids (approximately 4,000-4,500 white-tailed deer and 600 elk). These game farms range from having just a few animals to large commercial operations.

Game Farm Regulation Weaknesses and Concerns

During winter 2001-02, a number of weaknesses and issues were identified involving game farm regulation, licensee knowledge of regulatory requirements, and consistency of enforcement of those requirements. These issues have implications relative to potential CWD introduction into these game farms and transmission among captive and free-ranging white-tailed deer (and elk). Specific issues identified included the following:

1) game farm animal registration records and associated data (e.g., animal inventory, additions and losses from herds) had not been computerized. Consequently, game farm records were not easily accessible or amenable to the scrutiny necessary for effective monitoring and enforcement;

2) there are no specific fencing regulations for game farms with white-tailed deer and elk, other than that they be adequate to contain the animals; they lack specific height requirements and are inadequate for preventing contact between, or commingling of, captive and free-ranging cervids;

3) reporting of escapes of captive deer or elk from game farms was <u>not</u> required;

4) there was no specific regulatory language prohibiting the intentional release of captive deer or elk into the wild;

5) there are no specific requirements for unique individual identification of captive deer or elk on game farms;

6) there is poor compliance with regulations requiring submission of reports, sales receipts, and accurate annual inventories (e.g., during the 1999-2000 and 2000-2001 license years, violation rates of 35-44% were detected);

7) there is poor compliance with disease-testing requirements (e.g., tuberculosis, brucellosis) by captive deer operations prior to importing and exporting of animals;

8) there has been no surveillance or testing requirements for CWD specific to game farms;

9) accounts of sales by brokers and game farm auction houses are poor;

10) MNDNR-licensed game farms at times have been used as "emergency" type rehabilitation centers for orphaned wild newborn fawns; and

11) MNDNR Enforcement inspections of game farms have too often been inconsistent.

Much of the game farm regulatory language is antiquated and was formulated when game farms were primarily licensed for raising pheasants and other game birds, not cervids. Many of the regulations are vague or subject to various interpretations. The result is that in many violation cases, the benefit of the doubt often goes to the violator, and fines and penalties are often inadequate to be effective

MNDNR Response to Game Farm Regulatory Concerns

Until 29 August 2002, CWD had not been detected in captive or free-ranging cervids in Minnesota, but evidence was mounting that the risk of CWD introduction into Minnesota was increasing. This has been particularly true in the absence of an effective CWD Surveillance Program for *all* captive cervids, including those under the regulatory jurisdiction of the MNDNR. The need for intensified geographic surveillance of free-ranging cervids (discussed previously) also was becoming evident.

Relative to MNDNR-regulated captive cervid operations, management needs of highest priority have included:

1) computer-entry and annual database maintenance of all registration data for all captive cervid operations, including total number of animals, species, sex, age, deaths, causes of deaths, movement of animals into and out of the operation, and records of disease-testing;

2) strengthening fencing requirements to minimize the risk of ingress and egress of cervids and commingling of captive and free-ranging cervids at the fence;

3) specifically prohibiting intentional release of captive cervids and requiring immediate reporting of animals that have escaped;

4) requiring 2 forms of identification for each individual animal, 1 of which is permanent;

5) requiring CWD-testing of all animals that die, in addition to requiring reporting of all deaths; and

6) providing all game farm licensees with a clear summary of all regulatory requirements so that the pertinent laws and rules are comprehensible and compliance can be enforced.

Since identifying the above needs, the MNDNR has computerized all registration data for captive cervid operations registered with the agency. Further, the MNDNR is working with other agencies and organizations in an attempt to comprehensively address the management of captive cervids under one uniform system. This will require a legislative initiative in the 2003 session, which is currently being prepared. In the meantime, the MNDNR, in cooperation with the BAH, has begun to strengthen importation and release provisions, and to secure a source of funding for long-term CWD management through existing rule-making authorities. **The following outlines approved Senate and House Floor amendments adopted in April 2002:**

1) Farmed cervidae may not be released or allowed to run at large. Cervidae that have escaped must be reported to the MNDNR within 24 hours, and if the owner can not capture escaped cervidae within 24 hours of escape, then the MNDNR may destroy the animal(s).

2) Wild cervidae that have entered the confinement area of a farmed cervidae facility must be destroyed by the owner, employee or an agent of the owner; be reported to the MNDNR within 24 hours of being destroyed; and the animal must be disposed of as prescribed by the MNDNR.

3) Cervidae may not be imported into the state from a herd that is infected or exposed to CWD or from a known CWD endemic area, as determined by the Board. Further, the cervidae may be imported into the state only from a herd that is not in a known CWD endemic area, as determined by the board, and from a herd subject to a state or provincial-approved CWD monitoring program for *at least 3 years*. Violation of this rule may result in the seizure and destroying of those cervidae by the MNDNR.

4) Fifty cents from each deer license is appropriated for emergency deer feeding and management of CWD, and this money is available until expended.

5) The MNDNR, BAH, and other interested parties shall study in concert and make recommendations on management actions designed to protect captive and free-ranging cervidae from CWD, specifically addressing cervidae fencing requirements, disease infection prevention, criteria for quarantining or depopulating infected herds, methods of harvest, identification of cervidae, and other issues.

APPENDIX A. CHRONIC WASTING DISEASE: STATUS OF OUR KNOWLEDGE

Occurrence and Distribution

Chronic wasting disease is a transmissible spongiform encephalopathy (TSE), which is a disease that alters the structure of the brain, particularly the gray matter, in a way that resembles a sponge-like appearance and texture. Much about CWD is still unknown, including its origin, exact mode of transmission, and the causative agent, although concerning the latter, current evidence strongly indicates that a proteinase-resistant prion (pronounced pree-on) protein (PrP^{res}) is the causative agent. The source of CWD may be related in some way to scrapie in domestic sheep, or a more plausible theory may be that CWD is caused by a point mutation of a normal membrane-bound prion protein in the brain (medulla oblongata), tonsils (in deer only), or lymphoid tissue.

The only known long-term distribution of CWD in free-ranging cervids includes 2 contiguous local areas in northeastern Colorado and southeastern Wyoming, which has expanded recently to include northwestern Nebraska. Up to16%, and a less than 1% CWD prevalence were reported for local populations of deer (mule and white-tailed deer) and elk, respectively, in certain management units. Further, recently in Colorado, cases of CWD have been detected in free-ranging mule deer and elk on the west side of the Continental Divide, and in mule deer in suburbs close to Denver. Infections in captive elk have been documented in Colorado, Wyoming, Nebraska, Oklahoma, Kansas, Montana, South Dakota, Minnesota, Saskatchewan, and Alberta; in captive mule deer and white-tailed deer at wildlife research facilities in Colorado and Wyoming; and most recently in captive white-tailed deer at a shooting preserve and at a game farm in Wisconsin. In 2002, CWD was detected in free-ranging white-tailed deer in South Dakota (1 deer), Wisconsin (40 deer), and Illinois (1 deer) and in a free-ranging mule deer near White Sands, New Mexico. Cases of CWD have been documented in free-ranging mule deer (4 deer) in Saskatchewan as well.

Incubation, Transmission, and Clinical Course of CWD

Incubation time, time from infection to appearance of clinical signs, typically is less than 2 years (12-24 months). However, incubation time has ranged up to 34 months. Maximum course of the disease (i.e., infection to death) can exceed 25 months in deer and 34 months in elk. The exact mode of transmission of CWD is unknown; however, circumstantial and experimental data indicate *horizontal* (or lateral) transmission in captive cervids (similar for scrapie in domestic sheep), either by direct animal-to-animal contact or by environmental contamination. For cervids, the routes of transmission are *presumed* to be by exposure to saliva, urine, feces, or placental tissue, with infection occurring through the alimentary canal (mouth/nose→ esophagus→ stomach→ intestines). If this transmission mode is confirmed for free-ranging cervids, then it follows that practices such as artificial feeding that unnaturally concentrate free-ranging deer or elk could potentially exacerbate the risk of infection. In contrast to outbreaks of mad cow disease, where exposure to animal protein-contaminated feed was documented, this has not been the case for captive or wild cervids infected with CWD. Presently, feed contamination is not considered a likely underlying transmission mechanism. Whereas, the importance of maternal transmission (mother to fetus or nursing young) as a mode of scrapie transmission in domestic sheep has at least been debated, its importance relative to CWD persistence in captive and wild cervid herds has been contraindicated thus far by current reports. Although the route of agent-shedding from infected individuals is presently unknown, it is believed that the rate of agent-shedding may very well increase as the disease progresses. Thus far, evidence also indicates that there is no difference between males and females or across age classes in susceptibility to CWD.

Importantly, *natural* transmission of TSEs (i.e., BSE, CWD) between domesticated bovids (i.e., cattle, bison), sheep and cervids has not been documented. Evidence indicates that domestic livestock (e.g., cattle, sheep, and goats) are not naturally susceptible to CWD. "Studies of cattle intensely exposed to CWD-infected deer and elk via oral inoculation or confinement with infected mule deer and elk have remained healthy for over 5 years" (Williams et al. 2002, *Journal of Wildlife Management* 66:555). A number of species are "experimentally susceptible" to CWD. That is, if CWD prions or prions of other TSEs are injected directly into the brain (intracerebral inoculation), they may develop the respective TSE disease. Research has shown that the experimental route of transmission of CWD was inefficient in goats, cattle, and mice when compared to the same experimental transmission route used for BSE ("mad cow disease") or scrapie. When healthy deer have been inoculated with brain tissue from scrapie-infected sheep, the deer developed CWD; however, when healthy sheep were intracerebrally inoculated with CWD-infected tissue, they did not develop scrapie or CWD.

The clinical course of CWD can vary from days to a year. That is, once clinical signs are apparent, cervids rarely survive more than 12 months. Chronic wasting disease is a progressive, fatal disease, with no vaccine to prevent the disease or treatment for reversing its course (recovery), and there is no evidence of immunity (e.g., antibodies). There has been no effective, practical antemortem (live-animal) test for diagnosis until recently; a live-test for deer (not elk) involving tonsil biopsy and immunohistochemical analysis for PrR^{res} accumulation has demonstrated promise, and may be more sensitive than the post-mortem analysis of the obex of the medulla oblongata in the brain. The practicality of this test remains to be decided; it may be more applicable to screening captive deer.

Clinical Signs of CWD

All signs or symptoms of CWD do not occur in all cases, and many of these signs are symptoms of other diseases and conditions as well. Further, the occurrence and severity of symptoms will depend in part on the stage (*early* versus *advanced*) of the disease. Below is a comprehensive list of the clinical signs of CWD: (1) loss of fear of humans; (2) nervousness or hyperexcitability; (3) teeth-grinding; (4) ataxia or loss of coordination; (5) notable weakness; (6) intractability; (7) inability to stand; (8) rough dull haircoat; (9) excessive salivation; (10) flaccid, hypotonia of the facial muscles; (11) drooping of the head and ears; (12) excessive thirst (polydipsia); (13) excessive urination (polyuria); (14) esophageal hypotonia and dilation, difficulty swallowing, and regurgitating ruminal fluid and ingesta; (15) severe emaciation and dehydration, and (16) death.

It is important to note that while some primary symptoms may be directly related to CWD, others may be secondary, more of a consequence of the deteriorating body condition (emaciation), related physiology, and compromised immunity (e.g., pneumonia, abscesses, enteritis, or internal parasitism) that often accompany emaciation.

Pathological Signs of CWD

Pathological signs of the disease include: (1) emaciation associated with absence or serous atrophy of subcutaneous and visceral adipose tissue or fat, and yellow gelatinous bone marrow; (2) subacute to chronic bronchopneumonia; (3) digestive tract (abomasal or omasal) ulcers; (4) enlarged adrenal glands; (5) watery or frothy rumen contents; and (6) histological lesions. These lesions have primarily and most consistently been observed in the brain and spinal cord. (7) Immunohistochemistry (IHC) is very sensitive and specific to CWD and is typically used to confirm diagnoses by measuring accumulations of PrP^{res} in brain tissues (specifically in the obex of the medulla oblongata) of infected deer and elk. This abnormal prion protein is antigenically indistinguishable from the scrapie-associated prion protein (PrP^{Sc}) found in brain tissues of domestic sheep infected with scrapie, but other differences have been noted. PrP^{res} has *not* been detected in uninfected cervids. This test can detect CWD infection before lesions are observable; however, IHC(+) results are not detected until at least 3 months after infection. Lesions do not always accompany PrP^{res} accumulation and IHC(+) results. (8) Scrapie associated fibrils (SAFs) have been observed by electron microscopy in the brain tissue of infected cervids, but not in uninfected cervids. (9) Generally, blood (whole blood and serum) and urine profiles have remained within the normal range, with the exception that certain characteristics have reflected the emaciated condition of the infected animals. Low specific gravity of the urine, is the one urine characteristic that may be directly related to CWD, specifically to degenerative encephalopathic changes in the hypothalamus. The hypothalamus is important in regulating antidiuretic hormone, which influences concentrations of urinary electrolytes (e.g., Na) and osmolality.

Chronic Wasting Disease and Human Health

According to health officials of the World Health Organization, U. S. Food and Drug Administration, and the Center for Disease Control, there is no evidence indicating a link between CWD and neurological diseases that affect humans. Further, the infective prions of CWD have *never* been found in the muscle tissue or meat of CWD-infected deer or elk. However, as always, health officials advise hunters *not* to consume meat of animals that are infected with CWD or appear sick in any way. Further, they recommend that hunters follow simple precautions when field dressing their deer or elk. Recommendations include the following:

1) do not shoot, handle, or consume any deer or elk that appears sick, and report the animal to the local MNDNR conservation officer or area wildlife manager;

2) wear rubber glovers when field dressing carcasses;

3) minimize handling of the brain and spinal tissues;

4) wash hands and instruments thoroughly after field-dressing is completed;

5) avoid consuming the brain, spinal cord, eyes, spleen, tonsils, and lymph nodes. (Normal field dressing, including boning out the carcass will remove most, if not all, of these body parts. Trimming away all fatty tissue will remove any remaining lymph nodes); and

6) request that your animal is processed individually, without meat from other animals being added to meat from your animal.

APPENDIX B. STATUS OF CAPTIVE ELK AND DEER OPERATIONS, REGULATORY AUTHORITY, INFECTIONS, AND MANAGEMENT IN OTHER SELECT STATES

Colorado

There are 121 elk ranches in Colorado, accounting for 12,000 elk (9,000 adults, 3,000 in the 2002 calf crop), most of which are registered with the Department of Agriculture. No captive deer are registered with the Department of Agriculture. Only a few elk operations, and 6-7 captive deer operations in the entire state, comprised of about 200 deer, are registered with the Division of Wildlife. The Division has minimal management responsibility of most captive operations, except involving site and report reviews.

The earliest detection of CWD in captive deer occurred in a wildlife research facility in Fort Collins in 1967. Since then, additional infections have been identified in deer and elk in that research facility, as well as in another in southeastern Wyoming. Thus far, positive cases of CWD have been identified in at least 9 licensed (i.e., commercial) captive operations. This includes elk that had been traced out to 38 other operations from the operations within the endemic area where the original infections were detected. Elk from the herds originally infected also have been traced to commercial herds in North Dakota, South Dakota, New Mexico, Utah, Minnesota, Wisconsin, Texas, Oklahoma, Idaho, Indiana, Illinois, Kansas, Missouri, Nebraska, and Pennsylvania. All exposed elk in each state have been identified and CWD-tested, or are at least under quarantine.

Management responses of the Department of Agriculture have ranged from quarantine to complete depopulation of exposed herds. CWD-infected, trace, and exposed elk herds that have been depopulated involved more than 3,000 elk. The captive facilities of greatest concern were 2 operations located outside of the CWD endemic area. The Division of Wildlife's concern for protecting free-ranging cervids in the vicinity surrounding 2 CWD-positive facilities prompted them to pay $330,000 for double-fence construction around the facilities.

Chronic Wasting Disease in Free-Ranging Elk and Deer

Chronic wasting disease was first diagnosed in free-ranging cervids in a contiguous area of northeastern Colorado and southeastern Wyoming in 1981. In northeastern Colorado, CWD has been diagnosed in 18 game management units, which cover about 10,000 square miles (about 10% of Colorado's land mass). Chronic wasting disease has infected up to 13% of free-ranging deer and 1% of elk in certain local management units within this endemic area. Overall within the endemic area (15,000 mi^2 or 5,790 km^2), CWD prevalence has been estimated at 4.9% for mule deer, 2.1% for white-tailed deer, and 0.5% for elk. During the past year, CWD has been diagnosed in free-ranging mule deer and/or elk outside of the endemic area (northeastern Colorado), both in the suburbs of Denver, as well as in 5 Game Management Units (2 elk, 12 mule deer) on the west slope of the Rocky Mountains. Additional CWD(+) deer and elk have been detected in deer and elk in northwestern Colorado and in the endemic area of northeastern Colorado as the state's hunting seasons continue. As of 12 November, tests of more than 6,500 brain stems have been completed of more than 8,000 submitted, and 50 were CWD(+), including 16 outside the endemic area.

Chronic Wasting Disease Surveillance Programs

In May 1998, Colorado was one of the first states to adopt a CWD Surveillance Program. The surveillance and importation components of their program are mandatory for all elk operators registered with the Department of Agriculture. That is, all alternative livestock mortalities, 15 months and older, regardless of cause, must be reported and a brain stem submitted for IHC-testing for CWD. The importation component also applies to *all* cervids, and requires that animals may only be imported from herds that have been under surveillance for CWD for at least 60 months. The "status" component of the CWD Surveillance Program is voluntary, but it is important to each operation's ability to export elk, because many other state CWD Surveillance Programs will restrict importing to elk from herds that have attained specific CWD Surveillance Program status or certification. This part of the program requires annual inventories and inspections of the elk operations. The Department of Agriculture is also working to change the rule addressing fencing of captive operations to ensure that the fencing is "effective." Currently, fencing efficacy is being addressed through a double-barrier rule (i.e., double-fencing, electric fencing). The Department believes that strict individual animal identification regulations, annual inventories, and inspections of operations and records will provide the most effective animal movement control and the mechanism for reconciling deaths and CWD specimen submission. Importantly, the Department of Agriculture recently purchased an "air-curtain incinerator" ($46,000) to provide for thorough disposal of CWD-infected carcasses. This incinerator burns at 1,700-2,800° F; at least 1,500° F is required to adequately destroy the PrP^{res} accumulations in CWD-infected cervids.

For captive cervid operations licensed with the Division of Wildlife, a CWD Surveillance Program has been in place since 1998. Further, the Colorado Division of Wildlife and Colorado Wildlife Commission have adopted a long range comprehensive CWD policy. The policy addresses numerous critical issues, including: (1) disease management (i.e., minimize the potential for CWD to spread beyond the endemic area and reduce the current prevalence of CWD in the endemic area), (2) development of Data Analysis Unit (DAU) plans for the endemic area, (3) research, (4) the role of hunting in the endemic area, (5) hunter information (e.g., human health), (6) use of Division staff to remove animals from the endemic area for management and/or research, (7) testing of animals killed in the endemic area, (8) the role of the Department of Agriculture in CWD management, (9) movement of live animals (under Division of Wildlife jurisdiction), (10) removal and disposal of carcasses from the endemic area, and (11) communication.

A critical part of the Colorado Division of Wildlife's management policy for CWD has been aggressive targeted surveillance and culling of deer and elk exhibiting clinical signs consistent with CWD, followed by IHC-testing of brain stem samples and tonsils (useful in deer only) for CWD. Geographically-focused random surveys, involving more than 5,500 sampled deer and elk have also been conducted within and outside the endemic area to determine prevalence and spatial distribution of affected animals. Presently, submission and testing of brain stems for CWD is mandatory and free for deer and elk harvested within the endemic area of northeastern Colorado; testing is voluntary and is being offered at a low rate (about $17.00) for animals harvested outside the endemic area. During 2002 hunting seasons, the Division expects that 20,000-50,000 brain stems will be tested statewide.

The Division disposes of carcasses in 2 ways. Most go to a landfill (in the endemic area) after being double-bagged. Other carcasses go to the laboratories at Colorado State University and the University of Wyoming for incineration according to recommended standards. Additionally, Colorado has implemented new regulations that restrict the transport of certain carcass parts of wild or domestic cervids out of its endemic area or into Colorado from CWD-infected areas of other states or countries. Carcass parts that may be transported include: meat that is cut and wrapped, quarters or other portions of meat with no part of the spinal column or head attached, boned-out meat, hides with no heads, upper canine teeth of elk, and finished taxidermied heads. If hunters wish to take antlers with the skull plate from the endemic area, the skull plate must be sufficiently cleaned (i.e., no meat or tissue attached).

Nebraska

There are 91 captive elk/deer operations in Nebraska that include approximately 4,000 elk. White-tailed deer and mule deer are not permitted in captivity in Nebraska; exotic cervids are allowed. There are 1-2 small captive white-tailed deer and 5-6 mule deer operations that were grandfathered in. These deer operations can not import deer, but they can export their deer. In 1997, the Nebraska Department of Agriculture received all management responsibility, including enforcement (e.g., monitoring, inspections), for all captive cervids.

Chronic wasting disease infection has been detected in 4 commercial elk operations in northwest Nebraska, not far from the endemic area of northeast Colorado-southeast Wyoming. The earliest was a facility with very good records, and the infection was detected before CWD was receiving much attention. One elk exhibiting clinical signs of CWD was put down and tested positive. The total herd included about 130 elk. Eighty to 100 elk were shot, and because they all tested negative, and because the records were very thorough, the only other action was a 3-year quarantine. The second CWD infection was identified in a small herd of 15 elk, and the entire herd was depopulated. In the third operation (Edwards' elk facility) tested, 8 of 80 elk and 11 of 21 white-tailed deer were CWD(+), initially. There was strong circumstantial evidence that the infected deer were free-ranging animals that were attracted and corralled into one of the adjacent fenced pastures by the operator before the first infections in elk were diagnosed; subsequently the deer had contact with the infected elk. This facility was depopulated during the summer of 2002. In an attempt to determine the source and spatial limit of CWD in free-ranging deer in and around the Edwards' operation, the Commission of Game and Parks conducted additional deer drives (with culling) during the week of 9 January 2002, collecting an additional 79 brain stems for CWD-testing. One hundred and seventy-one and 138 samples were collected from deer inside and outside the Edwards' fenced pasture, respectively. As of 1 October 2002, test results showed 10 of the 138 brain samples from free-ranging animals tested IHC(+) for CWD and 89 of 171 from inside the pen were positive. During early March 2002, a cooperative culling and CWD-testing effort with South Dakota resulted in all CWD (-) results for 103 deer collected on the Nebraska side of their mutual border. According to Nebraska officials, this is narrowing the focus of CWD in northern Sioux County, Nebraska, to an area within 10 miles of the Edwards' captive operation.

Between 1997 and 1999, the Game and Parks Commission conducted a modest survey of free-ranging deer by collecting 80 brain stems from hunter-harvested animals in southwest Nebraska. All tested negative for CWD. In 2000, 750 additional heads collected by hunter-harvest and tested, yielded 1 mule deer positive for CWD. A second IHC(+) mule deer was identified when the Commission culled another 150 deer in the southern panhandle. Of 804 samples collected from free-ranging deer during 2001, 802 were IHC(-), but 1 IHC(-) for the brain sample was IHC(+) for the tonsils, and 1 deer was IHC(+) for the brain stem. (In deer, the PrP^{res} accumulates in the tonsils earlier than in the brain.) The tonsil-positive deer was shot within 7 miles of the 2 IHC(+) free-ranging mule deer tested in 2000, while the other positive deer was in a new location approximately 50 miles from the others. To date, the Nebraska Game and Parks Commission has culled (not including brain stems from hunter-harvested deer) and tested (or in the process) 426 deer for CWD.

In an effort to remove as many captive cervid operations from the Nebraska endemic area as possible, the Nebraska Department of Agriculture and USDA-APHIS recently completed the depopulation of 15 captive cervid operations in the Nebraska Panhandle. About 1,000 elk were included in the depopulation effort, and are currently being tested for CWD. As a result of this effort, so far, 1 additional elk facility (in Sioux County) has had an elk test positive for CWD, bringing the total number of CWD(+) captive operations in Nebraska to 4. Three of the 4 have been depopulated, the remaining operation was quarantined for 3 years with no additional positives, and the quarantine was lifted in the spring of 2001. Seven facilities chose not to participate in this effort.

Currently, carcass disposal is accomplished by depositing them in approved dead animal pits at licensed landfills. The Commission is still attempting to obtain an air-curtain incinerator for future carcass disposal. The use of bait for hunting deer, elk, mountain sheep and pronghorn antelope in Nebraska is now illegal based on recent changes in state regulations.

Chronic Wasting Disease Surveillance Program and Importation

The Department of Agriculture has a CWD Surveillance Program, which applies to *all* cervids. Major components of their program include: (1) definitions of commonly used terms (e.g., affected herd, trace-back herd, trace-forward herd, etc...) that conform with the National CWD Surveillance Program (to be implemented soon), (2) requirements for entry into the program, (3) program protocol (General Provisions, Inspections, Program Status, Management of CWD Affected or Exposed Herds, Acquisitions and Commingling, Use of Semen and Embryos, Animals Imported from Foreign Countries), (4) herd information, and (5) laboratory submission of samples. This latter part requires that all deaths of captive cervids at least 16 months of age must be reported and brain stems IHC-tested for CWD.

Currently there is a broad ban on most cervid importation. Importation is prohibited for *any cervids* from Colorado and Saskatchewan, and from any herd that has received animals from these states within the past 5 years. Importation is also banned for any cervids from any facility that has had a CWD-positive or exposed animal during the past 5 years. Furthermore, cervids imported into Nebraska must have been enrolled in a CWD Surveillance Program for a least 36 months, and an imported animal must be accompanied by documentation of its complete history to its birth herd. Imported cervids are isolated until a state veterinary representative confirms that the identification numbers agree.

The Game and Parks Commission formulated a CWD Management Plan which includes 4 broad areas of action to address critical issues related to CWD in free-ranging deer and elk. The areas of action are: (1) informing and educating the public (including hunters), constituents (e.g., wildlife producers, meat processors, taxidermists), NGPC and other agency personnel (e.g., local, federal) concerning CWD; (2) limiting distribution of CWD in deer and elk (e.g., (a) preventing inadvertent movement of CWD-infected wild deer and elk and inadvertent introduction of CWD into captive cervid operations, (b) continue field investigations and surveillance to monitor changes in prevalence and distribution of CWD cases); (3) reducing prevalence of CWD in local free-ranging deer and elk populations (e.g, reduce the potential for CWD transmission; and (4) conduct and support research on epizootiology and management of CWD (e.g., transmission routes, live-test for CWD, treatment, modeling to examine effects of CWD on affected populations, and effectiveness of management responses).

South Dakota

South Dakota has 50-60 herds of about 1,500 captive elk and 100-300 captive deer. Until 1993, no state department had actual jurisdiction over the captive cervid operations, and the existing laws were vague. In 1993, the Animal Industry Board (AIB) of the Department of Agriculture gained responsibility for *all* captive cervid operations. In December 1997, 2 captive elk herds were discovered to have CWD. In 1998, 8 additional captive elk herds were diagnosed with CWD or to have been exposed to CWD. All 10 herds were immediately quarantined. Through a law passed in 1998, AIB initiated a CWD Surveillance Identification Program for captive cervid operations statewide. The quarantine means that no elk movement is permitted into or out of the facilities for at least 5 years. Bear Country, in Rapid City, was one of 3 operations owned by the Casey family in South Dakota that had CWD-infected elk, and therefore was under quarantine. The Bear Country site was permitted to re-open to the public while under quarantine, but only after double-fencing was constructed. The last of 7 private herds that were eventually confirmed to have CWD was depopulated early in 2001. This was a herd sold to the North American Elk Breeder's Association for research. The State Veterinarian then declared all captive cervids in South Dakota free of CWD in March 2001. In August 2002, a captive elk herd (147 animals) in the Black Hills was found to be CWD-positive. This herd is adjacent to a site of 1 of the original CWD quarantined and depopulated captive elk herds. This new CWD herd was depopulated in September 2002.

Chronic Wasting Disease in Free-Ranging Elk and Deer

Only 1 white-tailed deer in captivity has tested IHC(+) in South Dakota; it was among some wild deer fenced into a "buffer pasture" adjacent to a pasture with a CWD-infected elk herd. In a collaborative (1997-1999) effort to determine the risk of CWD infection in free-ranging cervids, the South Dakota Department of Game, Fish, and Parks (DGF&P) and South Dakota State University collected heads from a total of 128, 519, and 368 hunter-harvested mule deer, white-tailed deer, and elk, respectively, in geographically-focused surveillance areas throughout the state. All brain stem samples tested negative for CWD. No collection or testing of heads from free-ranging cervids was conducted during 2000; however, the survey was resumed in fall 2001 when 500 additional elk and deer heads were collected. About 400 of these brain stems were collected in southwestern South Dakota. In early February 2002, 1 of these was reported to be CWD(+). This CWD(+) was from a white-tailed deer shot in the northeastern part of Fall River

County, about 10 miles east-southeast of Hot Springs, which is about 26 miles north of the Nebraska border. However, it is about 50 miles northeast of the CWD-infected (elk and deer) Edward's Ranch (in Nebraska). During late February, South Dakota began its first culling and testing operations. Ninety deer were collected in southwestern South Dakota, not far from where the CWD(+) deer were detected in Nebraska; all tested CWD (-). Additional culling and testing within 5 miles around where the South Dakota CWD-infected white-tailed deer was shot, resulted in a sample of 52 deer, of which none tested positive. Since 1997, 1,693 deer and elk have been tested for CWD. During fall 2002, a 5-year old free-ranging bull elk in Wind Cave National Park, exhibiting clinical signs consistent with CWD, was shot and tested positive. Alternative management actions in this case are being considered. Additionally, a 2.5 year-old white-tailed deer buck killed in a vehicular collision within the city limits of Rapid City tested positive for CWD. This fall, South Dakota DGF&P has submitted a total of 1,600 brain stems from elk (472), white-tailed deer (657), and mule deer (471), most of which have been collected from hunter-harvested animals. Presently, South Dakota is disposing of carcasses and heads in the Rapid City landfill, as per the advice of their State veterinarian.

Chronic Wasting Disease Surveillance Program and Management Policy

South Dakota AIB's CWD Surveillance Identification Program is similar to Minnesota's program in that it basically (1) requires annual herd inventories; (2) requires surveillance and CWD-testing of animals that have died, are slaughtered, or are destroyed after exhibiting symptoms consistent with CWD; (3) designates herd status based on years of monitoring in the program; and (4) imposes rules for importing and adding cervids to a captive herd. Importation of cervids into South Dakota requires specific written certifications addressing each animal's herd and movement history, and documentation of herd monitoring demonstrating that the animal has not been exposed to CWD in any herd (i.e., trace-back or trace-forward within the past 5 years).

According to this program and supportive statutes/rules, cervids that have escaped from a captive operation must be reported immediately and become the property of AIB. The AIB determines whether the animal, if captured, is returned to the permittee or transferred to the DGF&P. Typically, if an animal escapes, the owner has 2-3 days to capture it before the DGF&P can take action. However, if an elk or deer escapes from a CWD-infected or exposed herd, then the DGF&P can destroy the animal immediately.

Before issuance of a permit to operate a captive cervid facility, the AIB and DGF&P may inspect the facility and must be satisfied that it does not include any free-ranging cervids. If free-ranging cervids have been fenced in, they must be removed at the owner's expense before a permit is issued. Disposal of the animals is decided by AIB and DGF&P. South Dakota's DGF&P has not yet adopted a formal CWD management policy, but rather, has thus far taken an "*operational approach*." At this point, according to Ron Fowler (Wildlife Program Administrator), "whatever is needed, including funds, travel to meetings for information-gathering, cervid brain stem collections and CWD-testing, etc..., the agency will support in attempts to manage CWD." A CWD Management Plan is in the final stages of being approved.

Wisconsin

In Wisconsin there are about 272 captive elk operations (total of 10,815 elk), 100 exotic and other deer operators, and 575 white-tailed deer farms (total of 22,500 deer). During the mid-1990s, registration and management responsibilities for captive elk, red deer, and all other exotic cervids were transferred from the Wisconsin Department of Natural Resources (DNR) to the Department of Agriculture, Trade and Consumer Protection (DATCP). The DNR retains management responsibility for the white-tailed deer farms, but this responsibility will be transferred to DATCP as of 1 January 2003. Currently, if an operation has white-tailed deer and elk (or other exotic cervids), then it must register with the DNR and the DATCP.

CWD Surveillance Program and Management Policy

The Department of Agriculture has helped captive cervid producers with CWD surveillance since 1998, but created a mandated state CWD Monitoring Program under emergency rule this spring after discovery of CWD in Wisconsin's wild deer. The CWD Monitoring Program applies to *all* species of cervids, and (1) limits inter-state imports to farms/operations of origin that are participating in CWD monitoring or have a 5-year history of being a closed herd with no clinical evidence of CWD, (2) requires farms that ship live deer/elk to conduct CWD-testing on all animals at least 16 months of age that die, and (3) requires farms that send deer/elk to slaughter or allow hunter-harvesting (and removal of any parts) to have each of those animals (at least 16 months of age) CWD-tested. "Hobby" farms that do not ship live animals, send animals to slaughter, or have hunters harvest animals and remove parts from the farm are not required to participate in the CWD Monitoring Program. The CWD Monitoring Program requires farms that ship live animals to do individual animal identification, annual herd censuses, death and transaction reporting, and provide an annual veterinary herd health letter.

To date approximately 130 Wisconsin cervid farms have had at least 1 animal tested for CWD. Since 1998, over 600 deer/elk have been tested. All have been negative, until September 2002, when 1 hunter-harvested white-tailed deer tested positive from a breeding farm/hunting preserve in Portage County. As of 1 October 2002, this farm and 5 additional trace-back cervid farms (Marathon, Walworth, Portage, Dane counties) have been quarantined, and subsequently, an additional CWD(+) deer was diagnosed in at least 1 of the Walworth County farms. State officials have reported (24 October update) that several deer had escaped from this farm in March 2002. The investigation is ongoing.

Until recently, there have been no bans or extraordinary restrictions on importation of deer, elk, or exotic cervids into Wisconsin. All 20 elk imported into Wisconsin from infected herds in Colorado have been traced, and all but 2 have tested negative for CWD or have survived for 5 years without clinical signs of CWD. The 2 elk that weren't tested died before the trace-outs were done.

The Wisconsin DNR has produced a draft CWD Management Plan for free-ranging deer and elk, which will be finalized soon. The DNR has been conducting targeted surveillance and geographically-focused random surveys to determine if CWD is present in free-ranging deer. During 1999-2000, approximately 600 brainstem samples were collected from hunter-harvested deer, "suspect" deer, and some urban deer taken by sharp-shooters during winter. Some of the sample collection was focused around elk ranches known to have received animals from CWD(+)

Colorado ranches. All of these were IHC(-) for CWD. During fall 2001, the DNR collected about 550 brain samples from hunter-harvested deer brought to check stations in areas known to have high numbers of deer taken and where there has been no sampling effort previously. All analyses were conducted at the National Veterinary Services Laboratory in Ames, Iowa, and on 28 February 2002, the DNR reported CWD infection (positive tests) for 3 male white-tailed deer that had been shot within 3 miles of one another, Deer Management Unit 70A, in Dane County. These bucks were 2.5-3.0 years old, and one was reported to be in poor condition. In response, the Wisconsin DNR established a surveillance area of 415 square miles surrounding the area of initial CWD discovery, and set a sampling goal of 500 deer to be culled and tested in the surveillance area. About 516 deer were harvested and brain stem-sampled over the next month, and 15 deer tested CWD(+).

On May 1, an approximate 400-square mile "Eradication Zone" was established that included all the locations where CWD(+) deer had been detected and a 4.5-mile buffer zone around all of these locations. The ultimate goal for this affected area is to cull and test as many of the deer as possible, as quickly as possible, in an attempt to eradicate the disease. To achieve this goal, landowners in the Zone have been permitted to harvest deer or invite government sharpshooters to harvest deer during week-long monthly hunts during summer 2002. Approximately 1,500 deer have been harvested and sampled; 13 additional CWD(+) cases have been identified from the 601 results reported. As of 1 October 2002, 31 CWD(+) deer had been identified from 1,200 deer tested in this affected area of south-central Wisconsin, which translated into a prevalence rate of approximately 2.5%. By 24 October, the number of CWD(+) deer in the Zone had risen to 40.

Eradication efforts and sampling/testing of deer from the CWD affected area will continue through extended fall 2002 hunting seasons in the Eradication Zone. A 40-mile radius buffer zone (the "CWD Management Zone") has been identified around the Eradication Zone; the goal for this zone is to significantly reduce deer densities (to 10 deer/square mile) to help with disease control. Extended fall hunting seasons and liberal licenses will be used. Additionally, Wisconsin plans to sample and test at least 500 deer from every county (or county cluster where deer densities are lower) during fall 2002, a total of 40,000-50,000 deer.

Michigan

In Michigan, *captive* cervids (deer and elk) are considered livestock, and consequently, fall under the regulatory jurisdiction of the Michigan Department of Agriculture(MDA). This agency is responsible for licensing, registration, and inspection of the state's 900-1,000 captive cervid facilities, which includes approximately 25,000 deer and elk. The shifting of complete regulatory authority for all captive cervid facilities to the MDA occurred relatively recently (June 2000). Michigan's estimated 1.8 million *free-ranging* white-tailed deer and elk are the management responsibility of the Michigan Department of Natural Resources (MDNR). The MDNR and the Department of Environmental Quality are still responsible for assessing the impact of new facilities on free-ranging wildlife and their habitat and for assuring that no free-ranging animals are enclosed within the fenced pastures of new operations. If a captive cervid escapes, the official response may involve a joint effort of the MDA and the MDNR to capture the animal. If free-ranging animals are directly involved, then the MDNR assumes primary enforcement responsibility.

CWD Surveillance Program and Management Policy

To date, all tests for CWD in captive cervids have been negative. Similarly, the MDNR has been conducting targeted surveillance for "suspect" free-ranging deer and elk for several years, and all have tested negative for CWD. Additionally, the MDNR has collected about 450 brain stems from hunter-harvested deer during 1998-1999; again, all were CWD(-). While the MDNR continued targeted surveillance, it did not continue random surveys (i.e., brain stem samples from hunter-harvested deer) during 2000 or 2001.

Collectively, the MDNR, MDA, and the Michigan Natural Resources Commission (policy-making body) have taken the following steps to attempt to prevent CWD introduction into free-ranging and captive cervids in their state:

> 1) Prohibited supplemental deer feeding in the Upper Peninsula (UP), beginning with the 4 UP counties bordering Wisconsin and including the remaining 11 counties by May 2003. Supplemental feeding is already banned in the Lower Peninsula. The objective of these bans is to discourage high deer densities that are artificially supported by feeding and to reduce nose-nose contact and the risk of disease transmission.
>
> 2) Established a 50-mile buffer zone around Michigan's borders. If a CWD(+) deer or elk is detected within this buffer, all baiting and feeding activities in the adjacent peninsula will be banned immediately.
>
> 3) After detection of CWD in Wisconsin, a ban on all cervid imports from Wisconsin was implemented (as of 6 March 2002). Subsequently, a 1-year ban was enacted, effective 26 April 2002, on *all* imports of deer and elk to privately-owned cervid operations.
>
> 4) Further, for captive cervid operations, the state requires mandatory herd inventory reporting, fence inspections, standards for fence construction, and record-keeping for all animal movements.

In August 2002, the MDNR and the MDA released Michigan's Surveillance and Response Plan. Surveillance efforts will include ongoing "targeted" surveillance, as well as "active" surveillance ---- healthy appearing deer harvested by hunters. By these means, Michigan plans to test approximately 6,000 free-ranging deer and elk statewide during the next 3 years. Although Michigan plans to sample all of its 83 counties, priority will be assigned according to epidemiological factors: number of privately-owned cervid facilities, presence of cervid research facilities, and geographic location.

The MDA's Surveillance Plan includes targeting potential risk imports of the past: (1) Animals identified by the USDA as possibly CWD-exposed. These have all been traced and tested negative for CWD. (2) Wisconsin cervids imported over the past 3 years, before that state's discovery of CWD, have all been identified and located, and will be purchased and CWD-tested. (3) All deaths of captive cervids at least 16 months old will require CWD-testing in accordance with herd plans developed by MDA's State Veterinarian office. (4) CWD is a "reportable disease per the state's animal health laws;" consequently anyone *suspecting* CWD in an animal must report it to the MDA immediately.

The state's Response Plan to CWD should it be detected, will include a coordinated multi-agency (and institutional) effort to identify the spatial distribution of the disease, determine its prevalence, limit disease transmission, and eradicate it if possible, while keeping their public informed. Generally, depending on whether captive or free-ranging cervids are affected, actions may involve quarantines; depopulation or culling and CWD-testing; maintaining low densities of free-ranging cervids for prolonged periods of time in affected areas; increased surveillance and restrictions on movement of carcasses of free-ranging cervids; restrictions on baiting and feeding near affected areas; and banning of rehabilitation of cervids statewide.

Other States and Canadian Provinces

A summary of CWD incidence in captive and free-ranging cervids, CWD surveillance programs, and CWD management policies was not included for all states or Canadian provinces. However, since 1989, CWD infection of captive elk also has been reported for Oklahoma, Montana, Kansas, Alberta, as well as in 39 herds in Saskatchewan. Evidence indicates that all of the positive captive elk in Saskatchewan were traced back to one Canadian herd that had imported CWD-infected elk before 1990 from a U. S. herd that was subsequently diagnosed with CWD. Additionally, CWD-infected *free-ranging* mule deer (a cluster of 3, and 2 recently detected 120 miles from that foci) in Saskatchewan have also been reported, as has a CWD(+) mule deer in New Mexico and a white-tailed deer in Illinois. Wyoming has confirmed its first cases of CWD in free-ranging mule deer west of the Continental Divide and will continue testing brain stems from hunters in the affected areas.

Sources of Information

The basis for this document is information derived from interviews with and documents from the following: Russ Bay (DVM, Veterinary Diagnostic Laboratory, University of Minnesota), Kimberly Blackford (Minnesota Board of Animal Health), Scott Bradley (Conservation Officer, Minnesota Department of Natural Resources), Jim Collins (DVM, Veterinary Diagnostic Laboratory, University of Minnesota), Lynn Creekmore (DVM, USDA Veterinary Services), Wayne Cunningham (DVM, Colorado Department of Agriculture), Ron Fowler (Wildlife Program Administrator, Division of Wildlife, South Dakota Department of Game, Fish, and Parks), Douglas Hoort (DVM, Michigan Department of Agriculture), Rick Kahn (Terrestrial Field Operations Manager, Colorado Division of Wildlife), Terry Kreeger (DVM, Wyoming Game and Fish Department), Julie Langenburg (DVM, Wisconsin Department of Natural Resources), Joseph Marcino (Fish and Wildlife Pathologist, Minnesota Department of Natural Resources), Michael Miller (DVM, Colorado Division of Wildlife), Bruce Morrison (Nebraska Game and Parks Commission), Kristina Petrini (DVM, Minnesota Board of Animal Health), Dan Obrien (DVM, Michigan Department of Natural Resources), D. O'Conner (DVM, Wisconsin Department of Agriculture), Steve Schmitt (DVM, Michigan Department of Natural Resources), Elizabeth Williams (DVM, Department of Veterinary Services, University of Wyoming), and a number of others.

APPENDIX C. MINNESOTA BOARD OF ANIMAL HEALTH'S CWD SURVEILLANCE PROGRAM FOR ELK

The Minnesota Board of Animal Health's CWD Surveillance Program consists of 4 basic elements (copied from BAH 2001): herd inventory, surveillance, herd status levels, and herd additions.

Herd inventory requires that (1) the first inventory be completed prior to program entry, (2) annual inventories are conducted 9-15 months from the entry date, and (3) a veterinarian licensed and accredited in Minnesota must conduct all inventories.

Surveillance requires that (1) the brain of all cervids (elk, deer, etc...) at least 16 months of age that die or are slaughtered are to be submitted by a veterinarian to the University of Minnesota Veterinary Diagnostic Laboratory for CWD testing (appropriate samples will be forwarded to an accredited laboratory, e.g., as in Ames, Iowa), and (2) a copy of the laboratory report must be submitted with the annual herd inventory.

Herd status levels are: Level A, first year of participation; Level B, second and third years of participation; Level C, fourth and fifth years of participation; and Level D, at the end of the fifth year of participation.

Herd additions are allowed only from herds of equal or greater status. Addition of an elk from a herd of lower status, reduces the herd receiving that individual to that lower status.

All costs associated with herd inventory, surveillance, and laboratory analyses for CWD are at the owner's expense. Although the current CWD Surveillance Program was initially designed for elk only, the BAH does have captive deer and deer/elk operations enrolled and participating in the program. Further, captive deer or elk operations do not have to be registered with the BAH to voluntarily enroll in the program. If a BAH-registered captive cervid operation includes deer and is enrolled in the CWD program, then the brain of *any cervid* at least 16 months old that dies or is slaughtered must be submitted for CWD testing. Also, BAH requirements and jurisdiction apply regardless of where CWD infection is detected. The determining factor is not species, but rather whether the disease is considered a threat to livestock. Consequently, if an elk or deer on a game farm registered with the DNR is diagnosed with CWD, then the BAH has the responsibility and authority to act, ranging from quarantining the herd/facility of the infected animal to complete depopulation. Of course, a primary weakness in current management systems, particularly for the DNR-registered game farms, is whether deer exhibiting signs of CWD infection will be detected, reported, and tested.

Currently, the BAH does not strongly encourage enrollment into their CWD Surveillance Program by captive deer operations for the following reasons:

1) there have been no reported cases of CWD infection in captive deer; therefore the *perceived* threat of infection is less than for elk,

2) the deer farming industry is not showing support for a CWD monitoring program, and

3) funds and personnel are insufficient to implement and enforce an expanded CWD Surveillance Program that includes the captive white-tailed deer game farms of Minnesota.

APPENDIX D. NATIONAL CHRONIC WASTING DISEASE SURVEILLANCE PROGRAM

In 1998 and 1999, the United States Animal Health Association (USAHA) passed resolutions to endorse development of a federal CWD monitoring/surveillance program. In late 1999, representatives from numerous agencies and interest groups, including Veterinary Services of the USDA's Animal and Plant Health Inspection Service (APHIS), state Departments of Agriculture, Departments of Wildlife, federal and state diagnostic laboratories, producer associations (e.g., North American Elk Breeders Association) and others met to formulate an initial draft of this program. In late 2000, USAHA endorsed continued development of the earlier draft and a final version has now been proposed for approval. The goal of the National CWD Program "... is to eradicate CWD from captive *elk* herds in the U. S." Most of the state CWD surveillance programs already in existence apply to all cervids, and even though aspects of many of these CWD programs were considered in formulating the national program, the latter applies only to captive elk and elk hybrids. Though states may apply the federal program's "... surveillance methods to all cervids, the monitoring, reporting, certification, and indemnification aspects of the national program apply only to captive elk." Standards of state programs must be at least as stringent as standards of the national program. USDA/APHIS will permit interstate movement of captive elk only from herds enrolled in a CWD certification program.

Generally, technical elements of herd certification in the National CWD Program include:

1) fencing effective for reducing the risk of transmission between captive and free-ranging cervids;

2) approved or certified collectors of brain stem samples (i.e., obex of medulla oblongata) for testing;

3) annually verified herd inventories, separate registration and maintenance of herd subunits that are managed independently;

4) animal identification by 2 approved forms (one being an ear tatoo);

5) precise geographic identification of operation premises;

6) laboratories certified for CWD-testing by the National Veterinary Services Laboratory in Ames, Iowa; and

7) 60 months required as the quarantine period, as well as the time-frame for trace back/trace forward investigations.

Standardized herd designations, terminology, and definitions of the National CWD Program are important to assuring thorough and uniform understanding of the numerous requirements of the certification process, herd designation, herd investigations and herd plans, which are critical to minimizing the risk of CWD transmission with movement of captive animals between operations. A herd plan describes the necessary actions to be taken by a captive elk (cervid) operator in response to identification of a suspect, CWD positive, or exposed herd and is based on a comprehensive epidemiological investigation and risk assessment by state/federal officials. Elements of a herd plan may include whole herd depopulation, quarantine, reproductive control, selective culling and testing of animals, continued surveillance, fencing, and others. Standardized terminology and definitions are provided below (from USAHA document, 2001); detailed explanations of herd designations may be provided upon request.

Term	**Definition**
Animal	Domesticated or captive white-tailed deer, mule deer, elk, or exotic deer.
Animal, CWD exposed	An animal that is, or has been in the last 5 years, part of a CWD positive herd.
Animal, CWD positive	An animal that has been diagnosed with CWD by means of an official CWD test conducted by a laboratory certified by USDA/APHIS.
Animal, CWD negative	An animal that has tested negative for CWD by means of an official CWD test conducted by a laboratory certified by USDA/APHIS.
Animal, CWD suspect	An animal for which laboratory evidence or clinical signs suggest a diagnosis of CWD.
Captive	Animals that are privately or publicly maintained or held for economic or other purposes within a perimeter fence or confined space. Animals that are held for research purposes are not included.
Certification	A program of surveillance, monitoring and related actions designed to provide a status to captive deer and elk herds relative to chronic wasting disease.
Cervid	All members of the cervidae family and hybrids including deer, elk, moose, caribou, reindeer, and related species.
Chronic wasting disease	A transmissible spongiform encephalopathy (TSE) of cervids.

Commingling	Animals that have direct contact with each other, have less than thirty (30) feet of physical separation, or that share management equipment, pasture, or water sources/watershed. Animals are considered to have commingled if they have had such contact within the last 5 years.
Enrollment date	The day, month, and year in which an owner's herd is officially enrolled in the CWD certification program by an appropriate State official.
Herd	A group of animals that are (a) under common ownership or supervision and are grouped on one or more parts of any single premise (lot, farm, or ranch) or (b) all animals under common ownership or supervision on 2 or more premises which are geographically separated but on which animals have been interchanged or had direct or indirect contact with one another.
Herd inventory	An official list of all of the animals belonging to a herd including verification of the official or approved animal identifications.
Herd plan	A written herd management agreement developed by the herd owner, state and federal veterinarians, and others approved by the respective federal, state, and tribal officials. A herd plan sets out the steps to be taken to eradicate CWD from a CWD positive, exposed, or suspect herd.
Herd, CWD positive	A herd in which a CWD positive animal resided at the time it was diagnosed and which has not been released from quarantine.
Herd, suspect	A herd for which laboratory evidence or clinical signs suggest a diagnosis of CWD, but for which laboratory results have been inconclusive or not yet conducted.
Herd, exposed	A herd in which a CWD positive or exposed animal has resided 60 months prior to the diagnosis.
Herd, trace back	An exposed herd in which a CWD positive animal resided in any of the 60 months prior to the diagnosis.
Herd, trace forward	An exposed herd that has received exposed animals from a positive herd within 60 months of the diagnosis of CWD in the positiver herd.
Hold order	A temporary order issued by a state or federal official prohibiting movement of animals from a premise.

ID, official	A form of identification approved by the USDA/APHIS administrator and the state chief animal health official.
Owner	An individual, partnership, company, corporation or other legal entity that has legal or rightful title to an animal or herd of animals.
Premises	The ground, area, buildings, water sources, and equipment commonly shared by a herd of animals.
Premises plan	The section of a herd plan which outlines actions to be taken with regard to possible environmental contamination due to a CWD positive or exposed herd.
Quarantine	An order issued by a state or federal official prohibiting movement of animals for a given period of time from a premises.
Status date	The day, month, and year on which the respective state official approves a change in the status of a herd in regard to CWD.
Test, official CWD	A CWD test approved by the USDA/APHIS administrator.

The following regulations of the National CWD Surveillance Program are more specifically addressed in other documentation (may be provided upon request):

(1) herd certification standards as regards fencing, surveillance, biological sampling, annual verified herd inventories, mandatory reporting of death, sold animals, and interstate movements of captive elk, official and unique animal identifiers, premise locations, herd status, positive diagnosis of CWD, and development and implementation of a herd plan;

(2) options for disposition of CWD positive, exposed, or suspect herds; and

(3) minimum requirements for interstate movement of captive elk.

APPENDIX E. DOCUMENTS ADDRESSING THE POSITION OF THE MINNESOTA POLLUTION CONTROL AGENCY ON DEER AND ELK CARCASS DISPOSAL RELATIVE TO CWD

November 4, 2002

TO: **Minnesota's 30 Mixed Municipal Solid Waste Landfill Operators**
SKB Rosemount Industrial Landfill Operator
Minnesota's 6 Waste Combustor Operators

RE: Disposal of Deer Carcasses

I am writing to provide you with information from the Minnesota Pollution Control Agency (MPCA) about issues associated with disposal of deer carcasses. We hope that this information assists you in making decisions about whether to accept deer carcasses at your facility.

With the deer hunting firearms season fast approaching, you may receive inquiries about the disposal of wastes from deer processing. The Chronic Wasting Disease (CWD) issue has caused concern about how to properly handle and manage deer wastes so that human health, the wild deer herd, and the environment are protected.

The MPCA has been working with the Minnesota Department of Health (MDH), the Minnesota Department of Natural Resources (DNR), the Minnesota Board of Animal Health (BAH) and the Department of Agriculture (MDA) in planning for the potential management of CWD should it be discovered in Minnesota's wild deer herd.

The MPCA and the MDH have reviewed the available research regarding CWD and waste disposal. Based on that review and what others are doing, we believe that incineration above 1100° F is the preferred method. However, given the large number of deer carcasses that will need to be disposed of, we believe that disposal at a Lined Mixed Municipal Solid Waste (MSW) or Ash Landfill or at the SKB Rosemount Industrial Landfill, are safe practicable alternatives to incineration. We also believe that disposal using these options would greatly reduce the risk of spreading CWD to other deer, should CWD be found in Minnesota. Direct burial of deer that test positive for CWD is not appropriate at this time.

My staff have been in contact with several disposal facilities already on this matter and are working with them to modify their Industrial Solid Waste Management Plans (ISWMP) so that those facilities can accept this waste material. I have instructed my staff to prepare draft language for inclusion in ISWMP's that is available for you if your facility is interested in accepting this type of waste. Please contact your MPCA regional solid waste compliance person if you want to obtain this language. A list of MPCA staff to contact is included below in this letter.

The Wisconsin DNR completed an analysis that discusses the risks associated with land filling of deer that have CWD. This assessment was prepared by the Wisconsin DNR with input from landfill engineers, wastewater and air management experts, veterinarians, and epidemiologists from several agencies. They also received input from prion experts in Europe and other states. MPCA and MDH

Minnesota's 30 Mixed Municipal Solid Waste Landfill Operators
SKB Rosemount Industrial Landfill Operator
Minnesota's 6 Waste Combustor Operators

Staff have reviewed this information and find that it is thorough and represents the latest information on this subject. The assessment is available at web site, www.dnr.state.wi.us

The Wisconsin DNR completed an analysis that discusses the risks associated with land filling of deer that have CWD. This assessment was prepared by the Wisconsin DNR with input from landfill engineers, wastewater and air management experts, veterinarians, and epidemiologists from several agencies. They also received input from prion experts in Europe and other states. MPCA and MDH staff have reviewed this information and find that it is thorough and represents the latest information on this subject. The assessment is available at web site, www.dnr.state.wi.us

For further information about the emerging CWD issue, here are some other web sites that can be reviewed:

www.dnr.state.mn.us
www.bah.state.mn.us
www.health.state.mn.us
www.cvm.umn.edu/cahfs
www.aphis.usda.gov

In summary, we believe that incineration above 1100° F, disposal in a Lined MSW or Ash Landfill, or the SKB Rosemount Industrial Landfill are acceptable options for disposal of deer carcasses that present very minimal risk.

For questions about this letter, or about your Industrial Solid Waste Management Plan, please call:

Brainerd	Curt Hoffman	(218) 828-6198
Detroit Lakes	Roger Rolf	(218) 846-0774
Duluth	Tim Musick	(218) 723-4708
Metro	Katie Koelfgen	(651) 297-8506
Rochester	Mark Hugeback	(507) 280-5585
Willmar	Don Nelson	(651) 296-8621

Sincerely,
Karen A. Studders
Commissioner

KAS:mh

Minnesota's 30 Mixed Municipal Solid Waste Landfill Operators
SKB Rosemount Industrial Landfill Operator
Minnesota's 6 Waste Combustor Operators

Enclosure: List of Lined Mixed Municipal Solid Waste and Ash Landfills, Lined Industrial Landfills and Waste Combusters that can be approved to accept deer carcasses or deer ash.

cc: County Solid Waste Officers
Commissioner Allen Garber, DNR
Commissioner Gene Hugoson, MDA
Commissioner Jan Malcolm, MDH
Dr. Bill Hartman, BAH

Attachment A

Mixed Municipal Landfills that can Accept deer carcasses or deer ash.*

Lined Mixed Municipal Landfills
Blue Earth/Ponderosa SLF
Brown County SLF
Burnsville SLF
Clay County SLF
Cottonwood Co SLF
Crow Wing County SLF
East Central SLF
Elk River SLF
Fergus Falls SLF
Greater Morrison SLF
Kandiyohi County SLF
Lyon Co SLF
Mar-Kit SLF
Nobles Co SLF
NE Otter Tail Ash LF
NRG Becker Ash LF
NSP Red Wing Ash LF
NSP Wilmarth Ash LF
Olmsted-Kalmar LF
Pine Bend SLF
Polk County LF
Pope-Douglas Ash LF
Red Wing Ash LF
Renville SLF
Rice County SLF
Spruce Ridge SLF
Steele County SLF
St. Louis County SLF
Superior FCR LF
WLSSD SLF

Lined Industrial Landfills that can accept deer carcasses or deer ash.*

Lined Industrial Landfills
SKB Industrial LF

Incinerators that can accept deer carcasses or deer ash.*

Waste Combustor Facilities
City of Red Wing
Olmsted County
Perham
Pope-Douglas County
HERC
City of Fergus Falls

**** Operators must request, and the MPCA must approve, modifications to their Industrial Solid Waste Management Plan.***

November 5, 2002

To: **Mixed Municipal Solid Waste Landfill Operators**
Select Industrial Landfill Operators
RE: **Disposal of Deer Carcasses**

On November 4, 2002, Minnesota Pollution Control Agency Commissioner Karen Studders sent you an informational letter on Chronic Wasting Disease (CWD) and the landfilling of animal carcasses. Carcasses and ash waste from the incineration of carcasses is considered an industrial solid waste if it is generated by any commercial processing or by a Minnesota Department of Natural Resources deer culling operation. If your facility is planning on accepting this type of waste, your Industrial Solid Waste Management Plan (ISWMP) will need to be amended. Enclosed is suggested minimal language you may include in your amendment. You may include additional protections or strategies specific to your facility. This plan does not supersede the previously permitted ISWMP for the facility, but may be added as an amendment to the ISWMP. The suggested language addresses the acceptance and disposal procedures for deer and elk carcasses and for carcass ash waste that may or may not be infected with CWD. Isolated carcasses, which are put into the normal residential Mixed Municipal Solid Waste stream by hunters, are considered household wastes and are not managed through the ISWMP.

If your facility will be accepting these types of waste, please contact your regional Solid Waste Program staff listed below. Plan amendments will be given expedited review by staff.

Brainerd Region	Curt Hoffman	(218) 828-6198
Detroit Lakes Region	Roger Rolf	(218) 846-0774
Duluth Region	Tim Musick	(218) 723-4708
Metro Region	Katie Koelfgen	(651) 297-8506
Rochester Region	Mark Hugeback	(507) 280-5585
Willmar Region	Don Nelson	(652)296-8621

Sincerely,

Rodney E. Massey, P.E.
Division Director
Regional Environmental Management Division

REM:kr
cc: MPCA Regional Managers

INDUSTRIAL SOLID WASTE MANAGEMENT PLAN GENERIC CONDITIONS FOR THE ACCEPTANCE OF DEER AND ELK CARCASSES OR CARCASS ASH WASTE

The following plan is designed for implementation at permitted Mixed Municipal Solid Waste (MSW) Landfills and certain approved Industrial Landfills in the state of Minnesota. This plan does not supersede the previously permitted Industrial Solid Waste Management Plan (ISWMP) for the facility, but may be added as an Addendum to the ISWMP. The following Addendum addresses the acceptance and disposal procedures for deer and elk carcasses and for carcass ash waste that may or may not be infected with Chronic Wasting Disease (CWD). Carcass and ash waste is considered an industrial solid waste if it is generated by any commercial processing or by a Minnesota Department of Natural Resources deer culling operation. Isolated carcass wastes which are put into the normal residential MSW waste stream by hunters are considered household wastes and are exempted from management by an ISWMP.

If you, at a minimum, choose to add the following language into an Addendum to your ISWMP, approval from the Minnesota Pollution Control Agency (MPCA) to accept deer carcass wastes at your facility will be considered granted. You must also notify the MPCA in writing of this modification to your ISWMP upon making the decision to accept carcass wastes.

<u>Pre-acceptance Procedures:</u>

- The facility must follow the usual procedures contained in its approved ISWMP for acceptance of any industrial solid waste, including any necessary notifications and basic pre-acceptance procedures.

<u>Acceptance and Handling Procedures:</u>

- The landfill operator must designate a specific area high in the fill for disposal of carcasses and carcass ash waste loads.
- Carcass ash waste may not be disposed of if wind speeds exceed ten (10) miles per hour at the time of disposal.
- Loads of carcasses or carcass ash waste must be immediately covered with a minimum of one (1) foot of compacted MSW or other approved cover materials.
- The operator must minimize any unnecessary manual handling of the waste and must follow any appropriate safety precautions or plans. At a minimum, operators should consider use of rubber gloves and safety glasses if some manual handling of carcasses is needed.
- Once the carcasses or carcass ash are disposed of, the operator must make a notation on a facility map or diagram which contains the quantity disposed (in cubic yards, tons, or the total number of animals), along with the vertical and horizontal location within the fill phase.

APPENDIX F. CERVID IMPORT REQUIREMENTS FOR MINNESOTA (BAH)

(Includes all members of the family Cervidae, including deer, elk, moose, reindeer, caribou)
Revised March 2002

1. A permit must be obtained prior to the importation of any Cervidae.

2. All Cervidae imported into Minnesota must be accompanied by a Certificate of Veterinary Inspection (CVI) issued by an accredited veterinarian.

3. All Cervidae imported into Minnesota must be individually indentified using one or more of the following: USDA metal eartag, Electronic ID, ear or lip tattoo with 4 or more digits, or NAEBA tag

4. Tuberculosis test requirement:

   a. Movement from **accredited** herds

      - No further tuberculosis testing required for importation.
      - The TB accredited herd number must be written on the CVI.

   b. Movement from **qualified** or **monitored** herd

      - Animal must have a negative TB test within 90 days of shipment unless the whole herd test (including the animal for movement) was conducted within 90 days of movement.
      - The TB qualified or monitored herd number must be written on the CVI.

   c. Movement from **unclassified** herds

      - Animal must be negative on 2 TB tests conducted not less than 90 days apart. Test dates and results must be written on the CVI.
      - Second test must be done within 90 days of movement.
      - Animals must be isolated from all other members of the herd during the testing period.
      -

   d. Movement of cervids from Michigan
      Special restrictions and testing requirements apply. Call the Board of Animal Health at 651-296-2942.

   e. Movement of cervids from Canada
      Call the USDA office at 651-290-3691 and the Board of Animal Health at 651-296-2942 for requirements.

f. Movement of cervids into Minnesota TB accredited, qualified, or monitored herds. Herd additions must be from same or higher status or herd will lose its status unless additional testing is done before and after import. Call the Board of Animal Health if you have questions about herd additions to TB accredited, qualified, or monitored herds.

5. Brucellosis test requirement

   a. All cervids > 6 months of age must have a negative Brucellosis test within 30 days of movement into Minnesota, unless originating from a Brucellosis certified herd.

6. Chronic Wasting Disease Requirement

   a. No cervid originating from an area considered to be endemic for Chronic Wasting Disease will be allowed entry into Minnesota. This area includes:

      Wyoming: Albany, Carbon, Converse, Laramie, Platte, Niobrara, Goshen, Platte
      Nebraska: Kimball, Sioux, Banner, Scotts Bluff, Cheyenne, Deuel, Keith, Perkins, Chase
      Colorado: Boulder, Gilpin, Larimer, Weld, Logan, Morgan, Phillips, Sedgwick, Washington, Eagle, Garfield, Grand, Jackson, Larimer, Moffit, Rio Blanco, Routt, Summitt
      South Dakota: Fall River
      Wisconsin: Dane, Iowa, Sauk, Columbia, Juneau, Jefferson, Rock, Green, Lafayette, Crawford, Grant, Richland, Walworth
      Illinois: Boone, Stephenson, Winnebago
      Saskatchewan: Must have approval from the BAH

   b. No cervid can be imported that is from a herd that is infected or exposed to Chronic Wasting Disease, or that has purchased a cervid from an infected herd unless the herd has been cleared to the satisfaction of the Board.

   c. All cervids imported must be from a herd that has been participating in a state recognized CWD surveillance program for at least 3 years. The CWD herd number and numbers of years in the program must be written on the CVI.

CONDITION OF MOOSE (*ALCES ALCES*) IN NORTHEASTERN MINNESOTA

Glenn D. DelGiudice, Mark S. Lenarz, Michael Schrage, Andrew Edwards, and Michael E. Nelson

BACKGROUND

A study of moose (*Alces alces*) in northeastern Minnesota was prompted recently by an abrupt decrease (50%) in the population during 1988-1990, followed by moose numbers that have remained low and stable for as long as 13 years (Lenarz et al. 2002). The overall goal of the study is to generate data that will provide a clearer understanding of the ecological mechanism(s) underlying the population dynamics observed (Lenarz et al. 2002). Consequently, as explained by these authors, one of the primary objectives is to "determine annual rates of non-hunting mortality…" for moose in this part of the state. Because winter is the most nutritionally challenging season of the year for northern cervids, and nutrition has been shown to be a mechanistic link between environmental variation (e.g., winter tick [*Dermacentor albipictus*] infestation) and variation of moose populations (DelGiudice 1997), assessment of winter condition of moose recruited into the present study was deemed a worthwhile field objective. Logistical constraints and considerations associated with capture and handling of free-ranging moose during the study's first winter field season (2001-02) precluded condition assessments; however, such evaluations during this past winter's (2002-03) capture operations were feasible and successful. Herein, we report the results of condition assessments for live-captured moose during winter 2002-03.

METHODS

During 26 February-2 March 2003, adult ($\geq$1.5 year old) moose were immobilized with a carfentanil and xylazine combination delivered by a dart rifle from a helicopter. Details of the capture/chemical immobilization procedure, as well as a description of the study area, are provided elsewhere in this Research Summary (Lenarz et al. 2003).

Condition of moose was assessed by the following 3 methods: (1) ultrasonic measurements of rump fat thickness (Stephenson et al. 1998, 2002); (2) Franzmann's condition classification (FCC), developed specifically for moose (Franzmann 1977); and (3) the portion of a body condition scoring system developed for elk (*Cervus elaphus*), which concentrates on visual and palpation assessments of fat repleteness of the rump (BCS_r, Cook et al. 2001). We measured subcutaneous rump fat thickness (mm) with a portable ultrasound device (Sonovet 600 model, Universal Medical Systems, Inc., Bedford Hills, N. Y.) and a 5-MHz 8-cm linear-array transducer. Measurements were made at the midway point ("mid") between the tips of the iliums and the right or left tuber ischium (pin bone) and at the point of maximum fat thickness ("maxfat"), which we located by scanning lateral to the sacral ridge towards the pin bone. Location of maxfat was immediately cranial to the cranial process of the pin bone. Due to differences in body size of males and females, application of a scaling factor (0.83) to maxfat measurements of males permitted comparison to adult females (Stephenson et al. 1998).

The FCC and the BCS_r are described in Tables 1 and 2. Compared to the BCS_r, the FCC system includes a more complete assessment of the conformation of the moose's entire body related to condition.

RESULTS AND DISCUSSION

We assessed the condition of 37 (19 females, 18 males) of the 42 adult moose captured and handled. Overall mean maxfat was 16.0 mm (SE = 1.6, range = 0-38 mm). Maxfat was less in bulls than in cows, though the difference was not significant (Table 3). In captive moose, maxfat measurements have ranged between 0 and 70 mm, and were directly related ($r^2 = 0.96$, $P < 0.001$) to ingesta-free body fat (IFBFAT) contents of approximately 2.5-17.5% (Stephenson et al. 1998). Applying the regression of Stephenson et al. (1998), maxfat measurements of our free-ranging moose indicate an estimated mean IFBFAT of about 8.5% and a range of < 5.6-12.5%. Studies of captive moose (and other cervids) have shown that at 5-5.6% IFBFAT, rump fat will be depleted (i.e., maxfat = 0 mm).

The mean FCC and BCS_r scores were 7.2 (range = 3-10, scale of 10) and 3.4 (range = 2-4.5, scale of 5). According to both of these scoring systems, although not significantly, mean condition scores were lower for bulls than cows (Table 3). There was a significant correlation ($r = 0.83$, $P < 0.0001$) between the FCC and BCS_r scores for all moose. Additionally, maxfat was significantly correlated to FCC scores ($r = 0.56$, $P < 0.001$) and BSS_r scores ($r = 0.53$, $P = 0.002$). The strength of the relationship between the scoring systems and maxfat measurements is limited, because the scoring systems are characterized by discrete scores, whereas the maxfat measurements are continuous; consequently, a range of maxfat measurements may be associated with a given score.

The late winter, mean maxfat measurements (16.00 mm and 95% confidence limits = 12.9, 19.1 mm) and associated estimated IFBFAT contents (roughly 8-10%) of our free-ranging moose indicate that most of them were in good condition, which was consistent with the unusual mild weather conditions and shallow snow cover that characterized winter 2002-03 in northeastern Minnesota. This agrees with our assignment of qualitative assessments of "very good," "good," and "fair-poor" to FCC scores as presented in Table 4, which indicates that about 76% of the moose were in good to very good condition. The most notable case of a moose in poor condition, was a female with no rump fat (maxfat = 0), the lowest FCC and BCS_r scores (3 and $\leq$ 2, respectively) of all 37 moose scored, and which died within hours of release, despite a typical, relatively rapid apparent recovery from the chemical immobilization.

The potential value of the condition assessments of the radiocollared moose may occur at the individual and population scales. They may provide insight relative to the survival or fate (i.e., cause of mortality) of each individual moose. Further, as this study progresses, annual condition assessments of new recruits of the study cohort may contribute to our understanding of the impacts of varying environmental conditions (e.g., winter severity/habitat quality, winter tick infestation) on performance (i.e., survival rates, reproductive success) of the local population over time.

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Table 1. Franzmann's condition classification for moose, used to assess winter condition of 37 free-ranging adult (19 females, 18 males) moose, 26 February-2 March 2003, northeastern Minnesota.

10.	A prime, fat animal with thick, firm rump fat by sight. Well fleshed over back and loin. Shoulders round and full.
9.	A choice, fat moose with evidence of rump fat by feel. Fleshed over back and loin. Shoulders round and full.
8.	A good, fat moose with slight evidence of rump fat by feel. Bony structures of back and loin not prominent. Shoulders well fleshed.
7.	An average moose with no evidence of rump fat, but well fleshed. Bony structures of back and loin evident by feel. Shoulders with some angularity.
6.	A moderately fleshed moose beginning to demonstrate **one** of the following conditions: (A) definition of neck from shoulders; (B) upper foreleg (humerous and musculature) distinct from chest; or (C) rib cage prominent.
5.	A condition in which **two** of the characteristics listed in Class 6 are evident.
4.	A condition in which all three of the characteristics listed in Class 6 are evident.
3.	A condition in which the hide fits loosely about neck and shoulders. Head is carried at a lower profile. Walking and running postures appear normal.
2.	Signs of malnutrition are obvious. The outline of the scapula is evident. Head and neck are low and extended. The moose walks normally but trots and paces with difficulty, and cannot canter.
1.	A point of no return. A generalized appearance of weakness. The moose walks with difficulty and can no longer trot, pace or canter.
0.	Dead

Table 2. Body condition scoring system modified from Cook et al. (2001), used to assess the condition of 37 free-ranging adult (19 females, 18 males) moose, 26 February-2 March 2003, northeastern Minnesota.

5 .	Sacral ridge, ilium, ischium are virtually discernible.
4.	Sacral ridge is discernible from ilium approximately midway to base of tail. Ischium and sacro-sciatic ligament are discernible.
3.	Entire sacral ridge is discernible, but not prominent.
2.	Sacral ridge is prominent to base of tail.
1.	Sacral ridge, ilium, ischium, tuber coxae, and sacro-sciatic ligament (entire top of rump) are prominent.

Table 3. Mean (± SE) maximum rump fat (maxfat) thickness measured by portable ultrasonography, and body condition scores (Franzmann's condition classification [FCC] and rump portion of body condition scoring system [BCS_r] modified from Cook et al. 2001) of 37 free-ranging adult (19 females, 18 males) moose, 26 February-2 March 2003, northeastern Minnesota. Range of values occurs in parentheses.[a]

Sex	Maxfat (mm)[a]		FCC		BCS_r	
	Mean	SE	Mean	SE	Mean	SE
Females	17.4	2.4	7.4	0.4	3.6	0.2
	(0-38.0)		(3.0-10.0)		(2.0-4.5)	
Males	14.6	2.0	7.0	0.3	3.2	0.1
	(3.3-25.7)		(4.0-9.0)		(2.0-4.3)	

[a]Descriptions of the FCC and BCS_r systems are provided in Tables 1 and 2, respectively.

[b]n = 16 for males and females due to temporary malfunctioning of portable ultrasound.

Table 4. Qualitative condition classification of 37 free-ranging adult (19 females, 18 males) moose according to Franzmann's condition classification, 26 Febraury-2 March 2003, northeastern Minnesota.

	Franzmann's Condition Score			Total
	≥ 8 (Very Good)	$7 \leq x < 8$ (Good)	≤ 6 (Fair-Poor)	
Number of moose	15	13	9	37
Percent of total	40.54	35.14	24.32	100.00

[a]A description of Franzmann's condition classification is provided in Table 1.

ASSESSING THE RELATIONSHIP OF CONIFER THERMAL COVER TO WINTER DISTRIBUTION, MOVEMENTS, AND SURVIVAL OF FEMALE WHITE-TAILED DEER IN NORTH CENTRAL MINNESOTA

Glenn D. DelGiudice

BACKGROUND

The goal of this long-term investigation is to assess the value of conifer stands, as winter thermal cover/snow shelter, to white-tailed deer (*Odocoileus virginianus*) at the population level. Historically, conifer stands have declined dramatically in Minnesota and elsewhere in the Great Lakes region. The level of logging of all tree species collectively, and conifer stands specifically, has recently reached the estimated allowable harvest. Most land management agencies and commercial landowners typically restrict harvests of conifers compared to hardwoods, because of evidence at least at the individual level, indicating the seasonal value of this vegetation type to various wildlife, including deer. However, agencies anticipate greater pressure to allow more liberal harvests of conifers in the future. Additional information is needed to assure future management responses and decisions are ecologically sound. Both white-tailed deer and the forests of the Great Lakes region have significant positive impacts on local and state economies, and they are highly regarded for their recreational value.

The null hypothesis is that conifer stands have no effect on the survival, movement, and distribution of white-tailed deer during winters of varying severities. Relative to varying winter severities, the specific objectives of the comprehensive, quasi-experimental approach of this study are to: (1) monitor deer movements between seasonal ranges by aerial radio-telemetry, and more importantly, within winter ranges, for determination of home range size; (2) determine habitat composition of winter home ranges and deer use of specific vegetation types; (3) monitor winter food habits; (4) monitor winter nutritional restriction and condition via sequential examination of deer weights, body composition, blood and bladder urine profiles, and urine specimens suspended in snow (snow-urine); (5) monitor age-specific survival and cause-specific mortality of all study deer; and (6) collect detailed weather data in conifer, hardwood, and open habitat types to determine the functional relationship between the severity of winter conditions, deer behavior (e.g., use of habitat), and survival.

This study employs a replicated manipulative design, which is a modification of the Before-After-Control-Environmental Impact design (BACI; Stewart-Oaten et al. 1986; see DelGiudice and Riggs 1996). The study involves 2 control (Willow Lake, Dirty Nose Lake) and 2 treatment sites (Inguadona Lake, Shingle Mill Lake), a 5-year pre-treatment (pre-impact) phase, a conifer harvest serving as the experimental treatment or impact (4-year phase), and a 5-year post-treatment phase. The 4 study sites are located in the Grand Rapids-Remer-Longville area of north central Minnesota and are 10.4-22.0 km^2 (4.0-8.5 mi^2) in area. The study began with the Willow Lake and Inguadona Lake sites during winter 1990-91; the Shingle Mill Lake and Dirty Nose Lake sites were included beginning in winter 1992-93.

The objective of the experimental treatment (impact) was to reduce moderate ($\geq$40-69% canopy closure) and optimum conifer thermal cover/snow shelter ($\geq$70% canopy closure) to what is considered a poor cover class (< 40% canopy closure). We just completed our 13th winter of data collection and the 4th year of the post-treatment phase.

This report is not a comprehensive summary of the study, rather I discuss the progress of numerous aspects, and I update various summary descriptive statistics.

PROGRESS AND SUMMARY OF RESULTS

Capture, Handling, and Ages of Study Deer

During this study, we have had 1,043 deer captures, including recaptures. Because the study focuses on females, male fawns (in their first winter) and adult males have been eartagged and released. As of 31 March 2003, 388 female deer, including 43 female newborns, have been recruited into the study. Additionally, 47 male newborns have been captured and radiocollared. The newborns were captured during springs 1997 (2 females, 3 males), 1999 (4 females, 4 males), 2000 (3 females, 8 males), 2001 (21 females, 10 males), and 2002 (13 females, 22 males). Twin stillborns were also found during spring 1997. See additional information concerning the newborn deer portion of the study in Carstensen and DelGiudice (this Research Summary).

During 4 February - 20 March 2003, we had 37 captures, including 23 recaptures. Of the 19 individual deer captured, 7 were fawns (3 females, 4 males) and 12 were adults ($\geq$1.5 year old; 8 females, 4 males). Low capture success was attributable to this winter being one of the least severe of the study (winter severity index [WSI] = 58). But more importantly, snow cover throughout most of this winter was the shallowest of the study, with mean julian week snow depths rarely accumulating >10 cm. Consequently, based on our telemetry data, there was little migration of deer to the winter range study sites, and deer densities were low. Further, during winters of little snow, deer on the study sites tend to be less nutritionally desperate; therefore, it was difficult to entice them into Clover traps with bait.

During winter 2000-01, we documented the highest fawn:doe capture ratio (105 fawns:100 does). Winter 2000-01 was relatively severe (WSI = 153), but it followed an unprecedented 3 consecutive mild winters (P. Bouley, State Climate Office, personal communication). Pregnancy rates of captured adult does were 100% during winters 1998-2000. Presumably, each winter was associated with high reproductive success of does as well. It appears that the severity of winter 2000-01 did not have a dramatic negative impact on subsequent reproductive success, as the fawn:doe ratio of captured deer remained relatively high (25 fawns:31 does or 81:100) during winter 2001-02. During consecutive severe winters 1995-96 and 1996-97, fawns:100 does declined from 64:100 to 32:100, respectively. The low fawn:doe ratio of winter 1996-97 was likely primarily attributable to the preceding historically severe winter (WSI = 183), during which the mortality rate of radiocollared does was the highest (29.3%) of the past 13 years. Further, observations indicated that reproductive success of surviving does following severe winter 1995-96 was exceptionally low, thus a small number of fawns would have entered winter 1996-97. In contrast, snow conditions were not nearly as severe during winter 2000-01; much of its high WSI value was attributable to atypically low ambient temperatures during December and February. Snow conditions impose a greater challenge on doe condition and survival than winter ambient temperatures (DelGiudice et al. 2002). I would expect that snow conditions rather than ambient temperatures would also have a greater adverse effect on reproductive success of surviving does, consequently a relatively high number of fawns entered mild winter 2001-02.

Of the 19 deer captured during winter 2002-03, 6 new females (3 fawns, 3 adults) were recruited into the radiocollared study cohort. Consequently, including does already radiocollared when this winter began, 62 females have been monitored during December 2002-May 2003.

Handling of each deer included chemical immobilization (intramuscular injection of a xylazine HCl/ketamine HCl combination), weighing, blood and urine-sampling (for assessment of nutritional, stress, and reproductive status [Warren et al. 1981, 1982; Wood et al. 1986; DelGiudice et al. 1987*a*,*b*, 1990*a*,*b*, 1994]), extraction of a last incisor for age-determination (Gilbert 1966), various morphological measurements, and administration of a broad-spectrum antibiotic. All does were checked for pregnancy with a dop-tone or visual ultrasound; only 4 pregnant does (including 1 captured adult doe initially radiocollared during a previous winter) were fitted with vaginal radio transmitter implants (Advanced Telemetry Systems, Inc., Isanti, MN). As in previous winters of the study, most female fawns and does were fitted with VHF radiocollars (Telonics, Inc., Mesa, Az) for monitoring subsequent movements and survival of the deer; however, 1-5 does have been fitted with global positioning system (GPS) radiocollars (Advanced Telemetry Systems, Inc ., Isanti, MN). Additionally, winter 2002-03 was the 5th winter during which handling of some does included *in vivo* determinations of body composition (i.e., total body water, fat, protein, and mineral) by the deuterium-dilution technique. Deuterium is a natural isotope of H_2O. Importantly, we have now examined body composition of deer during an historically severe winter (1996-97), the least severe winter of the study (2001-02), and during a severe winter with high deer densities (2000-01). Additional details are provided in Carstensen and DelGiudice (this Research Summary). Upon completion of handling, all deer immobilizations were reversed with an intravenous injection of yohimbine HCl.

Measured at the end of each calendar year, or at death (or at last contact for lost radio signals) within a specific year, mean age of collared female deer remained similar among the 4 study sites during the 5-year pre-treatment phase (1991-1995), the 4-year experimental treatment phase (1996-1999), and thus far during the post-treatment phase. Consequently, observed differences in deer survival among sites within each of the study phases will not be confounded by differences in age among sites (DelGiudice and Riggs 1996). Equally as important, after 1991, mean age of deer on all 4 sites (pooled) also remained stable and has ranged from 4.8 ($\pm$ 0.4 [SE], $n = 22$) in 1991 to 7.2 ($\pm$ 0.6, $n = 61$) years old (Fig. 1). During 2002, mean age was 5.5 ($\pm$ 0.4) years old, compared to 6.0 ($\pm$ 0.2) years old during the remainder of the study overall, and age at capture during winter 2002-03 ranged from 0.5 to 4.5 years old.

According to progesterone concentrations ($\geq$1.8 ng/ml, Wood et al. 1986), the pregnancy rate of captured adult ($\geq$1.5 year old) females has remained consistently high throughout the study (Fig. 2), ranging from 79 to 100% during winters 1990-91 to 2001-02. During 9 of these years the pregnancy rate was 90-100%. Only 1 fawn has been assessed as pregnant by this method. Of 25 does determined pregnant in the field by ultrasound and fitted with vaginal transmitter implants during each of winters 2000-01 and 2001-02, 19 and 17 were alive and had active transmitters by the start of fawning seasons 2001 and 2002, respectively (see Carstensen and DelGiudice in this Research Summary for further details).

Capturing the Variability of Winter Severity

Weather is one of the strongest forces impacting wildlife populations and their numbers. Nutrition is intricately related to all aspects of a deer's ecology, and it acts as a mechanistic thread between environmental variability and the variability of deer populations. For northern deer in the forest this becomes most evident during winter when diminished quantity, availability, and quality of food resources and severe weather conditions impose the most serious challenge to their survival. This long-term study continues to document highly variable winter weather conditions, which permits a more complete examination and understanding of the relationship between winter severity, conifer cover and the many aspects of white-tailed deer ecology that we are investigating (e.g., movements, distribution, food habits, cause-specific mortality, and age-specific survival). We are examining the variability of weather conditions in several different ways. Specifically, Figure 3 illustrates the Minnesota Department of Natural Resources' (MNDNR) WSI, which is calculated by accumulating a point for each day with an ambient temperature $\leq -17.8^{\circ}$ C (0° F) and an additional point for each day with a snow depth $\geq$ 38.1 cm (15"). The WSI for our study sites has now ranged from 45 (winters 1999-00 and 2001-02) to 183 during the past 13 winters. The WSI of winter 2002-03 was not the lowest (WSI = 58); however, snow cover was shallower than during any other winter. The biological significance of this is that depth of snow cover is the component of the WSI that has the greatest negative effect on deer survival (DelGiudice et al. 2002). Figure 4 shows mean daily minimum ambient temperatures (monthly) and mean weekly (julian) snow depths throughout winter 2002-03. Thus far, the study has captured a wide range of weather conditions, which will enhance the value of all interpretations of data related to deer survival and other aspects of their ecology. A severe winter during the post-treatment phase of the study has eluded us, and would prove most valuable.

To relate the variability of ambient temperature to deer in a more biologically meaningful or functional way, I calculated the *effective critical temperature* for an average size adult female deer (-7° C or 19.4° F) and the number of days per month when the maximum ambient temperature was at or below this threshold (Fig. 5). At or below this temperature threshold, heat losses may exceed energy expenditure for standard metabolism and activity, and additional heat is generated to maintain homeothermy (McDonald et al. 1973). On these days, a physiological (e.g., accelerated mobilization of fat reserves) or behavioral response (e.g., change in habitat use) by the deer would be necessary to meet this environmental challenge. Similarly, I used a snow depth threshold of $\geq$41 cm (16.1"), about two-thirds chest height of adult female deer, because energetically expensive bounding often becomes necessary at this depth, and overall movements become markedly restricted (Kelsall 1969, Kelsall and Prescott 1971, Moen 1976). Figure 5 depicts the pronounced variability of days during the 13 winters when it is biologically reasonable to expect that there were potentially serious energetic implications associated with ambient temperature or snow depth. It is noteworthy that extensive statistical analyses of age-specific survival and weather data from the first 6 years of our study (DelGiudice et al. 2002), as well as from other studies of deer and other cervids, have shown that snow conditions (depth and density) impose a far greater challenge to survival than ambient temperature. However, our data also indicate that during a very severe winter (e.g., 1996), the consequences of cold temperatures on individual deer with rapidly depleting or exhausted fat reserves should not be underestimated.

Cause-Specific Mortality of Deer

The "crude mortality rate" of our study deer was calculated by dividing the number of radiocollared deer that died during a reference period (e.g., winter defined as Dec-May) by the total number of deer that were radiocollared and monitored during that period. With each year, new data collected from the field, including recaptures of does with expired collars (i.e., "lost signals"), permit revision of mortality statistics. During 1 January 1991-31 December 2002, annual mortality rates of radiocollared females ranged from 9.1 to 47.6% (Fig. 6). The mortality rate of 2002 was relatively typical at 23.1%. As has been mentioned in previous reports, the atypical mortality of 1992 (47.6%, Fig. 6) was largely attributable to elevated hunter harvest (37.1%, Fig. 6) associated with an increase in antlerless permits, whereas during 1994 and 1996, a preponderance of old females, severe weather conditions, and wolf (*Canis lupus*) predation contributed to the higher mortality rates. As reflected by the hunter-caused mortality rate in Figure 6, no antlerless permits were issued in the vicinity of our winter study sites or of the spring-summer-fall ranges of our study deer during 1996 and 1997, and very few were issued during the 1998 season. However, in 1999 there was an increase in hunter-caused mortality of the radiocollared deer, and this increased further to the study's second highest level during 2000 (19.4%, Fig. 6). Except for during 1994 and 1996, when winters were moderately severe to severe, annual wolf-caused mortality of female deer was 4.1-14.5%, the maximum wolf predation rate occurring during 2001. Overall, wolf predation accounted for 44 % of the total deer mortality (i.e., relative importance) occurring during November-May 1991-2003. Mean age of female deer killed by wolves during 9 of the first 12 winters of the study was 6.0 ($\pm$ 1.8, n = 9)-11.7 ($\pm$ 1.7, n = 8) years old. During the other 3 winters, the mean age of wolf-killed deer was 4.5 ($\pm$ 3.7, n = 3), 3.6 ($\pm$ 1.7, n = 3), and 2.8 ($\pm$ 0.7, n = 3). Hunter harvest has accounted for 31% of the radiocollared deer mortality.

Most of the annual non-hunting mortality of the study deer occurs during winter, and typically, winter mortality of the collared adult female deer has been low (2.0-12.5%, Fig. 7). The highest winter mortality rates (16.2-29.3%) of does have occurred during 3 of the 4 most severe winters (1993-94, 1995-96, and 2000-01, Fig. 7). With the inclusion of data from winter 2002-03, the relationship between WSI and percent winter mortality of adult female deer continued to be reasonably strong (r^2 = 0.52) and significant (P = 0.005, Fig. 8). Sixteen of the 17 mortalities (94.1%) of collared females occurring during winter 2000-01 were the result of predation, and 58.8% of the total winter mortality was by wolf predation. During winter 2001-02, all of the 7 mortalities observed were by predation, and 86% (6 of 7) was by wolf predation.

For 11 adult female mortalities (1 was an uncollared doe) from which femurs were available during winter 2000-01, mean femur marrow fat (FMF) was 59.1% ($\pm$ 6.4, range = 33.9-94.9%). Mean FMF was 44.3% ($\pm$ 20.8, range = 9.2-81.1%) for 3 fawn mortalities. These low FMF contents indicate that average condition was poor (< 5% total body fat). During mild winter 2001-02, the mean FMF of 5 adult females was 73.4% ($\pm$ 11.2), but the FMF contents steadily decreased over time from 93.0% (25 Feb) to 35.0% (4 Apr). The FMF content of 1 fawn that died on 26 March was only 17.0%. During winter 2002-03, mean FMF of 5 deer mortalities was 89.8% ($\pm$ 0.7)

Monitoring Wolf Activity

As the study has progressed over the past 13 years, wolf activity on the 4 sites appears to have increased. Wolves were extirpated from the area of the study sites during the 1950-60s, and just 5-6 years prior to initiation of the study had re-entered and became re-established in the area. When the study began in winter 1990-91, the area of the study sites was on the leading edge of wolf range expansion in Minnesota. Since spring 1993, we have captured and radiocollared 37 (19 females, 18 males) wolves from 7-9 packs which range over the 4 study sites (Table 1). Fates of these collared wolves include being killed by members of neighboring packs, shot and killed by humans, killed by cars, natural causes, radio failure, and dispersal out of the vicinity of the study sites.

During 1993-2001, we monitored 31 wolves, and documented a median survival from date of capture of 1,328 days (3.7 years, 90% confidence interval = 686-1,915 days) (DelGiudice, unpublished data). Eleven wolves, all adults (4 males, 7 females), died during this study period; 7 (64%) of these mortalities were human-related.

Based on aerial observations, pack sizes have ranged from 2 to 8 members. Current status of each of the collared wolves is listed in Table 1. As is somewhat typical of wolf packs, the territories of our collared wolves have been relatively stable and have ranged in size from 62 to 186 km^2 (24-72 mi^2). Radio telemetry location data of the collared wolves are being used to more closely monitor their activity and distribution relative to the distribution and movements of the radiocollared deer. We will capture and radiocollar additional wolves this summer. As mentioned above, year-round monitoring and examination of mortalities of radiocollared deer provide additional important information concerning wolf activity on the study sites.

Habitat Analyses and Updates

Detailed baseline habitat analyses using stereoscope interpretation of color infrared air photos and geographic information systems (GIS, Arc/Info and ArcView) have been completed . Forest stand types are classified by dominant tree species, height class, and canopy closure class. Open habitat types, water sources, and roads have also been delineated. We are updating the coverage to include the final experimental cuts that were conducted on the treatment sites (Inguadona Lake, Shingle Mill Lake) and to account for any changes in type classification associated with succession during the last 13 years. Additionally, we have been exploring a number of analytical methods used for assessing habitat availability, use and selection by deer.

Acknowledgments and Project Cooperators

I gratefully acknowledge the invaluable diverse skills and contributions of Barry Sampson, Dave Kuehn, and Ken Kerr to all aspects of this project. I am very appreciative of volunteers Richard Nelles and Rod Schloesser, who have contributed significant amounts of time and effort to the winter and spring field seasons for the past 3-6 years. More than 100 enthusiastic, competent, and dedicated interns have made collection of winter field data possible, and I am appreciative of their contributions as well. I also thank Mark Lenarz, Group Leader for the Forest Wildlife Populations and Research Group, for his continued support. Ongoing contributions by Don

Pierce, Gary Anderson, John Tornes, and Dan Hertle (MNDNR); Larry Olson, Jerry Lamon, and Ellisa Bredenburg (Cass County Land Department); Kelly Barrett and John Casson (U. S. Forest Service); John Hanson (Blandin Paper Co.); Carl Larson and Michael Houser (Potlatch Corp.) have been essential to the success of this study.

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Table 1. History of radio-collared gray wolves, north central Minnesota, 1993-2003 (Ad = adult, juv = juvenile).

Wolf no.	Pack	Capture date	Sex	Age class	Fate	Date
2093	Willow	May 1994	F	Ad	Shot	Mar 1996
2094	Willow	May 1994	M	Ad	Shot	Nov 1997
2056	Willow	May 1996	M	Ad	Not collared	
2058	Willow	May 1996	F	Ad	Prob. Shot	Aug 1996
2052	North Ingy	May 1993	M	Ad	Unknown	Dec 1996
2087	South Ingy	May 1993	F	Ad	Died natural causes, (emaciated, mangey)	Aug 2, 1998
2062	South Ingy	Aug 1997	F	Ad	Shot	Feb 1998
2089	Shingle Mill	May 1993	F	Ad	Killed by wolves	Sept 1994
2050	Shingle Mill	May 1993	M	Ad	Collar chewed off	Aug 1993
2095	Shingle Mill	May 1995	F	Ad	Lost signal	Nov 1995
2064	Shingle Mill	Aug 1996	F	Juv	Lost signal	Jun 23, 1998
2060	Shingle Mill	Aug 1996	F	Juv	Lost signal	Feb 1, 2000
		Jul 1998 recaptured				
2059	Shingle Mill	Aug 1996	M	Juv	Lost signal	Oct 1996
2085	Dirty Nose	May 1993	M	Ad	Dispersed	Oct 1993
2054	Dirty Nose	May 1993	M	Ad	Dispersed	Sept 1993
2091	Dirty Nose	Apr 1994	F	Ad	Radio failed	May 27, 1998
2092	Dirty Nose	Apr 1994	F	Ad	Radio failed	May 27, 1998
2096	Morrison	May 1995	F	Ad	Dropped transmitter	Bov 22, 1996
2252	Willow	Apr 1998	M	Ad	Road kill	Jun 1998
2253	Dirty Nose	Apr 1998	F	Ad	Unknown mortality	Aug 3, 1998
2254	Shingle Mill	Jul 1998	M	Ad	Dropped transmitter	Jul 17, 2001
2066	Morrison	Jul 1998	M	Ad	Killed by wolves	Jun 4, 1999
2067	Shingle Mill	Jul 1998	M	Juv	Collar chewed off	Jul 1998
2068	Holy Water	Jul 1998	M	Ad	Lost signal	Aug 27, 1999
2069	South Ingy	Jul 1998	M	Ad	Lost signal	Dec 4, 1998
2070	South Ingy	Jul 1998	F	Ad	Lost signal	Jul 3, 2002
2255	South Ingy	Jul 1998	F	Ad	Dispersed	Mar 22,1999
2256	Dirty Nose	Aug 1999	M	Ad	Dropped Transmitter	Jul 6, 2001
2257	E. Dirty Nose	May 1999	M	Ad	Lost signal	Jan 14, 2001
2258	Willow L	Aug 1999	M	Ad	Dispersed	Mar 16, 2000
2259	Dirty Nose	July 2000	M	Ad	Dispersed	Jul 2001
2261	Shingle Mill	Aug 2000	M	Ad	Dropped Transmitter	Apr 10, 2002
2074	South Ingy	Aug 2001	F	Ad	Shot by Farmer	Oct 23, 2002
2073	Shingle Mill	Aug 8, 2001	F	Juv	Dropped Transmitter	Aug 28, 2001
2071	Shingle Mill	Aug 2002	F	Ad	On the Air	
2141	Inguadona	Sep 2002	F	Juv	Dropped Transmitter	Sep 22, 2002

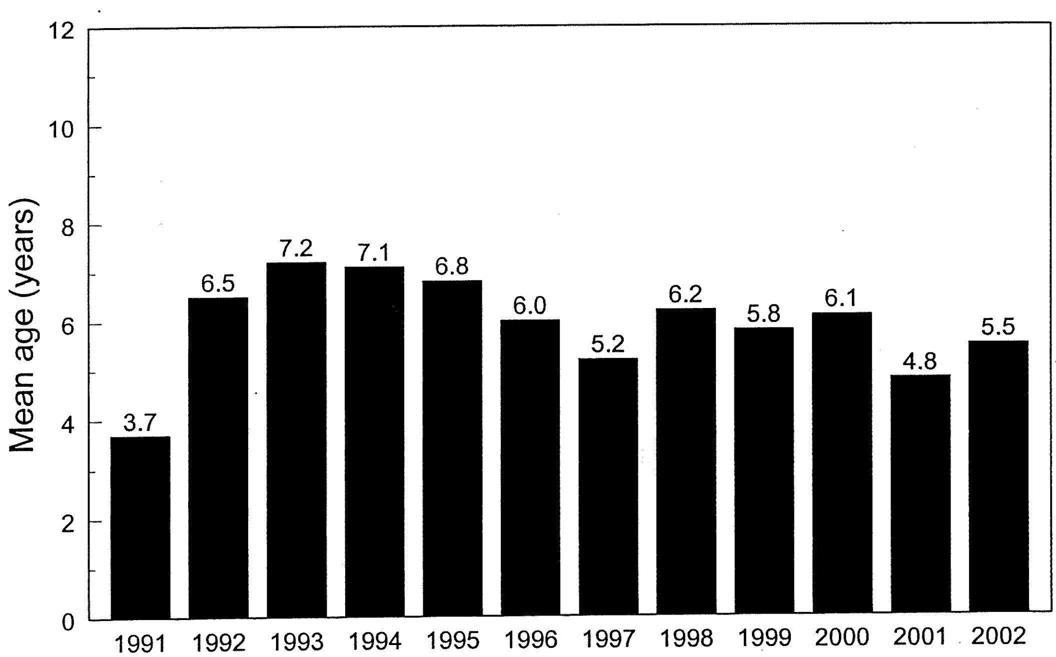


Figure 1. Mean age of radiocollared female white-tailed deer among years, north central Minnesota, 1 January 1991-31 December 2002. (Sample sizes were 22, 34, 61, 65, 53, 75, 74, 47, 52, 45, 87, and 80 respectively.)

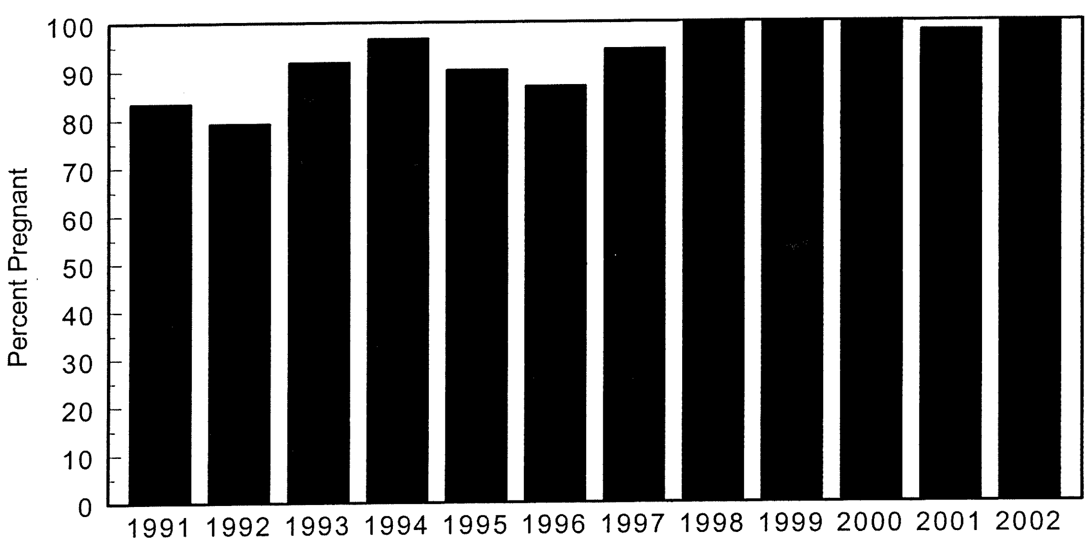


Figure 2. Pregnancy rate of adult (≥1.5 year old) white-tailed deer (4 study sites pooled) in north central Minnesota, winters 1990-91 to 2000-02.

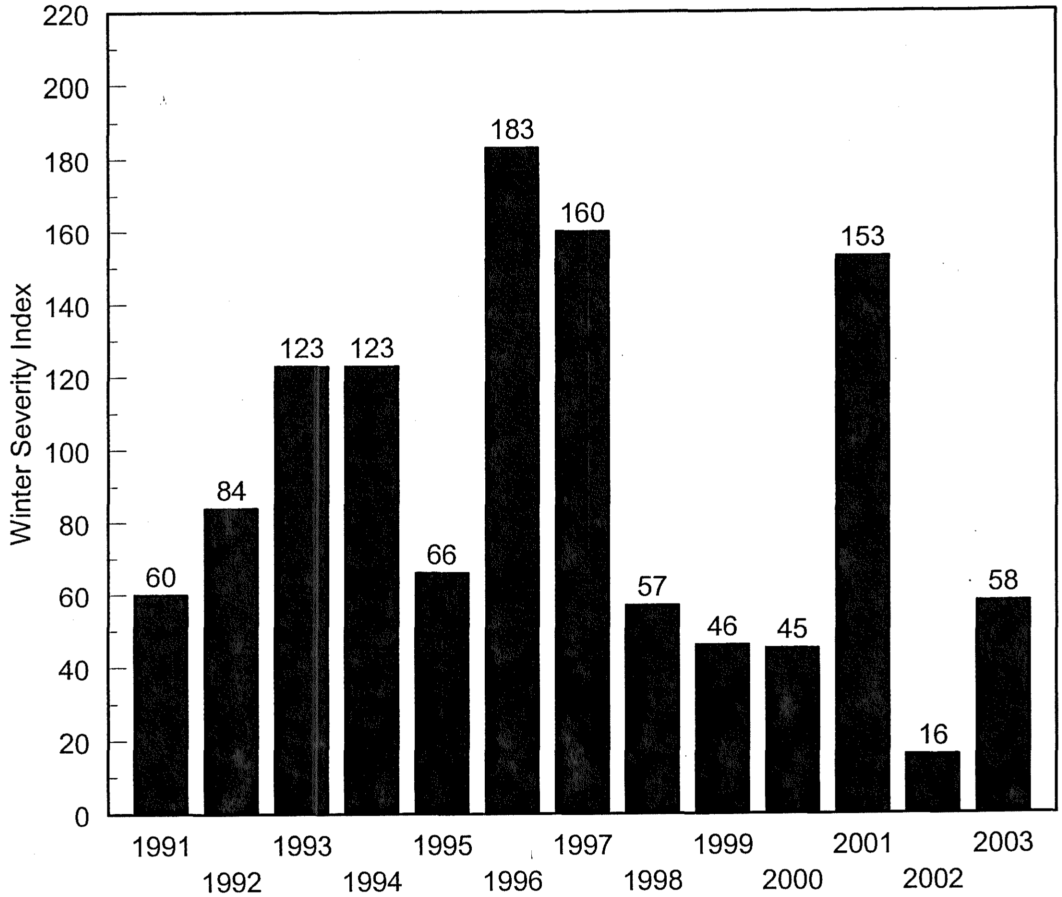
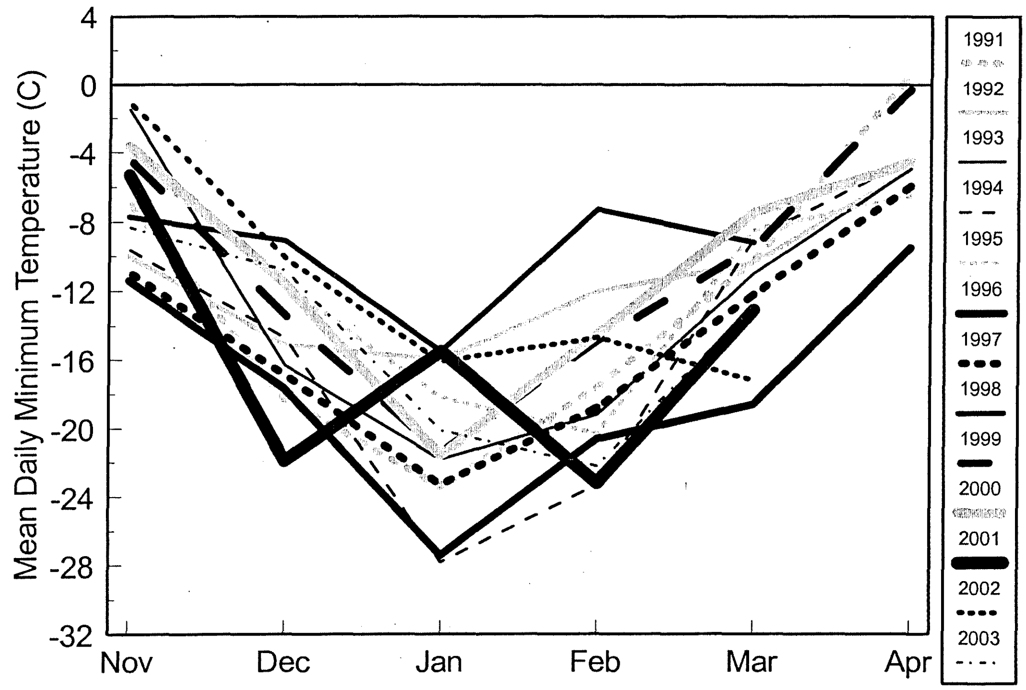


Figure 3. Winter severity index for white-tailed deer study sites, north central Minnesota, winters 1990-91 to 2002-03. (One point is accumulated for each day with an ambient temperature $\leq$ -17.8° C, and an additional point is accumulated for each day with snow depths $\geq$38.1 cm.)



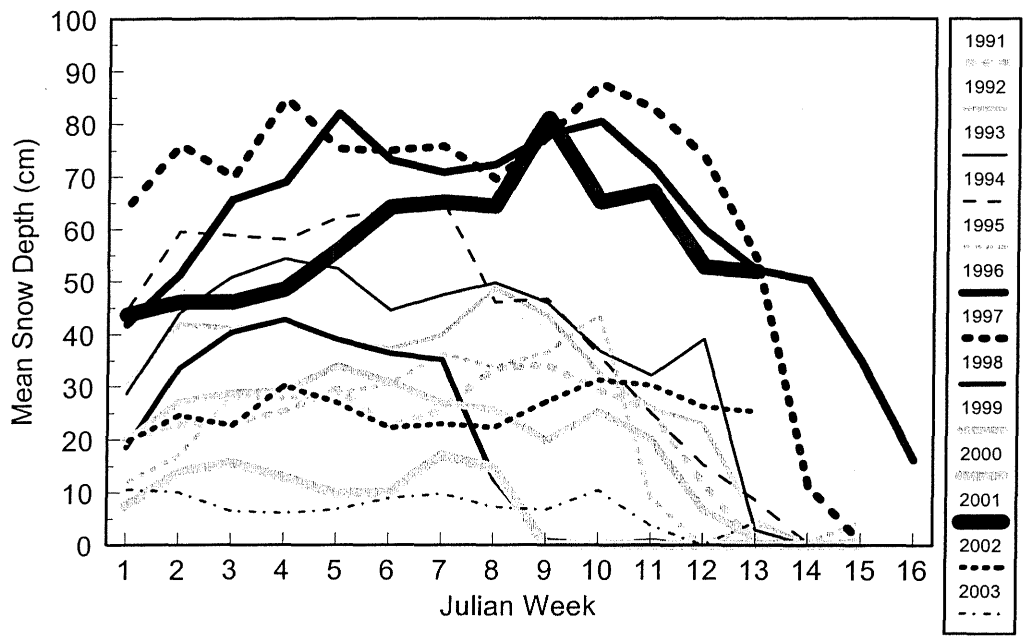
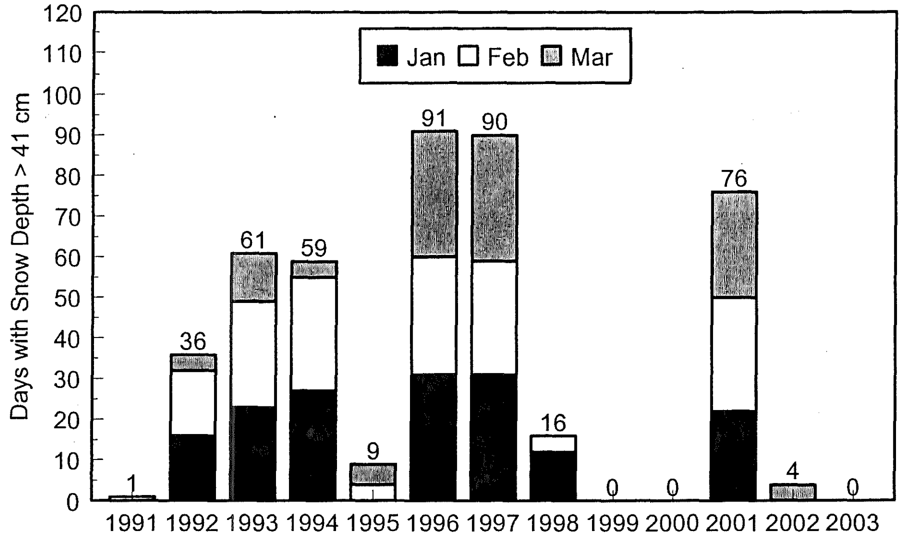


Figure 4. Mean daily minimum ambient temperature (top, Nov-Apr 1990-2003) and mean weekly (julian) snow depths (bottom, Jan-Apr 1991-2003) for white-tailed deer study sites, north central Minnesota.



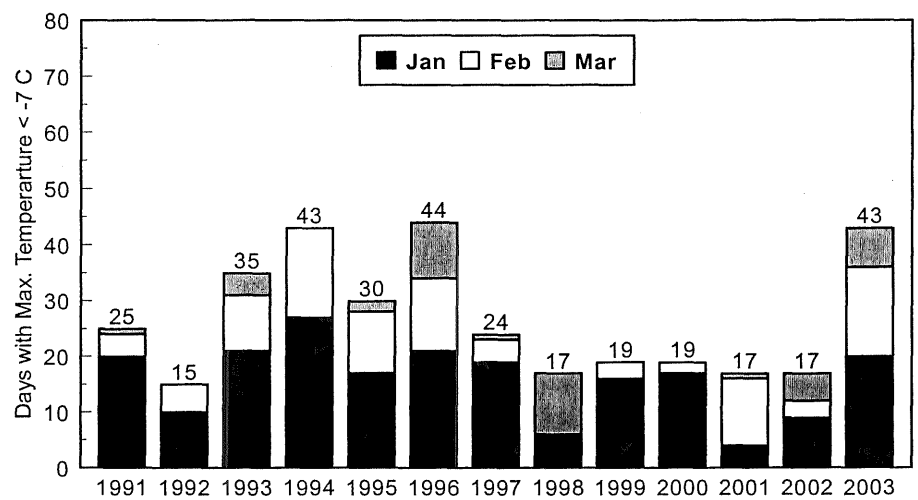


Figure 5. Number of days with snow depths ≥41 cm (top) and maximum ambient temperatures ≤ -7° C (bottom, *effective critical temperature* for an average size doe [60 kg]), north central Minnesota, January-March 1991-2003.

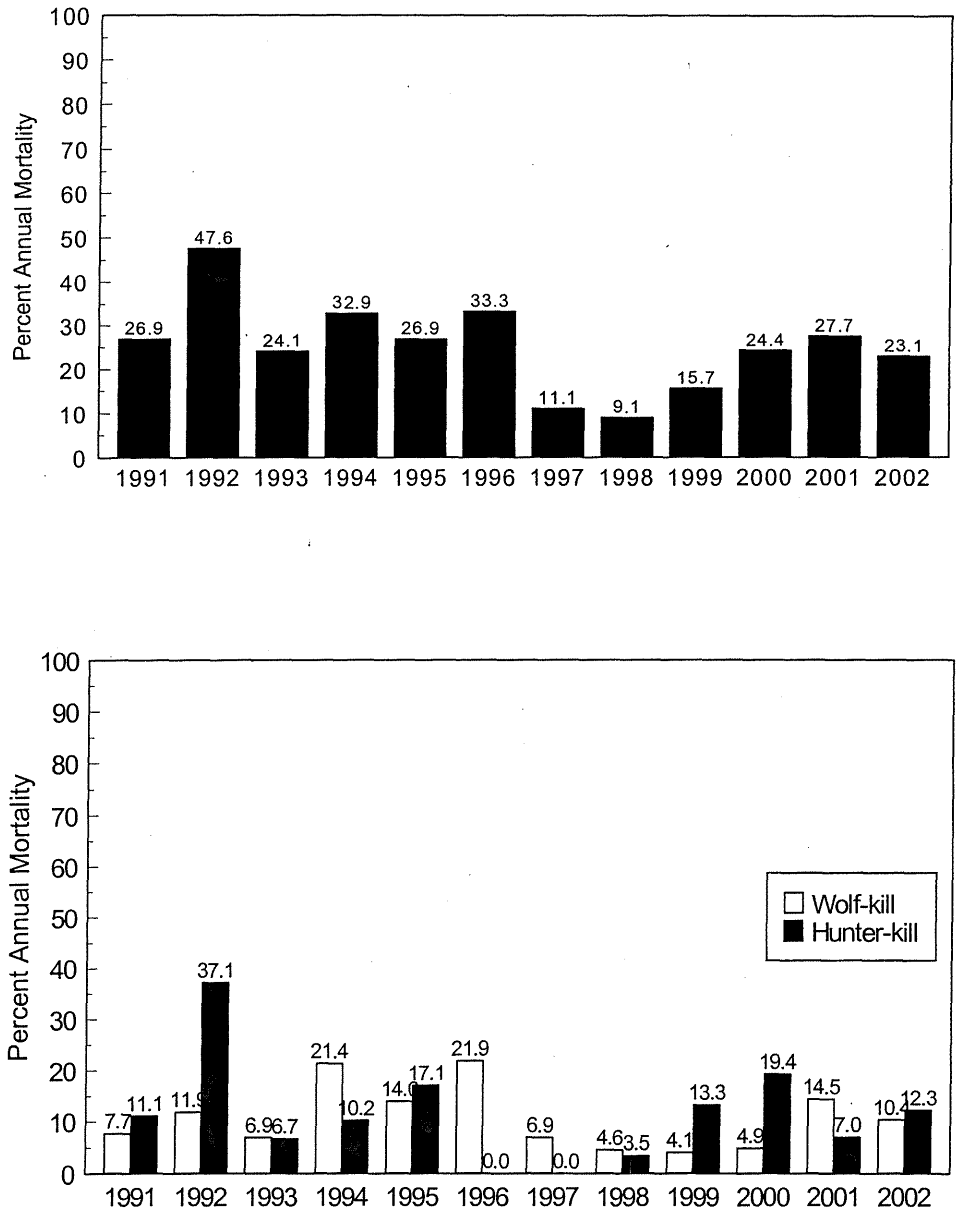


Figure 6. Annual (1 Jan-31 Dec) percent mortality of radiocollared, female white-tailed deer (top) and annual percent mortality attributable to wolf predation and hunter harvest (bottom, 4 sites pooled), north central Minnesota, 1991-2002. (Sample sizes were 26, 42, 58, 70, 52, 66, 72, 44, 51, 41, 83, and 78, respectively.) Hunter harvest was calculated with the maximum number of collared females entering Nov; no antlerless permits were issued in 1996 and 1997, and very few were issued in 1998.)

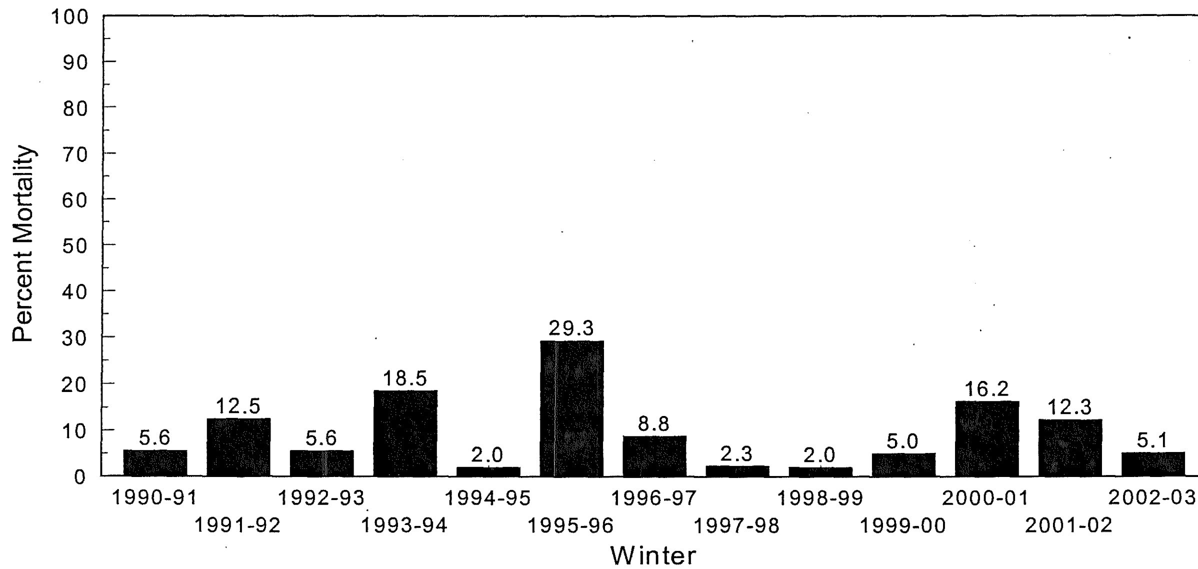


Figure 7. Winter percent mortality (Dec-May) of radiocollared, adult (≥1 year old) female white-tailed deer (4 sites pooled), north central Minnesota, winters 1990-91 to 2002-03. (Sample sizes were 18, 40, 54, 65, 50, 58, 68, 43, 49, 40, 68, 73, and 59, respectively; no deer were radiocollared during Dec 1990.)

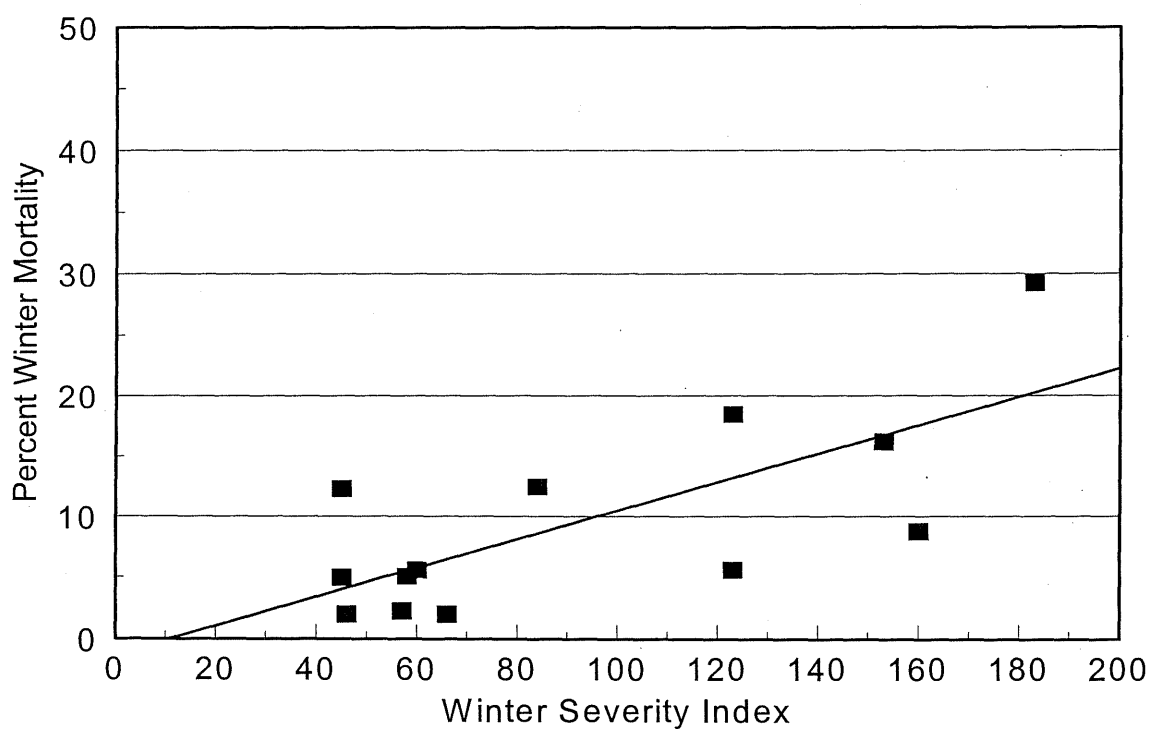


Figure 8. Relationship between MNDNR winter severity index (Nov-May) and percent winter (Dec-May) mortality ($Y = -0.0127 + 0.001x$, $r^2 = 0.52$, $P = 0.005$) of radiocollared, adult (≥1.5 year old), female white-tailed deer (4 sites pooled), north central Minnesota, winters 1990-91 to 2002-03.

ECOLOGY AND POPULATION DYNAMICS OF BLACK BEARS IN MINNESOTA

David L. Garshelis, Pamela L. Coy and Karen V. Noyce

We initiated a telemetry study on black bears in the Chippewa National Forest (CNF), near the center of the Minnesota bear range, during the summer of 1981. Beginning in 1991, two additional telemetry projects were started near the southern fringe of the bear range, one in the Camp Ripley Military Reservation and one in Pine County. The Pine County project was a 2-year study conducted by a graduate student (Kontio et al. 1998). The Camp Ripley study also began as a graduate student project (Ternent 1995), but we have continued the work there. Another graduate student project was started in Voyageurs National Park (VNP) in 1997, and we have taken over the monitoring of a few adult females there.

These projects presently involve visiting radiocollared bears once or twice in their winter dens (December – March), mainly to observe condition and reproduction, and periodically checking their status (alive, dead, dispersed) during the active season (April – October). During the 21-year span of this study, from 1981 through completion of den visits in March 2002, a total of 594 individual bears were handled in and around CNF, 62 at Camp Ripley, 50 in Pine County and 58 at VNP. Because most of these bears were radiocollared, they could be tracked to their dens and handled (measured, weighed, collar refitted or changed) at least once each year, until they died.

Principal objectives of this study include: (1) continued monitoring of reproduction and cub survival, (2) additional (improved) measurements of body condition, heart function, and wound healing, (3) examination of habitat use and movements with GPS telemetry, and (4) investigation of female dispersal near the southern fringe of the expanding bear range. As of April 2002, the start of the current year's work, we were monitoring 18 collared bears in the CNF, 8 at Camp Ripley, and 5 in VNP.

RESULTS

Trapping and Collaring

Trapping efforts this summer focused on recapturing 2 bears with dead radiocollars (1 in CNF, 1 in Camp Ripley) and attempting to capture more females in the lowland portions of the CNF study area, where reproduction has tended to be lower (but survival higher) than in the uplands.

We successfully recaptured 1 of the 2 bears with dead radiocollars. The other one was later found in her winter den and recollared. Additionally, we caught 3 other females and 10 males (only 5 that we collared) in CNF, and caught 1 (already-collared) female and 1 unmarked adult male at Camp Ripley. One of the males caught in CNF had previously been caught (and eartagged) as a nuisance animal in Wisconsin. We collared this bear, but subsequently lost track of it, despite aerial searches across northern Minnesota and into Wisconsin.

Movements

During the first 10 years of this study, we obtained aerial locations of each collared bear in the CNF on an approximately weekly basis. These data were used to correct for closure in density estimates (Garshelis 1992), and to gain an understanding of seasonal movements and home range size. We recognized that home range estimates are largely a function of the number of locations obtained, and in that sense, our weekly locations were probably inadequate.

We have been using collars containing both VHF radios and GPS units during the past few years to obtain more reliable data on movements and habitat use. Data from 4 GPS-collared bears were obtained this year. We compared home range sizes obtained from aerial VHF locations to home ranges based on GPS locations (on the same bears) at Camp Ripley, and observed that GPS data yielded home range estimates that were 2.2–3.5x larger (Table 1). This result is similar to what has been reported for comparisons of VHF and GPS-collected data on grizzly bears and wolves elsewhere (Ballard et al. 1998, Arthur and Schwartz 1999). The difference is due mainly to the larger sample sizes obtained from GPS units.

GPS data also were useful for distinguishing home range overlap. With sparse data it may appear that 2 adjacent home ranges do not overlap, whereas more intensive sampling may reveal more extensive overlap. Our previous weekly VHF locations in the CNF suggested that adult female bears were territorial; the central parts of their home ranges may have been shared by their female subadult offspring, but not by other related or unrelated adult females. GPS data collected on two adjacent adult females at Camp Ripley this year corroborated those earlier findings (Fig. 1). These results are interesting in that black bear studies in most other places have indicated that females have highly-overlapping home ranges.

Mortality

Legal hunting has been the predominant cause of mortality among radiocollared bears in this study (>90%). In previous years hunters were encouraged to treat collared bears as they would any other bear so that the mortality rate of collared bears would be representative of the population at large. With fewer collared bears left in the study, and the focus now primarily on reproduction rather than mortality, we sought to protect the remaining sample of bears. We asked hunters not to shoot radiocollared bears, and we fitted these bears with bright orange collars so hunters could more easily see them in dim light conditions. This reduced but did not eliminate hunting mortality of radiocollared bears: 3 of 25 collared bears from the CNF were shot by hunters; none of the 13 collared bears from Camp Ripley or VNP area was killed by a hunter. No other collared bears died for certain, although one collar was found during winter on a frozen beaver pond. We presumed that this bear died and its collar was carried out on the ice by another animal (it was chewed), but the circumstances in this case were unclear.

Reproduction

No cubs had been born to radiocollared mothers in the CNF area during the winter of 2001–2. Although food conditions in 2001 were poor, the seemingly poor reproduction among collared bears was just an artifact of the sample of bears, all of which happened to have had cubs the previous year so were unavailable to have cubs again the following year.

Yearly food conditions affect mainly ages of first reproduction (Noyce and Garshelis 1994). Natural foods were abundant in 2002, and accordingly, two 4-year-old CNF bears had their first cubs in 2003. Since the beginning of this study, 43% of 4-year-olds in the CNF have produced cubs (plus 3% of 3-year-olds), often following good food years. At Camp Ripley, where hard mast (especially oak) can at times be quite abundant, bears have a somewhat earlier age of first reproduction than in CNF. This year one of two 3-year-olds produced cubs, although she abandoned them after our den visit. In VNP, all adult bears that had failed to produce last year had cubs this year, including one 6-year-old who produced her first litter. One 9-year-old in VNP, who previously produced 2 litters that did not survive, had her third litter this year.

Litter size is less responsive to yearly food conditions. This year, one 15-year-old CNF female produced her third litter of 4 cubs, but a 10-year-old that produced 4 cubs 2 years ago produced only a single cub this year. One 29-year-old, monitored since the first year of this study, produced her last litter at age 25. Across all years, CNF females produced 2.6 cubs/litter (Table 2). This is similar to that observed at Camp Ripley (2.4; Table 3), but somewhat greater than in VNP (2.0; Table 4), where food abundance is generally much less, especially during the fall.

We checked litters in their mother's den a year after they were born to assess cub mortality; we assume that all missing cubs died. Since 1981, 83% of cubs born to collared mothers in the CNF survived. Sample sizes were too small to compare yearly cub survival (Table 2). Cub survival at Camp Ripley (76%) was similar to CNF; however, at VNP cub survival (only 43%) was significantly lower (P=0.0002). Male cub mortality has averaged about twice that of females in all areas (23% M vs 11% F in CNF; 31% M vs 18% F in Camp Ripley; 75% M vs 33% F in VNP). Sex ratios at birth were skewed towards males in all areas (52–57%; Tables 2–4), so the higher cub mortality for males resulted in a near 50:50 sex ratio among yearlings.

Tests of Expandable Collars

We started deploying experimental, expandable radiocollars on yearlings during 2000, and have since used these on some 2-year-olds as well. The expansion mechanism is controlled by a friction setting, which in the first year of experimentation was set too lightly, enabling the collars to be pulled off by the bears. We have since modified the design and have had greater success in collars being retained after expansion. In early winter 2002 we put expandable collars on 8 yearlings and 2 2-year-olds. One collar was dropped prematurely, 2 were not checked, and the other 7, checked in dens in early 2003, all had expanded and were retained. No yearlings were collared this year, but expandable collars were fitted on one 2-year-old and one 3-year-old at Camp Ripley. We are using expandable collars on these older bears at Camp Ripley because in that area bears grow more quickly, due to more abundant mast, and so are prone to neck irritation from a non-expandable collar.

Heart Function and Wound Healing of Hibernating Bears

During the winter of 2001–2, we began a collaborative study of heart function in hibernating bears with two experts in the field, Dr. Paul Iaizzio (University of Minnesota) and Tim Laske (Medtronic). We continued that work this year. Five bears were studied in December 2002 and then again in March 2003. Heart function was measured with ultrasound imaging and a 12-lead EKG. Tests of wound healing were conducted by removing a plug of skin (~0.5 cm diameter) and subsequently examining the healing process. In all cases, these wounds completely healed from December to March, with no evident scarring.

Current Monitoring

After completion of den visits in spring 2003, 35 bears (21 in CNF, 9 in Camp Ripley, 5 in VNP) were radiocollared, including 3 with GPS collars. These bears will be monitored for mortality periodically during the active season, and then tracked to their 2003–4 den sites.

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Table 1. Perceived home range sizes (minimum convex polygons) of bears with combination VHF-GPS radiocollars in Camp Ripley Military Reserve, 2000–2002. Larger numbers of GPS locations resulted in larger perceived areas of use than indicated by data from aerial VHF tracking. Also shown for comparison is one bear in the CNF for which only GPS location data were obtained during 2002; CNF females were thought to have home ranges of about 5–8 mi^2, based on previous data from aerial VHF tracking.

Study area	Year	Bear No.	Aerial VHF data		GPS collar data		GPS:VHF areas
			Points	Area (mi^2)	Points	Area (mi^2)	
Camp Ripley	2000	20	15	5.8	205	20.5	3.5
	2001	13	15	7.8	230	25.4	3.3
	2002	13	14	8.2	215	18.3	2.2
	2002	41	10	7.1	370	18.4	2.6
CNF	2002	739			653	24.5	

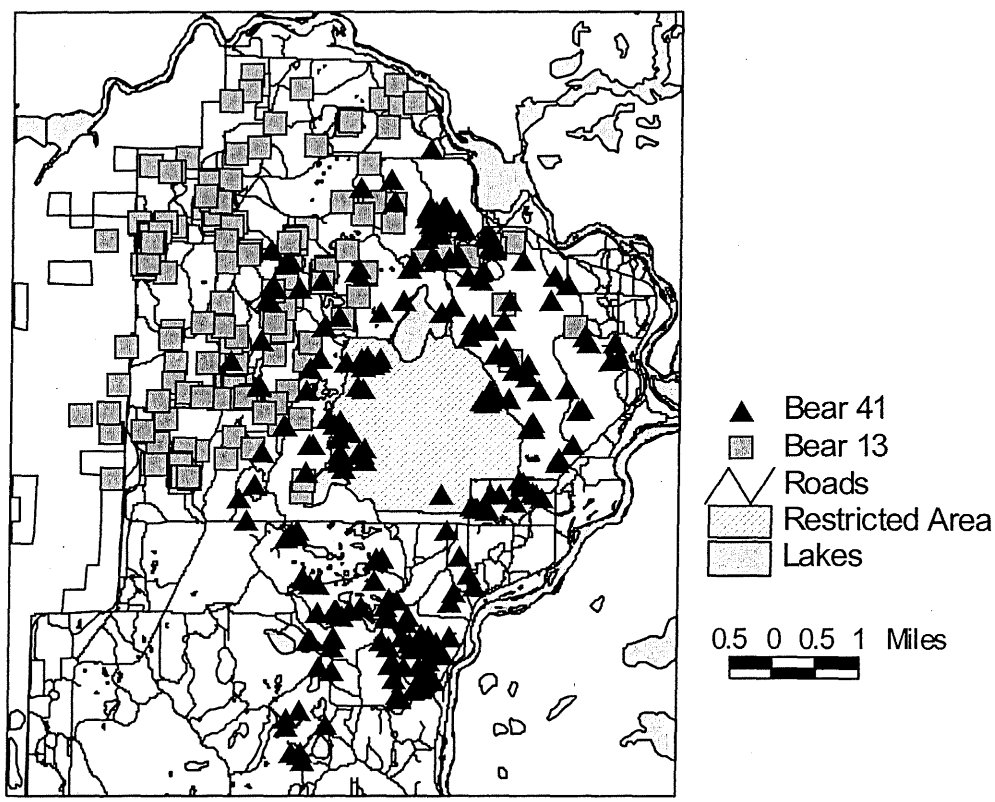

Figure 1. Locations obtained on 2 adult female bears with GPS collars in Camp Ripley during 2002, showing limited home range overlap (territoriality).

Table 2. Black bear cubs examined in dens of radiocollared mothers in or near the Chippewa National Forest during March, 1982–2003.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
1982	4	12	3.0	67%	25%
1983	7	17	2.4	65%	15%
1984	6	16	2.7	80%	0%
1985	9	22	2.4	38%	31%
1986	11	27	2.5	48%	17%
1987	5	15	3.0	40%	8%
1988	15	37	2.5	65%	10%
1989	9	22	2.4	59%	0%
1990	10	23	2.3	52%	20%
1991	8	20	2.5	45%	25%
1992	10	25	2.5	48%	25%
1993	9	23	2.6	57%	19%
1994	7	17	2.4	41%	29%
1995	13	38	2.9	47%	14%
1996	5	12	2.4	25%	25%
1997	9	27	3.0	48%	23%[b]
1998	2	6	3.0	67%	0%
1999	7	15	2.1	47%	9%
2000	2	6	3.0	50%	17%
2001	5	17	3.4	76%	15%
2002	0	0	—	—	—
2003	4	9	2.3	22%	—
Overall	**157**	**406**	**2.6**	**52%**	**17%**

[a] Cubs that were absent from their mother's den as yearlings were considered dead.
[b] Excluding 1 cub that was killed by a hunter after being translocated away from its mother.

Table 3. Black bear cubs examined in dens of radiocollared mothers in Camp Ripley Military Reserve during March, 1992–2003.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr
1992	1	3	3.0	67%	0%
1993	3	7	2.3	57%	43%
1994	1	1	1.0	100%	—[a]
1995	1	2	2.0	50%	0%
1996	0	0	—	—	—
1997	1	3	3.0	100%	33%
1998	0	0	—	—	—
1999	2	5	2.5	60%	20%
2000	1	2	2.0	0%	0%
2001	1	3	3.0	0%	33%
2002	0	0	—	—	—
2003	3	8	2.7	63%	—
Overall	**14**	**34**	**2.4**	**56%**	**24%**

[a] The only cub born to a collared female left its mother in early spring, due to human disturbance.

Table 4. Black bear cubs examined in dens of radiocollared mothers in Voyageurs National Park during March, 1999–2003.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr
1999	5	8	1.6	63%	20%
2000	2	5	2.5	60%	80%
2001	3	4	1.3	50%	75%
2002	0	0	—	—	—
2003	5	13	2.6	54%	—
Overall	**15**	**30**	**2.0**	**57%**	**57%**

HOME RANGE CHARACTERISTICS, RESOURCE SELECTION, AND SURVIVAL OF RIVER OTTER IN SOUTHEAST MINNESOTA

Thomas A. Gorman, John D. Erb, Brock R. McMillan, Christopher S. DePerno, and Daniel J. Martin.

INTRODUCTION

River otter (*Lontra canadensis*) historically occurred throughout North America, however since European settlement a drastic reduction in their range has occurred (Towell and Tabor 1982, Melquist and Hornocker 1983). By the 1970's river otter were considered either extirpated or rare in 20 states and the remaining states had experienced declines in otter populations (Towell and Tabor 1982, Nilsson 1980, Raesly 2001). The reduction was likely due to changes in land use practices such as wetland drainage, and stream channelization, and from unregulated trapping, and water pollution (Halbrook et al 1981, Henny et al 1981). Improvements in water quality, habitat management, population monitoring, and successful reintroduction programs, have contributed to the recovery of river otters across much of their historical range (Raesly 2001). Otters are currently present in every state within their historic range except New Mexico (Raesly 2001).

The river otter is indigenous to Minnesota and was historically distributed statewide (Swanson et al. 1945). The river otter was an unprotected species in Minnesota prior to 1917, when the species received complete protection. During 1943, limited trapping began and was legal in only three years until 1953, at which point a two-week, annual season was implemented (Landwehr 1985). Since 1977, the river otter trapping season has been conducted in the fall, has increased from two weeks to two months, and has expanded from the northern portion of the state to the central portion of the state (Berg and DonCarlos 1998). Populations of river otters in northern Minnesota have increased over the past 25 years, and are now considered stable (Erb et al. 1999). Current anecdotal evidence suggests the population size of river otter has been slowly increasing in the southern portion of the state; incidental captures by trappers targeting other furbearing species have been increasing. However, the extent of this increase in the size of the population is unknown (Erb and DePerno 2000).

Otters have relatively low fecundity; based on carcass analysis from the late 70's through early 80's, only 20% of 2 year old river otter and 61% of three year old otter were successfully impregnated in northern Minnesota (Berg 1984). Therefore, otters may be slow to recover from significant declines in population size (Melquist and Dronkert 1987). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) lists river otter under Appendix II; the river otter resembles other otter species that are endangered in other parts of the world. Harvest and population data of river otter must be presented before a state can obtain export tags from the U.S. Fish and Wildlife Service (USFWS) (Chilelli et al. 1996). Baseline ecological information on the river otter is necessary to address some of the limitations that exist for otter populations regionally and across the species geographic range. The objectives of this study were to determine the influence of age, sex, and season on home range characteristics, resource selection, and survival of river otters in southeast Minnesota.

STUDY AREA

This study was conducted along the Mississippi River drainage in Winona and Wabasha Counties in southeast Minnesota. The majority of the research was centered on the McCarthy Lake Wildlife Management Area (MWMA), Whitewater Wildlife Management Area (WWMA), and the Upper Mississippi River National Wildlife and Fish Refuge (UMNWFR). Also, the backwaters of the Mississippi River and the major tributaries (primarily the Zumbro River and the Whitewater River) which flow into the Mississippi River from the west were included in the study area.

The topography of the study area was predominantly blufflands with as much as 183 meters of relief. The blufflands are a bedrock plateau covered with a windblown layer of silt that has been significantly eroded by rivers. Historically, the study area was dominated by black oak (*Quercus velutina*), jack pine (*Pinus banksiana*), shagbark hickory (*Carya ovata*), and American basswood (*Tilia americana*) on poorly drained slopes, red oak (*Quercus rubra*), American basswood, and black walnut (*Juglans nigra*) in the deep valleys, and tallgrass prairie on the ridges and in the drier valleys (University of Minnesota Extension Service 2003).

Annually, southeast Minnesota receives 86.9 cm of precipitation with an annual mean temperature of 9.4° C, a mean minimum annual temperature of 4.3° C and a mean maximum annual temperature of 14.4° C (Midwestern Regional Climate Center 2003).

METHODS

River otters were captured in fall 2001 and 2002 (August 15-November 1) and spring 2002 (April 15 -June 1). All handling procedures were approved by the Minnesota State University, Mankato Institutional Animal Care and Use Committee (Project # 01-3). Otter trapping occurred at areas of high-intensity use such as crossover trails (trails traveling across land between two bodies of water) and latrine sites. Sleepy Creek® #11 double-jawed foothold traps (Sleepy Creek Manufacturing, Berkley Springs, WV) were used to capture otters (Shirley et al. 1983, Blundell et al 1999). When an otter was captured it was transferred to a transport tube, and taken to Plainview Veterinary Clinic for surgical implantation of a radio transmitter (Models: 1245 2-stage, 1250 2-stage, 1250 3-stage; Advanced Telemetry Systems, Inc.(ATS), Isanti, MN).

Prior to surgery, otters were administered a combined intramuscular injection of ketamine and xylazine. The radio transmitters were surgically implanted into the peritoneal cavity through a paralumbar incision. While under anesthesia, an upper premolar was extracted for aging by cementum annuli (Kuehn and Berg 1984), and a blood sample was drawn for DNA and toxicology analysis. Sex, weight, head circumference, chest circumference, length of right hind foot, total body length, condition and wear of teeth, and overall body condition were recorded. Otters were ear tagged with number 1 monel ear tags and web tagged with number 3 monel web tags (National Band and Tag Company, Newport, KY). To minimize infection the otters received 2cc of long acting penicillin, 1cc of baytril, and 2cc of clostridium anti-toxin. Otters were allowed to naturally recover from anesthesia, and were released at the site of capture within 6 to 72 hours.

River otters were radio tracked for an average of 2-3 locations per week from the ground using an ATS R4000 scanning receiver and a three-element Yagi antenna via triangulation and homing methods. Triangulation was conducted from obtaining ≥ 2 bearings from known locations within 15 minutes. Also, radio tracking was conducted at approximately 10-day intervals via a Cessna Skylane 182 equipped with a four-element Yagi antenna on each wing.

To test the bias and precision of our equipment and triangulation techniques, beacon transmitters were placed at locations unknown to the observer and were located using triangulation techniques. The bearings obtained while conducting triangulation (estimated bearings) were compared to the true bearings and the difference (error) between these bearings were used to assess bias (error not different from 0) and precision (standard deviation of the error) (White and Garrot 1990). Locations obtained using triangulation data were analyzed using Locate II (Nams 1990) and were adjusted using the standard deviation of the bearing error. Additionally, aerial locations were tested by using a straight-line distance between the true location and the observed location.

PROGRESS

Since fall 2001 26 otter have been captured 28 times (Table 1). Two otters have been recaptured, 8 mortalities (4 incidental furbearer trapping-related mortalities, 1 automobile-caused mortality, 3 capture-related mortalities), and 1 probable radio failure (Table 1). The preliminary annual survival rate from April 2002 through March 2003, calculated using the Kaplan-Meier estimator (Kaplan and Meier 1958) and adjusted for staggered entry (Pollock et al. 1989), was 80.5% (95% CI 63.6, 97.4).

During fall 2001 3 otters (2 male; 1 female) were captured and catch rates averaged 83.0 trap nights/ otter. During spring 2002 15 otters (10 male; 5 female) were captured and catch rates averaged 89.3 trap nights/ otter. During fall 2002 8 otters (2 male; 6 female) were captured and catch rates averaged 139.5 trap nights/ otter (excluding all non targets and sprung or inoperable traps). Also, 2 male otters were captured in November 2002 by an avocational trapper during the legal fur harvest season and were relinquished alive to field personnel. These otters were restrained by field personnel and equipped with a radio transmitter implant.

Preliminary data on bias and precision of the triangulation equipment and techniques indicate the system was not detectably different from 0 ($n = 55$, $t = -1.421$, $p = 0.161$). These results indicate that our system has little bias. However, our bearings are less precise than anticipated ($n = 55$, $SD = 5.562$), which limits the level of spatial resolution when estimating resource selection. Preliminary data on the straight-line distance between actual and observed aerial locations indicates that aerial locations along with observer knowledge are fairly precise ($n = 8$, $\bar{x} = 177.03$ meters, $SD = 83.40$ meters).

Since being captured, otters have been tracked an average of 2-3 times per week throughout all seasons. Data is still being collected and it is premature to speculate on home range and resource selection at this time.

FUTURE PLANS

Estimated locations from triangulation data, homing, and aerial flights will be combined to estimate home ranges for each individual otter using the fixed kernel estimator. Fixed kernel home ranges will be estimated with the Animal Movements extension in ArcView 3.3 (Environmental Systems Research Institute, Inc., Redlands, CA) and will be compared among seasons, and ages, and between sexes.

We will investigate resource selection at the second order, or landscape scale (Johnson 1980). At this broad spatial scale, the home range of the individual river otter will be considered the sampling unit (Johnson 1980, Wilson et al. 1998). Determining the availability of resources within the study area may present many potential biases. It is possible to alleviate some of these biases by measuring not only the relative abundance, but also the relative distribution of resources within the study area (Wilson et al. 1998). Selection of resources at the second order scale will be examined using compositional analysis (Aebischer et al. 1993). The resources of interest for this analysis describe the major land-use practices at this scale that we speculate are of biological significance to otters. A separate analysis with a different suite of continuous resource variables will be conducted using a logistic regression approach (Manly et al. 2002). These variables will estimate the effect of resource complexity on river otter resource selection on the landscape. ArcView 3.3 will be used to measure the amount of available and used resources for both analyses.

For the final survival analysis we will develop a set of a priori candidate models to evaluate factors such as the effects of sex, age, and season on survival of river otters in the study area. We will use an information-theoretic approach, specifically Akaike's Information Criteria (Burnham and Anderson 1998), to determine which models best fit the empirical data.

Trapping will resume from April through May 2003 with a goal of catching 10 new otters. Radio tracking will continue on the ground with an average of 2-3 locations per week through June 2004, and aerial tracking will continue an average of once every 10 days through December 2004 or through the life of the transmitter. Formal analysis of home ranges, resource selection, and survival will be conducted over the summer and fall of 2004.

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Table 1. Status of river otters captured in southeast Minnesota, 2001-2002.

Otter ID	Date of Capture	Location[a]	Current Status
Juvenile M1	10-Oct-2001	WWMA	alive
Adult M2	11-Oct-2001	WWMA	alive
Adult F1	16-Oct-2001	WWMA	accidental harvest
Adult M3	24-Apr-2002	UMNWFR	alive
Adult M4	28-Apr-2002	WWMA	capture mortality
Adult M2	28-Apr-2002	WWMA	recapture
Yearling F2	28-Apr-2002	WWMA	alive
Yearling M5	29-Apr-2002	WWMA	alive
Adult M6	05-May-2002	WWMA	alive
Yearling F3	10-May-2002	WWMA	alive
Adult F4	12-May-2002	WWMA	alive
Adult M7	20-May-2002	WWMA	radio failure
Yearling M8	22-May-2002	Bartlett Lake	capture mortality
Adult M9	23-May-2002	WWMA	alive
Adult M10	24-May-2002	TWMA	automobile mortality
Adult F5	24-May-2002	Zumbro River	alive
Adult M11	26-May-2002	Bartlett Lake	alive
Yearling F6	27-May-2002	Zumbro River	alive
Juvenile F7	31-Aug-2002	WWMA	alive
Adult F8	02-Sep-2002	UMNWFR	alive
Juvenile M12	03-Sep-2002	WWMA	capture mortality
Juvenile F9	04-Sep-2002	WWMA	accidental harvest
Juvenile M12	05-Sep-2002	WWMA	recapture
Adult F10	06-Sep-2002	UMNWFR	alive
Juvenile F11	10-Sep-2002	Zumbro River	accidental harvest
Yearling F12	14-Sep-2002	UMNWFR	accidental harvest
Adult M13	08-Nov-2002	UMNWFR	alive
Yearling M14	16-Nov-2002	UMNWFR	alive

[a]WWMA = Whitewater Wildlife Management Area, UMNWFR = Upper Mississippi National Wildlife and Fish Refuge, TWMA = Thorpe Wildlife Management Area.

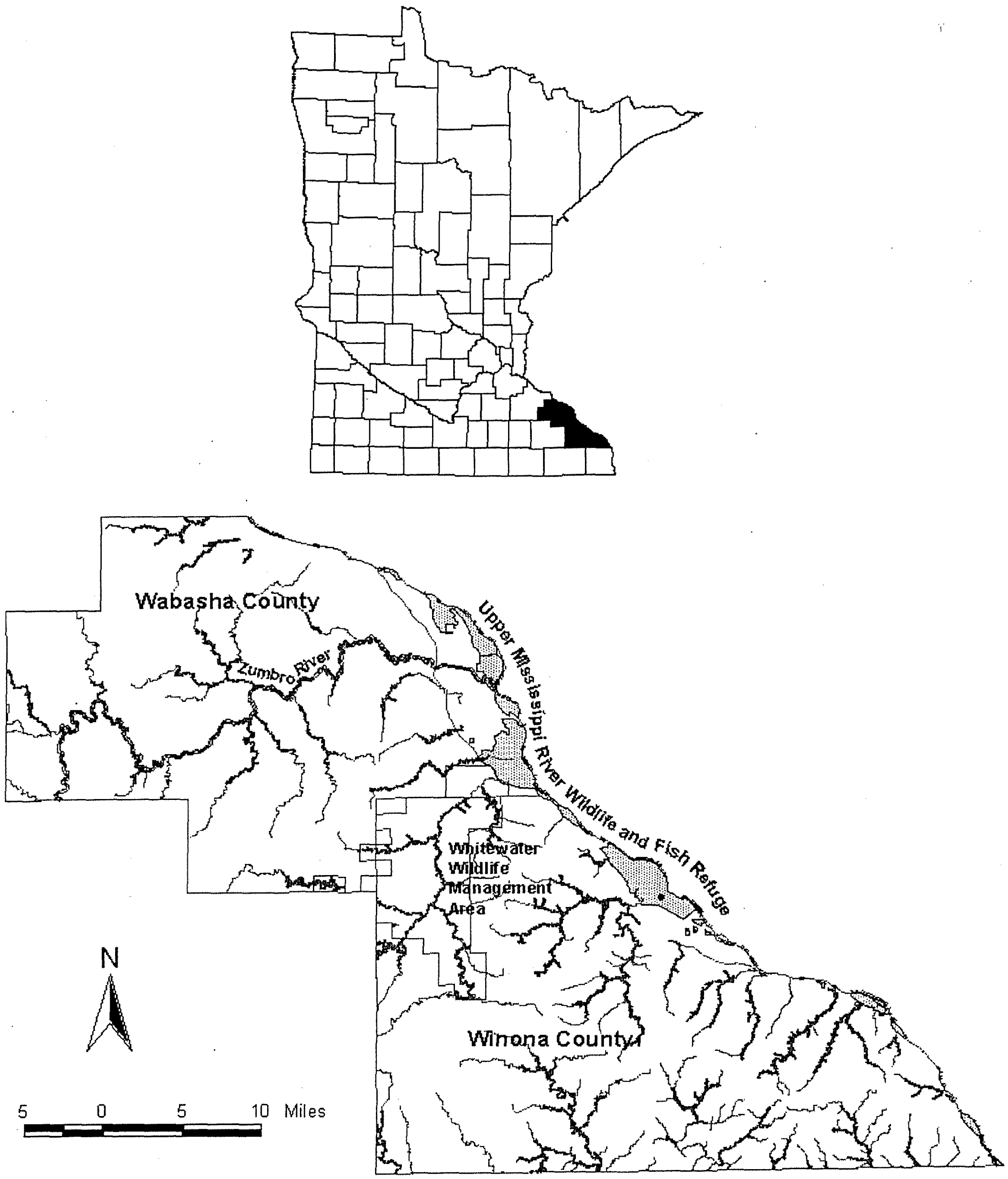

Figure 1. River otter study area in southeast Minnesota, 2002-2003.

USING SUBSAMPLED POINTS ANALYSIS TO ASSESS USE OF THE JACK PINE COVER TYPE BY WHITE-TAILED DEER AT CAMP RIPLEY, MINNESOTA

Carolin Humpal and Glenn D. DelGiudice

BACKGROUND

Management guidelines of the Minnesota Department of Natural Resources (MNDNR) and other land management agencies integrate forest and wildlife management via practices that attempt to maximize timber productivity and yield, while enhancing wildlife habitat quantity and quality. The specific habitat needs of white-tailed deer (*Odocoileus virginianus*) are a consideration when designing timber harvests in north central Minnesota.

In Minnesota's Forest Zone, conifer thermal cover of deer typically includes dense stands of northern white cedar (*Thuja occidentalis*), spruce (*Picea spp.*), and balsam fir (*Abies balsamea*), and in some areas, jack pine (*Pinus banksiana*) and red pine (*P. resinosa*). Current DNR guidelines limit the harvesting of these particular species because of their "value" as winter thermal cover and snow shelter.

Camp Ripley is located in the Transition Zone of the state. Thermal cover at the Camp is quite different than in the Forest Zone and is characterized by mixed stands of jack pine and hardwoods. Far less is known about the relationship between white-tailed deer and the type of thermal cover typically observed at Camp Ripley and elsewhere in the Transition Zone. It is apparent from observations of overbrowsing on winter ranges of deer at Camp Ripley that jack pine may have a second important value to deer in the Transition Zone---that is as a source of nutrition.

It has been suggested that "food is the basic requirement" of deer, but as sufficient food becomes less available for fulfilling energy requirements, thermal cover becomes physiologically important as a means of reducing energy lost as heat and for maintaining thermal balance. In western Minnesota, it was observed that deer did not seek cover, despite ambient temperatures < -18° C (0° F), when adequate food was available to maintain positive energy balance. Higher digestible energy available to deer from crop residue in agricultural fields juxtaposed to certain peripheral portions of Camp Ripley, compared to that available from natural browse alone in other portions of the Camp, may have a significant influence on how and when deer use thermal cover (i.e., jack pine stands) distributed over the Camp's landscape, as well as on aspects of their seasonal migration. In addition to the specific source of the digestible energy, the severity of winter weather conditions may strongly influence nutritional restriction.

The jack pine-hardwood type of the deer's winter range at Camp Ripley may have a third important function for deer, that is as a refuge from wolf (*Canis lupus*) predation, thus, contributing to a "balance" between the 2 species. Recently, timber wolves have become re-established within Camp Ripley's boundaries. Preliminary data indicate that their home range is relatively small, possibly due to the high deer densities. Further, there is an inverse relationship between winter severity and the nutritional condition of deer in Minnesota and a direct relationship between snow depth and wolf predation, which may increase the relative importance of the jack pine type to deer during severe winters.

There has been little study of Camp Ripley's deer in recent years, thus reliable information concerning deer-habitat-wolf interactions to serve as a basis for sound management decisions is sparse and sorely needed. It is clear that we must significantly increase our knowledge of the functional relationship that exists between deer and thermal cover in the Transition Zone (e.g., Camp Ripley) under varying environmental conditions to better understand the range of habitats that will fulfill the needs of deer. Important to understanding this relationship, we must become more informed about the interactive roles of deer nutrition and predation by the recently established wolves. With the increasing concern for the harvesting of jack pine stands within the Camp and the recent commencement of a wolf study, a study addressing these relationships was timely with respect to the quality of information it would yield in support of future deer management.

The goal of this study is to examine the relative influences of winter severity and nutrition on use of the jack pine-hardwood habitat type as thermal cover/snow shelter by white-tailed deer in Camp Ripley. Our study involved 4 field seasons (winters 1998-99 to 2001-02) for data collection and 2 study sites. Specific objectives were to determine (1) the distribution and home ranges of female deer on winter range, (2) their seasonal migration patterns, (3) vegetative composition of their winter home ranges and cover type use patterns relative to winter severity, (4) survival and cause-specific mortality rates, and (5) the influence of nutrition on deer use of conifer cover. Herein, we highlight and discuss some of our findings from the last 2 years of the study (2001 and 2002) relative to nutrition and habitat use/selection. Habitat availability and use data from these 2 years have been the focus of the most intense exploration of appropriate analytical alternatives. Use of point locations derived from radio telemetry for examining vegetation use by deer ignores the error associated with radio locations. Samuel and Kenow (1992) proposed a method to deal with telemetry error using a subsample of points within the error ellipse associated with each point location. This method was refined by Kenow et al. (2001). We employed this method for our assessment of habitat use/selection. Application of this method to the first 2 years of data is in progress. Select details of the 4 winters of telemetry monitoring and findings addressing deer survival, cause-specific mortality, migration, and winter home range size are available in Humpal et al. (2002). The most comprehensive information and discussion of all data are available in Humpal (2003) and Mangipane (M.S. Thesis in preparation).

METHODS

The Southwest study site (SW, 32.1 km^2) was part of a deer winter range located in the southwestern part of Camp Ripley (Fig. 1). Deer on this *experimental* site made daily use of standing corn and crop residue on agricultural fields adjacent to Camp boundaries, as well as of supplemental feed provided by landowners. The Northwest site (NW, 24.5 km^2) was part of a deer winter range located in the northwestern portion of the Camp and served as a *control* site. Deer on this site subsisted primarily on natural forage and browse.

Capture and Handling Operations

During 2-4 February 1999, 40 female deer were captured by net-gun dispatched from a helicopter (Helicopter Capture Services, Marysvale, UT). Nineteen (18 adults, 1 fawn) and 21 (20 adults, 1 fawn) females were captured and handled on the NW and SW sites, respectively. All captured females were blindfolded and injected intramuscularly (IM) by hand-held syringe with a combination of 100 mg xylazine hydrochloride and 300 mg ketamine hydrochloride. Once induced, rectal temperature was monitored; deer were eartagged, blood-sampled by venipuncture of the jugular vein; and a last incisor was extracted for aging. We fitted deer with VHF or global positioning system (GPS) radiocollars (Advanced Telemetry Systems, Inc., Isanti, MN), and we administered a broad-spectrum antibiotic preparation IM before release. Mean recovery time of deer after intravenous injection of yohimbine was 13 minutes ($n = 30$).

During 27-28 January 2000, 18-19 February 2001, and 29-30 January 2002, capture operations were repeated to replace does that died or from which GPS collars were released prior to battery expiration (90-120 days post-capture). Also, does were added to the study cohort in anticipation of battery failure in VHF collars that had been out for ≥2 years. During the capture operations of January 2000, we also collected serial blood specimens from chemical induction (baseline) to 45 minutes post-induction at 15-minute intervals to study potential stress effects of the capture technique on the deer. Serum samples were analyzed for cortisol, creatine phosphokinase, and lactate dehydrogenase. Mean recovery times for winters 2000-2002 ranged from 4.0 to 14.6 minutes ($n = 61$) post-injection of yohimbine.

Weather Data Collection

Six 200-m transects were established in the NW site to monitor snow depth and impaction (indicator of snow density); 3 were located in mature jack pine-hardwood stands and 3 were located in open fields. Snow depth (cm) and impaction (to nearest 3 cm) were measured daily at 3 random locations along each transect. Daily minimum and maximum temperatures were recorded within each vegetation type (Maximum/Minimum Thermometer, Taylor Environmental Instruments, Inc., Fletcher, NC) during January-March. On-site weather data were supplemented with data from the Minnesota Climatological Database collected at Little Falls, Minnesota, 11 km south of Camp Ripley. The MNDNR's winter severity index (WSI) was calculated by accumulating 1 point for each day during November 1–April 30 with an ambient temperature ≤ -17.8°C and 1 point for each day with a snow depth ≥38.1 cm.

Nutrition

Landowners in the area surrounding Camp Ripley reported that SW deer consumed all standing corn by late December in average winters. In order to sustain or increase any potential effect of nutrition on habitat use, supplemental feed (whole corn, Bjerga's Feed Store, Little Falls, MN) was provided at the SW study site. Three gravity-feeders were placed in each of 3 fields immediately outside the Camp boundary during January–March 2001 and 2002. Feeders were filled every other day with 10 kg of corn, and orts were measured. Because landowners also provided supplemental feed, measurement of orts at study feeders provided an estimate of the minimum amount of feed consumed by deer in the area. Chemical analysis of fecal and snow-urine samples were used to indicate use of supplemental feed and distance traveled to feeders (DelGiudice et al. 1989, Tarr and Pekins 2002). These findings are presented in Humpal (2003).

Vegetation Type Use and Availability

Ten radiocollared deer were randomly selected on each study site in 1999 for frequent radio-locating (i.e., located 3–7 times weekly, January–March). Locations were used to determine vegetation type use (Mangipane et al. 2001). In subsequent years of the study, additional collared does were selected randomly to replace intensively monitored deer that died between winter study periods or that did not return from spring-summer-fall range.

Deer were located using ground-based radio telemetry. Handheld GPS units (GPS 12 Personal Navigator, Garmin Corporation, Olathe, KS) were used to determine the Universal Transverse Mercator (UTM) coordinates for receiver locations; 3 simultaneous bearings were then taken, and the deer's location was estimated with XYLOG (Dodge and Steiner 1986) in the field. Standard deviation of bearing errors was calculated using the methods of White and Garrott (1990). Transmitters were placed throughout the study sites, and locations were determined by hand-held GPS unit. Bearings were then taken and compared to the actual angle from a minimum of 3 receiver locations. All members of the field crew took a minimum of 20 bearings, and errors were pooled to produce a group standard deviation; in both 2001 and 2002, a standard deviation of 8° was used in XYLOG for estimating location and error ellipse. Locations with error ellipses ≥6.0 ha (approximate average vegetation patch size on Camp Ripley) were rejected, and attempts were made to decrease the ellipse size. As winter progressed each deer was located throughout the daylight hours; 2–3 nocturnal locations were estimated as well.

Vegetation type availability on the study sites was determined by interpretation of color infrared air photos (1:15,840 scale) and digital orthophotoquads, followed by ground-truthing (B. Mangipane, unpublished data). Vegetation types, 13 in the SW and 11 in the NW, were digitized in a geographic information system (ArcView GIS Version 3.1, Environmental Systems Research Institute, Inc., Redlands, CA) and used along with imported radio and visual locations of collared deer to investigate vegetative composition of locations, location error ellipses, and winter home ranges (Mangipane et al. 2001).

Prior to analysis of vegetation use, all data were examined for independence of locations. The Animal Movements Extension of ArcView (Hooge and Eichenlaub 1997) was used to obtain the Schoener's ratio; Swihart and Slade's (1985*a*) method was then used to determine if locations were independent. Time between locations was also calculated for each deer to determine if the interval was sufficient to allow the deer to traverse its home range, which is considered another measure of independence (White and Garrott 1990).

Four criteria were established to determine if outliers could be eliminated from home range and vegetation selection analyses. Aberrant locations were excluded from the analysis, if: they occurred < 3 weeks after capture, there was evidence that the animal moved as a result of numerous locating attempts, the locations occurred outside of the delineated border of the study site, or the distance traveled to the outlier was greater than twice the average distance between locations and the animal stayed in that area for < 1 week. The minimum convex polygon (MCP) method was used to estimate home range for analysis of deer use of vegetation types.

Because analysis of point radio locations for examining deer use of vegetation ignores the error associated with ground telemetry, we employed subsampled points analysis (Samuel and Kenow 1992, Kenow et al. 2001). Points are generated using the error distribution for each radio location and describe the probability of use of each vegetation type within the error ellipse. The SUBSAMPL and HABUSE programs described by Kenow et al. (2001) were used to perform this analysis. Points generated in this way, as well as the point locations (Humpal 2003), were analyzed using the method of Neu et al. (1974). Habitat use was analyzed at the second and third orders, corresponding to home range and location levels (Johnson 1980) for both individual and pooled data of deer. Minimum convex polygons, constructed using the subsampled points of error ellipses, were used to determine vegetation available for third order selection within home ranges. All locations for all deer in both 2001 and 2002 were used to generate a MCP representing each study site. Vegetation within this area was considered available for second order selection. The vegetation coverage was "clipped" outside the MCPs using the geoprocessing wizard in ArcView, to determine the area of each vegetation type available.

Statistical Analyses

Two-sample *t*-tests with pooled variance were used to compare daily minimum and maximum ambient temperatures and weekly snow depth and impaction from winters 2000–01 and 2001–02 (Statistix for Windows 7.0, Analytical Software, Tallahassee, FL). Selection of individual vegetation types was determined using Wilson's method to construct a score confidence interval for the point locations (Agresti and Coull 1998, Humpal 2003). Wald confidence intervals were constructed for the subsampled points (Neu et al. 1974, Byers et al. 1984, Agresti and Coull 1998), with addition of the misclassification variance described by Samual and Kenow (1992). The Wald confidence interval formula cannot produce a solution for a count of zero. Therefore, the score confidence interval solution from the point analysis was substituted into the subsampled points to allow selection analysis of vegetation types with a zero count for a particular deer (Humpal 2003). Bonferroni correction was applied to adjust for multiple comparisons. If the expected proportion fell below the confidence interval, the vegetation type was used "more" than expected (i.e., selected); if it was greater than the interval, the type was used "less" than expected (i.e., avoided); and "no selection" (i.e., used in proportion to availability) was assumed when the expected proportion fell within the interval (Neu et al. 1974). Selection between vegetation types, years, and sites were compared with Poisson regression (MacAnova, Department of Statistics, University of Minnesota, Minneapolis, MN). Proportional uses of vegetation types generated by the subsampled data set were examined by ANOVA (with and without transformation) to test for differences in selection among vegetation types, between years (i.e., winter severity effect) and sites (i.e., nutrition effect) with recognition that the data were highly correlated. All means are presented with their standard error.

RESULTS

Weather

Weather during the 2 winters of this study was markedly different. The WSI for 2000–01 was 104, compared to only 28 for 2001–02. Points accumulated for temperatures $\leq$ -17.8°C were 51 (2001) versus 24 (2002), but the most dramatic difference was in the points accumulated for snow depth (Fig. 2). During winter 2000–01, 53 days had depths $\geq$38 cm, versus only 4 days (late Nov–early Dec) in winter 2001–02. Similarly, mean weekly snow depths (41.9 ± 3.5 and 6.6 ± 1.8 cm) during January–March differed ($P < 0.001$) between the 2 years. A high correlation between snow depth and impaction ($r = 0.97$) resulted in differing snow impactions ($P < 0.001$) between winters as well. The January–March, mean daily minimum temperatures were not significantly different ($P = 0.062$) between years (-15.3 ± 1.5 versus -13.1 ± 1.6°C); mean maximum temperature was slightly higher ($P = 0.012$) in winter 2001–02 (-2.0 ± 1.3 versus -0.2 ± 1.2°C).

Nutrition

Supplemental food was provided in 9 gravity-fed feeders located in 3 fields just across the Camp Ripley boundary from the SW site. These feeders were heavily used throughout each winter. During 12 January–26 March 2001, 2,977 kg of corn were consumed. Approximately 3,215 kg of corn were consumed during 6 January–26 March 2002. Within 17 days of initiating feeding, typically all corn was consumed within 12–24 hours of filling the feeders. There were signs of heavy deer use (trails and beds) within and near the fields containing the feeders. During 1 2.3-hour period, 18 deer (including 1 collared doe) were observed using feeders in 1 field.

Home Range and Vegetation Type Analysis

A total of 517 and 951triangulated and visual locations of intensively monitored deer were available for analysis of vegetation use during 2001and 2002. Two deer with < 20 locations were excluded, 1 each from the NW and SW sites. The mean number of locations per animal was 29.3 ± 0.8 (range = 22–33) and 48.6 ± 1.6 (range = 29–59) in 2001 and 2002, respectively. Mean error ellipse sizes were 2.4 ± 0.06 and 2.2 ± 0.04 ha for 2001 and 2002.

Results of tests for independence of locations for individual deer suggested that the assumption of independence was valid. Four of 38 deer were found to have independent locations using the Schoener's ratio (Swihart and Slade 1985*b*). Although most deer did not meet requirements for independence using that test, mean time between locations was long enough to consider locations independent (White and Garrott 1990). Mean time between locations was 53.5 ± 1.6 (range = 44.3–77.1) and 31.3 ± 1.2 (range = 25.9–46.5) hours in 2001 and 2002; these lengths of time would allow a white-tailed deer to traverse its home range.

Subsampled Points Analysis

Analysis of the subsampled data set showed many of the same trends that were revealed by point analysis (Humpal 2003). Individual deer used vegetation types differently, which is ignored when pooling values among deer (Figs. 3-6). Typically, brushland, agricultural land, tamarack/marsh, and development/open water were used less than or as expected by deer in both second and third order selection for both sites (Figs. 3-6). These vegetation types also showed the most consistency among individuals with most points tightly clustered around the zero selection line in both winters. Only 1 or 2 individuals at a site used a specific vegetation or habitat type more than expected in either winter (Figs. 3-6).

Other vegetation types were used differently between years and sites. These differences were not always significant, but distribution of points around the zero selection line shows trends. Deer used aspen and jack pine more than other cover types, but use ranged from avoidance to selection for both sites in both winters for second order analysis (Figs. 3 and 4). All deer on the NW site used oak less than expected in more severe winter 2001, which was probably influenced primarily by the deeper snow cover. In 2002, the range of use was greater, and included more and less use than expected. Deer on the SW site used the hardwood type less than or as expected (with 1 exception) in both winters, but NW deer on average used hardwoods more than expected during both years. Use of the red pine (/white spruce) type also differed between sites; in 2001, use by NW deer ranged from as expected to selection. Southwest deer mostly used this type as expected. However, in 2002, deer on both sites used red pine as expected.

Generally, third order analysis reduced the spread among individual use of specific vegetation types. Aspen, jack pine, and red pine were all used as or more than expected on the NW site in 2001, whereas deer on the SW were less consistent in their use of these vegetation types (Fig. 5). Grassland was used more than expected by SW deer, but NW deer tended to use it less than expected. Overall, vegetation type use in the milder winter of 2002 showed less variation, with most deer using vegetation near expected levels (Fig. 6). Mean proportion of use for each vegetation type by site and year is presented in Figure 7.

DISCUSSION

To justify pooling radio-location data of deer in examining vegetation selection, the assumptions that use and availability are the same or similar for all animals must be met (Thomas and Taylor 1990, Alldredge and Ratti 1992, Aebischer et al. 1993, Alldredge et al. 1998, Dasgupta and Alldredge 2000). Scatterplots can be used to determine if individuals are using vegetation types similarly, thus justifying pooling data (Thomas and Taylor 1990). All collared deer at Camp Ripley did not use all vegetation types in the same way; consequently selection was determined for individual animals. This makes drawing conclusions on patterns of vegetation use more complicated. Difficulties in assessing selection were compounded by the limited number of locations; Thomas and Taylor (1990) recommend $\geq$50 observations on $\geq$20 animals for adequate power for hypothesis-testing. Use of the subsampling procedure increases power and corrects for vegetation type misclassification, but the small number of locations, especially in 2001, may have masked some selection (Samuel and Kenow 1992). Nonetheless, Poisson regression of point data (Humpal 2003), ANOVA analysis of proportional use data, and visual inspection suggest that not only were vegetation types not used randomly, but that there were differences in selection between years and study sites at both orders (second and third) of selection.

Interest in the use of jack pine by white-tailed deer on wintering areas within Camp Ripley prompted this study. During more severe winter 2001, all deer on both study sites used jack pine more than or as expected (relative to availability) at the home range to study site order (i.e., second order) of selection. At the location to home range level (i.e., third order), 1 deer on the NW and 2 on the SW site used jack pine less than expected with the remainder using this type as expected. Two deer on the SW site did not have jack pine in their home ranges; both were off Camp near a home with a feeder. Results showed more variation in the milder winter of 2002. On the NW site, 3 deer used jack pine less than expected and 2 selected jack pine at the second order of analysis; SW site deer used jack pine as expected, except for 1 deer selecting for it.

There was a dramatic difference in second order use of oak on the NW site between years (Figs. 3 and 4). It was avoided in 2001, with little variation among individuals; in 2002 there was much greater use by some deer and a great deal of variation in amount of use. This may have been related to shallower snow cover and greater access to oak mast. Red pine was used more on the NW site at both orders of selection in 2001 (Figs. 3 and 5). Grassland, brushland, agriculture, tamarack/marsh, and development/water were all used as expected by most individuals at both orders within years and sites; because of the limited area and/or utility of these vegetation types, this result was not unexpected. Overall, there was less variation in 2002, with use closer to expected for most vegetation types.

For both sites there were differences in mean proportional use between years (Fig. 7). Generally, it is believed that use of conifer cover increases with increased snow depth and winter severity, but not all studies have detected this relationship (Rongstad and Tester 1969, Ozoga and Gysel 1972, Moen 1976, Blouch 1984, Sabine et al. 2001). In more severe winter 2001, deer used jack pine and aspen the most on both sites. However, the greater use of jack pine by NW deer (>50% more use in 2001 versus 2002) and greater use of aspen by SW deer may be an indicator of the influence of better nutrition (i.e., crop residue and supplemental feed) available to the SW deer. Apparently consistent with this reasoning, oak use increased dramatically in 2002, particularly by NW deer. Although winter 2000–01 was much more severe than 2001–02, it may not have been severe enough to cause more substantial differences in vegetation type selection between years. The difference in jack pine use by SW deer between years was far more modest, which again may reflect the difference in available nutrition. Further, white-tailed deer also browse jack pine; similar use for foraging in both years may have masked observable changes in use of this cover type for shelter (Blouch 1984).

Based on use, jack pine (and aspen) appears to be an important vegetation type for deer on both sites at Camp Ripley. It had relatively high mean use in both mild and more severe winters, and presumably, its importance as browse and cover would continue to increase in more severe winters. Use by deer on both sites was almost identical during mild winter 2002, and they seemed to select for jack pine at both the home range and location levels. Although, individual deer showed differences in use of this vegetation type, overall patterns suggest that at minimum, deer use jack pine in proportion to its availability. Further analysis of available data could clarify the relative importance of various age classes of jack pine to white-tailed deer, further refining management's understanding of deer use of this vegetation type.

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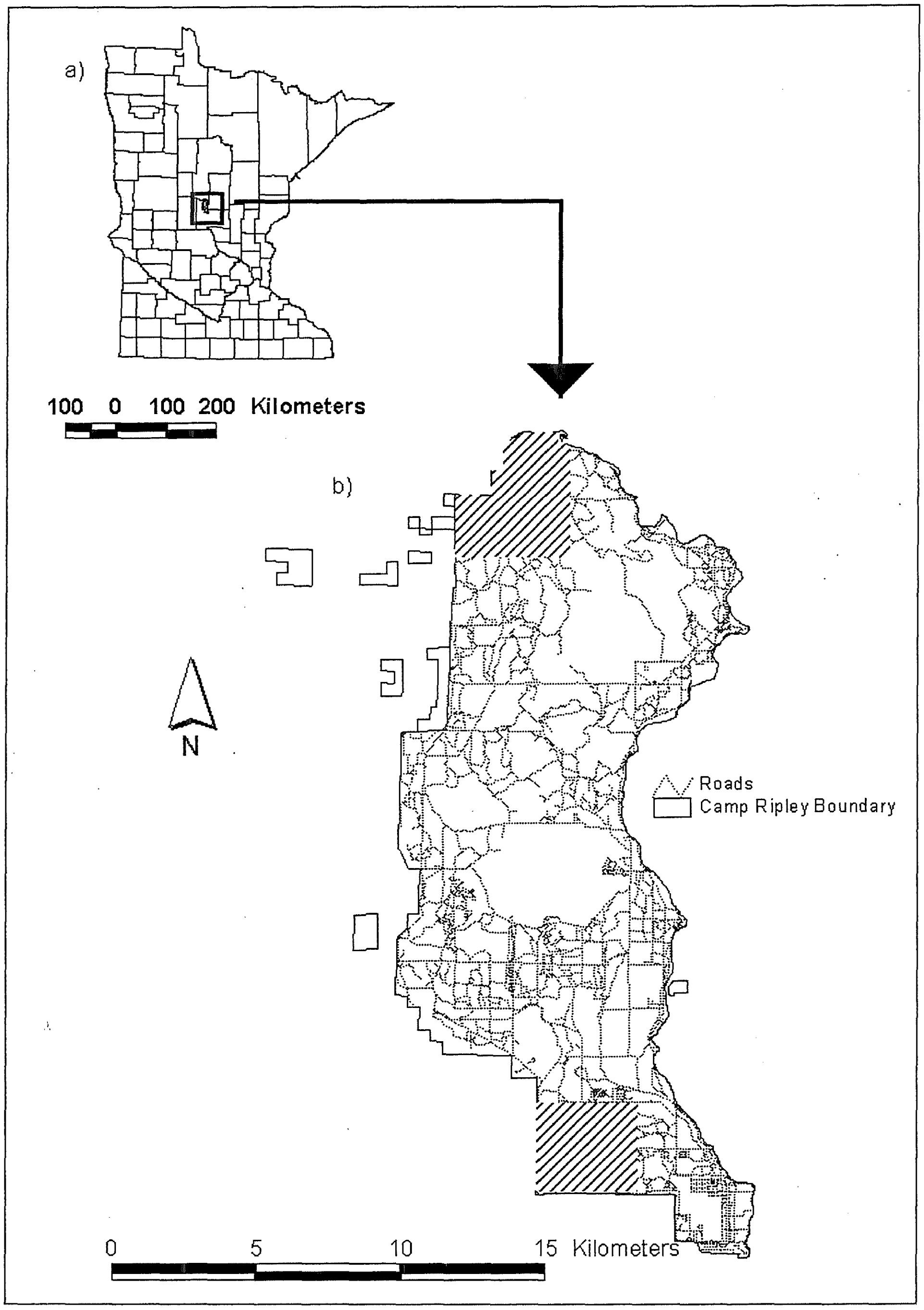


Figure 1. Location of Minnesota Army National Guard Camp Ripley Training Site (Camp Ripley) within Morrison County in central Minnesota (a). Location of Southwest and Northwest study sites (shaded areas) within Camp Ripley (b).

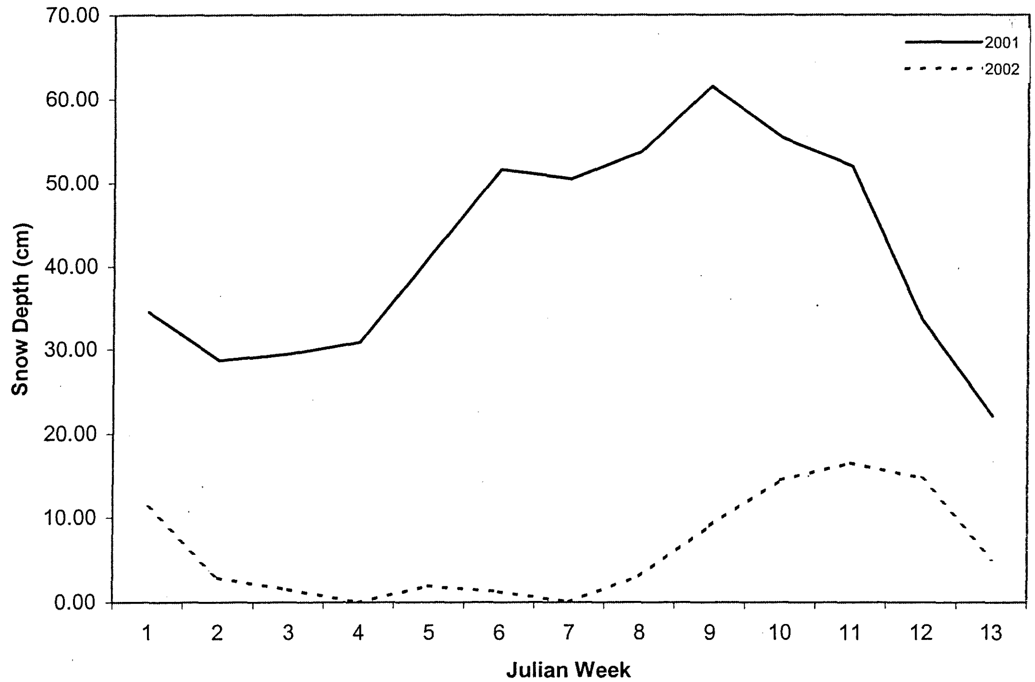


Figure 2. Mean weekly snow depths at Camp Ripley, Minnesota, January-March 2001 and 2002 (supplemented with data from nearby Little Falls, Minnesota, Minnesota Climatological Database 2000 and 2001).

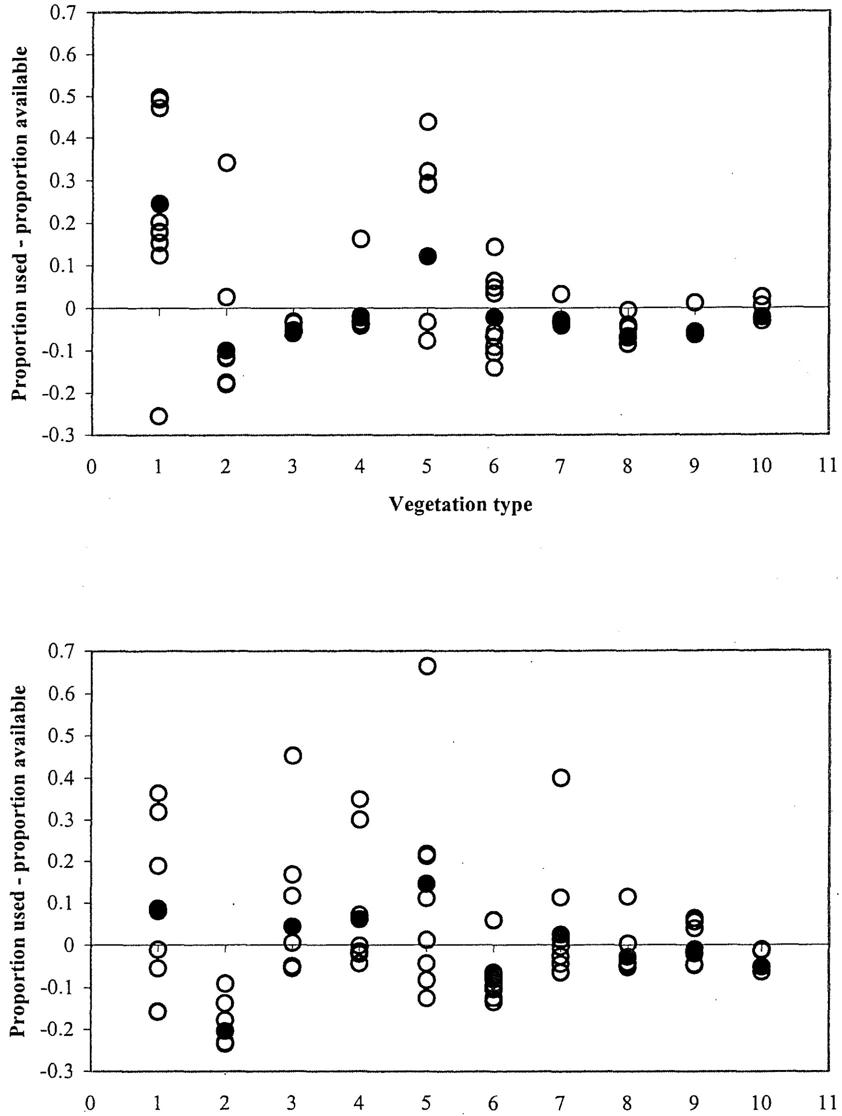
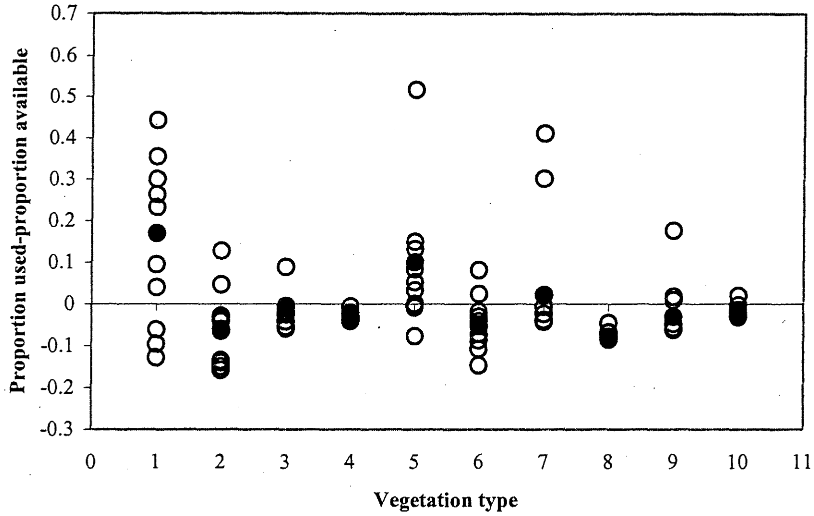


Figure 3. Second order vegetation type selection (i.e., home range use compared to study site availability) by adult (≥1.5 years old) female white-tailed deer on the Northwest (top) and Southwest (bottom) study sites of Camp Ripley, Minnesota during January-March 2001. Proportion used minus proportion available presented for individual deer (open circles) and pooled data (solid circles); distance from the 0-line indicates degree of selection or avoidance. Vegetation types are: (1) aspen, (2) oak, (3) hardwood, (4) red pine (red pine/white-spruce in Southwest), (5) jack pine, (6) grassland, (7) brushland, (8) agriculture, (9) tamarack/marsh, and (10) development/open water.



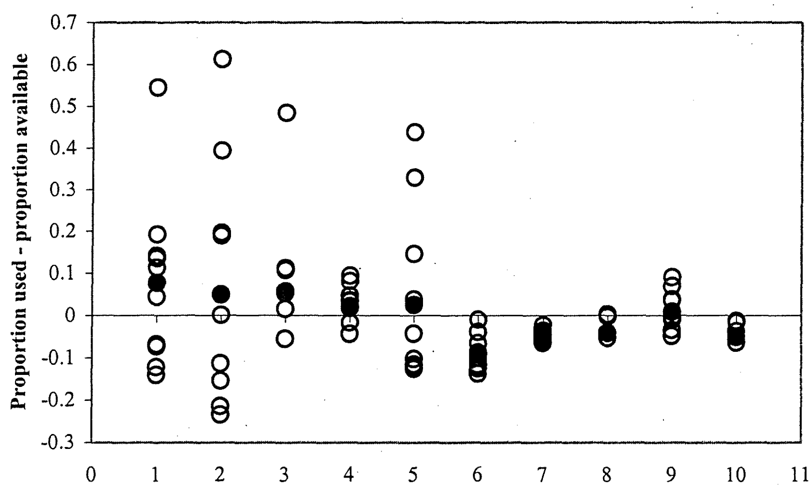
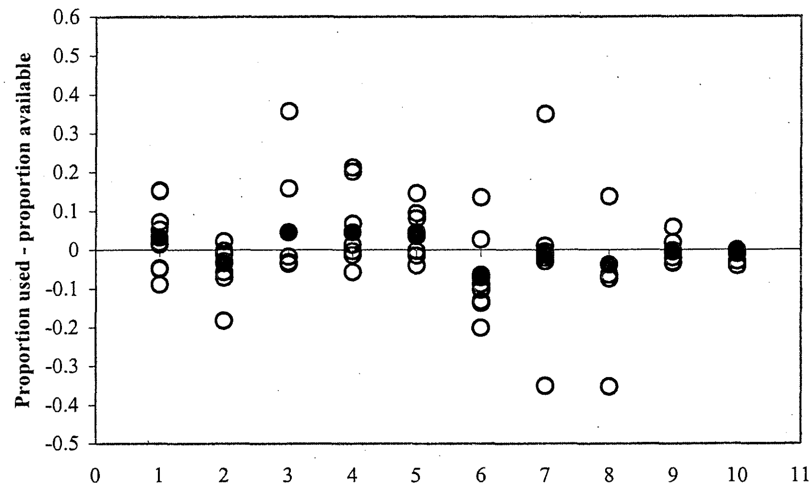


Figure 4. Second order vegetation type selection (i.e., home range use compared to study site availability) by adult (≥1.5 years old) female white-tailed deer on the Northwest (top) and Southwest (bottom) study sites of Camp Ripley, Minnesota during January-March 2002. Proportion used minus proportion available presented for individual deer (open circles) and pooled data (solid circles); distance from the 0-line indicates degree of selection or avoidance. Vegetation types are: (1) aspen, (2) oak, (3) hardwood, (4) red pine (red pine/white-spruce in Southwest), (5) jack pine, (6) grassland, (7) brushland, (8) agriculture, (9) tamarack/marsh, and (10) development/open water.



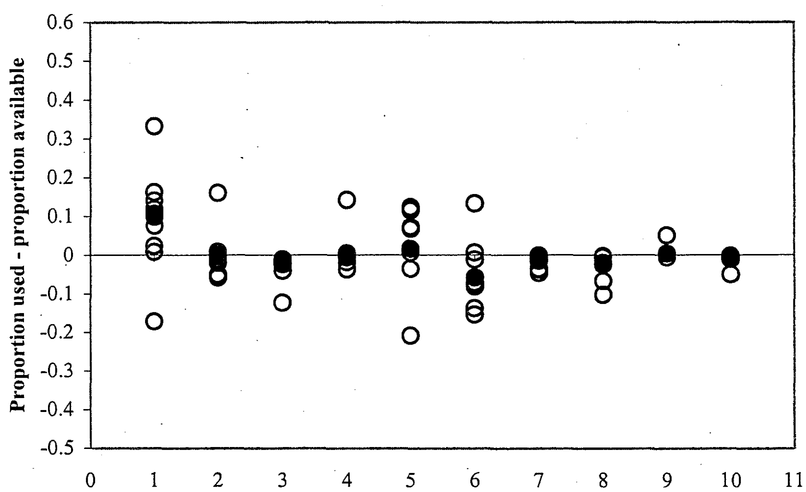


Figure 5. Third order vegetation type selection (i.e., locations compared to home range availability) by adult (≥1.5 years old) female white-tailed deer on the Northwest (top) and Southwest (bottom) study sites of Camp Ripley, Minnesota during January-March 2001. Proportion used minus proportion available presented for individual deer (open circles) and pooled data (solid circles); distance from the 0-line indicates degree of selection or avoidance. Vegetation types are: (1) aspen, (2) oak, (3) hardwood, (4) red pine (red pine/white-spruce in Southwest), (5) jack pine, (6) grassland, (7) brushland, (8) agriculture, (9) tamarack/marsh, and (10) development/open water.

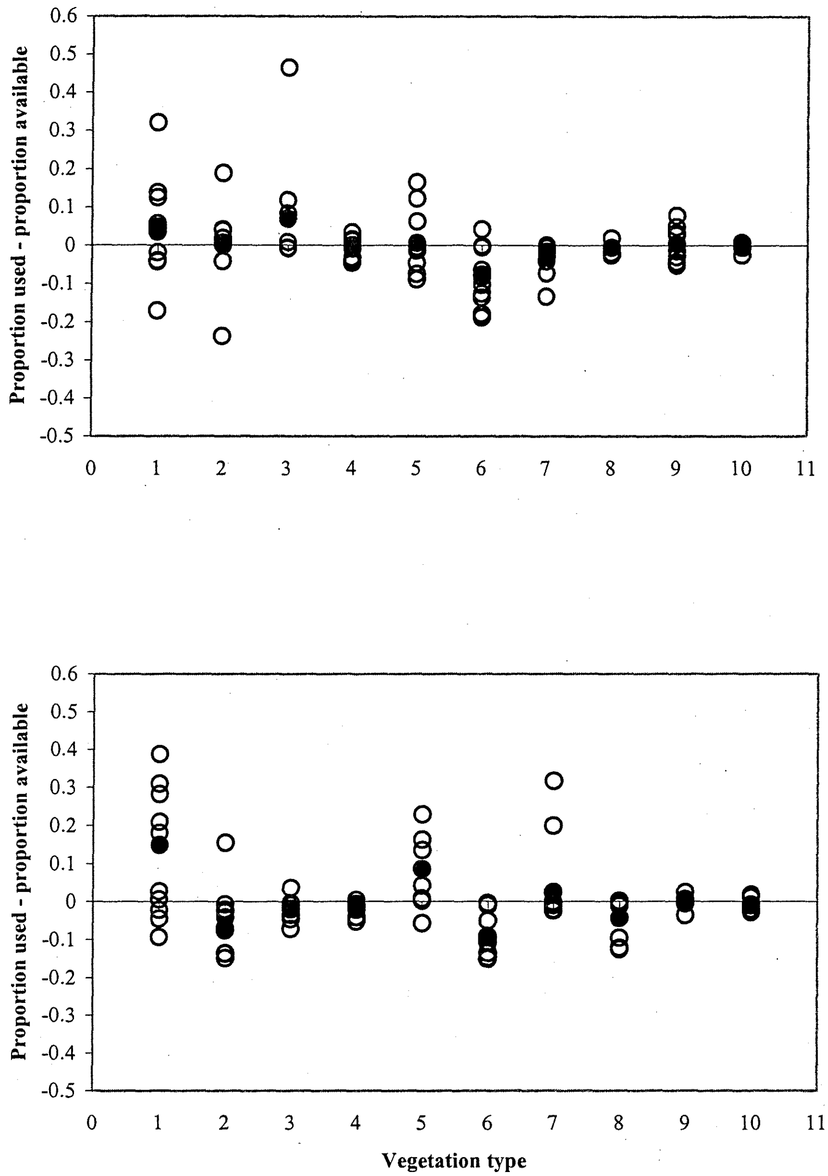


Figure 6. Third order vegetation type selection (i.e., locations compared to home range availability) by adult (≥1.5 years old) female white-tailed deer on the Northwest (top) and Southwest (bottom) study sites of Camp Ripley, Minnesota during January-March 2002. Proportion used minus proportion available presented for individual deer (open circles) and pooled data (solid circles); distance from the 0-line indicates degree of selection or avoidance. Vegetation types are: (1) aspen, (2) oak, (3) hardwood, (4) red pine (red pine/white-spruce in Southwest), (5) jack pine, (6) grassland, (7) brushland, (8) agriculture, (9) tamarack/marsh, and (10) development/open water.

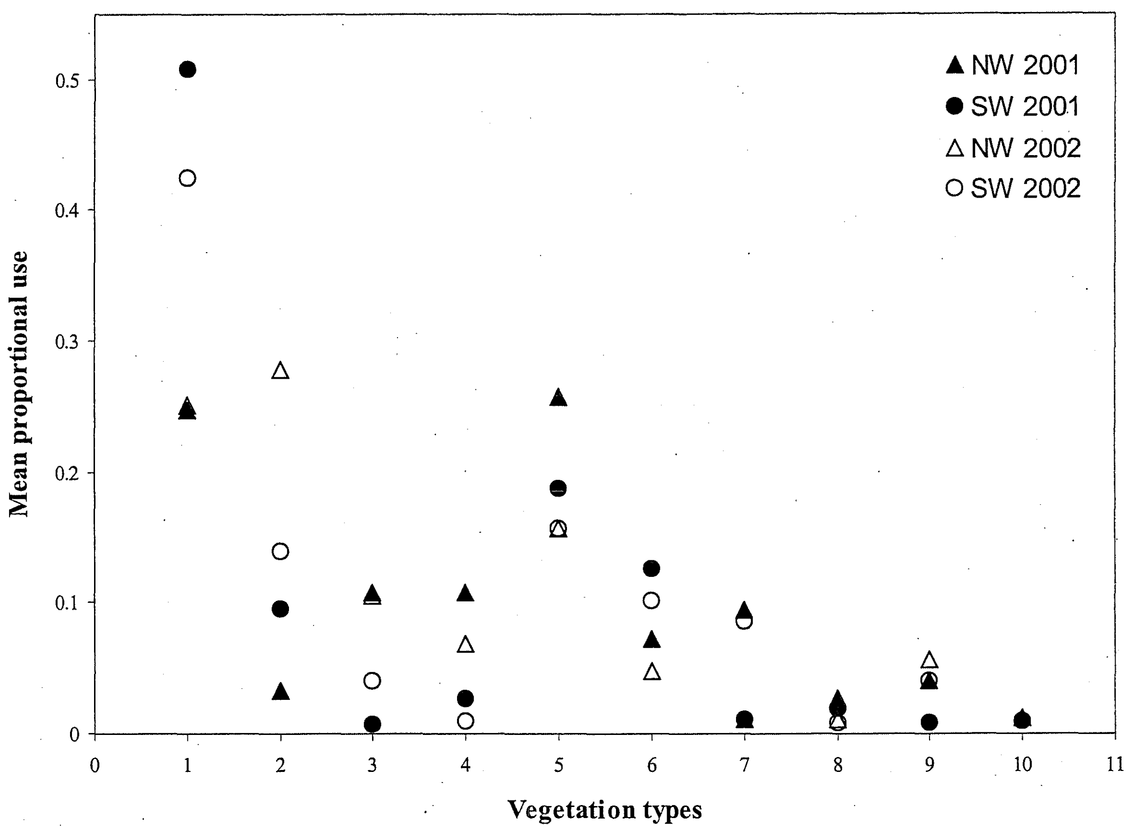


Figure 7. Mean proportional use by adult (≥1.5 years old) female white-tailed deer of 10 vegetation types on the Northwest (NW) and Southwest (SW) study sites of Camp Ripley, Minnesota, January-March 2001 and 2002. Vegetation types are: (1) aspen, (2) oak, (3) hardwood, (4) red pine (red pine/white spruce on SW site), (5) jack pine, (6) grassland, (7) brushland, (8) agriculture, (9) tamarack/marsh, and (10) developments/open water.

USING GPS COLLARS ON NORTHERN WHITE-TAILED DEER TO COMPARE NOCTURNAL AND DIURNAL WINTER MOVEMENTS AT CAMP RIPLEY ARMY NATIONAL GUARD TRAINING SITE, MINNESOTA

Christopher O. Kochanny, Buck A. Mangipane, and Glenn D. DelGiudice

Conventional tracking of white-tailed deer (*Odocoileus virginianus*) with VHF radiocollars to determine home ranges and straight-line distance of movements is commonly limited by poor weather, need for frequent aircraft flights and daylight, infrequent and small numbers of locations, and location estimates with large errors. There have been few radio-tracking studies of nocturnal movements of northern deer. Consequently, most present estimates of seasonal home range size and distribution are based on diurnal movements of deer. During winters 1998-99 and 1999-2000, we instrumented 24 does with GPS collars, programmed to record a location once per hour. Deer were monitored from late January through March. A total of 15,476 locations were collected with a mean of 910 locations per deer during a two and a half-month period. We hypothesized that deer would reduce their nocturnal movements and constrict associated home ranges compared to diurnal movements and homes ranges, possibly as a means of conserving energy. We will present and discuss our findings relative to estimates of home range and distance of straight-line movements derived from conventional VHF telemetry, as well as to current knowledge of winter energy and activity budgets of white-tailed deer.

*Abstract presented in the Proceedings of The Wildlife Society Ninth Annual Conference, 2002.

FECAL FIBER AS AN INDICATOR OF SUPPLEMENTAL FEED USE BY WHITE-TAILED DEER AT CAMP RIPLEY ARMY NATIONAL GUARD TRAINING SITE, MINNESOTA

Carolin A. Humpal and Glenn D. DelGiudice

Fiber content of feces can serve as an indicator of diet composition of white-tailed deer (*Odocoileus virginianus*) and distance traveled to feeders. Diets of natural browse produce pellets of a higher fiber content then diets that include supplemental feed (e.g., corn). Deer pellets were collected within 2 study areas (one with widespread supplemental feeding, one with limited access to feeders) in north central Minnesota during winter 2001. Sampling areas were divided into zones 0, 0-1, or >1 km from the nearest feeder. Three sequential collections (Jan-Mar) resulted in a total of 225 specimens from the 5 zones. Each specimen was analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL). In general, fecal fiber increased with distance from the feeders. However, specimens with fiber content indicative of supplemental feed use were collected up to 2.4 km from the nearest feeder. Significant differences in fiber content were observed among distance zones, collections, and study areas. ADF produced the most significant differences in all comparisons. Additional collections will be conducted during winter 2002 to further assess the influence of winter severity on various aspects of supplemental feed use by deer.

*Abstract presented in the Proceedings of The Wildlife Society Ninth Annual Conference, 2002.

MOOSE POPULATION DYNAMICS IN NORTHEASTERN MINNESOTA

Mark S. Lenarz, Michael Nelson, Michael Schrage, and Andrew Edwards

BACKGROUND AND JUSTIFICATION

Moose formerly occurred throughout much of the forested zone of northern Minnesota, but today, most occur within two disjunct ranges in the northeastern and northwestern portions of the state. The present day northeastern moose range includes all of Lake and Cook counties and most of northern St. Louis County. Records from the Superior National Forest (Peek et al. 1976) suggest that moose numbers increased dramatically in the late 1920's, but plummeted in the mid 1930's, and remained low until the mid to late 1960's. Population estimates from aerial surveys in northeastern Minnesota, conducted since 1959, suggest that the population gradually began to increase in the 1970's and 1980's to a peak of 6,900 in 1988 and then dropped to 3,700 by 1990. In recent years, moose numbers have apparently stabilized around 4000 animals.

We can only speculate as to the causes of past fluctuations in the northeastern moose population. Undoubtedly, moose numbers were reduced in the early decades of this century by the cumulative effects of settlement: over-hunting and timber harvest followed by wide-spread wildfire. The increase in moose numbers in the late 1920's probably reflected the closure of the moose season in 1921 combined with the ideal habitat provided by the early stages of the second growth forest. It is less clear why the population declined so dramatically in the mid 1930's. Increased poaching associated with the Great Depression, maturation of the forest habitat, and increased exposure to "brainworm" (*Parelaphostrongylus tenuis*) from higher deer numbers, probably all contributed to the reduction in moose numbers. In the early 1970's, the gradual increase in moose numbers corresponded with record low deer numbers throughout the northeast possibly as a result of a reduced the incidence of *P. tenuis* related mortality. Predation was probably reduced as well, because wolf numbers declined in portions of the northeast in response to the reduced deer numbers (Mech 1986). It is also possible that hunter selectivity for bulls (beginning in 1971) may have increased the population growth rate by increasing the proportion of females in the herd. Between 1988 and 1990, moose numbers decreased over 50%. Circumstantial evidence suggested that much of the mortality was associated with massive infestations of an external parasite, the "winter tick" (*Dermacentor albipictus*). Research suggests that outbreaks of this parasite may be related to weather (Drew and Samuel 1985, Samuel and Welch 1991) and if so, are independent of moose density.

That moose numbers in northeast Minnesota have not increased in recent years is an enigma. Research in Alaska and northern Canada has indicated that non-hunting mortality in moose populations is relatively low. When these rates are used in computer models to simulate change in Minnesota's northeastern moose population, moose numbers increase dramatically, counter to the trend indicated by aerial surveys. Several non-exclusive hypotheses can be proposed to explain this result: i) average non-hunting mortality rate for moose in northeastern Minnesota is considerably higher and/or more variable than measured in previous studies; ii) recruitment rates estimated from the aerial surveys and used in the model are biased high; and/or iii) moose numbers estimated by the aerial survey in recent years are biased low.

OBJECTIVES:

1) Determine annual rates of non-hunting mortality for northeastern moose.
Simulation modeling suggests that Minnesota's northeastern moose population should be increasing. The results from annual aerial surveys, however, indicate that numbers have remained relatively constant, despite conservative harvest levels. The proposed study will establish whether high levels of non-hunting mortality are preventing this population from increasing, identify causes of non-hunting mortality and determine whether is if feasible to develop an index that can be used to predict annual variation in this mortality.

2) Determine annual rates of reproduction in northeastern moose.
Research in northwestern Minnesota indicated that a low proportion of cow moose were pregnant and that this contributed to a decline in moose numbers. The proposed study will document annual pregnancy, twinning, and calf mortality rates to determine whether reduced reproduction is preventing the population from increasing and attempt to identify indices that predict annual variation in reproduction.

3) Calibrate aerial moose survey methodology
Aerial surveys assume that observers do not tabulate some proportion of moose. This proportion varies among observers, habitat types, snow conditions, and timing of the survey. The proposed study will document the magnitude of this proportion and identify ways to improve the survey methodology.

Methods

Mortality was determined by monitoring a sample of up to 60 radio-collared moose. The transmitter in each radio-collar contains a mortality sensor that increases the pulse rate (mortality mode) if it remains stationary for more than 6 hours. During the first year of the study, the GPS location of each moose was determined weekly from the air. Beginning in March 2003, GPS locations were determined for half of the moose each week and a mortality check was conducted on the remaining moose. When a transmitter was detected in mortality mode, we located the moose and conducted a necropsy to determine, if possible, the cause of death.

Serum samples were collected from each cow moose at capture and pregnancy was determined from progesterone levels in these samples (Haigh et al. 1981). Following birth, the presence/absence of a calf with a radio-collared cow was determined when possible during the telemetry flights.

As part of the 2003 aerial moose survey, all plots containing radio-collared moose were flown using the same survey protocol as that in randomly drawn plots. A sightability correction factor (SCF) was calculated, based on the proportion of radio-collared moose observed.

Results to Date

In February 2002, Helicopter Capture Services (HCS) of Marysvale, Utah, captured and radio collared 24 moose (7 bulls and 17 cows) in northeastern Minnesota, using a net-gun. Residual trees in clear-cuts and regrowth made it difficult to capture moose with the net-gun and radio collared moose were not evenly dispersed over the study area. In March 2003, Quicksilver Air of Fairbanks, Alaska, captured an additional 42 moose (21 bulls and 21 cows) using a dart gun. Following the March captures, radio-collared moose were much more evenly dispersed across the study area (Fig. 1).

As of 1 May 2003, 7 radio-collared moose (2 bulls and 5 cows) have died. A hunter killed one bull and wolves apparently killed the second. Wolves killed one cow and the remaining 4 cows died from some unknown non-traumatic cause. Calculated non-hunting mortality for bulls and cows was 4% and 29%, respectively. The cow mortality was substantially higher than documented for populations outside of Minnesota (generally 8 to 12%).

Serum samples from 61of the radio-collared moose were tested for the presence of *P. tenuis*-specific antibodies using an enzyme-linked immunosorbent assay procedure (ELISA) (Ogunremi et al. 1999). Nine of the 61 moose (7 cows and 2 bulls) were sero-positive for antibodies against *P. tenuis*. One of the sero-positive bulls was apparently killed by wolves in late April 2003.

In 2002, the pregnancy rate was estimated at 92% based on serum progesterone. Similar estimates for the northwest moose population between 1996 and 1999 averaged 50% (Cox et al, in prep). By October, 62% of the northeast cows were accompanied by single or twin calves, which represented a calf/cow ratio of 0.77. This compares favorably with 0.70 calves/cow estimated in this year's aerial survey. The samples from the 2003 capture effort have not been analyzed yet.

The SCF estimated during the 2003 aerial moose survey (1.87) was considerably higher than that in most years because poor snow conditions made it difficult to see moose. The SCF calculated independently from the proportion of radio-collared moose observed in plots containing radio-collared moose was very similar (2.04).

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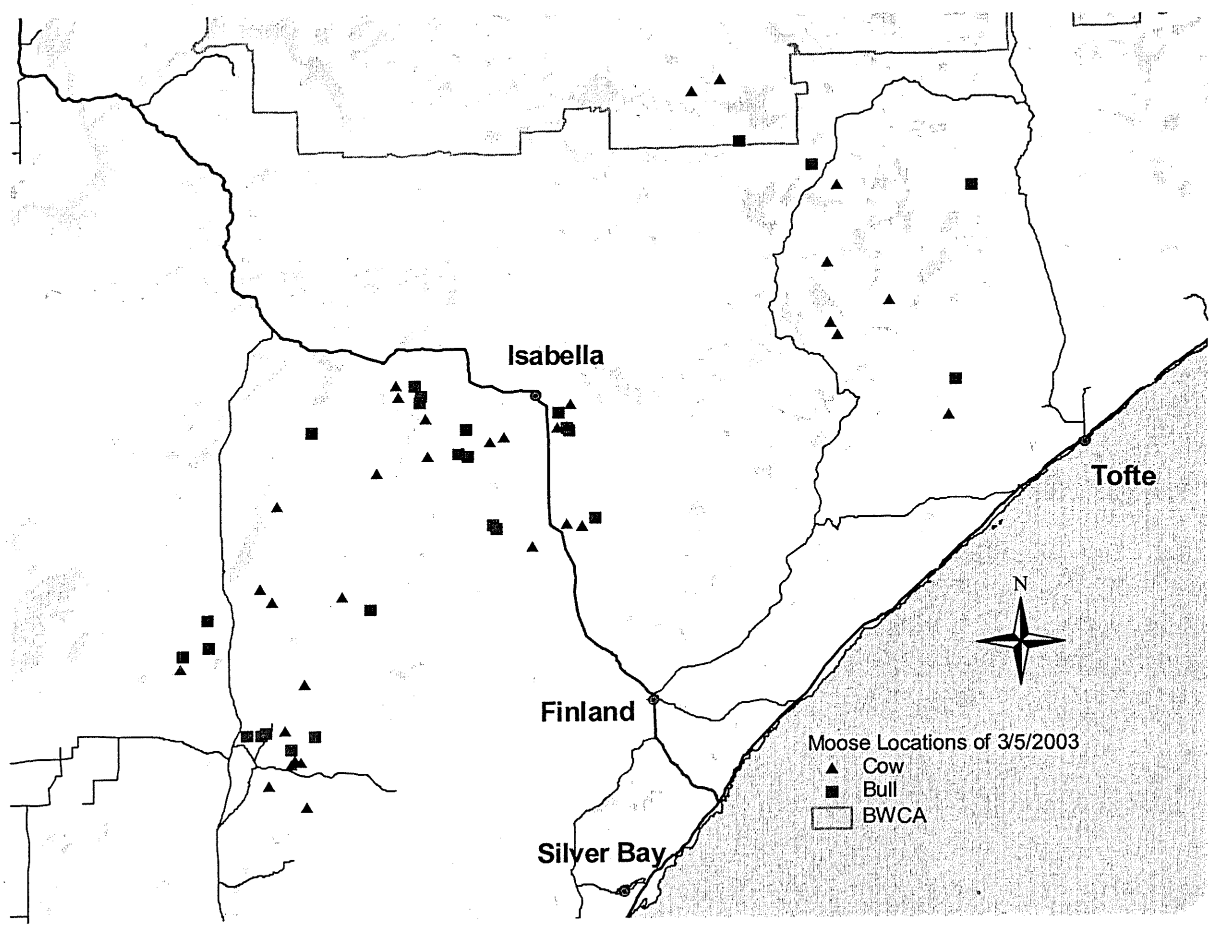

Figure 1. Locations of radio-collared moose in northeast study on 6 March 2003.

RIVER OTTERS IN SOUTHEAST MINNESOTA: ACTIVITY PATTERNS AND THE VIABILITY OF AN AERIAL SNOW-TRACK SURVEY TO MONITOR POPULATION TRENDS.

Daniel J. Martin[1], John D. Erb[2], Brock R. McMillan[1], and Thomas A. Gorman[1]

Background and Justification

The river otter (*Lontra canadensis*) is a semi-aquatic member of the family Mustelidae and is indigenous to the state of Minnesota. Over the past century, populations of river otter declined due to environmental degradation (including drainage and pollution of wetlands) and unregulated trapping (Nowak 1999). Recently, however, river otter numbers have increased throughout much of their original range in North America (Miller 1992, Serfass et al. 1993, Chilelli et al. 1996). This rebound can be attributed to successful reintroduction programs, increased legal protection of river otters and their habitat, and more effective management techniques (Melquist and Dronkert 1987, Chilelli et al. 1996, Raesly 2001). Similarly, anecdotal evidence (e.g., non-target capture by trappers) suggests that abundance and distribution of river otters has recently been increasing in many areas of southern Minnesota (Erb et al. 2000, Erb and DePerno 2001).

Though their numbers appear to be increasing, river otter habitat in southern Minnesota is more isolated and largely confined to narrow riverine corridors. Combined with moderate fecundity, river otters in southern Minnesota may thus be more susceptible to negative environmental impacts and harvest pressures (Tabor and Wight 1977, Melquist and Dronkert 1987, Erb and DePerno 2001). Currently, harvest of river otters is prohibited in the southern half of the state due to previous absence or low abundance.

The ability to detect trends in abundance of river otters is beneficial for management and conservation of this species in Minnesota. In addition, the USFWS currently requests population status information from states issued CITES export tags for harvested otter. Methods for monitoring trends in abundance of river otter have historically focused on harvest data or latrine surveys (Reid et al. 1987, Chilelli et al. 1996). However, indices based on those methods may be inaccurate due to compounding economic and ecological effects (e.g., increase in price paid for pelts), as well as behavioral variability (e.g., seasonal variation in latrine use) (Kruuk and Conroy 1987, Romanowski et al. 1996).

Aerial snow-track (AST) surveys have successfully been used to monitor populations of other furbearer species (Golden 1994, Becker et al. 1998). These surveys allow the coverage of large areas in a short amount of time relative to alternative methods. Because river otters primarily inhabit aquatic ecosystems, restricting survey routes to these systems should optimize efficacy of the survey as compared with similar surveys for many other furbearer species. In addition, river otters traveling on snow often leave tracks that are easily distinguishable from sign of other

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species. These factors, combined with a climate that consistently produces adequate snowfall, further warrant testing of an AST survey for monitoring trends in population size of river otters in Minnesota. Aerial snow-track survey data are likely influenced by movements of river otters. Therefore, activity and movement patterns of river otters will be determined in order to refine standardized methods for AST surveys. In addition, information describing the relationship between behaviors of river otters and their spatial ecology should improve the quality of decisions affecting management of both wetland habitats and river otters.

Objectives

AST Surveys: A key assumption for snow-track surveys to be comparable through time is that variation in abilities of detecting river otter sign among observers must be small. In addition, quantifying daily and monthly variability in track counts within a winter likely improves the ability of the index to account for these temporal variables. Thus, the primary objectives of the 2002-2003 phase of this study were to determine the feasibility of AST surveys of river otters by examining variation in detection of river otter sign among observers. In addition, preliminary data on variability in track counts within a winter were also examined. If observer variability is small relative to variability among sites, a model based on AST survey data will be further developed to index populations of river otter. This index will be based initially on data collected during preliminary surveys conducted in 2001-2002 (Erb and DePerno 2001) and subsamples from 2002-2003 surveys. Power analysis and model parameters will be further tested with survey data collected during the 2003-2004 winter.

Activity and Movement Patterns: Descriptions of movement patterns of river otters will help managers better understand seasonal habitat requirements, spatial relations between conspecifics, and may help in defining spatial parameters of the AST survey design. We will determine diel activity and movement patterns of river otters in all seasons and in relation to ambient environment conditions (e.g., weather parameters), habitat characteristics, and sympatric relationships of river otters.

Study Area

The study area is located in the Paleozoic Plateau of southeast Minnesota, a subunit of the Eastern Broadleaf Forest ecosystem, and includes the Blufflands area along the western edge of the Southern Mississippi River Basin, which consists of a loess-capped plateau furrowed with river valleys (MN DNR Ecological Services). AST survey routes were flown over the Zumbro and Whitewater Rivers, and two sections of the Mississippi River (Miss.) (Fig. 1). River otters used for determining activity patterns are located throughout the study area. A subsample of river otters from the Whitewater River Valley was used to determine movement patterns.

Methods

AST Surveys: Aerial snow-track surveys were conducted from a Bell OH-58A+ helicopter. Although more expensive than a fixed-wing aircraft, a helicopter was used because of increased visibility (e.g. larger windows), speed control (sustained stable flight at low speeds), and maneuverability (B. Maas pers. commun.). Each observer was required to have a minimum of 3 hours of training in detection of river otter sign in snow from an aircraft prior to participation in the study. During 2002, observers were trained by conducting AST surveys over the Mississippi River Valley and the Minnesota River Valley.

Global Positioning System (GPS) waypoints were collected directly above permanent visual landmarks in order to delineate AST survey routes (Fig. 1). On routes along the Mississippi River, additional waypoints were recorded as necessary in order to locate redirections in the survey flight path. Because the flight paths were restricted to the main channels, only beginning and end waypoints were recorded on smaller rivers (i.e., the Whitewater and Zumbro Rivers).

Variability among observers was determined using 2 or 3 different observers individually surveying the same routes on the same day. In order to negate bias from prior observations, the helicopter pilot was neither involved in observation nor confirmation of river otter sign. Several environmental factors, such as cloud cover, were recorded for each survey in order to test their potential impacts on observer variability. Aerial snow-track surveys were flown after snowfalls greater than 2.5 cm in depth, from 1–4 days after a snowfall, and when other logistical considerations allowed (e.g., weather conditions permitted flight). Location of river otter sign was recorded using a Garmin 150 Global Positioning System (GPS), and any sign observed >5 seconds (flight time) from the previous recorded sign was logged. Integrated variation in the standardized speed limits and altitude for each survey route was a necessary compromise between effective viewing distance, safety, and tortuosity of a given river (B. Maas pers. commun.; Table 1).

Movement and Activity Patterns: River otters were captured and tagged with a radio-transmitter as described by Erb and DePerno (2001). Radio-tracking was performed using an ATS Challenger Model R400 radio telemetry receiver with a 3-element Yagi hand-held antennae. River otters were relocated via triangulation using ≥2 azimuths recorded within a ≤30-minute period. Each river otter was relocated between 2 and 6 times during a 6-hour tracking session. Tracking sessions were conducted based on a randomized, stratified-block sampling design (Table 2).

Activity of an individual river otter was determined as either active or inactive based on variation in signal cutout during individual locations. All river otters marked for this study were included in the sample.

Results

AST Surveys: Sixty AST surveys were conducted among 4 survey routes from 15 January–11 March 2003 (Table 4). Preliminary results suggest that variability among observers was low compared to variation between days after snowfall and among sites (see Fig. 2 for example from survey on Whitewater River). Cloud cover appears to have the greatest impact on variability among observers. Hence, we believe further development of the AST survey index is warranted.

Movement and Activity Patterns: Seven radio-implanted river otters were tracked in the Whitewater River Valley to determine movement patterns. A total of 78 tracking sessions were completed between 1 June 2002 and 8 May 2003 (Table 3). Most tracking sessions to determine movement patterns involved between 2 and 6 locations of the river otters. River otters in the Whitewater Valley appear to be active primarily at night. However, activity is not restricted to a specific time period. Movement of river otters in the Whitewater Valley is generally restricted during winter months as compared to warmer months.

Future Plans

AST Surveys: We will continue AST survey flights in winter 2003–04. Statistical analysis will be conducted to quantify the influence of observer, stream size-class, days since snowfall, date, and weather conditions on survey data and index values. Combined with power analysis, this information will provide the basis for further development of a sampling design and an index with the greatest potential to detect changes in numbers of river otter.

Movement and Activity Patterns: Location estimates from recorded azimuths will be generated using program Locate II and further spatial analysis will be completed using ESRI ArcView. The activity level for each triangulated location of an individual river otter will be determined as: (# of active locations / # of total locations)*100 = % fixes active. In order to determine factors that potentially affect diel activity and movement patterns of river otters, we will examine: Euclidean date, biological season (Table 3), time of day (Table 2), mean hourly surface temperature, mean daily precipitation, mean hourly barometric pressure, luminance (including sky condition and moon phase), snow depth, water turbidity, sex of river otter, and age-class of river otter. Movement patterns will be analyzed by comparing maximum, minimum, range, standard deviation, and mean distance moved by individuals, social groups, and demographic groups (i.e., sex and age-class) of river otters. Estimated activity levels will be compared with movement patterns for each river otter in order to determine the utility of this method for estimating activity patterns.

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Tables and Figures

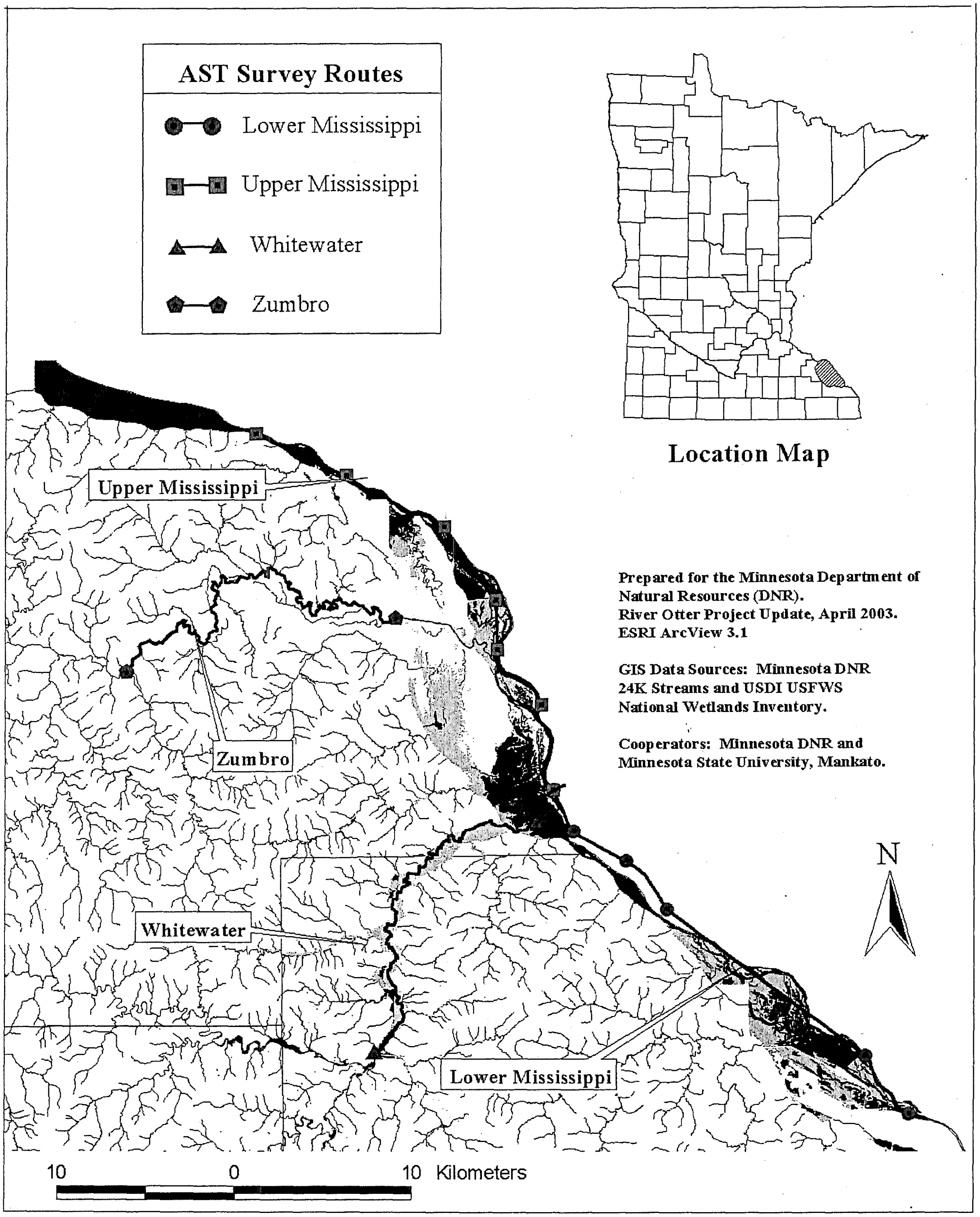

Figure 1. Aerial Snow-track survey routes used for determining variability in river otter sign recorded among observers; Minnesota, 2003.

Table 1. Altitude and flight-speed limit standards used during Aerial snow-track surveys.

AST survey route	*Altitude* (m)	*Ground-speed* (kph)
Lower Mississippi River	~76	72-81
Whitewater River	~46	48-57
Upper Mississippi River	~91	72-81
Zumbro River	~46-61	72-81

Table 2. Stratified-block sampling scheme used for tracking of river otters via radio-telemetry in southeastern Minnesota.

Time-block	*Hours*
Morning Crepuscular	04:00-10:00
Diurnal	10:00-16:00
Evening Crepuscular	16:00-22:00
Nocturnal	22:00-04:00

Table 3. Biological seasons of river otters and number of tracking sessions completed to date by time-block (1 June 2002—8 May 2003; *n* = 78).

	Birthing / breeding	*Pup-rearing*	*Winter maintenance*
Time-block	1 Mar.—31 May	1 June—15 Oct.	16 Oct.—29 Feb.
Morning Crepuscular	2	4	12
Diurnal	4	2	14
Evening Crepuscular	3	5	13
Nocturnal	5	2	12
Total	14	13	51

Table 4. Number of observers that completed Aerial snow-track surveys by route and date, 2003 ($n = 60$).

	AST Survey Route				Days Since Snowfall
# Observers	Lower Miss.	Upper Miss.	Whitewater	Zumbro	
15 Jan.	2	0	2	0	2
29 Jan.	3	0	3	0	1
30 Jan.	3	3	3	0	2
7 Feb.	2	1	2	1	2
8 Feb.	3	3	3	3	3
4 Mar.	2	2	1	2	1
5 Mar.	3	3	1	3	2
11 Mar.	2	2	0	2	3
Total	20	14	15	11	

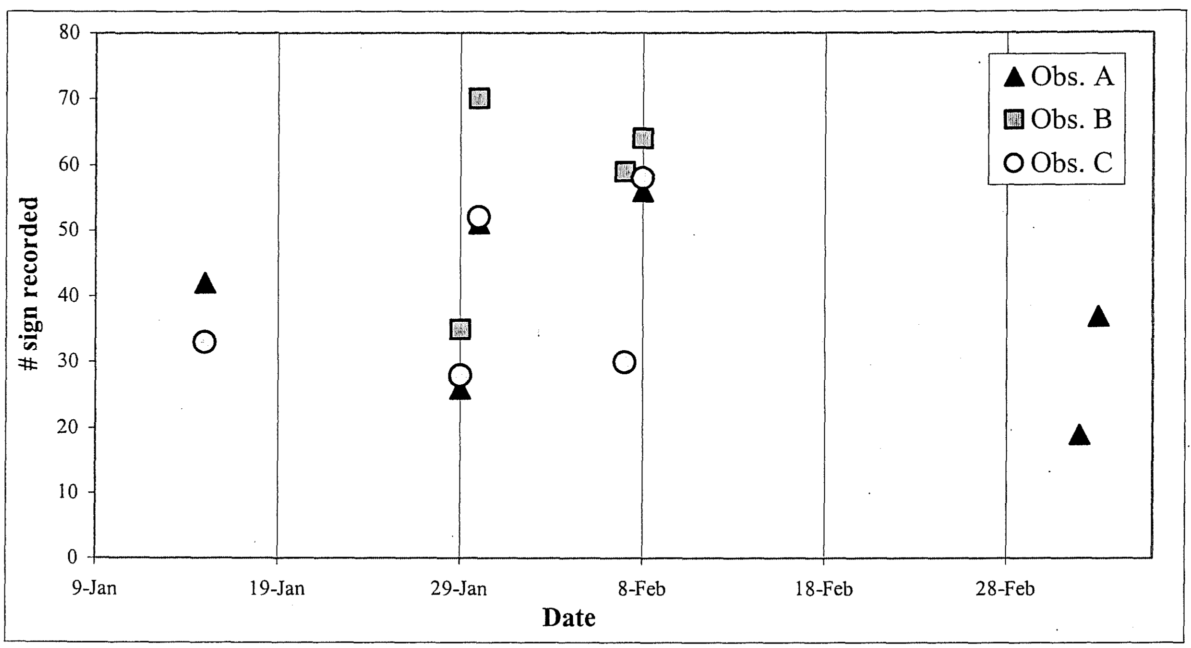

Figure 2. Example of aerial snow-track survey data, showing variation in number of river otter sign recorded among observers by fight date on the Whitewater River, MN. Number of river otter sign recorded by observers on subsequent days varies more than does number of sign recorded by different observers on the same day.

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TESTING THE EFFICACY OF HARVEST BUFFERS ON SEASONAL WETLANDS IN FORESTED LANDSCAPES

Mark A. Hanson, James Church[1], Anthony T. Miller[2], and Brian Palik[3]

Seasonally-flooded wetlands (*sensu* Stewart and Kantrud 1971) are abundant landscape features throughout much of the Laurentian Mixed Forest in Minnesota. Diverse communities of aquatic and semi-aquatic organisms including waterfowl, amphibians, and invertebrates depend on these habitats as foraging areas, sites for egg laying and reproduction, and completion of other life cycle elements. Habitat requirements for many wetland-dependent species in forested landscapes are poorly known. Also, influences of clearcut timber harvest may influence seasonal wetland characteristics and habitat suitability for native species in unexpected ways. Voluntary site-level guidelines have recently been formulated for timber harvesting adjacent to aquatic habitats (Minnesota Forest Resources Council 1999). These protocols recommend retention of forested "buffers" within riparian management zones following clearcut timber harvest near streams, lakes, and open water wetlands, but make no similar recommendations for small, seasonally-flooded wetlands. This may be unfortunate given the suggestion of Palik et al. (2001) that functional links are strong between small wetlands and adjacent landscapes, at least at some spatial scales.

We are assessing aquatic invertebrate communities within 16 seasonally-flooded wetlands in response to four timber harvest (or buffer) scenarios in adjacent, aspen-dominated landscapes in north central MN (near Remer). Study wetlands were embedded within harvest treatments and each wetland/harvest-buffer combination was replicated four times. Thus, four wetland sites were classified as controls (no harvest), full buffer (50-foot uncut buffer), partial buffer (thinned 50-foot buffer) and no buffer remaining (clearcut timber harvest to wetland margin) (Figure 1). We gathered data during May-July 2000 to assess pre-harvest characteristics and natural variation within invertebrate communities at these sites. All timber harvesting occurred during fall-winter 2000-01, thus data gathered during April-July 2001-03 have potential to reflect treatment effects in our response variables. We also plan to gather data during the remainder of 2003 and 2004, thus we expect to have one pre-, and four post-treatment years of data for final analyses. Samples were gathered using surface-associated activity traps (Hanson et al. 2000) deployed for 24 hrs along randomly-chosen transects in study wetlands. Resulting data were analyzed with indirect (principle components analysis, PCA) and direct (redundancy analysis, RDA) gradient analysis using CANOCO 4.0 (Ter Braak and Smilauer 1998). RDA is a linear form of gradient analysis (Ter Braak 1995, Van Wijngaarden et al. 1995) and is especially useful for relating community data to environmental gradients such as our harvest treatments and other variables. We focused on invertebrates because they are known to be important components in diets of breeding waterfowl (Krapu and Reinecke 1992) and because they are useful as indicators of ecological characteristics in aquatic habitats (Resh and Jackson 1993).

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Our research has several objectives. First, we intend to characterize natural patterns of variability within aquatic invertebrate communities resident in seasonal wetlands in this forested landscape. Second, we are testing efficacy of harvest buffers by evaluating responses of these invertebrate communities to specific harvest scenarios applied in association with aspen clearcutting. Finally, using invertebrate community characteristics, along with data gathered by other study collaborators, we hope to identify functional links that may exist between seasonal wetland communities and adjacent landscape features. Other study collaborators are assessing additional wetland responses including physical and chemical characteristics, breeding forest birds, vegetation, hydrological aspects, and other site-level features. This update is a partial summary of preliminary data analyses; results and interpretation may change as additional data are gathered and interpreted.

We identified significant sources of variation in invertebrate communities in wetland study sites, both before and after timber harvest in adjacent uplands. Prior to timber harvest, major sources of variance in these communities were duration of ponding (hydroperiod; 17 %), geographic location (27%), and water chemistry characteristics including concentrations of total organic carbon (16.5 %) and ammonia (10%; Miller et al. in prep.). On 18 June 2001, following harvest, major sources of variance included influences of hydroperiod (37 %) and clearcut timber harvest (10%; Figure 2). Although preliminary, these results are generally consistent with those reported by Ossman (2001) from similar studies of seasonally-flooded wetlands in variable-age aspen stands, also located in north central MN (Buena Vista and Paul Bunyan state forest areas near Bemidji). As expected, results from 2000 (pre-harvest) also indicated that invertebrate communities varied dramatically over time in our study wetlands. Composition of samples fluctuated, both over a single growing season, and among wetland study sites (Figure 3). This means that, at least in terms of aquatic invertebrates, natural temporal fluctuation exceeded magnitude of variability among wetlands on a given sampling date. By July each year, most study sites were completely dry and, in many cases, showed little superficial evidence of prior inundation.

Preliminary analyses support current views in ecology which hold that invertebrate communities in small, seasonally-flooded wetlands should be strongly influenced by abiotic features at the site-scale (Wellborn et al. 1996), and that these communities should reflect characteristics of adjacent uplands (Palik et al. 2001). Our data appear to reflect some influence of clearcut timber harvest, although causal mechanisms associated with this response are unclear. We have not yet specifically tested for effects of harvest buffers. It is interesting to note that Palik et al. (2001) detected no influence of forest age-structure on invertebrate communities in small wetlands that were the subject of a different study in north central MN. We believe that additional data and analyses will help clarify wetland responses to clearcut timber harvest and allow us to better assess efficacy of harvest buffers in preserving integrity of wetland communities.

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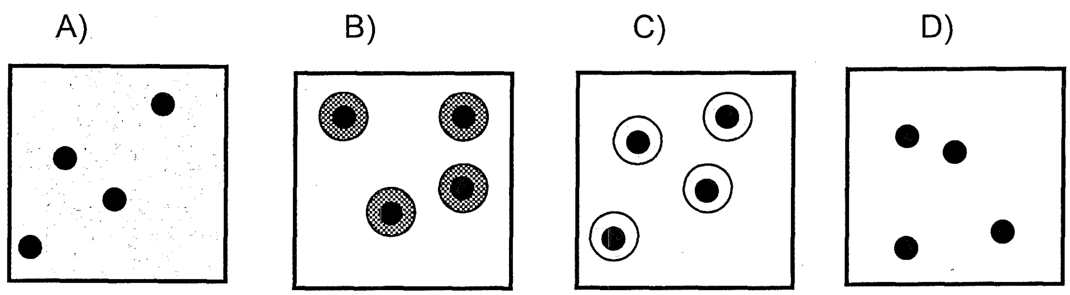

Figure 1. Drawings depict four experimental harvest/buffer configurations as a) Control (no harvest), b) Full buffer (no harvest within 50 feet of study wetlands, c) Thinned buffer (50 percent thinning within buffer), and d) no buffer (clearcut to wetland margins).

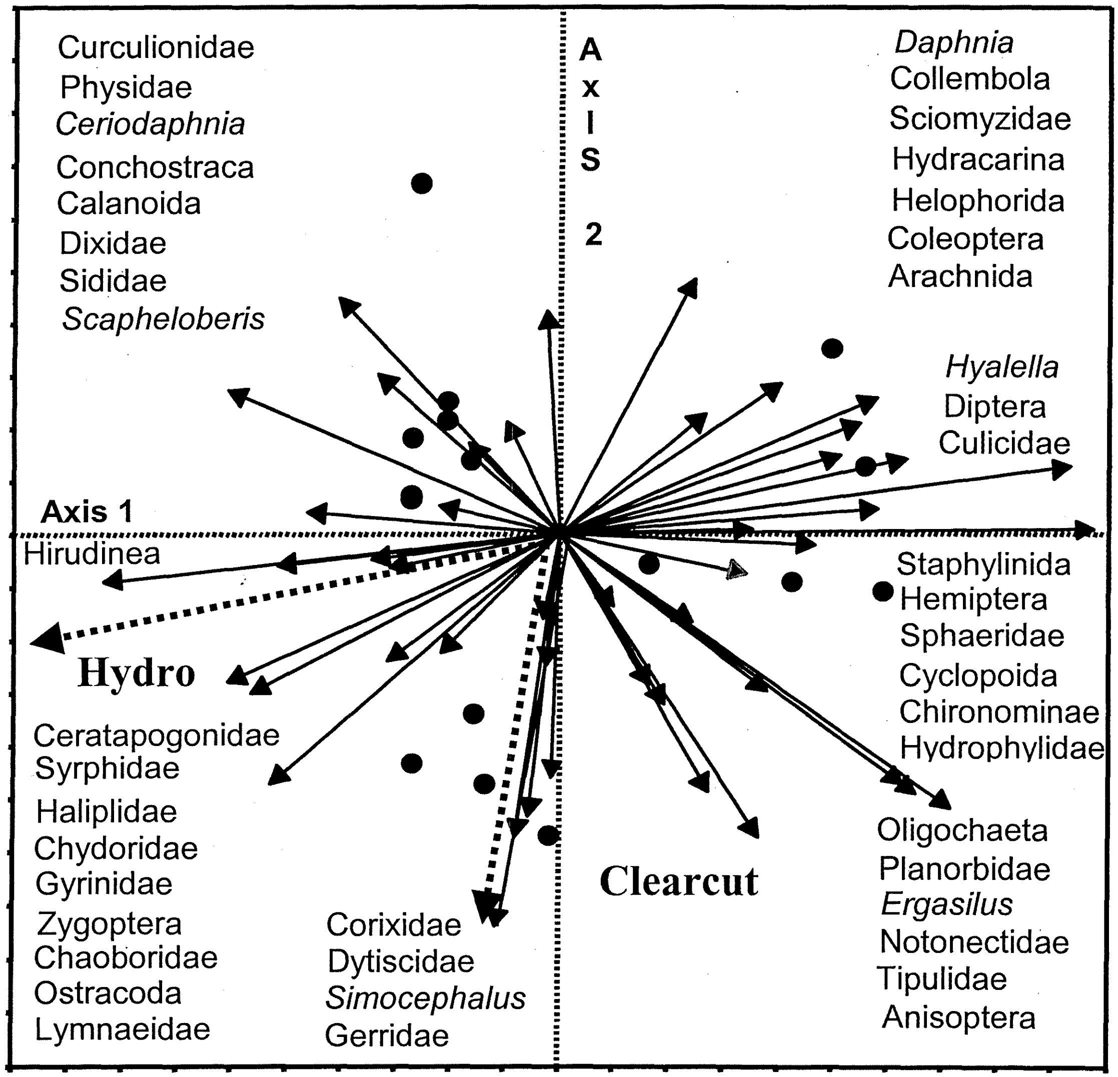

Figure 2. Direct gradient analysis (redundancy analysis) from 18 June 2001 indicating associations among wetland site scores (dots, based on aquatic invertebrates), environmental variables (heavy dotted lines show vectors for Hydro=hydroperiod, Clearcut=clearcut harvest), and selected invertebrate taxa. Location of invertebrate taxon names reflect direction of association. Influences of hydroperiod and clearcut timber harvest were identified as significant using forward selection procedures. All analyses performed using CANOCO 4.0 (Ter Braak and Smilauer 1998).

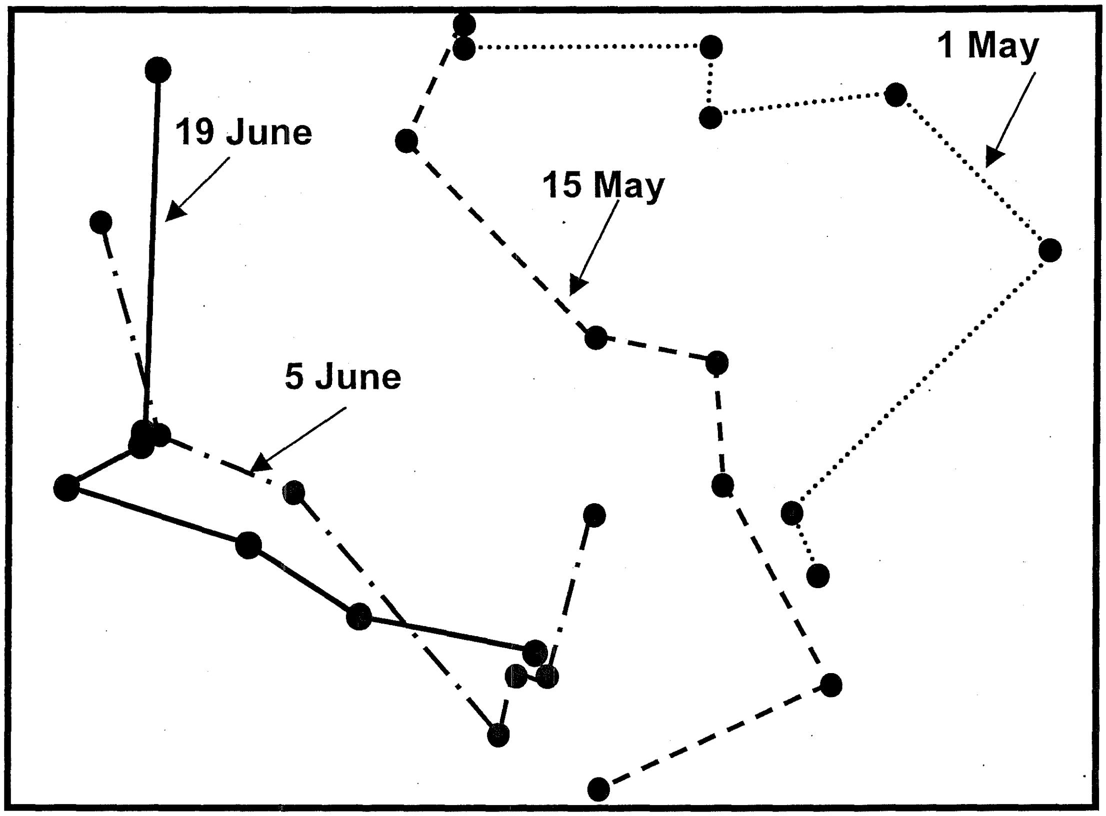

Figure 3. Principle components analysis depicting invertebrate community characteristics in 7 study wetlands during period of 15 May – 19 June 2000 (pre-harvest). Wetland study sites connected with same line were sampled on same date. Changing position (wetland site scores) over time indicated fluctuation in numbers and composition of invertebrate communities in these sites.

FINAL REPORT ON MINNESOTA'S 1999-2002 EXPERIMENTAL SEPTEMBER CANADA GOOSE SEASON EXTENSION

Stephen J. Maxson, Jeffrey S. Lawrence, and Margaret H. Dexter

History of September Seasons in Minnesota

Special September Canada goose seasons have been used since 1987 in Minnesota to increase harvest of resident giant Canada geese. The U.S. Fish and Wildlife Service (Service) established criteria for holding September Canada goose seasons in the mid-1980's. Prior to 1995, states were required to conduct a 3-year experiment monitoring the special season. Following completion of the experiment, states were required to continue to monitor hunter activity and goose harvest. Beginning in 1995, states could open September Canada goose seasons from September 1-15 without meeting any experimental season requirements. In 1999, the Minnesota Department of Natural Resources received approval for a 3-year experimental extension of the September season beyond September 15 to September 22. In 2002, approval was received to extend the experiment for a fourth year.

States were required to collect hunter activity and harvest data until they began participation in the new Harvest Information Program (HIP) being established by the Service and states. Minnesota began the HIP in 1997, but this survey did not provide a good sample of special goose season hunters until 2000, when Minnesota began Point of Sale licensing. Minnesota needed to continue to monitor hunter activity and harvest during 1999-2002 in conjunction with the experimental extension of this season.

Minnesota established its first September goose hunt in the Twin Cities Metropolitan Goose Zone in 1987 and since then zones and season dates have changed many times in an effort to put additional harvest pressure on increasing giant Canada goose populations (Minn. Dep. of Natural Resour. 1991, 1993*a*, 1993*b*, Lawrence 1993, 1994, 1996*a*, 1996*b*). The season was expanded to include most of Minnesota in 1996, and all of the state beginning in 1999. Hunting was prohibited within 100 yards of surface water, with a few lake-specific exceptions in the Twin Cities Metro Zone, until 1998, when it was allowed in the West Goose Zone starting the second Saturday of the season. In 1999, an experimental 7-day extension (16-22 Sep) was added to the season throughout the state except the Northwest Goose Zone. In 2000, the season was similar to 1999, except that hunting within 100 yards of surface water was allowed for the entire season in the West Goose Zone and the boundary of the Southeast Goose Zone was moved to the east. Seasons were unchanged in 2001 and 2002. This report presents results of the evaluation of the experimental season extension.

Goal: Control population size and/or growth of resident giant Canada goose (*Branta canadensis maxima*) flocks in Minnesota to minimize nuisance and depredation problems and to improve tolerance levels of landowners experiencing crop damage.

Objectives:

1. Reduce the growth of resident giant Canada goose flocks in problem areas by harvesting additional local Canada geese during an experimental extension of the early September Canada goose season from 16-22 September.
2. Increase harvest pressure on local molt migrant giant Canada geese that typically do not return to Minnesota until mid-late September and are usually not subject to harvest during the current early September Canada Goose Season which ends on 15 September.
3. Reduce the number of complaints of nuisance and/or depredation.
4. Ensure that harvest from efforts to achieve Objectives 1 – 3 does not include more than 10% migrant geese.

Methods

The experimental season ran from 16-22 September in the West, Southeast, Twin Cities Metro, and Remainder of the State zones (Fig. 1) each year. Bag limits, shooting hours, and zones were the same for the experimental extension as during September 1-15, except the Northwest Zone was closed during the extension. The daily bag limit was 2 geese per day in the Southeast Zone. Elsewhere, the daily bag limit was five geese. Shooting hours were 1/2 hour before sunrise to sunset. Taking of Canada geese during September seasons was prohibited on or within 100 yards of all surface waters, except in the West Goose Zone and a few specific areas in the Twin Cities Metro Zone. Goose hunters were required to obtain a $3.00 permit ($4.00 in 2001, 2002) to participate in the September season.

<u>Hunter Questionnaire Survey</u>

Permittees were randomly selected to receive a post-season hunter survey. In 1999, lacking a listing of Special Goose Hunt Permit purchasers, questionnaires were sent to a random sample of HIP registrants who indicated they had hunted geese the previous year. In 2000, Minnesota implemented a Point-of-Sale electronic licensing system, so for the first time since 1996, there was a list of Special Goose Hunt Permit purchaser names and addresses from which to draw the survey sample. The questionnaire sent to hunters asked which zone they hunted most (primary hunt zone). Also, for each day hunted, it asked the county in which they hunted, the number of geese bagged, and the number of geese crippled but not retrieved. Because some of the counties include 2 or more zones, harvest in counties that were in more than one zone was: 1) assigned to the primary hunt zone, or 2) if the harvest was in a county that was partially in the West Goose Zone and Remainder Goose Zone, it was assigned to the West Goose Zone if the hunter indicated hunting within 100 yards of surface water, or 3) if the county of harvest was not in the primary hunt zone, then the harvest was assigned to the zone that contained the larger portion of the county. Hunter success and harvest were determined based upon primary hunt zone.

Questionnaires were sent to 3,700, 3,000, 3,100, and 3,100 permittees in 1999, 2000, 2001, and 2002, respectively. Questionnaires were individually numbered, and up to 3 questionnaires were mailed until individuals responded. Completed questionnaires were double key-punched to reduce errors.

Statistical Analysis Systems (SAS Institute Inc. 1988*a,b*) computer programs were written to summarize responses to the questionnaire survey. Data were checked for obvious errors, and records with an obvious respondent or keypunch error were corrected or deleted. Duplicate responses were deleted.

Parts Collection

Department of Natural Resources field personnel collected data (culmen length, central tail feather length, age, sex) on harvested geese. These data were used to classify geese into three groups (small, medium, large) (Appendix A). Small and medium sized geese were assumed to be migrants while large geese were assumed to be resident giants.

Band Analysis

We obtained banding and recovery files from the U.S. Geological Survey Bird Banding Lab (2002 Banding CD). We selected recoveries of Canada geese shot in Minnesota that were: 1) banded in Minnesota during June-August, or 2) banded in other states or provinces during June-August. AOU code 1729 was used to select band recoveries of small Canada geese during the September season. We checked for recoveries of geese banded on the Eastern Prairie Population (EPP) breeding grounds based on criteria established by the Mississippi Flyway Technical Section EPP Canada Goose Committee (EPP Committee 2000). Only bandings of geese banded as young or adults captured with young geese were included in the sample of known-EPP geese (i.e., nonbreeding geese were excluded). Nonbreeding geese include many molt migrant giant Canada geese and may include interior geese affiliated with other populations (Lawrence et al. 2000).

We examined the temporal band recovery distribution of known-age, Minnesota-banded Canada geese (i.e., banded as young) during the overall September season to test objective 2, that hunters would harvest more molt migrant Canada geese with the season extension. We compared the proportion of September season band recoveries that was recovered during the extension (16-22 Sept) for each age group. Direct recoveries (i.e., recovered during the year of banding) of adult Canada geese were also examined, since these geese were captured during molt in Minnesota and thus did not participate in the molt migration that year.

Results and Discussion

Hunter Questionnaire Surveys

Goose Zones - Because the 1999 questionnaires were sent to HIP registrants who said they hunted geese the previous year (see Methods), we were unable to directly target September season hunters and we received few returns from hunters who participated in the experimental hunt. We deemed this sample to be inadequate and did not analyze those data. Here we present data from the 2000-2002 harvest surveys (Tables 1-3).

For the September season as a whole, an average of 41,802 Special Canada Goose Season permits was recorded by the DNR License Bureau. Response rate to the surveys averaged 65.9% (Tables 1-3). During the 16-22 September experimental season, 21.7-32.4% of the permit purchasers indicated that they hunted at least once. The majority of the hunters hunted most in the Remainder of the State Zone, followed by the West, Twin Cities Metro, and Southeast Goose Zones each year. Active hunters were afield an average of 1.8 to 2.8 days per zone, and retrieved 0.3 to 2.0 geese, when totaled according to their primary hunt zone. Success varied among zones and years, but averaged 50.2% overall.

For the September season as a whole, the retrieved harvest totaled 90,021, 101,021, and 83,764 during 2000, 2001, and 2002, respectively (Lawrence et al. 2001, MN DNR unpubl.). Harvest during the 16-22 September experimental season was 19,640, 15,171, and 15,955 during the same three years (Tables 1-3). Thus the experimental extension contributed 21.8% (2000), 15.0% (2001) and 19.0% (2002) (mean = 18.6%) to the September harvest. The Service adjusts their mail survey statistics by a memory and prestige response bias factor of 0.848 for geese bagged in the Mississippi Flyway (Voezler et al. 1982:56). Special hunt harvest estimates have not been adjusted for prestige and memory bias for other Minnesota hunter surveys (Minn. DNR, 1991, 1993a,b); however, multiplying September experimental season harvest by the adjustment factor would indicate harvests of 16,655 (2000), 12,865 (2001), and 13,530 (2002).

Goose Management Blocks – Harvest data during the experimental season were also broken down by Goose Management Block (GMB) (Fig. 2, Table 4). The highest harvest occurred in the Central, and Fergus Falls GMBs. Relatively little harvest occurred in the Lac qui Parle, Northeast, and Red Lake GMBs.

Parts Collection Data

Goose measurement data (Table 5) were broken down by year and Goose Management Block (Fig. 2). The proportion of migrant geese harvested ranged from 3.1-7.9% among years. Overall, of 1,114 geese measured, 4.6% were migrants (4.2% medium, 0.4% small). The Mississippi Flyway Technical Section (July, 2002) suggested that we also categorize geese by size based on adults only. Using adults only, the proportions of migrant geese harvested were 7.0% (1999, n = 158), 3.5% (2000, n = 258), 4.7% (2001, n = 150), and 3.4% (2002, n = 146). The overall proportions of migrant geese harvested (within and among years) are well within the 10% criteria for September special seasons.

Review of a preliminary report of this evaluation by the Mississippi Flyway Council Technical Section (February 2002), raised concerns about the proportion of migrant geese harvested in several GMBs during one or more years. In most instances, the problem appeared to be the result of small sample sizes of measured geese in those GMBs. These concerns led to additional parts collections during 2002 (Table 5). With the addition of these data, overall, all GMBs except Lac qui Parle (10.2%) and Northeast (13.9%) were below the 10% criteria (Table 5). Both of these GMBs are low harvest areas during the experimental portion of the September season (Table 4). During 2000-2002, the Lac qui Parle GMB averaged only 3.7% of the state harvest while the Northeast GMB averaged only 2.9% of the harvest.

The Lac qui Parle GMB is of particular concern because Lac qui Parle WMA is a major fall staging area for EPP geese and numbers exceeding 100,000 can be present in November. However, during the third week of September, standard fall surveys by WMA personnel indicated there were only 5,000, 500, 500, and 100 Canada geese at the WMA during 1999, 2000, 2001, and 2002, respectively. During this time of the year, many of these geese were likely resident giants. Using data on total harvest in the Lac qui Parle GMB (Table 4) and the proportion of migrant geese harvested in this GMB (Table 5), we determined that the 2000 harvest exceeded the 10% limit by 18 geese and that the 2001 harvest exceeded the limit by 8 geese. The 2002 harvest did not exceed the limit. Further, using data on mean annual harvest in the Lac qui Parle GMB (616 geese, Table 4) and the total percent of migrants harvested in the GMB (10.2%, Table 5), we determined that the average harvest exceeded the 10% limit by 1 goose.

The parts collection data (Table 5) indicated that the Northeast GMB had a harvest totaling 13.9% migrants for 1999-2002 combined. However, this estimate is based on a sample of only 36 geese. The Northeast GMB is primarily boreal forest habitat without major goose concentration areas. This habitat type will not support high densities of Canada geese. Consequently, both geese and goose hunters are thinly spread over a large area, which makes it difficult for MN DNR personnel to obtain geese to measure. Further, the habitat in this GMB makes it very unlikely that there will ever be a proportionately large harvest in this part of the state. Using data on mean annual harvest in this GMB (479 geese, Table 4) and the total percent of migrants harvested in the GMB (13.9%, Table 5), the average harvest exceeded the 10% limit by 19 geese.

The numbers of geese harvested in excess of the 10% limit in the Lac qui Parle and Northeast GMBs are a tiny proportion of the overall experimental season harvest in Minnesota which is well below the 10% limit. Given the significant summer depredation problems Minnesota experiences in the Lac qui Parle GMB and the increasing complaints from lakeshore property owners in the Northeast GMB due to overabundant resident geese, MN DNR does not feel that harvesting a handful of migrant geese over the 10% limit warrants shutting down the 16-22 September season in the Lac qui Parle and Northeast GMBs.

Band Recovery Analysis

There have been 152 recoveries of small Canada geese (AOU = 1729) in Minnesota during September–December since 1987, the first year September Canada goose seasons began in Minnesota. However, there have been no band recoveries of small Canada geese during the September Canada goose seasons in Minnesota. There were 22 recoveries of small Canada geese in Minnesota during 1999-2001.

During the September seasons in 1999-2001, 5 recoveries of known-EPP Canada geese were reported in Minnesota (Fig. 1). None of these were young of the year when harvested. Only two of these recoveries were during the experimental portion of the season (Sept. 16-22). During the same period, there were 213 recoveries of breeding EPP geese and their young during the regular and December Canada goose seasons. Thus, while approximately 40% of Minnesota's Canada goose harvest occurs during the September seasons, only 2.3% of the EPP band recoveries were reported during this season.

There were 17 recoveries of nonbreeding Canada geese banded on the EPP breeding grounds during the 1999-2001 September seasons in Minnesota (Fig. 1). Three of these recoveries were during the experimental portion of the season. The nonbreeding geese banded in northern Manitoba are a mixture of molt migrant giant Canada geese and *B. c. interior* from the EPP and possibly other populations (Lawrence et al. 2000). Note that no nonbreeding geese were banded on the EPP breeding grounds during summer 2001. There were 108 recoveries of nonbreeding geese during Minnesota's 1999-2001 regular and December Canada goose seasons, thus 13.6% of the nonbreeding goose recoveries occurred during the September season. Most of these geese were recovered in locations that were not traditional EPP harvest areas (Fig. 1), consistent with the hypothesis that many of these geese that were banded were nonbreeding giant Canada geese.

One of the objectives (#2) for extending the September Canada goose season was to harvest more returning molt migrant Canada geese. In Wisconsin, approximately half of the molt migrant geese returned after mid-September (Zicus 1981). Approximately 90% of the one-year olds, 70% of the two-year olds, 53% of the 3-year olds, and 31% of the 4+-year olds departed on molt migration from West Central Illinois (Lawrence et al. 1998); we would expect similar age-specific participation in the molt migration from Minnesota. Comparing the 1-15 September versus 16-22 September periods during 1999-2001, 42% of the band recoveries of one-year old Canada geese hatched in Minnesota were during the experimental extension, compared to 8% of the 4+-year olds and 11% of the direct recoveries of adults (Fig. 3). Also, 11% of the young were harvested in the experimental period of the season. Thus, the season extension was successful at increasing harvest on those age classes (1-3 years old) that likely had significant numbers of birds absent during much of the early part of the season. These birds were vulnerable to harvest when they returned to Minnesota from their molt migration.

There were also geese banded in other states and provinces that were recovered during the September seasons in Minnesota (Table 6). The majority of these were from Iowa, Missouri, Illinois, and Wisconsin. The proportion of band recoveries from geese banded in states to the south/east of Minnesota was greater than for Minnesota- or Manitoba-banded geese during 16-22 September, likely because most geese harvested in Minnesota from these more southern states are returning from the molt migration to their natal areas. Geese from these areas are a small proportion of Minnesota's September-December Canada goose harvest (e.g., Harvest derivations for Minnesota from 1998-2000: Iowa – 2% of Minnesota Canada goose harvest, Missouri – 1%, Illinois - 1%, Wisconsin – 1%, T. Moser, U.S. Fish and Wildlife Service unpubl. Report, 13 July 2002). The highest number of band recoveries from geese banded elsewhere was from Iowa, yet Minnesota accounted for 14.3% and 9.2% of the 1996-1999 total band recoveries for young and adult Canada geese banded in Iowa, respectively (Iowa DNR, Canada goose populations and harvest in Iowa, unpubl. Draft report, 12/22/00).

Conclusion

Results from the hunter surveys, parts collection, and banding analysis indicate that the season extension was successful at increasing the harvest of Minnesota-breeding Canada geese. Approximately 40% of Minnesota's Canada goose harvest occurs during the overall September season (Lawrence et al. 2001); yet only a small proportion of our migrant goose harvest is during this season. The 16-22 September season extension provided for about 19% of the September harvest, and was important to increase harvest of molt migrant geese that are returning to Minnesota in mid-September. September season Canada goose harvests in Minnesota have been the largest on record the last 3 years (Lawrence et al. 2001, MN DNR unpubl.).

In addition, migration patterns of the Eastern Prairie Population of Canada geese have shifted later in the fall, with the majority of the flock staying in Manitoba until later in October or November. Historically, geese would arrive at Lac qui Parle Wildlife Management Area in mid-September, but these early arrivals have moved later into the fall, too (MN DNR unpubl.). While we slightly exceeded the 10% migrant criteria in two low-harvest Goose Management Blocks, this resulted in few additional non-target birds being harvested, numbers we believe are insignificant, especially given the importance of the September season and extension to Minnesota's harvest of resident giants. Based upon these results, Minnesota Department of Natural Resources requested that the U.S. Fish and Wildlife Service make the 16-22 September season extension operational beginning in 2003.

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Table 1. Overall permit sales, hunter activity, and harvest during the experimental September Canada Goose season (16-22 September) in Minnesota, 2000.

Parameter	West	Southeast	Twin Cities Metro	Remainder	Total
ALL ZONES					
Total permits sold					45,277
Questionnaires delivered/mailed					2,939
Useable questionnaires returned					1,957
% responding					66.6
Active Hunters					634
% active hunters					32.39
BY ZONE					
% Distribution of hunters by primary hunt zone	22.87	1.74	15.77	59.62	100
% successful	40.7	45.5	50.0	48.9	47.2
Days/active hunter	2.21	1.82	2.58	2.01	
Geese/active hunter	1.06	1.18	1.57	1.39	
Unretrieved harvest/active hunter	0.11	0.62	0.19	0.22	
% unretrieved harvest	9.4	34.4	10.8	13.7	
EXPANDED:					
Active hunters	3,354	255	2,313	8,743	14,665
Hunter days (95% CI)	7,412	464	5,967	17,573	31,416
	(811)	(111)	(950)	(1,164)	(3,036)
Retrieved harvest (95% CI)[1]	3,555	301	3,631	12,153	**19,640**
	(1,183)	(262)	(1,072)	(1,866)	(4,383)
Est. Unretrieved harvest (95% CI)	369	158	439	1,923	2,889
	(256)	(184)	(252)	(835)	(1,527)
Total Harvest (95% CI)	3,924	459	4,070	14,076	22,529
	(1,439)	(446)	(1,324)	(2,701)	(5,910)

[1]Harvest estimates not adjusted for memory/exaggeration bias.

Table 2. Overall permit sales, hunter activity, and harvest during the experimental September Canada Goose season (16-22 September) in Minnesota, 2001.

Parameter	West	Southeast	Twin Cities Metro	Remainder	Total
ALL ZONES					
Total permits sold					40,127
Questionnaires delivered/mailed					3,024
Useable questionnaires returned					1,901
% responding					62.9
Active Hunters					557
% active hunters					29.30
BY ZONE					
% Distribution of hunters by primary hunt zone	23.16	1.08	10.41	65.35	100
% successful	57.4	33.3	41.4	46.7	48.5
Days/active hunter	1.98	1.83	2.19	1.86	
Geese/active hunter	1.62	0.33	0.91	1.25	
Unretrieved harvest/active hunter	0.32	0.00	0.06	0.17	
% unretrieved harvest	16.0	0.0	6.0	12.0	
EXPANDED:					
Active hunters	2,723	127	1,224	7,683	11,757
Hunter days (95% CI)	5,392	232	2,681	14,290	22,595
	(774)	(98)	(589)	(1,072)	(2,533)
Retrieved harvest (95% CI)[1]	4,411	42	1,114	9,604	**15,171**
	(1,146)	(51)	(467)	(1,631)	(3,295)
Est. Unretrieve harvest (95% CI)	871	0	73	1,306	2,250
	(453)	(0)	(87)	(568)	(1,108)
Total Harvest (95% CI)	5,282	42	1,187	10,910	17,421
	(1,599)	(51)	(554)	(2,199)	(4,403)

[1]Harvest estimates not adjusted for memory/exaggeration bias.

Table 3. Overall permit sales, hunter activity, and harvest during the experimental September Canada Goose season (16-22 September) in Minnesota, 2002.

Parameter	West	Southeast	Twin Cities Metro	Remainder	Total
ALL ZONES					
Total permits sold					40,002
Questionnaires delivered/mailed					3,036
Useable questionnaires returned					2,070
% responding					68.2
Active Hunters					449
% active hunters					21.69
BY ZONE					
% Distribution of hunters by primary hunt zone	25.17	2.22	12.92	59.69	100
% successful	51.3	40.0	55.2	56.7	54.8
Days/active hunter	2.29	2.80	2.09	2.24	
Geese/active hunter	1.75	1.00	1.55	1.97	
Unretrieved harvest/active hunter	0.26	0.14	0.11	0.21	
% unretrieved harvest	12.9	12.3	6.6	9.6	
EXPANDED:					
Active hunters	2,184	192	1,121	5,179	8,676
Hunter days (95% CI)	5,001	538	2,343	11,601	19,483
	(615)	(277)	(438)	(993)	(2,323)
Retrieved harvest (95% CI)[1]	3,822	192	1,738	10,203	**15,955**
	(1,146)	(183)	(595)	(2,042)	(3,966)
Est. Unretrieve harvest (95% CI)	568	27	191	2,143	2,929
	(311)	(53)	(123)	(520)	(1,007)
Total Harvest (95% CI)	4,390	219	1,929	12,346	18,884
	(1,457)	(236)	(718)	(2,562)	(4,973)

[1]Harvest estimates not adjusted for memory/exaggeration bias.

Table 4. Estimated harvest of Canada geese by Goose Management Block (GMB) in Minnesota during the 16-22 September experimental hunting season, 2000-2002.

	2000		2001		2002		Mean	
GMB	N[1]	%[2]	N	%	N	%	N	%
Mahnomen	2,514	12.8	1,836	12.1	1,787	11.2	2,046	12.0
Fergus Falls	3,163	16.1	3,429	22.6	2,760	17.3	3,117	18.7
Lac qui Parle	471	2.4	485	3.2	893	5.6	616	3.7
Talcot	1,139	5.8	986	6.5	654	4.1	926	5.5
Nicollet	2,671	13.6	1,912	12.6	2,585	16.2	2,389	14.1
Central	4,694	23.9	3,125	20.6	3,239	20.3	3,686	21.6
Red Lake	471	2.4	228	1.5	287	1.8	329	1.9
Northeast	354	1.8	667	4.4	415	2.6	479	2.9
Metro	3,044	15.5	1,153	7.6	1,883	11.8	2,027	11.6
Rochester	1,119	5.7	1,350	8.9	1,452	9.1	1,307	7.9
Total	19,640	100.0	15,171	100.0	15,995	100.0	16,935	

[1]Retrieved harvest.
[2]Per cent of retrieved harvest.

Table 5. Estimated proportion of migrant Canada geese harvested by Goose Management Block (GMB) in Minnesota during the 16-22 September experimental hunting season, 1999-2002. Estimates are based on goose culmen and tail feather measurement data collected from hunters by MN DNR Wildlife Managers.

	1999		2000		2001		2002		***Total***	
GMB	N[1]	% Migr[2]	N	% Migr	N	% Migr	N	% Migr	N	% Migr
Mahnomen	41	2.4	61	3.3	15	13.3	48	4.2	165	4.2
Fergus Falls	38	2.6	99	3.0	71	1.4	-	-	208	2.4
Lac qui Parle	53	11.3	36	13.9	26	11.5	62	6.5	177	10.2
Talcot	51	3.9	21	0.0	51	7.8	-	-	123	4.9
Nicollet	24	0.0	29	0.0	19	0.0	-	-	72	0.0
Central	32	6.2	73	1.4	21	14.3	123	0.8	249	2.8
Red Lake	9	0.0	28	0.0	12	8.3	-	-	49	2.0
Northeast	5	0.0	4	25.0	11	36.4	16	0.0	36	13.9
Metro	9	0.0	3	0.0	0	0.0	-	-	12	0.0
Rochester	4	0.0	5	20.0	2	0.0	12	8.3	23	8.7
Total	266	**4.5**	359	**3.6**	228	**7.9**	261	**3.1**	1,114	**4.6**

[1]Number of geese measured.
[2]Percent of measured geese classified as migrants (i.e., Interiors, Lessers).

Table 6. Number of summer-banded Canada geese[a] recovered in Minnesota, by banding location, during the September Canada goose season by period, 1999-2001.

State/Province	*N* by period		% of September 1-22 band recoveries during Sept. 16-22 period[b]
	Sep 1-15	Sep 16-22	
Georgia	0	1	
New Jersey	0	1	
New York	1	0	
Illinois	40	27	40.1
Iowa	145	75	34.1
Missouri	50	21	29.6
Wisconsin	33	19	36.5
Kansas	6	3	
Nebraska	1	0	
Oklahoma	3	1	
South Dakota	4	0	
Manitoba[d]	21	6	22.2
Ontario	0	2	
Subtotal	304	156	33.9
Minnesota[c]	503	113	18.3
TOTAL	807	269	25.0

[a] – excludes transported geese.
[b] – Calculated where total band recoveries > 26.
[c] – excludes Northwest Goose Zone.
[d] - includes geese banded in Eastern Prairie Population range.

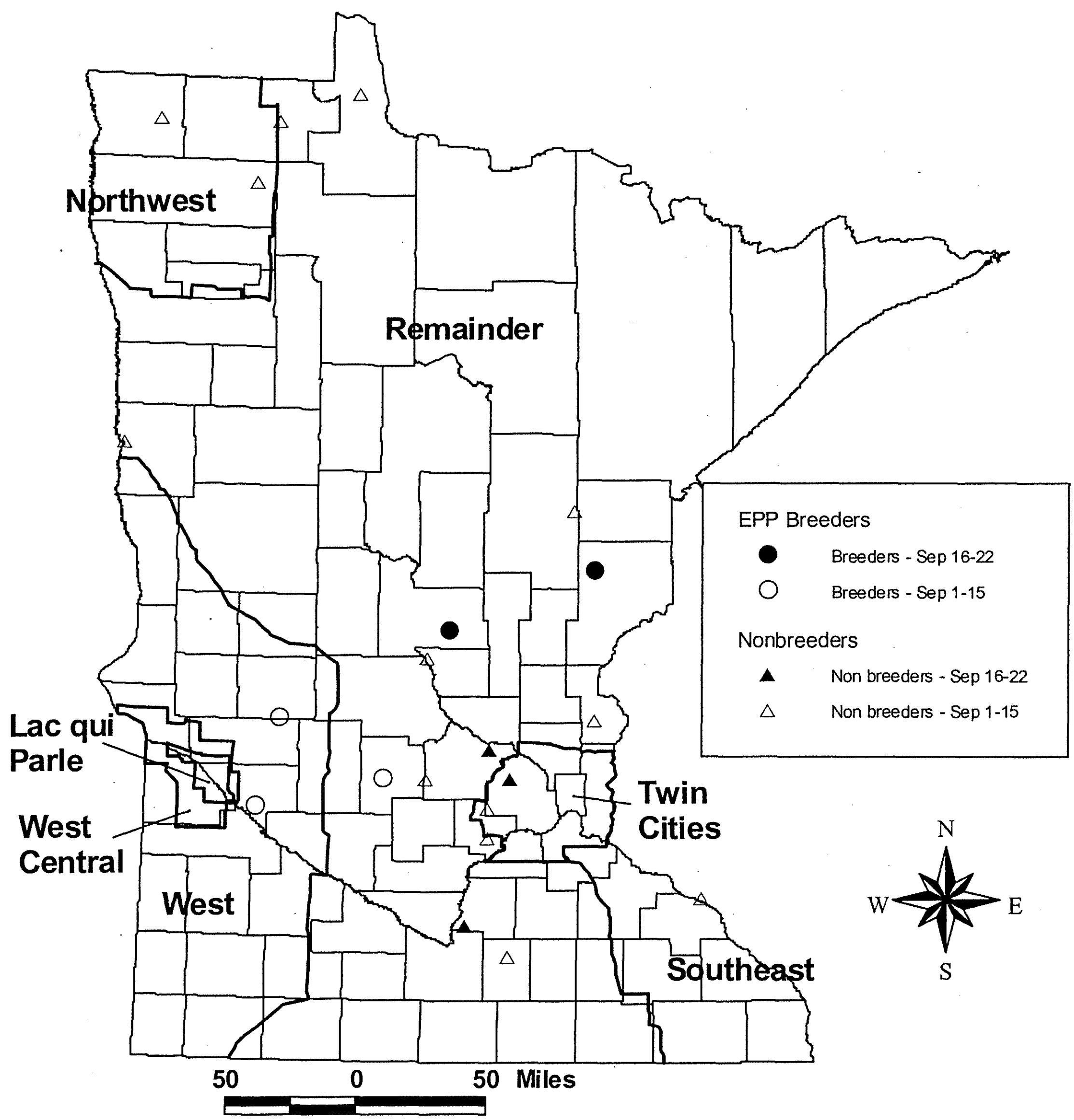

Figure 1. Distribution of band recoveries in Minnesota from Canada geese banded on the Eastern Prairie Population Breeding Grounds in northern Manitoba, by September time period, 1999-2001. EPP breeders were geese banded as young or molting adults with young. Nonbreeders were banded as molting adult geese without young.

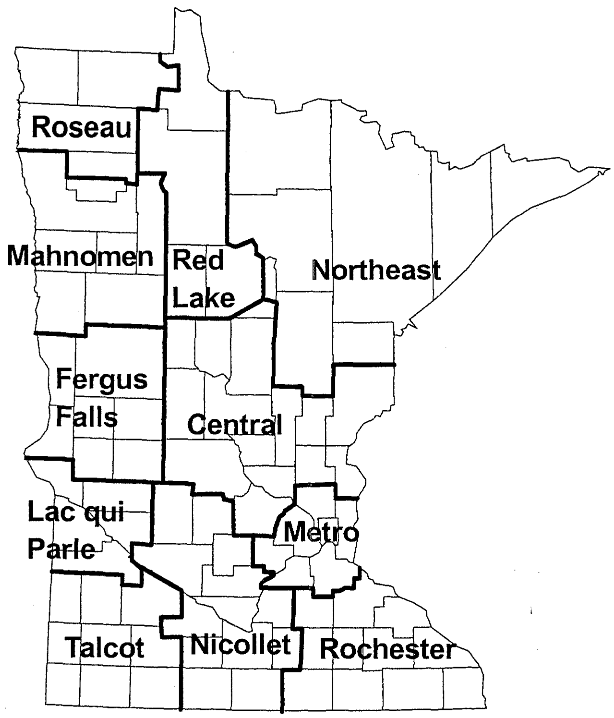

Figure 2. Goose Management Blocks in Minnesota.

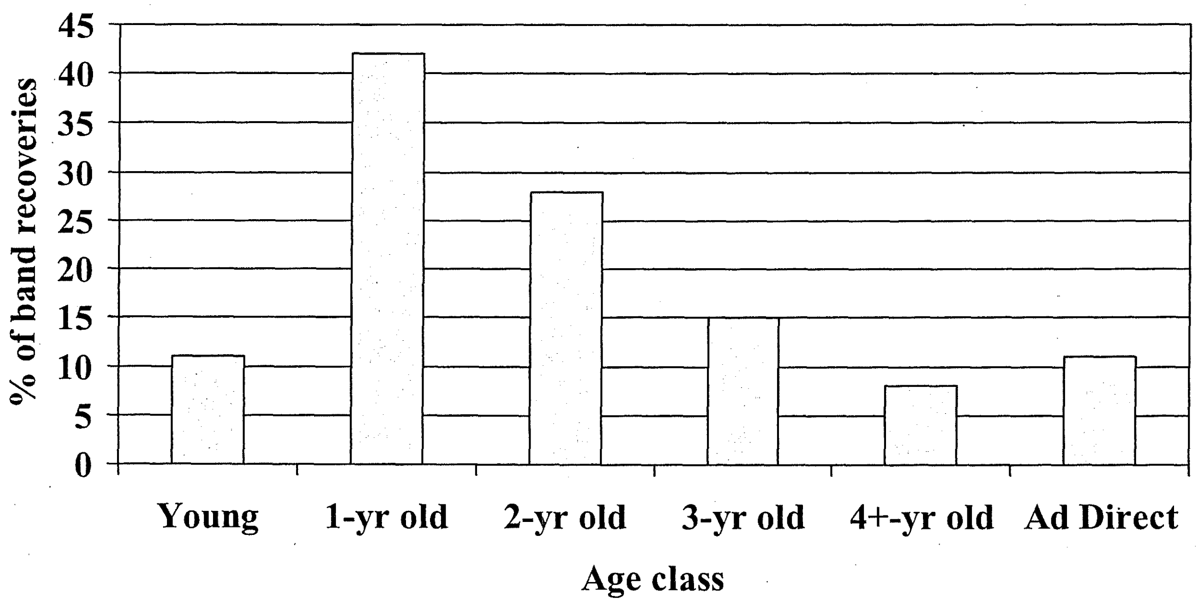

Figure 3. Percent of the total September Canada goose season band recoveries that were taken during 16-22 September in Minnesota, by age class, 1999-02. Recoveries are for geese banded in Minnesota during the summer.

Appendix A. Measurement criteria (mm) for determining size class of Canada geese in Minnesota.

	Male		Female	
Size and age class	Culmen	Tail[1]	Culmen	Tail[1]
Adult				
Small	<=45.0		<=42.0	
Medium	> 45.0 <= 54.4		> 42.0 <= 51.0	
	> 54.5 <= 58.4	< 155	> 51.0 <= 54.4	< 147
Large	> 58.4		> 54.4	
	> 54.5 <= 58.4	>= 155	> 51.0 <= 54.4	=> 147
Immature				
Small	<=45.0		<=42.0	
Medium	> 45.0 <= 54.4		> 42.0 <= 51.0	
	> 54.5 <= 58.4	< 135	> 51.0 <= 54.4	< 130
Large	> 58.4		> 54.4	
	> 54.5 <= 58.4	>= 135	> 51.0 <= 54.4	=> 130

[1] Total length of a pulled central tail feather.

NORTHERN FOREST WETLANDS: CHARACTERISTICS AND INFLUENCES OF FOREST-AGE STRUCTURE.

Fred J. Ossman[1] and Mark A. Hanson

Seasonal wetlands are abundant and broadly distributed throughout northern Minnesota's aspen-dominated landscapes. Interest in seasonal forest wetlands has increased in recent years due to the lack of ecological information and the abundance of these habitats. Seasonal wetlands, and their associated communities, are functionally linked to adjacent forested uplands. Forest wetlands receive a major portion of their energy inputs through the deposition of leaf-litter from the adjacent forest. Forest harvesting is a common throughout this region. Timber harvesting may modify vegetation and local patterns of hydrology, increase sedimentation, reduce evapotranspiration rates, and contribute to soil desiccation. These forest activities, especially clearcutting, influence characteristics of forest wetlands, thus it is likely that biotic communities and physical attributes of these ecosystems are also altered.

Seasonal wetlands receive most of their water input in the form of snowmelt during early spring. Flooding stimulates a sequence of invertebrate populations beginning with invertebrates which are able to over winter and complete their entire life cycle within the confines of a particular seasonal wetland (Wiggins et al 1980, Neckles et al.1990). Later, predatory invertebrates (as well as other organisms) arrive and exploit this large food source. Because forest wetlands are functionally linked to the adjacent upland forest, modifications to the uplands may alter annual development of community structure. Forested wetlands in northern Minnesota are often among the earliest aquatic resources to become ice-free and thus provide habitat for higher order consumers such as breeding ducks.

Some recent evidence indicates that forest harvesting may truncate natural hydrological cycles in and around forest wetlands by raising water tables and flooding regimes in wetland areas (Dube et al. 1995, Verry 1997, Roy et al 2000). Disruption of natural hydrology may result in unanticipated changes to the native invertebrates and their associated life cycles. This seems especially likely given that community structure in seasonal wetlands may be subject more to physical features than to biotic influences (Schneider and Frost 1996, Wellborn et al. 1996).

In 1999, we began a five-year study of 24 seasonally-flooded ($\leq$ 1.5 acres) wetlands in the Buena Vista and Paul Bunyan state forests, within aspen-dominated landscapes of northern Minnesota. Study wetlands were assigned to three "age-class" levels of treatment and a control (Figure 1) based upon forest (stand) age-since-harvest using natural breaks identified with Arcview. To account for local influences within each state forest (due to soil characteristics, etc.), we blocked study sites on the basis of proximity. Thus, we also assigned study wetlands to "clusters", each cluster consisting of 4 adjacent wetlands (1 in each of 4 treatment groups) all located within the same general forest area. Each state forest (hence each subsection of the Ecological

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Classification System [ECS] Almedinger and Hanson 1998) contained three clusters of four Wetlands; each cluster included one control, 2 effect/recovery sites, and 1 clearcut treatment site (total of 12 sites per state forest). "Control sites" were those with no adjacent forest harvesting during the past 59+ years. "Treatment sites" included one 59+year site which was harvested during the winter of 2000-2001 (clearcut treatment) and two effect/recovery sites consisting of wetlands in stands harvested 10-34 (young-age) and 35-58 (mid-age) years before present. Overall, our design included 6 replicate sites within these four age-class treatments, and two ECS subsection levels. We believe this replication is needed given high variability that is typical of wetland communities.

Our study has two goals. Phase I (pre-clearcut treatment) characterized aquatic invertebrate communities and identified important physical characteristics contributing variation to these communities. Phase II (post-treatment) assessed changes resulting from of clearcutting activities in the adjacent forest. Four years are now complete; the final field season is in progress.

We sampled aquatic invertebrates using surface-associated activity traps (SAT; Hanson et al. 2000) deployed for 24 hr at random locations near the margin of each wetland. Five traps were used concurrently in each wetland. Aquatic macroinvertebrates were sampled during open-water periods, at approximately 3-week intervals during May, June, and July 2002. Water quality was also monitored during May, June, and July using one-liter surface dip samples collected from the center of each wetland. Water samples were tested for chlorophyll *a*, total phosphorus (TP), and total Kjeldahl nitrogen (TKN) at the MN Department of Agriculture laboratory in St. Paul, MN. We assessed turbidity, water temperature, total alkalinity, and specific conductance in each wetland at least twice during the open water period. Turbidity was measured using a LaMott portable nephelometer. Total alkalinity (TA) was determined by titration (Lind 1979). Specific conductance (SpCd) and dissolved oxygen (DO) were measured on site using YSI portable meters. Upland soil temperatures (Soil Temp) were obtained using a soil thermometer. We assessed extent of average percent canopy closure at 5 locations in each wetland using a Lemmon spherical densiometer (Lemmon 1957).

Resulting data were analyzed using indirect and direct gradient analysis. We used principal components analysis (PCA), an indirect gradient analysis, and partial-redundancy analysis (pRDA), a direct gradient analysis, to identify relationships between invertebrate community characteristics and physical features, and to partition variance attributed to each significant environmental variable (ter Braak 1995, ter Braak and Smilauer 1998, Jongman et al. 1995).

Results of PCA and RDA depicted natural seasonal patterns within the invertebrate communities. Full-model RDA indicated that invertebrate community structure was influenced by upland forest age-structure with increasing abundance of predatory invertebrates highly correlated with wetlands adjacent to younger-aged aspen stands. Predatory invertebrate abundance was negatively correlated with increased canopy-closure. Time of sampling showed increasing influence of predatory invertebrates on invertebrate community structure as the growing season progressed. As hydroperiod increased, abundance, and thus influence of predatory invertebrates increased. Specific conductance, pH, and soil temperature were also found to have important influences on invertebrate community structure (Figures 2 and 3).

Magnitude of canopy-closure over wetlands was found to be important to the invertebrate community structure during all four years. This may reflect changing water temperature patterns, reduced litter inputs, or other influences of canopy and forest-age structure. Abundance of predatory invertebrates strongly correlated with young-age forest stands where wetlands are characterized by longer hydroperiods and greater initial depth than similar old-age sites. More site-obligate taxa (*Eubranchipus sp*., Conchostraca, etc.) showed higher abundances in wetlands associated with old-growth type forests. These old-growth wetlands were characterized having a shorter hydroperiod and increased canopy-closure. Several other environmental characteristics were significantly correlated with unique features of the invertebrate communities. Using pRDA, we determined that sampling period was influential across most pre- and post-treatment periods (Figures 2 and 3). This result depicts variation within invertebrate communities and shows differences in community structure following arrival of predatory invertebrates.

Clearcut timber harvest produces large-scale disturbance within forested landscapes. Tree removal may elevate water tables (Verry 1997, Roy et al. 2000), modify local hydrology (Roy et al. 2000), and limit energy inputs to adjacent wetlands. Other unanticipated ecological responses to timber harvest are possible. For example, extending hydroperiods of these wetlands may allow invertebrate predators to persist in these wetlands and disrupt natural invertebrate community dynamics. Hence, other animals including amphibians and early arriving birds and waterfowl, may face added competition for food resources before larger water bodies become ice-free. We expect that subsequent data and analyses should provide better characterization of these wetlands and help clarify relationships between wetland communities and clearcut timber harvest.

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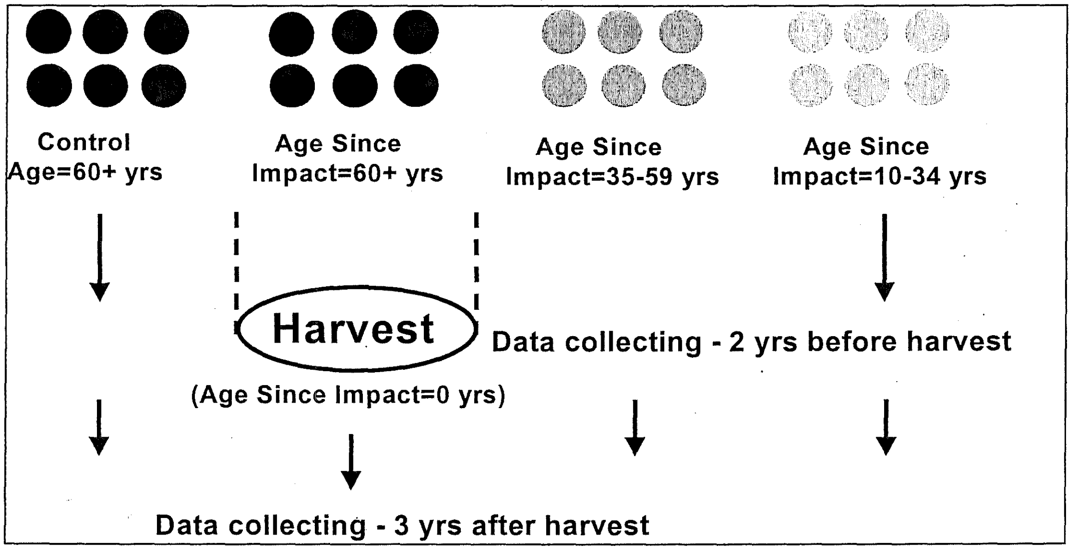
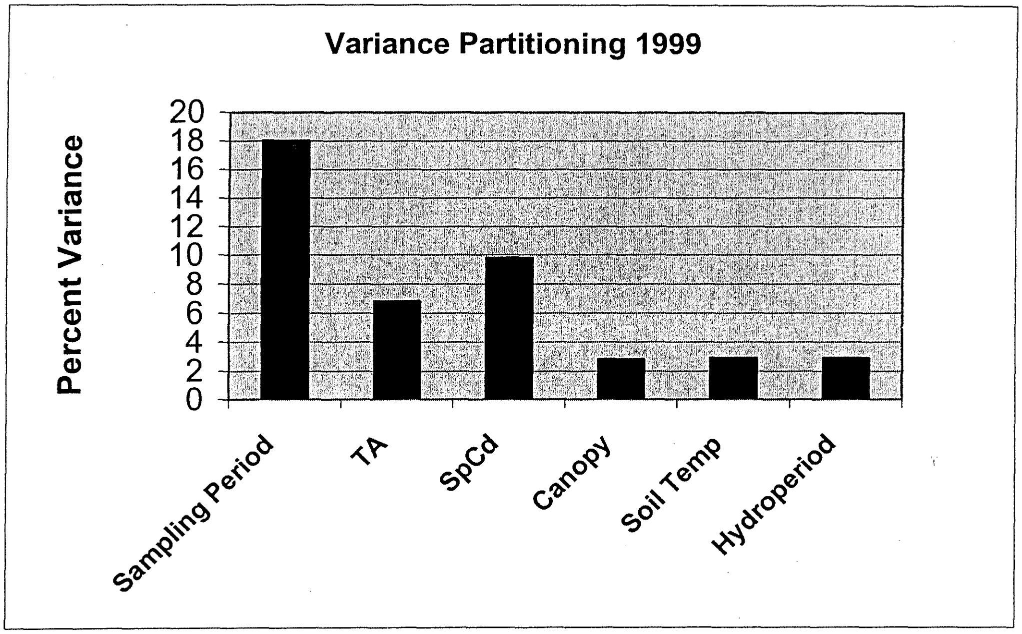


Figure 1. Wetland study design depicting treatment and effect/recovery groups. Phase I includes data collected from first two years of the study. Clear-cut treatment was conducted the winter between the second and third years. Phase II includes sampling efforts for additional three years post-treatment. Study was replicated (second row) in a second state forest to detect differences of subsection locality based on the Ecological Classification System (Almendinger and Hanson 1998). Note: The four groups represent the chronology of the adjacent landscape relative to years since last forest harvest.



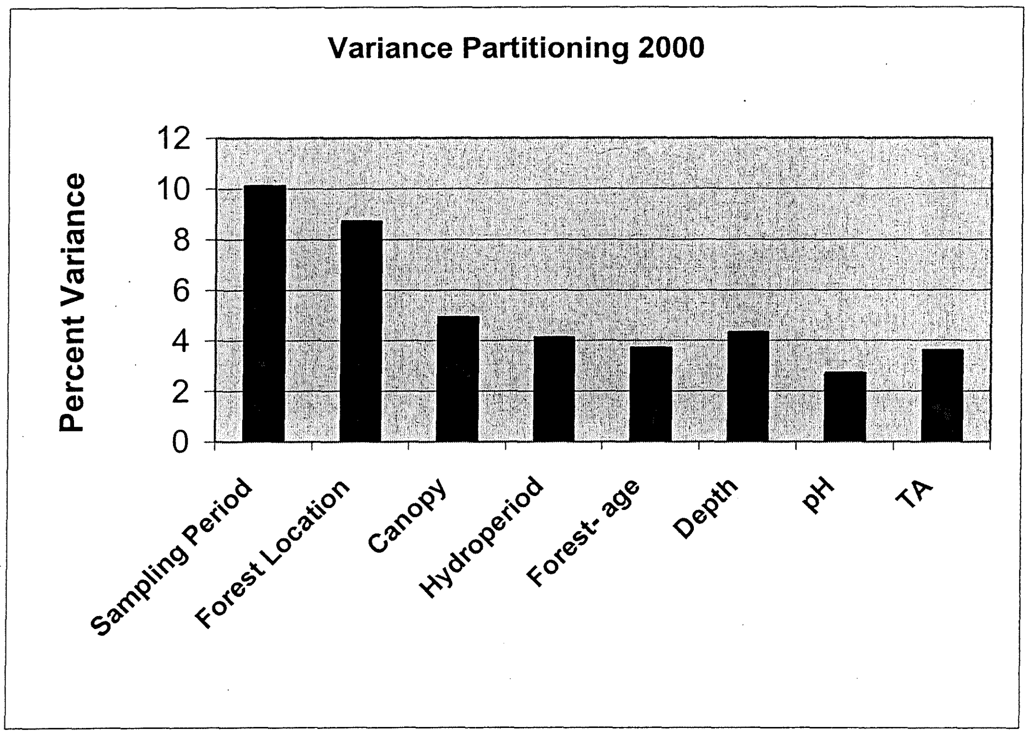


Figure 2. Results of variance partitioning following partial-RDA of invertebrate data From field seasons years 1999 and 2000 (with sample period and forest location Treated as a covariable). Variances reflect total variance attributed by each environmental variable. Combined interaction effects between all combinations were minimal at 3.8% for 1999 and 3.3% for 2000.

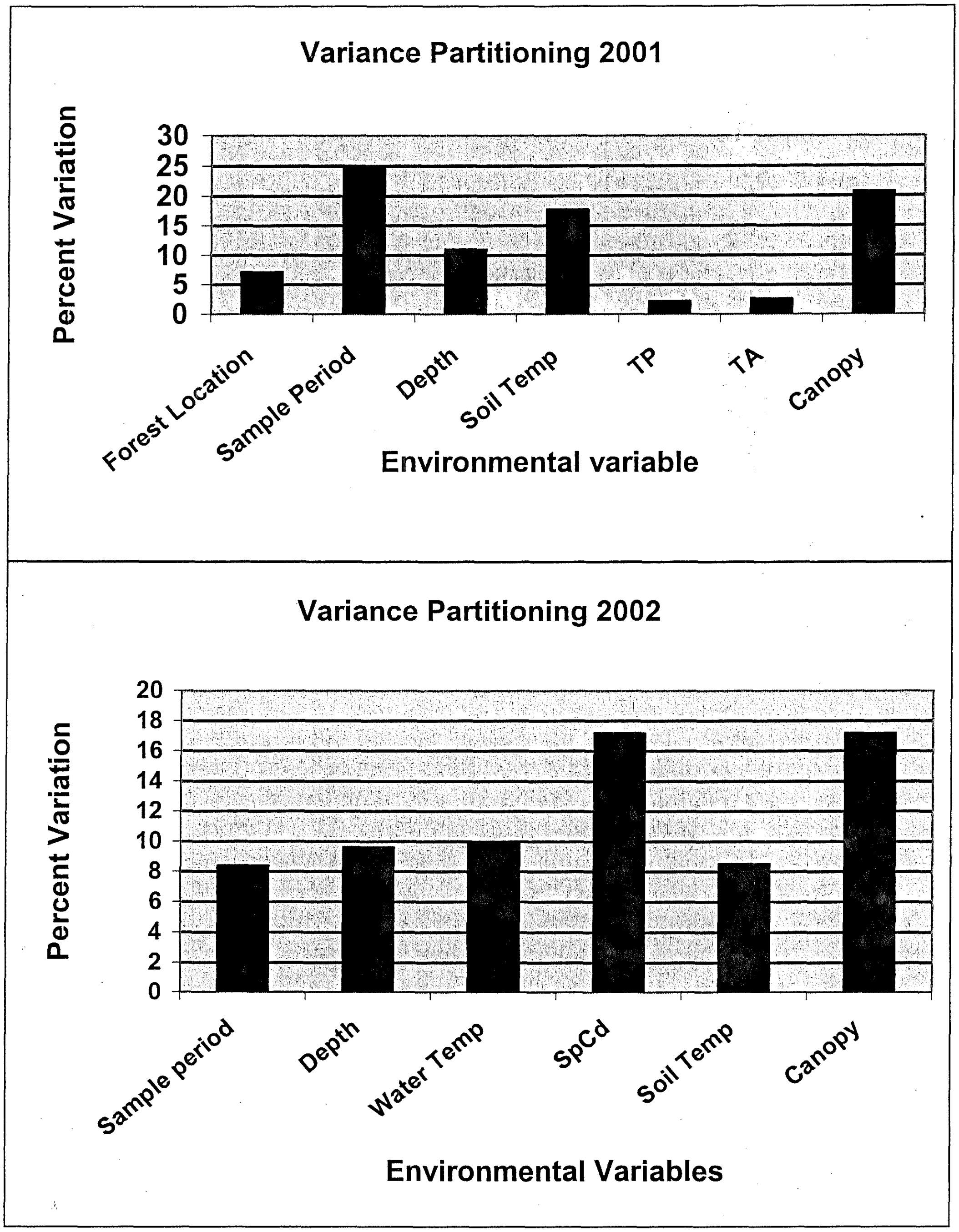


Figure 3. Results of variance partitioning following partial-RDA of invertebrate data from field seasons years 2001 and 2002 (with sample period and forest location treated as a covariable). Variances reflect total variance attributed by each environmental variable. Combined interaction effects between all combinations were minimal at 2.6% for 2001 and 3.9% for 2002.

SPACE-TIME MODELING OF A DISCRETE ECOLOGICAL RESPONSE: CHARACTERIZATION OF MALLARD NESTING IN MINNESOTA*

Abhik Das[1], Michael R. Riggs[2], Michael C. Zicus, and David P. Rave

ABSTRACT

Discrete responses in the form of binary, categorical or count data, distributed over space and time, are common in ecology. For example, the U.S. Prairie Pothole Joint Venture seeks to increase waterfowl populations by reducing nest loss to predators. Mallards (*Anas platyrhynchos*) nesting in constructed nest structures often experience higher nest success than those nesting on the ground. Occupancy of these structures can be thought of as a binary (yes/no) outcome. Identifying environmental features (such as land use and cover attractiveness) responsible for the geographic distribution of nests over time is crucial to understanding the ecological mechanism affecting mallard nest distribution. Using this knowledge to predict occupancy of structures would be particularly useful for waterfowl management, since it would optimize deployment of structures where probability of use was greatest. In this study, we developed a generalized linear mixed model (GLMM) to characterize the spatio-temporal distribution of mallard nests in 2 types of nest structures. Our approach used logistic regression, which is natural for binary data, while extending its scope to accommodate both spatial structure and temporal trends. Moreover, in order to identify the size of the area surrounding the nesting structure that had the most influence on nest occupancy, we present a likelihood-based procedure for model selection in a GLMM. The results show that, even after adjusting for spatio-temporal effects, ecological features such as nesting cover attractiveness, type of nesting structure, and size of open-water area in deployment wetlands were significantly associated with nest occupancy. Our approach can accommodate space-time modeling for any discrete outcome. Thus, given the prevalence of such data in ecological studies, we believe these methods are broadly applicable to a variety of ecological research questions.

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FACTORS INFLUENCING INCUBATION EGG MASS LOSS FOR THREE SPECIES OF WATERFOWL*

Michael C. Zicus, David P. Rave, Michael R. Riggs[1]

Abstract

Bird's eggs reportedly lose ~15% of fresh mass before pipping. Most studies have provided no information regarding variability within or among species, which is essential to understanding bird adaptations to environments. We modeled influence of nest type, clutch size, and egg size on daily mass loss of mallard (*Anas platyrhynchos*), common goldeneye (*Bucephala clangula*), and hooded merganser (*Lophodytes cucullatus*) eggs and compared fractional mass loss among species. Mallard eggs in structures lost more mass than those incubated on the ground. For all species, daily mass loss increased as incubation progressed, was affected by an interaction between egg size and incubation time, but was not influenced by clutch size. Average-sized eggs in mallard ground, mallard early- and late-structure, common goldeneye, and hooded merganser nests lost 7.9 g (15.2%), 11.0 g (20.3%), 10.6 g (20.3%), 10.3 g (15.5%), and 9.2 g (15.8%) of fresh mass, respectively. Smallest eggs lost less mass, but a larger fraction of fresh mass, than larger eggs. Egg mass variability was partitioned into: years, nests within years, and eggs within nests and years. Variability was evenly distributed in mallard ground nests; however, among-eggs within-nest variance predominated early and late structure nests. In contrast, among-nests variation was the dominant source in goldeneye and mergansers. Each model explained much ($R^2 \approx 0.9$) of the egg mass variation.

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*Abstract of paper submitted to Physiological and Biochemical Zoology.

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Below are recent scientific reports and other publications by personnel in the Wildlife Populations and Research Unit. Some titles by Unit personnel pertain to work done while employed by the DNR, but other reports are on work done elsewhere (e.g., as a graduate student, employed by another agency, while on leave of absence, etc.) An (*) before an author's name indicates that the report was listed as in press, or in review, in previous summaries of research project findings. Included under scientific reports are those which have been published, and those accepted for publication (in press), and completed manuscripts submitted for publication (in review).

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