Summaries of Wildlife Research Findings

2007

Minnesota Department of Natural Resources
Division of Fish and Wildlife
Wildlife Populations and Research Unit

Minnesota
DEPARTMENT OF NATURAL RESOURCES

SUMMARIES OF WILDLIFE RESEARCH FINDINGS 2007

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MANAGING BOVINE TUBERCULOSIS IN WHITE-TAILED DEER IN NORTHWESTERN MINNESOTA: A 2007 PROGRESS REPORT

Michelle Carstensen[1], David Pauly, Michael DonCarlos, and Lou Cornicelli

SUMMARY OF FINDINGS

Bovine tuberculosis (TB), first discovered in 2005, has now been found in 11 cattle operations in northwestern Minnesota. To date, all of the infected cattle herds have been depopulated and the Board of Animal Health (BAH) has continued an investigation of herds in the area as well as conducted a statewide surveillance effort. The strain has been identified as one that is consistent with bovine TB found in cattle in the southwestern United States and Mexico. In November 2007, the Minnesota Department of Natural Resources (MNDNR) conducted bovine TB surveillance of hunter-harvested white-tailed deer (*Odocoileus virginianus*) within a 15-mile radius of the infected farms. Results indicated that 5 of the 1,085 deer tested positive for bovine TB; estimated disease prevalence of 0.46% (SE=0.2%). All infected deer were harvested within 5 miles of Skime, Minnesota, which is in close proximity to 7 of the infected livestock operations. In response to additional deer found infected with bovine TB since 2005, the MNDNR also conducted a targeted deer removal operation during winter 2007, using sharpshooters from the United States Department of Agriculture (USDA) Wildlife Services. An additional 488 deer were removed through this project, yielding 6 more cases of infected deer. Further, a recreational feeding ban, covering 4,000 mi^2 in northwestern MN, was instituted in November 2006 to help reduce the risk of deer to deer transmission of the disease and enforcement officers have been working to stop illegal feeding activities. Also, in 2006, the Minnesota State Legislature passed an initiative that allocated $54,000 to deer-proof fencing materials for livestock producers within 5 miles of a previously infected farm; MNDNR erected 15 fences on 11 cattle premises during summer 2007. The findings of additional infection in cattle herds as well as the deer has resulted in the downgrading of Minnesota's bovine TB status to "modified accredited", which has increasing testing requirement for cattle statewide. The MNDNR will continue to conduct hunter-harvested surveillance in fall 2008 to monitor infection in the local deer population, and consider the continuation of aggressive management actions (e.g., sharpshooting deer in key locations) to address concerns of deer becoming a potential disease reservoir.

INTRODUCTION

Bovine tuberculosis is an infectious disease that is caused by the bacterium *Mycobacterium bovis (M. bovis)*. Bovine TB primarily affects cattle, however, other animals may become infected. Bovine TB was first discovered in 5 cattle operations in northwestern Minnesota in 2005. Since that time, 2 additional herds were found infected in 2006, and 4 more in 2007; resulting in further reduction of the state's bovine TB accreditation to modified accredited in early 2008. To date, 18 wild deer have been found infected with the disease in northwestern MN. Although bovine TB was once relatively common in U.S cattle, it has historically been a very rare disease in wild deer. Prior to 1994, only 8 wild white-tailed and mule deer (*Odocoileus hemionus)* had been reported with bovine TB in North America. In 1995, bovine TB was detected in wild deer in Michigan. Though deer in Michigan do serve as a reservoir of bovine TB, conditions in northwestern Minnesota are different. Minnesota has no history of tuberculosis infection in deer or other wildlife, and the *M. bovis* strain isolated from the infected Minnesota herd does not match that found in Michigan. Also, there are much lower deer densities in the area of the infected herds than in the affected areas of Michigan. Further, unlike Michigan, Minnesota does not allow baiting, which artificially congregates deer and increases the likelihood of disease transmission.

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Bovine TB is a progressive, chronic disease. It is spread primarily through the exchange of respiratory secretions between infected and uninfected animals. This transmission usually happens when animals are in close contact with each other. Animals may also become infected with bovine TB by ingesting the bacteria from eating contaminated feed. It can take months to years from time of infection to the development of clinical signs. The lymph nodes in the animal's head usually show infection first and as the disease progresses, lesions (yellow or tan, pea-sized nodules) will begin to develop on the surface of the lungs and chest cavity. In severely infected deer, lesions can usually be found throughout the animal's entire body. Hunters do not always readily recognize small lesions in deer, as they may not be visible when field dressing deer. In fact, most infected deer appear healthy. In Michigan, only 42% of the bovine TB positive deer had lesions in the chest cavity or lungs that would be recognized as unusual by most deer hunters. While it is possible to transmit bovine TB from animals to people, the likelihood is extremely rare. Most human tuberculosis is caused by the bacteria *M. tuberculosis*, which is spread from person to person and rarely infects animals.

METHODS

A fall Surveillance Zone was developed that encompassed a 15-mile radius around Skime, Salol, and Grygla, Minnesota centering on the locations of the infected livestock operations (Figure 1). A sampling goal was determined to ensure 95% confidence of detecting the disease if prevalent in >1% of the deer population. Given the large geographic area and abundance of deer, the goal was to collect approximately 1,000 samples from hunter-harvested deer within the Surveillance Zone.

At the registration stations, hunters were asked to voluntarily submit lymph node (LN) samples for bovine TB testing. Hunter information was recorded, including the hunter's name, address, telephone number, MNDNR number, and location of kill. Maps were provided to assist the hunters in identifying the location (Township, Range, Section, and Quarter-section) of the kill. Cooperating hunters were entered into a gun raffle and given a Cooperator's patch.

Tissue collection procedures included a visual inspection of the chest cavity of the hunter-killed deer. Six cranial Lens (parotid, submandibular, and retropharyngeal) were visually inspected for presence of lesions and extracted for further testing. Samples were submitted to the Veterinary Diagnostic Laboratory (VDL) at the University of Minnesota for histological examination and acid-fast staining. All samples were then pooled in groups of 5 and sent to the National Veterinary Services Laboratories (NVSL) in Ames, IA for culture. Any suspect carcasses (e.g., obvious lesions in chest cavity or head) were confiscated at the registration stations and the hunter was issued a replacement deer license at no charge. Suspect carcasses were transported in their entirety to the VDL for further testing.

Additionally, MNDNR implemented efforts to further reduce deer numbers in the post-hunting season in the bovine 140-mi^2 TB-infected Core Area, through the use of sharpshooters. During winter 2006-2007, sharpshooter-harvested deer were transported intact to a central processing facility at Thief Lake Wildlife Management Area. Sample collection and handling was similar to that described above. Carcasses were salvaged for venison and available to the public.

Prior to the start of the winter 2006-2007 sharpshooting effort, MNDNR conducted an aerial survey of the bovine TB Management Zone and Core Area to assess deer numbers and distribution (Figure 2). This information was used to guide sharpshooting activities and estimate the percentage of deer removed from the area.

RESULTS AND DISCUSSION

In winter 2006-2007, we collected 488 samples from sharpshooter-harvested deer in the bovine TB Core Area (Figure 3). This included 219 adult (>2.5 years old) females, 30 adult males, 38 yearling (1.5 years old) females, 34 yearling males, 82 female fawns (0.5 year old), and 85 male fawns. We identified 6 deer as "suspects," meaning they had obvious lesions in the lungs or chest cavity that were consistent with clinical signs of bovine TB. All of these deer were shot in the same general location in the southwestern part of the Core Area, which is a traditional deer-wintering area on state land. It is unknown whether these suspects are migratory deer and moved into this wintering area from their spring-summer-fall ranges elsewhere in the Core Area, or are resident deer. Given the population estimate of 923 ± 150 deer within the Core Area, we have removed approximately 42-63% of this deer population. Lastly, deer that were removed through this project were salvaged for venison. Thief Lake staff distributed 451 deer to interested folks from the local area as well as greater distances, including the Twin Cities.

In fall 2007, we collected 1,085 samples from hunter-harvested deer; this includes 4 whole carcasses that were confiscated from hunters due to the presence of suspicious lesions in the chest cavity or lymph nodes. All of these deer were confirmed positive for the disease by NVSL. An additional positive deer was detected that did not have obvious lesions in the chest cavity, but was part of a pool of 5 deer that were cultured positive for *M. bovis*. Upon re-examination of the lymph nodes from these 5 individual deer, microscopic lesions were found in one set of lymph nodes, and this deer was confirmed positive upon reculture. All 5 confirmed TB-positive deer were harvested approximately 5 miles from Skime, Minnesota (Figure 4). The apparent prevalence of this disease (0.46 ± 0.2%) and the geographic distribution of infected deer remain unchanged from the previous 2 years. The strain of bovine TB from the infected deer matched the strain isolated from the infected cattle herds in the Surveillance Zone and was consistent with bovine TB strains commonly found in the southwestern U.S. and Mexico.

The proximity of the infected deer to infected cattle herds, the strain type, and the fact that disease prevalence (<0.5%) is low, supports our theory that this disease spilled-over from cattle to wild deer in this area of the state. To date, we have sampled 3,085 deer in the bovine TB Surveillance Zone since 2005, and a total of 18 confirmed culture-positive deer. Further, all deer found infected to date would have been alive in 2005, when the initial detection of bovine TB in cattle occurred.

In November 2006, a ban on recreational feeding of deer and elk was instituted over a 4,000mi^2 area to help reduce the risk of disease transmission among deer and between deer and livestock (Figure 5). During a February 2007 enforcement flight, 29 illegal feeding sites were identified on 22 properties within the Bovine TB Management Zone; enforcement officers investigated all cases and illegal activities were stopped. Enforcement officers continue to enforce this rule and compliance is thought to be very high within the Bovine TB Management Zone.

Further, the Minnesota State Legislature passed a $54,000 funding initiative in 2006 that increased the amount of deer-proof fencing materials that can be provided by the MNDNR to cattle producers within 5 miles of a bovine TB-infected herd. The intent of this legislation is to protect stored feed from deer depredation and reduce the risk of deer to deer or deer to cattle transmission of the disease. The program allowed for up to $5,000 of deer-proof fencing materials per qualified livestock producer. During the summer of 2007, MNDNR erected 15 deer-proof fences on 11 cattle premises.

The presence of bovine TB in additional cattle herds and wild deer in Minnesota has led the USDA to further demote the state's bovine TB status from "modified accredited advanced" to "modified accredited"; resulting in mandatory testing of cattle and restrictions on cattle movements statewide. As part of the requirements to regain TB-Free accreditation, USDA required BAH to test 1,500 cattle herds statewide for the disease. By the end of 2007, BAH had completed this requirement, testing 1,596 herds, and did not find infection outside the endemic area in northwestern Minnesota. The MNDNR is committed to assisting the BAH in regaining Minnesota's TB-Free status as soon as possible. To accomplish this, the MNDNR will continue to conduct surveillance in 2008 and beyond.

ACKNOWLEDGEMENTS

There is no way to pull off a project of this scale without lots of assistance and good leadership from St. Paul and regional staff, including Ed Boggess, Dennis Simon, Dave Schad, Jason Abraham, Paul Telander, John Williams, and Mike Carrol. For all the help with field collections, we'd like to thank area staff from Thief Lake, Red Lake, Norris Camp, and Thief River Falls, as well as students and faculty from the University of Minnesota, College of Veterinary Medicine. Also thanks to Bob Wright, Marshall Deters, and the enforcement pilots (Tom Pfingsten and John Heineman) for conducting a deer survey within the Bovine TB Management Zone, as well as identifying illegal deer feeding activities. Also thanks to John Fieberg and John Giudice for analyzing the survey data. Nick Reindl and his crew built all the fences. We also want to recognize the tremendous amount of work conducted by USDA-Wildlife Services staff, including Bill Paul and John Hart from Grand Rapids and disease biologists Beth Johnson (New Jersey), Dr. Sheldon White (North Carolina), and Ryan Powers (North Dakota). Also, North Dakota Game & Fish loaned us their wildlife veterinarian, Dr. Erika Butler, for a week of lymph node extraction and we thank them for her assistance with our project. Lastly, we would like to thank Dave Pauly, whom was on a 1-year mobility assignment to the wildlife health program, for all his hard work and dedication to this project.

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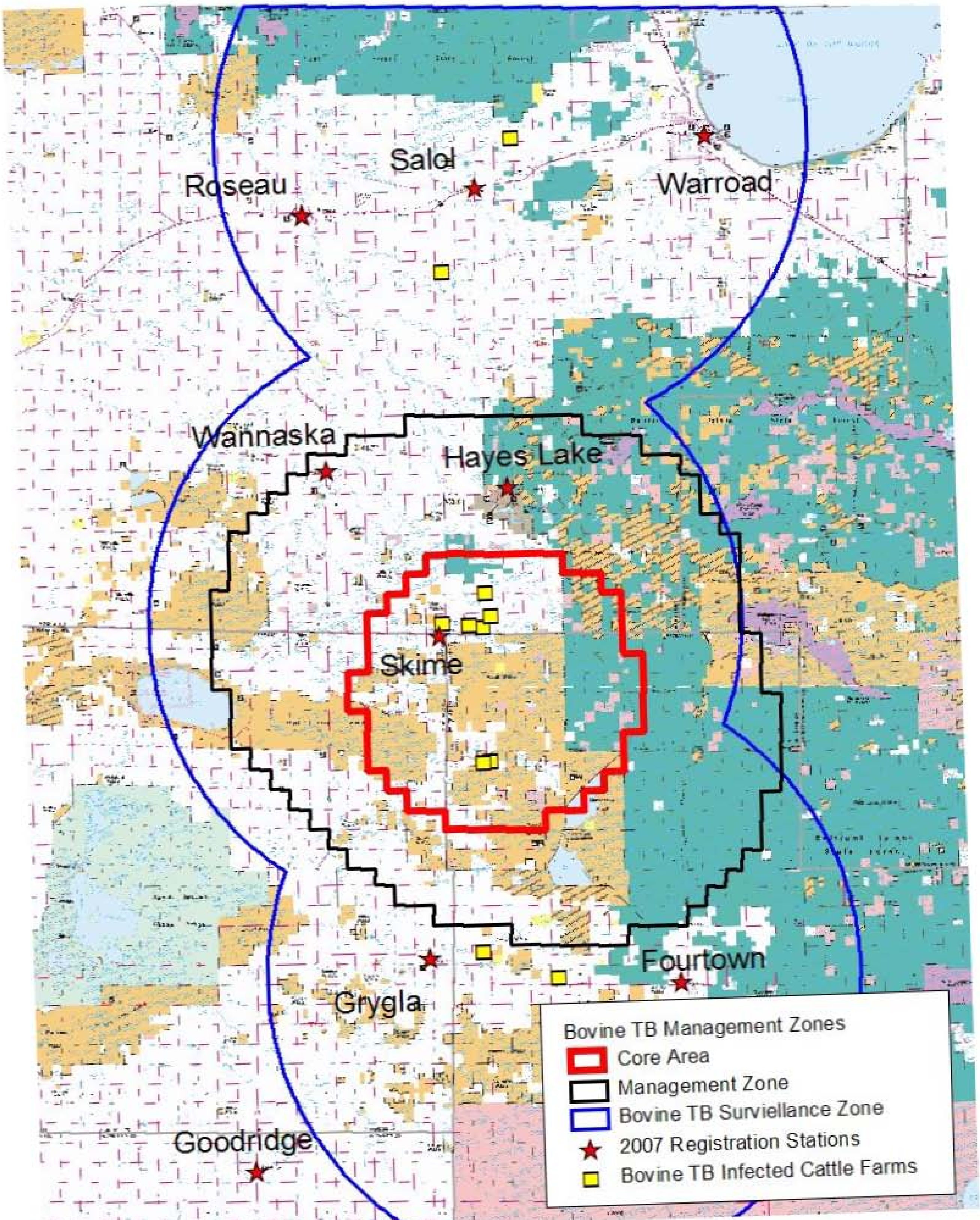


Figure 1. Locations of deer registration stations for sampling hunter-harvested deer for bovine tuberculosis during fall 2007.

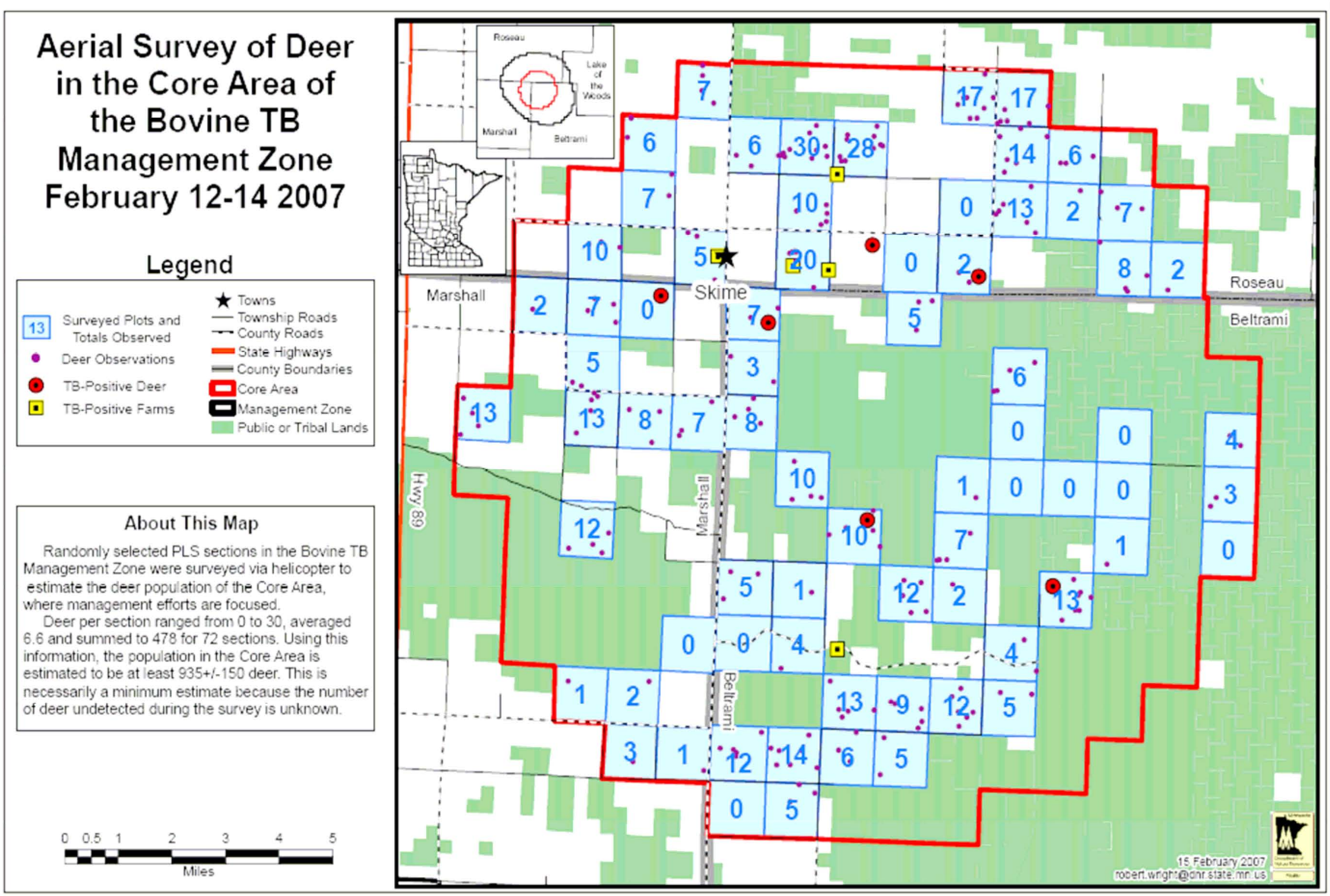


Figure 2. Results of aerial white-tailed deer survey of the bovine TB Core Area in February 2007.

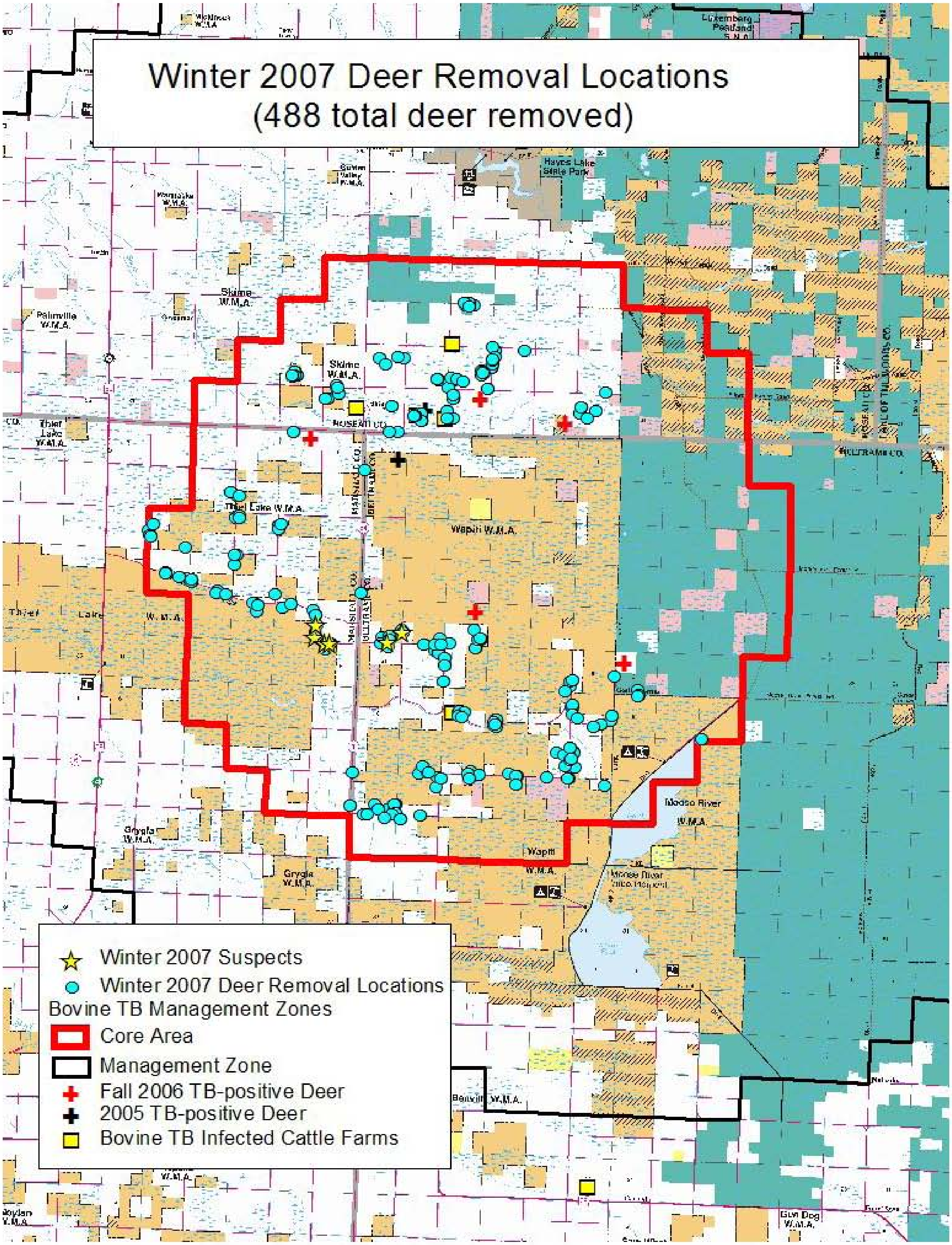


Figure 3. Locations of deer removed by USDA sharpshooters during February-April, 2007 within the bovine TB Core Area (delineated in red), a 140mi^2 area within bovine tuberculosis Management Zone (delineated in black).

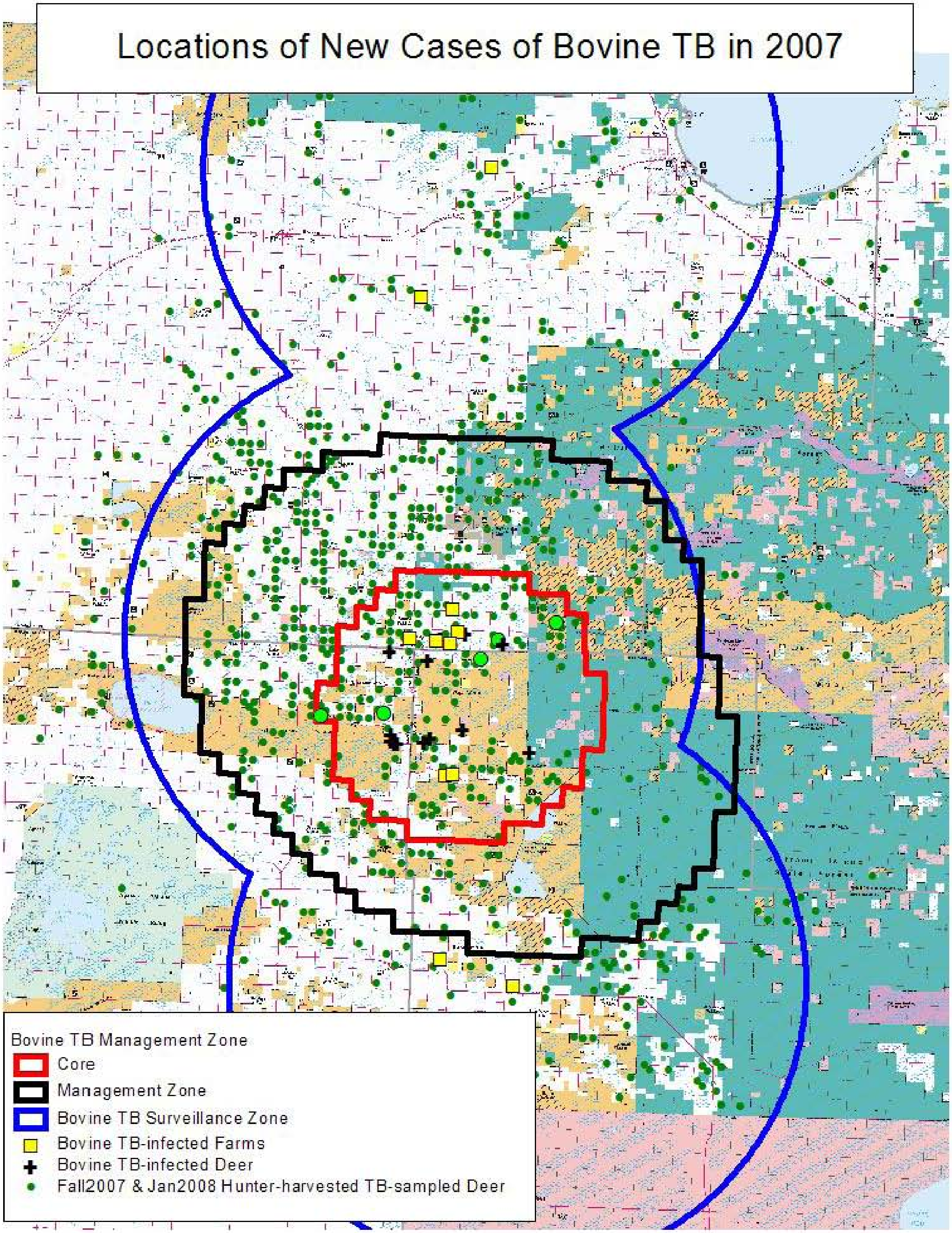
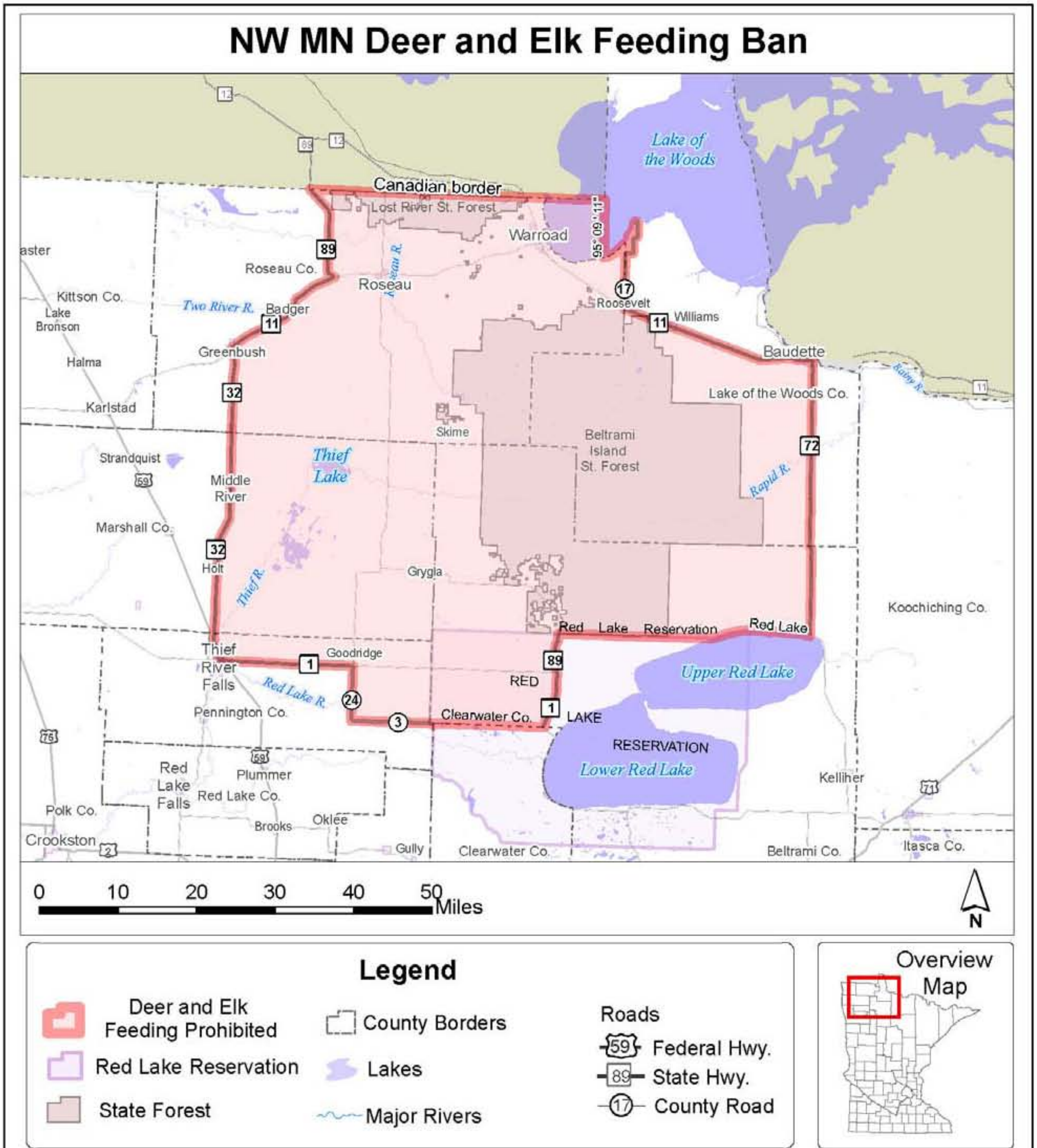


Figure 4. Locations of white-tailed deer sampled for bovine tuberculosis in the Surveillance Zone in northwestern Minnesota, fall 2006. Deer found infected with the disease in 2007 are noted with large green circles, and black crosses correspond to infected deer from 2005-2006.



Deer and Elk Feeding Ban Boundary Description

Beginning at State Trunk Highway (STH) 89 and the Canadian border; thence along the Canadian border to longitudinal point 95 degrees, 9 minutes, 11 seconds; thence due south to the shore of Lake of the Woods; thence along the shore of Lake of the Woods to County Road (CR) 17; thence along CR 17 to STH 11; thence along STH 11 to STH 72; thence along STH 72 to the north shore of Upper Red Lake; thence along the north shore of Upper Red Lake to the boundary of the Red Lake Indian Reservation; thence along the boundary of the Red Lake Indian Reservation to STH 89; thence along STH 89 to STH 1; thence south along STH 1 to the Clearwater County line; thence along the Clearwater County line to the Pennington County line; thence due west to the intersection of CR 27 and CR 3; thence along CR 3 to CR 24; thence along CR 24 to STH 1; thence along STH 1 to STH 32; thence along STH 32 to STH 11; thence along STH 11to STH 89; thence along STH 89 to the point of beginning.

Figure 5. Area in northwestern Minnesota where recreational feeding of deer and elk was banned in November 2006, as a preventative measure to reduce risk of disease transmission.

SURVEILLANCE FOR HIGHLY PATHOGENIC AVIAN INFLUENZA IN MINNESOTA'S WATERFOWL

Michelle Carstensen[1] and Michael DonCarlos

SUMMARY OF FINDINGS

As part of a national strategy for early detection of highly pathogenic avian influenza (HPAI) in North America, Minnesota Department of Natural Resources (MNDNR) and the United States Department of Agriculture (USDA) conducted surveillance for the virus in waterfowl in the state. A combined total of 1,558 birds were sampled for HPAI in Minnesota during 2007. Testing did not result in any positive cases of HPAI, especially the Asian strain of subtype H5N1, however numerous duck species (n=7) did test positive for a low pathogenic strain of avian influenza with the subtype H5 or N1. Approximately 95,843 wild birds were sampled throughout the United States in 2007, and no positive cases of HPAI were detected. It is likely that Minnesota will continue surveillance for the virus in the state's waterfowl next year, in cooperation with the Mississippi Flyway, Council of the U.S. Fish and Wildlife Service, and the USDA.

INTRODUCTION

Recent worldwide attention on the spread of a highly pathogenic strain of avian influenza, subtype H5N1, from Asia to Europe and Africa in 2006 has led to the development of a coordinated National Strategic Plan for early detection of HPAI-H5N1 introduction into North America by wild birds. Although movements of domestic poultry or contaminated poultry products, both legally and illegally, are believed to be the major driving force in the spread of HPAI-H5N1, migratory birds are thought to be a contributing factor.

This national plan outlined a surveillance strategy that targeted sampling of wild birds species in North America that have the highest risk of being exposed to or infected with HPAI-H5N1 because of their migratory movement patterns. Currently, these include birds that migrate directly between Asia and North America, birds that may be in contact with species from areas in Asia with reported outbreaks, or birds that are known to be reservoirs of AI. A step-down plan was developed by the Mississippi Flyway Council in 2006 identifying Minnesota as a key flyway state needed to participate in regional sampling for early detection of HPAI-H5N1 in migratory ducks, geese, and shorebirds.

In June 2007, the MNDNR entered into a $100,000 cooperative agreement with the United States Department of Agriculture's Wildlife Services (USDA-WS) to sample 750 wild birds (either live-caught or hunter-harvested) in Minnesota for HPAI-H5N1 during 2007. In addition to the 750 samples to be collected by MNDNR, USDA-WS was also planning to collect a similar number of samples in the state during the same period. Bird species that were targeted include those listed as priority species in the National Strategic Plan or approved for sampling in Minnesota by the Mississippi Flyway Council.

Avian influenza is a viral infection that occurs naturally in wild birds, especially waterfowl, gulls, and shorebirds. It is caused by type A influenza viruses that have 2 important surface antigens, hemagglutinin (H) and nuraminidase (N), that give rise to 144 possible virus subtypes. Influenza viruses vary widely in pathogenicity and ability to spread among birds. The emergence of an Asian strain HP-H5N1 virus in 1996 and subsequent spread of the virus in Asia, Africa, and Europe has killed thousands of wild birds and millions of domestic poultry. In 1997, HP-H5N1 became zoonotic in Hong Kong and to-date has infected at least 380 humans in Eurasia and Africa, resulting in over 240 deaths.

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METHODS

The MNDNR planned to sample 125 common goldeneye (*Bucephala clangula*) and 125 ring-necked ducks (*Aythya collaris*) during the summer months, primarily in conjunction with planned banding activities. In the fall, through hunter surveillance, the above 2 species were targeted along with the following: 100 Northern pintails (*Anas acuta*), 100 mallards (*Anas platyrhynchos*), 100 American green-winged teal (*Anas crecca*), 100 American blue-winged teal (*Anas discors*), 50 Northern shovelers (*Anas clypeata*), and 50 American wigeon (*Anas americana*). USDA-WS planned to sample a similar number of either the duck species mentioned above or other from their functional group (e.g., dabblers, divers, shorebirds) as well as 50 Canada geese (*Branta Canadensis*). If sampling goals per species could not be met, other targeted waterfowl species within the same functional group can be sampled and counted toward the state's total. Sampling strategies were coordinated between the MNDNR and USDA-WS to maximize access to targeted birds species through existing banding operations and fall hunter-harvested surveillance.

Cloacal and oral-pharyngeal swabs were used to collect samples and they were submitted to the Veterinary Diagnostic Laboratory in St. Paul, MN for initial screening for the virus. If positive for avian influenza virus, samples were forwarded to the National Veterinary Services Laboratories in Ames, IA for strain-typing.

RESULTS AND DISCUSSION

From April 1, 2007 through March 31, 2008 MNDNR and USDA collected a total of 1,558 samples from wild-caught live birds (*n*=585), hunter-harvested birds (*n*=896), and mortality/morbidity events (*n*=77). USDA also collected 706 fecal samples. Thus, a combined total of 2,264 birds were sampled for HPAI-H5N1 in Minnesota in 2007 (Figure 1, Table 1).

Testing did not result in any positive cases of HPAI-H5N1; however 7 different duck species tested positive for a low pathogenic strain of avian influenza with the subtype H5, and 3 tested positive for an N1 subtype (Figure 2, Table 2). The testing protocol was limited to the screening for H5, H7, and N1 subtypes only.

According to the latest numbers on the United States Geologic Survey's website (http://wildlifedisease.nbii.gov/ai/), approximately 95,843 birds have been sampled for HPAI-H5N1 in the U.S. in 2007. No positive cases of HPAI-H5N1 have been found anywhere in North American to date. However, NVSL did report 293 positive low pathogenic H5 cases nationwide.

Surveillance for HPAI-H5N1 will likely continue in Minnesota, and other parts of the U.S. next year. The USDA has banked all samples taken in 2006 and 2007, and is currently accepting proposals from state agencies and universities for further avian influenza research. Minnesota remains prepared to assist with future surveillance objectives if needed. In addition, the MNDNR has developed a surveillance and response plan for HPAI in wild birds, which includes increased vigilance of mortality and morbidity events within the state.

ACKNOWLEDGEMENTS

This project would not have been possible without the valuable contribution of the waterfowl research group, including Jeff Lawrence, Steve Cordts, Jim Berdeen, and Jim's group of banding interns. Other MNDNR staff that provided valuable assistance to this project included Joel Huener, Marshall Deters, Stan Wood, Perry Leogering, Joel Anderson, Dave Trauba, Kevin Kotts, and Blane Klemek. I would also like to recognize our USDA-WS partner on the project, Paul Wolf, for his efforts to ensure that we met our overall sampling goals.

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Table 1. Bird species sampled for highly pathogenic avian influenza H5N1 by Minnesota Department of Natural Resources and United States Department of Agriculture-Wildlife Services in 2007. Table includes live-bird, hunter-harvested, mortality/morbidity, and fecal sampling[1].

Species sampled	*n*
Ducks	
American Coot	4
American Green-Winged Teal	253
American Wigeon	85
American Blue-Winged Teal	282
Canvasback	12
Common Goldeneye	71
Common Merganser	17
Gadwall	24
Greater Scaup	5
Hooded Merganser	19
Lesser Scaup	125
Mallard	399
Northern Pintail	272
Northern Shoveler	90
Red-breasted Merganser	1
Redhead	16
Ring-Necked Duck	255
Wood Duck	139
Canada Geese	60
Other	
American White Pelican	20
Caspian Tern	4
Common Loon	1
Double-Crested Cormorant	8
Herring Gull	8
Ring-Billed Gull	8
Total	2,178

[1]Fecal samples (n = 86) not attributable to an individual species were excluded.

Table 2. Results of avian influenza testing by the National Veterinary Services Laboratories (NVSL) from samples submitted by Minnesota in 2007.

Species	Date collected	Test type[1]	Test result	County	Lat/long
American Green-Winged Teal	09/04/2007	AI NVSL – Subtyping	H10N3	Roseau	48.95324 / -96.01311
American Green-Winged Teal	09/04/2007	AI NVSL – Subtyping	H3N1	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/30/2007	AI NVSL – Subtyping	H4N8	Nicollet	44.27786 / -94.235
American Green-Winged Teal	09/29/2007	AI NVSL - Subtyping	H6N8	Anoka	45.32768 / -93.07622
American Green-Winged Teal	09/04/2007	AI NVSL - AIV N1 RRT-PCR	POS	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/30/2007	AI Screen - AIV H5 RRT-PCR	POS	Nicollet	44.27786 / -94.235
American Green-Winged Teal	09/04/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/04/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/04/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/04/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95383 / -96.06305
American Green-Winged Teal	09/04/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95324 / -96.01311
American Green-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Anoka	45.32768 / -93.07622
American Green-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Nicollet	44.27786 / -94.235
American Wigeon	10/01/2007	AI NVSL - AIV H5 RRT-PCR	POS	Marshall	48.47798 / -95.92484
American Wigeon	10/05/2007	AI NVSL - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
American Wigeon	10/01/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.47798 / -95.92484
American Wigeon	10/05/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
American Wigeon	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Itasca	47.3167 / -93.79055
Blue-Winged Teal	09/29/2007	AI NVSL - Subtyping	H4N6	Murray	43.97879 / -95.5338
Blue-Winged Teal	09/29/2007	AI NVSL - AIV H5 RRT-PCR	POS	Big Stone	45.22232 / -96.19533
Blue-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Chisago	45.39415 / -92.95867
Blue-Winged Teal	09/30/2007	AI Screen - AIV H5 RRT-PCR	POS	Murray	43.97879 / -95.5338
Blue-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Wabasha	44.21768 / -91.9279
Blue-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Big Stone	45.22232 / -96.19533
Blue-Winged Teal	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Murray	43.97879 / -95.5338
Lesser Scaup	10/28/2007	AI NVSL - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
Lesser Scaup	10/27/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
Lesser Scaup	10/28/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
Mallard	09/29/2007	AI NVSL - Subtyping	H3N8	Cass	46.99385 / -93.91222
Mallard	09/29/2007	AI NVSL - Subtyping	H6N1	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI NVSL - Subtyping	N4	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI NVSL - AIV H5 RRT-PCR	POS	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI NVSL - AIV N1 RRT-PCR	POS	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Clearwater	47.408989 / -95.2981
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Nicollet	44.27786 / -94.235
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Anoka	45.26978 / -93.12812
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Murray	43.97879 / -95.5338
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Cass	46.99385 / -93.91222
Mallard	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Cass	46.99385 / -93.91222
Northern Pintail	09/29/2007	AI NVSL - Subtyping	H11N9	Marshall	48.47798 / -95.92484
Northern Pintail	09/11/2007	AI NVSL - Subtyping	H3N6	Roseau	48.9583 / -96.06305
Northern Pintail	09/29/2007	AI NVSL - Subtyping	N1	Anoka	45.32768 / -93.07622
Northern Pintail	10/19/2007	AI NVSL - Subtyping	N1	Marshall	48.50534 / -95.86086

Table 2 continued.

Northern Pintail	09/29/2007	AI NVSL - Subtyping	N4	Anoka	45.32768 / -93.07622
Northern Pintail	09/29/2007	AI NVSL - AIV N1 RRT-PCR	POS	Anoka	45.32768 / -93.07622
Northern Pintail	09/11/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.9583 / -96.06305
Northern Pintail	09/14/2007	AI Screen - AIV H5 RRT-PCR	POS	Roseau	48.95383 / -96.06305
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Anoka	45.32768 / -93.07622
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	St Louis	46.90168 / -92.23829
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Clearwater	47.408989 / -95.2981
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.47798 / -95.92484
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.47798 / -95.92484
Northern Pintail	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.47798 / -95.92484
Northern Pintail	10/19/2007	AI Screen - AIV H5 RRT-PCR	POS	Marshall	48.50534 / -95.86086
Northern Shoveler	09/29/2007	AI NVSL - Subtyping	H3N9	Itasca	47.3167 / -93.79055
Northern Shoveler	09/29/2007	AI Screen - AIV H5 RRT-PCR	POS	Itasca	47.3167 / -93.79055

[1]Test results include AI NVSL Subtyping = identifies other strains of avian influenza that are not H5; AI NVSL-AIV N1 RRT-PCR = tests for N1 avian influenza subtype; AI NVSL-AIV H5 RRT-PCR = test for the H5 avian influenza subtype.

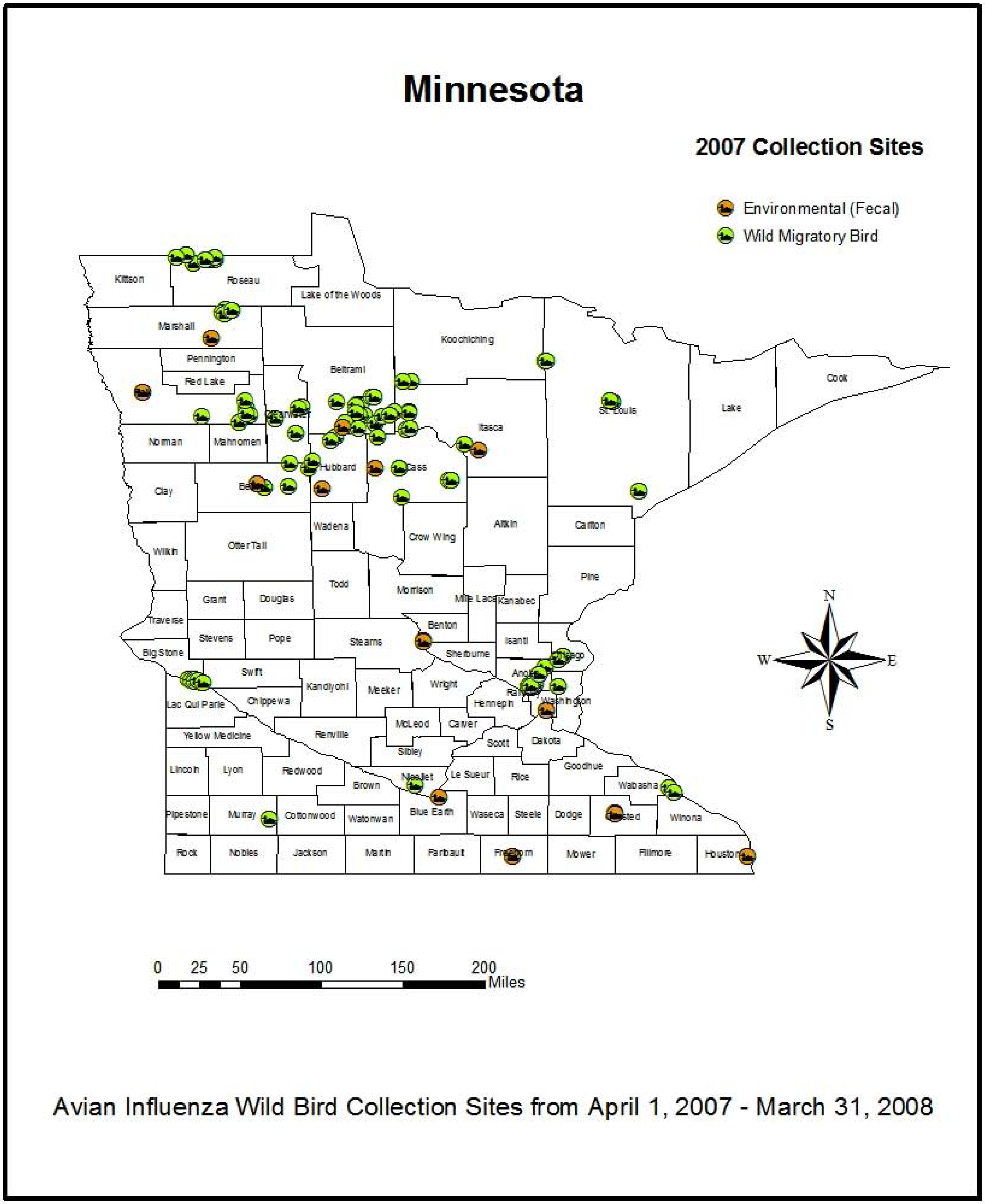

Figure 1. Collection sites from which live bird and environmental (fecal) samples were tested for highly pathogenic avian influenza in Minnesota during 2007.

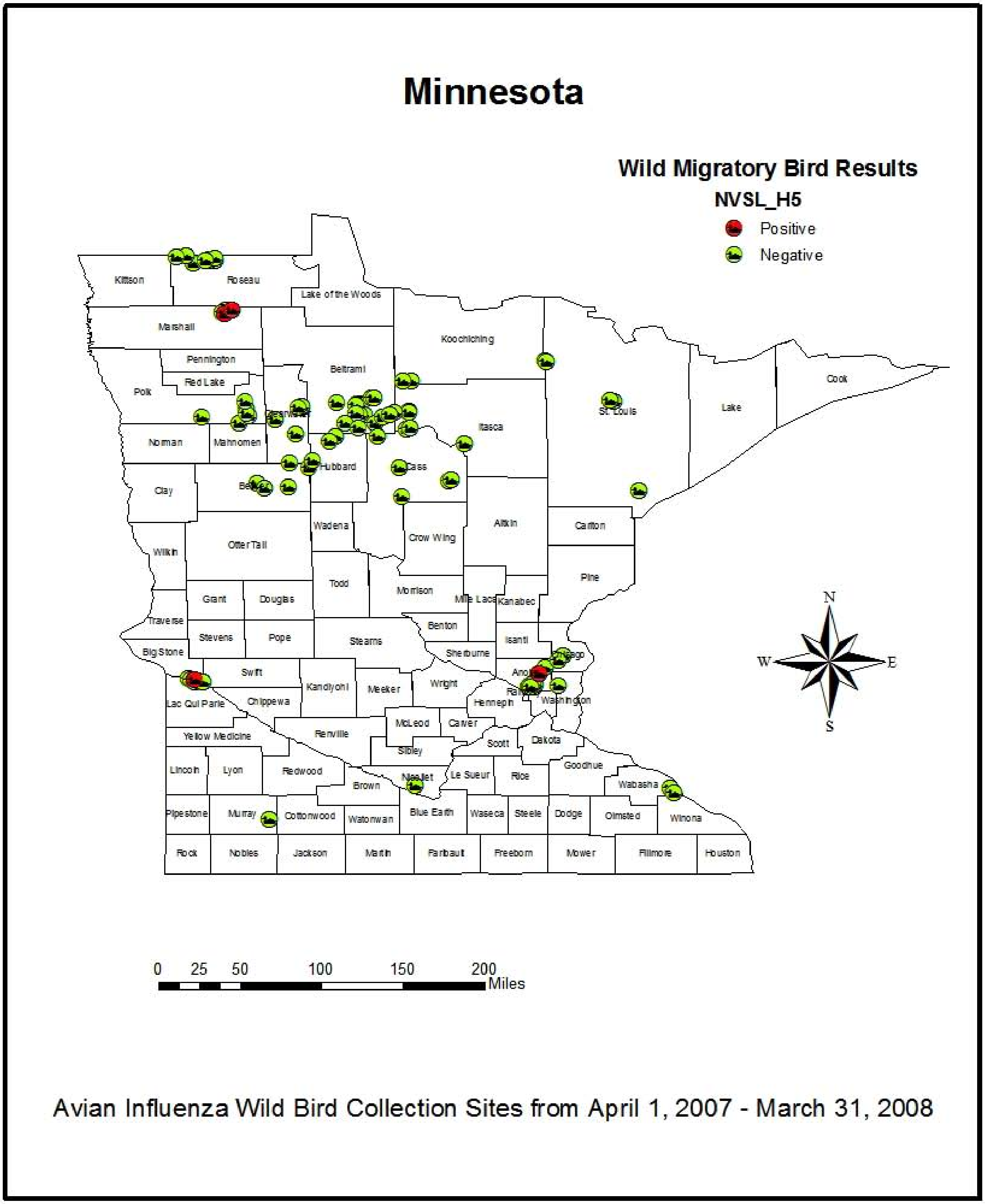

Figure 2. Collection sites where a low pathogenic H5 strain was detected (red dots) among the waterfowl sampled in Minnesota during 2007.

PRELIMINARY RESULTS FROM THE 2007 HUNTER HARVESTED MOOSE HEALTH ASSESSMENT PROJECT

Michelle Carstensen[1], Erika Butler, David Pauly, Mark Lenarz, Mike Schrage, and Lou Cornicelli

SUMMARY OF FINDINGS

The purpose of this project is to screen 2007-2009 hunter-harvested (and presumably healthy) moose (*Alces alces*) for a variety of disease agents. The results are intended to indicate what diseases the NE MN moose population is being exposed to as well as to provide some comparisons for similar testing completed with non-hunting moose mortalities from the same population. Positive results were reported for eastern equine encephalitis, West Nile Virus, malignant catarrhal fever, anaplasmosis, bovine viral diarrhea virus 1 and 2, *Leptospira sp,* and parainfluenza virus 3. A variety of fecal parasites were identified on fecal examination and multiple organisms were cultured from lung and liver samples. Histological examination was performed on all submitted tissues, with a variety of results. All results were negative for *Mycobacterium paratuberculosis*, brucellosis, bovine herpes virus 1, blue tongue virus, epizootic hemorrhagic disease, *Neospora*, chronic wasting disease, and bovine tuberculosis.

INTRODUCTION

The estimated 2006 non-hunting mortality of 34% for adult moose in this population is higher than reported elsewhere in North America. Recent population survey results suggest a declining moose population, with a 23% decline noted between 2006 and 2007. In addition, hunter success rates have declined from 84% in 1993 to an all time low of 58% in 2005. Significantly lower cow:calf ratio was reported in 2006, lower than the average estimated for the previous 21 years. There have also been increased reports of clinically ill animals. Parasites have been documented, including *Parelaphostrongylus tenuis, Echinococcus granulosus, Eelaphora schneideri,* and *Sarcocystis spp*., liver flukes (*Fascloides magna*) and winter ticks (*Dermacenter albipictus*). Copper deficiency has been documented in some moose. Many causes of mortality remain unknown with numerous prime-age animals dying – often during low stress periods of the year. Poor antler development has been noted in some bull mortalities.

The purpose of this project is to screen 2007-2009 hunter-harvested (and presumably healthy) moose for a variety of disease agents. The results are intended to indicate what diseases the NE MN moose population is being exposed to as well as to provide some comparisons for similar testing completed with non-hunting moose mortalities from the same population. While some of the test results may be all negative, this does not necessarily mean that the disease is not present in or impacting the population. Some diseases cause death so quickly, or without an immune response, that finding a positive in a seemingly healthy animal would be extremely rare.

METHODS

In order to conduct this herd health assessment, hunters (both tribal and state) were asked to collect samples of lung, liver, blood, feces, hair and an incisor for aging. We provided a presentation and instructions relative to the moose health survey at the mandatory MNDNR Moose Hunt Orientation Sessions. Hunters were mailed a sample kit with instructions prior to the orientation sessions. Post-harvest, these samples were dropped off at official registration stations by the hunters when they registered their moose. At the time of registration, hunters were asked to locate their kill site on appropriate maps.

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Blood was centrifuged and serum was extracted. Liver and lung samples were split, with half placed in a formalin jar, while the other half was fresh-fixed (and later frozen) in whirlpak bags. The hunter collected blood from the chest cavity as soon after death as possible, using a large syringe from which samples were placed in serum tubes and kept cool. If the hunter found anything unusual, those samples were collected and split between the preservative methods. We provided hunters with all equipment needed for sample collection/preservation. Also, retropharyngeal lymph nodes and/or obexes were removed by trained MNDNR staff at the registration stations with permission of the hunter (Figure 1).

Portable freezers were located in advance at the stations to maintain the tissue samples. Stations were staffed with Wildlife Health Program employees, tribal employees, and ‘volunteer’ students (as per CWD/bovine TB station protocol).

Sample kits included the following items: styrofoam cooler; 1-60cc syringe for blood collection; 6-15cc serum tubes for blood storage; 3 whirlpaks for a sample of liver, lung and feces; 2 specimen jars with formalin for liver and lung samples; 2 coin envelopes for tooth and hair; datasheet; protocol; Sharpie marker; 1 pair of large vinyl gloves; and 1 icepack.

Samples were submitted to the University of Minnesota Veterinary Diagnostic Laboratory (U of M VDL), where much of the testing occurred. The National Veterinary Services Laboratories (NVSL) in Ames, IA performed additional tests that could not be conducted at the U of M VDL.

RESULTS AND DISCUSSION

A total of 135 sampling kits were turned in by moose hunters (110 state, 25 tribal) at MNDNR registration stations throughout moose range in northeastern Minnesota (Figure 1). Of the kits submitted, 118 were complete, with the reminder being partial submissions. The quality of the samples were quite good, with very few errors in tissue identification or insufficient quantities. The following is a brief overview of the major findings:

Eastern Equine Encephalitis (EEE)

A total of 116 samples were submitted to NVSL for Virus Neutralization (VN) testing. A total of 5 were positive (5/116 = 4.3%). Two of these positive samples had titers at 100, while 3 had titers greater than or equal to 100.

The positive results indicate that these animals were exposed to the EEE virus as the VN test prevents cross-reactivity with other viruses. A titer that is greater than 100 is considered a VERY strong positive and means that the serum was able to neutralize nearly 100% of the virus.

EEE is spread by mosquitoes and causes neurologic signs and often death. It poses a greater mortality threat for most species than West Nile Virus does (though the effects of EEE infection have not been studied in moose).

West Nile Virus (WNV)

A total of 117 samples were submitted to NVSL for VN testing. A total of 45 samples were positive (45/117 = 38.5%). Thirty-two of the positive samples had titer levels at 10, 6 had titer levels at 100, and 7 had titers greater than or equal to 100.

The positive results indicate that these animals were exposed to the WNV virus as the VN test prevents cross-reactivity with other viruses. A titer that is greater than 100 is considered a VERY strong positive and means that the serum was able to neutralize nearly 100% of the virus.

Little is known about the effects of WNV in moose. In white-tailed deer (*Odocoileus virginianus*) it has been found that they often have a low titer and no clinical signs. However, the USDA has found that reindeer (*Rangifer tarandus*). infected with WNV have high mortality rates and high titers. This indicates that the virus is more serious for some species than others.

Malignant Catharral Fever (MCF)

A total of 117 samples were submitted to NVSL for peroxidase-linked assay (PLA) testing. If the PLA test came back positive, the samples were screened with a VN test. A total of 8 samples tested positive on the PLA test (8/117 = 6.8%). Four of these 8 were positive at 1:100 and 4 were positive at 1:20. Of the 8 that were positive on PLA, 5 were negative on the VN and the serum was unsuitable for VN in 3.

The PLA test is more sensitive than the virus isolation, meaning it is much better at identifying positives, while the VN is more specific which means it is better at identifying true negatives. There were a couple of problems with this testing. The PLA reacts with multiple Gammaherpes Viruses (such as the wildebeest strain, the sheep strain, the deer strain, etc). A PLA positive does not indicate what strain has been found, only that one has. The higher the positive value with the PLA test, the stronger the positive in the sample. The VN test only screens for the wildebeest strain (which is exotic to the U.S.) and would be negative if other strains are present. This means a sample that was positive on PLA and negative on VN was likely exposed to a gammaherpes virus, but not the wildebeest strain.

Gammaherpes viruses have been documented to cause serious illness and death in moose and other ruminants. The clinical symptoms can mimic brain worm as the animals often exhibit neurological deficits, go blind, and often thrash on the ground prior to death. While infection with MCF frequently results in death, carrier status can occur and is identified with serology. Zarnke et al. found serologic evidence of exposure in numerous species across Alaska and reported 1% prevalence in moose (2002).

The best test for MCF is a polymerase chain reaction (PCR)) on whole blood. This would allow identification of active infection as well as determining which strain is present. If possible, whole blood should be collected from all euthanized moose as well as hunter-harvested animals.

Fecal Examination for Parasites

A total of 123 fecal samples were screened for evidence of parasites. Evidence of parasitism was found in 18 of the samples (18/123 = 14.6%). Five of the samples contained *Nematodirus*, 5 contained *Moniezia*, 6 contained Strongyle type ova, 1 contained *Nematodirus/Moniezia*, and 1 contained *Dictyocaulus*. Negative results do not necessarily mean the animal was parasite free, only that it was not actively shedding at the time the feces were collected.

Fecal Sedimentation

A total of 12 fecal samples underwent fecal sedimentation. Sedimentation is used to determine the presence of a patent liver fluke infection. None of the samples were positive for liver fluke ova**.**

Moose are considered dead-end hosts for liver fluke, though reports of moose passing fluke ova in their feces exist. Negative results do not mean that the animals weren't infected with liver flukes, only that they were not actively shedding ova in their feces. Samples will not be submitted for fecal sedimentation next year as moose are not expected to shed fluke ova in their feces.

Liver and Lung Culture

A total of 121 livers were cultured for bacteria. No significant growth was found in 119 samples, *E. coli* was isolated from 1 sample, and *Pantoea sp*. was isolated from 1 sample. A total of 125 lung samples were submitted for bacterial culture. No significant growth was found in 124 of the samples and *E. coli* was isolated from 1 sample.

The *E. coli* isolations are likely due to cross-contamination from contents of the intestinal tract.

Culture-Other

One abscess was submitted and cultured. *Arcanobacterium pyogenes* was isolated. *Arcanobacterium pyogenes* is a bacterium commonly found in infected wounds and abscesses of ruminants and other animals. Samples from 2 spleens were submitted for culture. No significant growth was documented in 1, and *Pantoea sp*. was isolated from the other.

Pulmonary *Mycoplasma* Culture

A total of 119 lung samples were submitted for *Mycoplasma* culture. None was isolated.

Mycobacterium paratuberculosis (Johne's)

A total of 90 fecal samples were submitted for *M. paratuberculosis* culture. At this time, 53 of the results have been reported as negative, while 37 are pending. PCR was run on 118 fecal samples, with all results negative, and Biocor (serology) was run on 121 samples, with all of the results negative.

The negative fecal cultures and PCR results indicate that those moose were not actively shedding the bacterium. The negative Biocor results indicate that these animals had not been exposed to the bacterium.

All species of ruminants are believed to be susceptible to Johne's and it is frequently diagnosed in cattle and sheep (Manning and Collins, 2006). Clinical signs in wild ruminants are similar to those seen in sheep, though 1 moose with diarrhea, which resulted in death, was diagnosed with Johne's (Soltys et al., 1967). Serologic evidence of exposure to Johne's in moose has been documented, with 9/426 (2.1%) seropositive moose in Norway (Tryland et al., 2004).

Anaplasmosis

A total of 117 samples were screened for Anaplasmosis (*Anaplasma phagocytopila*, formerly *Ehrlichia phagocytophila*) with the card test. One of these samples was positive (1/117 = 0.9%). Positive test results indicates that exposure to this bacterium is occurring.

Moose are known to be susceptible to infection with *A. phagocytophilum*. In Norway, anaplasmosis was diagnosed in a moose calf, which displayed apathy and paralysis of the hind-quarters (Jenkins et al., 2001). This moose was concurrently infected with *Klebseilla* pneumonia, to which the calf's death was attributed, though the *Klebseilla* infection was most likely secondary to and facilitated by the primary infection with *A. phagocytophilum* (Jenkins et al., 2001). In sheep, this disease produces significant effects on the immunological defense system, increasing their susceptibility to disease and secondary infections (Larson et al., 1994).

A. phagocytophilum is known to occur in MN. In fact, from 1998-2005, 790 human cases were reported in MN and in recent years the MN Department of Health has documented an expansion in the areas in which MN residents are exposed to vector-borne diseases (MN Department of Health). The NE MN population of moose overlaps with the primary area of tick-borne disease risk determined by the MN Department of Health and NE MN often has a significant infestation of winter ticks.

Brucellosis

A total of 112 samples were submitted for *Brucella* screening with the card test. All of the results were negative. These negative results indicate that these animals were not likely exposed to the bacterium.

While naturally occurring fatal *Brucella* infections have been documented in free ranging moose (Honour and Hickling, 1993) and serologic evidence suggests that moose are being exposed to *Brucella sp*. (Zarnke, 1983), evidence suggests that the prevalence is low (Honour and Hickling, 1993).

Bovine Viral Diarrhea Virus (BVD) 1 & 2

A total of 120 samples were submitted for serum neutralization (SN) testing for BVD 1 & 2. Two of these results were positive (2/120 = 1.7%). One was positive at 1024/4096 and 1 was positive at 128/256. These results indicate that the moose population is being exposed to BVD. These 2 positives were surprisingly high.

BVD is considered a major disease of cattle and is thought to be the most common infectious cause of reproductive failure in beef herds in the western U.S. BVD is also considered a disease of wild ruminants such as moose, caribou (*Rangifer tarandus*), and deer. Some clinical signs of BVD include diarrhea, dehydration, fever, impaired vision and hearing, depression, abortions, and weakened neonates. Serologic evidence of BVD has been documented in 4 of 22 moose sampled in Alberta (Thorsen and Henderson, 1971).

Bovine Herpes Virus 1 (BHV)

A total of 120 samples were screened for BHV using a SN test. All results were negative

Blue Tongue Virus (BTV)

A total of 121 samples were screened using a Competitive Enzyme-Linked Immunoabsorbent Assay (cELISA) for BTV. All results were negative.

Epizootic Hemorrhagic Disease (EHD)

A total of 121 samples were screened for EHD using an Agar Gel Immuno Diffusion (AGID) test. All results were negative.

Leptospira sp.

A total of 121 samples were screened for 6 species of *Leptospira* using a microscopic agglutination test (MAT).

- *L. bratislava*: Four total positives (4/121 = 3.3%); 2 had titer levels at 100, 2 had titer levels at 200.
- *L. canicola*: Two total positives (2/121 = 1.7%); 1 had a titer of 100, 1 had a titer at 200.
- *L. grippothyphosa*: Three total positives (3/121 = 2.5%); 2 had a titer at 100, 1 had a titer at 200.
- *L. hardjo*: None of the samples tested positive.
- *L. interrogans* serovar *icterohaemorrhagicae*: 2 total positives (2/121 = 1.7%); 1had a titer at 100, 1 had a titer level at 200.
- *L. pomona*: Ten total positives (10/121 = 8.3%); 4 had a titer at 100, 1 had a titer at 200, and 5 had a titer at 400.

Positive results indicate exposure to the bacterium is occurring. Leptospirosis is known to be present in Alaskan moose. Randall Zarnke found serologic evidence of exposure in 39/618 of moose on the Kenai Peninsula, while all 34 caribou, 11 Dall sheep (*Ovis dalli dalli*) and 15 wolves (*Canis lupus*) screened were negative (2000).

Neospora

A total of 122 samples were screened for *Neospora* with an ELISA test. All samples were negative.

While clinical disease due to infection is best described in domestic animals, reports of ill effects due to *Neospora* infection in wildlife do exist. Systemic neosporosis was diagnosed in a California black-tailed deer (*Odocoileus hemionus*) that was found dead (Woods et al., 1994) and the parasite was identified in the brain of a full-term stillborn deer from a zoo in France (Dubey et al., 1996).

Antibodies to Neospora have been found in numerous species of wildlife, including 8/61 moose from NE MN (Gondim et al., 2004).

Parainfluenza Virus 3 (PI)

A total of 122 samples were screened for PI 3 using a haemagglutination inhibition (HI) test. There was 1 positive result (1/122 = 0.8%). It had a titer of 10. Positive results indicate that exposure to the virus has occurred.

Domestic ruminants are considered the main source of infection for free-ranging ruminants. However, studies of white-tailed deer, which were geographically isolated from livestock, indicate that large wild ruminant populations can maintain PI and latency of the viruses allows them to be maintained in a restricted host population for a long period (Sadi et al. 1991).

Chronic Wasting Disease (CWD)

A total of 14 obex samples were screened for CWD using immunohistochemistry (IHC). All were negative. Twelve additional samples were submitted, but were unable to be tested due to incorrect tissue. A total of 23 retropharyngeal lymph nodes were screened for CWD using IHC. All were negative. An additional 1 sample was submitted, but was not tested due to incorrect tissue.

Bovine Tuberculosis

Lymph node samples were submitted for bovine tuberculosis culture. The number of samples submitted is currently unavailable, however, all results have been reported as negative.

Liver Histopathology

A total of 114 liver samples underwent histological examination. There were no significant findings with 57 of the samples. Thirty-nine of these samples had a diffuse, hepatocellular lipidosis, of which 27 were classified as mild and 12 were classified as moderate. Fourteen of the samples exhibited varying types and degrees of hepatitis. Perihepatitis was described in 3 samples. Four of the samples exhibited evidence of fluke infection, either currently or previously. Three samples exhibited fibrosis. There were single cases of lymphoid hyperplasia, hydatid cysts, and possible capsulitis/peritonitis.

Lung Histopathology

A total of 126 lung samples underwent histological examination. There were no significant findings in 93 of the samples examined. Pulmonary hemorrhage, likely related to the gunshot, was documented in 10 of the samples. Hydatid cysts, likely *Echinococcus*, were found in 5 samples. Lymphoid hyperplasia was observed in 6 samples. Four samples had chronic pleuritis. Varying types and degrees of pneumonia were found in 4 samples. Single cases of bronchitis, emphysema, an eosinophilic granulama, and intrabronchial foreign material (likely agonal aspiration) were reported.

Other Histology

A total of 24 brainstem samples underwent histologic examination. Twenty-three had no significant findings and 1 had mild hemorrhaging, which was likely related to the gunshot. Twenty-one lymph nodes were examined. Twenty exhibited no significant findings and 1 of them had blood resorption, which was likely related to the gunshot. Fifteen spleens were examined. None of them exhibited any significant findings. One sample of cerebellum, kidney, heart, and brain were examined, with no significant findings. One sample of the colon and small intestine were examined and found to have enteritis.

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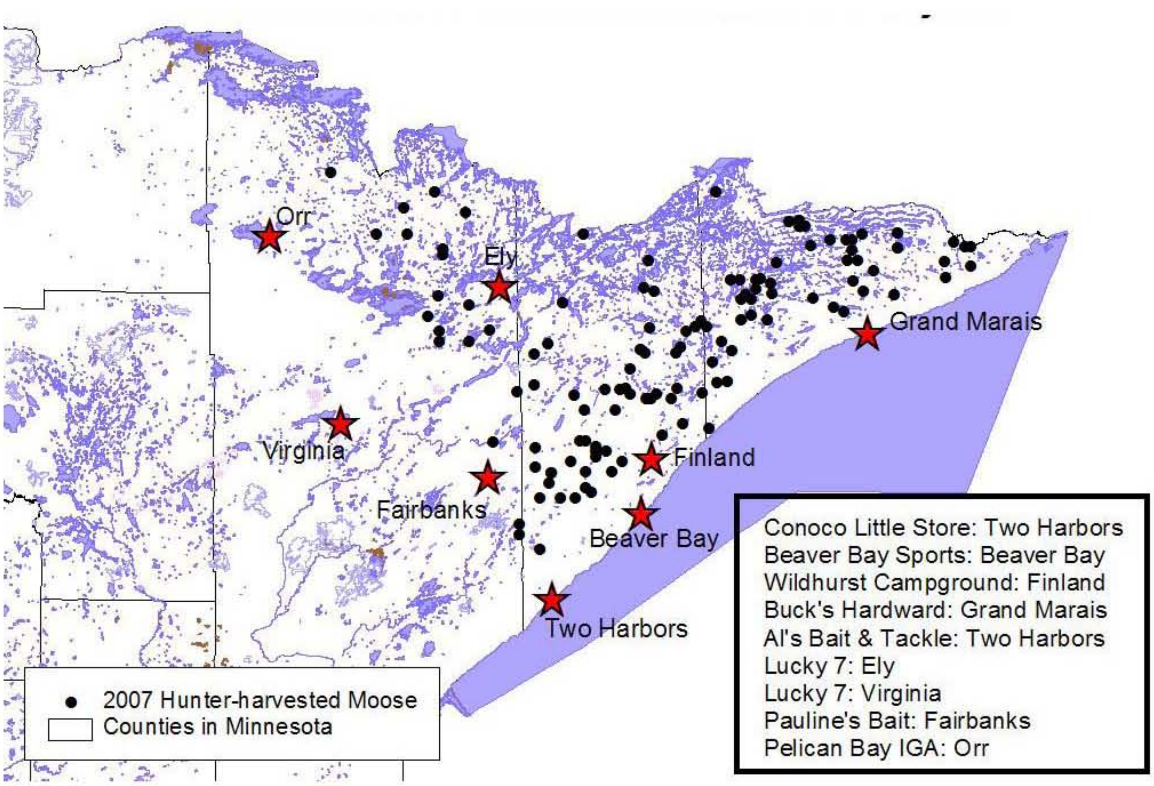

Figure 1. Locations of 2007 hunter-harvested moose included in health assessment project

ESTIMATING WHITE-TAILED DEER ABUNDANCE USING AERIAL QUADRAT SURVEYS

Brian S. Haroldson

SUMMARY OF FINDINGS

I estimated white-tailed deer (*Odocoileus virginianus)* abundance in select permit areas (PA) using stratified random and 2-dimensional systematic quadrat surveys to recalibrate deer population models and evaluate the impact of deer season regulation changes on population size. With rare exception, precision of population estimates was similar among permit areas. However, because population estimates were not corrected for sightability, estimates represent minimum counts and are biased low. Beginning in 2009, I will begin to develop a sightability estimator to adjust estimates for animals missed during surveys.

INTRODUCTION

Management goals for animal populations are frequently expressed in terms of population size (Lancia et al. 1994). Accurate estimates of animal abundance allow for documentation of population trends, provide the basis for setting harvest quotas (Miller et al. 1997), and permit assessment of population and habitat management programs (Storm et al. 1992).

The Minnesota Department of Natural Resources (MNDNR) uses simulation modeling to estimate and track changes in deer abundance and, subsequently, to develop harvest recommendations to keep deer populations within goal levels. In general, model inputs include estimates of initial population size and spatial/temporal estimates of survival and reproduction for various age and sex cohorts. Because simulated population estimates are subject to drift as model input errors accumulate over time, it is imperative to periodically recalibrate the starting population within these models with independent deer population estimates (Grund and Woolf 2004).

Minnesota's deer numbers are managed according to numeric population goals within 125 PAs. MNDNR recently revised deer population goals within each PA using a consensus-based, round–table approach consisting of 15-20 citizens representing varied interest groups (e.g. deer hunters, farmers, foresters, environmental groups, etc.; Stout et al. 1996). Revised goals are used to guide deer-harvest recommendations. Currently, deer populations exceed management goals in many PAs. A conventional approach of increasing the bag limit within the established hunting season framework has failed to reduce deer densities. As a result, MNDNR has begun testing the effectiveness of 3 non-traditional harvest regulations to increase the harvest of antlerless deer and reduce overall population levels (Grund et al. 2005). Accurate estimates of deer abundance are needed to evaluate these regulations.

My objective in this investigation is to provide independent estimates of deer abundance in select PAs that are within 20% of the true mean with 90% confidence (Lancia et al. 1994). Abundance data will be used to recalibrate population models to improve population management and to evaluate impacts of deer season regulation changes on deer abundance.

METHODS

I estimated deer populations in selected PAs using a quadrat-based, aerial survey design. Quadrat surveys have been used to estimate populations of caribou (*Rangifer tarandus*; Siniff and Skoog 1964), moose (*Alces alces*; Evans et al. 1966), and mule deer (*O. heimonus*; Bartmann et al. 1986) in a variety of habitat types. I employed a stratified, random sampling design, with quadrats stratified into 2 abundance classes (low, high) based on relative deer densities, in PAs where the local wildlife manager had prior knowledge about deer abundance and distribution. In other areas, I used a 2-dimensional systematic sampling design (Cressie 1993, D'Orazio 2003). Systematic designs are typically easier to implement, maximize sample distribution, and are often more efficient than simple or stratified random sampling designs (Cressie 1993, D'Orazio 2003).

Within each PA, quadrats were delineated by Public Land Survey section boundaries and a 20% sample was selected for surveying. Sample size calculations indicated this sampling rate was needed to meet accuracy and precision objectives. I excluded quadrats containing navigation hazards or high human development, and selected replacement quadrats in stratified PAs. Replacement quadrats were unavailable in the systematic PAs because of the rigid, 2-dimensional design. I used OH-58 helicopters during most surveys. A Cessna 182 airplane was used in 3 PAs dominated by intensive row-crop agriculture. To increase visibility, I completed surveys after leaf-drop and when snow cover measured at least 15 cm. A pilot and 2 observers searched for deer along transects spaced at 270-m intervals until they were confident all deer were observed. I used a real-time, moving-map software program (DNR Survey; MNDNR 2005), coupled to a global positioning system receiver and a tablet-style computer, to guide transect navigation and record deer locations and aircraft flight paths directly to ArcView GIS (Environmental Systems Research Institute 1996) shapefiles. I estimated deer abundance from stratified surveys using SAS Proc SURVEYMEANS (SAS 1999) and from systematic surveys using formulas developed by D'Orazio (2003). I evaluated precision using coefficient of variation (CV), defined as standard deviation of the population estimate divided by the population estimate, and relative error (RE), defined as the 90% confidence interval bound divided by the population estimate (Krebs 1999).

RESULTS AND DISCUSSION

I completed 5 surveys during January-February 2005, 8 surveys during January-March 2006, 7 surveys during January-March 2007, and 4 surveys during December 2007-February 2008 (Table 1). Stratified fixed-wing surveys were conducted in PAs 421 and 423. Based on long-term deer harvest metrics, population estimates in these areas were biased low. Several possibilities may explain this result: 1) deer were clustered in unsampled quadrats; 2) deer were wintering outside PA boundaries; 3) sightability was biased using fixed-wing aircraft; and/or 4) kill locations from hunter-killed deer were reported incorrectly. Land cover in these PAs was dominated by intensive row-crop agriculture. After crops were harvested each fall, deer habitat was limited to riparian areas, wetlands, abandoned farm groves, and undisturbed grasslands, including those enrolled in state and federal conservation programs. Although recreational feeding of deer could influence distribution, wildlife managers believed it was not a common practice in these PAs. Thus, I had no evidence to support non-traditional deer distribution in these units. I also had no reason to believe hunter registration errors had greater bias in these units than in other PAs. Although it was possible that deer occupied unsampled quadrats by chance, the use of optimal allocation to increase sampling effort in high strata plots because of expected higher deer densities should minimize this possibility. Furthermore, we surveyed 100% of the high-strata plots in PA 421, resulting in no unsampled quadrats. Sightability bias, however, is greater in fixed-wing aircraft than helicopters (LeResche and Rausch 1974, Kufeld et al. 1980, Ludwig 1981) and likely explained much of the bias I observed in these PAs. Consequently, all surveys have subsequently been conducted using a helicopter.

With the exception of PAs 421, 423, and 201, precision (CV, RE) of the population estimates was similar among PAs (Table 1). High precision in PA 421 was, in part, an artifact of sample design. Based on optimal allocation formulas, we selected and surveyed all high strata quadrats. Thus, because no sampling occurred within the high stratum (100% surveyed), sampling variance was calculated only from low strata quadrats. We observed few deer in these low strata quadrats, which resulted in low sampling variance and high precision of the population estimate. It is unlikely that this design (i.e., sampling 100% of high strata quadrats) will be feasible in all areas, especially if deer are more uniformly distributed throughout the landscape.

In contrast, survey precision in PAs 423 and 201 was poor. We observed few deer during either survey (*n*=144 and 56, respectively) and nearly all observations occurred within 1 or 2 quadrats. As a result, associated confidence intervals exceeded 60% of the population estimate (Table 1). Kufeld et al. (1980) described similar challenges with precision due to nonuniformity of mule deer distribution within strata in Colorado.

I did not correct population estimates for sightability. Thus, estimates represent minimum counts and are biased low. Although sightability correction factors for deer are available in the literature (Rice and Harder 1977, Ludwig 1981, Stoll et al. 1991, Beringer et al. 1998), I believe it would be inappropriate to apply them to our survey areas because of differences in sampling design and habitat characteristics. Beginning in 2009, I will attempt to develop a sightability estimator to adjust for animals missed during surveys. This estimator will improve population estimates by reducing visibility bias. Future analysis will also include *post-hoc* evaluation of habitat features present in quadrats containing deer. This will provide additional empirical data for use in quadrat stratification. In addition, the impact of winter feeding on deer distribution will be examined to determine if pre-survey stratification flights (Gasaway et al. 1986) are warranted.

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Table 1. Deer population and density estimates derived from aerial surveys in Minnesota, 2005-2008.

Sampling design	Year	Permit area	Population estimate N	Population estimate 90% CI	CV (%)	Relative error (%)[a]	Density estimate (deer/mi^2) Mean	Density estimate (deer/mi^2) 90% CI	Model estimate (deer/mi^2)
Systematic	2005	252	2,999	2,034 – 3,969	19.5	32.2	2.9	2.0 – 3.9	2
		257	2,575	1,851 – 3,299	16.9	28.1	6.2	4.4 – 7.9	7
	2006	204	3,432	2,464 – 4,401	17.0	28.2	4.6	3.3 – 5.9	5
		209	6,205	5,033 – 7,383	11.4	18.9	9.7	7.9 – 11.5	5
		210	3,976	3,150 – 4,803	12.5	20.8	6.3	5.0 – 7.6	7
		256	4,670	3,441 – 5,899	15.9	26.3	7.1	5.3 – 9.0	5
		236	6,774	5,406 – 8,140	12.1	20.2	16.8	13.4 – 20.2	37
	2007	225	5,341	4,038 – 6,645	14.7	24.4	8.0	6.0 – 9.9	24
		227	5,101	4,245 – 5,960	10.1	16.8	9.8	8.2 – 11.5	13
		346	7,896	5,736 – 10,062	16.4	27.4	22.7	16.5 – 29.0	31
	2008	265	4,575	3,766 – 5,384	10.7	17.7	9.2	7.6 – 10.9	n/a[b]
		266	3,853	2,733 – 4,977	17.5	29.1	6.2	4.4 – 8.0	n/a[b]
Stratified	2005	206	2,486	1,921 – 3,051	13.7	22.5	5.2	4.0 – 6.4	5
		342	3,322	2,726 – 3,918	10.8	17.7	9.1	7.5 –10.7	10
		421	631	599 – 663	3.0	5.0	0.8	0.8 – 0.9	5
	2006	201	274	100 – 449	37.6	61.9	1.6	0.6 – 2.7	6
		420	1,740	1,301 – 2,180	15.2	25.1	2.6	2.0 – 3.3	3
		423	472	179 – 764	37.4	61.5	0.9	0.3 – 1.4	5
	2007	343	6,982	5,957 – 8,006	8.9	14.6	10.1	8.6 – 11.6	29
		344	4,116	3,375 – 4,857	10.7	17.7	19.7	16.1 – 23.2	49
		347	5,482	4,472 – 6,492	11.1	18.2	12.6	10.3 – 14.9	13
		349	10,103	8,573 – 11,633	9.1	15.0	20.4	17.3 – 23.5	35
	2008	422	1,019	848 – 1,189	10.1	16.6	1.6	1.3 – 1.8	8
		262	2,065	1,692 – 2,437	10.9	17.9	3.0	2.5 – 3.6	n/a[b]

[a]Relative precision of population estimate. Calculated as 90% CI bound ⁄ N.

[b]Permit area boundaries were recently modified. No model estimate is available

ESTIMATING WHITE-TAILED DEER DENSITY USING TRAIL CAMERAS AT ITASCA STATE PARK IN NORTHWESTERN MINNESOTA

Emily J. Dunbar and Marrett D. Grund

SUMMARY OF FINDINGS

White-tailed deer (*Odocoileus virginianus*) densities in the farmland zone of Minnesota are estimated using simulation modeling and aerial surveys. Simulation modeling is not well suited for modeling population dynamics in small areas, such as Itasca State Park (Permit Area 287). In 2005, Itasca State Park was chosen as a study area to test alternative deer hunting regulations. Deer density estimates were needed to evaluate the effect of antler-point restriction regulations (>3-points-on-a-side) on the deer population in the park. A trail camera study was initiated in 2006 to monitor the population. Forty-two cameras were systematically placed at a density of 1 camera/130 ha. The ratio of legal bucks to sub-legal bucks (fork and spike bucks), and buck:antlerless deer ratios were calculated for 2, 3-week sampling periods before and after the hunting season. A change-in-ratio formula was used to estimate number of antlered deer. Total number of deer was estimated using sex and age ratio data. During 2006, cameras captured 12,484 images of deer over the 6-week sampling period. The pre-hunt deer density at the park was estimated at 85 deer/km^2 (33 deer/mile^2). This estimate was comparable to deer densities estimated by simulation modeling in adjacent permit areas (PAs). We conclude that the camera technique did provide a reasonable population estimate in 2006. The study was continued in 2007, but data entry is not complete.

INTRODUCTION

In 2005, Itasca State Park was chosen as a study area to test a 3-points-to-a-side antler-point restriction regulation for deer hunting. Deer density estimates were needed to evaluate the effect of the antler-point restriction on the density and demographics of the deer population.

Deer densities in the farmland zone of Minnesota have traditionally been estimated using simulation modeling and aerial surveys. Simulation modeling has been used throughout the farmland zone to estimate deer densities in individual PAs. Aerial surveys have been used in some PAs to recalibrate deer density estimates (Haroldson and Giudice 2006). However, due to errors caused by demographic stochasticity and seasonal movement patterns, simulation modeling is not recommended for small areas (Grund 2001). The small size of this park (approximately 130 km^2) made population modeling impractical. Also, aerial surveys were not feasible due to dense coniferous cover that existed in parts of the park. While deer density estimates were not available for the park, the simulated deer density immediately north of the park was estimated at 65 deer/km^2 (25 deer/mi^2) in spring 2007 (Lenarz 2007).

Infrared-triggered cameras have been used to estimate deer populations in a variety of habitat types and study area sizes (Moore 1995, Jacobson et al. 1997, Koerth et al. 1997, Warlock et al. 1997, and Roberts et al. 2006). Jacobson et al. (1997) developed a camera technique to estimate deer density using known numbers of individually identifiable mature bucks and associated age and sex ratios from the deer herd. In Texas, Koerth et al. (1997) compared camera population estimates to helicopter counts and concluded that both techniques provided reliable deer density estimates.

In Fall 2005, a pilot camera study initiated at Itasca State Park determined that a greater sampling effort, systematic sampling design, and pre-baiting of sites was needed. In 2006, the study was adjusted to accommodate the pilot study findings and provide a population estimate. The study was continued in 2007 and data are in the process of being entered. The study is planned to continue in 2008.

OBJECTIVE

- To estimate density and demographics of the deer herd at Itasca State Park.

METHODS

The trail camera study was conducted at Itasca State Park, located in northwestern Minnesota in 2006 from September to December. The park is approximately 130 km^2. The study area we used was approximately 6,400 ha located in the center of the park in order to minimize effects that movement patterns would have on deer observations along the perimeter of the park. Following the protocol developed by Jacobson et al. (1997), 42 trail cameras were placed at a density of 1 camera/130 ha systematically throughout the study area using the Systematic Point Sample tool in ArcView 3.3. Minor adjustments were needed to avoid wetland areas (Figure 1).

Each site was located in the field using a global positioning system unit and flagged. Sites were baited with 23 kg (50 lbs) of shelled corn 3 weeks prior to placing the cameras in the field. An additional 11 kg (25 lbs) of corn was added to each site 1 week before camera sampling began. A Bushnell TrailScout Pro 2.1 Mega Pixel (MP) or 3.0 MP trail camera was used at each site. Cameras were attached at a height of 1.5 m to a nearby tree using a cable. Each camera faced north and was 4-6 m from the established bait pile. Cameras were angled slightly downward to aim the infrared beam to a height approximately 1 m above the bait pile. Cameras were programmed to take pictures day and night with a 1-minute delay between pictures to minimize multiple pictures of the same deer. Cameras were in the field for 3 weeks both before and after the regular firearms season. Batteries and memory cards were replaced and corn (11 kg) was added to the baited area on a weekly basis.

Each image was examined using Adobe Photoshop 3.0, and images of species other than deer were deleted. We classified each deer as legal buck (3 points to a side), sub-legal buck, or antlerless deer. We excluded images if we were unable to classify a deer to an appropriate category.

Using harvest data for the PA and number of legal bucks in each sampling period, a standard change-in-ratio formula (Paulik and Robson 1969) was used to calculate the number of legal bucks:

$$N = (R_x - RP_2)/(P_1 - P_2)$$

where R_x = number of legal bucks harvested in PA 287
R = total number of all bucks harvested in PA 287
P_1 = proportion of legal bucks in preseason buck population
P_2 = proportion of legal bucks in postseason buck population

The density of bucks (D_B) was then calculated, and the density of antlerless deer (D_{AL}) was estimated by the following formula;

$$D_{AL} = D_B \text{ (1/ \% of bucks in preseason population)}$$

RESULTS AND DISCUSSION

Trail cameras captured 16,708 images during the 2, 3-week sampling periods. More images were captured during the postseason (9,349) than during the preseason period (7,359). Approximately 75% of the images contained a photo of a deer. Other species we observed included black bear (*Ursus americanus*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), snowshoe hare (*Lepus americanus*), a variety of avian species, gray wolf (*Canis lupus*), mice (*Peromyscus* spp.), squirrels (*Sciurus* spp. and *Tamiasciurus hudsonicus*), chipmunks (*Tamias striatus*), and humans. Some images (16%) contained no visible animal, and distortion of the image also caused some deer to be unidentifiable (8%). Thus, 11,368 images were useable for project purposes.

During the preseason period, we observed 1,505 legal bucks, 800 sub-legal bucks, and 3,420 antlerless deer images. During the postseason period, we observed 1,773 legal bucks, 1,509 sub-legal bucks, and 5,080 antlerless deer images. These camera and associated harvest data produced a preseason estimate of 85 deer/km^2 (33 deer/mile^2) using the change-in-ratio model. This prehunt density estimate agreed with simulated estimates produced by Lenarz (2007) when factored with harvest and winter mortality. We acknowledge that correlation between 2 estimates does not validate or invalidate either technique. However, the Lenarz (2007) model has been effective throughout the forested region of Minnesota to monitor deer population dynamics for >10 years. Thus, we were encouraged by the general agreement between the 2 estimates. Data collected in subsequent years will help assess the repeatability of the camera technique across years.

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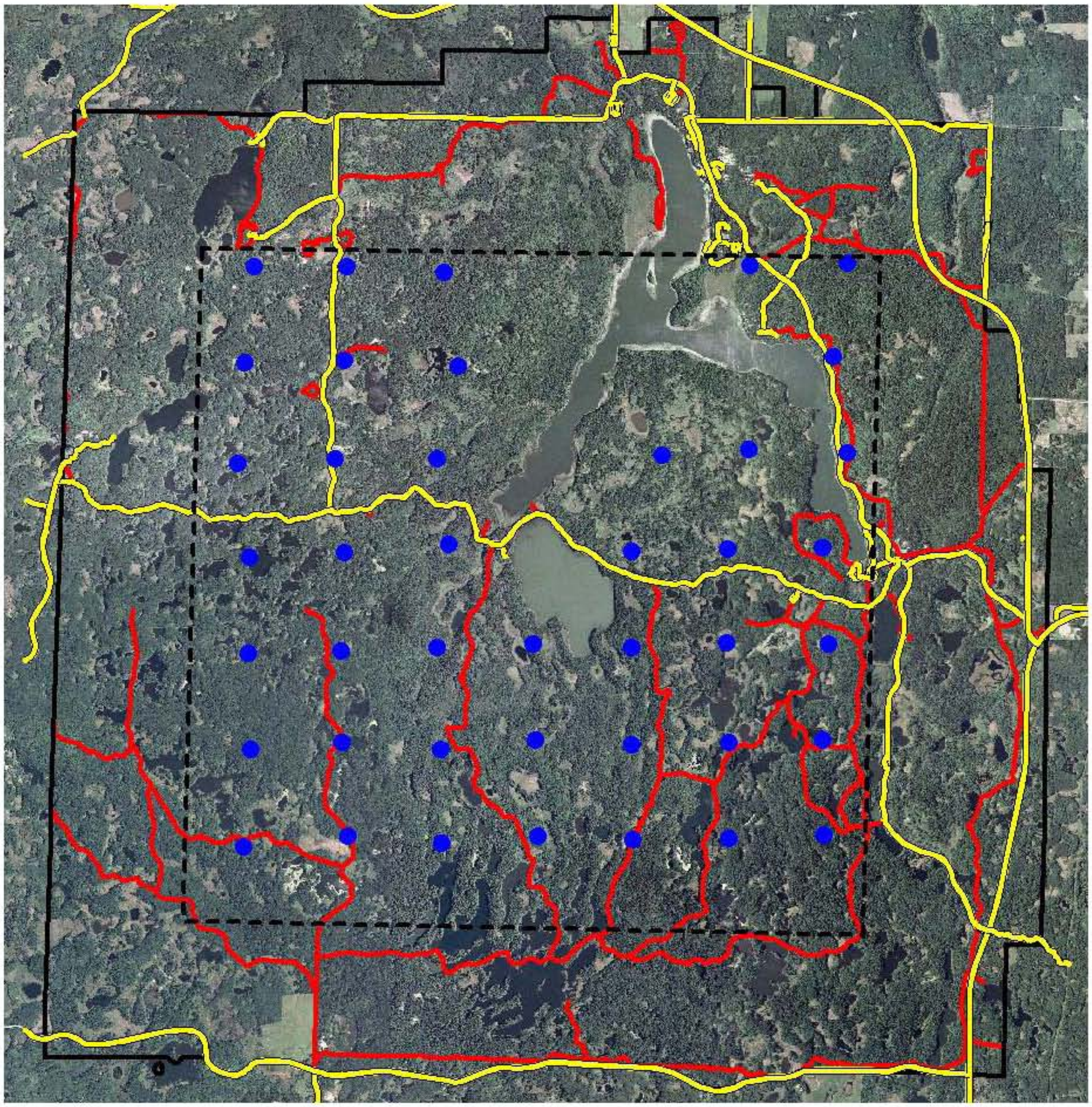

Figure 1. Locations of trail cameras (dots) in the study area (dashed line) at Itasca State Park, Minnesota in 2006.

EVALUATING THE EFFECTS AN EARLY ANTLERLESS-ONLY DEER HUNTING SEASON HAS ON ANTLERLESS HARVESTS

Marrett Grund

SUMMARY OF FINDINGS

I examined white-tailed deer (*Odocoileus virginianus*) harvest data associated with an early antlerless-only (EA) season offered in Minnesota. Individuals who purchased an early antlerless-only license had higher harvest success rates than hunters who did not purchase an early antlerless-only license. A higher percentage of early antlerless-only hunters also harvested multiple antlerless deer. Antlerless harvests associated with early antlerless-only hunters were approximately 300% higher than harvests associated with other hunters. I concluded that including an early antlerless-only season would increase the antlerless harvest. However, total antlerless harvest did not substantially increase because of very low hunter participation in the early antlerless-only season. I suggest conducting additional hunter surveys to assess why hunters have not participated in the early antlerless-only season and to determine methods to increase participation.

INTRODUCTION

Deer densities are above population goal levels in approximately half of Minnesota. Minnesota Department of Natural Resources (MNDNR) liberalized deer hunting regulations over the past 10 years in attempt to increase antlerless harvests thereby reducing deer densities. However, deer densities continued to increase in many permit areas despite the liberal hunting regulations. In 2005, MNDNR initiated a research project to evaluate alternative hunting regulations that may further increase antlerless harvests (Grund et al. 2005). An EA hunting season was 1 of the regulations tested in this experiment.

The concept of an EA season is to provide hunters with an additional opportunity to harvest an antlerless deer prior to the regular firearms season. Hunter participation in the EA season is voluntary, and previous research indicated that approximately 60% of deer hunters would hunt in an EA season if offered in the permit area they normally hunt (Fulton et al. 2006). A concern of MNDNR about the EA season was that hunters who were successful at harvesting an antlerless deer during the EA season would be less likely to harvest antlerless deer during other hunting seasons (herein referred to as Non-EA seasons). Thus, the potential existed that the EA season would simply shift antlerless harvest from 1 season to another and therefore EA harvest would not be additive to the overall harvest. This paper evaluates harvest patterns associated with the first 3 years of EA hunting seasons to address the compensatory/additive harvest concern.

OBJECTIVES

- Compare harvest patterns of hunters participating in the EA season against those hunters who did not participate.

METHODS

An EA season was offered in 5 permit areas in northwestern Minnesota and 3 permit areas in the north metro region of Minnesota during 2005, 2006, and 2007. EA seasons were offered in an additional 15 permit areas during 2007. The EA season was held the second weekend of October each year. Participating hunters were required to purchase an EA license at a reduced cost.

EA hunters, identified in MNDNR 2005, 2006, and 2007 Electronic Licensing System (ELS) databases, were categorized according to their respective permit areas. Individuals who purchased regular firearms licenses in the same permit areas, but did not purchase an EA hunting license (Non-EA hunters), were also identified in each database. All analyses were performed on 8 permit areas (209, 210, 225, 227, 236, 256, 257, and 260) that held an EA season since 2005, and on 8 permit areas (214, 221, 222, 241, 243, 244, 346, and 349) that implemented an EA season in 2007.

For the 8 permit areas hunted since 2005, I tallied the number of EA and Non-EA hunters each year. I then used the ELS deer harvest database to identify the number of EA hunters who harvested 0, 1, or 2 deer in each permit area during the EA season (bag limit was 2 antlerless deer during the EA season). I also determined the number of EA hunters who also harvested 0, 1, 2, or >2 antlerless deer during Non-EA seasons (annual bag limit was 5 antlerless deer). For making comparisons to Non-EA hunters, I used the ELS deer harvest database to determine the number of Non-EA hunters who harvested 0, 1, 2, and >2 antlerless deer each year. I then conducted a simple frequency analysis to estimate the percentage of individuals who harvested 0, 1, 2, and >2 deer for each group of hunters. To compare harvest efficiency between groups, I projected numeric antlerless harvests by standardizing the number of hunters in each group. I simply assumed there were 100 individuals hunting in each group and projected the numeric antlerless harvest based on the proportion of hunters who harvested 0, 1, 2, and >2 deer to standardize the results and make comparisons between the groups of hunters.

Similar analyses were performed on the 8 permit areas that were added in 2007. The primary difference was that I first identified the hunters who purchased an EA hunting license in 2007, and calculated the number of hunters who harvested 0, 1, 2, and >2 antlerless deer in all deer hunting seasons (EA and Non-EA) in 2007. I then identified the same individuals in the 2005 and 2006 ELS harvest databases and calculated the number of individuals harvesting 0, 1, 2, and >2 antlerless deer during those years. I then identified hunters who did not purchase an EA license in those 8 permit areas during 2007 and performed the same analyses. By conducting this analysis, I was able to identify whether an individual hunter harvested a deer in 2007 and then determine if the same individual also harvested a deer in 2005 or 2006. I compared harvest efficiency between groups of hunters and across years to determine if the EA season increased the overall number of antlerless deer killed during all hunting seasons.

RESULTS AND DISCUSSION

Participation Rates

For the 8 permit areas with EA hunting since 2005, hunter participation rates in the EA hunting season was low in all permit areas, averaging 14%, 16%, and 16% in 2005, 2006, and 2007, respectively. Participation rates in the northwest Minnesota permit areas were comparable to those observed in the north metro permit areas. These observed participation rates were noticeably lower than the predicted participation rates (60%), which were based on hunter survey data collected before the season was offered in 2005 (Fulton et al. 2006).

Similarly, participation rates were generally low in the 8 permit areas where an EA season was first offered in 2007. Participation rates were somewhat higher in permit areas located in central Minnesota (range=20-23% participation) than in southeastern Minnesota permit areas (range=13-15% participation).

An opportunity exists to increase the antlerless harvest during the EA season by increasing the percentage of hunters participating in the EA season. Additional modifications to the EA season may provide incentives for additional hunters to participate in this season. For example, previous survey data indicate that the ability to harvest an antlered deer is an important factor for hunters to support a regulation (Fulton et al. 2006). Perhaps allowing an individual to hunt antlered deer after registering 2 antlerless deer would increase hunter participation rates in the EA season. Further consideration about alternative methods to increase participation rates is clearly warranted if the intent is to increase antlerless deer harvests during the EA season.

Harvest Patterns

Early Antlerless-Only Permit Areas established in 2005

Approximately 33% of hunters harvested 1 antlerless deer during each EA hunting season (Table 1). Hunter success rates in the northwest permit areas were higher (45-55% individuals harvested deer) than those observed in the north metro (25-30% individuals harvested deer). Only 5% of hunters harvested 2 antlerless deer during the EA hunting seasons.

EA hunters also had slightly higher success rates (approximately 35%) during the Non-EA seasons than Non-EA hunters (approximately 30%). About 25% of hunters harvested 1 antlerless deer during Non-EA seasons regardless of whether they purchased an EA license. However, I observed higher percentages of EA hunters harvesting multiple antlerless deer during Non-EA seasons (Table 1).

Early Antlerless-Only Permit Areas established in 2007

Hunters who purchased an EA license for the first time in 2007 had high success rates even without the EA season in 2005 and 2006 (Table 2). However, while the success rate (approximately 33%) remained the same for Non-EA hunters in 2007, the success rate increased from approximately 50% in 2006 to 60% in 2007 for the EA hunters (Table 2). In addition, a higher percentage of these EA hunters harvested multiple antlerless deer in 2007 than they did in 2005 and 2006 (Table 2).

These results indicate that adding the EA season will increase hunter success rates as well as the percentage of hunters harvesting multiple antlerless deer. The results in Table 2 also suggest that EA hunters may be a unique group of hunters who are more willing to harvest antlerless deer, because these hunters had higher success rates than Non-EA hunters even when an EA season was not offered in 2005 and 2006. Thus, attempting to recruit additional hunters into this season may be challenging because the Non-EA hunters may have less interest in harvesting an antlerless deer regardless of hunting season. Further analyses should be conducted on Non-EA hunters to assess their willingness to harvest antlerless deer based on past harvest data.

Projected Antlerless Harvests

Even during the short, 2-day EA season, EA hunters had higher kill rates per hunter during the EA season than Non-EA hunters did during the Non-EA seasons in the permit areas established in 2005 (Figure 1). Similarly, EA hunters also had higher kill rates per hunter than Non-EA hunters during the Non-EA hunting seasons. EA hunters had approximately 300% higher kill rates per hunter than Non-EA hunters when the EA and Non-EA harvests were totaled for the EA hunters in 2007.

Likewise, projected harvests were higher for EA hunters in the EA permit areas established in 2007 (Figure 2). Harvest rates per hunter for Non-EA hunters were comparable among years, and were consistently lower than the group of hunters who purchased an EA license in 2007. Although the 2007 kill rate per hunter remained the same for Non-EA hunters, the kill rate per hunter increased by 30% for the group of hunters who purchased an EA license in 2007 (Figure 2).

These projected harvests suggest that including an EA season will effectively increase the antlerless harvest by increasing the success rate for EA hunters and increase the percentage of EA hunters harvesting multiple antlerless deer. In addition, it does not appear that adding the EA season will reduce the antlerless harvest for Non-EA hunters, which indicates that the additional harvest that occurs by EA hunters is additive.

MANAGEMENT IMPLICATIONS

These findings suggest that the EA hunting season will increase the antlerless harvest. However, wildlife managers should not expect marked increases in antlerless harvests with the type of EA season used during this study. An attempt should be made to increase participation rates during the EA season. Increasing participation rates is an opportunity that should be explored for increasing the effectiveness of the EA season because: 1) participation rates for the EA season were very low, and 2) it will likely be challenging to find ways (e.g., extending the EA season, adding another EA season) to increase harvest rates for EA hunters because the projected harvest rates were very high even with the existing EA season format. Additional human dimensions research should be conducted to improve our understanding about why hunters are not participating in the EA season and what could be done to increase participation rates.

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Table 1. Percentage of hunters harvesting 0, 1, 2, and >2 antlerless deer during the early antlerless-only and during other available hunting seasons in early antlerless-only season permit areas[a] established in 2005, 2005 – 2007, Minnesota. For early antlerless-only hunters, harvests occurring during the early antlerless-only season were not included with the other hunting seasons.

	Early antlerless-only hunters							Non-early antlerless-only hunters			
	Early antlerless-only season[b]			Non-early antlerless-only seasons							
	0	1	2	0	1	2	>2	0	1	2	>2
2005	62	34	4	66	24	7	3	71	24	4	1
2006	58	35	7	66	25	7	2	71	24	4	1
2007	67	28	5	64	26	8	2	71	23	5	1

[a]Permit areas 209, 210, 225, 227, 236, 256, 257, and 260
[b]The bag limit of antlerless deer in the early antlerless-only season was 2 antlerless deer

Table 2. Percentage of hunters harvesting antlerless deer in permit areas[a] where early antlerless-only seasons were first implemented in 2007, Minnesota. Both groups of hunters were first identified in the 2007 deer harvest data, then the same hunters were identified in the 2005 and 2006 deer harvest databases. Values reflect percentages of individuals harvesting 0, 1, 2, >2 antlerless deer each year.

	Early antlerless-only hunters				Non-early antlerless-only hunters			
	0	1	2	>2	0	1	2	>2
2005	50	33	11	6	66	27	5	2
2006	52	30	13	5	66	26	6	2
2007	39	37	16	8	67	26	5	1

[a]Permit areas 214, 221, 222, 241, 243, 244, 346, and 349

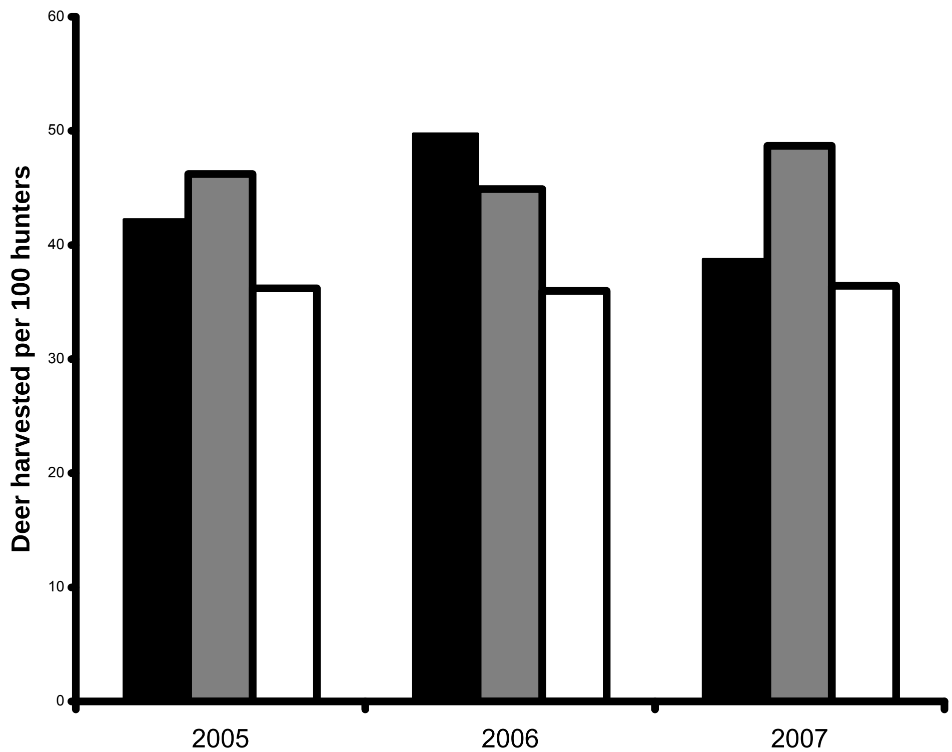

Figure 1. Number of antlerless deer harvested: 1) for every 100 early antlerless-only hunters during the early antlerless-only season (black), 2) for every 100 early antlerless-only hunters in other available hunting seasons (grey), and 3) for every 100 non-early antlerless-only hunters (white) in the early antlerless-only permit areas established in 2005, Minnesota, 2005-2008.

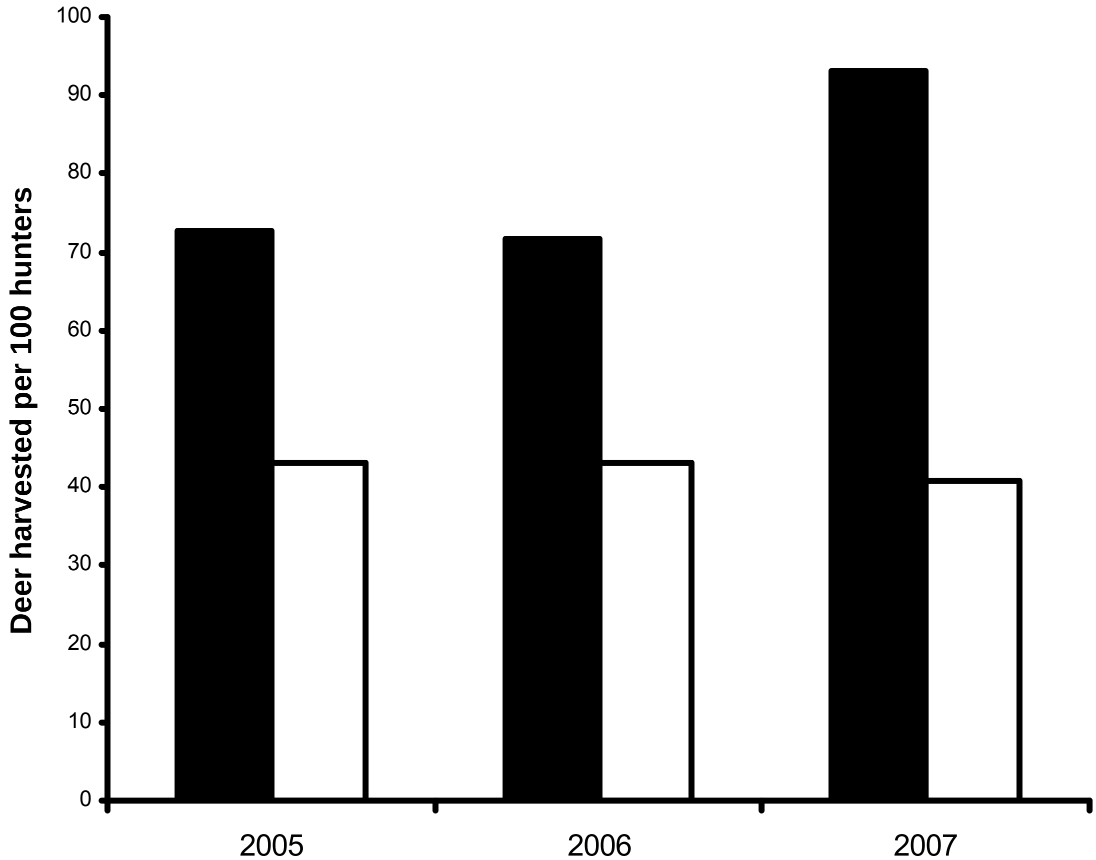

Figure 2. Number of antlerless deer harvested for every 100 early antlerless-only hunters who purchased an early antlerless-only license in 2007 (black), and the number of deer harvested for every 100 hunters who did not purchase an early antlerless-only license in early antlerless-only permit areas established in 2007 (white), Minnesota. Values for the early antlerless-only hunters in 2005 and 2006 depict the number of antlerless deer harvested without an early antlerless-only season.

FACTORS AFFECTING POPULATION INDICES OF RING-NECKED PHEASANTS

Alison Munsterman[1], Brock McMillan[1], Kurt Haroldson, and John Giudice

SUMMARY OF FINDINGS

The purpose of this study was to assess the validity of using replicated roadside surveys to estimate abundance of ring-necked pheasants (*Phasianus colchicus*) on 18, 23-km^2 (9-mi^2) study areas in southern Minnesota by comparing roadside indices to crowing indices adjusted for detection probability. For the crowing index, we used an auditory mark-recapture method to estimate mean detection probability. Crowing indices ranged from 1.2-6.4 males/stop. Roadside indices ranged from 0.9-11.9 males/route and were correlated to unadjusted crowing indices (r^2 = 0.42, P = 0.003). For crowing surveys, mean conditional probability of detection (conditional on males that crowed at least once during 3, 2-minute listening intervals) varied among study areas, was positively correlated with the total crows detected during the first 2-minute listening period, negatively correlated with the amount of disturbance/stop, and was slightly lower during the first listening period than during the second and third period.

INTRODUCTION

To make knowledgeable decisions, wildlife managers often need to estimate species population parameters (e.g., Hicks et al. 1941, Efford et al. 2005). Population size monitoring allows managers to make inferences on how a population is responding to environmental or regulatory changes and plan appropriate management alternatives (Ruff 1939, Eberhardt and Simmons 1987, Thomas 1996, Gibbs et al. 1998).

Populations of ring-necked pheasants are difficult to estimate because pheasants do not have the flocking habits of other birds, are relatively secretive, and difficult to capture (Brown 1947, Thomas 1996, Lancia et al. 2005). Therefore, pheasant populations are typically monitored using population indices. Although carefully designed population indices may provide unbiased estimates of population trends (Bart et al. 2004), they also suffer from high amounts of variability (Fisher et al. 1947).

The 2 most common types of population indices used for pheasants are roadside surveys and crowing surveys (Brown 1947, Rice 2003, Haroldson et al. 2006). Advantages of roadside surveys are that roads are easy to access and surveys require fewer personnel than other survey methods, which make roadside surveys relatively inexpensive. Roadside surveys are a type of convenience sampling, and the accuracy of roadside population indices may be affected by factors such as weather, road-related disturbance, distribution of roads and habitats, and variation in detection probability (Kimball 1949, Kozicky 1952, Anderson 2003, Hutto and Young 2003). Although weather may be controlled through carefully designed survey protocol, roads are non-randomly distributed and may not be representative of the habitats on the study area. In addition, detection probability is unknown.

We postulated that crowing surveys may not be affected by as many variables as roadside surveys. We hypothesized that factors such as road-related disturbance and the non-random distribution of roadside survey routes within the study area may affect the ability to detect pheasants during roadside surveys, but careful selection of crowing survey stops may yield representative coverage of a survey area and reduce the effect of road-related disturbance. In addition, we postulated that detection probability may be estimated with an auditory mark-recapture technique.

In this study, we used replicated surveys to compare crowing and roadside indices of male pheasants on 18 study areas in southern Minnesota. For the crowing index, we used

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closed mark-recapture methods to estimate mean detection probability and evaluate the assumption that the expected value of mean detection probability was similar among study areas. Our objectives were to: (1) evaluate use of an auditory mark-recapture technique to estimate mean detection probability of crowing male pheasants; (2) assess the validity of using replicated roadside surveys by comparing roadside indices to crowing indices (adjusted for detection probability) across the 18 study areas; and (3) evaluate factors that may influence the accuracy of roadside and crowing indices.

STUDY AREA

This study was conducted on 18 study areas in southern Minnesota. To facilitate pheasant surveys, 9 study areas were selected in each of 2 regions located near Windom and Faribault, Minnesota (Figure 1). Study areas averaged 23 km^2 (9 mi^2) in size and varied in the amount and distribution of grassland habitat, winter habitat, roads, and relative pheasant density (Haroldson et al. 2007).

METHODS

We conducted 10 crowing and 10 roadside surveys on each study area between 20 April and 31 May 2007. Crowing surveys and roadside surveys were scheduled independently (not necessarily on the same days). Trained observers conducted surveys on mornings meeting standardized weather conditions; however, surveys were completed even if weather conditions worsened during the survey. Observers rotated systematically among study areas to reduce the effect of observer bias.

Crowing Surveys

We located and conducted surveys at 9 stops on each study area. Stops were evenly distributed across each study area, based on an estimated 0.8 km (0.5 mile) auditory radius, to achieve maximum possible coverage of the study area and minimize overlap among stops (Figure 2). Where possible, we located stops on roads to facilitate convenient access. Where roads were not available, we located stops up to 0.4 km (0.25 mile) from roads. Due to road coverage and landscape obstacles (e.g., lakes), 2 study areas had only 8 stops.

Crowing surveys began 45 minutes before sunrise and were completed by sunrise on mornings with <16 km/hour (10 mile/hour) winds and no precipitation (Kimball 1949, Kozicky 1952, Luukkonen et al. 1997). Two observers performed surveys on each study area, dividing the 9 stops between them (4-5 stops/observer). The starting location for each survey route was selected randomly, and direction of travel was selected to minimize travel time and observer overlap. At the beginning and end of each survey route, observers recorded temperature, wind speed, and amount of dew. The percent of sky covered by clouds was recorded at the end of the survey route.

At each stop, observers counted the number of crowing males and the number of times each male crowed for 2 minutes. Sightings of pheasants and vocalizations other than crows were not recorded. At the end of each listening period, observers recorded which males they were certain were unique and which were potentially confused with adjacent males. Observers classified disturbance affecting their ability to hear crowing pheasants into 4 categories: none, low (e.g., distant tractor noise), medium (e.g., intermittent traffic), or high (e.g., constant background noise). For each study area, we calculated a population index (male pheasants counted/stop) from the mean number of crowing males counted/stop over all 10 repeated surveys.

We used extended listening periods at 4 of the 9 stops on each study area and day to evaluate whether a closed population capture-recapture approach (Huggins 1989) could be used to estimate the mean detection probability of male pheasants. Observers at mark-recapture stops continued to survey for 2 additional 2-minute listening periods immediately following the first listening period. The second and third listening periods identified which birds heard during the first period were heard again, and also birds that had not previously been heard.

Roadside Surveys

Roadside surveys were conducted at sunrise on mornings with <60% cloud cover, <16 km/hour (10 mile/hour) winds, temperatures >0°C, and dew present. Roadside survey routes ranged from 16-19 km (10-12 miles) in length and were conducted mainly on gravel roads. Starting location and direction of travel were randomly selected for each survey and observers rotated among study areas to reduce effects of observer bias. Observers drove approximately 24 km/hour (15 miles/hour) along survey routes and recorded the sex and number of pheasants observed. Observers used Global Positioning System receivers to record the location and time of each pheasant observation (Haroldson et al. 2007). For each study area, we calculated a population index (male pheasants counted/route) from the total number of male pheasants counted/total survey distance driven over all 10 repetitions. We standardized the index to males/16.1 km (males/10 miles) to adjust for variation in survey distance among study areas.

Habitat Evaluation

We estimated the amount and distribution of grass habitat available to pheasants by cover mapping to a Geographic Information System from recent aerial photographs. Cover types were verified by ground-truthing all habitat patches visible from roads.

RESULTS AND DISCUSSION

Observers completed 177 of 180 crowing surveys and all 180 of 180 roadside surveys. Pheasants were heard crowing on all study areas, with indices ranging from 1.2-6.4 males/stop (Table 1). Crowing frequencies ranged from 0.0-10.5 crows/male/stop with a mean of 1.7 crows/male. Pheasants were observed on all study areas during roadside surveys. Roadside indices ranged from 0.9-11.9 males/route (Table 1). Roadside indices were correlated with unadjusted crowing indices ($r^2 = 0.42$, $P = 0.003$). We observed more pheasants along gravel roads than paved roads ($t = -2.63$, $P = 0.013$, Figure 3) during roadside surveys, but not during crowing surveys ($t = -1.74$, $P = 0.09$, Figure 4).

We considered 16 mark-recapture models (Table 2) that described possible sources of heterogeneity in detection probability for crowing surveys. The best approximating model (M13) indicated that mean conditional probability of detection (conditional on males that crowed at least once during the 3, 2-minute listening intervals) varied among study sites (Figure 5), was positively correlated with the total crows detected during the first 2-minute listening period, negatively correlated with the amount of disturbance/stop, and was slightly lower during the first listening period than during the second and third period. There was evidence that the relationship between the crows detected during the first listening period and detection probability varied among study areas, but it is unclear whether this interaction reflected measurement error while recording crows or true spatial variation in the relationship between detection probability and crowing frequency and intensity. Conversely, mean detection probability was not strongly correlated with road type, weather conditions, survey date, or contractor (observer groups). The latter was not unexpected because our survey protocols were designed to minimize these effects on both roadside and crowing surveys.

We are currently analyzing data and have few results at this time. We plan to complete data analysis by June 2008 and have a final report by September 2008.

ACKNOWLEDGEMENTS

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Table 1. Pheasant crowing and roadside indices after repeated surveys (n) on 18 study areas in southern Minnesota during spring 2007.

		Crowing index		Roadside index	
Region	Study area	N	Males/stop	N	Males/route[a]
Windom	19	10	4.6	10	11.5
	20	10	6.4	10	10.5
	21	10	3.5	10	6.3
	22	10	5.5	10	11.9
	23	9.5[b]	5.0	10	11.0
	24	9.5[b]	4.7	10	4.2
	25	10	3.9	10	3.4
	26	10	5.5	10	7.9
	27	9.5[b]	2.7	10	2.7
Faribault	28	10	3.0	10	11.0
	29	10	3.9	10	3.2
	30	10	2.7	10	4.1
	31	10	4.2	10	7.1
	32	10	3.1	10	5.5
	33	10	3.7	10	4.2
	34	10	3.7	10	3.8
	35	10	3.5	10	2.1
	36	10	1.2	10	0.9

[a]Route length standardized to 16.1 km (10 miles).
[b]For 1 survey, half of stops were not surveyed.

Table 2. Closed population capture-recapture models (Huggins 1989) used to estimate and evaluate factors affecting conditional probability of detection in pheasant crowing surveys in southern Minnesota, spring 2007.

Model	Covariates[a]	Npar	AICc	ΔAICc	Weight	Deviance
13	t2bin + site * t1crows + disturb	38	13067	0.0	1	12991
11	t2bin + site + t1crows + disturb	21	13210	142.2	0	13168
14	t2bin + sagrass + t1crows + disturb	5	13237	169.8	0	13227
16	t2bin + sagrass + contract + t1crows + disturb	10	13238	170.8	0	13218
10	site + t1crows + disturb	20	13253	186.0	0	13213
8	t1crows + disturb	3	13284	216.4	0	13278
9	t1crows + I(t1crows^2) + disturb	4	13286	218.4	0	13278
15	t2bin + site + rtype	21	13561	493.9	0	29898
6	site + disturb	19	13596	528.7	0	13558
12	contract+jdate+mbsun2+avg.dewst+avg.temp +avg.wind+avg.clds+disturb	13	13609	541.5	0	13583
3	site	18	13618	550.1	0	29960
7	rtype + disturb	4	13668	600.5	0	13660
2	contract	6	13675	607.7	0	30042
5	disturb	2	13678	610.8	0	13674
4	rtype	3	13703	635.5	0	30076
1	1	1	13723	655.4	0	30100

[a] t2bin= crows detected during the second and third listening periods
site=study area
t1crows= crows detected during the first listening period
disturb= level of disturbance encountered by observer
sagrass= percent of grass habitat located within the study area
contract= observer groups
rtype= road type (paved, gravel, or off-road)
jdate= julian date
mbsun2= minutes before sunrise
avg.dewst= average amount of dew present at start of survey
avg.temp= average temperature
avg.wind= average wind speed
avg. clouds= average amount of cloud cover

Figure 1. Locations of study areas (white squares) within Minnesota's pheasant range (shaded portion of the map), spring 2007.

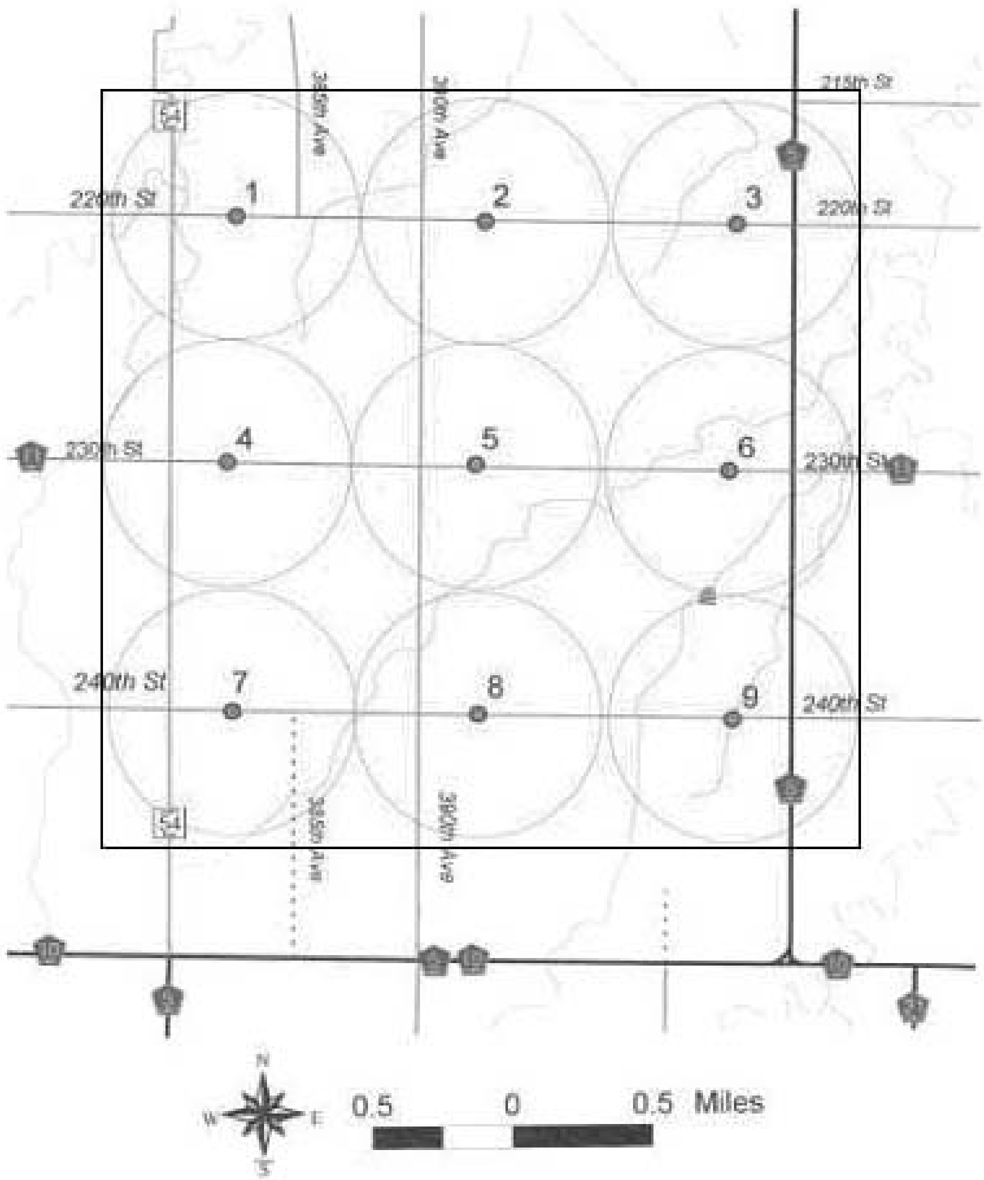

Figure 2. Typical study area showing 9 crowing survey listening stops and estimated 0.8 km (0.5 mile) auditory radii, Minnesota, spring 2007.

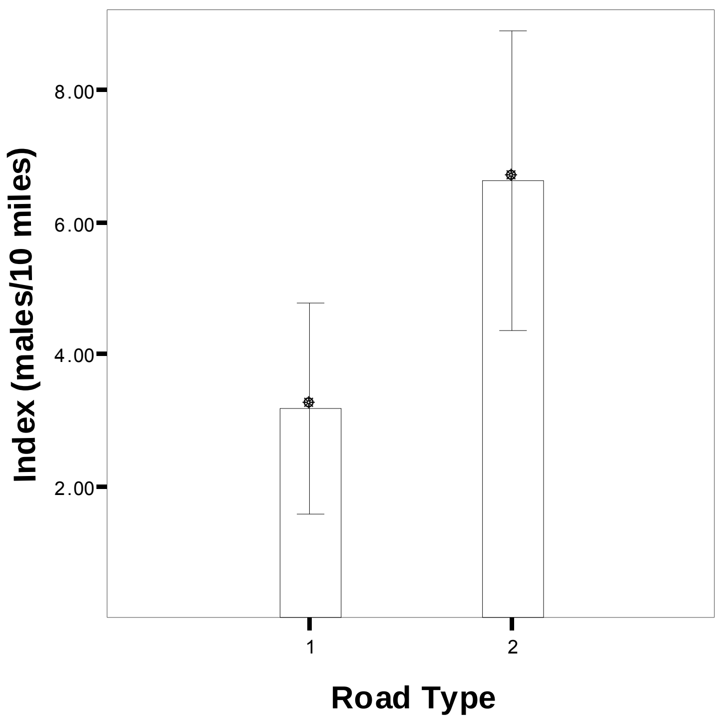

Figure 3. Effect of road type (1 = paved, 2 = gravel) on mean roadside survey indices in Minnesota, spring 2007. Error bars show 95% confidence intervals of means.

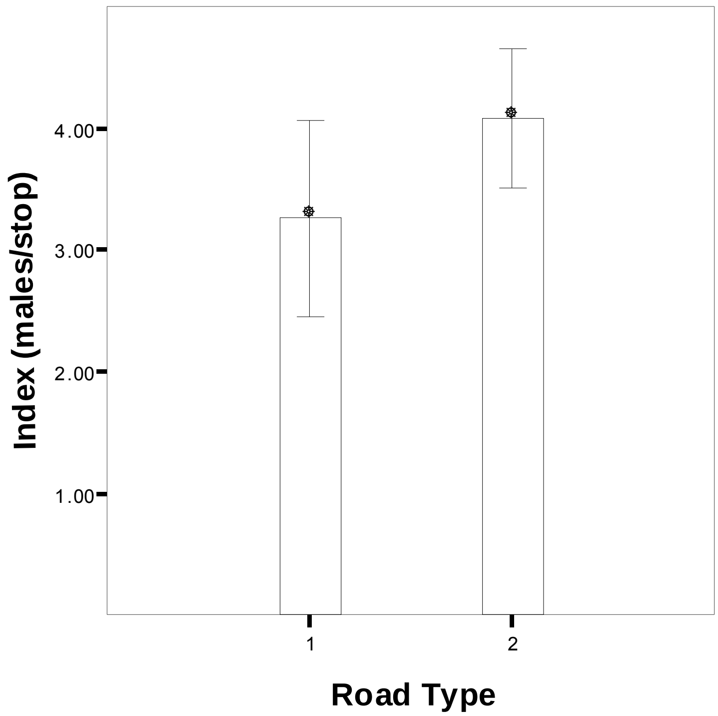

Figure 4. Effect of road type (1 = paved, 2 = gravel) on mean crowing survey indices (during the first listening period) in Minnesota, spring 2007. Error bars show 95% confidence intervals of means.

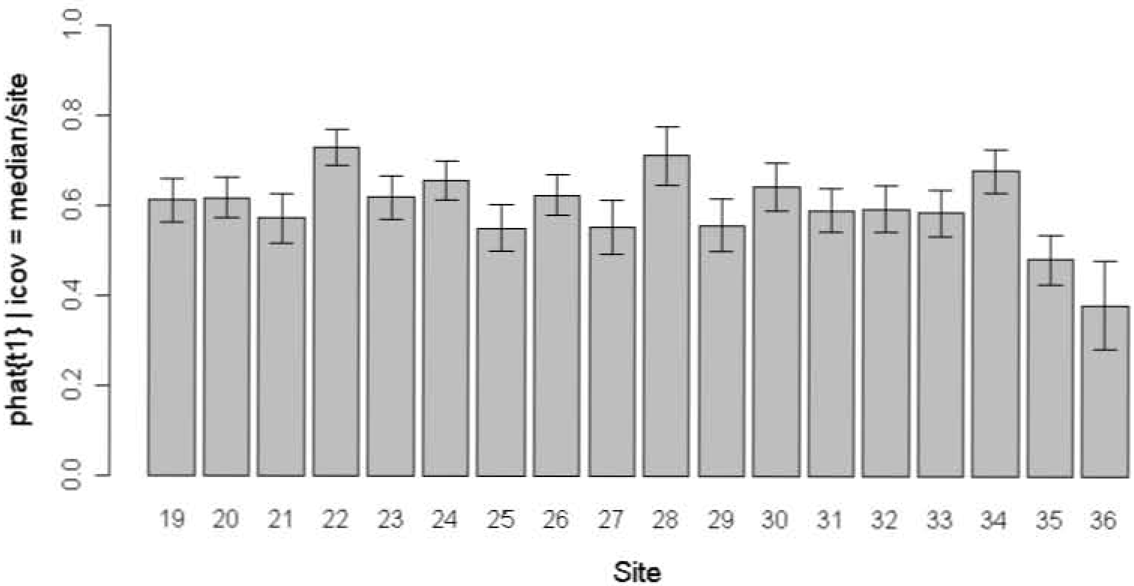

Figure 5. Mean conditional probability of detection in 10 replicated crowing surveys on 18 study areas in southern Minnesota during spring 2007. Site-specific estimates of detection are based on median covariate values for total crowing calls/stop and relative disturbance/stop.

WILD TURKEY RESEARCH NEEDS SURVEY

Eric Dunton

SUMMARY OF FINDINGS

I conducted a wild turkey (*Meleagris gallopavo*) research needs survey to determine informational needs of natural resources professionals in Minnesota. The most common information or research need for habitat management included identification of turkey habitat requirements and improved understanding of turkey responses to habitat manipulations. The most common turkey ecology information needs were related to turkeys occurring on the northern edge of their range and included factors such as winter sources of food, mortality factors, depredation, and competition between turkeys and other species. Information needs for harvest management focused primarily on the population/permit setting process. Finally, respondents wanted information on urban turkey issues, and strongly advocated ending the turkey translocation program

INTRODUCTION

Brinkman and Kimmel (2000) developed a list of informational needs to improve wild turkey management in Minnesota from a research needs survey of Minnesota Department of Natural Resources (MNDNR) staff. The Long Range Plan for the Wild Turkey in Minnesota (MNDNR 2006) required an updated research needs survey in 2007. Thus, I surveyed MNDNR and National Wild Turkey Federation (NWTF) staff to identify current research and informational needs. This information will be used to develop focused research projects that address important information needs.

METHODS

I sent 100 surveys (Appendix 1) via e-mail on 5 December 2007 to MNDNR Regional Wildlife Managers, Assistant Regional Wildlife Managers, Area Wildlife Managers, Assistant Area Wildlife Managers, and a select group of MNDNR Conservation Officers, MNDNR Foresters, MNDNR Parks Managers, and NWTF personnel. I sent a follow-up reminder on 21 December 2007 to 84 non-respondents and a third and final reminder on 22 January 2008 to 72 non-respondents.

RESULTS

The overall response rate for the survey was 39% after 3 e-mailings (Table 1). The majority (69%) of respondents stated they needed more information to effectively manage wild turkeys in their work area. Commonly cited needs were for information on MNDNR's wild turkey population/permit allocation model (50%), managing urban turkey problems (45%), effects of forest management on turkeys (44%), winter sources of food (40%), timber stand improvement (38%), and effect of early mowing on turkeys (38%) (Table 2). A majority (55%) of respondents reported adequate information on turkey mortality factors (Table 3). However, the most frequent request for research information was for turkey mortality factors (59%). Other requests were for research information on hunter density/hunt quality (55%), winter sources of food (48%), turkey depredation (48%), and forest habitat management techniques (47%) (Table 3).

More information on habitat management techniques for wild turkeys was needed for invasive species control (48%), mowing effects (45%), and grassland management (44%) (Table 4). No consistent responses were received from respondents when asked to identify management practices that should be evaluated for inefficiencies (Table 5). Nearly all respondents (90%, n=21) identified trap and transplant as a program that should not be continued (Table 6).

Of the 23 respondents reporting urban turkey issues in their work area, the most common problems were roosting on houses/buildings, pecking at reflections in windows, eating from bird feeders (52%), depredation in cattle feedlots or stored grain facilities (17%), concern about release of game farm birds (13%), and lack of information available to the public for managing urban nuisance turkey problems (9%) (Table 7).

When asked to identify research projects that should be initiated, respondents offered a variety of responses (Table 8). Habitat-related projects (45%) were the most common response.

Respondents identified the biggest challenges to turkey management in the next decade as managing urban/nuisance/depredation issues (35%), hunter access to private land for hunting (23%), northern turkey management (12%), and ending the trap and transplant program (12%) (Table 9).

When asked to rank the top 5 research or evaluation needs, respondents ranked the following items in order of importance (1 = most important, 5 = least important): forest habitat management (mean rank = 1.6), winter sources of food (2.3), habitat management in prairie/agricultural system (2.8), invasive species control (3.0), urban turkey management (3.2), and land acquisition (3.2) (Table 10). However, priorities varied among respondents. The 5 research or evaluation needs most frequently selected were habitat management in prairie/agricultural system (64% of respondents), land acquisition (50%), setting permit quotas to balance opportunity with hunt quality and safety (50%), winter sources of food (45%), invasive species control (41%), and urban turkey management (41%). Other research needs identified by respondents are listed in Table 11.

DISCUSSION

The response rate in this survey was much lower than for an earlier research needs survey (69%; Brinkman and Kimmel 2000) and responses had more variation. However, I detected common themes that appeared across multiple questions. The most common information or research need for habitat management included identification of turkey habitat requirements and improved understanding of turkey responses to habitat manipulations. This was important both in northern Minnesota where populations are expanding and in prairie/agricultural areas where turkey habitat is generally limited to riparian corridors.

Respondents also indicated a need for information on turkey ecology at the northern edge of Minnesota's turkey range, including winter sources of food, mortality factors, depredation, and competition between turkeys and other species.

Although most questions in the survey pertained to future research, I also asked questions about management projects. Respondents strongly indicated a need for information on the population/permit setting process and factors used in a model used for this process (Kimmel 2000). Respondents also need information on urban turkey issues. Finally, respondents strongly advocated ending the turkey translocation program, which represents a similar opinion from the 1999 survey (Brinkman and Kimmel 2000).

ACKNOWLEDGEMENTS

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Table 1. Groups surveyed and number of respondents for the 2007 wild turkey research needs survey, 2007, Minnesota.

Survey Groups	Surveyed	Respondents
Minnesota DNR Wildlife Section		
Region 1	24	10
Region 2	21	3
Region 3	22	10
Region 4	21	9
Minnesota DNR Conservation Officers	5	4
Minnesota DNR Forestry Section	2	2
Minnesota DNR Parks Section	3	1
National Wild Turkey Federation	2	0
Total	**100**	**39**

Table 2. Response for question 2: Do you have adequate information on the following wild turkey ecology and management topics? Wild turkey research needs survey, 2007, Minnesota.

		Response (%)		
Informational need	n	Yes	No	No opinion
Population/permit allocation model	32	38	50	13
Managing urban turkey problems	33	33	45	21
Effects of forest management on turkeys	34	50	44	6
Winter sources of food	35	57	40	3
Timber stand improvement	32	56	38	6
Effects of early mowing on turkeys	32	50	38	13
Turkey mortality factors	33	55	36	9
Turkey winter survival	34	53	35	12
Turkey productivity	33	52	33	15
Turkey habitat requirements	35	63	29	9
Other - Northern turkey ecology	2			
Other - Turkey registration compliance	1			
Other - Identifying game farm birds	1			
Other - Disease prevalence	1			
Other - Genetics	1			
Other - Turkey interactions with domestic fowl	1			
Other - Optimal permit numbers	1			

Table 3. Response for question 3: Should the DNR should conduct research on the following topics? Wild turkey research needs survey, 2007, Minnesota.

		Response (%)		
Research topics	n	Yes	No	No opinion
Turkey mortality factors	34	59	18	24
Hunter density/hunt quality	33	55	18	27
Winter sources of food	33	48	24	27
Turkey depredation	33	48	24	27
Forest habitat management techniques	30	47	20	33
Turkey habitat requirements	34	41	29	29
Population model sensitivity	32	41	16	44
Turkey winter survival	32	38	34	28
Turkey productivity	32	34	31	34
Urban turkey problems	32	34	28	38
Other -Competition with other species	1			
Other - Genetics	1			
Other - Population in prairie/ag habitat	1			
Other - Spring dispersal from wintering flocks	1			

Table 4. Response for question 4: Do you need more information on any of the following habitat management techniques for wild turkeys? Wild turkey research needs survey, 2007, Minnesota.

		Response (%)		
Management technique	n	Yes	No	No opinion
Invasive species control	31	48	39	13
Prescribed fire	31	45	45	10
Mowing (effects, height, timing)	31	45	32	23
Oak regeneration and management	32	44	44	13
Grassland Management	32	44	34	22
Timber stand improvement	33	36	48	15
Other- grass mixes to plant	1			
Other - value of food plots	1			

Table 5. Responses for question 5: Which management practices should be evaluated for inefficiencies, and how might these practices/techniques be improved? Wild turkey research needs survey, 2007, Minnesota.

n	Management practice
4	Evaluate trap and transplant program
2	Benefit of native species compared to non-native need more information
2	Best management practice for forest openings, need more information
2	Turkey habitat management in prairie/ag area, need more information
1	Use of food plots by turkeys
1	Monitoring and evaluation of habitat projects on private lands
1	Spring permit allocation model
1	Harvest mortality (compensatory or additive)
1	Urban and nuisance turkey management
1	Need more information on forest stand improvement
1	Grassland management in relation to bio-harvest, impacts on turkeys
1	Turkeys being vectors for invasive species dispersal (buckthorn), need more information
17	**Total respondents**

Table 6. Responses for question 6: Are there any wild turkey management activities that you feel should not be continued? Wild turkey research needs survey, 2007, Minnesota.

n	Management activity
19	End Trap and Transplant
1	Move hunting hours back to 5 p.m. closure
1	Planting and maintaining non-native vegetation on public land
1	Do not develop a fall permit allocation model
21	**Total respondents**

Table 7. Responses for question 7: What urban turkey management issues do you face in your work area? Wild turkey research needs survey, 2007, Minnesota.

n	Urban turkey issues
12	No urban turkey issues in work area
12	Roosting on houses buildings, pecking at reflection, eating from bird feeders
4	Turkey presence in cattle feed lots or stored grain facilities, issues associated with depredation
3	Release of game farm birds that lead to nuisance complaints
2	Need website to refer public on dealing with urban/nuisance turkeys, need better Information and education
1	Need more information on how to differentiate game farm birds from wild birds
1	Evaluate peoples interest in turkeys over time as density increases and find ways to control density in urban areas without hunting

Table 8. Responses for question 8: Are there any new wild turkey research projects that you feel should be initiated? Wild turkey research needs survey, 2007, Minnesota.

n	Research project
4	Minimum habitat requirements for turkeys in mixed prairie/ag habitat
3	Assessment of diseases in turkeys and disease management
2	Competition between turkeys and other species
2	Spring turkey dispersal from wintering flocks and factors that affect dispersal
1	Monitor loss of hardwoods and changing land use practices
1	Interactions between sandhill cranes and turkeys and possible disease transmission between species
1	Turkey habitat management in northern Minnesota
1	Affect of prescribed fire on reducing maple/basswood and stimulating oak regeneration, and affect prescribed fire has on controlling invasive species
1	Monitor affects of oak regeneration after timber sales using various cutting methods (I.e., clearcuts, shelterwood, group selection)
1	Turkey mortality and productivity
1	Forest habitat management techniques to encourage hard mast and soft production
1	Value of corn food plots
1	Oak regeneration
1	Genetic origins of flocks in western Minnesota
1	Impact of coyotes and other predators on turkey population outside historic range
1	Urban turkey problems
1	Northern turkey food habits
1	Northern turkey ecology
1	Evaluate permit setting process to gauge impact of hunter density on hunt quality
1	Impact turkeys have on oak regeneration in southern Minnesota
22	**Total respondents[a]**

[a] some respondents provided > 1 response

Table 9. Responses for question 9: In the next decade, what do you see as the biggest challenge to turkey management in Minnesota? Wild turkey research needs survey, 2007, Minnesota.

n	Turkey management
9	Managing urban/nuisance turkeys and real or perceived crop depredation
6	Hunter access to private land and hunter interference
3	Northern turkey issues; winter survival, providing quality winter habitat, maintaining populations without feeding
3	Ending trap and transplant program
2	Rural development resulting in loss of habitat and hunting opportunity
2	Loss of oaks due to succession to maple/basswood, proper oak management
1	Managing turkeys in mixed ag/prairie habitat
1	Loss of habitat and loss of protected land in programs (i.e., conservation reserve program [CRP])
1	Providing quality habitat for public hunting, there is little money for acquisition of quality forested land in prairie/ag landscape
1	Hunt quality and not quantity
1	People management, finding balance between
1	Influence of game farm birds on wild populations
26	**Total respondents**

Table 10. Responses for question 10: Select 5 items below from either category that you feel have the greatest need for research or evaluation and rank them in order of importance from 1 to 5 (1 = most important, 5 = least important). Wild turkey research needs survey, 2007, Minnesota.

Wild turkey research or informational/evaluation need	Mean rank	Respondents (%)
Forest habitat management	1.6	32
Winter sources of food	2.3	45
Habitat management in mixed prairie/agricultural system	2.8	64
Invasive species control	3	41
Urban turkey management	3.2	41
Land Acquisition	3.2	50
Use of food plots by turkeys	3.3	32
Turkey winter survival	3.3	18
Survey hunters to quantify satisfaction and hunt quality	3.3	18
Fall population survey	3.5	9
Setting permits to achieve; a high quality hunt, maximize hunting opportunity, maintain Safety	3.5	50
Population/permit allocation model	4	23
Trap and Transplant	4.3	14
Other	2.3	27
Other - Annual mortality study	2	9
Other - Depredation management	4	5
Other - Disease management	1	5
Other - Genetics	2	5
Other - Turkey survival in farmland region	1	5
Other - Northern turkey ecology	3	5
Other - Impact on tree regeneration	1	5
Other - Productivity	1	5
Other - Control of game farm birds	5	5

Table 11. Responses to question 11: Additional comments. Wild turkey research needs survey, 2007, Minnesota.

n	Comment
3	Hunter density too high, need to be more concerned with quality hunting rather than quantity of permits that are being offered
1	Need more public involvement with turkey management and permit setting
1	Make more permits available, develop alternative strategies for issuing permits (i.e., over the counter for last 2 time periods, or after a permit has been filled make it available to someone else for remainder of time period)
1	Remove or alter landowner preference, landowners should have to hunt on their own land if they are awarded preference
1	Habitat development/acquisition/land preservation need to be accelerated
1	Concern about competition between turkeys and other species, affect turkeys are having on other species outside of historic range
1	Concern over what affect artificially high turkey populations are having on oak regeneration

Appendix 1.

2007 Wild Turkey Research Needs Survey

The purpose of this survey is to determine and prioritize informational needs for effective wild turkey management in Minnesota

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Name:__________________________

1. Do you need information to more effectively manage wild turkeys in your work area?
_____Yes _____No

2. Do you have adequate information on:

	Yes	No	No opinion
Turkey habitat requirements	___	___	____
Winter sources of food	___	___	____
Timber stand improvement	___	___	____
Effects of early mowing on turkeys	___	___	____
Effects of forest management on turkeys	___	___	____
Turkey winter survival	___	___	____
Turkey productivity	___	___	____
Turkey mortality factors	___	___	____
Managing urban turkey problems	___	___	____
Population/permit allocation model	___	___	____
Other – specify__________________	___	___	____
Other – specify__________________	___	___	____
Other – specify__________________	___	___	____

3. Do you think the DNR should conduct research on:

	Yes	No	No opinion
Forest habitat management techniques	___	___	____
Turkey habitat requirements	___	___	____
Winter sources of food	___	___	____
Turkey winter survival	___	___	____
Turkey mortality factors	___	___	____
Turkey productivity	___	___	____
Turkey depredation	___	___	____
Urban turkey problems	___	___	____
Hunter density/hunt quality	___	___	____
Population model sensitivity	___	___	____
Other – specify_____________________	___	___	____
Other – specify_____________________	___	___	____

4. Do you need more information on any of the following habitat management techniques for wild turkeys?

	Yes	No	No opinion
Timber stand improvement	____	____	_____
Oak regeneration and management	____	____	_____
Invasive species control	____	____	_____
Prescribed fire	____	____	_____
Mowing (effects, height, timing)	____	____	_____
Grassland management	____	____	_____
Other – specify_______________	____	____	_____
Other – specify_______________	____	____	_____
Other – specify_______________	____	____	_____

5. Which management practices should be evaluated for inefficiencies, and how might these practices/techniques be improved?

6. Are there any wild turkey management activities that you feel **should not be** continued?

7. What urban turkey management issues do you face in your work area?

8. Are there any new wild turkey research projects that you feel should be initiated?

9. In the next decade, what do you see as the biggest challenge to turkey management in Minnesota?

10. Select **5** items below from either category that you feel have the greatest need for research or evaluation and rank them in order of importance from **1** to **5** (1 = most important, 5 = least important).

Habitat Management/Turkey Biology	**Rank**
Use of food plots by turkeys	_____
Winter sources of food	_____
Forest habitat management	_____
Habitat management in mixed prairie/agricultural system	_____
Invasive species control	_____
Urban turkey management	_____
Turkey winter survival	_____
Land acquisition	_____
Trap and transplant	_____
Other-specify_________________	_____
Other-specify_________________	_____

Surveys/population modeling/permit setting	
Survey hunters to quantify satisfaction and hunt quality	_____
Fall population survey	_____
Population/permit allocation model	_____
Setting permits to achieve; a high quality hunt, maximize hunting opportunity, and maintaining safety	_____
Other-specify_________________	_____
Other-specify_________________	_____

11. Additional comments:

EVIDENCE OF WILD TURKEYS IN MINNESOTA PRIOR TO EUROPEAN SETTLEMENT

Jennifer R. Snyders[1], Martin D. Mitchell[1], and Richard O. Kimmel

SUMMARY OF FINDINGS

Some scholars question the existence of wild turkeys (*Meleagris gallopavo*) in Minnesota prior to European settlement. We conducted a literature search for reliable evidence of wild turkey existence in Minnesota. There were 6 reliable historic wild turkey sightings for southern Minnesota. Based on these sightings, we estimated the northern ancestral wild turkey range for Minnesota (Figure 1).

INTRODUCTION

Over the past 4 decades, wild turkeys have been successfully reintroduced into Minnesota (Minnesota DNR 2006). At the turn of the 20th century, the wild turkey population declined and was extirpated in much of the United States due to over hunting and loss of habitat (Aldrich 1967a, Lewis 1987, Kennamer et al. 1992, Minnesota DNR 2006). The last documented sighting of wild turkeys in Minnesota prior to restoration was in 1871 (Leopold 1931, Latham 1956). Still, some scholars question whether wild turkeys were indigenous to Minnesota, because historical references are incomplete or perhaps erroneous. There are apparently no historical specimens and Swanson (1940) stated that “no trustworthy turkey record for Minnesota” exists. The objective of this research was to locate, summarize, and evaluate the various reports about wild turkeys in Minnesota, prior to European settlement.

METHODS

We conducted a literature search for historical documentation of wild turkeys in Minnesota. The literature that we searched included books, articles and reports in archives, journal entries, and publications from the Minnesota Historical Society and the Wisconsin Historical Society. The objectives for this research was to evaluate the accuracy of the historical information pertaining to wild turkeys in Minnesota and estimate their ancestral range.

RESULTS

It has been questioned whether wild turkeys were actually native to Minnesota (Roberts 1932; Aldrich 1967b). As noted, Swanson (1940) found “no trustworthy turkey record for Minnesota.” Roberts (1932: 425) stated: “There is no absolutely positive evidence that the Wild Turkey ever existed in Minnesota. No eye-witness has left a written record so far as can be found, and no Minnesota specimen is in existence. The tales of a few old men, which were passed on to the generation of fifty years ago, are all that remain.”

Aldrich (1967b) reported a specimen marked “Minnesota” located in the University of Kansas’ collection for the basis of including Minnesota in the northern ancestral wild turkey range. However, according to the museum records no known “Minnesota” specimen exists (Mark B. Robbins, Ornithology collection manager, personal communication: 2008).

There is confusion over the nomenclature used for wild turkeys in historic literature (Schorger 1942). In historic records, outarde and cogs d’Inde have been used for wild turkey in addition to Canada goose (*Branta canadensis*) and sandhill crane (*Grus canadensis*). Canada goose, to the French in Quebec and Illinois was known as outarde (Schorger 1942). Outarde has also been used in reference to an Indian (Connor 1804). The wild turkey has also been called dindon and bustard (Schorger 1942). Schorger (1942) mentions that outarde was also a large stocky bird that spreads its tail during the mating period, which describes a wild turkey.

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Early explorers gave names to animals that they encountered that were similar to those in Europe (Schorger 1942). In the upper Mississippi Valley, the sandhill crane became known as turkey or northern turkey (Schorger 1942). Schorger (1942) mentions a reference of cogs d'Inde sitting in trees; which he states can only mean wild turkeys and not a Canada goose.

Louis Hennepin, in 1680, mentioned killing bustards (or wild turkeys) while traveling along the Mississippi River near Lake Pepin (near Lake City, Minnesota) (Hennepin 1698). Schorger (1942) does not give strength to these claims, because Hennepin later mentions 3-4 turkeys being killed by one shot. Schorger (1942) concluded that the terminology is varied throughout Hennepin's writings. For example, in the Lake Pepin reference, cogs d'Inde and outarde refer to wild turkeys, but in other parts of Hennepin's book, they clearly did not refer to wild turkeys (Schorger 1942).

Another reference to wild turkeys near Lake Pepin on the Mississippi River occurred in 1766 (Carver 1766). Carver (1766) mentioned observing wild turkeys in his journals when traveling near Lake Pepin. Schorger (1966) discredits his reference, because he claims Carver plagiarized Hennepin. Carver's work has been very controversial, but Parker (1976) felt Carver's writings were reliable.

Leopold (1931) includes Carver's 1776 sighting in his wild turkey ancestral range in southern Minnesota. Leopold (1931) also used 2 references: from Blue Earth County along the Minnesota River dated 1773 and in Rock County dated 1871. Leopold (1931) did not give the source of the Rock County sighting. Pond (1773) was the source of the Blue Earth County sighting. Pond (1773) notes that the land along the "River St. Peter" had an abundance of animals including turkeys in the woods and meadows. In a footnote, the River St. Peter is the Minnesota River. The exact location of the wild turkey sightings along the Minnesota River was not given.

We found 2 other turkey sightings for Minnesota from the 1850s. Roberts (1919: 29) refers to a conversation he had with Dr. Wm. C. Portmann in June 1893 about wild turkeys in Jackson County, Minnesota:

> "About thirty years ago, a farmer named Stone killed four Wild Turkeys from a flock of about thirty that lived in a piece of heavy timber in a bend of the Des Moines River just at the Iowa-Minnesota line. The farmer himself told Dr. Portmann of the occurrence. Another old resident of Jackson corroborated the statement."

Also, Roberts (1932: 427) cites a survey that was conducted by T. Surber in 1920 on the Root River Valley in Fillmore County, Minnesota. A statement about wild turkeys from John C. Smith, an early settler, was dated December 2, 1929 and reads:

> "In reply to your letter of November 30, in regard to Wild Turkeys in southeastern Minnesota at an early date. My father settled near Forestville in 1850, when only twelve years old. Many times I have heard him tell of shooting Wild Turkeys. One that he told of shooting was a great old gobbler that he got only after many days of hunting. This bird was killed near the headwaters of the south branch of the Root River in Forestville Township. This much I am sure of, that Wild Turkeys were at one time found in Forestville Township in the early days, say 1850 to 1860."

Roberts (1932) noted that limited evidence existed to support the presence of wild turkeys in Minnesota, and, if present, they existed "only in the extreme southern part of the state along the Mississippi River and its tributaries and at the headwaters of the Des Moines River in Jackson County."

Hatch (1892) noted that wild turkeys were found in southwestern Minnesota around the 1860s. He states, "Thirty-three years ago the Wild Turkey was not a rare bird in northwestern Iowa and southwestern Minnesota, since which I have received no report from it, and I am of the opinion that it has now (1891) totally disappeared from our State. Possibly a straggler may yet be recognized in the southwest extreme of the timber land of that section, and if so I trust that the fact may find publicity through some channel."

Zimmer (1923) stated that wild turkeys were located in every state but Washington, Oregon, California, Nevada, Utah, Idaho, Wyoming, and Montana in the exploration and settlement days. He also mentions that large wild turkey numbers were still being reported in the upper valleys of the Mississippi River. The Pre-Columbian estimated wild turkey population for Minnesota was 250 with the birds occupying roughly 500 square miles (Schorger 1966).

Most wild turkey habitat (deciduous forests) in southern Minnesota is found: (a) along the Mississippi River and its adjoining tributaries from its junction with the Minnesota River to the Iowa border; (b) on the Minnesota River from Mankato to Minneapolis; and (c) north of St. Paul along the St. Croix River (Wunz 1992). The former comprises the largest block of habitat because many of the Mississippi's tributaries drain the Driftless area. This area is made up of intensely incised coulees that comprise micro-climates for hardwoods such as black walnut (*Juglans nigra*), black cherry (*Prunus serotina*), Kentucky coffeetree (*Gymnocladus dioicus*) and various oak species such as red oak (*Quercus rubra*), white oak (*Quercus alba),* and bur oak (*Quercus macrocarpa*) (Schlesinger and Funk 1977, Williams 1990). Black walnuts in Minnesota are at the northern end of their range (Schlesinger and Funk 1977, Williams 1990).

When looking at the historical range of wild turkeys in Minnesota it was useful to also examine data for Wisconsin, because similar habitats for wild turkeys were present and the St. Croix River and Mississippi River form the border between Minnesota and Wisconsin. Sufficient evidence indicates that wild turkeys occupied southern Wisconsin from Prairie du Chien to Green Bay (Schorger 1942). Oak forests, suitable wild turkey habitat, extended 200 miles north of Prairie du Chien along the Mississippi River between Minnesota and Wisconsin (Evrard 1993).

There are references of wild turkeys north of the Twin Cities in Pine County, Minnesota and Burnett County, Wisconsin. However, at the time of settlement, records of wild turkey observations by early settlers were very rare, likely because of a severe winter in 1842-43 with heavy snow that possibly instigated the extirpation of wild turkeys from much of Wisconsin (Hoy 1882, Schorger 1942, Kumlien and Hollister 1951). A ‘northern’ reference is from a fur-trade site on the Snake River near what is today Pine City in Pine County, Minnesota. Thomas Connor (1804) stated in his diary on 18 October, “Piero gave me 1 Outarde and 12 large Ducks.” It is not clear what outarde means in this context, because earlier in this reference, an outarde meant an Indian. Evrard (1993) believed that the outarde in this context was likely a wild turkey. In this context it appears that the animal was a turkey and not a Canada goose, because he refers several times to geese in this entry. Evrard (1993) stated that John Sayer, the fur trader at the North West Company, received the outarde from Ojibway hunters near Pine City, Minnesota. Interestingly, Evrard's statement about the Ojibway hunter and trader Sayer are not present in the original source material (Connor 1804). The inclusion of Ojibway is important because by this time the Ojibway had occupied the northern-forested realms of Minnesota and had driven the Dakota onto the southern prairies of Minnesota (Froiland 1990). Thus, Ojibway in this context implies a northern location.

A wild turkey bone was found in Burnett County, Wisconsin, approximately 30 miles northeast of Pine City, Minnesota. The bone was found at a site that used to be the North West Company and XY Company fur trading post that was occupied during the winters of 1802-03 and 1804-05 (Ewen 1983). During the 1800s the dominant tree type was white pine (*Pinus strobus*) and the river was lower and narrower (Ewen 1983). Turkey was in the list of identified species, but was reported by Ewen (1983) as, “tentative identifications due to the fragmentary nature of the element or lack of comparative specimen.” The bone that was identified as *Meleagris gallopavo*, was found in the NW Company site (Ewen 1983).

DISCUSSION

Some authors believe the evidence that wild turkeys are native to Minnesota is inconclusive, and without an actual specimen, Minnesota should not be included in the ancestral wild turkey range (Roberts 1932, Aldrich 1967b, Green and Janssen 1975). Based solely on this criterion, there is not enough evidence to conclude wild turkeys were native to Minnesota. However, based on many sightings of wild turkeys prior to European settlement and shortly thereafter, we believe enough evidence exists to support that wild turkeys inhabited southern Minnesota before being extirpated from much of the Midwest in the late 1800s and early 1900s.

Wild turkeys were found in the river valleys of the Mississippi, Minnesota, Rock, and Des Moines Rivers. Based upon maps of Minnesota's pre-settlement vegetation, wild turkey habitat was found in these areas of Minnesota (Marschner 1974).

Several authors have drawn the northern extent of wild turkey's ancestral line to include southern Minnesota (Leopold 1931, Mosby 1949, Mosby 1959, Eaton 1992, Wunz 1992). Schorger's (1966) version of the wild turkey northern ancestral line contained only southeastern Minnesota. Leopold's (1931) version covered only southwestern Minnesota, although he noted sightings in southeastern Minnesota.

We project the northern ancestral line for wild turkeys in Minnesota in Figure 1, based on 6 wild turkey sightings from 1680, 1766, 1773, 1850, 1863, and 1871 in southern Minnesota (Hennepin 1680, Carver 1766, Pond 177, Roberts 1919, Leopold 1931, Roberts 1932). The wild turkey sightings in Pine County, Minnesota and Burnett County, Wisconsin, while noted in Figure 1, are assumed unreliable, based on qualifications in the original documents as noted earlier in this report. Connor (1804) and Ewen (1983) provided evidence that wild turkeys could have existed as far north as Pine County, Minnesota around the early 1800s. Some authors doubt the reliability of these references because the nomenclature that was used for wild turkeys in historical writing is confusing. If wild turkeys were found this far north, they were probably very rare and likely moved up the Mississippi River Valley and the St. Croix River Valley during mild winters and later killed off during winters with deep and persistent snow cover.

Since the exact location of the 1773 sighting in Figure 1 is unknown, the northern ancestral line includes a large portion of the Minnesota and Mississippi River Valleys (Figure 1). Based on the pre-settlement vegetation (Marschner 1974) and Pond's (1773) journal, there was suitable wild turkey habitat found along the Mississippi River to the Minneapolis/St. Paul region and south along the Minnesota River. Wild turkeys could have been found along the Minnesota River from the Minneapolis/St. Paul region south to Mankato.

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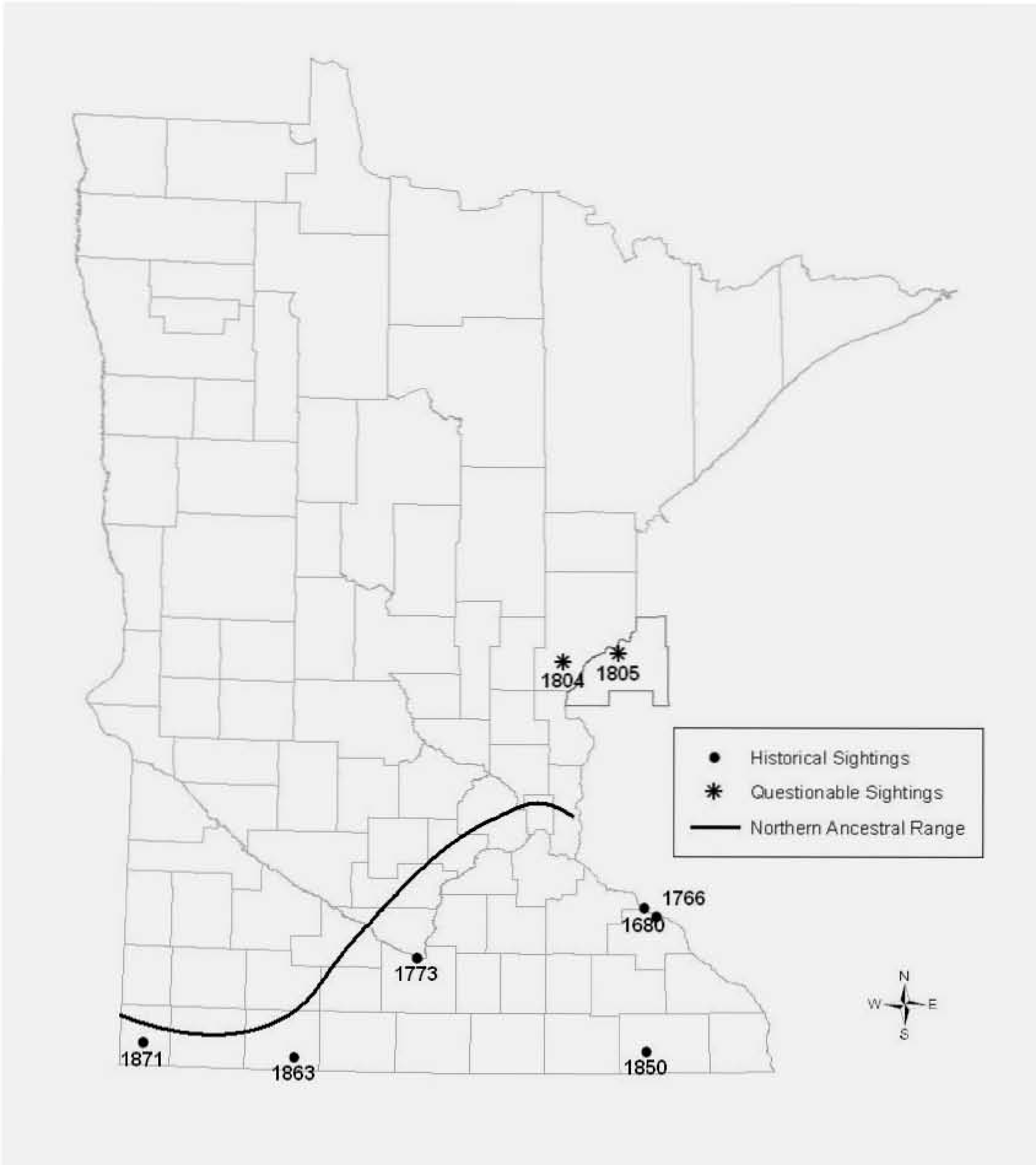

Figure 1. Northern ancestral range and sightings of wild turkeys in Minnesota.

FUNCTIONS OF FOOD PLOTS FOR WILDLIFE MANAGEMENT ON MINNESOTA'S WILDLIFE MANAGEMENT AREAS

Molly A. Tranel, Wes Bailey, and Kurt Haroldson

SUMMARY OF FINDINGS

The purpose of this document is to identify the primary functions of food plots managed by the Minnesota Department of Natural Resources (MNDNR), and determine whether they accomplish their intended purposes. This report identifies 7 major functions of food plots used by the Section of Wildlife. These functions included: (1) providing winter food; (2) providing food and loafing areas for migrants; (3) depredation abatement; (4) holding wildlife on public land for hunting or viewing; (5) grassland management; (6) reproductive habitat; and (7) public relations. For each function, we provide scientific or anecdotal evidence demonstrating that food plots are effective in accomplishing their intended purpose in some, but not all, circumstances.

INTRODUCTION

Food plot management is the second highest land management expenditure for the Minnesota Department of Natural Resources Section of Wildlife. As a result, the Section has initiated a review of the scope, functions, and effectiveness of managing food plots for wildlife on public Wildlife Management Areas (WMAs) and private lands. The purpose of this document is to identify the primary functions of food plots managed by the MNDNR, and determine whether they accomplish their intended purposes.

Food plots are often referred to in the literature as supplemental feeding, lure crops, or agronomic plantings. Supplemental feeding, however, can also include feeders or provision of grain piles for wildlife. Our use of the term 'food plot' does not include grain piles or feeders. For the purpose of this report, we define food plots as "small areas planted to annual or perennial agricultural crops to provide a supplemental food source for wildlife" (MNDNR 2007). We consider use of forest openings to be a separate issue warranting its own discussion, and therefore we do not discuss forest openings in this review.

Isley (1993) identified 4 purposes of food plots on WMAs administered by MNDNR: (1) provide nutrition; (2) keep wildlife near cover; (3) reduce depredations; and (4) provide recreation. This report expanded on Isley's (1993) purposes and identified 7 major functions of food plots used by the Section of Wildlife, discussed below. These functions were initially outlined by the MNDNR Farmland Wildlife Committee, and expanded upon by surveying MNDNR wildlife area managers for major units. We then reviewed the literature to find evidence supporting or disputing each function. For many of the functions, however, evidence was lacking or anecdotal. A brief summary of our findings is provided for each.

Function #1: Provide Winter Food for Resident Wildlife (especially pheasants, wild turkeys, and deer)

Ample evidence exists demonstrating use of winter food plots by a variety of game species. There are reports of food plot use by such wildlife as pheasants (*Phasianus colchicus*) (Larsen et al. 1994, Bogenschutz 1995, Gabbert et al. 1999, Evrard 2000, Gabbert et al. 2001), wild turkeys (*Meleagris gallopavo*) (Porter et al. 1980, Kane et al. 2007), bobwhite quail (*Colinus virginianus*) (Robel et al. 1974, Burt 1976), prairie grouse (*Tympanuchus cupido* and *T. phasianellus*) (Manske and Barker 1988), and white-tailed deer (*Odocoileus virginianus*) (Johnson et al. 1987, Smith et al. 2007). Larsen et al. (1994) documented food plot use by songbirds, lagomorphs, rodents, and squirrels. Donalty et al. (2003) concluded in a Texas study that the majority of winter food plot consumption was from nongame wildlife.

One purpose of food plots is to increase reproductive and survival rates of upland game birds by maintaining healthy body condition during winter and early spring. Bogenschutz (1995) found that female pheasants with access to corn and sorghum food plots had higher quality diets and more fat reserves than females without access to food plots during 1 year of a 2-year study. Ability to meet dietary requirements during late winter and early spring may affect onset of egg-laying, total egg production, and hen survival during the reproductive period (Breitenbach et al. 1963, Gates and Woehler 1968, Draycott et al. 1998). Furthermore, pheasant hens with food plots within their home range have shown higher winter survival than those lacking food plots (Gabbert 1997). Pheasants make greatest use of food plots when located within 300-600 m of heavy winter cover (Johnson 1973, Larsen et al. 1994). Food plots have also been found to increase population densities (Burt 1976, Ellis et al. 1969), body weights, and fat reserves in bobwhite quail (Robel 1969, Robel et al. 1974).

During a severe winter in southeastern Minnesota, survival was enhanced for wild turkey populations with access to corn food plots (Porter et al. 1980). North of historical wild turkey range in central Minnesota, food plots enhanced survival during 2 winters with below-average snow (Kane et al. 2007). The authors found that in a winter with above-average snow, however, survival was low even with corn food plots, suggesting that food plots have limited effectiveness in deep snow. Use of food plots by wild turkeys likely depends on multiple variables including turkey awareness of food plot location and mobility as affected by snow. Wright et al. (1996) reported starvation by Wisconsin turkeys within 0.7 km of standing corn when deep snow restricted movement.

Occasional severe winters in northern Minnesota exceed the physiological adaptations of white-tailed deer, resulting in over-winter mortality (Karns 1980). Supplemental deer feeding can reduce winter mortality (Doman and Rasmusssen 1944, Baker and Hobbs 1985) and may improve female reproductive success (Ozaga and Verme 1982). However, because the nutritional carrying capacity is very high in the farmland region of Minnesota, deer are in healthy condition at the onset of winter and the need for ancillary food sources is typically unwarranted (M. Grund, MNDNR, personal communication). Food plots provide a concentrated, palatable food source, which results in close interactions among individual deer, and may increase disease transmission (Palmer and Whipple 2006). Furthermore, in much of the forested and transition zones of Minnesota, the deer management goal is to reduce deer densities (Grund 2007, Lenarz 2007). Thus, employing management techniques designed to increase survival and reproduction in these areas is in direct conflict with population management goals (M. Grund, MNDNR, personal communication).

Food plots may be effective for enhancing body growth and antler characteristics of white-tailed deer. Vanderhoof and Jacobson (1989) found that 0.5% of an area in food plots year round increased body mass, number of antler points, beam circumferences, and beam lengths in Mississippi. Johnson et al. (1987) documented a 19% increase in live weights of yearling male white-tailed deer after establishing cool-season food plots in the mesic habitat of Louisiana. In a deer herd that was already biologically healthy, Johnson and Dancak (1993) found that diet quality was not significantly improved by the use of food plots in a southern pine-mixed hardwood forest. Because the deer population was managed below the biological carrying capacity, they concluded that food plot programs were not justified based on biological effects.

In some cases, supplemental feeding could decrease survival by attracting predators. In a study of spatial patterns of bobcats (*Lynx rufus*) in relation to supplemental food provided for northern bobwhite quail, Godbois et al. (2004) found that bobcats were observed to be about 10 times closer to supplemental food (both spread grain and food plots) than expected.

Function #2: Provide Spring and Fall Food Resources and Loafing Areas for Migratory Birds

Survival and reproduction of waterfowl are affected by body condition during migration, which is determined by food availability. Food plots can be an important source of energy and nutrients for migrating waterfowl if consideration is given to the type of food planted and the time of year it will be available for wildlife (Maxon et al. 2007). Gates et al. (2001) found that Canada geese (*Branta canadensis*) in the Mississippi Valley need an abundant source of high energy food (e.g., corn) during fall and winter, especially when foraging opportunities are limited by weather and hunting. Green forage and non-agricultural foods provide important sources of protein and other nutrients during all seasons (Gates et al. 2001), and high protein may be necessary to efficiently convert carbohydrates (e.g., corn) to the fat needed during spring migration (McLandress and Raveling 1981a,b). Additionally, food plots may become more important to migrants as waste grain becomes less available in agricultural lands due to more efficient farming methods (Krapu et al. 2004).

In Iowa, migrating mallards (*Anas platyrhynchos*) used moist-soil or corn-vegetated wetlands more than emergent wetlands or soybean-vegetated wetlands (LaGrange and Dinsmore 1989). Gruenhagen and Fredrickson (1990) found that mallards in Missouri ate moist-soil seeds and agricultural food to help meet their energy needs for migration. They suggested that both wetland and agricultural habitats might be important for meeting the energy requirements of migrants. While corn is a heavily used food source for migrants, soybeans are poorly suited for meeting nutrient needs of migrating wildlife requiring a high-energy diet (Krapu et al. 2004). Linz et al. (2004) encouraged land managers in Nebraska to consider sunflower fields as part of their crop rotation to provide late-season habitat for summer resident birds undergoing feather replacement and pre-migratory fattening, transients already migrating, and winter residents migrating from more northerly locations. They observed 49 species of birds using fall sunflower fields (blackbirds, sparrows, finches, and doves were most abundant).

Food plots are heavily used at the 22,000-acre Lac Qui Parle State Game Refuge in west-central Minnesota. Benson (1959) reported that after food plots and a sanctuary were established in 1958, “favorable response to the feeding strips and the safety of the sanctuary by geese and mallards was clearly evident.” The combination of food plots and sanctuary has continued at Lac Qui Parle. The number of waterfowl that used the sanctuary increased from 1,500 Canada geese and 10, 000 mallards in 1959 (Benson 1961) to 14,000 Canada geese and 40,000 mallards between 1964 and 1966 (Benson 1966). Food plots are still used at Lac Qui Parle, and the refuge peaks at over 100,000 geese each fall (D. Trauba, MNDNR, personal communication). Other large WMAs, including Thief Lake and Roseau River, also use food plots to provide food for a large number of migrants.

Food plot use by the Interlake-Rochester Population of giant Canada geese is particularly heavy during severe winters. When snow depth exceeds 8 inches, food plots are used until all corn is depleted (usually late December to mid-January), whereas geese make very little use of MNDNR food plots during mild winters (Maxon et al. 2007).

Function #3: Depredation Abatement (especially for deer and waterfowl)

In 1967, the MNDNR Depredation Control Committee recommended that feed crops remain unharvested on state leased lands surrounding refuges for consumption by waterfowl, and that plantings, especially small grains, on state land be increased through cooperative farming agreements (Minnesota Outdoor Recreation Resources Commission 1967). Food plots are still used by the State as a means of preventing or reducing depredation on private lands. Food plots planted to prevent damage to crops by wildlife are often referred to as “lure crops”. Lure crops can be established in areas with a history of wildlife damage and allowing animals to feed there, or by paying a landowner for the crop in a field already being fed on by wildlife

(Cleary 1994). The first method has been successful in North Dakota and Wyoming for depredating ducks and geese (Gustad 1979, Fairaizl and Pfeifer 1987). Stowell and Willging (1991) reported that lure crops were effective in reducing depredation by Canada geese and, in some cases white-tailed deer, and they speculated that lure crops could also prevent depredation by bears. Lure cropping has been used with mixed success to intercept or shortstop deer from entering busy highways (Woods and Wolfe 1988; Craven and Hygnstrom 1994) and airports (Seamans 2001), and to prevent damage to private croplands (Smith et al. 2007).

Smith et al. (2007) reported use of abundant food plots on a large WMA in North Dakota may have contributed to a population increase of white-tailed deer that exceeds the capacity to control by hunting. Similarly, Brown and Cooper (1996) believed that food plots and supplemental feeding may increase “nutritional carrying capacity”, resulting in damage to the natural vegetative community by concentrating more deer in less space. Matschke et al. (1984) recommended treating deer depredation on forest and agricultural crops through deer harvest regulations that keep the population in balance with its natural habitat. Because food plots may increase nutritional carrying capacity, many wildlife biologists recommend food plots be used as a temporary mitigation strategy and not a long-term solution to depredation management (Matschke et al. 1984, Woods and Wolfe 1988, Brown and Cooper 1996).

Function #4: Hold Wildlife on Public Lands for Improved Hunting/Viewing (wildlife watching, birding) Opportunities

While we did not find any scientific literature supporting the claim that food plots hold wildlife on public lands for improved hunting or viewing opportunities, this function is generally accepted among wildlife managers and the hunting public. Influencing harvest was cited as an important function of food plots in the northeastern U.S. in Krusac and Michael’s (1979) survey of 32 state wildlife agencies. Schultz et al. (2003) suggested establishing sunflower or wheat fields near urban areas to attract mourning doves (*Zenaida macroura*) to improve hunting opportunities for the urban public. They felt that food plots may provide a valuable food source for nongame wildlife, while also providing game for hunters.

Johnson and Dancak (1993) reported that hunters often request food plots be used on public lands, possibly as a result of food plot advertisements in hunting magazines. MNDNR wildlife managers reported that hunters often ask for locations of food plots on major units. Although use of food plots by wildlife is well documented (see Function 1 above), we found no studies that compared wildlife use of lands with food plots to those without. However, Johnson and Dancak (1993) found that deer hunter success was not affected by presence of food plots in a southern pine-mixed hardwood forest.

Attempts by Kopischke (1975) in south central Minnesota to use food plots to hold deer in secure winter habitat were not successful. He reported that “established" wintering areas were used instead of the food plots. In contrast, Smith et al. (2007) documented long distance movements by white-tailed deer in North Dakota to utilize food plots on a large WMA from November to April, followed by return movements in spring and early summer. Smith et al. (2007) suggested food plots were attracting and holding deer on the WMA during winter.

While food plots are popular among hunters for (at least the perception of) attracting game animals to an area, the ethics of such hunting practices have been questioned. If hunting over bait is generally considered unethical (and, in some cases, illegal), why is hunting near food plots accepted? Brown and Cooper (1996) explored the ethical issues involved with managing game through feeding programs (food plots, baiting, and crib feeding). Peyton (2000) referred to maintaining artificially high numbers of deer through feeding, in lieu of suitable winter habitat, as “open-range ranching” which provides a crop of game animals. He asked whether wildlife management efforts are encouraging stewardship or simply promoting a form of agriculture among hunters (e.g., “farming deer without fences”).

Function #5: Aid in Grassland Management

Harper (2003) described the use of cool-season food plots as a source of supplemental food for bobwhite quail, while also serving as a firebreak to contain prescribed burns. MNDNR wildlife managers commonly use food plots in conjunction with mowed lines as firebreaks on WMAs. In addition, wildlife managers use food plots to prepare sites for planting grasslands. Farming sites as food plots kills undesirable vegetation and uses up chemical residue in the soil, leaving a clean seedbed for planting sensitive prairie plants. Finally, managers use food plots as a physical (via annual tillage) and chemical barrier to contain woody vegetation from encroaching into grasslands.

Function #6: Hayfields and Small Grains Provide Reproductive Habitat

Hayfields can provide valuable habitat in landscapes where natural grasslands have been degraded and reduced. However, some important qualifications when assessing the breeding habitat value of hayfields are size and landscape context, and the timing and frequency of haying. Many grassland species exhibit minimum area requirements, and will not nest in grassland patches below a certain size (Winter and Faaborg 1999, Herkert et al. 2003). Hayfields can provide needed heterogeneity in a landscape matrix where row crops dominate. For example, a diversified landscape (e.g., hayfields and cropland) appeared to enhance pheasant nest survival (Clark and Bogenschutz 1999). Porter (1977) noted female wild turkeys increased use of hayfields and pastures through July and August in southeastern Minnesota. Similarly, Wright et al. (1989) reported that turkey hens with broods used pastures and idle fields more than expected. McMaster et al. (2005) found 26 species of birds nesting in haylands in Saskatchewan, including songbirds and waterfowl.

Mowing hay drastically alters the structure of the vegetation, which affects species differently depending on their habitat preferences (Frawley and Best 1991). In the Prairie Pothole Region, ducks have been found to nest in hayfields (Klett et al. 1988), but hayfields were less attractive than idle grasslands because the previous year's hay operation removes much of the residual vegetation that attracts nesting ducks early in the spring. Dale et al. (1997) found that various species of grassland songbirds nested in hayfields, but they were less attractive than native grasslands. Mowing hay also can cause nest losses as well as mortality of fledglings and adults (Frawley 1989, Rodenhouse et al. 1993). If mowing is frequent, many birds may not be able to complete their nesting cycles, and Dale et al. (1997) recommend that most hayfields be mowed only in alternate years with some hayfields left idle for 3 or more years to increase bird productivity.

In Wisconsin, Murphy et al. (1985) determined that white-tailed deer used hayfields during fawning season when other crops were being planted or were in early growth stages. It was suggested that preference for grassland and shrub habitat during the fawning season and in summer probably was due to the greater availability there of forbs and grasses (Murphy et al. 1985). In Minnesota, Brinkman et al. (2004) observed that high neonate survival was likely associated with a low predator density, quality vegetation structure at neonate bed sites, and high nutritional condition of dams. However, they suggest that any effects of fawning habitat on survival are speculative because fawning habitat quality has not been evaluated in the intensively farmed regions of Minnesota (Brinkman et al. 2004). Likewise Gould and Jenkins (1993) did not determine fawning site selection, but they found that Conservation Reserve Program (CRP) grasslands were important habitat to females during fawn rearing, both for resting and active periods, and particularly at night.

Function #7: Public Relations with County Commissioners, Farmers, and Sporting Clubs

In a survey of 32 state wildlife agencies, edge effect, supplemental food, and public relations were the main reasons for food plot management (Krusac and Michael 1979). In this survey, public reaction to food plots was favorable in all states that received public feedback. Our interviews with wildlife managers throughout Minnesota's farmland region found a consistent belief that food plots are good for public relations. Arranging for farmers to maintain food plots on WMAs establishes a landlord-renter relationship in which MNDNR wildlife managers offer a valuable commodity (cropland) to farmers. The farmer becomes invested in what happens with the WMA and watches over it as he would his own land. This relationship establishes lines of communication between MNDNR and the farming community. Although this relationship is valuable in itself, it can lead to additional work accomplished (e.g., barter for other services, such as mowing parking lots), future land acquisitions, and reduced complaints about noxious weeds. Also, county commissioners in the farmland region often like to see part of MNDNR acquisitions remain in cropland and local farmers remain connected to the property

In a plan to increase pheasant populations, South Dakota Department of Game, Fish, and Parks (1988) advocated food plots as "an excellent medium for involving local sportsmen groups." A, wildlife food plot contest was implemented in Minnesota to involve local youth organizations in wildlife management (Dornfeld 1989). Sporting clubs also actively promote and encourage planting food plots and seed mixes specifically designed for target game species (Pheasants Forever 2008). Woods et al. (1996) and Hayslette (2000) demonstrated that personal involvement with management had a strong effect on hunter satisfaction with habitat management. Involvement of sporting clubs through food plot plantings may lead to higher hunter satisfaction on WMAs.

DISCUSSION

We identified 7 primary functions of food plots managed by the MNDNR on WMAs and private lands. For each function, we found scientific or anecdotal evidence demonstrating that food plots were effective in accomplishing their intended purpose in some, but not all, circumstances. The effectiveness of food plots in serving their intended purpose depended partly on factors (such as weather and human attitudes) that are beyond the control of wildlife managers.

Additional research is needed to quantify the effectiveness of food plots in meeting their intended functions. For example, effectiveness of food plots in increasing survival and reproductive rates of resident game birds depends on winter severity. Managers provide food plots every year because they cannot predict when severe winters will occur and because they perceive a high, but unquantified, cost in public relations for not being prepared. Thus, information is needed to quantify both the magnitude of biological benefits to birds and societal benefits to the public. On the other hand, identifying certain food plot characteristics could increase the effectiveness of food plots in their desired function. For example, because food plots serve resident game birds best when located within 300-600 m of heavy winter cover, food plots further from winter cover should probably be questioned.

One food plot function for which we found little support was providing winter food for deer in Minnesota's farmland/transition region (M. Grund, MNDNR, personal communication). Because of the infrequency of killing winters and the current management emphasis on reducing deer population density in much of Minnesota (Grund 2007, Lenarz 2007), use of food plots may not be justifiable in these areas.

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THE VALUE OF FARM PROGRAMS FOR PROVIDING WINTER COVER AND FOOD FOR MINNESOTA PHEASANTS

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SUMMARY OF FINDINGS

The purpose of this study was to determine how much winter habitat is needed to sustain local populations of ring-necked pheasants (*Phasianus colchicus*) over a range of winter conditions. We estimated relative abundance of pheasant populations on 36 study areas using roadside surveys. In addition, we estimated amounts of winter cover, winter food, and reproductive cover on each study area by cover mapping to a geographic information system (GIS). During 2003-2007, pheasant population indices varied in association with weather and habitat. A preliminary evaluation indicated that mean pheasant indices were positively related to habitat abundance (r^2 = 0.115; P = 0.02) for all study areas combined, but this relationship was not significant for all regions. Five consecutive mild winters have hampered our ability to estimate winter habitat needs. Future work will include improved estimates of habitat abundance, and more complex analysis of the association between pheasant indices and habitat parameters. Final products of this project will include GIS habitat models or maps that managers can use to target habitat development efforts where they may yield the greatest increase in pheasant numbers.

INTRODUCTION

Preferred winter habitat for ring-necked pheasants in the Midwest includes grasslands, wetlands, woody cover, and a dependable source of food (primarily grain) near cover (Gates and Hale 1974, Trautman 1982, Perkins et al. 1997, Gabbert et al. 1999). However, emergent wetlands and woody habitats that are large enough to provide shelter during severe winters have been extensively removed from agricultural landscapes, and grasslands and grain stubble are inundated by snow during some years. During severe winters, pheasants without access to sufficient winter habitat are presumed to perish or emigrate to landscapes with adequate habitat. Birds that emigrate >3.2 km (2 miles) from their breeding range are unlikely to return (Gates and Hale 1974).

Over 400,000 ha (1 million acres) of cropland in Minnesota's pheasant range are currently retired under the Conservation Reserve Program (CRP). Wetland restorations, woody habitats and food plots are eligible cover practices in the CRP, but most appear inadequate in size, design, or location to meet pheasant habitat needs. Furthermore, small woody plantings sometimes established on CRP lands may reduce the quality of adjacent grass reproductive habitat without providing intended winter cover benefits.

Pheasants use grasslands for nesting and brood rearing, and we previously documented a strong relationship between grassland abundance and pheasant numbers (Haroldson et al. 2006). However, information is lacking on how much winter habitat is needed to sustain pheasant populations during mild, moderate, and severe winters. The purpose of this study is to quantify the relationship between amount of winter habitat and pheasant abundance over a range of winter conditions. Our objectives are to: (1) estimate pheasant abundance on study areas with different amounts of reproductive cover, winter cover, and winter food over a time period capturing a range of winter severities (≥5 years); (2) describe annual changes in availability of winter cover as a function of winter severity; and (3) quantify the association between mean pheasant abundance (over all years) and amount of reproductive cover, winter cover, and winter food.

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METHODS

We selected 36 study areas of contrasting land cover in Minnesota's core pheasant range to ensure a wide range of habitat configurations. Study areas averaged 23 km^2 (9 $miles^2$) in size, and were selected to vary in the amount of winter cover, winter food, and reproductive cover. We defined winter cover as cattail (*Typha* spp.) wetlands ≥4 ha (10 acres) in area (excluding open water), dense shrub swamps ≥4 ha (10 acres) in area, or planted woody shelterbelts ≥0.8 ha (2 acres) in area, ≥60 m (200 feet) wide, and containing ≥2 rows of conifers (Gates and Hale 1974, Berner 2001). Winter food was defined as grain food plots left unharvested throughout the winter and located ≤0.4 km (1/4 mile) from winter cover (Gates and Hale 1974). Reproductive cover included all undisturbed grass cover ≥6 m (20 feet) wide. To facilitate pheasant surveys, we selected study areas that were square in shape and contained a uniform distribution of roads through the study area interior. Nine study areas were selected in each of 4 regions located near Marshall, Windom, Glenwood, and Faribault, Minnesota (Figure 1).

We estimated amounts of winter cover, winter food, and reproductive cover on each study area by cover mapping to a GIS using recent (2003, 2004, 2005, and 2006) aerial photographs. In addition, we mapped large habitat patches within a 3.2-km (2-mile) buffer around study area boundaries to assess the potential for immigration to and emigration from study areas. We used Farm Service Agency GIS coverages of farm fields (Common Land Units) as base maps, and edited field boundaries to meet the habitat criteria of this project. Cover types were verified by ground-truthing all habitat patches visible from roads. Because cover mapping of cattail wetlands, shrub swamps, and undisturbed grasslands is still in progress, for this progress report we made preliminary estimates of the amounts of these habitats from GIS coverages of the National Wetlands Inventory (NWI), Wildlife Management Areas (WMAs), Waterfowl Production Areas (WPAs), and CRP enrollments. We recognize that not all cattail wetlands, shrub swamps, and undisturbed grasslands are included in these GIS coverages.

We used historical climate summaries (Minnesota Climatology Working Group, http://climate.mn.edu) to calculate an index to winter severity for each year (2003-2007) and region. Our winter-severity index was based on Evrard (1996) and was calculated as the sum of the number of days with minimum temperature ≤–18 °C (0°F) and number of days with snow depth ≥15 cm (6 inches). We defined winter for a given year as 1 December of the previous year to 31 March.

We estimated relative abundance of pheasant populations on each study area using roadside surveys (Haroldson et al. 2006). Roadside surveys consisted of 16–19 km (10–12 mile) routes primarily on gravel roads (≤ 6 km [4 miles] of hard-surface road). Observers drove each route starting at sunrise at an approximate speed of 24 km/hour (15 miles/hour) and recorded the number, sex, and age of pheasants observed. Surveys were repeated 10 times on each study area during spring (20 April – 20 May) and summer (20 July – 20 August). Surveys were conducted on mornings meeting standardized weather criteria (cloud cover <60%, winds ≤16 km/hour [10 miles/hour], temperature ≥0°C [32°F], dew present) 1–2 hours before sunrise. Surveys were completed even if conditions deteriorated after the initial weather check. We attempted to survey all study areas within a region on the same days, and observers were systematically rotated among study areas to reduce the effect of observer bias.

Observers carried Global Positioning System receivers while conducting roadside surveys to record their time and position throughout each survey (track logs), and to record the location of observed pheasants (waypoints). We inspected all track logs for each observer to ensure that surveys were conducted at the correct time, location, and speed of travel.

For each study area and season, we calculated a population index (pheasants counted/route) from the total number of pheasants counted/total survey distance driven over all 10 repetitions. We standardized the index to pheasants/161 km (pheasants/100 miles) to adjust for variation in survey distance among study areas. We evaluated temporal trends in pheasant abundance by calculating mean percent change in population indices by region and in total. We interpreted trends as statistically significant when 95% confidence intervals of percent change did not include 0.

To evaluate the effect of habitat on pheasant abundance, we calculated a cover index for each study area:

$$CI = [(UG/Max)x4 + (WCwFP/Max)x4 + (WCwoFP/Max)x2 + (FP/Max)] / 11$$

Where; UG = undisturbed grass (% of study area)
WCwFP = winter cover near a food plot (number of patches)
WCwoFP = winter cover without a nearby food plot (number of patches)
FP = food plot (number of patches)
Max = maximum observed value among all 36 study areas.

The cover index combined the effects of reproductive cover, winter cover, and winter food into a single weighted average (weight based on a preliminary estimate of relative importance). Potential values of cover index ranged from 0.0 (poorest habitat) to 1.0 (best habitat). We acknowledge that the cover index is an oversimplification, and we used it only to make simple, 2-dimentional plots for this early progress report. We evaluated the association of cover indices to pheasant population indices using simple linear regression.

RESULTS

We identified and mapped 355 patches of winter cover on the 36 study areas and surrounding 3.2-km (2-mile) buffers. Number of winter cover patches varied from 0-6 patches on study areas and 0-12 patches in surrounding buffers, totaling 0-18 patches on combined study areas and buffers.

Severity of winter weather was relatively mild during all 5 winters (2003-2007) of this study. Ranked winter severity indices (with rank of one being most severe) ranged from twenty-fifth to fifty-seventh for the 59-year period 1949-2007. Deep snow rendered the least robust patches of winter cover (e.g., 4-ha [10-acre] cattail wetlands) unavailable to pheasants for no more than 2 weeks during any of the 5 winters of this study.

Spring 2007 Surveys

Observers completed all 360 scheduled surveys (10 repetitions on 36 study areas) during the spring 2007 season. Despite strong efforts by surveyors to select days that best met weather standards, weather conditions were not consistent among surveys, ranging from excellent (calm, clear sky, heavy dew) to poor (wind >16 km/hour [10 miles/hour], overcast sky, no dew, or rain). Over all regions, 88% of the surveys were started with at least light dew present, which was similar to previous years (78-92%). Eighty-one percent of surveys were started under clear to partly cloudy skies (<60% cloud cover), 98% reported wind speeds <16 km/hour (10 miles/hour), and 100% of surveys were started on mornings with temperatures >0^{o}C (32^{o}F). Among regions, Faribault experienced the least dew (18% of surveys started with no dew) and most cloud cover (28% of surveys started with cloud cover ≥60%).

Pheasants were observed on all 36 study areas during spring 2007, but abundance indices varied widely among areas from 19.2–519.4 pheasants observed per route (Table 1). Over all study areas, the mean pheasant index was 202.0 birds/route, a 28% increase (95% CI: 10–46%) from spring 2006 and the highest observed during the 5 years of this study (Table 2). Total pheasants/route varied among regions from 77.6 in the Faribault region to 273.4 in the Marshall region (Table 2). Compared to 2006, total indices changed significantly only in the Glenwood region (101%; 95% CI: 57–145%; Table 2).

Hens were relatively abundant during spring 2007. The overall hen index averaged 120.5/route, a 31% increase (95% CI: 9–53%) from 2006 (Table 2). Among regions, the hen index ranged from 30.9/route in Faribault to 175.0/route near Marshall. Hen indices increased significantly from 2006 in Glenwood (121% increase; 95% CI: 70–172%) and Marshall (39% increase; 95% CI: 3–75%), remained unchanged in Windom, and decreased in Faribault (29% decrease; 95% CI: 14–44; Table 2). The observed hen:rooster ratio varied from 0.5 to 2.8 among study areas (Table 1). Fewer hens than roosters were observed on 1 study area in the Glenwood region and 8 areas in Faribault.

Summer 2007 Surveys

Observers completed all 360 scheduled surveys during the summer 2007 season. Weather conditions during the summer surveys ranged from excellent (calm, clear sky, heavy dew) to poor (light or no dew, overcast sky). Over all regions, 76% of the surveys were started with medium-heavy dew present, which was similar to 2006 (75%) but lower than 2005 (81%), 2004 (87%), and 2003 (81%). Prevelance of medium-heavy dew conditions this year were similar among the Faribault (83%), Marshall (81%), and Windom regions (82%), but much lower (56%) in Glenwood. For all regions combined, 73 percent of surveys were started under clear skies (<30% cloud cover), and 73% reported wind <6 km/hour (4 miles/hour). In comparison, 89% of the statewide August Roadside Surveys were started under medium-heavy dew conditions, 83% under clear skies, and 75% with winds <6 km/hour (4 miles/hour). The less desirable weather conditions reported in this study probably reflect the limited availability of 10 suitable survey days within the 31-day period.

Pheasants were observed on all 36 study areas during 2007, but abundance indices varied widely from 14.2–553.2 pheasants observed per route (Table 3). Over all study areas, the mean pheasant population index of 150.8 birds/route was not significantly different from 2006 (161.9 birds/route). Total pheasant indices varied among regions from 56.4 birds/route in the Faribault region to 281.3 birds/route in Marshall (Table 4). Regional indices of total pheasants were similar to 2006 (Table 4).

The overall hen index (28.8 hens/route) was similar to last year (28.7 hens/route), and varied among regions from 7.5 in the Faribault region to 53.1 near Marshall (Table 4). Hen indices decreased 31% (95% CI: –2 to–50%) in the Faribault region, but were not significantly changed from 2006 in the Glenwood, Faribault, or Windom regions (Table 4). The cock index increased significantly overall and in the Glenwood region (Table 4). The observed hen:rooster ratio varied from 0.2 to 3.7 among study areas (Table 3), and averaged 1.5 overall. Fewer hens than roosters were observed on 1 study area in the Windom region, 2 in the Glenwood region and 6 study areas in the Faribault region.

The 2007 overall brood index (21.0 broods/route) was similar to 2006 (23.1 broods/route), with regional indices ranging from 8.0 in Faribault to 37.2 in Marshall (Table 4). Regional brood indices were similar to 2006 except in Glenwood, where they decreased 24% (95% CI: -47 to -1%) (Table 4). Mean brood size averaged 4.9 chicks/brood overall, but varied among regions from 4.6 in Glenwood to 5.1 in Faribault. Mean brood size in 2007 increased 25% (95% CI: 9–41%) over that in 2006 in the Windom region and was similar to 2006 in Glenwood, Faribault, and Marshall (Table 4). On average, 20.5 broods were observed for every 100 hens counted during spring surveys, which was similar to last year. This brood recruitment index (broods/100 spring hens) varied among regions from 10.1 in Glenwood to 28.1 in Faribault. Brood recruitment indices decreased significantly only in the Glenwood region (95% CI: -36 to -78%) (Table 4).

Habitat Associations

For all study areas combined, the mean pheasant index (total pheasants/route averaged over summer 2003–2007) was significantly related to cover index ($r^2 = 0.15$; $P = 0.02$). Among regions, however, pheasant indices were significantly associated with cover indices for Marshall only ($r^2 = 0.72$; $P < 0.01$; Figure 2).

DISCUSSION

We expected a high spring hen population in 2007 given the relatively mild winter of 2007. The overall increase (all study areas combined) in hen indices was heavily influenced by the 121% increase in hens counted in the Glenwood region, where winter severity was mildest (2 periods of deep snow persisting only 2 weeks each). In contrast, winter severity was greatest in the Faribault region (11 weeks of persistent snow), where the hen index declined.

Weather during the reproductive period was warmer and drier than average, conditions conducive for increased nest success and chick survival. However, brood size increased only in the Windom region and the brood recruitment index (broods/100 spring hens) was relatively low, especially in the Glenwood region. Our study was not designed to determine cause for changes in population rates, but low recruitment during 2007 may have been a density-dependent response to high pheasant density (Berner 2001). Despite low rates of brood recruitment, total pheasant indices remained high due to above-average carryover of adults from 2006 plus average brood size in 2007.

At this early stage in our evaluation, we cannot explain the weak association between summer pheasant indices and habitat abundance (Figure 2). However, preliminary habitat estimates based on GIS coverages of the NWI, WMAs, WPAs, and CRP enrollments appear to have been incomplete, especially on the Glenwood and Faribault study areas. Habitat estimates will be improved as we complete cover mapping. In addition, future analyses of pheasant-habitat associations will use multiple regression models that treat reproductive cover, winter cover, and winter food as independent predictor variables.

Our study design called for at least 1 severe winter to estimate pheasant winter cover needs under the full range of Minnesota conditions. We expected pheasant populations to decline following severe winters, with the largest declines on study areas with the least amount of winter cover. However, 5 consecutive mild-moderate winters resulted in relatively high, stable pheasant populations on all study areas. Furthermore, the significant loss of CRP contracts expected during 2007-2009 will preclude an extension of this study. Thus, management implications resulting from this study may be limited to periods of mild-moderate winter weather.

We plan to complete annual cover mapping of all 36 study areas in 2008. Next, we will attempt to build a multiple regression model using data extracted from a previous pheasant habitat study (Haroldson et al. 2006) and test the model with data from this study. Finally, we will assess winter habitat availability in relation to snow depth and drifting during the next moderate-severe winter.

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Table 1. Pheasant population indices and sex ratios (female:male) after 10 repeated surveys (n) on 36 study areas in Minnesota, spring 2007.

			Birds/route[a]			
Region	Study area	n	Total	Cocks	Hens	F:M ratio
Marshall	1	10	437.3	156.0	281.3	1.8
	2	10	445.8	173.3	272.5	1.6
	3	10	364.1	152.4	211.7	1.4
	4	10	374.0	104.5	269.5	2.6
	5	10	251.7	99.6	152.1	1.5
	6	10	219.8	70.8	149.1	2.1
	7	10	173.6	46.8	126.8	2.7
	8	10	101.0	44.1	56.9	1.3
	9	10	93.4	38.2	55.3	1.4
Glenwood	10	10	100.0	42.5	57.5	1.4
	11	10	289.8	95.3	194.5	2.0
	12	10	306.7	139.5	167.1	1.2
	13	10	271.3	100.4	170.9	1.7
	14	10	250.4	115.5	134.9	1.2
	15	10	519.4	219.9	299.5	1.4
	16	10	139.0	71.0	68.1	1.0
	17	10	78.5	43.8	34.7	0.8
	18	10	282.4	108.3	174.1	1.6
Windom	19	10	430.5	114.7	315.8	2.8
	20	10	261.4	104.9	156.5	1.5
	21	10	164.2	62.6	101.6	1.6
	22	10	285.2	119.1	166.1	1.4
	23	10	269.3	110.4	158.9	1.4
	24	10	87.0	42.0	45.0	1.1
	25	10	92.5	30.4	62.1	2.0
	26	10	225.7	78.8	146.9	1.9
	27	10	58.3	27.4	30.9	1.1
Faribault	28	10	193.4	110.4	83.0	0.8
	29	10	50.5	32.2	18.3	0.6
	30	10	63.7	41.1	22.6	0.5
	31	10	111.8	71.1	40.7	0.6
	32	10	82.9	55.0	27.9	0.5
	33	10	80.2	42.2	37.9	0.9
	34	10	61.4	37.7	23.7	0.6
	35	10	35.4	21.2	14.2	0.7
	36	10	19.2	9.2	10.0	1.1

[a]Route length standardized to 161 km (100 miles).

Table 2. Regional trends (% change) in pheasant population indices on 36 study areas in Minnesota, spring 2003–2007.

			Birds/route[a]					% change	
Region	Group	n	2003	2004	2005	2006	2007	2006-2007	95% CI
Marshall	Total pheasants	9	87.2	116.3	110.4	211.4	273.4	34	±34
	Cocks	9	43.1	47.4	47.7	78.2	98.4	29	±33
	Hens	9	44.1	68.9	62.7	133.2	175.0	39	±36
Glenwood	Total pheasants	9	100.9	113.0	84.5	126.3	248.6	101	±44
	Cocks	9	48.7	47.2	40.2	60.3	104.0	88	±51
	Hens	9	52.2	65.9	44.3	66.0	144.6	121	±51
Windom	Total pheasants	9	162.3	179.7	167.6	234.3	208.2	-8	±16
	Cocks	9	69.4	75.8	65.0	90.5	76.7	-11	±15
	Hens	9	92.9	103.9	102.6	143.9	131.5	-6	±18
Faribault	Total pheasants	9	70.3	86.0	57.3	91.1	77.6	-15	±15
	Cocks	9	37.1	47.1	33.5	44.3	46.7	2	±20
	Hens	9	33.2	38.8	23.8	46.8	30.9	-29	±15
All	Total pheasants	36	105.2	123.8	104.9	165.8	202.0	28	±18
	Cocks	36	49.6	54.4	46.6	68.3	81.5	27	±18
	Hens	36	55.6	69.4	58.3	97.5	120.5	31	±22

[a]Route length standardized to 161 km (100 miles).

Table 3. Pheasant population indices and sex ratios (female:male) after 10 repeated surveys (n) on 36 study areas in Minnesota, summer 2007.

Region	Study area	n	Birds/route[a] Total	Cocks	Hens	F:M ratio	Chicks/ route[a]	Broods/ route[a]	Chicks/ brood	Broods/100 Summer hens	Broods/100 Spring hens
Marshall	1	10	553.2	52.3	89.2	1.7	411.7	74.8	5.5	0.838	0.266
	2	10	477.5	72.1	81.3	1.1	324.2	55.0	5.9	0.677	0.202
	3	10	145.6	24.8	49.0	2.0	71.8	21.4	3.4	0.436	0.101
	4	10	265.0	26.0	53.0	2.0	186.0	34.0	5.5	0.642	0.126
	5	10	406.7	50.8	57.5	1.1	298.3	50.0	6.0	0.870	0.329
	6	10	175.5	16.0	41.5	2.6	117.9	29.2	4.0	0.705	0.196
	7	10	315.5	26.4	66.4	2.5	222.7	43.6	5.1	0.658	0.344
	8	10	116.8	12.4	26.2	2.1	78.2	17.8	4.4	0.679	0.313
	9	10	75.7	13.2	14.1	1.1	48.4	9.1	5.3	0.645	0.165
Glenwood	10	10	58.0	5.0	10.0	2.0	43.0	8.0	5.4	0.800	0.139
	11	10	66.9	14.0	13.1	0.9	39.8	13.6	2.9	1.032	0.070
	12	10	124.8	27.1	32.9	1.2	64.8	20.0	3.2	0.609	0.120
	13	10	52.2	12.6	10.9	0.9	28.7	8.7	3.3	0.800	0.051
	14	10	183.3	14.0	31.6	2.3	137.7	27.2	5.1	0.861	0.202
	15	10	141.7	24.1	33.3	1.4	84.3	21.3	4.0	0.639	0.071
	16	10	66.7	6.2	16.7	2.7	43.8	8.6	5.1	0.514	0.126
	17	10	20.7	7.4	6.6	0.9	6.6	0.8	8.0	0.125	0.024
	18	10	128.7	23.6	22.7	1.0	82.4	19.4	4.2	0.857	0.112
Windom	19	10	214.7	17.4	59.5	3.4	137.9	36.8	3.7	0.619	0.117
	20	10	260.6	25.2	41.7	1.7	193.6	37.1	5.2	0.889	0.237
	21	10	147.4	10.0	28.9	2.9	108.4	25.3	4.3	0.873	0.249
	22	10	169.7	35.2	53.2	1.5	81.2	19.9	4.1	0.373	0.120
	23	10	175.2	24.3	39.1	1.6	111.9	25.7	4.3	0.658	0.162
	24	10	150.0	19.0	27.0	1.4	104.0	21.0	5.0	0.778	0.467
	25	10	83.2	12.6	14.5	1.1	56.1	9.3	6.0	0.645	0.150
	26	10	315.8	24.1	48.7	2.0	243.0	42.1	5.8	0.865	0.287
	27	10	28.7	10.4	2.6	0.3	15.7	3.5	4.5	1.333	0.113
Faribault	28	10	84.9	12.3	7.5	0.6	65.1	14.2	4.6	1.875	0.170
	29	10	19.8	5.0	1.0	0.2	13.9	3.0	4.7	3.000	0.162
	30	10	35.5	6.5	5.6	0.9	23.4	4.8	4.8	0.857	0.214
	31	10	116.7	13.7	16.7	1.2	86.3	14.7	5.9	0.882	0.361
	32	10	42.3	11.3	6.8	0.6	24.3	7.2	3.4	1.067	0.258
	33	10	72.0	2.6	9.5	3.7	59.9	10.4	5.8	1.091	0.275
	34	10	64.9	7.9	13.2	1.7	43.9	7.0	6.3	0.533	0.296
	35	10	57.5	9.7	6.2	0.6	41.6	8.8	4.7	1.429	0.625
	36	10	14.2	3.3	0.8	0.3	10.0	1.7	6.0	2.000	0.167

[a]Route length standardized to 161 km (100 miles)

.

Table 4. Regional trends (% change) in pheasant population indices on 36 study areas in Minnesota, summer 2003–2007.

			Birds/route[a]					% change	
Region	Group	n	2003	2004	2005	2006	2007	2006-2007	95% CI
Marshall	Total pheasants	9	142.6	114.9	190.5	280.9	281.3	11	±49
	Cocks		12.7	13.5	10.5	26.2	32.7	38	±43
	Hens		25.6	20.5	32.3	49.1	53.1	21	±50
	Broods		22.3	16.8	35.0	38.9	37.2	–3	±30
	Chicks/brood		4.6	4.8	4.2	5.0	5.0	2	±15
	Broods/100 spring hens		59.9	29.8	77.2	35.9	22.7	–24	±27
Glenwood	Total pheasants	9	139.9	57.9	135.7	132.1	93.7	–17	±26
	Cocks		9.2	8.3	8.0	11.8	14.9	34	±33
	Hens		23.5	12.3	20.7	20.8	19.7	18	±38
	Broods		20.2	8.3	17.2	19.2	14.2	–24	±23
	Chicks/brood		5.0	4.1	6.1	5.2	4.6	–6	±25
	Broods/100 spring hens		44.7	14.7	42.8	29.3	10.1	–57	±21
Windom	Total pheasants	9	283.5	179.8	187.0	152.8	171.7	19	±29
	Cocks		25.9	23.6	13.8	25.9	19.8	–14	±21
	Hens		50.9	36.2	37.4	32.7	35.0	9	±23
	Broods		36.2	24.2	29.4	23.0	24.5	10	±30
	Chicks/brood		5.4	5.0	4.6	3.9	4.8	25	±16
	Broods/100 spring hens		47.1	29.1	30.2	18.7	21.1	32	±53
Faribault	Total pheasants	9	164.6	54.4	90.5	81.7	56.4	–10	±52
	Cocks		9.5	13.0	8.0	7.8	8.0	16	±44
	Hens		23.6	13.1	14.8	12.2	7.5	–31	±29
	Broods		23.6	6.8	12.6	11.4	8.0	12	±91
	Chicks per brood		5.5	5.0	5.5	5.3	5.1	–1	±15
	Broods/100 spring hens		85.4	18.6	71.0	27.6	28.1	77	±157
All	Total pheasants	36	182.6	101.7	150.9	161.9	150.8	1	±18
	Cocks		14.3	14.6	10.1	17.9	18.8	18	±17
	Hens		30.9	20.5	26.3	28.7	28.8	4	±17
	Broods		25.6	14.0	23.6	23.1	21.0	–1	±23
	Chicks/brood		5.1	4.7	5.1	4.8	4.9	5	±9
	Broods/100 spring hens		59.3	23.1	55.3	27.9	20.5	7	±39

[a]Route length standardized to 161 km (100 miles).

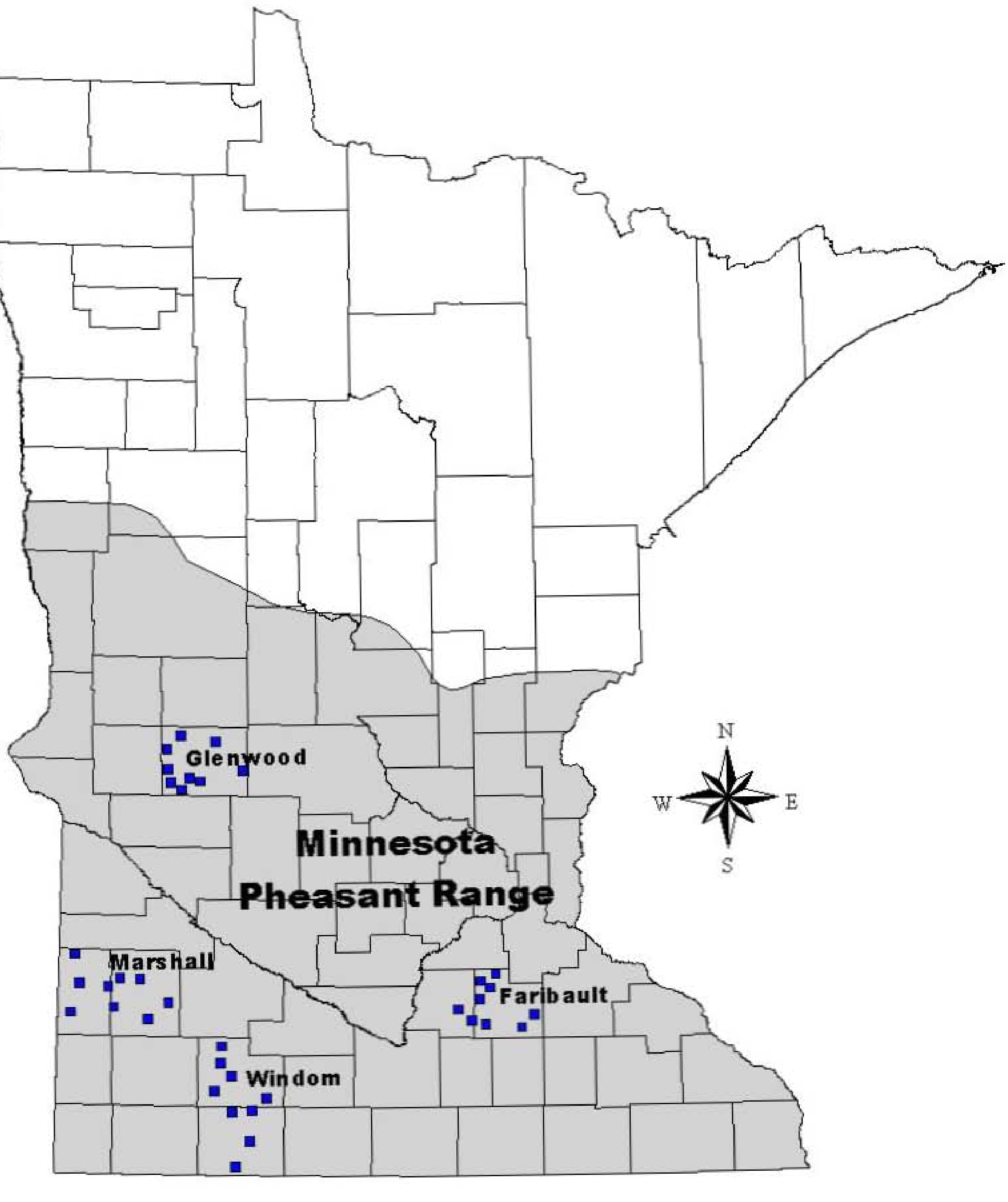

Figure 1. Locations of winter-habitat study areas within Minnesota's pheasant range, 2003-2007.

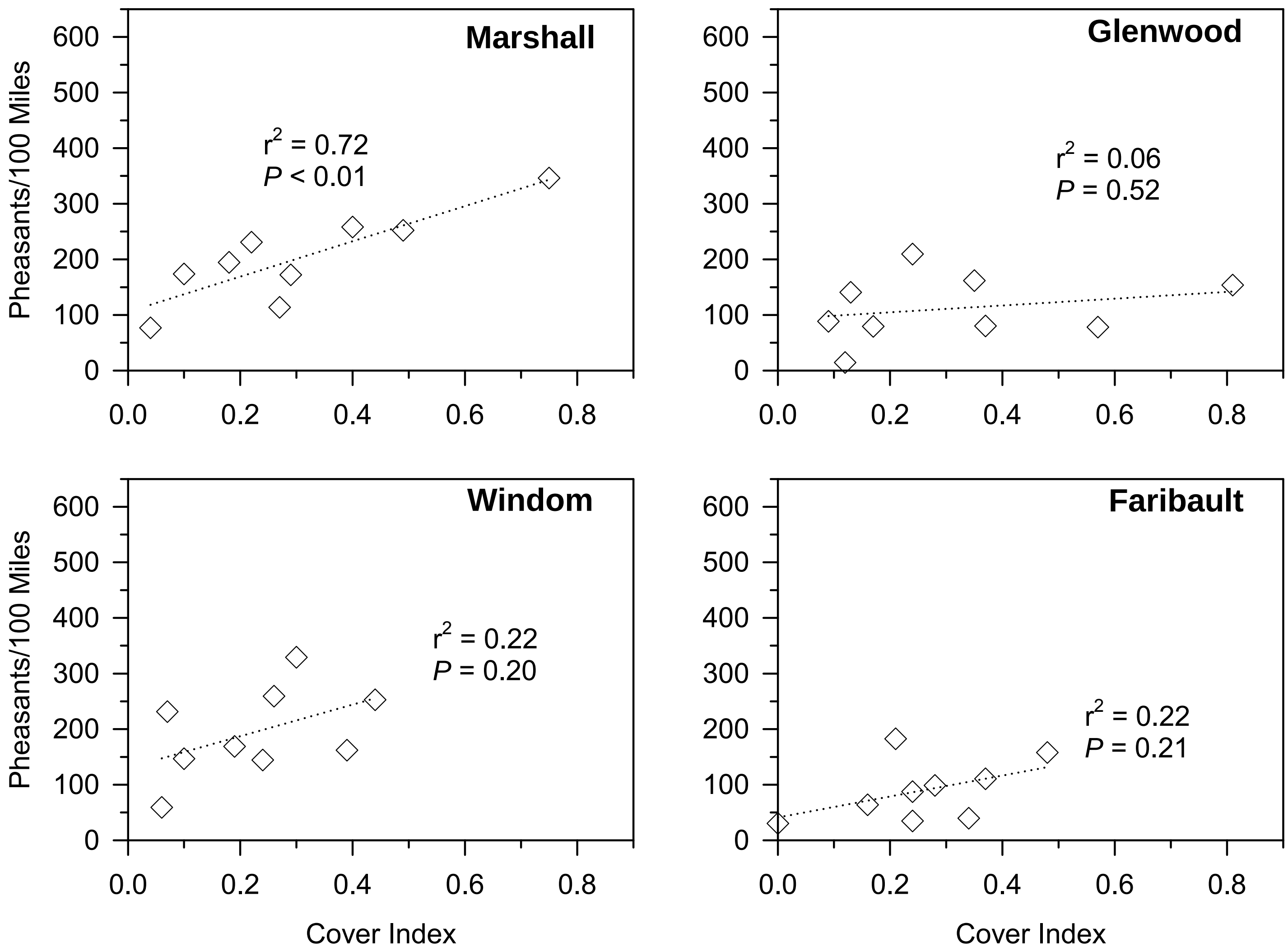

Figure 2. Relationship between relative pheasant abundance (pheasants counted/route) and amount of habitat (cover index) on 9 study areas in 4 regions in Minnesota during summer 2003-07. Route length was standardized to 161 km (100 miles).

MANAGEMENT-FOCUSED RESEARCH NEEDS OF MINNESOTA'S WILDLIFE MANAGERS-GRASSLAND MANAGEMENT ACTIVITIES

Molly Tranel

SUMMARY OF FINDINGS

In order to determine what areas of habitat management warranted research and to design research projects that address these information needs, Minnesota Department of Natural Resources (MNDNR) Habitat Evaluations Biologists conducted a survey of research needs. The majority of respondents needed information on all categories for the prairie/ grassland portion of the survey: (1) prairie/grassland burns;(2) prairie/grassland management; (3) food plot establishment and maintenance; and (4) woody cover development. Prairie grassland management had the greatest interest (94%) of the 4 management activities. Woody encroachment management was the most common need provided in open-ended responses.

INTRODUCTION

MNDNR Section of Wildlife committed staff time and funding to expand efforts to experiment with habitat management techniques and evaluate their effectiveness at accomplishing wildlife habitat and population goals. Three habitat evaluation positions were created in response to requests from MNDNR wildlife managers for help evaluating the effectiveness of habitat management for wildlife in Minnesota's farmland, wetland, and forest regions. In order to determine what areas of habitat management warranted research and to design research projects that address these information needs, MNDNR's Habitat Evaluations Biologists conducted a survey of research needs.

METHODS

Surveys were sent to MNDNR wildlife managers, assistant wildlife managers, regional wildlife managers, and assistant regional wildlife managers (n=65) by electronic mail on 15 January 2008. Reminders were sent to non-respondents on 31 January 2008. No responses were accepted after 14 February 2008.

The survey was categorized into 3 parts: 1) forest management activity, 2) prairie management activity, and 3) wetland management activity. This report summarizes only the prairie management activity. David Rave, Wetland Wildlife Populations and Research Group, will report separately on the wetland management activities portion of the survey and Wes Bailey, Forest Wildlife Populations and Research Group, will report on results of the forest management activities portion.

We provided each survey recipient with a table outlining 4 major management activities for the prairie region (Figure 1). These activities represented the major expenditure categories that MNDNR wildlife managers use to track funding for habitat management. For each of the activities, we asked "Does it need evaluation?" and respondents replied "Yes" or "No". We provided a list of specific examples beneath each activity, and we invited respondents to list other activities. When respondents indicated the activity needs evaluation, they were asked to rank the importance of evaluation for each example with a rank between 1 and 5 (1 meaning most important). Managers were encouraged to fill the survey out alone or with the other staff in their office. Because some respondents completed the survey in collaboration with others in their area office, but did not clarify how many respondents the survey represented, we counted each returned survey as from 1 respondent.

RESULTS

Thirty-six respondents completed the prairie portion of the survey. Of these, the majority of managers were from Region 1 (n=12) and Region 3 (n=10), followed by Region 2 (n=8) and Region 4 (n=6).

Prairie / Grassland Burns

Thirty-six respondents answered the question on prairie/grassland burn activities, with 69% replying that this activity needs evaluation. Of these, 92% assigned a rank to seasonal timing of burns, resulting in a mean rank of 1.2. Ranked second was frequency of burns (mean=1.9), followed by firebreak development (mean=3.2) (Table 1). Twenty-nine percent of people who reported a need for information on prairie/grassland burn activities offered additional examples of information needs, such as effect of burns on controlling woody encroachment (n=5) and the need for information on maintaining sedge meadows associated with waterfowl lakes and limiting factors to getting burns done and corrective measures (n=1).

Prairie / Grassland Management

Thirty-six respondents answered the question on prairie/grassland management activities, with 94% reporting a need for information on establishing, maintaining, and improving grasslands for wildlife. This was the highest “Yes” response rate of the 4 management activities, suggesting very high manager interest. Of the 34 people who answered “Yes” to this question, 68% assigned a rank to convert cool season stands to native grass (mean=2.2, Table 1). Eighty-two percent assigned a rank to species diversity (% grass/forbs) (mean=2.4), and exotic species removal and/or prevention was ranked 2.8 (frequency= 71%). Twenty-six percent of respondents who answered yes to this question included their own examples: effects of trees and woody encroachment (n=4), haying of grasslands for biofuel harvest (n=3), impacts on forbs by herbicides used for noxious weed control (n=3). Assessment of past plantings, wildlife use of restored grasslands, forb establishment and maintaining diversity, and increasing insect abundance were all listed once (n=1).

Food Plot Establishment and Maintenance

Thirty-seven respondents answered the question on food plot establishment and maintenance activities, with 57% of respondents indicating this activity needs evaluation. Of the 21 people who answered yes to this question, 86% assigned a mean rank of 1.2 to necessity of food plots, (Table 1). Forty-eight percent assigned a mean rank of 2.5 to food plot maintenance and 3.3 to providing seed to landowners (frequency= 52%). Forty-three percent of respondents who answered yes to this question provided other examples: food plot location and size (n=2) types of food plots to plant. (n=2). The following examples were reported once: cost effectiveness where GMO (Round up Ready) crops cannot be utilized, purchasing grain from private landowners for waterfowl management, wildlife benefits assessment, keeping farming cooperators in small food plot practices on Wildlife Management Areas (WMAs), habitat/land costs of food plots, use of perennial seed bearing plants vs. annual grains, and seed mix/fertilizer.

Woody Cover Development

Thirty-seven respondents answered the question on woody cover development activities, with 68% of people replying it needs evaluation. Of the 25 people who answered yes to this question, 80% assigned a mean rank of 1.4 to effectiveness of plantings (Table 1), and 64% ranked planting techniques with a mean of 2.2. Fifty-six percent of respondents included additional examples: effects of woody cover plantings (WCP) on grassland birds (n=5), species composition of

WCP (n=4). Other topics listed once were: necessity for pheasants, reforestation on former agricultural land, WCP location and size, wildlife value of WCP, private land WCP cost effectiveness, and wildlife use/value.

DISCUSSION

More managers from the forested Region 2 (n=8) completed the prairie management portion of the survey than from the farmland Region 4 (n=6). Many respondents took advantage of the opportunity to discuss management activities in detail by providing their own examples or clarifying their point in the "Other" spaces. These comments were helpful in mitigating some of the limitations of the structured format of the survey. For example, woody encroachment management was the most common response in the open-ended "Other" spaces (n=10). This response received a mean rank of 1.3 (n=6), suggesting that this is a concern for management. Interviews conducted by the Habitat Evaluations Biologists with managers across the farmland region of the state confirm this need for research on the effectiveness of woody encroachment control methods such as fire, cutting, and herbicide application.

For many of the management activities, respondents commented that research has already been conducted on specific topics, but that a literature review or best management practices would be beneficial. Providing information in this type of format could assist managers in remaining current on grassland management techniques and research.

The majority of respondents needed information on the 4 categories: 1) prairie / grassland burns, 2) prairie / grassland management, 3) food plot establishment and maintenance, and 4) woody cover development. Prairie grassland management had the greatest interest (94%) of the 4 management activities. Thus, wildlife managers are in greatest need of information on establishing, maintaining, and improving grassland habitats for wildlife. Converting cool season stands to native grass and species diversity were the 2 most important needs under this activity. Many of the additional comments provided throughout the prairie/grassland portion of the survey expressed the need for more information not only on techniques for planting native grass stands, but on how to keep such stands established and healthy. Respondents further specified concern on how the control of thistles using herbicide affects forb success and diversity.

Table 1. Mean rank (1 most important, 5 least) and frequency (# responding "Yes" / total # respondents) of management activities and provided examples for each activity, from a survey of MNDNR wildlife managers, Jan 2008.

PRAIRIE / GRASSLAND BURN ACTIVITIES		
Provided example	**Mean rank**	**Frequency**
Seasonal timing of burns	1.2	92%
Frequency of burns	1.9	88%
Firebreak development	3.2	46%
Other		29%
PRAIRIE / GRASSLAND MANAGEMENT		
Provided example	**Mean rank**	**Frequency**
Convert cool season stands to native grass	2.2	68%
Species diversity (% grass/forbs)	2.4	82%
Exotic species removal/prevention	2.8	71%
Grazing	3.1	74%
Patch-burn techniques	4.0	68%
Other		26%
FOOD PLOT ESTABLISHMENT / MAINTENANCE		
Provided example	**Mean rank**	**Frequency**
Necessity of food plots	1.2	86%
Food plot maintenance	2.5	48%
Providing seed to landowners	3.3	52%
Other		43%
WOODY COVER DEVELOPMENT		
Provided example	**Mean rank**	**Frequency**
Effectiveness of plantings	1.4	80%
Planting techniques	2.2	60%
Other		60%

Does it need evaluation? (Yes / No)	Prairie Management Activity	Rank (1 is highest)
________	**Prairie/grassland burns** (Prescribed burning to enhance/restore native prairie and other grassland communities and related wildlife habitat.) • Firebreak development • Seasonal timing of burns (spring, summer, or fall) • Frequency of burns (how long between burns?) • Other: ________________________	 _____ _____ _____ _____
________	**Prairie/grassland management** (All efforts related to the initial planting of native prairie/cool season grasslands as well as efforts to improve existing stands of grass.) • Converting cool season stands to native grass • Species diversity (% grass/forbs) • Grazing • Patch-burn techniques • Exotic species removal and/or prevention • Other: ________________________	 _____ _____ _____ _____ _____ _____
________	**Food plot establishment/maintenance** (All efforts related to food plot establishment and maintenance.) • Providing seed to landowners • Food plot maintenance • Necessity of plots • Other: ________________________	 _____ _____ _____ _____
________	**Woody cover development** (All efforts to establish and maintain woody cover for the improvement of farmland wildlife habitat.) • Planting techniques • Effectiveness of plantings • Other: ________________________	 _____ _____ _____

Figure 1. Selected questions on a survey sent to Wildlife Managers to assess information needs for habitat management in prairie/grasslands of Minnesota, Jan 2008.

EVIDENCE OF LEAD SHOT PROBLEMS FOR WILDLIFE, THE ENVIRONMENT, AND HUMAN HEALTH – IMPLICATIONS FOR MINNESOTA

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SUMMARY OF FINDINGS

There is considerable evidence published in professional scientific journals demonstrating that lead shot negatively impacts the health of wildlife, humans, and the environment. More than 100 species of birds (including upland birds, raptors, and waterfowl) have been weakened or killed by ingesting lead shot. The impacts of lead shot on wildlife include decreased survival, poor body condition, behavioral changes, and impaired reproduction. Studies in Canada, Greenland, and Russia have linked lead shot found in game animals to higher levels of lead in people who eat those game animals. Recent evidence shows that meat far from entry wounds may contain lead fragments. Effective nontoxic alternatives to lead shot are available at a similar cost. Countries, such as Denmark and The Netherlands, as well as some states in Australia have banned the use of lead shot. In North America, federal regulations prohibit the use of lead shot for waterfowl hunting and 26 states and provinces have additional nontoxic shot regulations for hunting doves, pheasants, and other species.

INTRODUCTION

Our nation has taken great strides to reduce environmental and human exposure to lead through restricting use of lead in gasoline and paints and restricting imported goods containing lead. However, lead continues to enter the environment and the diet of people through lead shot used by hunters.

Multiple reports published in professional scientific journals document that more than 100 species of birds (both waterfowl and upland birds) ingest lead ammunition that both weakens and kills them (Table 1). Some wildlife species, such as raptors (e.g., hawks, eagles, and condors), are "secondarily poisoned" by consuming animals that either ate or were shot with lead ammunition.

Thomas (1997) wrote that despite an awareness of the problems of lead shot to wildlife, regulatory action has been slow, "…due to hunters and international sport shooting organizations opposing the use of nontoxic substitutes and overt emphasis by government agencies on the burden of scientific proof for every situation, rather than taking preventative action according to the Precautionary Principle." (The precautionary principle supports decision-making processes involving serious or irreversible damage that are reasonable, rational, and responsible responses (Gilbert 2005)).

Wildlife mortality from ingestion of lead shot was first reported more than 100 years ago. In 1876, H. S. Calvert published "Pheasants Poisoned by Swallowing Shot" in *The Field* (Calvert 1876). In 1882, a second article about pheasants poisoned by lead shot appeared in the same publication (Holland 1882). In 1894, G. B. Grinnell published an article entitled, "Lead Poisoning," in *Forest and Stream* (Grinnell 1894). Since that time, professional journals have carried many manuscripts documenting wildlife being negatively impacted by hunters' use of lead shot: including die-offs from ingestion of lead shot, scientific studies regarding the toxicity of lead shot to wildlife, and lead accumulation in wildlife and human tissues resulting from lead shot. The impacts of lead shot on wildlife, the environment, and human health are of concern to many hunters and other people (Nontoxic Shot Advisory Committee 2006).

This report summarizes studies regarding ingestion of lead shot by wildlife species and the impacts of lead poisoning. Table 1 lists more than 100 species that have ingested and been poisoned by lead shot. Table 2 lists 15 recent examples of lead shot impacts on human health.

A companion to this document is a Literature Review (Tranel and Kimmel 2007) containing more than 500 references related to wildlife ingesting lead, wildlife being poisoned by lead ammunition, and lead impacts on the environment and human health.

Impacts of Lead Shot on Wildlife

There are hundreds of manuscripts published in the professional literature that provide scientific evidence of lead ingestion by wildlife, toxicity to wildlife, and lead accumulation in wildlife tissues from ingesting lead shot (Tranel and Kimmel 2007). Impacts of lead shot on wildlife include decreased survival, poor body condition, behavioral changes, and impaired reproduction. Tavecchia et al. (2001) reported decreased survival of mallards from lead ingestion in France. Spahn and Sherry (1999) noted increased nestling mortality was related to exposure of lead in little blue heron chicks in a wetland contaminated by heavy metals in Louisiana. Sileo et al. (1973) reported 25-45% reduction in body weight followed by death for Canada geese dosed with lead shot. Death as a result of poisoning from lead shot has been demonstrated for species including doves (Schulz et al 2006a, Schulz et al. 2007), mallards (Finley and Dieter 1978, Anderson and Havera 1985), and Canada geese (Cook and Trainer 1966). Fisher et al. (2006) suggested that behavioral changes resulting from lead poisoning can influence susceptibility to predation, disease, and starvation, which increases the probability of death. Experimental evidence has demonstrated impaired reproduction from lead shot ingestion for captive doves (Buerger et al. 1986) and domestic mallards (Elder 1954).

Lead shot impacts on wildlife were most obvious in heavily hunted areas, such as wetlands that were popular waterfowl hunting areas. Because grit is essential for the digestive systems of waterfowl (and most upland game birds) and birds do not differentiate between lead shot and grit of a similar size, wildlife feeding and gathering grit in these wetlands also pick up lead shot (Osmer 1940). Wilson (1937) reported lead poisoning in ducks, geese, and swans discovered in Back Bay, Virginia, and Currituck Sound, North Carolina. He analyzed gizzards; some of which contained more than 100 full-sized No. 4 lead shot and partly ground remains. Osmer (1940) noted that “ingestion of 6 No. 5 shot by a duck is fatal. Even 2 or 3 shot are often fatal.” Massive waterfowl die-offs were reported during the 20th century (Bellrose 1959).

Studies in Minnesota documented lead shot problems for bald eagles and Canada geese (Minnesota Department of Natural Resources 1981, Bengston 1984, Hennes 1985). Problems were considered severe enough at that time for a Steel Shot Zone to be established for Canada goose hunting at Lac Qui Parle Wildlife Management Area (Bengston 1984). Hennes (1985) noted that lead shot poisoning of bald eagles decreased, but wasn’t eliminated. A Trumpeter swan die-off in 2007 at Grass Lake in Wright County, Minnesota was attributed to poisoning from lead shot (Minnesota Department of Natural Resources 2007).

Impacts of lead shot at a population level are variable. Butler et al. (2005) noted that 3% of pheasants on shooting estates in Great Britain had lead in their gizzards. Kreager et al. (2007) examined gizzards from upland game birds harvested in Ontario, Canada and found lead pellets ingested by 8% of the chukars and 34% of the pheasants. They found that 13% of the livers (from chukars, pheasants, wild turkey, and Hungarian partridge) had elevated lead concentrations. Schulz et al. (2007) found that birds may expel lead shot after ingesting it, indicating incidence of lead exposure in wildlife may be lower than reported. Conversely, birds that expelled lead quickly suffered no obvious symptoms of lead poisoning (Schulz et al. 2007).

Fisher et al. (2006) suggested that a lack of evidence of poisoned species does not suggest a lack of poisoning. Die-offs and evidence of lead poisoning may not be apparent, because wildlife affected by lead poisoning may seek isolation and protective cover (Friend and Franson 1999). Furthermore, mortality due to non-lethal effects such as reproductive problems, lowered immunity, anemia, and weakened muscles could be higher than losses from direct lead poisoning (Michigan Department of Natural Resources 2002).

Wildlife Species Ingesting Lead Shot

In the "World Symposium on Lead in Ammunition," held in Rome, Italy in 2004, John Harradine from the United Kingdom, reported, "The issue of lead poisoning in wildlife as a consequence of shooting activities has long been debated as to its occurrence, its impact and how it should be managed. On the basis of evidence to date, and in general terms, waterfowl, some non-waterfowl species, and birds of prey are the groups of wildlife most at risk of poisoning by virtue of being most exposed to spent lead shot and vulnerable to its effects" (Harradine 2004). Table 1 documents lead ingestion or secondary lead poisoning for more than 100 wildlife species, including waterfowl, upland game birds, raptors, songbirds, mammals, and reptiles.

Bellrose (1959) summarized historic information on duck die-offs from lead poisoning. Die-offs ranged from hundreds of ducks in Indiana (1922) and in Louisiana (1930) to as many as 16,000 birds in Missouri (1945-1957) and Arkansas (1953-1954). Current use of lead shot for small game hunting (not waterfowl) potentially continues to deposit lead in wetlands continuing to impact waterfowl.

There is evidence that the problem extends to upland birds and raptors. Butler et al. (2005) reported lead exposure over a number of years (1996-2002) for ring-necked pheasants in Great Britain. Fisher et al. (2006) provides a review of 59 terrestrial bird species that have been documented to have ingested lead or suffered lead poisoning from ammunition sources. Nine were threatened species. Impacts of lead shot on doves and pheasants are considered by some scientists to rival the problem in waterfowl (Kendall et al. 1996, Harradine 2004). Ingestion of lead by wildlife, other than waterfowl and birds of prey, "appears to be extensive" and "some species, such as mourning dove and pheasant, however, which are subject to substantial hunting and which feed in those hunted areas, are exposed to relatively high levels of ingestion and its predictable consequences" (Harradine 2004).

Lead shot ingestion and toxicity problems for wildlife have been documented throughout the world where bird hunting exists. Tavecchia et al. (2001) found lead pellets in the muscles and gizzards of 11% of the mallards captured in France. In Spain, Mateo et al. (2003) reported lead poisoning from exposure to lead shot from prey species in 8 upland raptor species. Mörner and Petersson (1999) found lead poisoning in 2 woodpecker species in forested areas in Sweden suggesting that the woodpeckers searching for food removed lead pellets shot into trees.

Lead shot may secondarily poison wildlife that feed on hunted species. Studies have linked the likelihood of a species ingesting lead shot to feeding habits, with scavengers and predators that take game species the most susceptible (Pain and Amiard-Triquet 1993). Clark and Scheuhammer (2003) examined lead exposure in 184 dead raptors (16 species) found across Canada. They determined that, of the 3 most commonly encountered species, 3-4% died as a result of lead poisoning. They concluded that upland birds of prey and scavengers that eat game birds and mammals are at risk for lead poisoning from ingestion of lead ammunition used in upland hunting. They suggested that use of nontoxic ammunition for hunting upland game would effectively remove the only serious source of high lead exposure and lead poisoning for upland-foraging raptors.

Knopper et al. (2006) reported that carcasses from squirrel populations managed by shooting had lead levels lethal to raptors and suggested either collection of carcasses shot with lead or the use of nontoxic shot. Similar to the lead shot problems described by Clark and Scheuhammer (2003), deer carcasses containing lead fragments from bullets impact California condors (Cade 2007) and bald eagles (Franson 2007). Hunt et al. (2006) examined the remains of 38 deer killed with rifles and found that all deer killed with lead-based bullets contained bullet fragments. Mateo et al. (2003) analyzed bones from 229 birds of prey in Spain (11 species) and diagnosed lead poisoning in 8 raptor species that feed on wildlife targeted by hunters in upland habitats.

Lead Shot Problems for Humans

Lead poisoning in humans has occurred for at least 2,500 years (Eisler 1988). Today, it is widely known that lead is toxic to humans and can cause permanent developmental problems and death. Haldimann et al. (2002) concluded that frequent consumption of wild game meat had no effect on blood lead levels. However, studies in Canada, Greenland, and Russia have linked lead shot found in game animals to higher levels of lead in people who eat those game animals (Table 2). Levesque et al. (2003) stated, "lead shots may be a major source of lead exposure to humans that consume hunted game animals." This study found that lead shot was a source of lead exposure in the Inuit population; lead blood concentrations in 7% of Inuit newborns were higher than government-recommended levels. Studies linking game meat containing lead shot and elevated lead blood levels in children (Odland et al. 1999, Smith and Rea 1995) and newborns (Dewailly et al 2000, Hanning et al. 2003) are of particular interest.

Breurec et al. (1998) diagnosed lead poisoning in an adult patient who had frequently eaten game birds containing lead shot. Professional medical literature contains many references of humans carrying lead shot in their digestive tracts (Engstad 1932, Horton 1933, Hillman 1967, Madsen et al. 1988, Spitale and D'Olivo 1989, Moore 1994, Tsuji and Nieboer 1999, and Larsen and Blanton 2000). In animals shot for human consumption, meat far from the entry wound may contain lead. Scheuhammer et al. (1998) found fragments of lead far from wounds from shotgun pellets. Hunt et al. (2006) found lead fragments in meat away from rifle bullet wounds in game animals. Lead fragments, likely from bullets, were found in ground venison in North Dakota. This prompted North Dakota Health, Game and Fish, and Agriculture Departments to advise food pantries not to distribute or use donated ground venison because of the potential for lead contamination (North Dakota Department of Health 2008). Also, lead from shot may accumulate in tissues of game animals. In upland game birds and waterfowl killed by hunters using lead shot, 40% of 123 livers (Kreager et al. 2007) and 9% of 371 gizzard tissue samples (Tsuji et al. 1999) showed lead levels greater than Health Canada's guidelines for fish. Currently, no lead level guidelines exist for meat.

Tsuji et al. (1999) reported that, "People who consume *any* game species harvested with lead shot risk exposure to this metal by way of ingestion of tissue-embedded lead pellets and fragments." With alternatives to lead shot readily available (Sanborn n.d.), human exposure to lead through game meat is unnecessary (Rodrigue et al. 2005). Levesque et al. (2003) showed significant decreases in lead concentrations in umbilical cord blood after a public health intervention to reduce the use of lead shot by the Inuit population. Tsuji et al. (1999) suggested banning lead shot for all game hunting because of potential human health concerns.

Lead Shot Impacts in the Environment

The Minnesota Pollution Control Agency (1999) estimated that 2,610,720 pounds (1,184 metric tons) of lead shot were used annually in Minnesota in hunting and shooting ranges. In their legislative report on sources and effects of lead, they state, "The fact that lead ammunition is estimated to be the single largest source of lead released to the environment qualifies it as a concern that should be examined more closely."

De Francisco et al. (2003) estimated that lead shot can take 100 to 300 years to disappear from a site, allowing for concentration of large amounts of lead in areas of heavy hunting pressure. Although the breakdown is slow, lead shot pellets accumulating in the environment are not inert and ultimately the lead will be deposited as particles in soil and water (Scheuhammer and Norris 1995). Uptake of this lead by terrestrial and aquatic plants and animals can occur, leading to elevated lead concentrations.

Guitart et al. (2002) reported that a single lead shot could raise 12,000 liters of water to the European Union threshold guideline for lead in drinking water. Surface water contamination by lead shot from shooting ranges has been well documented (Stansley et al. 1992, Dames and Moore Canada 1993, Emerson 1994, USEPA 1994). Strait et al. (2007) found that shooting ranges contained areas where lead occurred at "concentrations significantly in excess of the

Michigan Department of Environmental Quality criteria and therefore pose a potential risk to the human users of the land as well as to the native wildlife." While shooting ranges contain far more spent shot than typical hunting areas, these studies demonstrate the ability of lead to accumulate over time and contaminate the surrounding environment and wildlife. Areas with acidic waters or soils are at particularly high risk for contamination from lead shot, as lead is more easily mobilized at a lower pH (Stansley et al. 1992).

Contamination of human food sources due to lead shot deposition has also been documented. Guitart et al. (2002) suggested that the high lead content of rice produced in Spain was a result of hunting with lead shot near rice fields. Rice et al. (1987) reported lead poisoning of cattle from ingestion of silage contaminated with lead shot. In addition, milk production decreased and stillbirths increased in cattle ingesting lead contaminated hay cut from a field used for clay pigeon shooting (Frape and Pringle 1984).

Alternatives to Lead Shot

Substituting nontoxic shot for lead shot could reduce lead shot impacts on the health of wildlife, humans, and the environment. Friend and Franson (1999) noted, "The use of nontoxic shot is the only long-term solution for significantly reducing migratory bird losses from lead poisoning." Migratory birds that have been shown to be impacted by lead shot include doves, waterfowl, and other species. Upland birds, such as ring-necked pheasants, are also impacted by lead shot.

Alternatives to lead shot were not readily available in the past, especially prior to the federal ban on lead shot for waterfowl hunting in the United States (US). However, other types of shot, particularly steel shot, are now available at a cost comparable to lead shot ammunition (Sanborn n.d.). Nontoxic shot is now also available for safe use in vintage and older shotguns (Cabela's 2008). Scheuhammer and Norris (1995) found that, while nontoxic alternatives to lead shot are more expensive than lead, they represent only a 1-2% increase in the average hunter's yearly expenses. There are currently 11 types of shot approved as nontoxic by the US Fish and Wildlife Service (US Fish and Wildlife Service 2006). Recent studies have demonstrated the effectiveness of steel shot. For example, Schulz et al. (2006b) evaluated crippling rates in waterfowl prior to and following implementation of nontoxic-shot regulations in the US. They found that, after a 5-year phase-in period, crippling rates for ducks and geese were lower after nontoxic shot restrictions were implemented.

Small game hunters have already begun to switch to nontoxic shot. In Minnesota, a recent survey, conducted by the University of Minnesota, Schroeder et al. (2008) found that 40% of pheasant hunters reported they are currently voluntarily using nontoxic shot.

Nontoxic Shot Regulations

Despite numerous reports of negative impacts of lead shot on wildlife worldwide, restrictions on the use of lead shot have been minimal (Thomas 1997). Interest in nontoxic shot regulations has resulted in discussions on restricting lead ammunition and some legislation on different continents.

Thomas and Twiss (1995) felt that lead contamination of Canadian lakes, a problem for waterfowl and other birds, could be reduced by regulating production and commerce in lead shot and sinkers. They suggested regulations from Canada, the US, and Mexico on a continental scale. In Europe, Denmark and The Netherlands have banned all uses of lead shot (Thomas 1997). Broad regulatory action to restrict lead shot across Europe has been discussed by various cross-continental groups, such as the European Council, the Bonn and Bern Conservations, and by the European Union (Thomas and Owen 1996). In Australia, lead shot restrictions vary by state from a total ban on lead shot to lead shot restrictions for waterfowl hunting similar to the US or suggesting nontoxic alternatives and leaving the choice of shot up to the hunters (Green 2004).

The most significant nontoxic shot regulation in the US was the federal ban on the use of lead shot for hunting waterfowl in 1991. This ban has been demonstrated to have a positive impact on wildlife. For example, Stevenson et al. (2005) found that lead concentrations in the bones of 2 species of ducks decreased after the federal ban on lead shot for waterfowl hunting. In comparison, they noted that bone lead concentrations showed no change for woodcock, a migratory upland species not impacted by the lead shot ban for waterfowl hunting.

Case et al. (2006) surveyed US states and Canadian provinces regarding nontoxic shot regulations and found that 45% (26) of surveyed states and provinces have nontoxic shot regulations beyond federal waterfowl regulations. Nine states and provinces that have nontoxic shot regulations were discussing additional regulations. Regulations for species other than waterfowl include 15 states and provinces with regulations for dove hunting, 22 for snipe, 13 for grouse, 12 for quail, and 12 for pheasants. Currently, Minnesota's nontoxic shot regulations beyond federal waterfowl regulations are for managed dove fields, which included 4 Wildlife Management Areas for 2007.

CONCLUSIONS

There is considerable evidence that lead shot negatively impacts the health of wildlife, humans, and the environment. This manuscript includes more than 175 citations related to this problem. More than 100 species of birds (including upland birds, raptors, and waterfowl) have been weakened or killed by ingesting lead shot (Table 1). The impacts of lead shot on wildlife include decreased survival, poor body condition, behavioral changes, and impaired reproduction. Humans can be exposed to lead in game meat, even when the shot is no longer present. Meat far from the entry wound may contain high levels of lead. Children and pregnant women are especially sensitive to lead exposure. Studies in Canada, Greenland, and Russia have linked lead shot found in game animals to higher levels of lead in people who eat those game animals (Table 2).

Effective nontoxic alternatives are available at a cost comparable to lead. Some countries (Denmark, The Netherlands, and some states in Australia) have banned the use of lead shot. In the US, federal legislation prohibits use of lead shot for waterfowl hunting and many states have additional nontoxic shot regulations for hunting doves, pheasants, and other species.

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Table 1. Species documented as ingesting or poisoned by lead shot. Due to the large amount of literature for many species, only selected references are listed.

SPECIES	SCIENTIFIC NAME	REFERENCE	LOCATION
Birds			
American black duck	*Anas rubripes*	White & Stendell (1977); Zwank et al. (1985)	North America
American coot	*Fulica americana*	Jones (1939); Anderson (1975)	North America; Illinois, USA
[C]American crow	*Corvus brachyrhynchos*	NYDEC (2000) as read in Golden & Rattner (2002)	New York, USA
[B]Andean condor	*Vultur gryphus*	Locke et al. (1969)	Captive
[B]Bald eagle	*Haliaeetus leucocephalus*	Jacobson et al. (1977); Clark & Scheuhammer (2003)	North America
Black-bellied whistling duck	*Dendrocygna autumnalis*	Estabrooks (1987)	Sinaloa, Mexico
Black-necked stilt	*Himantopus mexicanus*	Hall & Fisher (1985)	Texas, USA
Black scoter	*Melanitta nigra*	Lemay et al. (1989) as translated in Brown et al. (2006)	Quebec, Canada
Black swan	*Cygnus atratus*	Koh & Harper (1988)	Australia
Black-tailed godwit	*Limosa limosa*	Pain (1990)	France
Blue-headed vireo	*Vireo solitarius*	Lewis et al. (2001)	Georgia, USA
Blue-winged teal	*Anas discors*	Bellrose (1959); Zwank et al. (1985)	North America
Brant goose	*Branta bernicla*	National Wildlife Health Laboratory (1985)	North America
Brown thrasher	*Toxostoma rufum*	Lewis et al. (2001)	Georgia, USA
Brown-headed cowbird	*Molothrus atar*	Vyas et al. (2000)	North America
Bufflehead	*Bucephala albeola*	Scanlon et al. (1980); Sandersen and Belrose (1986)	North America
[A]California condor	*Gymnogyps californianus*	Church et al. (2006); Cade (2007)	North America
California gull	*Larus californicus*	Quortrup & Shillinger (1941)	North America
Canada goose	*Branta canadensis & B. hutchinsii*	Bellrose (1959); Szymczak & Adrian (1978)	North America
Canvasback	*Aythya valisineria*	Bellrose (1959); Havera et al. (1992)	North America
Chukar	*Alectoris chukar*	Walter & Reese (2003); Larsen et al. (2006)	Oregon, USA
Cinnamon teal	*Anas cyanoptera*	Bellrose (1959)	North America
Clapper rail	*Rallus longirostris*	Jones (1939)	North America
[B]Common buzzard	*Buteo buteo*	MacDonald et al. (1983); Battaglia et al. (2005)	France; Italy
Common coot	*Fulica atra*	Mateo et al. (2000)	Spain
Common eider	*Somateria mollissima*	Franson et al. (1995); Flint et al. (1997)	Alaska, USA
Common goldeneye	*Bucephala clangula*	Bellrose (1959); Anderson (1975)	North America
Common moorhen	*Gallinula chloropus*	Jones (1939); Locke & Friend (1992)	North America
Common pochard	*Aythya ferina*	Mateo et al. (2000)	Spain
[B, A]Common raven	*Corvus corax*	Scheuhammer & Norris (1995); Craighead & Bedrosian (2008)	Canada; Wyoming, USA
Common snipe	*Gallinago gallinago*	Pain (1990); Olivier (2006)	France
Common teal	*Anas crecca*	Mateo et al. (2000)	Spain
Common wood-pigeon	*Columba palumbus*	Clausen & Wolstrop (1979)	Denmark

SPECIES	SCIENTIFIC NAME	REFERENCE	LOCATION
[C]Cooper's hawk	*Accipiter cooperii*	Martin & Barrett (2001)	Canada
Dark-eyed junco	*Junco hyemalis*	Vyas et al. (2000)	North America
Dunlin	*Calidris alpina*	Kaiser et al. (1980)	British Columbia, Canada
[B]Egyptian vulture	*Neophron percnopterus*	Donazar et al. (2002)	Canary Islands
[B]Eurasian eagle owl	*Bubo bubo*	Mateo et al. (2003)	Spain
[B]Eurasian griffon	*Gyps fulvus*	Mateo et al. (2003); Garcia-Fernandez et al. (2005)	Spain
[B]Eurasian sparrowhawk	*Accipiter nisus*	MacDonald et al. (1983)	France
[C,B]European honey-buzzard	*Pernis apivorus*	Lumeij (1985)	The Netherlands
Gadwall	*Anas strepera*	Bellrose (1959); Mateo et al. (2000)	North America; Spain
Glaucous-winged gull	*Larus glaucescens*	National Wildlife Health Laboratory (1985)	North America
[A, B]Golden eagle	*Aquila chrysaetos*	Craig et al.(1990); Kenntner et al. (2007)	Idaho, USA; Switzerland
[C]Gray-headed woodpecker	*Picus canus*	Mörner and Petersson 1999	Sweden
Greylag goose	*Anser anser*	Mudge (1983); DeFrancisco (2003)	England; Spain
[B]Great horned owl	*Bubo virginianus*	Clark & Scheuhammer (2003)	Canada
Greater & Carribean flamingo	*Pheonicopterus ruber*	Schmitz et al. (1990); Mateo et al. (1997)	Yucatan, Mexico; Spain
Greater scaup	*Aythya marila*	Bellrose (1959)	North America
Greater white-fronted goose	*Anser albifrons*	Zwank et al. (1985)	Louisiana, USA
Green-winged teal	*Anas carolinensis*	Bellrose (1959); Zwank et al. (1985)	North America
Hardhead (duck)	*Aythya australis*	Baxter et al. (1998)	Australia
Herring gull	*Larus argentatus*	National Wildlife Health Laboratory (1985)	North America
Hungarian partridge	*Perdix perdix*	Keymer & Stebbings (1987); Kreager et al. (2007)	England; Canada
Jack Snipe	*Lymnocryptes minimus*	Olivier (2006)	France
Japanese quail	*Coturnix coturnix*	Yamamoto et al. (1993)	Japan
King rail	*Rallus elegans*	Jones (1939)	North America
[B]King vulture	*Sarcorhampus papa*	Decker et al. (1979)	Captive
[B]Laggar falcon	*Falco jugger*	MacDonald et al. (1983)	Captive
Lesser scaup	*Aythya affinis*	Bellrose (1959); Havera et al. (1992)	North America
Long billed dowitcher	*Limnodromus scolopaceus*	Hall & Fisher (1985)	Texas, USA
[B]Long-eared owl	*Asio otus*	Brinzal (1996)	Spain
Long-tailed duck	*Clangula hyemalis*	Flint et al. (1997); Skerratt et al. (2005)	Alaska, USA; North America
Magpie goose	*Anseranas semipalmata*	Harper & Hindmarsh (1990); Whitehead & Tschirner (1991)	Australia
Mallard	*Anas platrhynchos*	Bellrose (1959), Mateo et al. (2000)	North America; Spain
Maned duck	*Chenonetta jubata*	Kingsford et al. (1994)	Australia
Marbled godwit	*Limosa fedoa*	Hall & Fisher (1985); Locke et al. (1991)	Texas, USA; North America
Marbled teal	*Marmaronetta angustirostris*	Mateo et al. (2001); Svanberg et al. (2006)	Spain
Merganser	*Mergus spp.*	Bellrose (1959); Skerratt et al. (2005)	North America

SPECIES	SCIENTIFIC NAME	REFERENCE	LOCATION
Middendorff's bean goose	*Anser fabalis middendorffii*	Chiba et al. (1999)	Japan
Mottled duck	*Anas fulvigula*	Merendino et al. (2005)	Texas, USA
Mourning dove	*Zenaida macroura*	Lewis & Legler (1968); Schulz et al. (2006a)	North America
Mute swan	*Cygnus olor*	Bowen & Petrie (2007)	Great Lakes, Canada
Northern bobwhite quail	*Colinus virginianus*	Westemeier (1966); Keel et al. (2002)	Illinois, USA
[A, B]Northern goshawk	*Accipiter gentillis*	Martin & Barrett (2001); Pain & Amiard-Triquet (1993)	Canada; France
Northern pintail	*Anas acuta*	Bellrose (1959); Mateo et al. (2000)	North America; Spain
Northern shoveler	*Anas clypeata*	Bellrose (1959); Mateo et al. (2000)	North America; Spain
[c]Oriental white-backed vulture	*Gyps bengalensis*	Oaks et al. (2004)	Pakistan
Pacific black duck	*Anas superciliosa*	Baxter et al. (1998)	Australia
Pacific loon	*Gavia pacifica*	Wilson et al. (2004)	Alaska, USA
[B]Peregrine falcon	*Falco peregrinus*	MacDonald et al. (1983); Pain et al. (1994)	Captive; England
Pink-footed goose	*Anser brachyrhynchus*	Mudge (1983)	England
[B]Prairie falcon	*Falco mexicanus*	Redig (1980); MacDonald et al. (1983)	Captive
[B]Red kite	*Milvus milvus*	Mateo et al. (2003); Pain et al. (2007)	England
Red tailed hawk	*Buteo jamaicensis*	Sikarskie (1977); Clark & Scheuhammer (2003)	Canada
Red-crested pochard	*Netta rufina*	Mateo et al. (2000)	Spain
Red-legged partridge	*Alectoris rufa*	Butler (2005)	England
Redhead	*Aythya americana*	Bellrose (1959); Zwank et al. (1985)	North America
Ring-necked duck	*Aythya collaris*	Anderson (1975); Havera et al. (1992)	North America
Ring-necked pheasant	*Phasianus colchicus*	Hunter & Rosen (1965); Butler et al. (2005)	North America; England
Rock dove	*Columba livia*	DeMent et al. (1987)	New York, USA
Rough-legged hawk	*Buteo lagopus*	Locke & Friend (1992)	North America
Ruddy duck	*Oxyura jamaicensis*	Perry & Artmann (1979); Sanderson & Bellrose (1986)	North America
Ruffed grouse	*Bonasa umbellus*	Rodrigue et al. (2005); Kendall et al. (1984)	Virginia, USA; Canada
Sandhill crane	*Grus canadensis*	Windingstad et al. (1984); Franson & Hereford (1994)	North America
Scaled quail	*Callipepla squamata*	Campbell (1950); Best et al. (1992)	New Mexico, USA
Snow goose	*Anser caerulescens*	Bellrose (1959); Zwank et al. (1985)	North America
[A]Snowy owl	*Nyctea scandiaca*	MacDonald et al. (1983)	Captive
Sora rail	*Porzana carolina*	Artmann & Martin (1975); Stendell et al. (1980)	Maryland, USA
Spanish Imperial eagle	*Aquila adalberti*	Mateo et al. (2000); Pain et al. (2005)	Spain
Spectacled eider	*Somateria fischeri*	Franson et al. (1995); Grand et al. (1998)	Alaska, USA
[A]Steller's sea eagle	*Haliaeetus pelagicus*	Kurosawa (2000)	Japan
Trumpeter swan	*Cygnus buccinator*	Bellrose (1959); Blus (1994)	North America
Tufted duck	*Aytha fuligula*	Mudge (1983); DeFrancisco et al. (2003)	England; Spain
Tundra swan	*Cygnus columbianus*	Trainer & Hunt (1965); Blus (1994)	Wisconsin, USA; North America

SPECIES	SCIENTIFIC NAME	REFERENCE	LOCATION
[B]Turkey vulture	*Cathartes aura*	Clark & Scheuhammer (2003); Martin et al. (2008)	North America
Virginia rail	*Rallus limicola*	Jones (1939)	North America
[B]Western marsh-harrier	*Circus aeruginosus*	Pain & Amiard-Triquet (1993); Mateo et al. (1999)	France; Spain
[C]White-backed woodpecker	*Dendrocopus leucotos*	Mörner and Petersson (1999)	Sweden
White-faced ibis	*Plegadis chihi*	Hall & Fisher (1985)	Texas, USA
White-fronted goose	*Anser albifrons*	Bellrose (1959); Ochiai et al. (1993)	North America; Japan
White-headed duck	*Oxyura leucocephala*	Mateo et al. (2001); Svanberg et al. (2006)	Spain
White pekin (wild)	*Anas platyrhychos*	Schwab & Padgett (1988)	Virginia, USA
[A]White-tailed eagle	*Haliaeetus albicilla*	Kurosawa (2000); Krone et al. (2004)	Japan; Greenland
White-throated sparrow	*Zonotrichia albicollis*	Vyas et al. (2000)	North America
Whooper swan	*Cygnus cygnus*	Ochiai et al. (1992); Honda et al. (2007)	Japan
Whooping crane	*Grus americana*	Hall & Fisher (1985)	North America
Wigeon	*Anas americana*	Zwank et al. (1985); Mateo et al. (2000)	Louisiana, USA; Spain
Wild turkey	*Meleagris gallopavo*	Stone & Butkas (1972); Kreager et al. (2007)	New York, USA; Canada
Wood duck	*Aix sponsa*	Bellrose (1959); Sanderson & Bellrose (1986)	North America
[B]Woodcock	*Scolopax minor*	Scheuhammer et al. (2003)	Canada
Yellow-rumped warbler	*Dendroica coronata*	Lewis et al. (2001)	Georgia, USA
Mammals			
Gray squirrel	*Sciurus carolinensis*	Lewis et al. (2001)	Georgia, USA
[B]Domestic cattle		Rice et al. (1987)	
White tailed deer	*Odocoileus virginianus*	Lewis et al. (2001)	Georgia, USA
Reptiles			
[A, B]American alligator	*Alligator mississippiensis*	Camus et al. (1998); Lance et al. (2006)	North America; Captive
[B]Crocodile	*Crocodylus porosus*	Hammerton et al. (2003); Orlic et al. (2003)	North America; Australia

[A] Evidence of secondary poisoning from lead bullets.
[B] Evidence of secondary poisoning from lead shot.
[C] Source of lead unknown, lead shot suspected.

Table 2. Selected literature regarding elevated lead levels in humans consuming game meat harvested with lead shot.

Author	Country	Findings
Bjerregaard et al. 2004	Greenland	Blood lead adjusted for age and sex was found to be associated with the reported consumption of sea birds.
Breurec et al. 1998	Not reported	Patient diagnosed with adult lead poisoning by ingestion of game birds with small lead shots.
Dewaily et al. 2000	Canada, Artic	Ingestion of lead shot/fragments in game meat may be responsible for higher lead levels found in Inuit new-borns. Lead isotopes of shotgun cartridges were similar to those of Inuit new-borns.
Dewailly et al. 2001	Quebec, Canada	Evaluated 492 blood levels of lead and mercury in Inuit adults, revealed that smoking, age, and consumption of waterfowl were associated with lead concentrations (r^2 = .30, p < .001).
Guitart et al. 2002	Spain	Approximately 30,000 waterfowl hunters and their families, especially children, are at risk of secondary lead poisoning from lead poisoned birds in Spain.
Hanning et al. 2003	Canada	Traditional animal food intake, especially wild fowl, correlated significantly with umbilical cord blood lead, and reflected the legacy of using lead-containing ammunition.
Johansen et al. 2001	Ontario, Canada	Breast meat lead values in birds killed with lead shot were 10 times higher than birds not killed with lead shot. Shot is a significant source of lead in many people in Greenland.
Johansen et al. 2004	Greenland	Lead intake of Greenland bird eaters can largely exceed the tolerable lead intake guidelines, and the shot is a more important source of lead than previously estimated.
Johansen et al. 2006	Greenland	Found clear relationship pointing to lead shot as the dominating lead source to people in Greenland.
Levesque et al. 2003	Quebec, Canada	Lead from game hunting was a major source of human exposure to lead. Calls for international ban on lead shotgun ammunition.
Mateo et al. 2007	Spain	Consumption of half a pickled quail/week with embedded shot may cause the provisional tolerable weekly intake of lead by the Spanish consumer to be exceeded.
Odland et al. 1999	Russia	Suggests lead shot as the main source of lead in population in the Kola Peninsula, Russia.
Smith and Rea 1995	Canada	Elevated lead blood levels in children probably due to consumption of birds containing lead shot, suggest use of alternative shot.
Trebel and Thompson 2002	Canada	Young child exhibited elevated blood lead levels after ingesting spent air rifle pellets.
Tsuji et al. 1999	Ontario, Canada	Consumption of any game species harvested with lead shot risks exposure by way of ingestion of tissue-embedded lead pellets and fragments.

NONTOXIC AND LEAD SHOT LITERATURE REVIEW

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The following is: 1) a list of manuscripts relating to lead and nontoxic shot, lead toxicity, lead accumulation in soils and animal tissues, and the impacts of lead shot (and ammunition) on wildlife, humans, and the environment, and 2) summaries of selected manuscripts. This literature review was originally compiled with the help of student interns and appeared as an appendix in the *Nontoxic Shot Advisory Committee Report* compiled by the Section of Wildlife, Minnesota Department of Natural Resources, December 12, 2006 (Nontoxic Shot Advisory Committee 2006). Many of the summaries were written for this report by Roxanne Franke and later appended by Dan Smedberg, student interns from Minnesota State University-Mankato.
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NONTOXIC AND LEAD SHOT-RELATED MANUSCRIPTS

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Tsuji, L.J.S., E. Nieboer, J.D. Karagatzides, & D.R. Kozlovic. 1997. Elevated dentine lead levels in adult teeth of First Nation people from an isolated region of northern Ontario, Canada. Bulletin of Environmental Contamination and Toxicology 59:854-860.

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Wycoff, R.C., D.W. Wills, and L.L. Glasgow. 1971. An evaluation of recovery data from artificially seeded lead shot on Catahoula Lake, La Salle Parish, Louisiana. Proceedings of Annual Conference of Southeastern Association of Game and Fish Commissioners 25:245-254.

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SUMMARIES OF SELECTED MANUSCRIPTS:

Anderson, W. L., and S. P. Havera. 1985. Blood lead, protoporphyrin, and ingested shot for detecting lead poisoning in waterfowl. Wildlife Society Bulletin 13(1):26- 31.

- Gizzards were collected from 3,389 mallards at 26 locations in Illinois during the 1979 hunting season and inspected for lead.
- Blood also taken from 2,265 waterfowl at 7 locations and analyzed for concentrations of lead and PP (a blood pigment precursor to hemoglobin that increases as a response to lead poisoning).
- The percentage of 3,389 mallards with ingested shotgun pellets was 6.3% (determined by manual examination of grit), 7.9% (X-rayed), and 8.2% (found via flouoroscopy). Differences between the techniques were significant ($P < 0.05$).
- Radiology, as opposed to manual examination, is preferred for detecting shotgun pellets in gizzards, but provides only a conservative estimate for the severity of lead poisoning.
- Blood lead levels were found to be the most sensitive indicators of lead poisoning.
- Blood samples from mallards from 4 areas indicated that an average of 8.1% of the mallards had concentrations of lead that equaled or exceeded the threshold of lead poisoning (0.5 ppm) and an average of 3.9% had concentrations of PP that equaled or exceeded the threshold (40 ug/dl).

Beintema, N. (compiler). 2001. Lead poisoning in waterbirds. International Update Report 2000. African- Eurasian Waterbird Agreement, Technical series No. 3. Accessed Feb. 8, 2007. Available online:
http://www.unep-aewa.org/surveys/hunting_and_trade/wi_lead_poison_wbirds_en_2000.pdf

- Reviews the international environmental problem of lead shot ingestion by waterbirds.
- Provides an analysis of a questionnaire of 75 countries (governments and NGOs) and 9 international organizations worldwide.
- Addresses the current state of lead shot legislation, levels of lead shot awareness, coordination, research and development.
- Provides counter-arguments for not using non-toxic shot, and discusses differences between the shot types.
- Reviews relevant developments since 1995.
- Makes lead shot recommendations to governments, non-governmental organizations, hunters' associations and ammunition manufacturers.

Beintema, N. (compiler). 2004. Non-toxic shot: A path towards sustainable use of the waterbird resource. African- Eurasian Waterbird Agreement, Technical series No. 3. Accessed Feb. 8, 2007. Available online: http://www.unep-aewa.org/publications/technical_series/ts3_non-toxic_shot_english.pdf
- Review of worldwide status of lead shot use for waterbirds, and various conventions and agreements pertaining to the use of lead shot.
- Emphasizes that invisible losses of small, continuous numbers of birds are probably much greater than conspicuous, large-scale die offs.
- Argues that a switch to non-toxic shot is necessary to "preserve waterbirds and their habitats for the future."
- Reports an average of 15% of hunted waterfowl exhibit lead levels that are higher than the generally accepted health standard of half a milligram of lead / kilogram of meat (No citation).
- Argues that crippling rates will not necessarily increase by switching to steel shot.

Bellrose, F.C. 1959. Lead poisoning as a mortality factor in waterfowl populations. Illinois Natural History Survey Bulletin 27(1):235-288.
- Reviewed some history of lead poisoning in waterfowl citing literature from the 1930's - 1950's.
- Joint research project between Illinois Natural History Survey and Western Cartridge Co. (now Winchester) with objectives: 1) evaluating waterfowl losses due to lead, 2) look at alternatives to lead shot, 3) determine physiological effects of lead poisoning on waterfowl (Only the first objective reported in this paper).
- Early waterfowl dies offs were recorded as early as 1874 - (in 1894 article) reporting waterfowl dies offs near Galveston, TX, assumed from lead.
- Hundreds of ducks died from lead poisoning in Indiana in 1922.
- Feb. 1930 - coastal Louisiana die-off from lead poisoning. In a 200 acre rice field they found 199 dead ducks, mostly pintails and mallards.
- 'Recent' die offs (1930's-1950's) reported in a table listing location, time of occurrence, species, bird numbers, and reference. Number of birds in die-offs is as high as 16,000 in 2 cases (Missouri 1945-1957; Arkansas 1953-1954).
- Outbreaks dependent on size of late fall/early winter population in an area, species of ducks with similar feeding habits, type and amount of food available, amount of lead shot present, bottom conditions, water level, and ice cover.
- Die-offs are seasonal. Most die-offs during late fall and early winter - after high hunting pressure. Hunting activity keeps ducks from feeding in hunting areas reducing die-offs during hunting season. Spring die-offs rare in ducks, more common in swans and geese.
- "From a compassionate as well as management viewpoint, lead poisoning is a problem that should concern every sportsman."
- Review of some of the Illinois research.

Bjerregaard, P., P. Johansen, G. Mulvad, H.S. Pedersen, and J.C. Hansen. 2004. Lead sources in human diet in Greenland. Environmental Health Perspectives 112(15):1496-1498.

- A sample of the Greenland population was surveyed, and blood lead adjusted for age and sex was found to be associated with the reported consumption of sea birds.
- Participants reporting eating sea birds less than weekly had blood lead levels of ~75 μg /L, while those reporting eating several birds a week had concentrations of ~110 μg /L.
- Source of lead was believed to be lead shot used in harvesting birds.

Breurec, J.Y., A. Baert, J.P. Anger, and J.P. Curtes. 1998. Unusual diagnosis: non-occupational adult lead poisoning. Toxicology Letters 95(1):76.
- Reports two cases of non-occupational adult lead poisoning by ingestion. The symptoms are easy fatigue, abdominal pain, and constipation.
- One patient had frequently eaten game birds containing small shot, and her blood lead levels were 600 μg per L blood.

Buerger, T. T., R. E. Mirarchi, and M. E. Lisano. 1986. Effects of Lead Shot Ingestion on Captive Mourning Dove Survivability and Reproduction. Journal of Wildlife Management 50:1-8.
- Treatments involved force feeding mourning doves 0, 1, 2, or 4 No. 8 Lead shot.
- The mortality rates of the mourning doves receiving 1, 2, or 4 No. 8 Lead shot was 24, 60, and 52%, respectively. Birds not dosed with lead shot had 0% mortality.
- Mourning doves that did not survive typically died within 11 days of the dosing treatments.
- The lead concentrations in the kidneys and livers of doves that survived, whether dosed or not, were noticeably lower (but not significantly) than doves that did not survive.
- Ingestion of No. 8 lead shot by female mourning doves caused a reduction in the hatchability of their eggs, but did not have an effect on productivity or fertility.
- The reduction in hatchability was due to high early embryonic mortality, possibly from transfer of Lead from adult to embryo.

Burger, J., R.A. Kennamer, I.L. Brisbin, and M. Gochfeld. 1998. A risk assessment for consumers of mourning doves. Risk Analysis 18(5):563-573.
- Tested dove meat from a managed dove field and a non-hunted, but potentially contaminated area.
- Currently no set Reference Doses (Rfd) for Lead. Centers for Disease Control level of concern for lead is 10 μg/dL.
- Found that lead levels were highest in meat from the hunted area, posing a slightly increased risk for lead consumption in children eating dove meat regularly.
- Data suggests that hunting on public lands that have received high Lead shot volume in the past poses the greatest health risk to consumers of dove meat.
- Recommend closing dove fields containing high levels of lead shot to hunting as one method to reduce the risk of lead exposure, if concern warrants.
- Banning lead shot for hunting doves is desirable.

Butler, D. A., R. B. Sage, R. A. H. Draycott, J. P. Carroll, and D. Pottis. 2005. Lead exposure in ring-necked pheasants on shooting estates in Great Britain. Wildlife Society Bulletin 33(2):583-589.
- Authors noted this is the first pheasant study looking at a prevalence of lead shot ingestion.
- Wing-bone lead concentrations for 98 hen pheasants collected in 1997.
- Gizzards from 32 shooting estates during 2 springs and 2 hunting seasons.
- 3% of pheasants had ingested lead, no difference between years.
- No decline in body condition relative to amount of lead in wing bones.
- Found that ingestion of shot occurs in pheasants.
- Authors suggest “measures to reduce this problem”.

Cade, T.J. 2007. Exposure of California condors to lead from spent ammunition. Journal of Wildlife Management 71(1):2125-2133.

- Summarizes current scientific data supporting exposure of California condors to lead poisoning.
- 18 clinical necropsies revealed high levels of lead in body tissues and/or presence of lead shotgun pellets and bullet fragments.
- Condors showed crop paralysis and starvation with toxic levels of lead in blood.
- Lead exposure among free flying condors, many with clinically exposed or acute levels, is widespread.
- Temporal and spatial correlations exist between big game hunting seasons and elevated lead levels in condors.
- Lead isotope ratios from exposed condors show close similarity to isotope ratios of ammunition lead.
- Concluded that current levels of lead exposure are too high to allow reintroduced condors to develop self-sustaining populations in AZ and CA.

Campbell, H. 1950. Quail picking up lead shot. Journal of Wildlife Management 14:243-244.
- Dead quail was discovered and autopsied for cause of death.
- Gizzard contained 13 lead shot ranging in size from No. 4 to No. 8.
- No other cause of death was found, so it was suggested as a possibility, but not proven, that the quail died from lead poisoning.

Cao, X., L.Q. Ma, M. Chen, D.W. Hardison, Jr., and W.G. Harris. 2003. Weathering of lead bullets and their environmental effects at outdoor shooting ranges. Journal of Environmental Quality 32:526-534.
- Examined weathering of lead munitions and environmental effects at four shooting ranges.
- Found significant elevation of lead concentrations in soil, water, and vegetation. Lead levels in most sampled soils exceeded EPA's critical level.
- Recommended precautionary measures be taken while mowing grass on shooting ranges to minimize worker exposure to airborne lead.
- These increased levels in aboveground biomass increases wildlife exposure.
- Weathering of bullets is dependent on soil pH and amount of organic matter present.

Case, D.J. and Associates. 2006. Non-toxic shot regulation inventory of the United States and Canada. D.J. Case and Associate, Mishawaka, IN. 29 pp.
- Survey regarding nontoxic shot regulations and discussion for regulations; data for regulations for various species by state or province.
- 45% (26) states and provinces have nontoxic shot regulations beyond the federal waterfowl regulations.
- Nine states/provinces that have nontoxic shot regulations are discussing additional regulations; 17 with nontoxic regulations are not discussing additional regulations.
- Regulations exist for species other than waterfowl, for example 15 states/provinces have regulations for dove, 22 for snipe, 13 for grouse, 12 for quail, and 12 for pheasants.

Castrale, J.S. 1989. Availability of spent lead shot in fields managed for mourning dove hunting. Wildlife Society Bulletin 17:184-189.
- Studied abundance and accumulation of Lead shot in fields managed for dove hunting.
- Found lead shot can accumulate rapidly on soil surface over 1 hunting season, and it remains available to doves until plowed under.
- Recommends tilling fields immediately after hunting season or planting thick vegetation undesirable to foraging doves.

Cheatum, E. L., and D. Benson. 1945. Effects of lead poisoning on reproduction of mallard drakes. Journal of Wildlife Management 9(1):26-29.
- Mated mallard drakes that had recovered from severe lead poisoning with normal females.

- Three or four #4 shot ingested at intervals over a period of two months caused mortality by lead poisoning at a rate of approximately 20%.
- Hatchability of mallard eggs in the test group and control group was similar, with percentages of 58.5 and 58.3, respectively.
- Survival of the mallard ducklings was 66.7% in the test group and 69.6% in the control group.
- Fertility not reduced, however authors suggest vitality of males may impact reproduction in the wild.

Clark, A. J., and A. M. Scheuhammer. 2003. Lead poisoning in upland foraging birds of prey in Canada. Ecotoxicology 12:23–30.
- Examined lead exposure in 184 dead raptors found across Canada (16 species).
- 3–4% of total mortality in the 3 most commonly encountered species (red-tailed hawk, great horned owl, golden eagle) was attributed to lead poisoning.
- Conclude that upland-foraging birds of prey and scavengers, that typically include game birds and mammals in their diets, are at risk for lead poisoning from the ingestion of lead projectiles from ammunition used in upland hunting.
- The use of non-lead ammunition for hunting upland game would effectively remove the only serious source of high lead exposure and lead poisoning for upland-foraging raptors.

Cohen, S. Z. 2004. The Science Underlying Best Management Practices for Shooting Ranges: A Focus on Lead and Arsenic. Page 193-203 in World Symposium on Lead Ammunition, Scheinosst, A. (ed.), Published by the World Forum on the Future of Sport Shooting Activities.
- Best Management Practices (BMPs) are management plans used to minimize offsite pollution of lead, arsenic, and other toxic materials.
- Shooting ranges can be managed in an environmentally responsible manner if BMPs are used.
- BMPs vary according to each individual shooting range.
- Erosion is an important factor in controlling heavy metal mobility, particularly lead.
- Vegetation management is important because it provides plant uptake of nutrients and limits erosion of sediment that contains lead.
- Shooting ranges located in fertilized areas and near water resources typically have lower success in attempts to control mobility of heavy metals such as lead and arsenic.

Cook, R. S., and D. O. Trainer. 1966. Experimental lead poisoning of Canada geese. Journal of Wildlife Management 30:1-8.
- Wild-caught Canada geese were penned and exposed to lead shot and showed first signs of lead poisoning 5-7 days after ingestion.
- Amount of lead ingested directly correlated with time until death, as 25 or more lead pellets caused death within 10 days, while 10 or fewer lead pellets allowed survival for up to 72 days.
- Lead blood levels of poisoned Canada geese were found to range from 0.320-1.680 mg/100 g, while normal lead blood levels of Canada geese were found to be 0.018-0.037 mg/100 g.
- High levels of lead in blood and liver tissue, typical clinical signs, and pathological lesions were required in order to diagnose lead poisoning in Canada geese.
- Direct mortality from Lead poisoning may not be the greatest effect, but rather the effects on survival and reproduction in chronically poisoned birds may be more important.

Craighead, D. and B. Bedrosian. 2008. Blood lead levels of Common ravens with access to big-game offal. Journal of Wildlife Management 72(1):240-245.
- Examined blood samples from ravens feeding on hunter-killed gut piles.
- 47% of ravens sampled during hunting season had elevated blood levels, only 2% had elevated levels during nonhunting season.

Cummings School of Veterinary Medicine at Tufts University. Lead Poisoning. Department of Environmental and Population Health. Cummings School of Veterinary Medicine, North Grafton, Massachusetts. Accessed Feb. 4 2008. Available online: http://www.tufts.edu/vet/lead/index.html

- The website is "intended to address the prevalence of lead poisoning and the interconnection of this issue between species and taxonomic groups."
- Provides a summary and selected literature for lead issues such as: mechanisms of poisoning, aquatic birds, predatory birds, humans, environment, lead alternatives, etc.

Dewailly, E., P. Ayotte, S. Bruneau, G. Lebel, P. Levallois, and J.P. Weber. 2001. Exposure of the Inuit population of Nunavik (Arctic Quebec) to lead and mercury. Archives of Environmental Health 56(4):350-7.

- Evaluated 492 blood levels of lead and mercury in Inuit adults of Nunavik (Arctic Quebec, Canada).
- ANOVA revealed that smoking, age, and consumption of waterfowl were associated with lead concentrations ($r2 = .30$, $p < .001$).
- A significant proportion of reproductive-age women had lead and mercury concentrations that exceeded those that have been reportedly associated with subtle neurodevelopmental deficits in other populations.

Dieter, M. P. and M. T. Finley. 1978. Erythrocyte delta-aminolevulinic acid dehydratase activity in mallard ducks: duration of inhibition after lead dosage. Journal of Wildlife Management 42(3):621-624.

- 30 mallard males and 30 females were fed one No. 4 lead shot, and 8 mallard males and 8 males were not dosed and considered control birds.
- 2 of the birds expelled their shot, and were excluded from the study.
- After 3 weeks, only 5.5% of dosed ducks retained shot in the gizzards, suggesting a rapid and complete erosion of shot.
- Blood samples were taken from each bird and delta-aminolevulinic acid dehydratase (ALAD) enzyme levels were analyzed.
- Inhibition of ALAD has been proven to indicate the incidence and degree of lead contamination in waterfowl.
- Authors believe that waterfowl possessing more than 50 percent ALAD enzyme inhibition have been exposed to acutely high lead levels, which are caused by the ingestion and erosion of lead shot pellets present in the environment.

Edwards, D.H. 2002. Lead distribution at a public shooting range. Master's thesis. Virginia Tech, Blacksburg, VA. 41 pp.

- Part of a larger study that examined the amount and nature of lead munitions on selected shooting ranges, the rates of corrosion, and the degree to which lead was solubilized.
- Lead expended in munitions constitutes the largest influx into the American environment today (2002) , approximately 55,000 metric tons / year.
- In 1985 USFWS estimated that hunters averaged 8.6 shots / waterfowl bird bagged, with each shot expending 29-44 grams of lead.
- Progressive sampling revealed most of the lead shot dispersed in the surrounding forest, in this study. Shot was found embedded in trees >100 m from shooting box.
- Fine particles of lead were found near the shooting box. These smaller particles had greater surface area, and therefore potential to leach lead into the environment.

Elder, W. H. 1954. The Effect of Lead Poisoning on the Fertility and Fecundity of Domestic Mallard Ducks. Journal of Wildlife Management 18:315-323.

- Domestic Mallard ducks were obtained and fed and raised in the same manner to maintain accuracy.

- No. 6 lead shot pellets were placed in a small gelatin capsule and used on the ducks in four different breeding groups: both sexes poisoned, only females poisoned, only males poisoned, and neither sex poisoned.
- In the second year, ducks that received 18 No. 6 lead shot pellets suffered from severe toxemia, when combined with an all grain diet.
- Throughout the duration of the experiment, hens that were dosed with lead displayed lower fecundity (fewer eggs laid) than did non-dosed hens.

Erickson, D. W. and J. S. Lindzey. 1983. Lead and Cadmium in Muskrat and Cattail Tissues. Journal of Wildlife Management 47: 550-555.

- Lead and cadmium levels in cattails and liver and kidney tissues of muskrats were analyzed to determine the correlation of heavy metal between an animal and its environment.
- Elevated levels of lead in cattails and muskrats from the same site indicated that there is an obvious relationship between the levels of lead in the environment, and that assimilated into cattails and subsequently into muskrat tissues.

Estabrooks, S.R. 1987. Ingested lead shot in Northern red-billed whistling ducks (*Dendrocygna autumnalis*) and northern pintails (*Anas acuta*) in Sinaloa, Mexico. Journal of Wildlife Diseases 23(1):169.

- Reports occurrence of ingested Lead shot (no apparent poisoning) in northern Red-billed whistling ducks and Northern Pintails in Mexico.

Finley, M. T., and M. P. Dieter. 1978. Toxicity of experimental lead-iron shot versus commercial lead shot in mallards. Journal of Wildlife Management 42(1):32-39.

- Lab experiment with mallards, comparing lead-iron shot (38.1 % lead) or commercial lead shot.
- Mortality was higher in groups dosed with commercial lead shot than in groups given lead-iron shot.
- After 14 weeks, one #8 shot caused 35% mortality with higher amounts of lead causing 80-100% mortality. 5% mortality was caused by ingestion of two #4 lead-iron shot.

Fisher, I.J., D.J. Pain, and V.G. Thomas. 2006. A review of lead poisoning from ammunition sources in terrestrial birds. Biological Conservation 131(3):421-432.

- Review collates the current knowledge of lead poisoning from ammunition in non-waterbirds.
- 59 terrestrial bird species were documented (as of Oct. 2005) to have ingested lead or suffered lead poisoning from ammunition sources. 9 of these species were Globally Threatened or Near Threatened.
- Terrestrial birds are exposed to lead mainly through ingestion. Secondary poisoning of raptors also occurred.
- Retention time of lead, frequency, past history to exposure, environmental stress, and nutritional factors all can impact the level of Lead poisoning birds experience.
- In Canada, upland game birds and raptors are now more likely to contain lead shot than waterfowl.

Harradine, John. 2004. Spent lead shot and wildlife exposure and risks. Pages 119-130 in Scheinosst, A. (ed.), Proceedings of the World Symposium on Lead Ammunition. World Forum on the Future of Sport Shooting Activities. September 9-10, 2004. Rome, Italy.

- Cursory review of lead shot and wildlife, from the UK.
- P 119 – “Lead is a toxic material, and unlike many other essential metals, has no known biological function. Its ingestion or absorption by people, animals and plants carries risks of harm.”

- Lead poisoning of wildlife occurs by direct ingestion of shot, ingestion of shot by predatory or scavenging animals or birds eating prey containing lead shot, and ingestion of lead from within the bodies of prey animals or plants.
- P 127 – "The issue of lead poisoning in wildlife as a consequence of shooting activities has long been debated as to its occurrence, its impact and how it should be managed. On the basis of evidence to date, and in general terms, waterfowl, some non-waterfowl species, and birds of prey are the groups of wildlife most as risk of poisoning by virtue of being most exposed to spent lead shot and vulnerable to its effects."
- P127 – "Ingestion of lead by other types of wildlife (other than waterfowl and birds of prey), from the relatively few studies to date, appears to be extensive in terms of species in which ingestion has been recorded, but in many cases these amount only to infrequent or even rare occurrence. Some species, such as mourning dove and pheasant, however, which are subject to substantial hunting and which feed in those hunted areas, are exposed to relatively high levels of ingestion and its predictable consequences."
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Hui, C.A. 2002. Lead distribution throughout soil, flora, and an invertebrate at a wetland skeet range. Journal of Toxicology and Environmental Health, part A, 65(15):1093-1107.
- Lead pellets from skeet range in Southern California impart lead into the local soil, plants, and animals.
- Lead concentrations in soil are significantly correlated to shot pellet densities.
- Horn snails had mean lead concentrations 100 x greater than the leaves of plant species at the same site.
- "Avian predators of gastropods may receive minimum exposure to lead due to calcium in shells, but incidental ingestion of soil and direct ingestion of pellets may provide significant exposure to birds."

Hunt, W. G., W. Burnham, C. N. Parish, K. K. Burnham, B. Mutch, and J. L. Oaks. 2006. Bullet fragments in deer remains: implications for lead exposure in avian scavengers. Wildlife Society Bulletin 34(1):167-170.
- Conducted examinations on whole or partial remains of 38 deer killed with standard center-fire, breech-loading rifles.
- All whole or eviscerated deer killed with lead-based bullets contained bullet fragments.
- The proportion (90%) of offal piles containing fragments is not surprising, given that gut piles contain the thoracic organs normally targeted by hunters.
- Copper bullets do not have a high level of fragmentation in comparison to lead bullets.
- The high incidence of lead fragments and their distribution and density suggest a high potential for exposure of avian scavengers to lead.

Johansen, P., G. Asmund, and F. Riget. 2001. Lead contamination of seabirds harvested with lead shot — implications to human diet in Greenland. Environmental Pollution 112(3):501-504.
- Lead contamination of thick-billed murre hunted using lead shot was studied.
- Carcasses were cleaned, cooked, and visible pellets removed.
- Breast meat lead values in birds killed with lead shot were 10 times higher than birds not killed with lead shot (mean 0.22μg/g wet weight).
- Lead in the meat existed as small fragments, left during the passage of pellets through the breast.
- "Birds killed with lead shot are a significant source of lead, probably the most important single source, of the diet of many people in Greenland."
- US Center for Disease Control has defined a blood lead level of 100 μg/L as a level of medium concern, but there may not be a 'safe' lower limit.

Kendall, R. J., T. E. Lacher, Jr., C. Bunck, B. Daniel, C. Driver, C. E. Grue, F. Leighton, W. Stansley, P. G. Watanabe, and M. Whitworth. 1996. An Ecological Risk Assessment of Lead

Shot Exposure in Non-Waterfowl Avian Species: Upland Game Birds and Raptors. Environmental Toxicology and Chemistry 15(1):4-20.
- Exposure to spent lead shot by upland birds and ingestion of spent lead shot by raptors consuming wounded game can cause mortality and other harmful effects.
- "Ingestion of spent lead shot is the most common means of exposure to lead in upland game birds, particularly mourning doves."
- Mourning doves tested had evidence of ingested spent lead shot. Substantial risks of mortality in mourning doves are highest in habitats located in shooting or hunting areas.
- In contrast to game fields, data on shot densities in other habitats is extremely limited.
- The deposition of spent lead shot in upland hunting is almost 5 times greater than that associated with waterfowl hunting.
- Studies of waterfowl in the US suggest that lead poisoned birds are more susceptible to being shot.
- Effects of lead poisoning are exacerbated by exposure to cold temperatures and poor diets.

Knopper, L.D., P. Mineau, A.M. Scheuhammer, D.E. Bond, and D.T. McKinnon. 2006. Carcasses of shot Richardson's ground squirrels may pose lead hazards to scavenging hawks. Journal of Wildlife Management 70(1):295-299.
- Shooting with lead bullets and poisoning with bait are management practices for controlling Richardson's ground squirrels (RGS).
- Determined that 1 in 5 RGS carcasses had lead levels that were lethal in bald eagles.
- RGS carcasses appear to be a source of lead that could be fatal to scavenging (Ferruginous and Swainson's) hawks.
- Estimated that 6.5 RGS carcasses eaten over 23 days would contain a lethal dose of lead for scavenging raptors.
- Hazard could be avoided with the collection of carcasses and use of nontoxic-shot.

Kreager, N., B.C. Wainman, R.K. Jayasinghe, and L.J.S. Tsuji. 2007. Lead pellet ingestion and liver-lead concentrations in upland game birds from southern Ontario, Canada. Archives of Environmental Contamination and Toxicology (published online, ahead of print).
- 123 gizzards from upland game birds harvested by hunters in southern Ontario were examined for lead pellet ingestion.
- 5% of gizzard content samples for common pheasants had >10 pellets, suggesting acute lead poisoning.
- Lead pellets were ingested by chukars (8%) and the common pheasant (34%).
- 13% of bird livers analyzed had elevated lead concentrations (chuckars, pheasants, wild turkey, Hungarian partridge).
- Liver-lead concentrations above Health Canada's guidelines for human consumption of fish protein were found in 40% of livers analyzed.

LaBare, M.P., M.A. Butkus, D. Riegner, N. Schommer, and J. Atkinson. 2004. Evaluation of lead movement from the abiotic to biotic at a small-arms firing range. Environmental Geology 46(6-7):750-754.
- Lead concentrations were examined in sediment, soil, water, plants, fish, and invertebrates at a small-arms firing and skeet range in New York.
- There was an elevated concentration of lead in soil, sediment, and evidence of bioconcentration of lead by the surrounding biota.
- Earthworms had 90% and tadpoles 20% higher concentrations of lead at the firing and skeet range than at controls.
- Lead uptake by indigenous plants varied, and total leachable lead was highest in animals versus plants.

Lance, V.A., T.R. Horn, R.M. Elsey and A. de Peyster. 2006. Chronic incidental lead ingestion in a group of captive-reared alligators (*Alligator mississippiensis*): possible contribution to reproductive failure. Toxicology and Pharmacology 142:30–35.
- An American alligator (*Alligator mississippiensis*) breeding facility was established, and eggs produced showed a lower hatching rate than those collected from the wild.
- Tissues were collected at necropsy from 44 captive and 15 wild animals and assayed for metals. Results showed that captive alligators had significantly higher tissue levels of lead than wild alligators.
- High yolk lead was suggested as a probable cause for early embryonic death in alligator eggs.
- The high tissue lead levels in captive alligators was attributed to long-term consumption of nutria (*Myocastor coypus*) meat contaminated with lead shot.

Larsen, R.T. 2006. Ecological investigations of chukars (*Alectoris chukar*) in western Utah. Master's thesis. Brigham Young University, Provo, UT
- Found lead shot in 1.9% of the gizzards and 10.7% of the crops checked.
- Mentioned lead shot ingestion could be related to rocky nature of chukar habitat. Shot is available longer in this habitat because it is untilled.
- All the major shot sizes used for hunting in the study area correlate strongly with the diameter size of grit picked up by chuckars.

Lévesque, B., J.F. Duchesne, c. Gariépy, M. Rhainds, P. Dumas, A.M. Scheuhammer, J.F. Proulx, S. Déry, G. Muckle, F. Dallaire, and É. Dewailly. 2003. Monitoring of umbilical cord blood lead levels and sources of assessment among the Inuit. Occupational and Environmental Medicine 60:693-695.
- Analysis of 475 umbilical cords showed 7% of Inuit newborns had lead blood concentration levels equal to or greater than the intervention level adopted by many government agencies.
- Lead shot used for game hunting was an important source of lead exposure in the Inuit population. "Lead shots may be a major source of lead exposure to humans that consume hunted game animals."
- Cohort study showed significant decrease in cord blood lead concentrations after a public health intervention to reduce the use of lead shot.
- Recommends banning the use of lead ammunition for all hunting using shotguns, and recommends actively promoting the use of non-toxic shot.

Lewis, L.A., R.J. Poppenga, W.R. Davidson, J.R. Fischer, and K.A. Morgan. 2001. Lead toxicosis and trace element levels in wild birds and mammals at a firearms training facility. Archives of Environmental Contamination and Toxicology 41(2):208-214.
- Lead poisoning was diagnosed in a yellow-rumped warbler and gray squirrel. 7 yellow-rumped warblers and one solitary vireo were found dead due to lead poisoning.
- 72 wild animals (22 different species) were collected surrounding an outdoor firearms shooting range and tested for lead exposure.
- 24 (33.3%) animals (11 species) had lead levels >1.00 ppm, and 12 of these had levels >2.00 ppm.
- Findings indicate significant lead exposure of local wild bird and mammal communities via bullets and fragments in and on the soil surface of the four outdoor ranges.

Locke, L. N., S. M. Kerr, and D. Zoromski. 1982. Lead poisoning in common loons (*Gavia immer*). Avian Diseases 26(2):392-396.
- Common loons were necropsied and 3 loons were found to be lead poisoned.
- Lead fragments of fishing tackle were found in 2 loons with high lead liver levels.
- 13 other loons that died of other causes had low lead liver levels.

Ma, L. W., X. Cao, D. W. Hardison Jr., M. Chen, and W. Harris. 2004. Chemical and Physical Weathering of Pb Bullets in Soils of Florida Shooting Ranges. Page 165-171 in World Symposium on Lead Ammunition. Published by the World Forum on the Future of Sport Shooting Activities.

- Weathering of metallic lead bullets is a major source of lead contamination in shooting range soil.
- Chemical and physical weathering experiments were performed on lead bullets.
- Weathering of metallic lead bullets in soil can be decreased by reducing soil moisture level, by removing soil organic matter, and increasing soil pH.
- Abraded lead from bullets passing through soil has a large contribution to lead contamination in soils.
- Abrasions from the lead bullet allowed fragments and particles to disperse, exposing more surface area for possible corrosion.
- Metallic lead corrosion in the absence of soil was extremely slow, regardless of the level of moisture.

Martin, P.A., D. Campbell, K. Hughes, and T. McDaniel. 2008. Lead in the tissues of terrestrial raptors in southern Ontario, Canada, 1995-2001. Science of The Total Environment 391(1):96-103.

- Lead exposure in 225 birds of 19 species of terrestrial raptors was examined through analysis of bone, liver, and kidney tissues.
- Turkey vultures had the highest mean concentrations of lead compared to other raptors.
- Lead levels exceeded threshold concentrations associated with subclinical or acute toxicity in ~2% of raptors assessed.
- "…The continued use of lead shot for upland hunting in Ontario likely remains as one of the primary sources of lead and a continued risk to these birds of prey."
- Elevated lead in bone represents long-term lead exposure.

Mateo, R., M. Taggart, and A.A. Meharg. 2003. Lead and arsenic in bones of birds of prey in Spain. Environmental Pollution 126(1):107-114.

- Bones of 229 birds of prey from 11 species were analyzed for lead and arsenic to evaluate their exposure to lead shot.
- Lead poisoning has been diagnosed in 8 upland raptor species (Eurasian eagle-owl, Red kite, Eurasian griffon, etc.).
- Raptors feeding on species targeted by hunters in upland habitats suffer from lead poisoning.

McCracken, K. G., A. D. Afton, and M. Peters. 2000. Condition bias of hunter-shot ring-necked duck exposed to lead. Journal of Wildlife Management 64:585-590.

- Tested the null hypothesis that ducks shot by hunters do not differ physiologically from those collected randomly.
- Random collection of ducks was defined as shot at night with the aid of lights, and ducks shot by hunters were done so over decoys.
- Ring-necked ducks shot over decoys were in poorer physical condition than those collected randomly.
- Ingesta-free body mass, lipid, and protein were all negatively related to lead concentration in the adjusted model.
- "Lead exposure is likely to have far-reaching effects on over winter survival (including hunting mortality), not to mention subsequent abilities to migrate and reproduce successfully."
- "In conducting studies, researchers need to recognize and account for lead as a possible source of condition bias."

Michigan Department of Natural Resources. 2002. Michigan Wildlife Diseases Manual. Michigan Department of Natural Resources, Wildlife Disease Laboratory, Lansing, MI 48910-8106. Accessed Feb. 22, 2008. Available online: http://www.michigan.gov/dnr/0,1607,7-153-10370_12150_12220---,00.html

- Suggests that mortality directly due to lead poisoning may be secondary to the indirect, non-lethal effects such as reproductive problems, greater susceptibility to disease, infection, and predation.
- Plowing under areas shot over may be a technique to make lead shot unavailable to upland birds.

Migliorini, M., G. Pigino, N. Bianchi, F. Bernini, and C. Leonzio. 2004. The effects of heavy metal contamination on the soil arthropod community of a shooting range. Environmental Pollution 129(2):331-40.

- Soils at 7 clay pigeon shooting ranges were examined for heavy metals and their effects on the arthropod community.
- Significant amount of lead from spent shot is "bioavailable in the soil and can be bioaccumulated by edaphic organisms, entering the soil trophic network, but without biomagnification."

Minnesota Department of Natural Resources. 2007. Trumpeter swan die-off at Grass Lake, Wright County. DNR Fact Sheet. February 28, 2007. Division of Ecological Services, St. Paul, MN.

- At least 20 trumpeter swans died at the inlet of Grass lake in Wright Co., MN from January to February, 2007.
- The Swans typically wintered on the Mississippi River, but a mild winter created favorable conditions at Grass lake.
- Grass lake was an area of heavy duck hunting where lead shot was used extensively.
- 1 found to have ingested lead pellets – note below
- Follow-up letter indicated that 3 carcasses were obtained, and all three had lead shot.

Osmer, T. L. G. 1940. Lead shot: its danger to water-fowl. The Scientific Monthly 50(5):455-459.

- During waterfowl hunting season the chances of lead poisoning increase.
- Lead shot remains available to waterfowl after the hunting season.
- Osmer stated "It has been experimentally determined that the ingestion of 6 No. 5 shot by a duck is fatal. Even 2 or 3 shot are often fatal." (Osmer did not provide a citation or evidence for the statement.).
- Many lakes across the nation were hunted heavily before becoming refuges, which left these sites with accumulated old lead shot and a continuing potential for lead poisoning.
- Grit is essential for a ducks digestive system and apparently they cannot differentiate between lead shot, granite, or quartz of the same size.
- To determine the availability of lead shot to gravel sampling was done with a Peterson dredge in the areas where waterfowl feed.

Platt, J.B. 1976. Bald eagles wintering in the Utah desert. American Birds 30:783-788.

- Found that bald eagles feeding on jackrabbits shot with lead were ingesting shot, with 71% regurgitated pellets having shot in them.

Sanborn, W. n.d. Lead Poisoning of North American Wildlife from lead shot and lead fishing tackle. Draft. HawkWatch International, 1800 South West Temple, Suite 226, Salt Lake City, UT 84115. 31 pp.

- Summary of lead literature, contains 125 references through 2002.
- Table 1 lists pellet deposition in hunting areas. Note the final lines of Table 1 with hundreds of thousands of lead pellets/acre at Washington pheasant release sites.
- Table 2 (waterfowl), Table 3 (upland game birds) and Table 5 (raptors) lists evidence of

lead exposure and poisoning for more than 19 species.
- Table 6 - Birds poisoned by lead fishing tackle.
- Table 7 - Wildlife lead exposure at shooting ranges.
- Table 10 - Available nontoxic ammunition.
- Table 11 - Price comparison between lead and non-toxic pheasant loads.

Scheuhammer, A. M., D.E. Bond, N.M. Burgess, and J. Rodrigue. 2003. Lead and stable lead isotope ratios in soil, earthworms, and bones of American woodcock (*Scolopax minor*) from Eastern Canada. Environmental Toxicology and Chemistry 22:2585-2591.
- Wing bones collected from young of the year woodcock along with soil and earthworm samples at several sites in Canada were tested for total lead and stable lead isotopes.
- Woodcock with high bone lead accumulation had ratios substantially different from worms and soils sampled from same areas.
- Although woodcock feed extensively on soil invertebrates, ratios were consistent with ingestion of spent lead shotgun pellets.

Scheuhammer, A.M., and S.L. Norris. 1995. A review of the environmental impacts of lead shotshell ammunition and lead fishing weights in Canada. Occasional Paper Number 88, Canadian Wildlife Service. National Wildlife Research Centre, Hull, Quebec. 56 pp.
- Manuscript covers a variety of topics for Canada for lead shot and sinkers.
- Topics include production/use of lead shot and sinkers, environmental chemistry and toxicity of lead, alternatives.
- For hunting waterfowl, other birds, and small mammals, they estimate more than 1800 tons of lead is annually deposited into the environment (Table 2) in Canada.
- For trap and skeet, they estimate that between 128-260 tons of lead is deposited annually into the environment.
- "Ultimately all of the.." lead from shot and sinkers is transformed in the environment into particulate and molecular lead and dispersed through the environment to some degree. This can result in very high concentrations of lead in local environments.
- Tens to hundreds of years required for total breakdown of lead shot pellets depending on chemistry of water or soils. Aerobic, acidic conditions increase the rate of breakdown.
- Lead concentrations near clay target shooting ranges are very high and create significant risk of shot ingestion and poisoning to waterfowl.
- Lead from spent shot enters the food chain.
- Reviews lead toxicity in waterfowl and non-waterfowl species.
- Predators (eagles) experience lead poisoning mortality secondarily by eating prey containing lead shot in their tissues or gizzards.
- Millions of migrating ducks and geese, alive and healthy, carry lead in their tissues; exceeds 20% of the population of these species. Hunted upland game birds also carry shot in their tissues.
- Silage with lead can poison cattle. When lead pellets were removed in one study, there was still enough lead present in silage to be toxic.
- Loon mortality from lead sinkers of jigs.
- Three options to reduce lead are: habitat manipulation (lower water levels to get waterfowl to leave the area), coated shot (but ingestion of coated shot occurs), and alternative shot materials (steel, bismuth/tin, and zinc).

Scheuhammer, A. M., J. A. Perrault, E. Routhier, B. M. Braune, and G. D. Campbell. 1998. Elevated lead concentrations in edible portions of game birds harvested with lead shot. Environmental Pollution 102:251-257.
- Conducted field experiment in Canada, evaluating lead concentrations in pectoral muscles of hunter shot game birds.
- Of 827 right pectoral muscle pooled samples, 92 had lead concentrations > 0.5 µg /g wet weight.

- Although all visible pellets were removed, radiographs showed embedded fragments of lead.
- Embedded fragments of lead from shot are a potential source of dietary lead exposure for predators, and human consumers of wild game.
- Also notes that ~20% of free-living waterfowl carry lead shot in tissues from non-lethal or crippling shots.
- Recommend the use of non-toxic shot for hunting.

Scheuhammer, A. M., C. A. Rogers, and D. Bond. 1999. Elevated lead exposure in American woodcock (*Scolopax minor*) in eastern Canada. Archives of Environmental Contamination and Toxicology 36:334-340.

- Wing bones collected from 1,588 woodcock in Canada.
- A high proportion of woodcock had elevated lead concentrations, compared to other wild bird species.
- 52% adults and 29% young of yr. had concentrations >20.7g/g.
- American woodcock feeding habits are consistent with the occasional ingestion of lead shot, and ingestion of contaminated soil may be an important source of lead exposure.
- Concentrations of lead varied significantly by gender, age, and geographic region.

Schulz, J.H., P.I. Padding, and J.J. Millspaugh. 2006. Will mourning dove crippling rates increase with nontoxic-shot regulations? Wildlife Society Bulletin 34(3):861-865.

- Evaluated crippling rates in waterfowl prior to, during, and after implementation of nontoxic-shot regulations in the U.S.
- Prenontoxic-shot period crippling rates for ducks were lower than the 5 yr phase in period rates, but higher than non-toxic shot crippling rates.
- In geese, prenontoxic-shot period crippling rates and 5 yr phase in period rates were both greater than nontoxic-shot crippling rates, but did not differ significantly.
- Decline in crippling rate that followed full implementation of the nontoxic-shot regulation is of ultimate importance when considering the impacts of lead shot restrictions for mourning doves.
- Long-term mourning dove crippling rates might not increase as evidenced from historical waterfowl data.

Sileo, L., R. N. Jones, and R. C. Hatch. 1973. The effect of ingested lead shot on the electrocardiogram of Canada geese. Avian Diseases 17(2):308-313.

- Lab experiment: 5 geese dosed with 15 No. 6 lead shot, also fed corn along with commercial food (to enhance toxicity of the lead).
- Electrocardiograms and body weights were recorded daily until poisoned geese died, then necropsies were done.
- All dosed geese lost 25 to 45% of their initial body weight and died 11-45 days after ingesting lead.

Spahn, S.A. and T.W. Sherry. 1999. Cadmium and Lead Exposure Associated with Reduced Growth Rates, Poorer Fledging Success of Little Blue Heron Chicks (Egretta caerulea) in South Louisiana Wetlands. Archives of Environmental Contamination and Toxicology 37(3):377-384.

- Cadmium and lead were detected in food samples, guano, and feathers of little blue heron chicks in contaminated wetlands.
- Exposure to lead was correlated with increased nestling mortality.

Stendell, R. C., R. I. Smith, K. P. Burnham, and R. E. Christensen. 1979. Exposure of waterfowl to lead: a nationwide survey of residues in wing bones of seven species, 1972-73. US Government Printing Office 1802-M/7.

- Wing bones were collected from seven species of waterfowl from 3 flyways and analyzed for lead.

- 4,190 duck wing bones were collected in 1972, 1973 reflecting lead residues ranging from trace amounts (<0.5 ppm) to 361 ppm.
- Species of redheads, black ducks, mallards, canvasbacks, and pintails all had intermediate levels of lead. Wing bones of mottled ducks contained the highest levels and lesser scaup had the lowest level of lead.
- Compared geographic patterns of lead exposure in the species along flyways. For example immature mallard lead levels were higher from the Atlantic flyway than the Pacific and Mississippi flyway.

Stevenson, A.L., A.M. Scheuhammer, and H.M. Chan. 2005. Archives of Environmental Contamination and Toxicology 48(3):405-413.

- Found significant decrease in mallard and American black duck bone lead concentrations when comparing before and after the national ban on lead shot for waterfowl hunting.
- Declines were consistent with waterfowl hunter survey, which showed a high level of compliance to nontoxic shot regulation.
- American woodcock showed no decrease in mean bone lead concentration. 70% of waterfowl hunters surveyed who also hunt upland game birds continued to use lead shot.

Strom, S.M., K.A. Patnode, J.A. Langenberg, B.L. Bodenstein, and A.M. Scheuhammer. 2005. Lead contamination in American Woodcock (*Scolopax minor*) from Wisconsin. Archives of Environmental Contamination and Toxicology 49(3):396-402.

- Wing bones from hunter donated woodcock showed young of year were accumulating high lead levels.
- 43.4% young of year woodcock and 70% chicks had bone lead levels in elevated range.
- Elevated lead exposure in WI woodcock is common and begins shortly after hatch.
- Source of lead was not determined.

Tavecchia, G., R. Pradel, J. Lebreton, A.R. Johnson, and J. Mondain-Monval. 2001. The effect of lead exposure on survival of adult mallards in the Camargue, southern France. Journal of Applied Ecology 38(6):1197-1207.

- Captured 2710 adult mallards from a wintering area for several species of water birds.
- Investigated influence of lead pellet exposure (presence of ingested pellets and the presence of pellets in the muscles) on survival.
- Maximum count of pellets in the gizzard was 50, estimated proportion of gizzard-contaminated birds was 11%.
- Distribution in 4 groups: 68% no exposure to, 8% gizzard-contaminated only, 20% muscle-contaminated only, and 3.4% both gizzard and muscle contaminated.
- Survival of lead-affected mallards was 19% lower than unaffected birds for both types of lead exposure. The two sources of mortality were additive.

Thomas, V.G. 1997. The environmental and ethical implications of lead shot contamination of rural lands in North America. Journal of Agricultural and Environmental Ethics 10(1):41-54.

- Lead shot deposited in fields and woodlands near shooting ranges and intense, upland, hunting adds an enormous tonnage of lead to environments, worldwide.
- Many nations are slow to require use of nontoxic-shot, despite the marked awareness of the problems of lead shot contamination and toxicosis.
- “This is due to hunters and international sport shooting organizations opposing the use of non-toxic substitutes and overt emphasis by government agencies on the burden of scientific proof for every situation, rather than taking preventative action according to the Precautionary Principle.”
- The ethical approach of Denmark and The Netherlands, which banned all uses of lead shot, is advocated as a precedent for other nations to adopt.

Thomas, V. G., and Owen, M. 1996. Preventing lead toxicosis of European waterfowl by regulatory and non-regulatory means. Environmental Conservation 23(4):358-364.

- Proposals to eliminate the use of lead shot in wetlands has been made under Bonn and Bern Conservations.
- Proposal was also made by European Union –USA to reduce the use of different categories of lead under an Organization of Economic Cooperation and Development Council Act, but did not include lead shot.
- The passing of European Council regulation has seen the most effective remedy for the trans-boundary toxic problem.
- Responsibility to enact and enforce a European Council regulation is the prerogative of each member state, a single regulation would promote consistency of action amongst all states.

Thomas. V. G., and M. P. Twiss. 1995. Preventing lead contamination of lakes through international trade regulations. Lake and Reservoir Management 11(2):196.

- Lead contamination in Canada's lakes has been a potential problem for toxicosis in waterfowl and fish-eating birds.
- Under the Canadian Environmental Protection Act, Canada has the potential to regulate production and commerce in lead shot and sinkers.
- The North American Free Trade Agreement and its environmental adjunct, The North American Agreement on Environmental Cooperation could regulate trade in lead substitutes among parties.
- Actions taken by Canada, the USA, and Mexico would promote the security of water-birds habitats on a continental scale.

Trainer, D. O., and R. A. Hunt. 1965. Lead poisoning of whistling swans in Wisconsin. Avian Diseases 9(2):252-264.

- Mortality of swans due to lead poisoning has been recognized in Wisconsin since 1944.
- Wild Swans were collected for necropsy and analysis for lead.
- During 1964, more than 200 swans died in Wisconsin. Results (45 birds) established lead poisoning was responsible for the majority of the mortalities.
- Number of pellets recovered from the affected birds ranged from 0 to 201 and averaged 50 pellets per bird.

Tsuji, L.J.S., E. Nieboer, J.D. Karagatzides, R.M. Hanning, B. Katapatuk. 1999. Lead Shot Contamination in Edible Portions of Game Birds and Its Dietary Implications Ecosystem Health 5 (3):183–192.

- Study conducted in the Mushkegowuk region (western James Bay area of northern Ontario, Canada).
- Livers of 2% (5/233) of game birds collected showed lead concentrations >0.5 µg/g ww, and 9% (33/371) of the gizzard (striated muscle) tissue samples obtained through harvesting of waterbirds and upland game birds employing lead shot, showed lead levels greater than the Health Canada guideline for fish.
- "People who consume *any* game species harvested with lead shot risk exposure to this metal by way of ingestion of tissue-embedded lead pellets and fragments."
- A ban on the use of lead shot for *all* game hunting should be considered because of potential human health concerns.

Vyas, N.B., J.W. Spann, G.H. Heinz, W.N. Beyer, J.A. Jaquette, and J.M. Mengelkoch. 2000. Lead poisoning of passerines at a trap and skeet range. Environmental Pollution 107 (1):159-166.

- Tested blood and tissue lead levels in ground foraging passerines on woodlands surrounding a trap and skeet range.

- Sparrows and juncos sampled at the range had significantly higher lead exposure than those at an uncontaminated site.
- Most of the lead shot at the range was found in the top 3 cm of soil, where it is available to wildlife.
- Lead measurements in earthworms were between 660-840 ppm.

Vyas, N.B., J.W. Spann, and G.H. Heinz. 2001. Lead shot toxicity to passerines. Environmental Pollution 111 (1):135-138.

- Evaluated toxicity of a single 7.5 lead shot to passerines.
- On a comercial diet no mortalities, but on natural diet, 3 of 10 cowbirds died within 1 day.
- All but 1 surviving bird excreted the shot within 1 day, but birds which retained their shot died.
- "Despite the short amount of time that shot was retained, songbirds may absorb sufficient lead to compromise their survival."

Wilson, I. D. 1937. An early report of lead poisoning in waterfowl. Science, New Series 86(2236):423.

- Lead poisoning in ducks, geese and swans discovered in Back Bay, Virginia, and Currituck Sound, North Carolina.
- Analyzed gizzards contained over 100 full sized No. 4 lead shot and partly ground remains.

SUPPORT FOR, ATTITUDES TOWARD, AND BELEIFS ABOUT A BAN ON LEAD SHOT IN THE FARMLAND ZONE OF MINNESOTA

David C. Fulton[1], Susan A. Schroeder[1], William Penning, and Kathy DonCarlos

SUMMARY OF FINDINGS

The purpose of this study was to determine level of support or opposition to a ban on lead shot in the farmland zone of Minnesota and the attitudes and beliefs about such a ban. In addition we collected information about small game hunting participation and involvement. Data were collected from 2 study strata: the 7-county Twin Cities metropolitan area and the non-metropolitan areas of the state. Respondents were about equally divided in their support for a ban of using lead shot in the farmland zone within the next 5 years with 42% indicating they are likely to support a ban and 44% reporting they are unlikely to support a ban. Support for a ban was strongly correlated with attitudes toward a ban, and respondents with different attitudes toward a ban differed on their beliefs about the outcomes of such a ban.

INTRODUCTION

In a recent report to the Minnesota Department of Natural Resources (MNDNR), the Nontoxic Shot Advisory Committee (NSAC) agreed that further restrictions on the use of lead shot are inevitable at some future time. While no consensus on specific regulations was reached, the NSAC did agree that more restrictive regulations on the use of lead shot in shotgun hunting are warranted. Five viable options were identified as deeming further consideration, including a ban on using lead shot throughout the farmland zone of Minnesota.

The NSAC recognized that for more restrictive regulations to be implemented successfully, the impacted public must be well-informed and accepting of such regulations. The purpose of this study was to provide information about small game hunter perceptions and knowledge of using toxic/non-toxic shot and help identify appropriate message points for information and education programs addressing the issue of restricting the use of lead shot. Specific objectives of this study were to:

1. Identify levels of use of lead and non-toxic shot in the farmland zone by small game hunters;
2. Identify support/opposition for a ban on the use of lead shot in the farmland zone;
3. Identify attitudes toward a ban on the use of lead shot in the farmland zone;
4. Identify the key beliefs affecting attitudes toward a ban on lead shot
5. Identify the influence of conservation/stewardship values in shaping attitudes and beliefs about restricting the use of toxic shot;
6. Develop and test the effectiveness of targeted messages in changing attitude, beliefs, and behaviors concerning restrictions on the use of toxic shot.

This summary only highlights results for support for, attitudes toward and beliefs about a ban on lead shot in the farmland zone of Minnesota. For complete research results, including a copy of the survey instrument, please refer to Schroeder at al. (2008).

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[1]Minnesota Cooperative Fish and Wildlife Research Unit

METHODS

The population of interest in this study included all Minnesota residents who hunt small game. The sampling frame used to draw the study sample was the MNDNR's Electronic Licensing System (ELS). A stratified random sample of Minnesota resident small game hunters in the ELS was drawn. The initial study sample was stratified by residence of individuals (determined by ZIP code) and included 1) 800 individuals who lived in the seven-county Minneapolis/St. Paul metropolitan area, and 2) 1,200 individuals who lived outside the metropolitan area. The target sample size was n = 400 for the metropolitan region and 600 from the non-metropolitan region (n = 1,000 statewide).

Data were collected using a mail-back survey following a process outlined by Dillman (2000) to enhance response rates. The data collection instrument was a 12-page self-administered survey with 11 pages of questions. The questionnaire addressed the following topics:

- small game hunting activity and involvement,
- shotgun and shot use and preferences,
- beliefs, attitudes, and norms about lead shot,
- trust in the Minnesota Department of Natural Resources and media resources, and
- environmental values.

To measure and understand attitudes and beliefs about banning lead shot in the farmland zone, we followed the Theory of Reasoned Action (Ajzen and Fishbein 1980; Fishbein and Manfredo 1992). This approach has been used to examine a variety of wildlife management issues such as wolf reintroduction in Colorado (Pate et al. 1996) moose hunting in Anchorage (Whittaker et al. 2001), and lethal control of deer in Cuyahoga Valley National Park, Ohio (Fulton et al. 2004).

Based on the Theory of Reasoned Action, 2 key determinants of an attitude are the personal beliefs about a given action leading to particular outcomes and the evaluation of those outcomes. More explicitly, the relationship between an attitude toward a given action and personal beliefs is defined by the following equation:

$$A_{action} = f(\Sigma b_i e_i)$$

Where; A_{action} is the attitude toward a particular action;

b_i is the belief that the action will lead to a particular outcome (e.g., using non-toxic shot will cost me more money); and

e_i is the respondents evaluation of that outcome (e.g., how negative or positive is this additional expense)

A product of the beliefs and evaluations (BE product) is formed for each of the n outcomes. The overall attitude toward an action is the sum of all the BE products. Thus, an attitude toward the action is determined by the combination of multiple beliefs and evaluation of potential outcomes of an action.

RESULTS

Survey Response Rate

Of the 2,000 questionnaires mailed, 54 were undeliverable and 10 were sent to individuals whom had moved out of the state. Of the remaining 1,936 surveys, a total of 920 were returned, resulting in an overall response rate of 47.5%. Response rates for the metropolitan and non-metropolitan regions are summarized in Table 1.

Statewide Estimates

The study sample was drawn using a stratified random sample defined by metropolitan versus non-metropolitan residence. For this reason the data had to be weighted to reflect the proportion of the population in each region when making overall estimates (Table 2). In order to address nonresponse bias, statewide data is also weighted based on differences in responses to the main survey and the shortened survey used to gauge nonresponse bias.

Attitudes About Banning Lead Shot in the Minnesota Farmland Zone

Statewide, respondents were almost evenly split in their intention to support a ban on lead shot for hunting small game in the Minnesota farmland zone within the next 5 years—44.2% said it was unlikely that they would support such a ban, while 42.2% indicated that it was likely (Table 3). On average, metro respondents were somewhat more supportive of the ban than non-metro respondents.

Respondents were asked a series of questions concerning whether a ban on lead shot in the farmland zone would be harmful or beneficial, bad or good, and foolish or wise. About 45% of respondents indicated that the ban would be beneficial (Table 4), good (Table 5), and wise (Table 6). There were no significant differences between metro and non-metro respondents on these questions

Respondents were asked to rate the likelihood of 11 possible outcomes of banning lead shot for small game hunting in the Minnesota farmland zone, using the scale -3=extremely unlikely to +3=extremely likely (Figure 1 and Table 7). Items addressed environmental effects and impacts to hunters. There were no differences on any of these items between metro and non-metro respondents, therefore, Table 7 and 8 provide only the combined statewide findings.

Responses suggest that many small game hunters may perceive both environmental benefits and challenges to hunters as likely outcomes of a ban on lead shot in the farmland zone. Over half of the respondents felt that it was likely that banning lead shot for hunting small game in the farmland zone in Minnesota would: (a) help protect wildlife from lead poisoning, (b) benefit the quality of the environment, (c) prevent the spread of lead in the natural environment, (d) improve awareness about the dangers of lead in the environment. However, over half the respondents also thought it was likely that a ban would: increase crippling and wounding loss for small game hunting and require using less effective shot while hunting small game. Over three-fourths of respondents felt that the ban would require hunters to use more expensive ammunition. Over 40% of respondents felt that a ban would be unnecessary government regulation and would make it more difficult for some people to hunt. Nearly three-fourths of hunters said a ban is something most hunters would adjust to after a few seasons. About half of the hunters felt that it was likely that a ban would improve the image of hunters and that it was unlikely that a ban would decrease hunting opportunity in Minnesota.

Respondents were also asked to rate how good or bad 11 outcomes of banning lead shot would be using the scale -3=extremely bad to +3=extremely good (Figure 2 and Table 7). The majority of respondents felt that environmental benefits were good outcomes. Over 7 in 10 respondents felt that it was good to: (a) protect wildlife from lead poisoning; (b) benefit the quality of the environment; (c) prevent the spread of lead in the natural environment; and (d) improve awareness about the dangers of lead in the environment. However, over two-thirds of respondents felt the following outcomes for hunters were bad: (a) unnecessary government regulation; (b) increasing wounding loss for small game hunting; (c) using less effective shot while hunting small game; (d) using more expensive ammunition; (e) making it more difficult to find shells for their shotgun; and (f) decreasing hunting opportunities. Nearly three-fourths of respondents felt that improving the image of hunters was a good outcome. Nearly half of respondents felt that hunters adjusting to using non-lead shot was a good outcome, but over one-third were neutral about this outcome.

Using ANOVA, we compared the beliefs about the outcomes of a ban on lead shot in the farmland zone between respondents who were likely to oppose to those who were unlikely to support such a ban. We found significant differences in the beliefs and evaluations of all 11 outcomes at $p < 0.001$(Table 8).

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Table 1: Response rates for each management region.

	Initial sample Size	Number invalid	Valid sample size	Number of full surveys returned	Response rate %	Number of shortened surveys returned	Total response rate %
Metropolitan region	800	25	775	376	48.5%	53	55.4%
Non-metropolitan region	1,200	39	1,161	539	46.4%	100	55.0%
Total	2,000	64	1,936	915	47.3%	153	55.2%

Table 2: Proportion of state small game hunters by region of residence in Minnesota.

	Sample		Population	
	Frequency	Proportion	Frequency	Proportion
Statewide	915	100%	297,114	100%
Metro	376	41%	92,105	31%
Non-metro	539	59%	205,009	69%

Table 3: Likelihood of supporting a ban on lead shot to hunt small game in the farmland zone.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	873	22.0%	14.9%	7.3%	13.5%	12.8%	16.4%	13.0%	3.8
Metro	369	17.1%	14.4%	6.8%	10.6%	14.9%	19.2%	17.1%	4.2
Non-metro	522	22.2%	15.1%	7.3%	14.4%	11.7%	16.9%	12.5%	3.8
		χ^2= 11.078 n.s.; Cramer's V = 0.112							F= 7.308**; η=0.090

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4: Supporting a ban on lead shot to hunt small game in the farmland zone: HARMFUL/BENEFICIAL

	N	Extremely harmful	Quite harmful	Slightly harmful	Neutral	Slightly beneficial	Quite beneficial	Extremely beneficial	Mean
Statewide[1]	870	8.3%	3.8%	6.2%	35.0%	18.4%	15.4%	12.9%	4.5
Metro	370	7.8%	2.7%	7.6%	28.4%	21.1%	16.5%	15.9%	4.7
Non-metro	522	7.9%	4.0%	5.2%	36.0%	18.0%	16.1%	12.8%	4.5
				χ^2= 9.510 n.s.; Cramer's V = 0. 103					F= 1.464 n.s.; η=0.041

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5: Supporting a ban on lead shot to hunt small game in the farmland zone: BAD/GOOD

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	872	11.2%	7.2%	8.8%	27.6%	15.7%	16.2%	13.3%	4.3
Metro	370	9.2%	6.8%	8.6%	24.3%	16.2%	18.1%	16.8%	4.5
Non-metro	523	11.1%	6.9%	8.4%	28.1%	16.1%	16.4%	13.0%	4.3
				χ^2= 4.400; n.s. Cramer's V = 0.070					F= 2.775 n.s.; η=0.056

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 6: Supporting a ban on lead shot to hunt small game in the farmland zone: FOOLISH/WISE

	N	Extremely foolish	Quite foolish	Slightly foolish	Neutral	Slightly wise	Quite wise	Extremely wise	Mean
Statewide[1]	871	13.5%	8.6%	8.5%	24.2%	16.5%	16.2%	12.4%	4.2
Metro	369	10.6%	7.9%	8.7%	22.0%	17.3%	18.2%	15.4%	4.4
Non-metro	523	13.8%	8.4%	8.0%	24.3%	16.4%	16.6%	12.4%	4.2
				χ^2= 4.307 n.s.; Cramer's V = 0.069					F= 3.266 n.s.; η=0.060

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 7: Mean beliefs about and evaluations of outcomes of a ban on lead shot for hunting small game in the Minnesota farmland zone.

Outcome	Mean belief [1]	Mean evaluation[2]	Mean B*E
Banning lead shot for hunting small game in the farmland zone in MN…			
…would help protect wildlife from lead poisoning.	.469	1.617	2.139
…would benefit the quality of the environment.	.373	1.716	1.739
… would be unnecessary government regulation.	.314	-1.254	-.965
…would increase crippling and wounding loss for small game hunting.	.537	-1.252	-1.284
…would require using less effective shot while hunting small game.	.713	-1.497	-1.612
…would require using more expensive ammunition.	1.669	-1.252	-2.841
...would improve the image of hunters.	.155	1.272	1.003
...would prevent the spread of lead in the natural environment.	.778	1.577	2.086
…is something most hunters would adjust to after a few seasons.	1.042	.565	1.887
…would decrease hunting opportunity in Minnesota.	-.394	-1.662	.541
…would improve awareness about the dangers of lead in the environment.	.550	1.382	1.955

[1] Beliefs rated on a scale of -3 (extremely unlikely to +3 (extremely likely)
[2] Evaluations rated on a scale of -3 (extremely bad) to +3 (extremely good)

Table 8: Mean beliefs about and evaluations of outcomes of a ban on lead shot for hunting small game in the Minnesota farmland zone, *by likelihood to support a ban*.

Outcome	Mean belief[1]		Mean evaluation[2]		B*E	
Banning lead shot for hunting small game in the farmland zone in MN…	Oppose	Support	Oppose	Support	Oppose	Support
…would help protect wildlife from lead poisoning.	-0.683	1.676	0.996	2.279	.384	4.240
…would benefit the quality of the environment.	-0.771	1.565	1.216	2.268	-.202	3.956
… would be unnecessary government regulation.	1.213	-0.652	-1.667	-0.947	-3.077	.993
…would increase crippling and wounding loss for small game hunting.	0.973	0.116	-1.441	-1.202	-2.449	-.187
…would require using less effective shot while hunting small game.	1.336	0.130	-1.919	-1.183	-3.270	-.110
…would require using more expensive ammunition.	2.174	1.204	-1.784	-0.795	-4.513	-1.340
...would improve the image of hunters.	-0.824	1.121	0.670	1.912	-.616	2.744
...would prevent the spread of lead in the natural environment.	-0.199	1.769	1.237	1.999	.449	3.937
…is something most hunters would adjust to after a few seasons.	0.212	1.889	-0.250	1.405	1.075	3.061
…would decrease hunting opportunity in Minnesota.	0.421	-1.238	-1.849	-1.575	-1.086	2.238
…would improve awareness about the dangers of lead in the environment.	-0.386	1.484	0.808	2.001	.581	3.574

[1] Beliefs rated on a scale of -3 (extremely unlikely to +3 (extremely likely)
[2] Evaluations rated on a scale of -3 (extremely bad) to +3 (extremely good)

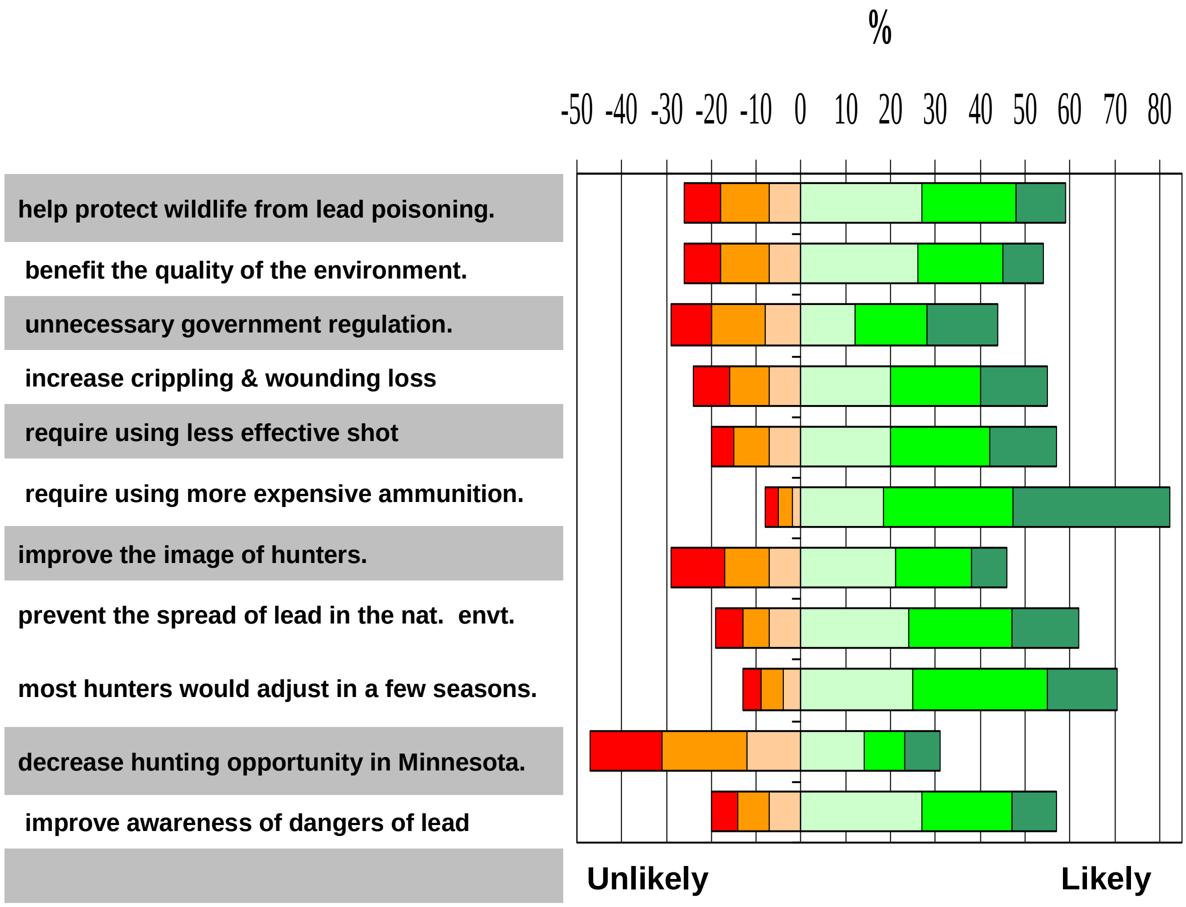

Figure 1. Beliefs about likelihood of outcomes from a ban on lead shot in the farmland zone of Minnesota (%). Dark shading “extremely” to light shading “slightly”.

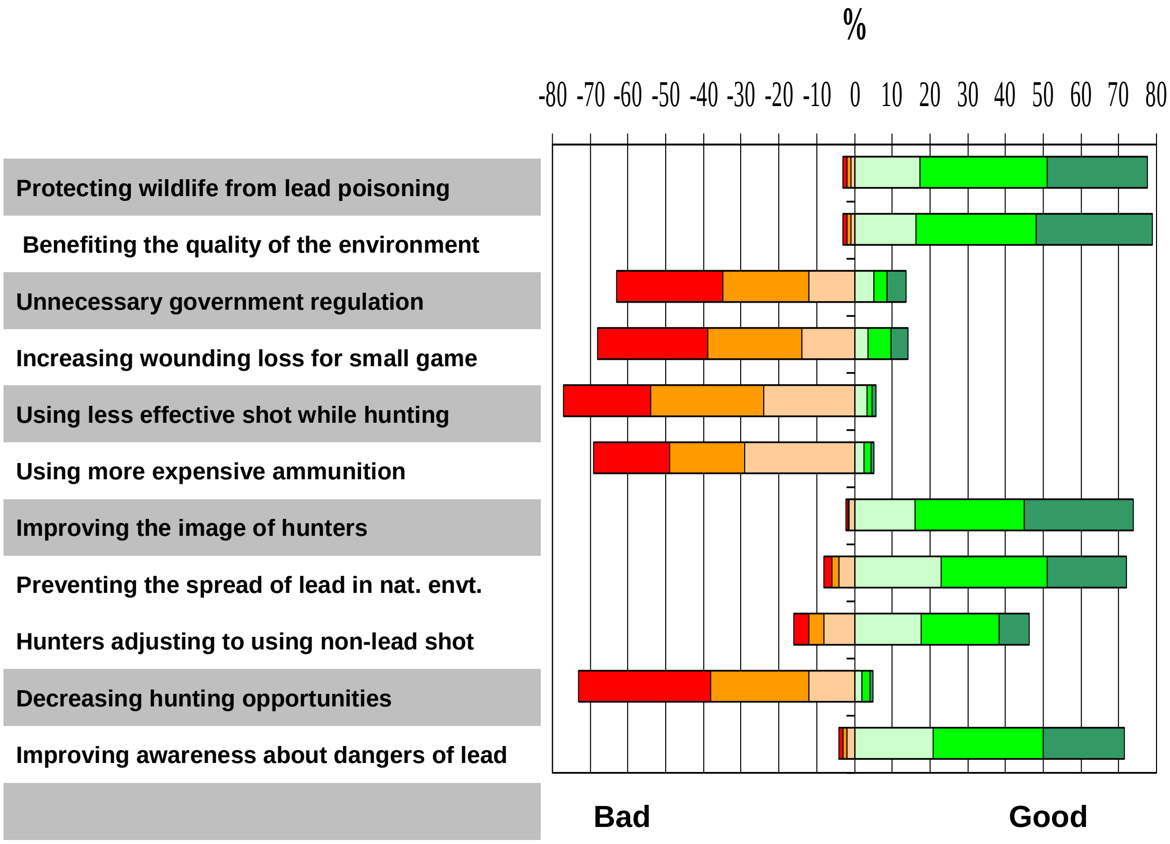

Figure 2. Beliefs that the outcomes are “extremely” bad to extremely “good” (%). Dark shading is “extremely” to light shading “slightly”.

EXAMINING VARIABILITY ASSOCIATED WITH BULLET FRAGMENTATION AND DEPOSITION IN WHITE-TAILED DEER AND DOMESTIC SHEEP

Marrett Grund, Lou Cornicelli, Leah Carlson, Michelle Carstensen, and Erika Butler

SUMMARY OF FINDINGS

Lead (Pb) is a toxic metal and is the primary material used in bullets to hunt white-tailed deer (*Odocoileus virginianus*). We conducted a study to examine bullet fragmentation patterns and to assess lead levels in white-tailed deer and domestic sheep (*Ovis aries*) using different types of bullets and firearms. The firearms we tested included a centerfire rifle, a shotgun, and an inline muzzleloader. For the centerfire rifle, we used lead bullets that are designed to expand rapidly upon impact and are frequently marketed by manufacturers for use while hunting mid-sized game such as white-tailed deer. We also tested lead bullets that are designed to retain a high percentage of their bullet weight as well as non-lead (Copper [Cu]) bullets. Not all data were available at the time we wrote this report, but we do summarize and speculate about data that were immediately available and also our direct observations. We caution readers not to use this report to set public policy because future findings based on final data analysis may conflict with our preliminary findings.

INTRODUCTION

Lead is a toxic, heavy metal found in the natural environment. It is also the most common metal used in ammunition for harvesting game species. Due to the known toxicological effects associated with lead, it poses a potential public safety concern for humans consuming venison from deer that were harvested using lead-based ammunition.

In terms of game harvest management, white-tailed deer are considered light, thin-skinned game and ammunition manufacturers market (recommend) bullets that are designed to expand rapidly upon penetration. Typically, bullets designed to expand rapidly are lead-based, and are designed to fragment with the intent to transfer the maximum amount of energy possible. Bullets of this type are often marketed for use while hunting mid-sized deer species (e.g., *Odocoileus* spp.), pronghorn (*Antilocapra americana*), bighorn sheep (e.g., *Ovis canadensis* spp.), and other species typically ranging from 34-136 kg (75-300 pounds). We will refer to these types of bullets as “Rapid Expansion” bullets throughout this report.

Alternatives to the Rapid Expansion bullets exist and are usually marketed as bullets that have properties that allow for a slower expansion. They typically penetrate deep into the body after striking thick skin, heavy bone, or thick muscle tissue. Bullets of this type usually include lead, but are designed not to fragment and are often marketed as retaining >90% of their weight after striking the animal. Bullets of this type are typically marketed for hunting larger animals such as elk (*Cervus canadensis*), moose (*Alces alces*) and other species weighing >226 kg (>500 pounds). It is important to point out that these bullets may be manufactured for calibers that are too small for larger game mammals (e.g., 6mm rifles), but the bullet is clearly different than the Rapid Expansion bullet because it is designed to retain a high percentage of its weight and not fragment. We will refer to these types of bullets as “Controlled Expansion” bullets throughout this report.

Some ammunition manufacturers also market bullets that are not lead-based but are designed for both mid-sized and large game mammals. These bullets are made entirely from copper or a copper-based alloy and are assumed to be a non-toxic alternative. These bullets are often marketed as: 1) “lead-free” to comply with non-toxic state regulations (e.g., California) and, 2) able to retain >95% of its weight after striking the animal, which implies that the bullet is not designed to fragment inside the animal. We will refer to these bullets as “Copper” bullets throughout this report.

The southern portion of Minnesota is a shotgun-only hunting area where the only legal ammunition for deer hunting is a shotgun slug or muzzleloader. Shotgun slugs are generally designed for mid-sized game mammals such as deer. The traditional slug is often referred to as a “Foster Slug”. This type of slug has rifling on the bullet, which purportedly makes it more effective while shooting through a smoothbore shotgun. The Foster Slug is lead-based and is the most common type of shotgun cartridge purchased for deer hunting. Ammunition manufacturers have recently begun making shotgun ammunition using Copper bullets and they are also marketed for use while hunting mid-sized game mammals.

The number of deer harvested in Minnesota during the muzzleloader season has increased exponentially over the past decade, particularly over the past 5 years. Both lead-based and Copper bullets are available for muzzleloader hunting and are marketed for use while hunting mid-sized and large game mammals.

To our knowledge, no studies have been published that examined the variability of bullet fragmentation and deposition using distinctly different categories of bullets available for centerfire rifles, shotguns, and muzzleloaders. However, Hunt et al. (2006) studied bullet fragmentation patterns in deer carcasses and offal piles using radiographs. While the study was able to confirm that metal fragments existed inside deer carcasses, the study used animals that were opportunistically made available to the researchers and only 23 deer carcasses were examined. In addition, these 23 deer were harvested using different calibers that would have had varying bullet weights, a description of the lead-based bullets used to kill 19 of the deer examined was not included (whether the bullet was a Rapid Expansion bullet or a Controlled Expansion bullet), estimated shot distances ranged from 37 to >200m (40 to >218 yards), and no deer were harvested using shotguns or muzzleloaders.

Similarly, Dobrowolska and Melosik (2008) analyzed lead concentrations in muscle tissues of wild boar (*Sus scrofa*) and red deer (*C. elaphus*) harvested by hunters in Poland. The authors concluded that muscle tissue closer to entrance/exit wound had a higher concentration of lead. However, their samples were not standardized as they were drawn opportunistically from animals harvested with different calibers and bullet types. The authors admitted that caliber and bullet type would be an important factor related to the extent of contamination, but that their study was not designed to address lead contamination levels in muscle; rather to simply point out that meat derived from game animals taken with lead-based bullets will be contaminated with lead.

Our intent was to conduct an experiment that would control for the centerfire caliber and focus on examining the variability of lead fragmentation and deposition associated with distinctly different categories of bullets and firearms used to harvest deer in Minnesota. Although the extent of contamination will likely vary based on caliber (and thus bullet weight), we believe measuring specific types of bullets (Rapid Expansion, Controlled Expansion, and Copper) will provide meaningful results that can be generalized among various rifle calibers. It was not our intent to endorse or defame any particular bullet manufacturer. We selected bullets based on their advertisement and availability. In examining advertisements, bullets designed to rapidly expand should not differ based on manufacturer. For example, the soft point bullet is designed to expand rapidly and no manufacturer claims to retain more energy than another.

OBJECTIVES

- To examine the variability of bullet fragments in relation to the wound channel;
- To determine the level of bullet fragmentation before and after thoroughly rinsing the carcasses shot with rapid expanding bullets; and
- To estimate the level of contamination in muscle tissues in relation to the wound channel after rinsing the carcass with water.

METHODS

This study was initiated in the spring of 2008 and the goal was to have research results available by late summer 2008. It was logistically impossible to obtain an adequate sample size of deer in late spring/early summer 2008. Thus, we used domestic sheep as a surrogate to white-tailed deer. Domestic sheep are ruminants, anatomically similar to deer, and were readily available for this study. Further, domestic sheep have comparable weights to white-tailed deer; their weight and size would certainly classify the species as mid-sized game if domestic sheep were considered a game species.

Seventy-two euthanized, domestic sheep and 8 white-tailed deer were used for this study. We obtained euthanized sheep, marked the coat with a bulls-eye using non-lead based spray paint, then marked the carcass for identification purposes using spray paint. Each sheep was propped up in a broadside position then shot in the thoracic cavity at 50 m. The treatments for this study included: 1) Rapid Expansion Bullets, 2) Controlled Expansion Bullets, 3) Copper Bullets, 4) Shotgun, and 5) Muzzleloader. A .308 Winchester was used to test the first 3 treatments (Rapid Expansion, Controlled Expansion, and Copper Bullets), a 12 gauge shotgun was used to test the Shotgun treatment, and a 50 caliber muzzleloader was used to test the Muzzleloader treatment. The study included 2 treatments each of Rapid Expansion, Controlled Expansion Bullets, and Muzzleloader Bullets. Each of these treatments had bullets made by a different manufacturer (Table 1).

Eight deer were killed on 23 April 2008 using a .308 Winchester with Rapid Expansion bullets that weighed 150 grains. Deer were killed in Permit Area 101 and were transported to the Farmland Wildlife Research office to be stored in a walk-in freezer. Each deer was shot <100 m of the sharpshooter. These deer were not eviscerated until the animals arrived at the necropsy laboratory in July. Sheep that were shot with comparable bullets will be compared to the 8 deer harvested on 23 April 2008.

Bullet fragments were analyzed using radiography with techniques similar to those used by Hunt et al. (2006). We removed the hide of the eviscerated carcass, inserted a carbon fiber tube through the wound channel then took a radiograph on the exit wound side. To test the effects rinsing had on bullet fragment number, we thoroughly rinsed the carcasses that were shot with Rapid Expanding Bullets with water, inserted a carbon fiber tube through the wound channel then took a second radiograph. Due to logistical constraints, we did not take a second radiograph of sheep shot with non-Rapid Expansion Bullets. We measured the maximum distance of fragments in relation to the carbon fiber tube, counted the number of fragments, and calculated the proportion of fragments that were within 13 cm (5 inches) on all radiographs.

The extent of lead contamination in muscle tissue was determined by using similar methods as those used in Dobrowolska and Melosik (2008). We collected a muscle tissue sample from 5, 25, and 45 cm (18 inches) from the exit wound (Figure 1). To assess the effects rinsing has on lead contamination, we rinsed carcasses shot by all bullet types and collected another 3 muscle tissue samples at the same distances.

We also measured the diameter of the entry/exit holes on each carcass. These measurements will be used as a "killing power" index and are used to illustrate the potential effectiveness of each bullet type for killing deer. Finally, we measured the wound channel lengths (linear distance between the entry and exit wound) to determine if wound channel length has an effect on fragmentation patterns or lead concentration levels.

RESULTS AND DISCUSSION

Results related to fragmentation distances, fragmentation patterns, and lead levels were not available at the time this report was written. Thus, we can only provide descriptive statistics for the data that were available in late July. We anticipate receiving all data by mid-August and have a technical report available by late August 2008.

Although our domestic sheep weighed less than the white-tailed deer used for this study, entry and exit hole diameters, and wound channel lengths were comparable between the 2 species (Table 1). The caudal end of eviscerated carcasses likely explains most of the weight differences between the 2 species, thus, the similarity in wound channel distances and entry/exit hole diameters was not unexpected. Based on these data, we believe the differences found among treatments (i.e., bullet types) with the domestic sheep will be directly comparable to what we would have found using white-tailed deer.

Entry holes for the Rapid Expanding Bullets were approximately twice the diameter of entry hole diameters for Controlled Expansion Bullets (Table 1). However, exit hole diameter diameters were comparable between Rapid Expansion and Controlled Expansion Bullets. Entry and exit holes for Copper Bullets were nearly identical to those calculated for Controlled Expansion Bullets. This finding is logical since Controlled Expansion and Copper Bullets are designed and marketed as having the capability to “mushroom” similar to Rapid Expanding Bullets. However, they are designed to expand midway through the wound channel rather than immediately upon impact like the Rapid Expanding Bullets. These findings would suggest that the trauma caused by Controlled Expansion Bullets is similar to the trauma caused by Rapid Expanding Bullets on the exit hole side of the animal. However, the diameter of the wound channel caused by Rapid Expansion Bullets will be greater on the entry hole side of the animal and therefore, will likely create more trauma throughout the thoracic cavity. Conversely, the trauma inflicted by the Controlled Expansion Bullets on the exit hole side of the animal is clearly adequate to humanely kill a mid-sized game mammal.

Although we were not able to provide quantitative results related to bullet fragmentation patterns or to assess lead levels at the time this report was written, we do feel comfortable summarizing some of our direct observations from the radiographs. It was very apparent that there are differences between the number of fragments counted between the Rapid Expanding Bullets compared to the Controlled Expanding Bullets and the Copper Bullets. It was typical to see a “cloud” of fragments surrounding the exit hole for animals shot with both types of Rapid Expanding Bullets. In contrast, we probably counted <5 bullet fragments on the radiographs of sheep that were shot with Controlled Expansion and Copper Bullets. We believe no, or very few, fragments will be observed on many radiographs of sheep shot with Controlled Expansion or Copper Bullets.

The number of visible fragments from radiographs of sheep shot with Shotgun Slugs was low. Occasionally, we may have observed a fragment in close proximity of the exit wound. However, we believe the number of fragments counted on radiographs of sheep shot with Shotgun Slug will be less than the number of fragments counted on radiographs of sheep shot with Controlled Expansion and Copper Bullets. Clearly, the number of fragments counted on the radiographs of sheep shot with Shotgun Slugs will be less than the number of fragments counted on Rapid Expanding Bullets. While we are not certain, the results from the fragmentation counts from radiographs of sheep shot with Muzzleloader bullets will likely be somewhat comparable to the findings for sheep shot with Shotgun Slugs.

We feel comfortable reporting these preliminary findings, however, we caution the use of any of our results until all data are analyzed and interpreted. Our data related to lead levels in muscle tissue were not available at the time this report was written and we were not able to speculate about direct observations because, lead “dust” and fragments are not visible like fragments are on radiographs.

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Hunt, W. G., W. Burnham, C. N. Parish, K. K. Burnham, B. Mutch, and J. L. Oaks. 2006. Bullet fragments in deer remains: Implications for lead exposure in avian scavengers. Wildlife Society Bulletin. 34: 167-170.

Table 1. Average (SD) entry and exit hole diameters (in inches), wound channel lengths (distance between entry and exit holes in inches), and weights (in pounds) of white-tailed deer and domestic sheep shot with different bullet types and weapons, Minnesota, 2008.

Weapon	Bullet type	Species	N	Carcass weight	Entry hole	Exit hole	Wound channel
Rifle	Ballistic Tip	Deer	8	68 (9)	1.0 (0.6)	2.7 (0.9)	8.6 (1.2)
	Ballistic Tip	Sheep	10	43 (7)	1.0 (0.6)	2.0 (0.6)	8.9 (1.0)
	Core-Lokt	Sheep	10	34 (11)	1.1 (0.4)	1.9 (0.6)	7.2 (0.8)
	Hornady Interbond	Sheep	10	29 (7)	0.6 (0.2)	1.8 (0.5)	7.8 (2.4)
	Winchester XP^3	Sheep	10	45 (8)	0.7 (0.2)	1.7 (0.4)	9.3 (1.3)
	Barnes TSX	Sheep	10	38 (9)	0.8 (0.3)	2.0 (0.7)	7.7 (1.7)
Shotgun	Foster Slug	Sheep	10	48 (11)	1.3 (0.2)	1.7 (0.3)	7.8 (1.3)
Muzzleloader	Powerbelt	Sheep	6	37 (6)	0.9 (0.1)	1.2 (0.2)	6.0 (0.8)
	Hornady XTP	Sheep	6	46 (22)	1.3 (0.6)	1.7 (0.6)	7.4 (1.5)

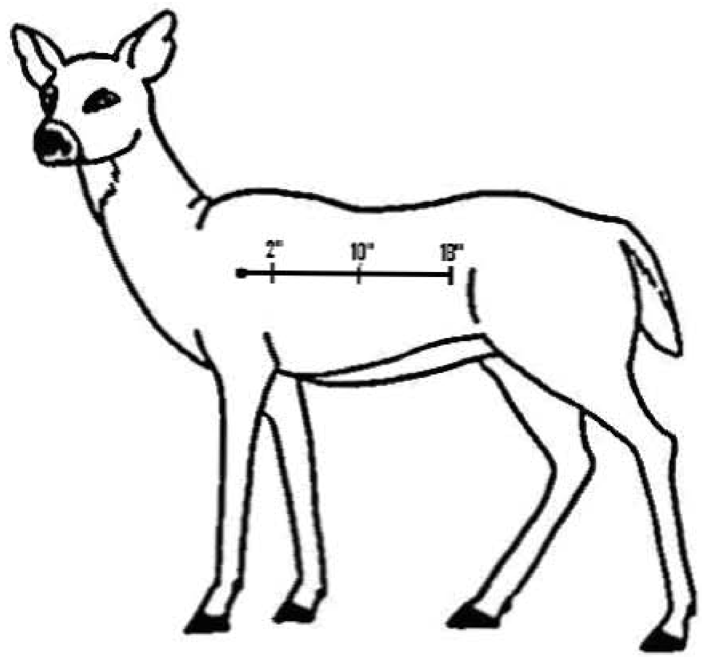

Figure 1. General locations on carcasses where muscle tissues were extracted in relation to the exit hole.

Small Game Hunter Lead Shot Study

Executive Summary

A cooperative study conducted by:

Minnesota Cooperative Fish and Wildlife Research Unit
Minnesota Department of Natural Resources

Small Game Hunter Lead Shot Study

Prepared by:

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Acknowledgements

This study was a cooperative effort supported by the Minnesota Department of Natural Resources, Division of Fish and Wildlife (DNR) and the U.S. Geological Survey through the Minnesota Cooperative Fish and Wildlife Research Unit at the University of Minnesota. We thank Rick Nordby for his assistance in working with the electronic licensing system. We also thank the many small game hunters who took the time to complete the survey and helped to further our understanding of this important clientele.

Suggested Citation

Schroeder, S. A., Fulton D. C., Penning, W., and DonCarlos, K. (2008). Small Game Hunter Lead Shot Study—Executive Summary. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology.

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Executive Summary

The purpose of this study was to provide information about small game hunter perceptions and knowledge of using toxic/non-toxic shot and help identify appropriate message points for information and education programs addressing the issue of restricting the use of lead shot. Specific objectives of this study were to:

1. Identify levels of use of lead and non-toxic shot in the farmland zone by small game hunters;
2. Identify attitudes toward restrictions on toxic shot;
3. Identify support/opposition for restrictions on the use of toxic shot;
4. Identify the key beliefs affecting attitudes toward restrictions on toxic shot;
5. Identify the influence of conservation/stewardship values in shaping attitudes and beliefs about restricting the use of toxic shot;
6. Develop and test the effectiveness of targeted messages in changing attitude, beliefs, and behaviors concerning restrictions on the use of toxic shot.

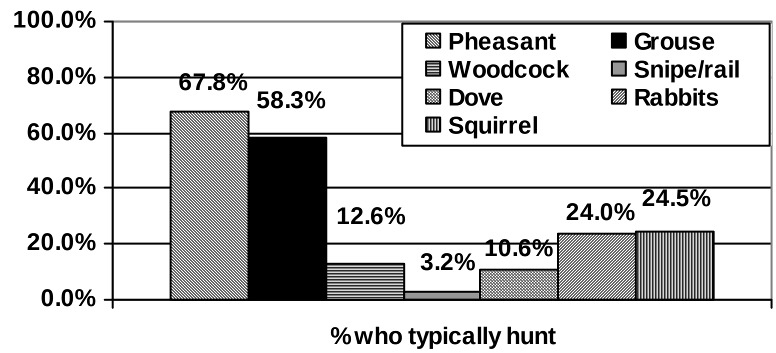
In order to address objectives 1 - 5, a mail survey was distributed to 2,000 small game hunters, including 800 from the seven-county Minneapolis/St. Paul metropolitan area and 1,200 from non-metropolitan counties. Nine hundred and twenty surveys were returned for an adjusted overall response rate of 47.5%. This summary provides a review of results related to the first five objectives. The sixth objective will be summarized separately. In addition, we provide information about hunter participation and involvement, and hunter trust in the Minnesota Department of Natural Resources and media outlets.

Hunter Participation and Involvement

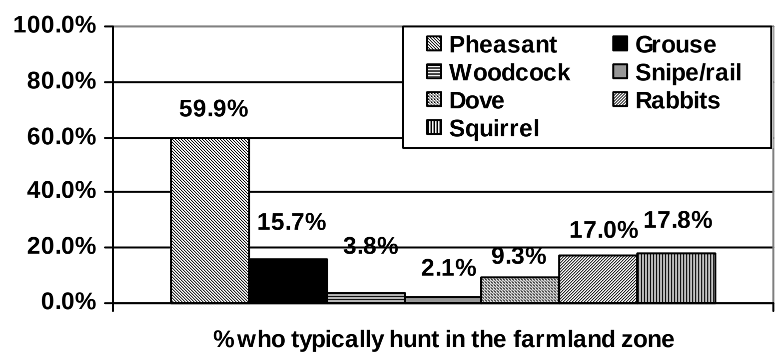
Nearly three-fourths of respondents (72.0%) had hunted for small game in the Minnesota farmland zone during the past 5 years. Over half of respondents reported that they typically hunted for pheasant (67.8%) or grouse (58.3%), while one-fourth or fewer respondents typically hunted for woodcock, snipe or rail, dove, rabbits, or squirrel in Minnesota (Figure S-1). Over half of respondents hunted for pheasant in the farmland zone of Minnesota (Figure S-2).

On average, respondents had been hunting small game in the Minnesota farmland zone for 21.4 years. About

Figure S-1: Proportion of respondents, statewide, who typically hunt for different types of small game



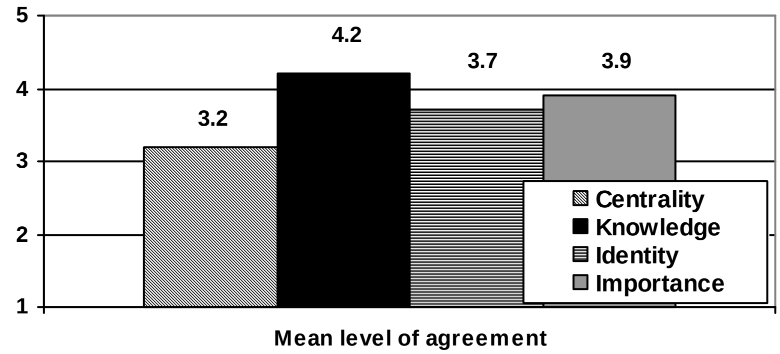
S-2: Proportion of respondents who typically hunt for different types of small game in the farmland zone



half of respondents reported frequently or always hunting with a dog, and about 60% of respondents reported hunting with children under age 12 at least some of the time.

Respondents rated items designed to measure their involvement with small game hunting. Researchers have conceptualized leisure involvement as multidimensional. Leisure involvement may include knowledge of the activity, the centrality or importance of the activity to ones lifestyle, identity or self expression related to participation in the activity, and the general importance of the activity. Respondents rated items related to knowledge, importance, and identity higher than the centrality of the activity (Figure S-8).

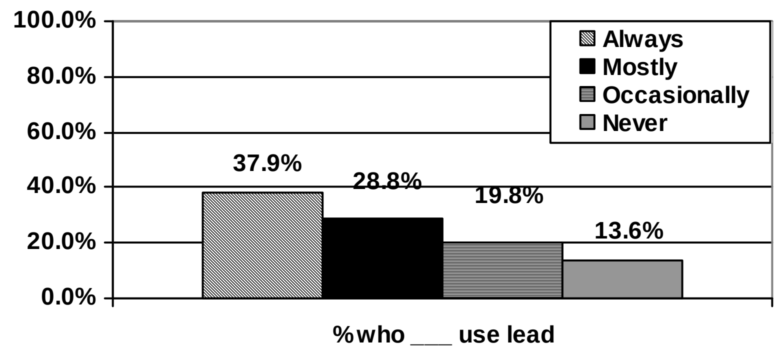
Figure S-3: Hunter involvement ratings



Shot and Shotguns Used for Small-Game Hunting

Survey recipients were asked if they always, mostly, occasionally, or never used lead shot for hunting small game. Over 60% of respondents used non-toxic (i.e. non-lead) shot at least some of the time when hunting for small game (Figure S-4). A slightly greater proportion of respondents who had hunted in the farmland zone in the past 5 years (14.2%) reported that they never used lead shot ($\chi^2 = 12.09$, $p < 0.01$). The majority of respondents reported using lead shot (compared to steel, bismuth or other) most often when targeting specific types of small game. However, use of lead shot varied depending on the game hunted. Nearly 4 in 10 respondents used non-toxic shot to hunt pheasants or snipe, but less than 2 in 10 used non-toxic shot to hunt grouse or woodcock. In general respondents reported using less than one box of shot per season for hunting each type of small game. The majority of respondents reported that they bought loaded shotgun shells (94.1%) compared to self-loading shells. On average, respondents had 10 boxes of loaded shotgun shells on hand.

Figure S-4: Proportion of respondents who use lead shot for small game hunting



Respondents reported using 12-gauge shotguns most often to hunt different types of small game (Table S-1). Use of 12-gauge shotguns ranged from about half of respondents for hunting squirrel and rabbits to about three-fourths for hunting snipe/rail or dove, to nearly 90% for hunting pheasants. A substantive proportion of respondents reported using 20-gauge shotguns, with use ranging from 9.8% of respondents for hunting pheasant to 29.3% for hunting woodcock. Respondents also reported use of .410 gauge for hunting rabbits (18.7%) and squirrel (26.5%). Less than 10% of respondents indicated using .410 gauge for hunting other types of small game. Less than 5% of respondents reported using 28-gauge, 16-gauge, or 10-gauge shotguns for hunting small game.

Table S-1: Gauge of shotgun used most often to hunt for different species.

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Pheasant	579	0.0%	0.2%	9.8%	1.7%	88.1%	0.2%
Grouse	480	5.0%	1.3%	23.2%	3.1%	67.1%	0.2%
Woodcock	92	2.2%	0.0%	29.3%	3.3%	65.2%	0.0%
Snipe/Rail	16	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%
Dove	76	3.9%	2.6%	15.8%	1.3%	76.3%	0.0%
Rabbits	123	18.7%	0.0%	26.0%	3.3%	51.2%	0.8%
Squirrel	98	26.5%	0.0%	25.5%	1.0%	46.9%	0.0%

[1] Percentages reflect only the proportion of statewide respondents that reported that they typically hunted for the species indicated.

[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

Table S-2: Number of boxes of shotgun shells used most often to hunt for different species in the farmland zone.

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Pheasant	510	27.5%	20.0%	31.6%	15.7%	4.9%	0.4%
Grouse	110	50.0%	18.2%	26.4%	4.5%	0.9%	0.0%
Woodcock	18	44.4%	38.9%	11.1%	0.0%	5.6%	0.0%
Snipe/Rail	4	50.0%	25.0%	25.0%	0.0%	0.0%	0.0%
Dove	65	26.2%	24.6%	32.3%	13.8%	1.5%	1.5%
Rabbits	103	50.5%	22.3%	16.5%	8.7%	1.0%	1.0%
Squirrel	105	57.1%	27.6%	11.4%	3.8%	0.0%	0.0%

[1] Percentages reflect only respondents that reported that they typically hunt for squirrel in the farmland zone

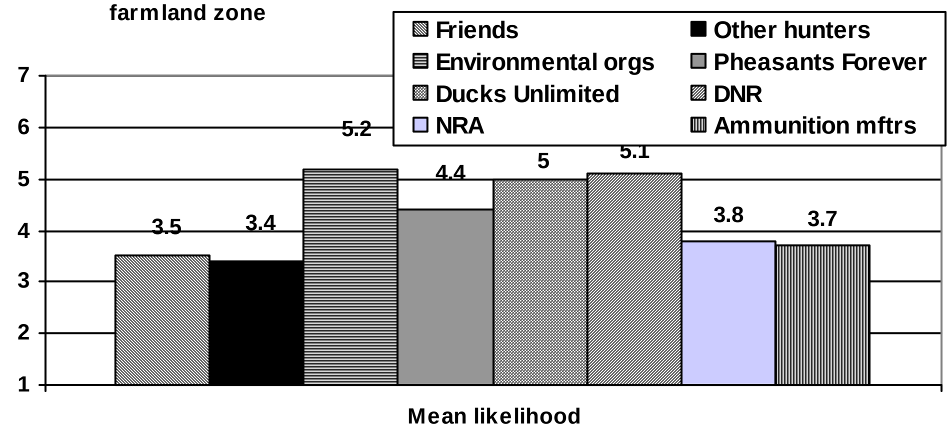
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.

Attitudes and Norms About Banning Lead Shot in the Minnesota Farmland Zone

Attitudes. Respondents were asked to rate the likelihood of possible outcomes of banning lead shot for small game hunting in the Minnesota farmland zone. Items addressed environmental effects and impacts to hunters. Responses suggest that small game hunters perceive both environmental benefits and challenges to hunters as likely outcomes of a ban on lead shot in the farmland zone. Over half of the respondents felt that it was likely that banning lead shot for hunting small game in the farmland zone in Minnesota would: help protect wildlife from lead poisoning, benefit the quality of the environment, prevent the spread of lead in the natural environment, and improve awareness about the dangers of lead in the environment. However, over half the respondents also thought it was likely that a ban would: increase crippling and wounding loss for small game hunting and require using less effective shot while hunting small game. Over three-fourths of respondents felt that the ban would require hunters to use more expensive ammunition. Over 40% of respondents felt that a ban would be unnecessary government regulation and would make it more difficult for some people to hunt. Although hunters reported that a ban might create some challenges, their response to several items suggests that hunters would adapt to a ban and that a ban might even improve the image of hunters. Nearly three-fourths of hunters said a ban is something most hunters would adjust to after a few seasons. Nearly half of hunters felt that it was likely that a ban would improve the image of hunters and that it was unlikely that a ban would decrease hunting opportunity in Minnesota.

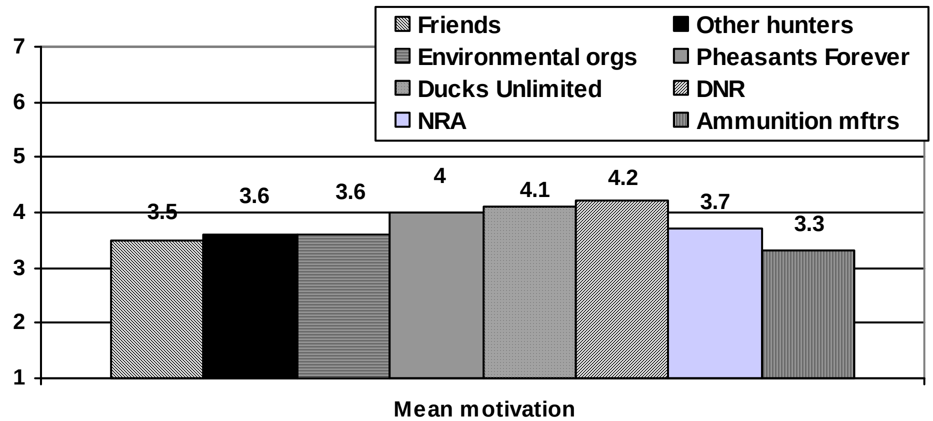
Respondents were also asked to rate how good or bad the possible outcomes of banning lead shot would be using the scale. The majority of respondents felt that environmental benefits were good outcomes. Over 7 in 10 respondents felt that it was good to: protect wildlife from lead poisoning, benefit the quality of the environment, prevent the spread of lead in the natural environment, and improve awareness about the dangers of lead in the environment. However, over two-thirds of respondents felt the following outcomes for hunters were bad: unnecessary government regulation, increasing wounding loss for small game hunting, using less effective shot while hunting small game, using more expensive ammunition, making it more difficult to find shells, and decreasing hunting opportunities. Nearly three-fourths of respondents felt that improving the image of hunters was a good outcome. Nearly half of respondents felt that hunters adjusting to using non-lead shot was a good outcome, but over one-third were neutral about this outcome.

Figure S-5: Likelihood of groups supporting a lead shot ban in the farmland zone



Norms. Respondents were asked to rate the likelihood of groups thinking they should support a ban on lead shot in the Minnesota farmland zone. Results are shown in Figure S-5. Respondents felt it was unlikely that their friends, other hunters, the National Rifle Association (NRA), and ammunition manufacturers would think they should support a ban. Respondents felt it was likely that environmental organizations, Pheasants Forever, Ducks Unlimited, and the Minnesota Department of Natural Resources would want them to support a ban. Respondents were also asked to report their motivation to comply with these groups; results are shown in Figure S-6. Respondents indicated that they would be somewhat more motivated to do what Pheasants Forever, Ducks Unlimited, and the Minnesota DNR wanted them to do. It should be noted that between one-third and one-half of respondents gave neutral responses to the items addressing whether they were motivated to do what referent groups thought they should do.

Figure S-6: Motivation to comply with groups



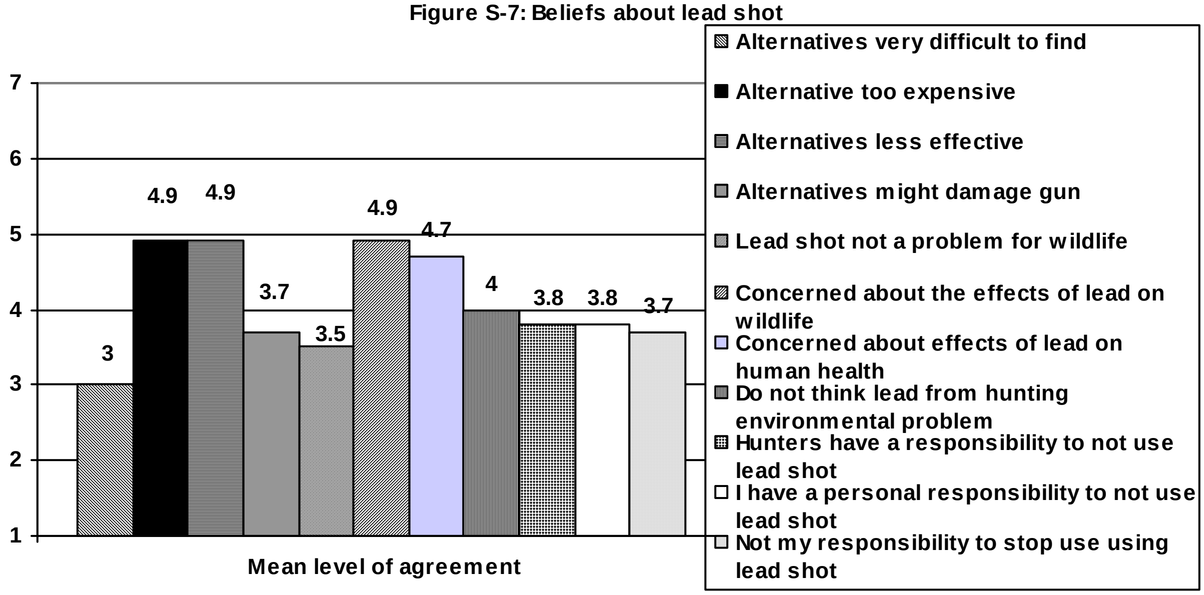
Support for/Opposition to Restrictions on Lead Shot

Respondents were fairly evenly split in their intention to support a ban on lead shot for hunting small game in the Minnesota farmland zone within the next 5 years—44.2% said it was unlikely that they would support such a ban, while 42.2% indicated that it was likely. Respondents were asked a series of questions asking whether such a ban would be harmful or beneficial, bad or good, and foolish or wise. About 45% of respondents indicated that a ban would be beneficial, good, and wise with another 25-35% of respondents feeling neutral about these items.

Beliefs Related to Lead Shot

Respondents were asked to rate beliefs about the use of lead shot for small game hunting. Items addressed (a) the availability, cost, and effectiveness of lead shot alternatives, (b) the problems associated with lead shot, and (c) responsibility for reducing use of lead shot (Figure S-7).

Figure S-7: Beliefs about lead shot



A substantial proportion of respondents were neutral or uncertain on their beliefs about lead shot. More than 25% of respondents rated the following beliefs neutral: (a) I think lead is more effective than alternatives, (b) I think alternatives to lead shot might damage my shotgun, (c) I think hunters have a responsibility to NOT USE lead shot, (d) I think I have a personal responsibility to NOT USE lead shot, and (e) It is not my responsibility to stop using lead shot. There were several items where respondents were fairly evenly divided between those who agreed and those who disagreed, including: (a) I do not think the lead from hunting is an environmental problem (40.9% disagree, 39.9% agree), (b) I think I have a personal responsibility to NOT USE lead shot (40.1% disagree, 33.9% agree), (c) I think hunters have a responsibility to NOT USE lead shot (39.7% disagree, 31.0% agree), and (d) I think alternatives to lead shot might damage my shotgun (39.1% disagree, 30.7% agree).

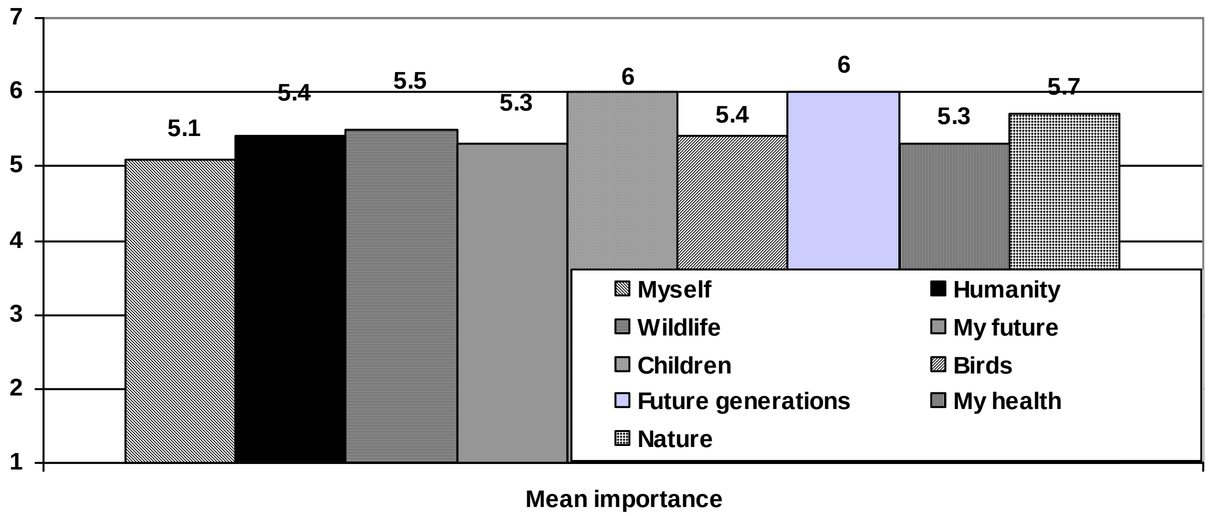
Environmental Values and Consequences of Environmental Problems

Survey recipients completed items that measure a new ecological paradigm, which measures individuals' endorsement of an ecological worldview (Dunlap et al., 2000). More than half of the respondents agreed that: (a) when humans interfere with nature it often produces disastrous consequences, (b) humans are severely abusing the environment, (c) the earth has plenty of natural resources if we just learn how to develop them, (d) plants and animals have as much right as humans to exist, (e) despite our special abilities humans are still subject to the laws of nature, (f) the earth is like a spaceship with very limited room and resources, (g) the balance of nature is very delicate and easily upset. More than half of the respondents disagreed that: (a) humans have the right to modify the natural environment to suit their needs, (b) the balance of nature is strong enough to cope with the impacts of modern industrial nations, and (c) humans will eventually learn enough about how nature works to be able to control it.

A substantial proportion of respondents were neutral or uncertain on survey items used to gauge environmental values. More than 25% of respondents rated the following items neutral: (a) human ingenuity will ensure that we do NOT make the earth unlivable, (b) the so-called "ecological crisis" facing humankind has been greatly exaggerated, (c) the earth is like a spaceship with very limited room and resources, (d) if things continue on their present course, we will soon experience a major ecological catastrophe, and (e) we are approaching the limit of the number of people the earth can support. There were several items where respondents were fairly evenly divided between those who agreed and those who disagreed, including: (a) if things continue on their present course, we will soon experience a major ecological catastrophe (35.6% disagree, 37.1% agree), (b) human ingenuity will ensure that we do not make the earth unlivable (37.6% disagree, 35.6% agree), and (c) the so-called "ecological crisis" facing humankind has been greatly exaggerated, (39.1% disagree, 30.7% agree).

Respondents were asked to indicate why they were concerned about environmental problems. Results are shown in Figure S-8.

Figure S-8: Concern about consequences of environmental problems important to

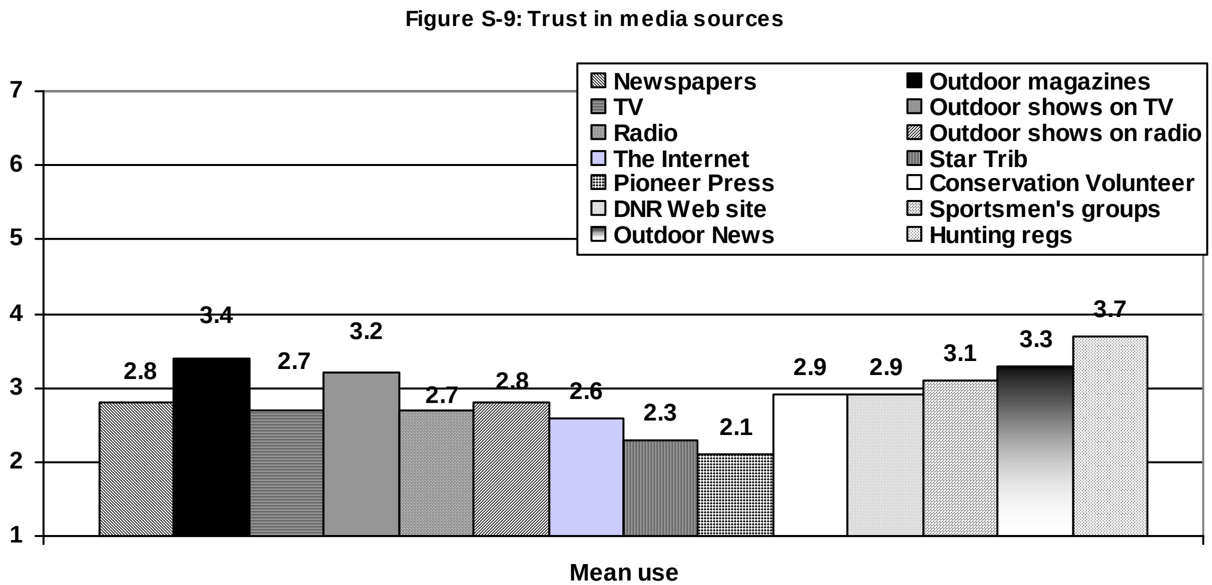


Attitudes About the Minnesota Department of Natural Resources and Research on Lead Shot

Respondents were asked to rate their trust in the Minnesota Department of Natural Resources (DNR) and in research about lead shot. On average respondents were fairly neutral in their trust of the Minnesota DNR. Between 40% and 50% of respondents agreed that: (a) when deciding about the use of lead shot for small game hunting in Minnesota, the DNR will be open and honest in the things they do and say, (b) the DNR can be trusted to make decisions about using lead shot for small game management that are good for the resource, (c) the DNR will make decisions about using lead shot for small game in a way that is fair, and (d) the DNR listens to small game hunters' concerns. Between one-fourth and one-third of the respondents neither agreed nor disagreed with these statements about the Minnesota DNR. Two statements addressed the influence of research on support for a ban on lead shot—two-thirds of respondents would be more likely to support a ban on lead shot if research shows that it has a negative effect on game species or on non-game species.

Trust in and Use of Media Resources

Respondents were asked to indicate how much they rely on and trust information about hunting from 14 sources (Figure S-9).



Relationship of Attitudes and Norms to Support for a Lead Shot Ban

We compared the attitudes about a ban on lead shot in the farmland zone between respondents who were likely to support to those who were unlikely to support such a ban. We identified 7 key outcomes (i.e. protecting wildlife from lead poisoning, benefiting the quality of the environment, unnecessary government regulation, improving the image of hunters, preventing the spread of lead in the natural environment, decreasing hunting opportunities, and improving awareness about the dangers of lead in the environment) where ban supporters and opposers differed in whether they thought the outcome was likely or unlikely to occur.

We also compared the norms about a ban on lead shot in the farmland zone between respondents who were likely to support to those who were unlikely to support such a ban. We identified 4 key groups (i.e. friends, other hunters, Pheasants Forever, and the NRA) where ban supporters and opposers differed in whether they thought the group would be likely or unlikely to support a ban.

We found respondent attitudes, but not norms, were significant predictors of intention to support a ban on lead shot for hunting small game in the Minnesota farmland zone. This suggests that DNR communications emphasize the key beliefs that relate to peoples' attitudes about a lead shot ban. If one or more of the targeted beliefs is changed, hunters may be more likely to change their attitude and more likely to change their intention to support a ban. Specifically, the DNR might want to emphasize that a ban on lead shot would protect wildlife from lead poisoning, benefit the quality of the environment, improve the image of hunters, prevent the spread of lead in the natural environment, improve awareness about the dangers of lead in environment, but that a ban would not decrease hunting opportunities or lead to unnecessary government regulation.

Conclusions

These survey results suggest that many small game hunters use non-toxic shot, at least some of the time. However, hunters are fairly evenly split in their likelihood of supporting a ban on the use of lead shot in Minnesota's farmland zone. Responses suggest that many small game hunters perceive both environmental benefits and challenges to hunters from a possible ban on lead shot in the farmland zone. Likelihood of supporting a ban on lead shot in the farmland zone was positively correlated with pro-ecological values and with trust in the Minnesota Department of Natural Resources. It was negatively correlated with years of hunting in the farmland zone, involvement in small game hunting, frequency of using lead shot, number of boxes of loaded shotgun shells on hand, frequency of hunting with a dog, and frequency of hunting with children under age 12. There were few differences between metropolitan and non-metropolitan small game hunters in their beliefs, attitudes, and norms related to lead shot.

Small Game Hunter
Lead Shot Study

Appendices

A cooperative study conducted by:

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Minnesota Department of Natural Resources

Small Game Hunter Lead Shot Study

Prepared by:

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Appendix A: Methodology

Introduction

Study Purpose and Objectives

In a recent report to the Minnesota Department of Natural Resources, the Nontoxic Shot Advisory Committee (NSAC) agreed that further restrictions on the use of lead shot are inevitable at some future time. While no consensus on specific regulations was reached, the NSAC did agree that more restrictive regulations on the use of lead shot in shotgun hunting are warranted. Five viable options were identified as deeming further consideration. Currently, there is potential legislation that would restrict the use of lead shot on public and/or private land in the farmland/prairie zone of Minnesota in the next few years.

The NSAC recognized that for more restrictive regulations to be implemented successfully, the impacted public must be well-informed and accepting of such regulations. The purpose of this study was to provide information about small game hunter perceptions and knowledge of using toxic/non-toxic shot and help identify appropriate message points for information and education programs addressing the issue of restricting the use of lead shot. Specific objectives of this study were to:

1. Identify levels of use of lead and non-toxic shot in the farmland zone by small game hunters;
2. Identify attitudes toward restrictions on toxic shot;
3. Identify support/opposition for restrictions on the use of toxic shot;
4. Identify the key beliefs affecting attitudes toward restrictions on toxic shot;
5. Identify the influence of conservation/stewardship values in shaping attitudes and beliefs about restricting the use of toxic shot;
6. Develop and test the effectiveness of targeted messages in changing attitude, beliefs, and behaviors concerning restrictions on the use of toxic shot.

The questions used to address each objective are provided in the survey instrument (Appendix A) and discussed in more detail in the subsequent sections.

Methods

Sampling

The population of interest in this study included all Minnesota residents who hunt small game. The sampling frame used to draw the study sample was the Minnesota Department of Natural Resource’s (DNR) Electronic Licensing System (ELS). A stratified random sample of Minnesota resident small game hunters in the ELS was drawn. The initial study sample was stratified by residence of individuals (determined by ZIP code) and included 1) 800 individuals who lived in the seven-county Minneapolis/St. Paul metropolitan area, and 2) 1,200 individuals who lived outside the metropolitan area. five regions (Fig. I-1). The target sample size was n = 400 for the metropolitan region and 600 from the non-metropolitan region (n = 1,000 statewide).

Data Collection

Data were collected using a mail-back survey following a process outlined by Dillman (2000) to enhance response rates. We constructed a relatively straightforward questionnaire, created personalized cover letters, and made multiple contacts with the targeted respondents. Potential study respondents were contacted four times between September 2007 and January 2008. In the initial contact, a cover letter, survey questionnaire, and business-reply envelope were mailed to all potential study participants. The personalized cover letter explained the purpose of the study and made a personal appeal for respondents to complete and return the survey questionnaire. Approximately 3 weeks later, a second letter with another copy of the survey and business-reply envelope was sent to all study participants who had not responded to the first mailing. Three weeks after the second mailing a third mailing that included a personalized cover letter and replacement questionnaire with business-reply envelope was sent to all individuals with valid addresses who had not yet replied. Approximately eight weeks after the third survey mailing a short one-page survey was distributed to assess nonresponse bias.

Survey Instrument

The data collection instrument was a 12-page self-administered survey with 11 pages of questions (Appendix A). The questionnaire addressed the following topics:

- small game hunting activity and involvement,
- shotgun and shot use and preferences,
- beliefs, attitudes, and norms about lead shot,
- trust in the Minnesota Department of Natural Resources and media resources, and
- environmental values.

Data Entry and Analysis

Data were keypunched and the data were analyzed on a PC using the Statistical Program for the Social Sciences (SPSS for Windows 15.0). We computed basic descriptive statistics and frequencies for the statewide results. Metropolitan and non-metropolitan results were compared using one-way analysis of variance and cross-tabulations.

Several statistics presented in the report are used to show the association between variables. Pearson product moment correlations are used to show the linear relationship between two measured (interval-level) variables. Pearson correlations range from -1.0 (perfect negative association) to 1.0 (perfect positive association), with 0 indicating no linear association (Norusis, 2002). The chi-square statistic is used to test whether two categorical variables are independent. The chi-square statistic is not a good measure of association (Norusis, 2002), so the Cramer's V statistic is provided to show the strength of the relationship. Values for Cramer's V range from 0.0 (no association) to 1.0 (perfect association) (Norusis, 2002). Analysis of variance (ANOVA) is used to test hypotheses about differences in two or more population means (Norusis, 2002). In this report ANOVA is used to compare: (a) the means of measured (interval-level) variables based on one multiple-category (polytomous) variable, or (b) the means of multiple interval-level variables. ANOVA produces the F ratio. Large values for the F ratio indicate that the sample means vary more than you would expect (Norusis, 2002). The correlation ratio (eta) is calculated for one-way ANOVA calculations in this report, to indicate the strength of the relationship. Like the Cramer's V statistic, eta (η) ranges from 0.0 (no association) to 1.0 (perfect association) (Norusis, 2002).

Scales of multiple items (i.e. questions) were included in the survey to measure constructs like involvement in small game hunting. The reliability of items that make up a scale indicates the extent to which the scale yields consistent results over repeated observations (Eagly and Chaiken, 1993). Other ways of thinking about the reliability of a measure are: (a) "the extent to which it is free from random error" (Eagly and Chaiken, 1993, p. 64), or (b) "how well scores on the measuring instrument correlate with themselves" (Eagly and Chaiken, 1993, p. 64). We use Cronbach's alpha to report the reliability of the scales in this report. Factor analysis was used to explore the relationship between items in scales. Factor analysis "represents relations among observed variables in terms of latent constructs" (Knoke, Bohrnstedt and Mee, 2002, p. 414). Presumably, the latent constructs generate the covariances observed among observed variables (Knoke, Bohrnstedt and Mee, 2002).

Survey Response Rate

Of the 2,000 questionnaires mailed, 54 were undeliverable and 10 were sent to a person who had moved out of the state. Of the remaining 1,936 surveys, a total of 920 were returned, resulting in an overall response rate of 47.5%. Response rates for the metropolitan and non-metropolitan regions are summarized in Table I-1. Please note that the chart of response rates does not include 5 full-length surveys and 2 shortened surveys that were returned without identification numbers. These surveys were included in statewide results but could not be included in regional analyses.

Table I-1: Response rates for each management region

	Initial sample size	Number invalid	Valid sample size	Number of full surveys returned	Response rate %	Number of shortened surveys returned	Total response rate %
Metropolitan region	800	25	775	376	48.5%	53	55.4%
Non-metropolitan region	1,200	39	1,161	539	46.4%	100	55.0%
Total	2,000	64	1,936	915	47.3%	153	55.2%

Population Estimates

Statewide Estimates

The study sample was drawn using a stratified random sample defined by metropolitan versus non-metropolitan residence. For this reason the data had to be weighted to reflect the proportion of the population in each region when making overall estimates (Figure I-2). In order to address nonresponse bias, statewide data is also weighted based on differences in responses to the main survey and the shortened survey used to gauge nonresponse bias.

Regional Estimates

At the regional level, estimates were calculated based on the region of residence. Weights correcting for nonresponse bias were calculated based on differences in responses to the main survey and the shortened survey used to gauge nonresponse bias and applied to these data. While there were a few statistically significant differences between the weighted and unweighted data, weighting the data did not change results beyond the margin of error for the survey and the effect size of all differences were minimal. For this reason, data were not weighted for the regional estimates reported here.

Table I-2: Proportion of state small game hunters by region of residence in Minnesota.

Region of residence	Sample		Population	
	Frequency	Proportion	Frequency[1]	Proportion
Metro	376	41%	92,105	31%
Non-metro	539	59%	205,009	69%
Statewide[2]	915	100%	297,114	100%

[1] Source: DNR license database

Appendix B: Tables of Survey Results

Section 1: Small Game Hunting Activity and Involvement

Respondents were asked to report which types of small game they typically hunted for, and whether they hunted for different types of game in the Minnesota farmland zone. They were also asked to rate their involvement in small-game hunting.

Small-game hunting participation

Nearly three-fourths of respondents (72.0%) had hunted for small game in the Minnesota farmland zone during the past 5 years (Table 1-1). A significantly greater proportion of metropolitan residents (77. 3%) had hunted in the farmland zone compared to non-metropolitan residents (68.0%) (χ^2= 8.893**; Cramer's V = 0.101).

Over half of respondents reported that they typically hunted for pheasant (67.8%) or grouse (58.3%), while about one-fourth reported that they hunted for squirrel (24.5%) or rabbits (24.0%). Less than one-fifth of the respondents typically hunted for woodcock (12.6%), dove (10.6%), or snipe/rail (3.2%). Significantly greater proportions of metropolitan respondents typically hunted for pheasant and grouse, and significantly smaller proportions hunted for squirrel and rabbits (Table 1-2). Table 1-3 displays the average number of days that respondents hunted for different types of small game.

Over half of respondents (59.9%) reported that they typically hunted for pheasant in the farmland zone, while less than one in five respondents reported that they typically hunted for the other types of small game in the farmland zone (Table 1-4). A significantly greater proportion of metropolitan respondents typically hunted for woodcock in the farmland zone, and significantly smaller proportions of metro respondents hunted for squirrel and rabbits in the farmland zone (Table 1-4). Table 1-5 displays the average number of days that respondents hunted for different types of small game in the farmland zone.

On average, respondents had been hunting small game in the Minnesota farmland zone for 21.4 years, and there was no significant difference between metropolitan and non-metropolitan respondents (Table 1-6). About half of respondents reported frequently or always hunting with a dog, with metropolitan respondents hunting more frequently with dogs (Table 1-7). About 60% of respondents reported hunting with children under age 12 at least some of the time, with respondents from outside the metro area hunting more frequently with children (Table 1-8).

Involvement in small game hunting

Respondents were asked to rate 20 items addressing their involvement and commitment to small game hunting, using the scale 1=strongly disagree to 5=strongly agree (Tables 1-9 to 1-29). The Cronbach's alpha for the 20-item scale was 0.907. Factor analysis identified four dimensions of involvement in small game hunting; (a) centrality, (b) knowledge/volitional control, (c) identity/social, and (d) importance (Table 1-29; Figure 1-1).

Six items loaded on the **knowledge/volitional control** factor (α=0.759, $\bar{x}$=4.2). Knowledge and control items included: (a) small game hunting is one of the most enjoyable things I do ($\bar{x}$=4.2) (Table 1-9), (b) I am knowledgeable about small game hunting ($\bar{x}$=4.2) (Table 1-10), (c) the decision to go small game hunting is primarily my own ($\bar{x}$=4.4) (Table 1-11), (d) I don't really know much about small game hunting ($\bar{x}$=1.8) (Table 1-16), (e) small game hunting interests me ($\bar{x}$=4.5) (Table 1-14), and (f) the decision to go small game hunting is not entirely my own ($\bar{x}$=2.3) (Table 1-22).

Seven items loaded on the **centrality** factor (α=0.878, $\bar{x}$=3.2). Centrality items included: (a) I find that a lot of my life is organized around small game hunting ($\bar{x}$=2.9) (Table 1-12), (b) small game hunting has a central role in my life ($\bar{x}$=2.9) (Table 1-13), (c) most of my friends are in some way connected with small game hunting ($\bar{x}$=3.4) (Table 1-14), (d) for me to change my preference from small game hunting to another leisure activity would require major rethinking ($\bar{x}$= 3.5) (Table 1-23), (e) I find a lot of my life organized around small game hunting activities ($\bar{x}$=2.9) (Table 1-24), (f) I have close friendships that are based on a common interest in small game hunting ($\bar{x}$=3.7) (Table 1-27), and (g) compared to other small game hunters, I own a lot of small game hunting equipment ($\bar{x}$=3.1) (Table 1-28).

Four items loaded on the **identity** factor (α=0.724, $\bar{x}$=3.7). Identity items included: (a) when I am small game hunting, others see me the way I want them to see me ($\bar{x}$=3.6) (Table 1-15), (b) you can tell a lot about a person when you see them small game hunting ($\bar{x}$=3.4) (Table 1-20), (c) when I am small game hunting I can really be myself ($\bar{x}$=3.8) (Table 1-21), and (d) I enjoy discussing small game hunting with my friends ($\bar{x}$=4.0) (Table 1-22).

Three items loaded on the **importance** factor (α=0.650, $\bar{x}$=3.9). Importance items included (a) I have acquired equipment that I would not use if I quit small game hunting ($\bar{x}$=4.0) (Table 1-18), (b) small game hunting is important to me ($\bar{x}$=4.1) (Table 1-25), and (c) even if close friends recommended another recreational activity, I would not change my preference from small game hunting ($\bar{x}$=3.6) (Table 1-26).

There were only a few significant differences between metropolitan and non-metropolitan respondents in their involvement with small game hunting. Non-metropolitan respondents agreed more strongly that most of their friends were in some way connected with small game hunting (Table 1-14). Metropolitan respondents agreed more strongly that they had acquired equipment that they would not use if they quit small game hunting (Table 1-18) and that even if close friends recommended another recreational activity that they would not change their preference from small game hunting (Table 1-25).

Table 1-1: Proportion of respondents who hunted for small game in the Minnesota farmland zone during the past 5 years

Region of residence	% of hunters[1] indicating they hunted in the Minnesota farmland zone in past 5 years: n	Yes	No
Statewide[2]	823	72.0%	28.0%
METRO	357	77.3%	22.7%
NONMETRO	507	68.0%	32.0%
		χ^2= 8.893**; Cramer's V = 0.101	

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-2: Percentage of hunters who hunt for specific types of small game in Minnesota

	Pheasant	Grouse	Woodcock	Snipe/Rail	Dove	Rabbits	Squirrel
Statewide	67.8%	58.3%	12.6%	3.2%	10.6%	24.0%	24.5%
METRO	71.3%	62.1%	15.3%	3.7%	8.9%	15.5%	20.0%
NONMETRO	64.0%	55.6%	11.5%	2.9%	11.7%	27.8%	26.3%
	χ^2= 5.449*; CV = 0.077	χ^2= 3.931*; CV = 0.065	χ^2= 2.772 n.s.; CV = 0.055	χ^2= 0.413 n.s.; CV = 0.021	χ^2= 1.797 n.s.; CV = 0.044	χ^2= 19.176***; CV = 0.144	χ^2= 4.957*; CV = 0.073

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-3: Average number of days hunting for specific types of small game in Minnesota

	Pheasant	Grouse	Woodcock	Snipe/Rail	Dove	Rabbits	Squirrel
Statewide	8.4	8.2	8.1	6.2	5.8	7.5	7.2
METRO	9.2	5.9	6.8	6.1	6.0	8.1	7.7
NONMETRO	6.9	9.4	8.7	6.6	5.6	7.5	7.4
	F=6.238*; η=0.111	F=20.882***; η=0.195	F=0.699 n.s.; η=0.069	F=0.249 n.s.; η=0.063	F=0.127 n.s.; η=0.034	F=0.005 n.s.; η=0.005	F=0.004 n.s.; η=0.004

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-4: Percentage of hunters who hunt for specific types of small game in the farmland zone

	Pheasant	Grouse	Woodcock	Snipe/Rail	Dove	Rabbits	Squirrel
Statewide	59.9%	15.7%	3.8%	2.1%	9.3%	17.0%	17.8%
METRO	62.4%	16.3%	6.3%	2.9%	7.9%	10.5%	13.9%
NONMETRO	56.5%	15.0%	2.7%	1.8%	10.2%	19.9%	19.6%
	χ^2= 3.201 n.s.; CV = 0.059	χ^2= 0.300 n.s.; CV = 0.018	χ^2= 7.105**; CV = 0.088	χ^2= 1.152 n.s.; CV = 0.035	χ^2= 1.462 n.s.; CV = 0.040	χ^2= 14.689***; CV = 0.126	χ^2= 4.948*; CV = 0.073

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-5: Average number of days hunting for specific types of small game in the farmland zone

	Pheasant	Grouse	Woodcock	Snipe/Rail	Dove	Rabbits	Squirrel
Statewide	10.5	6.5	7.3	7.7	5.3	7.7	7.4
METRO	7.4	5.1	6.2	6.4	5.5	6.4	6.7
NONMETRO	11.9	7.4	8.6	8.8	5.2	8.0	7.6
	F=20.781***; η=0.186	F=2.171 n.s.; η=0.077	F=1.920 n.s.; η=0.129	F=0.327 n.s.; η=0.075	F=0.396 n.s.; η=0.059	F=1.186 n.s.; η=0.077	F=0.465 n.s.; η=0.047

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-6: Years hunting small game in the farmland area of Minnesota

	n	Years
Statewide	825	21.4
METRO	356	21.2
NONMETRO	508	21.4
		F=0.028 n.s.; η=0.006

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-7: How often do you hunt with A DOG?

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	862	17.5%	12.9%	17.5%	23.6%	28.5%	3.3
METRO	372	13.4%	15.3%	18.3%	19.4%	33.6%	3.4
NONMETRO	531	19.8%	12.1%	17.3%	25.4%	25.4%	3.3
	χ^2= 15.566**; Cramer's V = 0.131						F=4.057*; η=0.067

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-8: How often do you hunt with CHILDREN UNDER 12?

9	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	847	40.3%	23.9%	25.2%	9.0%	1.7%	2.1
METRO	366	50.3%	23.5%	17.5%	8.2%	0.5%	1.9
NONMETRO	521	36.7%	23.2%	28.0%	10.0%	2.1%	2.2
	χ^2= 23.843***; Cramer's V = 0.164						F=19.873*** η=0.148

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-9: Involvement in small game hunting: Small game hunting is one of the most enjoyable things I do.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	864	1.0%	2.3%	11.9%	43.4%	41.4%	4.2
METRO	370	1.1%	2.2%	13.5%	41.6%	41.6%	4.2
NONMETRO	532	0.9%	2.3%	11.1%	44.2%	41.5%	4.2
	χ^2= 1.442 n.s.; Cramer's V = 0.040						F=0.218 n.s.; η=0.016

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-10: Involvement in small game hunting: I am knowledgeable about small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	864	0.3%	1.2%	12.6%	52.5%	33.3%	4.2
METRO	369	0.3%	1.4%	13.0%	51.5%	33.9%	4.2
NONMETRO	532	0.4%	1.1%	12.2%	53.4%	32.9%	4.2
	χ^2=0.484 n.s.; Cramer's V = 0.023						F=0.000 n.s.; η=0.000

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-11: Involvement in small game hunting: The decision to go small game hunting is primarily my own.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	853	0.6%	0.8%	5.4%	44.4%	48.8%	4.4
METRO	365	0.5%	0.8%	4.7%	43.8%	50.1%	4.4
NONMETRO	526	0.6%	1.0%	5.7%	44.5%	48.3%	4.4
	χ^2= 0.659 n.s.; Cramer's V = 0.027						F=0.477 n.s.; η=0.023

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-12: Involvement in small game hunting: I find that a lot of my life is organized around small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	862	8.3%	28.1%	35.1%	20.1%	8.3%	2.9
METRO	369	8.9%	28.5%	36.6%	17.3%	8.7%	2.9
NONMETRO	531	8.5%	27.3%	34.5%	21.7%	8.1%	2.9
	χ^2= 2.558 n.s.; Cramer's V = 0.053						F=0.521 n.s.; η=0.024

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-13: Involvement in small game hunting: Small game hunting has a central role in my life.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	855	10.1%	27.9%	33.3%	20.6%	8.1%	2.9
METRO	367	10.1%	28.3%	32.4%	19.9%	9.3%	2.9
NONMETRO	526	10.3%	27.8%	32.9%	21.5%	7.6%	2.9
	χ^2= 1.029 n.s.; Cramer's V = 0.034						F=0.041 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-14: Involvement in small game hunting: Most of my friends are in some way connected with small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	862	4.6%	19.7%	22.8%	42.1%	10.7%	3.4
METRO	369	6.0%	23.3%	24.4%	38.2%	8.1%	3.2
NONMETRO	531	4.0%	17.7%	22.2%	44.1%	12.1%	3.4
	χ^2= 10.696*; Cramer's V = 0.109						F=10.705**; η=0.109

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-15: Involvement in small game hunting: When I am small game hunting, others see me the way I want them to see me.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	858	2.9%	6.5%	33.9%	41.0%	15.8%	3.6
METRO	369	3.3%	9.2%	33.1%	38.2%	16.3%	3.6
NONMETRO	526	2.9%	5.5%	33.8%	41.4%	16.3%	3.6
	χ^2= 4.940 n.s.; Cramer's V = 0.074						F=1.528 n.s.; η=0.041

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-16: Involvement in small game hunting: I don't really know much about small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	858	41.7%	44.1%	9.9%	3.7%	0.5%	1.8
METRO	368	39.1%	46.2%	9.5%	4.3%	0.8%	1.8
NONMETRO	528	42.6%	43.6%	9.8%	3.6%	0.4%	1.8
	χ^2= 2.054 n.s.; Cramer's V = 0.048						F=1.151 n.s.; η=0.036

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-17: Involvement in small game hunting: Small game hunting interests me.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	845	0.5%	1.1%	6.6%	52.9%	38.9%	4.3
METRO	366	0.8%	0.8%	5.7%	53.8%	38.8%	4.3
NONMETRO	517	0.4%	1.2%	7.2%	52.6%	38.7%	4.3
	χ^2= 1.670 n.s.; Cramer's V = 0.043						F=0.039 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-18: Involvement in small game hunting: I have acquired equipment that I would not use if I quit small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	860	3.4%	10.4%	10.6%	39.4%	36.2%	4.0
METRO	369	3.4%	11.8%	12.0%	39.7%	33.2%	4.1
NONMETRO	527	4.3%	7.0%	8.1%	38.2%	42.3%	3.9
	χ^2= 13.412**; Cramer's V = 0.122						F=6.932**; η=0.088

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-19: Involvement in small game hunting: You can tell a lot about a person when you see them small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	861	4.3%	11.3%	36.4%	36.1%	11.9%	3.4
METRO	369	6.2%	9.2%	38.8%	34.4%	11.4%	3.4
NONMETRO	529	3.6%	11.9%	34.8%	37.8%	11.9%	3.4
	χ^2= 6.383 n.s.; Cramer's V = 0.084						F=1.107 n.s.; η=0.035

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-20: Involvement in small game hunting: When I am small game hunting I can really be myself.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	862	1.6%	2.8%	28.3%	48.2%	19.0%	3.8
METRO	370	2.2%	3.2%	30.0%	46.5%	18.1%	3.8
NONMETRO	530	1.3%	2.6%	27.5%	49.1%	19.4%	3.8
	χ^2= 2.160 n.s.; Cramer's V = 0.049						F=1.758 n.s.; η=0.044

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-21: Involvement in small game hunting: I enjoy discussing small game hunting with my friends.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	859	1.1%	2.6%	16.3%	60.3%	19.7%	4.0
METRO	367	1.1%	4.4%	12.5%	59.4%	22.6%	4.0
NONMETRO	529	0.9%	1.7%	18.0%	60.3%	19.1%	4.0
	χ^2= 10.924*; Cramer's V = 0.110						F=0.392 n.s.; η=0.021

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-22: Involvement in small game hunting: The decision to go small game hunting is not entirely my own.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	859	27.4%	38.3%	16.3%	14.9%	3.1%	2.3
METRO	370	30.3%	38.4%	14.6%	14.1%	2.7%	2.2
NONMETRO	527	25.8%	37.4%	17.6%	15.7%	3.4%	2.3
	χ^2= ; Cramer's V = 0.						F=2.978 n.s.; η=0.058

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-23: Involvement in small game hunting: For me to change my preference from small game hunting to another leisure activity would require major rethinking.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	861	5.1%	18.6%	24.5%	26.4%	25.4%	3.5
METRO	370	4.1%	21.4%	20.3%	29.7%	24.6%	3.5
NONMETRO	528	5.5%	17.4%	25.8%	25.2%	26.1%	3.5
	χ^2= 7.328 n.s.; Cramer's V = 0.090						F=0.002 n.s.; η=0.002

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-24: Involvement in small game hunting: I find a lot of my life organized around small game-hunting activities.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	860	8.0%	30.2%	32.7%	21.9%	7.3%	2.9
METRO	368	9.5%	33.4%	30.7%	18.8%	7.6%	2.8
NONMETRO	529	7.6%	29.3%	32.7%	22.7%	7.8%	2.9
	χ^2= 4.048 n.s.; Cramer's V = 0.067						F=2.830 n.s.; η=0.056

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-25: Involvement in small game hunting: Even if close friends recommended another recreational activity, I would not change my preference from small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	859	2.9%	14.3%	21.8%	40.3%	20.8%	3.6
METRO	368	3.8%	14.1%	18.2%	38.9%	25.0%	3.7
NONMETRO	528	2.7%	14.6%	22.7%	41.1%	18.9%	3.6
	χ^2= 7.065 n.s.; Cramer's V = 0.089						F=1.227 n.s.; η=0.037

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-26: Involvement in small game hunting: Small game hunting is important to me.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	859	0.3%	1.7%	14.1%	52.6%	31.3%	4.1
METRO	369	0.0%	2.2%	14.1%	48.5%	35.2%	4.2
NONMETRO	527	0.6%	1.5%	14.4%	53.9%	29.6%	4.1
	χ^2= 6.001 n.s.; Cramer's V = 0.082						F=1.608 n.s.; η=0.042

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-27: Involvement in small game hunting: I have close friendships that are based on a common interest in small game hunting.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	861	2.2%	10.3%	24.0%	44.3%	19.1%	3.7
METRO	370	4.3%	8.9%	20.8%	42.7%	23.2%	3.7
NONMETRO	528	1.1%	11.4%	25.6%	44.9%	17.0%	3.7
	χ^2= 16.866**; Cramer's V = 0.137						F=0.889 n.s.; η=0.031

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 1-28: Involvement in small game hunting: Compared to other small game hunters, I own a lot of small game-hunting equipment.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	863	6.2%	24.1%	37.7%	21.2%	10.8%	3.1
METRO	370	4.3%	26.8%	34.9%	22.4%	11.6%	3.1
NONMETRO	530	6.8%	24.0%	38.3%	20.6%	10.4%	3.0
	χ^2= 4.338 n.s.; Cramer's V = 0.069						F=0.815 n.s.; η=0.030

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

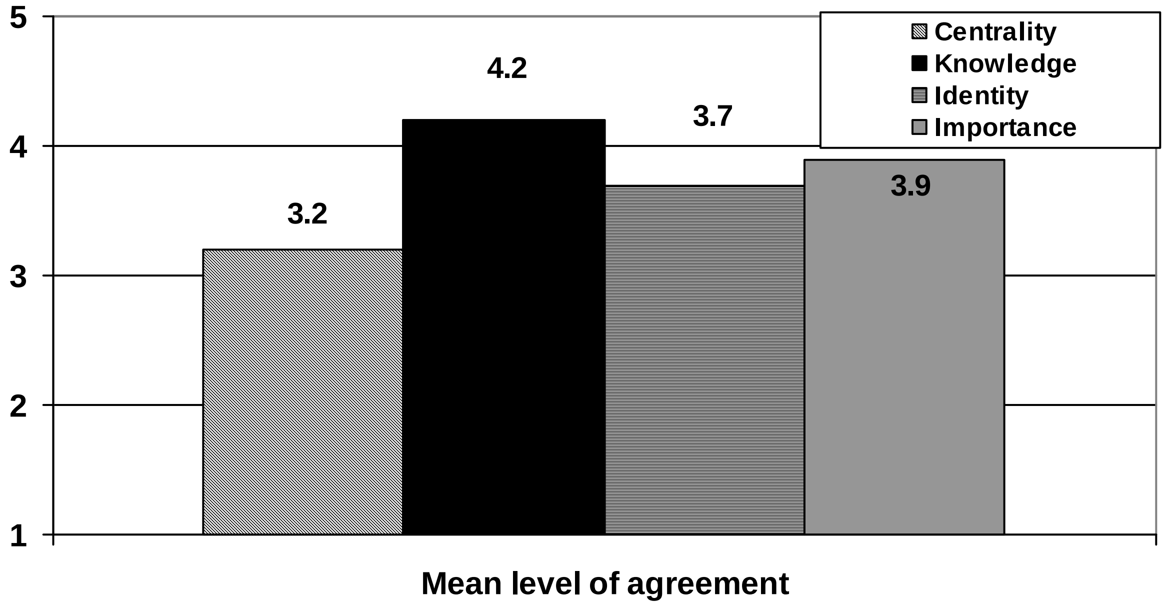
Table 1-29: Involvement With and Commitment to Small game hunting

	Mean[1]
Knowledge and control factor	4.2
- The decision to go small game hunting is primarily my own.	4.4
- I don't really know much about small game hunting. (REVERSED)	4.3
- Small game hunting interests me.	4.3
- Small game hunting is one of the most enjoyable things I do.	4.2
- I am knowledgeable about small game hunting.	4.2
- The decision to go small game hunting is not entirely my own. (REVERSED)	3.7
Importance factor	3.9
- Small game hunting is important to me.	4.1
- I have acquired equipment that I would not use if I quit small game hunting.	4.0
- Even if close friends recommended another recreational activity, I would not change my preference from small game hunting.	3.6
Identity factor	3.7
- I enjoy discussing small game hunting with my friends.	4.0
- When I am small game hunting I can really be myself.	3.8
- When I am small game hunting, others see me the way I want them to see me.	3.6
- You can tell a lot about a person when you see them small game hunting.	3.4
Centrality factor	3.2
- I have close friendships that are based on a common interest in small game hunting.	3.7
- For me to change my preference from small game hunting to another leisure activity would require major rethinking.	3.5
- Most of my friends are in some way connected with small game hunting.	3.4
- Compared to other small game hunters, I own a lot of small game hunting equipment.	3.1
- I find a lot of my life organized around small game hunting activities.	2.9
- Small game hunting has a central role in my life.	2.9
- I find that a lot of my life is organized around small game hunting.	2.9

[1] Mean is based on the scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4= agree, 5 = strongly agree.
n.s.=not significant, *P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001

Section 1: Small Game Hunting Activity and Involvement

Figure 1-1: Means on involvement/commitment factors to small game hunting.



Section 2: Shotgun and Shot Preferences and Use

Study participants were asked to indicate what gauge of shotgun they used most often to hunt for different types of game, how many boxes of shells they typically used in a season to hunt different types of game, and what type of shot they used most often.

Shotgun Gauge Used for Hunting Small Game

Respondents reported using 12-gauge shotguns most often to hunt the seven different types of small game hunted (Tables 2-1 to 2-7). Respondents also frequently reported using .410 and 20-gauge shotguns. There were no significant differences in shotgun use between metro and non-metro respondents

Shot Used for Small-Game Hunting

Survey recipients were asked if they always, mostly, occasionally, or never used lead shot for hunting small game (Table 2-8). Over one-third of respondents (37.9%) always used lead. Nearly one-fourth (28.8%) mostly used lead and 19.8% occasionally used lead. Less than one in five (13.6%) never used lead. Similarly, the majority of respondents reported using lead (compared to steel, bismuth or other) shot most often when targeting specific types of small game (Tables 2-9 to 2-15). In general respondents reported using less than one box of shot per season for hunting each type of small game (Tables 2-16 to 2-22). The majority of respondents reported that they bought loaded shotgun shells (94.1%) (Table 2-23). On average, respondents had 10 boxes of loaded shotgun shells on hand (Table 2-24). There was only one significant difference in shot use between metro and non-metro respondents—a smaller proportion of metro respondents who hunted dove reported using lead shot (46.2%) compared to lead shot use by non-metro respondents (82.4%) (Table 2-13).

Table 2-1: Gauge of shotgun used most often to hunt PHEASANT

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	579	0.0%	0.2%	9.8%	1.7%	88.1%	0.2%
METRO	263	0.0%	.4%	9.9%	1.5%	88.2%	0.0%
NONMETRO	343	0.0%	0.0%	9.6%	2.0%	88.0%	0.3%
		χ^2= 2.304 n.s.; Cramer's V = 0.062					

[1] Percentages reflect only respondents that reported that they typically hunt for pheasant
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-2: Gauge of shotgun used most often to hunt GROUSE

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	480	5.0%	1.3%	23.2%	3.1%	67.1%	0.2%
METRO	226	2.2%	0.9%	21.2%	3.1%	72.6%	0.0%
NONMETRO	284	6.0%	1.4%	24.3%	3.5%	64.4%	0.4%
		χ^2= 7.046 n.s.; Cramer's V = 0.118					

[1] Percentages reflect only respondents that reported that they typically hunt for grouse
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-3: Gauge of shotgun used most often to hunt WOODCOCK

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	92	2.2%	0.0%	29.3%	3.3%	65.2%	0.0%
METRO	47	2.1%	0.0%	21.3%	6.4%	70.2%	0.0%
NONMETRO	53	1.9%	0.0%	37.7%	1.9%	58.5%	0.0%
		χ^2= 4.050 n.s.; Cramer's V = 0.201					

[1] Percentages reflect only respondents that reported that they typically hunt for woodcock
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-4: Gauge of shotgun used most often to hunt SNIPE/RAIL

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	16	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%
METRO	8	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%
NONMETRO	8	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%
		χ^2=0.000 n.s.; Cramer's V = 0.000					

[1] Percentages reflect only respondents that reported that they typically hunt for snipe/rail
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-5: Gauge of shotgun used most often to hunt DOVE

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	76	3.9%	2.6%	15.8%	1.3%	76.3%	0.0%
METRO	28	7.1%	3.6%	7.1%	3.6%	78.6%	0.0%
NONMETRO	52	3.8%	1.9%	23.1%	1.9%	69.2%	0.0%
		χ^2= 3.651 n.s.; Cramer's V = 0.214					

[1] Percentages reflect only respondents that reported that they typically hunt for dove
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-6: Gauge of shotgun used most often to hunt RABBITS

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	123	18.7%	0.0%	26.0%	3.3%	51.2%	0.8%
METRO	42	9.5%	0.0%	23.8%	7.1%	59.5%	0.0%
NONMETRO	82	22.0%	0.0%	25.6%	3.7%	47.6%	1.2%
		χ^2= 4.433 n.s.; Cramer's V = 0.189					

[1] Percentages reflect only respondents that reported that they typically hunt for rabbits
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-7: Gauge of shotgun used most often to hunt SQUIRREL

	n	% of respondents who used…[1]					
		.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge
Statewide[2]	98	26.5%	0.0%	25.5%	1.0%	46.9%	0.0%
METRO	39	17.9%	0.0%	23.1%	5.1%	53.8%	0.0%
NONMETRO	61	29.5%	0.0%	26.2%	1.6%	42.6%	0.0%
		χ^2= 2.969 n.s.; Cramer's V = 0.172					

[1] Percentages reflect only respondents that reported that they typically hunt for squirrel
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-8: Typically use lead shot or non-lead shot when you hunt small game

	n	% of respondents who…[1]			
		Never use lead	Occasionally use lead	Mostly use lead	Always use lead (except for waterfowl)
Statewide[2]	873	13.6%	19.8%	28.8%	37.9%
METRO	365	16.2%	18.4%	31.2%	34.2%
NONMETRO	516	13.0%	20.0%	28.9%	38.2%
		χ^2= 3.099 n.s.; Cramer's V = 0.059			

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-9: Type of shot used most often to hunt PHEASANT

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	567	60.3%	38.8%	0.9%	0.0%
METRO	252	59.5%	39.7%	0.8%	0.0%
NONMETRO	335	60.0%	38.8%	1.2%	0.0%
		χ^2= 0.259 n.s.; Cramer's V = 0.021			

[1] Percentages reflect only respondents that reported that they typically hunt for pheasant
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-10: Type of shot used most often to hunt GROUSE

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	482	83.2%	16.0%	0.8%	0.0%
METRO	224	83.5%	16.5%	0.0%	0.0%
NONMETRO	284	83.5%	15.5%	1.1%	0.0%
		χ^2= 1.300 n.s.; Cramer's V = 0.069			

[1] Percentages reflect only respondents that reported that they typically hunt for grouse
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-11: Type of shot used most often to hunt WOODCOCK

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	91	82.4%	16.5%	1.1%	0.0%
METRO	49	73.5%	26.5%	0.0%	0.0%
NONMETRO	52	88.5%	9.6%	1.9%	0.0%
		χ^2= 5.691 n.s.; Cramer's V = 0.237			

[1] Percentages reflect only respondents that reported that they typically hunt for woodcock
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-12: Type of shot used most often to hunt SNIPE/RAIL

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	16	62.5%	37.5%	0.0%	0.0%
METRO	8	62.5%	37.5%	0.0%	0.0%
NONMETRO	8	62.5%	37.5%	0.0%	0.0%
		χ^2= 0.000 n.s.; Cramer's V = 0.000			

[1] Percentages reflect only respondents that reported that they typically hunt for snipe/rail
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-13: Type of shot used most often to hunt DOVE

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	77	72.7%	26.0%	1.3%	0.0%
METRO	26	46.2%	53.8%	0.0%	0.0%
NONMETRO	51	82.4%	15.7%	2.0%	0.0%
		χ^2= 12.504**; Cramer's V = 0.403			

[1] Percentages reflect only respondents that reported that they typically hunt for dove
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-14: Type of shot used most often to hunt RABBITS

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	145	83.4%	15.9%	0.0%	0.7%
METRO	47	78.7%	21.3%	0.0%	0.0%
NONMETRO	99	84.8%	14.1%	0.0%	1.0%
		χ^2= 1.606 n.s.; Cramer's V = 0.105			

[1] Percentages reflect only respondents that reported that they typically hunt for rabbits
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-15: Type of shot used most often to hunt SQUIRREL

	n	% of respondents who used…[1]			
		Lead	Steel	Bismuth	Other
Statewide[2]	139	84.9%	14.4%	0.0%	0.7%
METRO	52	87.6%	11.2%	0.0%	1.1%
NONMETRO	89	76.9%	23.1%	0.0%	0.0%
		χ^2= 3.984 n.s.; Cramer's V = 0.168			

[1] Percentages reflect only respondents that reported that they typically hunt for squirrel
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-16: Number of boxes of shells typically used in a season hunting PHEASANT in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	510	27.5%	20.0%	31.6%	15.7%	4.9%	0.4%
METRO	233	30.9%	24.5%	29.2%	10.7%	4.3%	0.4%
NONMETRO	298	26.2%	17.8%	32.2%	18.1%	5.0%	0.7%
		χ^2= 9.328 n.s.; Cramer's V = 0.133					

[1] Percentages reflect only respondents that reported that they typically hunt for pheasant in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-17: Number of boxes of shells typically used in a season hunting GROUSE in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	110	50.0%	18.2%	26.4%	4.5%	0.9%	0.0%
METRO	52	51.9%	19.2%	23.1%	5.8%	0.0%	0.0%
NONMETRO	64	46.9%	20.3%	28.1%	3.1%	1.6%	0.0%
		χ^2=1.726 n.s.; Cramer's V = 0.122					

[1] Percentages reflect only respondents that reported that they typically hunt for grouse in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-18: Number of boxes of shells typically used in a season hunting WOODCOCK in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	18	44.4%	38.9%	11.1%	0.0%	5.6%	0.0%
METRO	15	40.0%	46.7%	6.7%	0.0%	6.7%	0.0%
NONMETRO	6	50.0%	33.3%	16.7%	0.0%	0.0%	0.0%
		χ^2= 1.128 n.s.; Cramer's V = 0.232					

[1] Percentages reflect only respondents that reported that they typically hunt for woodcock in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-19: Number of boxes of shells typically used in a season hunting SNIPE/RAIL in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	4	50.0%	25.0%	25.0%	0.0%	0.0%	0.0%
METRO	3	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NONMETRO	2	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%
		χ^2=5.000 n.s. ; Cramer's V = 1.000					

[1] Percentages reflect only respondents that reported that they typically hunt for snipe/rail in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-20: Number of boxes of shells typically used in a season hunting DOVE in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	65	26.2%	24.6%	32.3%	13.8%	1.5%	1.5%
METRO	22	36.4%	18.2%	22.7%	18.2%	0.0%	4.5%
NONMETRO	45	24.4%	26.7%	33.3%	13.3%	2.2%	0.0%
		χ^2= 4.510 n.s.; Cramer's V = 0.259					

[1] Percentages reflect only respondents that reported that they typically hunt for dove in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-21: Number of boxes of shells typically used in a season hunting RABBITS in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	103	50.5%	22.3%	16.5%	8.7%	1.0%	1.0%
METRO	25	52.0%	20.0%	20.0%	8.0%	0.0%	0.0%
NONMETRO	77	50.6%	22.1%	15.6%	7.8%	1.3%	2.6%
		χ^2= 1.240 n.s.; Cramer's V = 0.110					

[1] Percentages reflect only respondents that reported that they typically hunt for rabbits in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-22: Number of boxes of shells typically used in a season hunting SQUIRREL in the farmland zone of Minnesota

	n	% of respondents who used…[1]					
		½ box or less	1 box	1-2 boxes	3-5 boxes	5-10 boxes	10+ boxes
Statewide[2]	105	57.1%	27.6%	11.4%	3.8%	0.0%	
METRO	30	56.7%	26.7%	16.7%	.0%	0.0%	0.0%
NONMETRO	75	57.3%	26.7%	10.7%	4.0%	0.0%	1.3%
		χ^2= 2.225 n.s.; Cramer's V = 0.146					

[1] Percentages reflect only respondents that reported that they typically hunt for squirrel in the farmland zone
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-23: Self-load or buy shotgun shells loaded

	n	% of respondents who…		
		Buy loaded shells	Self-load	Both
Statewide[1]	829	94.1%	0.8%	5.1%
METRO	348	93.4%	0.3%	6.3%
NONMETRO	510	94.5%	1.0%	4.5%
		χ^2= 2.743 n.s.; Cramer's V = 0.057		

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 2-24: If self-load, pounds of loose, lead shot currently on hand for self-loading

	n	Pounds on loose, lead shot on hand[1]
Statewide[2]	47	52.9
METRO	21	57.0
NONMETRO	28	46.9
		F=0.185; η=0.063

[1] Results reflect only respondents that reported that they self-load
[2] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 2: Shotgun and Shot Preferences and Use

Table 2-25: Number of boxes of loaded shotgun shells currently on hand

	n	Boxes of loaded shotgun shells on hand
Statewide[1]	794	10.0
METRO	334	10.1
NONMETRO	486	9.6
		F=0.060; η=0.009

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 3: Beliefs, Attitudes, and Norms About Lead Shot

Beliefs About Lead Shot

Respondents were asked to rate 11 items addressing their beliefs about the use of lead shot small game hunting, using the scale 1=extremely disagree to 7=extremely agree (Tables 1-1 to 1-11). Items addressed (a) the availability, cost, and effectiveness of lead shot alternatives, (b) the problems associated with lead shot, and (c) responsibility for reducing use of lead shot.

Respondents were asked four questions addressing their beliefs about alternatives to lead shot. About 60% of respondents disagreed that alternatives to lead shot were very difficult to find ($\bar{x}$=3.0) (Table 3-1). About two-thirds of respondents agreed that alternatives to lead shot are too expensive ($\bar{x}$=4.9) (Table 3-2). Nearly 60% of respondents agreed that lead is more effective than alternatives ($\bar{x}$=4.9) (Table 3-3). Nearly 40% disagreed that alternatives to lead shot might damage their shotgun, with about 30% neutral on this statement ($\bar{x}$=3.7) (Table 3-4).

Respondents were asked four questions addressing their beliefs about the problems and effects of lead shot. Slightly more than half of the respondents disagreed that they did not think lead shot causes any problems for wildlife ($\bar{x}$=3.5) (Table 3-5). Over 60% agreed that they were concerned about the effects of lead on wildlife ($\bar{x}$=4.9) (Table 3-6). Over half agreed that they were concerned about the effects of lead on human health ($\bar{x}$=4.7) (Table 3-7). Less than 40% agreed that they though lead from hunting was an environmental problem ($\bar{x}$=4.0) (Table 3-8).

Respondents were asked three questions to address responsibility for reducing use of lead shot. Nearly 40% of respondents disagreed that hunters have a responsibility to not use lead shot ($\bar{x}$=3.8) (Table 3-9). Similarly, about 40% of respondents disagreed that they had a personal responsibility to not use lead shot ($\bar{x}$=3.8) (Table 3-10). However, in a negatively worded item, slightly more that 40% of respondents disagreed that it was *not* their responsibility to stop using lead shot ($\bar{x}$=3.7) (Table 3-11).

Attitudes About Banning Lead Shot in the Minnesota Farmland Zone

Respondents were fairly evenly split in their intention to support a ban on lead shot for hunting small game in the Minnesota farmland zone within the next 5 years—44.2% said it was unlikely that they would support such a ban, while 42.2% indicated that it was likely ($\bar{x}$=3.8) (Table 3-12). On average, metro respondents were somewhat more supportive of the ban than non-metro respondents. Likelihood of supporting a ban on lead shot in the Minnesota farmland zone was positively correlated with trust in the Minnesota Department of Natural Resources (described in Section 4) ($r=0.547$, $p<0.001$) and pro-environmental values (Section 5) ($r=0.362$, $p<0.001$). It was negatively correlated with years of hunting in the farmland zone (Section 1) ($r=-0.086$, $p<0.05$), involvement in small game hunting ($r=-0.118$, $p<0.01$), frequency of hunting with a dog (Section 1) ($r=-0.096$, $p<0.01$), frequency of hunting with children under age 12 (Section 1) ($r=-0.143$, $p<0.001$), frequency of using lead shot (Section 2) ($r=-0.344$), and boxes of loaded shotgun shells on hand (Section 2) ($r=-0.139$).

Respondents were asked a series of questions asking whether a ban on lead shot in the farmland zone would be harmful or beneficial, bad or good, and foolish or wise. About 45% of respondents indicated that the ban would be beneficial (Table 3-13), good (Table 3-14), and wise (Table 3-15).

Section 3: Beliefs, Attitudes, and Norms About Lead Shot

Respondents were asked to rate the likelihood of 12 possible outcomes of banning lead shot for small game hunting in the Minnesota farmland zone, using the scale 1=extremely unlikely to 7=extremely likely (Tables 3-16 to 3-27). Items addressed environmental effects and impacts to hunters. Responses suggest that many small game hunters may perceive both environmental benefits and challenges to hunters as likely outcomes of a ban on lead shot in the farmland zone. Over half of the respondents felt that it was likely that banning lead shot for hunting small game in the farmland zone in Minnesota would: (a) help protect wildlife from lead poisoning ($\bar{x}$ =4.5) (Table 3-16), (b) benefit the quality of the environment ($\bar{x}$ =4.4) (Table 3-17), (c) prevent the spread of lead in the natural environment ($\bar{x}$ =4.8) (Table 3-23), (d) improve awareness about the dangers of lead in the environment ($\bar{x}$ =4.6) (Table 3-27). However, over half the respondents also thought it was likely that a ban would: increase crippling and wounding loss for small game hunting ($\bar{x}$ =4.5) (Table 3-19) and require using less effective shot while hunting small game ($\bar{x}$ =4.7) (Table 3-20). Over three-fourths of respondents felt that the ban would require hunters to use more expensive ammunition ($\bar{x}$ =5.7) (Table 3-21). Over 40% of respondents felt that a ban would be unnecessary government regulation ($\bar{x}$ =4.3) (Table 3-18) and would make it more difficult for some people to hunt ($\bar{x}$ =4.1) (Table 3-24). Although hunters reported that a ban might create some challenges, their response to several items suggests that hunters would adapt to a ban and that a ban might even improve the image of hunters. Nearly three-fourths of hunters said a ban is something most hunters would adjust to after a few seasons ($\bar{x}$ =5.0) (Table 3-25). Nearly half of hunters felt that it was likely that a ban would improve the image of hunters ($\bar{x}$ =4.2) (Table 3-22) and that it was unlikely that a ban would decrease hunting opportunity in Minnesota ($\bar{x}$ =3.6) (Table 3-26).

Respondents were asked to rate how good or bad 12 outcomes of banning lead shot would be using the scale 1=extremely bad to 7=extremely good (Tables 3-28 to 3-39). The majority of respondents felt that environmental benefits were good outcomes. Over 7 in 10 respondents felt that it was good to: (a) protect wildlife from lead poisoning ($\bar{x}$ =5.6) (Table 3-28), (b) benefit the quality of the environment ($\bar{x}$ =5.7) (Table 3-29), (c) prevent the spread of lead in the natural environment ($\bar{x}$ =5.3) (Table 3-35), and (d) improve awareness about the dangers of lead in the environment ($\bar{x}$ =5.4) (Table 3-39). However, over two-thirds of respondents felt the following outcomes for hunters were bad: (a) unnecessary government regulation ($\bar{x}$ =2.8) (Table 3-30), (b) increasing wounding loss for small game hunting ($\bar{x}$ =2.8) (Table 3-31), (c) using less effective shot while hunting small game ($\bar{x}$ =2.5) (Table 3-32), (d) using more expensive ammunition ($\bar{x}$ =2.8) (Table 3-33), (e) making it more difficult to find shells for the shotgun I use ($\bar{x}$ =2.7) (Table 3-34), and (f) decreasing hunting opportunities ($\bar{x}$ =2.3) (Table 3-38). Nearly three-fourths of respondents felt that improving the image of hunters was a good outcome ($\bar{x}$ =5.6) (Table 3-36). Nearly half of respondents felt that hunters adjusting to using non-lead shot was a good outcome, but over one-third were neutral about this outcome ($\bar{x}$ =4.6) (Table 3-38).

Norms About Banning Lead Shot in the Minnesota Farmland Zone

Respondents were asked to rate the likelihood of 8 groups thinking they should support a ban on lead shot in the Minnesota farmland zone, using the scale 1=extremely unlikely to 7=extremely likely (Tables 3-40 to 3-47). Over 40% of respondents felt it was unlikely that their friends ($\bar{x}$ =3.5) (Table 3-40) or other hunters ($\bar{x}$ =3.4) (Table 3-41) would think they should support a ban. Over 60% of respondents felt it was likely that environmental organizations would think they should support a ban ($\bar{x}$ =5.2) (Table 3-42). Many respondents felt that Pheasants Forever ($\bar{x}$ =4.4) (Table 3-43), Ducks Unlimited ($\bar{x}$ =5.0) (Table 3-44), and the Minnesota Department of Natural Resources ($\bar{x}$ =5.1) (Table 3-45) would also want them to support a ban. However, many respondents felt that the National Rifle Association ($\bar{x}$ =3.8) (Table 3-46) and ammunition manufacturers ($\bar{x}$ =3.7) (Table 3-47) would not want them to support a ban.

Respondents were asked to indicate how motivated they were to do what the referent groups wanted to do using the scale 1=extremely disagree to 7=extremely agree (Tables 3-48 to 3-54). Approximately 4 in 10 respondents reported that they would be less motivated to do what (a) their friends ($\bar{x}$=3.5) (Table 3-48), (b) other hunters ($\bar{x}$=3.6) (Table 3-49), (c) environmental organizations ($\bar{x}$=3.6) (Table 3-50), and (d) ammunition manufacturers ($\bar{x}$=3.3) (Table 3-55) wanted them to do. Between 35 and 40% of respondents indicated that they would be more motivated to do what (a) Pheasants Forever ($\bar{x}$=4.0) (Table 3-51), (b) Ducks Unlimited ($\bar{x}$=4.1) (Table 3-52), and (c) the Minnesota DNR ($\bar{x}$=4.2) (Table 3-53) wanted them to do. About one-fourth of respondents were motivated and about one-third were unmotivated to do what the NRA through they should do ($\bar{x}$=3.7) (Table 3-54). It should be noted that between one-third and one-half of respondents gave neutral responses to the items addressing whether they were motivated to do what referent groups thought they should do.

Table 3-1: Beliefs about using lead shot: Alternatives to lead shot are very difficult to find.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	864	23.8%	23.9%	13.2%	21.1%	8.8%	7.0%	2.2%	3.0
METRO	367	24.8%	24.5%	12.5%	20.2%	9.3%	6.3%	2.5%	3.0
NONMETRO	520	23.5%	23.7%	13.3%	21.5%	8.7%	7.5%	1.9%	2.9
	χ^2= 1.350 n.s.; Cramer's V = 0.039								F=0.218 n.s.; η=0.016

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-2: Beliefs about using lead shot: Alternatives to lead shot are too expensive.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	867	5.9%	8.6%	7.3%	13.1%	19.3%	22.1%	23.7%	4.9
METRO	367	5.7%	9.0%	6.5%	13.6%	20.2%	24.0%	21.0%	4.9
NONMETRO	522	6.1%	8.8%	7.9%	13.6%	18.6%	21.6%	23.4%	4.9
	χ^2= 1.926 n.s.; Cramer's V = 0.047								F=0.010 n.s.; η=0.003

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-3: Beliefs about using lead shot: I think lead is more effective than alternatives

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	865	5.2%	4.7%	5.7%	26.1%	17.1%	21.4%	19.8%	4.9
METRO	368	6.5%	5.2%	4.6%	25.3%	20.7%	21.2%	16.6%	4.8
NONMETRO	520	4.8%	4.8%	6.2%	26.3%	15.8%	21.5%	20.6%	4.9
	χ^2= 6.940 n.s.; Cramer's V = 0.088								F=1.147 n.s.; η=0.036

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-4: Beliefs about using lead shot: I think alternatives to lead shot might damage my shotgun

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	864	13.1%	15.9%	10.1%	30.2%	14.7%	10.1%	5.9%	3.7
METRO	367	14.7%	16.1%	11.2%	30.2%	13.9%	8.2%	5.7%	3.6
NONMETRO	519	12.7%	16.4%	9.2%	30.3%	15.0%	10.6%	5.8%	3.7
	χ^2= 2.943 n.s.; Cramer's V = 0.058								F=1.337 n.s.; η=0.039

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-5: Beliefs about using lead shot: I do not think lead shot causes any problems for wildlife.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	865	16.3%	17.9%	18.4%	21.3%	9.0%	9.4%	7.6%	3.5
METRO	367	16.1%	25.6%	15.0%	20.2%	7.6%	8.2%	7.4%	3.3
NONMETRO	521	17.3%	14.8%	19.8%	21.7%	9.4%	9.8%	7.3%	3.5
	χ^2= 17.715**; Cramer's V = 0.141								F=2.182 n.s.; η=0.050

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-6: Beliefs about using lead shot: I am concerned about the effects of lead on wildlife

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	866	5.7%	6.0%	3.8%	22.4%	22.0%	23.5%	16.8%	4.9
METRO	366	4.9%	4.9%	4.9%	19.9%	20.8%	23.2%	21.3%	5.0
NONMETRO	523	5.5%	6.7%	3.1%	22.8%	22.0%	24.1%	15.9%	4.8
	χ^2= 7.767 n.s.; Cramer's V = 0.093								F=2.283 n.s.; η=0.051

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-7: Beliefs about using lead shot: I am concerned about the effects of lead on human health.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	864	8.3%	8.5%	4.5%	24.0%	14.3%	23.3%	17.0%	4.7
METRO	365	9.6%	7.9%	3.6%	22.7%	13.4%	22.2%	20.5%	4.7
NONMETRO	522	7.3%	8.8%	4.8%	24.1%	14.2%	24.1%	16.7%	4.7
	χ^2= 4.725 n.s.; Cramer's V = 0.073								F=0.059 n.s.; η=0. 008

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-8: Beliefs about using lead shot: I do not think the lead from hunting is an environmental problem.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	867	11.6%	14.2%	15.1%	19.2%	15.9%	14.4%	9.6%	4.0
METRO	368	13.9%	14.9%	17.7%	16.0%	16.8%	12.0%	8.7%	3.8
NONMETRO	523	11.7%	14.3%	14.1%	19.9%	15.5%	15.3%	9.2%	4.0
	χ^2= 6.381 n.s.; Cramer's V = 0.085								F=2.087 n.s.; η=0. 048

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-9: Beliefs about using lead shot: I think hunters have a responsibility to NOT USE lead shot.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	866	14.2%	13.8%	11.7%	29.4%	12.4%	9.7%	8.9%	3.8
METRO	367	12.3%	10.4%	12.5%	28.9%	15.5%	9.3%	11.2%	4.0
NONMETRO	522	14.4%	14.8%	10.7%	29.1%	11.5%	10.5%	9.0%	3.8
	χ^2= 8.585 n.s.; Cramer's V = 0.098								F=3.015 n.s.; η=0. 058

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-10: Beliefs about using lead shot: I think I have a personal responsibility to NOT USE lead shot.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	868	15.1%	13.7%	11.3%	26.0%	13.0%	10.9%	10.0%	3.8
METRO	366	11.2%	10.7%	10.9%	27.9%	16.1%	11.7%	11.5%	4.1
NONMETRO	524	16.0%	14.5%	11.3%	24.8%	12.0%	10.7%	10.7%	3.8
	χ^2= 9.820 n.s.; Cramer's V = 0.105								F=6.059*; η=0. 082

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-11: Beliefs about using lead shot: It is not my responsibility to stop using lead shot.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	864	13.1%	14.7%	15.0%	31.7%	9.3%	8.6%	7.5%	3.7
METRO	366	14.5%	14.5%	18.3%	31.1%	9.8%	6.0%	5.7%	3.5
NONMETRO	521	13.1%	15.2%	13.8%	31.7%	8.8%	9.6%	7.9%	3.7
	χ^2= 8.208 n.s.; Cramer's V = 0.096								F=2.994 n.s.; η=0. 058

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-12: Likelihood of supporting a ban on lead shot to hunt small game in the farmland zone.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	873	22.0%	14.9%	7.3%	13.5%	12.8%	16.4%	13.0%	3.8
METRO	369	17.1%	14.4%	6.8%	10.6%	14.9%	19.2%	17.1%	4.2
NONMETRO	522	22.2%	15.1%	7.3%	14.4%	11.7%	16.9%	12.5%	3.8
	χ^2= 11.078 n.s.; Cramer's V = 0.112								F= 7.308**; η=0.090

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-13: Supporting a ban on lead shot to hunt small game in the farmland zone: HARMFUL/BENEFICIAL

	N	Extremely harmful	Quite harmful	Slightly harmful	Neutral	Slightly beneficial	Quite beneficial	Extremely beneficial	Mean
Statewide[1]	870	8.3%	3.8%	6.2%	35.0%	18.4%	15.4%	12.9%	4.5
METRO	370	7.8%	2.7%	7.6%	28.4%	21.1%	16.5%	15.9%	4.7
NONMETRO	522	7.9%	4.0%	5.2%	36.0%	18.0%	16.1%	12.8%	4.5
	χ^2= 9.510 n.s.; Cramer's V = 0. 103								F= 1.464 n.s.; η=0.041

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-14: Supporting a ban on lead shot to hunt small game in the farmland zone: BAD/GOOD

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	872	11.2%	7.2%	8.8%	27.6%	15.7%	16.2%	13.3%	4.3
METRO	370	9.2%	6.8%	8.6%	24.3%	16.2%	18.1%	16.8%	4.5
NONMETRO	523	11.1%	6.9%	8.4%	28.1%	16.1%	16.4%	13.0%	4.3
	χ^2= 4.400; Cramer's V = 0.070								F= 2.775 n.s.; η=0.056

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-15: Supporting a ban on lead shot to hunt small game in the farmland zone: FOOLISH/WISE

	N	Extremely foolish	Quite foolish	Slightly foolish	Neutral	Slightly wise	Quite wise	Extremely wise	Mean
Statewide[1]	871	13.5%	8.6%	8.5%	24.2%	16.5%	16.2%	12.4%	4.2
METRO	369	10.6%	7.9%	8.7%	22.0%	17.3%	18.2%	15.4%	4.4
NONMETRO	523	13.8%	8.4%	8.0%	24.3%	16.4%	16.6%	12.4%	4.2
	χ^2= 4.307 n.s.; Cramer's V = 0.069								F= 3.266 n.s.; η=0.060

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-16: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… help protect wildlife from lead poisoning.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	868	8.4%	10.7%	7.5%	14.9%	26.7%	21.1%	10.7%	4.5
METRO	374	8.8%	10.4%	6.7%	11.8%	27.0%	24.3%	11.0%	4.5
NONMETRO	533	7.7%	10.1%	7.3%	15.4%	27.4%	20.8%	11.3%	4.5
	χ^2=3.804 n.s. ; Cramer's V = 0.065								F=0.040 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-17: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… benefit the quality of the environment.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	869	7.8%	11.4%	7.8%	19.2%	25.5%	19.0%	9.3%	4.4
METRO	373	7.2%	11.0%	7.8%	17.4%	24.9%	22.8%	8.8%	4.5
NONMETRO	533	7.5%	11.3%	7.1%	19.3%	25.7%	18.6%	10.5%	4.4
	χ^2=3.170 n.s.; Cramer's V = 0.059								F=0.084 n.s.; η=0.010

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-18: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… be unnecessary government regulation.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	862	9.2%	11.6%	8.4%	27.4%	11.5%	16.3%	15.6%	4.3
METRO	371	8.6%	12.9%	9.4%	27.0%	10.2%	18.1%	13.7%	4.3
NONMETRO	529	9.8%	11.9%	7.8%	28.0%	12.3%	15.1%	15.1%	4.3
	χ^2=3.572 n.s.; Cramer's V = 0.063								F=0.001 n.s.; η=0.001

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-19: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… increase crippling and wounding loss for small game hunting.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	868	8.0%	9.3%	7.1%	20.9%	20.4%	19.8%	14.5%	4.5
METRO	373	8.6%	11.5%	5.4%	19.6%	21.7%	20.6%	12.6%	4.5
NONMETRO	533	7.7%	9.0%	7.9%	21.2%	20.1%	19.5%	14.6%	4.5
	χ^2=5.004 n.s.; Cramer's V = 0.074								F=0.375 n.s.; η=0.020

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-20: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… require using less effective shot while hunting small game.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	868	4.8%	7.9%	6.8%	23.9%	19.9%	21.5%	15.2%	4.7
METRO	373	4.6%	9.4%	7.8%	20.6%	21.2%	22.3%	14.2%	4.7
NONMETRO	532	5.6%	7.5%	6.6%	24.4%	20.1%	20.9%	14.8%	4.7
	χ^2=3.616 n.s.; Cramer's V = 0.063								F=0.000 n.s.; η=0.001

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-21: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… require using more expensive ammunition.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	869	2.6%	2.6%	1.6%	11.1%	18.1%	28.9%	35.1%	5.7
METRO	373	1.9%	2.4%	1.3%	11.0%	18.2%	35.9%	29.2%	5.7
NONMETRO	534	2.8%	2.8%	1.7%	11.2%	19.1%	25.7%	36.7%	5.6
	χ^2=12.594 n.s.; Cramer's V = 0.118								F=0.015 n.s.; η=0.004

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-22: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… improve the image of hunters.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	861	11.5%	10.2%	7.4%	25.5%	20.8%	16.8%	7.7%	4.2
METRO	371	10.2%	8.6%	7.3%	24.0%	23.2%	18.1%	8.6%	4.3
NONMETRO	529	11.3%	10.4%	7.2%	25.7%	20.0%	17.6%	7.8%	4.2
	χ^2= 2.454 n.s.; Cramer's V = 0.052								F=1.299 n.s.; η=0.038

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-23: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… prevent the spread of lead in the natural environment.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	867	6.0%	6.4%	7.0%	18.1%	24.3%	22.6%	15.4%	4.8
METRO	374	4.5%	7.5%	5.6%	16.3%	22.5%	24.3%	19.3%	4.9
NONMETRO	532	6.6%	5.6%	7.3%	17.7%	24.8%	22.9%	15.0%	4.8
	χ^2= 6.983 n.s.; Cramer's V = 0.088								F=2.313 n.s.; η=0.051

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-24: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… make it more difficult for some people to hunt.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	870	10.7%	14.3%	10.3%	22.9%	18.3%	12.5%	11.1%	4.1
METRO	374	13.1%	14.2%	9.4%	20.9%	20.3%	12.6%	9.6%	4.0
NONMETRO	534	10.1%	15.0%	10.9%	24.2%	17.0%	12.0%	10.9%	4.0
	χ^2= 5.040 n.s. Cramer's V = 0.075								F=0.173 n.s.; η=0.014

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-25: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota … is something most hunters would adjust to after a few seasons.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	867	4.0%	5.4%	4.4%	15.6%	25.0%	30.0%	15.5%	5.0
METRO	373	2.1%	5.9%	4.6%	12.6%	26.5%	31.6%	16.6%	5.2
NONMETRO	531	4.5%	5.1%	4.0%	16.2%	23.7%	31.1%	15.4%	5.0
	χ^2= 6.783 n.s.; Cramer's V = 0.087								F=1.450 n.s.; η=0.040

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-26: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… decrease hunting opportunity in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	868	15.4%	19.0%	12.1%	21.8%	14.4%	9.3%	8.0%	3.6
METRO	374	17.9%	20.3%	10.4%	22.7%	13.4%	6.7%	8.6%	3.5
NONMETRO	532	15.0%	19.2%	13.0%	21.6%	14.5%	9.6%	7.1%	3.6
	χ^2= 5.544 n.s.; Cramer's V = 0.078								F=0.806 n.s.; η=0.030

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-27: Likelihood that banning lead shot for hunting small game in the farmland zone in Minnesota would… improve awareness about the dangers of lead in the environment.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	868	6.4%	7.3%	6.8%	23.1%	26.6%	20.1%	9.6%	4.6
METRO	373	6.4%	6.7%	7.0%	20.9%	26.0%	20.6%	12.3%	4.6
NONMETRO	532	6.0%	7.7%	6.4%	22.9%	26.5%	21.4%	9.0%	4.6
	χ^2= 3.279 n.s.; Cramer's V = 0.060								F=0.544 n.s.; η=0.025

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-28: How good or bad is the outcome of… Protecting wildlife from lead poisoning

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	864	1.0%	0.6%	1.0%	18.1%	18.3%	34.7%	26.4%	5.6
METRO	371	1.1%	0.8%	1.3%	14.6%	17.3%	35.3%	29.6%	5.7
NONMETRO	530	0.9%	0.4%	0.9%	18.7%	18.3%	34.3%	26.4%	5.6
	χ^2= 4.295 n.s. Cramer's V = 0.069								F=1.194 n.s.; η=0.036

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-29: How good or bad is the outcome of… Benefiting the quality of the environment

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	864	0.7%	0.2%	0.8%	18.1%	16.4%	32.6%	31.1%	5.7
METRO	371	1.1%	0.3%	0.8%	13.5%	17.3%	31.3%	35.8%	5.8
NONMETRO	530	0.6%	0.2%	0.9%	19.1%	15.5%	34.0%	29.8%	5.7
	χ^2= 8.272 n.s.; Cramer's V = 0.096								F=2.605 n.s.; η=0.054

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-30: How good or bad is the outcome of… Unnecessary government regulation

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	853	29.9%	25.0%	11.4%	20.6%	5.4%	3.0%	4.8%	2.8
METRO	366	32.0%	21.6%	13.9%	17.2%	6.0%	4.4%	4.9%	2.8
NONMETRO	524	27.3%	26.5%	10.9%	22.7%	5.0%	2.9%	4.8%	2.8
	χ^2= 10.463 n.s.; Cramer's V = 0.108								F=.054 n.s.; η=0.008

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-31: How good or bad is the outcome of… Increasing wounding loss for small game hunting

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	862	29.9%	26.7%	12.8%	15.9%	3.7%	6.0%	5.0%	2.8
METRO	370	28.6%	26.2%	17.6%	13.0%	3.8%	7.3%	3.5%	2.7
NONMETRO	529	30.2%	26.5%	11.5%	16.8%	3.4%	5.9%	5.7%	2.8
	χ^2= 10.877 n.s.; Cramer's V = 0.110								F=.113 n.s.; η=0.011

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-32: How good or bad is the outcome of… Using less effective shot while hunting small game

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	866	24.3%	31.8%	22.5%	15.5%	3.5%	1.5%	1.0%	2.5
METRO	373	22.0%	29.2%	28.2%	15.3%	2.9%	1.9%	0.5%	2.6
NONMETRO	531	24.9%	32.6%	21.1%	15.1%	3.8%	1.3%	1.3%	2.5
	χ^2= 8.324 n.s.; Cramer's V = 0.096								F=0.526 n.s.; η=0.024

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-33: How good or bad is the outcome of… Using more expensive ammunition

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	862	20.7%	20.8%	29.7%	24.0%	2.2%	1.9%	0.7%	2.8
METRO	371	20.2%	19.7%	33.4%	21.8%	2.2%	1.6%	1.1%	2.8
NONMETRO	529	20.2%	20.8%	28.2%	25.1%	2.5%	2.5%	0.8%	2.8
	χ^2= 4.193 n.s.; Cramer's V = 0.068								F=0.215 n.s.; η=0.015

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-34: How good or bad is the outcome of… Making it more difficult to find shells for the shotgun I use

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	863	19.5%	25.1%	25.0%	27.4%	1.5%	1.0%	0.5%	2.7
METRO	372	19.6%	25.5%	27.7%	24.7%	.8%	.5%	1.1%	2.7
NONMETRO	529	18.9%	24.2%	24.4%	28.7%	1.7%	1.5%	0.6%	2.8
	χ^2= 6.343 n.s.; Cramer's V = 0.084								F=1.311 n.s.; η=0.038

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-35: How good or bad is the outcome of… Preventing the spread of lead in the natural environment

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	864	1.9%	1.7%	3.7%	21.6%	22.8%	27.6%	20.7%	5.3
METRO	373	2.7%	.3%	2.9%	15.8%	25.5%	27.1%	25.7%	5.5
NONMETRO	529	1.5%	2.5%	4.2%	22.5%	21.2%	28.2%	20.0%	5.2
	χ^2= 19.098**; Cramer's V = 0.146								F=5.333*; η=0.077

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-36: How good or bad is the outcome of… Improving the image of hunters

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	857	0.6%	0.1%	1.5%	23.8%	15.9%	28.9%	29.2%	5.6
METRO	371	1.1%	0.0%	0.8%	18.6%	20.2%	26.7%	32.6%	5.7
NONMETRO	524	0.4%	0.2%	1.7%	25.2%	13.7%	30.2%	28.6%	5.6
	χ^2= 15.417*; Cramer's V = 0.131								F=1.637 n.s.; η=0.043

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-37: How good or bad is the outcome of… Hunters adjusting to using non-lead shot

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	861	3.6%	3.8%	8.0%	38.4%	17.8%	20.2%	8.2%	4.6
METRO	371	2.4%	2.7%	7.5%	35.3%	21.3%	23.2%	7.5%	4.7
NONMETRO	528	4.0%	4.0%	7.8%	38.8%	16.1%	19.9%	9.5%	4.6
	χ^2= 8.609 n.s.; Cramer's V = 0.098								F=2.031 n.s.; η=0.048

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-38: How good or bad is the outcome of… Decreasing hunting opportunities

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	861	35.8%	27.2%	12.8%	19.7%	1.8%	1.7%	1.0%	2.3
METRO	369	38.2%	26.3%	13.3%	19.5%	1.1%	1.1%	0.5%	2.2
NONMETRO	529	34.2%	27.4%	12.3%	20.6%	2.3%	2.1%	1.1%	2.4
	χ^2= 5.223 n.s.; Cramer's V = 0.076								F=2.927 n.s.; η=0.057

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-39: How good or bad is the outcome of… Improving awareness about the dangers of lead in the environment

	N	Extremely bad	Quite bad	Slightly bad	Neutral	Slightly good	Quite good	Extremely good	Mean
Statewide[1]	863	1.1%	1.2%	1.9%	22.8%	21.9%	29.3%	21.8%	5.4
METRO	372	1.3%	0.8%	2.4%	19.4%	22.3%	33.1%	20.7%	5.4
NONMETRO	528	1.1%	1.3%	1.5%	23.3%	21.4%	27.8%	23.5%	5.4
	χ^2= 5.942 n.s.; Cramer's V = 0.081								F=.085 n.s.; η=0.010

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-40: Belief about whether MY FRIENDS think I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	860	18.1%	14.0%	9.3%	36.7%	9.7%	8.0%	4.2%	3.5
METRO	365	12.3%	13.7%	9.0%	39.2%	12.1%	9.0%	4.7%	3.7
NONMETRO	528	19.5%	13.3%	9.5%	35.8%	9.5%	8.0%	4.5%	3.4
	χ^2=9.128 n.s.; Cramer's V = 0.101								F=5.348*; η=0.077

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-41: Belief about whether OTHER HUNTERS think I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	861	18.6%	14.1%	13.4%	33.1%	10.7%	6.8%	3.4%	3.4
METRO	365	15.6%	12.3%	12.6%	35.3%	13.2%	7.1%	3.8%	3.5
NONMETRO	529	18.7%	14.2%	13.2%	32.3%	10.4%	7.4%	3.8%	3.4
	χ^2=3.832 n.s.; Cramer's V = 0.065								F=2.069 n.s.; η=0.048

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-42: Belief about whether ENVIRONMENTAL ORGANIZATIONS think I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	858	3.4%	3.1%	3.0%	26.7%	13.4%	24.1%	26.3%	5.2
METRO	363	2.5%	1.4%	2.2%	23.4%	13.2%	27.8%	29.5%	5.4
NONMETRO	527	3.4%	3.8%	3.4%	27.1%	13.5%	22.8%	26.0%	5.2
	χ^2=10.504 n.s.; Cramer's V = 0.109								F=7.726**; η=0.093

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-43: Belief about whether PHEASANTS FOREVER thinks I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	853	5.9%	5.0%	4.1%	48.7%	12.7%	16.2%	7.4%	4.4
METRO	360	5.0%	4.7%	5.6%	46.4%	12.2%	17.8%	8.3%	4.4
NONMETRO	524	5.9%	4.6%	3.8%	49.0%	12.6%	16.4%	7.6%	4.4
	χ^2=2.463 n.s.; Cramer's V = 0.053								F=0.274 n.s.; η=0.018

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-44: Belief about whether DUCKS UNLIMITED thinks I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	851	4.2%	3.4%	2.2%	36.8%	10.7%	21.2%	21.5%	5.0
METRO	361	2.8%	3.9%	2.2%	36.0%	10.0%	23.8%	21.3%	5.0
NONMETRO	522	4.4%	2.9%	2.3%	37.0%	10.9%	20.3%	22.2%	5.0
	χ^2=3.718 n.s.; Cramer's V = 0.065								F=0.356 n.s.; η=0.020

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-45: Belief about whether THE MINNESOTA DNR thinks I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	854	2.8%	3.0%	1.3%	33.7%	13.0%	25.6%	20.5%	5.1
METRO	362	1.9%	2.8%	1.1%	32.0%	13.8%	26.5%	21.8%	5.2
NONMETRO	524	3.1%	3.1%	1.3%	34.0%	12.6%	25.8%	20.2%	5.1
	χ^2=1.977 n.s.; Cramer's V = 0.047								F=1.365 n.s.; η=0.039

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-46: Belief about whether THE NATIONAL RIFLE ASSOCIATION thinks I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	850	12.6%	8.7%	8.9%	48.2%	9.3%	7.7%	4.7%	3.8
METRO	360	11.9%	11.9%	8.3%	45.6%	8.9%	8.1%	5.3%	3.7
NONMETRO	521	12.3%	7.9%	9.2%	48.4%	9.6%	7.7%	5.0%	3.8
	χ^2=4.459 n.s.; Cramer's V = 0.071								F=0.256 n.s.; η=0.017

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-47: Belief about whether AMMUNITION MANUFACTURERS think I should support a ban on lead shot in the farmland zone in Minnesota.

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Statewide[1]	854	13.7%	12.3%	9.0%	45.1%	6.3%	5.8%	7.8%	3.7
METRO	363	13.2%	12.1%	9.4%	45.7%	8.0%	5.2%	6.3%	3.6
NONMETRO	523	14.0%	12.4%	8.6%	44.6%	5.7%	6.1%	8.6%	3.7
	χ^2=3.667 n.s.; Cramer's V = 0.064								F=0.145 n.s.; η=0.013

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-48: I want to do what MY FRIENDS think I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	855	14.8%	14.7%	11.8%	36.8%	14.3%	5.6%	1.9%	3.5
METRO	364	12.9%	13.2%	13.2%	37.6%	17.0%	4.4%	1.6%	3.5
NONMETRO	526	14.6%	15.4%	11.6%	35.4%	13.9%	6.5%	2.7%	3.5
	χ^2=5.970 n.s.; Cramer's V = 0.082								F=0.150 n.s.; η=0.013

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-49: I want to do what OTHER HUNTERS think I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	854	12.9%	12.0%	12.5%	34.5%	19.6%	6.3%	2.3%	3.6
METRO	364	9.9%	10.7%	15.1%	34.1%	20.9%	7.4%	1.9%	3.8
NONMETRO	525	13.3%	12.4%	11.2%	34.3%	19.2%	6.3%	3.2%	3.7
	χ^2=7.240 n.s.; Cramer's V = 0.090								F=0.892 n.s.; η=0.032

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-50: I want to do what ENVIRONMENTAL ORGANIZATIONS think I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	853	16.1%	12.9%	9.8%	33.3%	15.1%	7.9%	4.8%	3.6
METRO	365	14.5%	12.1%	9.9%	31.0%	17.8%	10.4%	4.4%	3.7
NONMETRO	524	16.0%	13.0%	9.7%	33.4%	14.3%	8.2%	5.3%	3.6
	χ^2=4.079 n.s.; Cramer's V = 0.068								F=0.957 n.s.; η=0.033

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-51: I want to do what PHEASANTS FOREVER thinks I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	854	10.8%	7.7%	7.5%	37.5%	20.0%	10.8%	5.5%	4.0
METRO	364	8.5%	5.8%	6.9%	38.2%	22.3%	12.4%	6.0%	4.2
NONMETRO	525	11.2%	8.4%	7.4%	36.6%	18.9%	11.6%	5.9%	4.0
	χ^2=5.153 n.s.; Cramer's V = 0.076								F=3.213 n.s.; η=0.060

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-52: I want to do what DUCKS UNLIMITED thinks I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	853	10.6%	7.1%	6.8%	36.8%	18.6%	12.1%	8.0%	4.1
METRO	365	8.2%	5.8%	5.5%	35.3%	20.8%	15.9%	8.5%	4.4
NONMETRO	524	11.1%	7.4%	7.1%	36.8%	17.4%	11.3%	9.0%	4.1
	χ^2=8.574 n.s.; Cramer's V = 0.098								F=4.950*; η=0.074

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-53: I want to do what THE MINNESOTA DNR thinks I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	852	11.5%	6.6%	6.4%	34.0%	19.3%	13.0%	9.3%	4.2
METRO	362	8.8%	3.9%	5.5%	31.2%	22.9%	18.0%	9.7%	4.5
NONMETRO	525	11.8%	7.4%	6.5%	34.3%	17.3%	12.2%	10.5%	4.2
	χ^2=15.714*; Cramer's V = 0.133								F=7.572**; η=0.092

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-54: I want to do what THE NATIONAL RIFLE ASSOCIATION thinks I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	855	14.2%	8.6%	9.2%	43.3%	12.9%	7.5%	4.3%	3.7
METRO	364	12.9%	9.1%	8.8%	42.6%	14.8%	7.4%	4.4%	3.8
NONMETRO	526	14.3%	8.4%	9.1%	42.8%	12.0%	8.7%	4.8%	3.8
	χ^2=2.294 n.s.; Cramer's V = 0.051								F=0.038 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 3-55: I want to do what AMMUNITION MANUFACTURERS think I should do.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Statewide[1]	852	18.1%	12.5%	10.0%	47.5%	6.4%	3.0%	2.6%	3.3
METRO	364	18.1%	12.9%	9.6%	46.2%	8.5%	1.9%	2.7%	3.3
NONMETRO	524	17.7%	12.0%	10.3%	47.5%	5.5%	4.0%	2.9%	3.4
	χ^2=6.139 n.s.; Cramer's V = 0.083								F=0.138 n.s.; η=0.012

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 4: Trust in the Minnesota Department of Natural Resources and Media Resources

Attitudes About the Minnesota Department of Natural Resources and Research on Lead Shot

Respondents were asked to rate six statements to indicate their trust in the Minnesota Department of Natural Resources and in research about lead shot.

On average respondents were fairly neutral in their trust of the Minnesota DNR. Between 40% and 50% of respondents agreed that: (a) When deciding about the use of lead shot for small game hunting in Minnesota, the MnDNR will be open and honest in the things they do and say ($\bar{x}$=3.2) (Table 4-1), (b) The MnDNR can be trusted to make decisions about using lead shot for small game management that are good for the resource ($\bar{x}$=3.3) (Table 4-2), (c) The MnDNR will make decisions about using lead shot for small game in a way that is fair ($\bar{x}$=3.2) (Table 4-3), (d) The MnDNR listens to small game hunters' concerns ($\bar{x}$=3.1) (Table 4-4). Between one-fourth and one-third of the respondents neither agreed nor disagreed with these statements. Metropolitan respondents agreed more strongly with the first three statements (Tables 4-1 to 4-3).

Two statements addressed the influence of research on support for a ban on lead shot. Results suggest that approximately two-thirds of respondents would be more likely to support a ban on lead shot if research shows that it has a negative effect on game species ($\bar{x}$=3.8) (Table 4-5) or on non-game species ($\bar{x}$=3.7) (Table 4-6). Metropolitan respondents were significantly more likely to agree with these two statements.

Trust in and Use of Media Resources

Respondents were asked to indicate how much they rely on and trust information about hunting from 14 sources (Tables 4-7 to 4-20). Respondents relied most frequently on the DNR hunting regulations ($\bar{x}$=3.7) (Table 4-20), outdoor magazines ($\bar{x}$=3.4) (Table 4-4), *Outdoor News* ($\bar{x}$=3.3) (Table 4-19), outdoor shows on TV ($\bar{x}$=3.2) (Table 4-10), and sportsmen's groups ($\bar{x}$=3.1) (Table 4-18). The listed sources that were relied on the least were the St. Paul Pioneer Press ($\bar{x}$=2.1) (Table 4-15) and the Minneapolis Star Tribune ($\bar{x}$=2.3) (Table 4-14). All other sources fell between these groups. Compared to non-metropolitan residents, metropolitan residents relied more heavily on the Internet, the two Twin Cities newspapers, and the Minnesota DNR Website.

Media Resources

Table 4-1: Trust in MNDNR: When deciding about the use of lead shot for small game hunting in Minnesota, the MNDNR will be open and honest in the things they do and say

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	862	8.4%	18.0%	28.7%	34.4%	10.5%	3.2
METRO	369	6.8%	13.8%	24.4%	42.8%	12.2%	3.4
NONMETRO	529	8.7%	19.1%	29.7%	32.5%	10.0%	3.2
	χ^2=14.017**; Cramer's V = 0.125						F=10.135** ; η=0.106

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-2: Trust in MNDNR: The MNDNR can be trusted to make decisions about using lead shot for small game management that are good for the resource.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	864	8.7%	16.6%	26.4%	36.9%	11.5%	3.3
METRO	370	7.3%	13.5%	22.4%	42.4%	14.3%	3.4
NONMETRO	530	8.5%	17.4%	27.5%	36.0%	10.6%	3.2
	χ^2=9.515*; Cramer's V = 0.103						F=7.101**; η=0.089

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-3: Trust in MNDNR: The MNDNR will make decisions about using lead shot for small game in a way that is fair.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	860	8.8%	18.7%	28.0%	35.4%	9.2%	3.2
METRO	370	7.3%	15.7%	24.9%	40.3%	11.9%	3.3
NONMETRO	526	8.4%	19.4%	28.7%	35.2%	8.4%	3.2
	χ^2=7.441 n.s.; Cramer's V = 0.091						F=5.857*; η=0.081

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-4: Trust in MNDNR: The MNDNR listens to small game hunters' concerns

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	857	10.7%	18.0%	31.3%	32.0%	8.0%	3.1
METRO	367	10.4%	15.5%	30.2%	35.1%	8.7%	3.2
NONMETRO	524	9.9%	18.5%	31.3%	31.9%	8.4%	3.1
	χ^2=1.951 n.s.; Cramer's V = 0.047						F=0.638 n.s.; η=0.027

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-5: Trust in MNDNR: If research shows lead shot has negative effects on game species, I would be likely to support a ban.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	862	4.0%	7.6%	20.9%	44.2%	23.3%	3.8
METRO	369	1.9%	7.6%	14.6%	47.4%	28.5%	3.9
NONMETRO	529	4.5%	7.2%	22.7%	43.5%	22.1%	3.7
	χ^2=15.990**; Cramer's V = 0.133						F=10.068**; η=0.105

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-6: Trust in MNDNR: If research shows lead shot has negative effects on non-game wildlife, I would be likely to support a ban.

	N	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Statewide[1]	861	4.5%	7.2%	23.5%	43.5%	21.3%	3.7
METRO	370	2.7%	7.8%	14.6%	48.4%	26.5%	3.9
NONMETRO	528	4.9%	6.8%	26.5%	41.7%	20.1%	3.7
	χ^2=23.442***; Cramer's V = 0.162						F=11.256**; η=0.111

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-7: Trust and reliability of media sources: Newspapers in general

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	850	13.4%	20.6%	44.3%	20.5%	1.3%	2.8
METRO	369	14.9%	22.0%	42.3%	19.0%	1.9%	2.7
NONMETRO	520	12.3%	19.4%	45.0%	21.9%	1.3%	2.8
	χ^2=3.452 n.s.; Cramer's V = 0.062						F=2.071 n.s.; η=0.048

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-8: Trust and reliability of media sources: Outdoor Magazines in general

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	850	3.6%	10.3%	37.0%	45.0%	4.0%	3.4
METRO	369	1.9%	9.8%	36.6%	47.2%	4.6%	3.4
NONMETRO	520	4.8%	10.0%	37.5%	44.0%	3.7%	3.3
	χ^2=6.088 n.s.; Cramer's V = 0.083						F=3.660 n.s.; η=0.064

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-9: Trust and reliability of media sources: Television in general

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	852	13.3%	23.5%	42.2%	19.5%	1.6%	2.7
METRO	368	12.5%	27.4%	41.3%	17.1%	1.6%	2.7
NONMETRO	521	13.1%	21.7%	42.8%	20.7%	1.7%	2.8
	χ^2=4.608 n.s.; Cramer's V = 0.072						F=1.640 n.s.; η=0.043

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-10: Trust and reliability of media sources: Outdoor shows on TV

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	847	6.1%	12.0%	42.7%	35.0%	4.2%	3.2
METRO	366	4.9%	12.8%	41.0%	37.7%	3.6%	3.2
NONMETRO	518	6.6%	11.8%	42.9%	34.4%	4.4%	3.2
	χ^2=2.451 n.s.; Cramer's V = 0.053						F=0.367 n.s.; η=0.020

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-11: Trust and reliability of media sources: Radio in general

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	848	12.0%	24.8%	44.5%	17.5%	1.2%	2.7
METRO	364	12.9%	26.4%	41.5%	18.7%	0.5%	2.7
NONMETRO	521	11.5%	24.2%	45.1%	17.9%	1.3%	2.7
	χ^2=2.809 n.s.; Cramer's V = 0.056						F=0.807 n.s.; η=0.030

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-12: Trust and reliability of media sources: Outdoor shows on radio

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	851	11.8%	22.6%	41.9%	22.5%	1.3%	2.8
METRO	367	10.1%	24.8%	37.9%	25.9%	1.4%	2.8
NONMETRO	521	12.7%	21.7%	42.8%	21.5%	1.3%	2.8
	χ^2=5.208 n.s.; Cramer's V = 0.077						F=0.964 n.s.; η=0.033

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-13: Trust and reliability of media sources: The Web or internet

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	841	20.2%	21.4%	37.0%	18.8%	2.5%	2.6
METRO	364	13.5%	24.2%	39.0%	21.4%	1.9%	2.7
NONMETRO	515	22.5%	20.4%	35.9%	18.4%	2.7%	2.6
	χ^2=12.800*; Cramer's V = 0.121						F=4.642*; η=0.073

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-14: Trust and reliability of media sources: Minneapolis Star-Tribune

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	841	33.5%	20.3%	30.2%	14.7%	1.2%	2.3
METRO	365	25.8%	23.3%	33.2%	15.6%	2.2%	2.5
NONMETRO	515	35.7%	18.8%	29.1%	15.5%	0.8%	2.3
	χ^2=13.036*; Cramer's V = 0.122						F=5.813*; η=0.081

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-15: Trust and reliability of media sources: St. Paul Pioneer Press

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	838	37.5%	25.0%	27.1%	9.6%	0.8%	2.1
METRO	363	30.0%	27.8%	29.5%	11.6%	1.1%	2.3
NONMETRO	512	40.2%	23.4%	26.2%	9.6%	0.6%	2.1
	χ^2=10.131*; Cramer's V = 0.108						F=7.044**; η=0.089

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-16: Trust and reliability of media sources: Minnesota DNR Conservation Volunteer

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	847	18.4%	15.8%	32.1%	24.6%	9.1%	2.9
METRO	369	15.2%	14.6%	34.4%	27.4%	8.4%	3.0
NONMETRO	517	19.1%	15.9%	30.9%	23.8%	10.3%	2.9
	χ^2=4.823 n.s.; Cramer's V = 0.074						F=1.190 n.s.; η=0.037

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-17: Trust and reliability of media sources: Minnesota DNR website

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	841	20.3%	16.2%	29.5%	24.7%	9.3%	2.9
METRO	365	13.7%	15.1%	33.4%	31.5%	6.3%	3.0
NONMETRO	515	22.3%	16.1%	27.8%	22.9%	10.9%	2.8
	χ^2=21.841***; Cramer's V = 0.158						F=4.436*; η=0.071

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-18: Trust and reliability of media sources: Sportmen's groups

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	845	9.7%	15.0%	36.1%	34.2%	5.0%	3.1
METRO	368	8.7%	15.5%	34.8%	34.2%	6.8%	3.1
NONMETRO	516	10.1%	14.5%	36.6%	34.7%	4.1%	3.1
	χ^2=3.842 n.s.; Cramer's V = 0.066						F=.928 n.s.; η=0.032

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Media Resources

Table 4-19: Trust and reliability of media sources: Outdoor news

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	846	7.7%	12.8%	31.6%	38.7%	9.3%	3.3
METRO	367	6.8%	13.1%	32.4%	37.9%	9.8%	3.3
NONMETRO	518	8.3%	12.4%	30.9%	39.6%	8.9%	3.3
	χ^2=1.230 n.s.; Cramer's V = 0.037						F=.113 n.s.; η=0.011

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 4-20: Trust and reliability of media sources: DNR Hunter Handbook (hunting regs)

	N	Not at all	Seldom	Occasionally	Frequently	Always	Mean
Statewide[1]	848	3.9%	6.2%	28.4%	37.9%	23.6%	3.7
METRO	368	2.4%	7.1%	29.3%	38.9%	22.3%	3.7
NONMETRO	519	4.4%	5.6%	27.2%	37.4%	25.4%	3.7
	χ^2=4.487 n.s.; Cramer's V = 0.071						F=.114 n.s.; η=0.011

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Environmental Values

Environmental Values

Survey recipients completed 15 items that measure the new ecological paradigm (Dunlap et al., 2000) (Tables 5-1 to 5-15). More than half of the respondents agreed that: (a) when humans interfere with nature it often produces disastrous consequences ($\bar{x}$ =3.5) (Table 5-2), (b) humans are severely abusing the environment ($\bar{x}$ =3.4) (Table 5-4), (c) the earth has plenty of natural resources if we just learn how to develop them ($\bar{x}$ =3.4) (Table 5-5), (d) plants and animals have as much right as humans to exist ($\bar{x}$ =3.4) (Table 5-6), (e) despite our special abilities humans are still subject to the laws of nature ($\bar{x}$ =4.1) (Table 5-8), (f) the earth is like a spaceship with very limited room and resources ($\bar{x}$ =3.4) (Table 5-10), and (g) the balance of nature is very delicate and easily upset ($\bar{x}$ =3.7) (Table 5-12). More than half of the respondents disagreed that: (a) humans have the right to modify the natural environment to suit their needs ($\bar{x}$ =2.5) (Table 5-1), (b) the balance of nature is strong enough to cope with the impacts of modern industrial nations ($\bar{x}$ =2.3) (Table 5-7), and (c) humans will eventually learn enough about how nature works to be able to control it ($\bar{x}$ =2.4) (Table 5-13).

Consequences of Environmental Problems

Respondents were asked to respond to nine items to indicate why they were concerned about environmental problems (Tables 5-16 to 5-24). Respondents were most concerned about environmental problems because of consequences for children ($\bar{x}$ =6.0) (Table 5-20), future generations ($\bar{x}$ =6.0) (Table 5-22), and nature ($\bar{x}$ =5.7) (Table 5-24). They were least concerned about consequences for: (a) themselves ($\bar{x}$ =5.1) (Table 5-16), their future ($\bar{x}$ =5.3) (Table 5-19), and their own health ($\bar{x}$ =5.3) (Table 5-23).

Table 5-1: Environmental values: Humans have the right to modify the natural environment to suit their needs

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	855	24.0%	31.7%	17.6%	20.2%	6.5%	2.5
METRO	369	25.2%	28.2%	15.4%	23.8%	7.3%	2.6
NONMETRO	524	24.4%	32.8%	18.1%	18.9%	5.7%	2.5
	χ^2=5.875 n.s., Cramer's V=0.081						F=1.765 n.s.; η=0.044

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-2: Environmental values: When humans interfere with nature it often produces disastrous consequences

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	854	7.2%	16.5%	14.2%	40.6%	21.4%	3.5
METRO	368	8.2%	18.5%	14.7%	37.8%	20.9%	3.4
NONMETRO	524	6.5%	15.3%	13.9%	42.0%	22.3%	3.6
	χ^2=3.410 n.s., Cramer's V=0.062						F=2.750 n.s.; η=0.056

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-3: Environmental values: Human ingenuity will ensure that we do not make the earth unlivable

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	850	12.0%	25.6%	26.9%	27.2%	8.4%	2.9
METRO	367	12.3%	24.5%	25.3%	28.6%	9.3%	3.0
NONMETRO	521	11.9%	26.3%	27.1%	26.9%	7.9%	2.9
	χ^2=1.262 n.s., Cramer's V=0.038						F=0.496 n.s.; η=0.024

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-4: Environmental values: Humans are severely abusing the environment

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	841	10.1%	15.4%	17.3%	38.7%	18.5%	3.4
METRO	361	11.1%	16.1%	14.7%	37.4%	20.8%	3.4
NONMETRO	517	9.5%	15.3%	18.2%	39.5%	17.6%	3.4
	χ^2=3.545 n.s., Cramer's V=0.064						F=0.001 n.s.; η=0.001

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-5: Environmental values: The earth has plenty of natural resources if we just learn how to develop them

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	852	7.6%	18.8%	19.4%	38.8%	15.4%	3.4
METRO	367	9.5%	20.7%	17.2%	37.1%	15.5%	3.3
NONMETRO	523	7.1%	18.4%	20.5%	39.0%	15.1%	3.4
	χ^2=3.698 n.s., Cramer's V=0.064						F=1.079 n.s.; η=0.035

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-6: Environmental values: Plants and animals have as much right as humans to exist

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	851	11.2%	15.2%	20.6%	28.7%	24.3%	3.4
METRO	367	13.6%	15.3%	19.6%	24.8%	26.7%	3.4
NONMETRO	522	9.0%	15.1%	20.9%	30.7%	24.3%	3.5
	χ^2=7.483 n.s., Cramer's V=0.092						F=1.383 n.s.; η=0.039

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-7: Environmental values: The balance of nature is strong enough to cope with the impacts of modern industrial nations

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	854	26.0%	38.7%	17.2%	14.1%	4.1%	2.3
METRO	368	24.7%	39.7%	15.5%	15.8%	4.3%	2.4
NONMETRO	524	26.7%	38.7%	17.6%	13.2%	3.8%	2.3
	χ^2=2.104 n.s., Cramer's V=0.049						F=0.769 n.s.; η=0.029

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-8: Environmental values: Despite our special abilities humans are still subject to the laws of nature

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	853	1.0%	2.8%	14.4%	48.9%	32.9%	4.1
METRO	368	1.4%	2.2%	12.2%	45.9%	38.3%	4.2
NONMETRO	523	0.8%	3.3%	15.3%	49.5%	31.2%	4.1
	χ^2=6.914 n.s., Cramer's V=0.088						F=3.613 n.s.; η=0.064

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-9: Environmental values: The so-called "ecological crisis" facing humankind has been greatly exaggerated

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	851	12.5%	19.8%	27.2%	26.2%	14.4%	3.1
METRO	366	15.0%	19.9%	24.0%	26.0%	15.0%	3.1
NONMETRO	522	12.3%	19.7%	28.7%	25.9%	13.4%	3.1
	χ^2=3.402 n.s., Cramer's V=0.062						F=0.081 n.s.; η=0.010

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-10: Environmental values: The earth is like a spaceship with very limited room and resources

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	848	6.2%	16.4%	26.0%	37.0%	14.4%	3.4
METRO	366	7.9%	16.4%	21.6%	38.0%	16.1%	3.4
NONMETRO	520	5.0%	16.0%	27.5%	37.7%	13.8%	3.4
	χ^2=6.738 n.s., Cramer's V=0.087						F=0.036 n.s.; η=0.006

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-11: Environmental values: Humans were meant to rule over the rest of nature

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	848	18.8%	24.6%	24.7%	20.6%	11.4%	2.8
METRO	366	19.9%	23.5%	23.2%	20.8%	12.6%	2.8
NONMETRO	520	18.5%	24.4%	25.2%	21.7%	10.2%	2.8
	χ^2=1.845 n.s., Cramer's V=0.046						F=0.040 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-12: Environmental values: The balance of nature is very delicate and easily upset

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	847	3.1%	13.4%	19.0%	42.5%	22.0%	3.7
METRO	368	3.5%	14.4%	18.8%	38.9%	24.5%	3.7
NONMETRO	518	2.7%	12.4%	18.7%	44.2%	22.0%	3.7
	χ^2=3.196 n.s., Cramer's V=0.060						F=0.331 n.s.; η=0.019

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-13: Environmental values: Humans will eventually learn enough about how nature works to be able to control it

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	854	23.5%	35.7%	22.7%	16.4%	1.8%	2.4
METRO	368	23.1%	36.7%	20.9%	18.2%	1.1%	2.4
NONMETRO	524	23.5%	35.7%	23.3%	15.6%	1.9%	2.4
	χ^2=2.388 n.s., Cramer's V=0.052						F=0.009 n.s.; η=0.003

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-14: Environmental values: If things continue on their present course, we will soon experience a major ecological catastrophe

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	852	14.0%	21.6%	27.3%	24.9%	12.2%	3.0
METRO	368	17.1%	22.8%	24.7%	24.7%	10.6%	2.9
NONMETRO	522	11.9%	21.5%	28.0%	25.5%	13.2%	3.1
	χ^2=6.528 n.s., Cramer's V=0.086						F=4.538*; η=0.071

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-15: Environmental values: We are approaching the limit of the number of people the earth can support

	N	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Mean
Statewide[1]	853	10.6%	18.7%	29.0%	27.1%	14.7%	3.2
METRO	367	12.3%	17.7%	26.4%	27.2%	16.3%	3.2
NONMETRO	524	9.4%	19.1%	30.3%	26.9%	14.3%	3.2
	χ^2=3.702 n.s., Cramer's V=0.064						F=0.000 n.s.; η=0.000

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-16: I am concerned about environmental problems because of the consequences for: MYSELF

	N	Not at all important						Extremely important	Mean
Statewide[1]	852	2.6%	4.7%	7.7%	19.6%	23.2%	17.4%	24.8%	5.1
METRO	364	3.3%	4.4%	10.2%	17.6%	20.9%	16.8%	26.9%	5.1
NONMETRO	525	2.5%	4.4%	6.7%	20.0%	23.8%	18.1%	24.6%	5.1
	χ^2=5.925 n.s., Cramer's V=0.082								F=0.173 n.s.; η=0.014

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-17: I am concerned about environmental problems because of the consequences for: HUMANITY IN GENERAL

	N	Not at all important						Extremely important	Mean
Statewide[1]	852	2.0%	2.2%	5.4%	16.1%	22.9%	21.8%	29.5%	5.4
METRO	366	1.6%	2.5%	6.0%	16.1%	18.3%	24.0%	31.4%	5.4
NONMETRO	524	2.3%	1.9%	4.8%	16.0%	23.9%	21.0%	30.2%	5.4
	χ^2=5.476 n.s., Cramer's V=0.078								F=0.157 n.s.; η=0.013

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-18: I am concerned about environmental problems because of the consequences for: WILDLIFE

	N	Not at all important						Extremely important	Mean
Statewide[1]	849	1.2%	1.8%	5.7%	13.2%	20.6%	26.2%	31.2%	5.5
METRO	364	0.8%	1.4%	7.7%	12.1%	19.2%	26.4%	32.4%	5.6
NONMETRO	522	1.5%	1.9%	4.4%	13.2%	20.5%	26.2%	32.2%	5.6
	χ^2=5.655 n.s., Cramer's V=0.080								F=0.002 n.s.; η=0.001

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-19: I am concerned about environmental problems because of the consequences for: MY FUTURE

	N	Not at all important						Extremely important	Mean
Statewide[1]	851	2.2%	4.3%	5.8%	15.4%	23.5%	21.0%	27.8%	5.3
METRO	364	2.2%	4.1%	7.7%	14.3%	22.8%	21.2%	27.7%	5.3
NONMETRO	524	2.1%	4.4%	5.0%	15.3%	23.7%	21.0%	28.6%	5.3
	χ^2=2.948 n.s., Cramer's V=0.058								F=0.290 n.s.; η=0.018

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-20: I am concerned about environmental problems because of the consequences for: CHILDREN

	N	Not at all important						Extremely important	Mean
Statewide[1]	851	1.8%	1.5%	2.6%	8.1%	11.4%	21.7%	52.9%	6.0
METRO	366	1.4%	1.1%	2.7%	8.2%	10.9%	23.2%	52.5%	6.1
NONMETRO	523	1.9%	1.5%	2.5%	7.6%	11.1%	21.0%	54.3%	6.0
	χ^2=1.431 n.s., Cramer's V=0.040								F=0.011 n.s.; η=0.003

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-21: I am concerned about environmental problems because of the consequences for: BIRDS

	N	Not at all important						Extremely important	Mean
Statewide[1]	852	1.6%	2.8%	4.9%	16.5%	21.9%	23.1%	29.2%	5.4
METRO	364	1.1%	3.3%	5.8%	12.9%	20.1%	28.0%	28.8%	5.5
NONMETRO	525	1.7%	2.5%	4.4%	17.1%	22.3%	20.8%	31.2%	5.4
	χ^2=10.086 n.s., Cramer's V=0.107								F=0.159 n.s.; η=0.013

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Environmental Values

Table 5-22: I am concerned about environmental problems because of the consequences for: FUTURE GENERATIONS

	N	Not at all important						Extremely important	Mean
Statewide[1]	854	1.7%	1.3%	2.5%	9.5%	12.7%	24.7%	47.7%	6.0
METRO	366	1.4%	0.8%	1.9%	9.8%	11.5%	24.6%	50.0%	6.0
NONMETRO	525	1.7%	1.5%	2.5%	8.8%	12.8%	24.0%	48.8%	6.0
	χ^2=1.998 n.s., Cramer's V=0.047								F=0.532 n.s.; η=0.024

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-23: I am concerned about environmental problems because of the consequences for: MY OWN HEALTH

	N	Not at all important						Extremely important	Mean
Statewide[1]	853	2.3%	4.2%	4.9%	15.9%	21.5%	22.1%	29.2%	5.3
METRO	365	2.2%	3.6%	6.8%	16.4%	20.3%	21.6%	29.0%	5.3
NONMETRO	525	2.3%	4.4%	4.2%	15.0%	21.7%	21.7%	30.7%	5.4
	χ^2=3.916 n.s., Cramer's V=0.066								F=0.466 n.s.; η=0.023

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-24: I am concerned about environmental problems because of the consequences for: NATURE

	N	Not at all important						Extremely important	Mean
Statewide[1]	853	1.3%	1.2%	4.3%	10.8%	17.5%	26.8%	38.0%	5.7
METRO	365	0.8%	1.6%	4.4%	9.9%	18.1%	27.4%	37.8%	5.8
NONMETRO	525	1.5%	1.1%	3.8%	10.9%	16.6%	26.1%	40.0%	5.8
	χ^2=2.325 n.s., Cramer's V=0.051								F=0.044 n.s.; η=0.007

[1] A stratified sample based on region of residence was drawn. Statewide data is weighted to reflect metropolitan/non-metropolitan proportions in the population and to correct for non-response bias.
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

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Appendix C: Survey Instrument

Appendix A: Survey Instrument

Small Game Hunter
Lead Shot Study

A cooperative study conducted by the University of Minnesota for the Minnesota Department of Natural Resources

Your help on this study is greatly appreciated!

Please return your completed questionnaire in the enclosed envelope. The envelope is self-addressed and no postage is required. Thanks!

Minnesota Cooperative Fish and Wildlife Research Unit,
Department of Fisheries, Wildlife and Conservation Biology
University of Minnesota
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Q1. Did you <u>hunt for small game in the farmland zone</u> of Minnesota at anytime during the <u>past 5 years</u>? *(See map on the front cover that identifies the farmland zone.)*

❒ YES
❒ NO

Q2. In a typical year how many days do you hunt for the following small game <u>in Minnesota</u>?

	DAYS HUNTED STATEWIDE	DAYS HUNTED IN FARMLAND ZONE	DO NOT HUNT THIS SPECIES
PHEASANT	________DAYS	________DAYS	❒
GROUSE	________DAYS	________DAYS	❒
WOODCOCK	________DAYS	________DAYS	❒
SNIPE/RAIL	________DAYS	________DAYS	❒
DOVE	________DAYS	________DAYS	❒
RABBITS	________DAYS	________DAYS	❒
SQUIRREL	________DAYS	________DAYS	❒

Q3. What gauge of shotgun do you use <u>most often</u> to hunt the following game animals? *(Check one box for each row.)*

	.410	28 gauge	20 gauge	16 gauge	12 gauge	10 gauge	DO NOT HUNT WITH A SHOTGUN
PHEASANT	❒	❒	❒	❒	❒	❒	❒
GROUSE	❒	❒	❒	❒	❒	❒	❒
WOODCOCK	❒	❒	❒	❒	❒	❒	❒
SNIPE/RAIL	❒	❒	❒	❒	❒	❒	❒
DOVE	❒	❒	❒	❒	❒	❒	❒
RABBITS	❒	❒	❒	❒	❒	❒	❒
SQUIRREL	❒	❒	❒	❒	❒	❒	❒

Q4. How many boxes of shells (25 to a box) do you typically use in a season hunting the following types of small game in the FARMLAND ZONE of Minnesota? ***(Check one response for each row.)***

	1/2 a box or less	1 box	1-2 boxes	3-5 boxes	5 to 10 boxes	10+ boxes	I DO NOT HUNT FOR THIS SPECIES IN THE FARMLAND ZONE
PHEASANT	❒	❒	❒	❒	❒	❒	❒
GROUSE	❒	❒	❒	❒	❒	❒	❒
WOODCOCK	❒	❒	❒	❒	❒	❒	❒
SNIPE/RAIL	❒	❒	❒	❒	❒	❒	❒
DOVE	❒	❒	❒	❒	❒	❒	❒
RABBITS	❒	❒	❒	❒	❒	❒	❒
SQUIRREL	❒	❒	❒	❒	❒	❒	❒

Q5. What type of shot do you use most often when hunting for the following small game? ***(Check one box for each row.)***

	LEAD	STEEL	BISMUTH	OTHER
PHEASANT	❒	❒	❒	❒
GROUSE	❒	❒	❒	❒
WOODCOCK	❒	❒	❒	❒
SNIPE/RAIL	❒	❒	❒	❒
DOVE	❒	❒	❒	❒
RABBITS	❒	❒	❒	❒
SQUIRREL	❒	❒	❒	❒

Q6. Do you typically buy your shotgun shells loaded or do you self-load?

❒ BUY LOADED SHELLS→→SKIP TO Q8
❒ SELF-LOAD
❒ BOTH

Q7. How much loose, lead shot do you currently have for self-loading? _____pounds

Q8. About how many boxes of loaded shotgun shells do you currently have? ______boxes

Q9. Do you typically use lead shot or non-lead shot (steel, bismuth) when you hunt small game? *(Check one.)*

- ❒ NEVER USE LEAD
- ❒ OCCASIONALLY USE LEAD
- ❒ MOSTLY USE LEAD
- ❒ ALWAYS USE LEAD (EXCEPT FOR WATERFOWL)

Q10. We would like to find out some of your beliefs about using or not using lead shot at the current time. Please indicate the level to which you disagree or agree. *(Circle one for each row.)*

	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely Agree
Alternatives to lead shot are very difficult to find.	1	2	3	4	5	6	7
Alternatives to lead shot are too expensive.	1	2	3	4	5	6	7
I think lead is more effective than alternatives	1	2	3	4	5	6	7
I think alternatives to lead shot might damage my shotgun	1	2	3	4	5	6	7
I do not think lead shot causes any problems for wildlife.	1	2	3	4	5	6	7
I am concerned about the effects of lead on wildlife.	1	2	3	4	5	6	7
I am concerned about the effects of lead on human health.	1	2	3	4	5	6	7
I do not think the lead from hunting is an environmental problem.	1	2	3	4	5	6	7
I think hunters have a responsibility to NOT USE lead shot.	1	2	3	4	5	6	7
I think I have a personal responsibility to NOT USE lead shot.	1	2	3	4	5	6	7
It is not my responsibility to stop using lead shot.	1	2	3	4	5	6	7

Nationwide there is concern about the effects of using lead shot while hunting small game. Although lead is the primary component of shot and has been used for a couple of centuries, there are environmental concerns associated with its continued use. The use of lead shot for waterfowl hunting has been banned nationwide since 1991.

The Minnesota Department of Natural Resources is examining the issue of further restricting the use of lead shot in the state. Some other states are also examining this issue and some have already taken action. One recommendation of an advisory committee to the DNR is to phase out the use of lead shot for all small game species in the farmland zone on all public and private lands. The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The Farmland Zone generally does not include the forested areas in central and northern Minnesota.

Q11. Would you be likely or unlikely to support a ban on using lead shot to hunt small game in the farmland zone of Minnesota <u>within the next five years</u>? *(Circle one response below.)*

UNLIKELY	1	2	3	4	5	6	7	**LIKELY**
	extremely	quite	slightly	neither	slightly	quite	extremely	

Q12. Would you say supporting a ban on lead shot in the farmland zone of Minnesota is…HARMFUL OR BENEFICIAL? *(Circle one response below.)*

HARMFUL	1	2	3	4	5	6	7	**BENEFICIAL**
	extremely	quite	slightly	neither	slightly	quite	extremely	

Q13. Would you say supporting a ban on lead shot in the farmland zone of Minnesota is GOOD OR BAD. *(Circle one response below.)*

BAD	1	2	3	4	5	6	7	**GOOD**
	extremely	quite	slightly	neither	slightly	quite	extremely	

Q14. Would you say supporting a ban on lead shot in the farmland zone of Minnesota is WISE OR FOOLISH? *(Circle one response below.)*

FOOLISH	1	2	3	4	5	6	7	**WISE**
	extremely	quite	slightly	neither	slightly	quite	extremely	

Q15. We would like to know how <u>likely or unlikely</u> you believe the <u>following outcomes</u> would be <u>if lead shot was banned for hunting small game in the farmland zone in Minnesota</u>. *(Please circle the number that best represents your answer in each row.)*

Banning lead shot for hunting small game in the farmland zone in Minnesota…	**Extremely Unlikely**	**Quite Unlikely**	**Slightly Unlikely**	**Neutral**	**Slightly Likely**	**Quite Likely**	**Extremely Likely**
…would help protect wildlife from lead poisoning.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would benefit the quality of the environment.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
… would be unnecessary government regulation.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would increase crippling and wounding loss for small game hunting.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would require using less effective shot while hunting small game.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would require using more expensive ammunition.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
...would improve the image of hunters.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
...would prevent the spread of lead in the natural environment.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
...would make it more difficult for some people to hunt.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…is something most hunters would adjust to after a few seasons.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would decrease hunting opportunity in Minnesota.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
…would improve awareness about the dangers of lead in the environment.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Q16. Next we would like to know how good or bad you think the following outcomes are. ***(Please circle the number that best represents your answer in each row.)***

	Extremely Bad	Quite Bad	Slightly Bad	Neutral	Slightly Good	Quite Good	Extremely Good
Protecting wildlife from lead poisoning is...	1	2	3	4	5	6	7
Benefiting the quality of the environment is...	1	2	3	4	5	6	7
Unnecessary government regulation is...	1	2	3	4	5	6	7
Increasing wounding loss for small game hunting is...	1	2	3	4	5	6	7
Using less effective shot while hunting small game is...	1	2	3	4	5	6	7
Using more expensive ammunition is...	1	2	3	4	5	6	7
Making it more difficult to find shells for the shotgun I use is...	1	2	3	4	5	6	7
Preventing the spread of lead in the natural environment is...	1	2	3	4	5	6	7
Improving the image of hunters is...	1	2	3	4	5	6	7
Hunters adjusting to using non-lead shot...	1	2	3	4	5	6	7
Decreasing hunting opportunities...	1	2	3	4	5	6	7
Improving awareness about the dangers of lead in the environment is...	1	2	3	4	5	6	7

Q17. Next we would like to know how other people and groups feel about you supporting a ban on lead shot in the farmland zone in Minnesota. ***(Please circle the number that best represents your answer in each row.)***

	Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neutral	Slightly Likely	Quite Likely	Extremely Likely
Most of my friends think I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
Most other hunters I know think I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
Most environmental organizations think I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
Pheasants Forever thinks I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
Ducks Unlimited thinks I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
The Minnesota DNR thinks I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
The National Rifle Association (NRA) thinks I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7
Ammunition manufacturers think I SHOULD support a ban on lead shot in the farmland zone.	1	2	3	4	5	6	7

Q18. Next we would like to know how motivated you are to do what those people or groups would most want you to do. ***(Please circle the number that best represents your answer in each row.)***

Generally speaking I want to do what…	**Extremely Disagree**	**Quite Disagree**	**Slightly Disagree**	**Neutral**	**Slightly Agree**	**Quite Agree**	**Extremely Agree**
Most of my friends think I should do.	1	2	3	4	5	6	7
Most other hunters I know think I should do.	1	2	3	4	5	6	7
Most environmental organizations think I should do.	1	2	3	4	5	6	7
Pheasants Forever thinks I should do.	1	2	3	4	5	6	7
Ducks Unlimited thinks I should do.	1	2	3	4	5	6	7
The Minnesota DNR thinks I should do.	1	2	3	4	5	6	7
The National Rifle Association (NRA) thinks I should do.	1	2	3	4	5	6	7
Ammunition manufacturers think I should do.	1	2	3	4	5	6	7

Q19. Please let us know how you feel about the Minnesota Department of Natural Resources and research about lead shot. (*Please circle one response for each of the following statements).*

	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
When deciding about the use of lead shot for small game hunting in Minnesota, the MnDNR will be open and honest in the things they do and say	1	2	3	4	5
The MnDNR can be trusted to make decisions about using lead shot for small game management that are good for the resource.	1	2	3	4	5
The MnDNR will make decisions about using lead shot for small game in a way that is fair.	1	2	3	4	5
The MnDNR listens to small game hunters' concerns	1	2	3	4	5
If research shows lead shot has negative effects on game species, I would be likely to support a ban.	1	2	3	4	5
If research shows lead shot has negative effects on non-game wildlife, I would be likely to support a ban.	1	2	3	4	5

Q20. In recent years some people have expressed concern about global warming and other environmental issues, but not everyone agrees. We are interested in knowing what you believe about people and the environment. Please indicate whether you agree or disagree with the following statements. *(Circle one response for each statement.*)

Statement	**Strongly Disagree**	**Mildly Disagree**	**Neutral**	**Mildly Agree**	**Strongly Agree**
Humans have the right to modify the natural environment to suit their needs	**1**	**2**	**3**	**4**	**5**
When humans interfere with nature it often produces disastrous consequences	**1**	**2**	**3**	**4**	**5**
Human ingenuity will ensure that we do **not** make the earth unlivable	**1**	**2**	**3**	**4**	**5**
Humans are severely abusing the environment	**1**	**2**	**3**	**4**	**5**
The earth has plenty of natural resources if we just learn how to develop them	**1**	**2**	**3**	**4**	**5**
Plants and animals have as much right as humans to exist	**1**	**2**	**3**	**4**	**5**
The balance of nature is strong enough to cope with the impacts of modern industrial nations	**1**	**2**	**3**	**4**	**5**
Despite our special abilities humans are still subject to the laws of nature	**1**	**2**	**3**	**4**	**5**
The so-called “ecological crisis” facing humankind has been greatly exaggerated	**1**	**2**	**3**	**4**	**5**
The earth is like a spaceship with very limited room and resources	**1**	**2**	**3**	**4**	**5**
Humans were meant to rule over the rest of nature	**1**	**2**	**3**	**4**	**5**
The balance of nature is very delicate and easily upset	**1**	**2**	**3**	**4**	**5**
Humans will eventually learn enough about how nature works to be able to control it	**1**	**2**	**3**	**4**	**5**
If things continue on their present course, we will soon experience a major ecological catastrophe	**1**	**2**	**3**	**4**	**5**
We are approaching the limit of the number of people the earth can support	**1**	**2**	**3**	**4**	**5**

Q 21. People are generally concerned about environmental problems because of the consequences that result from the problems. However, people differ in the consequences that concern them the most. Please rate the following items from 1 (not at all important) to 7 (extremely important) in response to the question:

I am concerned about environmental problems because of the consequences for _____.

	Not at all Important						Extremely Important
Myself	1	2	3	4	5	6	7
Humanity in general	1	2	3	4	5	6	7
Wildlife	1	2	3	4	5	6	7
My future	1	2	3	4	5	6	7
Children	1	2	3	4	5	6	7
Birds	1	2	3	4	5	6	7
Future generations	1	2	3	4	5	6	7
My own health	1	2	3	4	5	6	7
Nature	1	2	3	4	5	6	7

Q22. For the following media sources please indicate how much you rely on and trust the information about hunting and natural resources from that source? *(Please circle the number that best represents your answer in each row)*.

	Not at all	Seldom	Occasionally	Frequently	Always
Newspapers in general	1	2	3	4	5
Outdoor Magazines in general	1	2	3	4	5
Television in general	1	2	3	4	5
Outdoor shows on TV	1	2	3	4	5
Radio in general	1	2	3	4	5
Outdoor shows on radio	1	2	3	4	5
The Web or internet	1	2	3	4	5
Minneapolis Star-Tribune	1	2	3	4	5
St. Paul Pioneer Press	1	2	3	4	5
Minnesota DNR Conservation Volunteer	1	2	3	4	5
Minnesota DNR website	1	2	3	4	5
Sportmen's groups	1	2	3	4	5
Outdoor news	1	2	3	4	5
DNR Hunter Handbook (hunting regs)	1	2	3	4	5

Q23. Please indicate how much you agree or disagree with the following statements about small game hunting. (*Please circle <u>one</u> response <u>for each.)</u>*:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Small game hunting is one of the most enjoyable things I do.	1	2	3	4	5
I am knowledgeable about small game hunting.	1	2	3	4	5
The decision to go small game hunting is primarily my own.	1	2	3	4	5
I find that a lot of my life is organized around small game hunting.	1	2	3	4	5
Small game hunting has a central role in my life.	1	2	3	4	5
Most of my friends are in some way connected with small game hunting.	1	2	3	4	5
When I am small game hunting, others see me the way I want them to see me.	1	2	3	4	5
I don't really know much about small game hunting.	1	2	3	4	5
Small game hunting interests me.	1	2	3	4	5
I have acquired equipment that I would not use if I quit small game hunting.	1	2	3	4	5
You can tell a lot about a person when you see them small game hunting.	1	2	3	4	5
When I am small game hunting I can really be myself.	1	2	3	4	5
I enjoy discussing small game hunting with my friends.	1	2	3	4	5
The decision to go small game hunting is not entirely my own.	1	2	3	4	5
For me to change my preference from small game hunting to another leisure activity would require major rethinking.	1	2	3	4	5
I find a lot of my life organized around small game-hunting activities.	1	2	3	4	5
Even if close friends recommended another recreational activity, I would not change my preference from small game hunting.	1	2	3	4	5
Small game hunting is important to me.	1	2	3	4	5
I have close friendships that are based on a common interest in small game hunting.	1	2	3	4	5
Compared to other small game hunters, I own a lot of small game-hunting equipment.	1	2	3	4	5

Q24. How many years have you hunted small game in the farmland area of Minnesota?

__________**YEARS**

Q25. How often do you hunt with…	**Not at all**	**Seldom**	**Occasionally**	**Frequently**	**Always**
A dog	**1**	**2**	**3**	**4**	**5**
Children under 12	**1**	**2**	**3**	**4**	**5**

Thanks for your help! Please return your survey in the enclosed, self-addressed, stamped envelope.

Small Game Hunter
Lead Shot Communication Study

Executive Summary

A cooperative study conducted by:

Minnesota Cooperative Fish and Wildlife Research Unit
Minnesota Department of Natural Resources

Small Game Hunter
Lead Shot Communication Study

Prepared by:

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Acknowledgements

This study was a cooperative effort supported by the Minnesota Department of Natural Resources, Division of Fish and Wildlife (DNR) and the U.S. Geological Survey through the Minnesota Cooperative Fish and Wildlife Research Unit at the University of Minnesota. We thank Rick Nordby for his assistance in working with the electronic licensing system. We also thank the many small game hunters who took the time to complete the survey and helped to further our understanding of this important clientele.

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Executive Summary

The purpose of this study was to help identify appropriate message points for information and education programs addressing restriction of lead shot. The specific objective was to develop and test the effectiveness of targeted messages in changing attitudes, beliefs, and behaviors concerning restrictions on the use of toxic shot.

A random sample of 4,800 resident small game hunters was drawn from the Minnesota Department of Natural Resources (DNR) electronic licensing system. The sample was divided into a sample of 1,200 for a control group and 400 for each of nine treatment groups. Individuals in the sample received an 8-page self-administered survey with the control or treatment communication on the cover page. The questionnaire addressed the following topics:

- message quality,
- narrative versus factual nature of the message,
- message involvement,
- evaluation of the message,
- likelihood of supporting a ban on lead shot in the Minnesota farmland zone,
- agreement with message recommendations, outcome involvement, and behavioral intentions,
- importance of values associated with conformity and freedom, and
- background hunting small game.

A total of 2,127 surveys were returned before the cut-off date for response, resulting in an overall response rate of 45.4%. An additional 184 surveys were returned after the cut-off date for a total response rate of 49.4%.

Respondent Characteristics

The average age of respondents was 46 years. On average, respondents had been hunting for small game for 33.5 years. Nearly all of the respondents (97.1%) had hunted for small game in Minnesota during the past 5 years. About three-fourths (75.4%) of respondents had hunted for small game in the farmland zone in the past 5 years. About 60% of respondents used non-lead shot at least some of the time, compared to about 40% of respondents who always used lead shot to hunt small game. There were no statistically significant differences among the control and treatment groups in age, number of years hunting small game, participation in small game hunting in recent years, or use of lead shot.

Messages

Based on a review of the literature on persuasive messaging, we developed one control and nine treatment messages. Messages included a: (a) control message, (b) basic factual message, (c) basic factual message with declarative statement from the Minnesota Department of Natural Resources, (d) basic factual message with concession question, (e) basic factual message with a qualifier statement, (f) basic factual message with value-expressive component, (g) basic factual message with social-adjustive component with aligned norms, (h) basic factual message with social-adjustive component with non-aligned norms, (i) basic factual message adapted to third-person narrative, and (j) basic factual message adapted to first-person narrative. The control message was as follows:

> Nationwide there is concern about the effects of using lead shot while hunting small game. Although lead is the primary component of shot and has been used for a couple of centuries, there are environmental concerns associated with its continued use. The use of lead shot for waterfowl hunting has been banned nationwide since 1991.
>
> The Minnesota Department of Natural Resources is examining the issue of further restricting the use of lead shot in the state. Some other states are also examining this issue and some have already taken action. One recommendation of an advisory committee to the DNR is to phase out the use of lead shot for all small game species in the farmland zone on all public and private lands.
>
> (The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

The basic factual message was as follows:

> Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.
>
> Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.
>
> A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.
>
> **Support a ban on toxic lead shot in Minnesota's farmland zone.**
>
> (The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

The message with the DNR declarative statement substituted the statement "The Minnesota Department of Natural Resources would like your support of a ban on toxic lead shot in Minnesota's farmland zone" for "Support a ban on toxic lead shot in Minnesota's farmland zone." The message with the concession question included the question Why would you oppose regulations banning the use of toxic shot?" instead of a declarative statement. The message with a qualifier added the phrase "although it means additional government regulation," at the beginning of the second paragraph. The value expressive message added two sentences to the beginning of the second paragraph. They were: "You love nature and the outdoors and value your hunting heritage. You want future generations to enjoy hunting and outdoor experiences like you do now." The social-adjustive, norms aligned message added the sentence "You know that a growing number of hunters have voluntarily switched from lead to non-toxic shot and that sportsmen's groups like Ducks Unlimited support the use of non-toxic shot." The social-adjustive, with non-aligned norms message added the sentence: "You know that many hunters are still using lead shot even though sportsmen's groups like Ducks Unlimited support the use of non-toxic shot."

In addition to these messages, we constructed two narrative-style messages. The third-person narrative message was as follows:

> Joe is listening to the radio on his way out to hunt pheasants. He hears a story about how 26 states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.
>
> Joe knows that lead is a toxin that can kill humans and wildlife when it is eaten. Indeed, he has heard recent news reports about concerns related to lead in children's toys and about doves, loons, and trumpeter swans dying from lead poisoning.
>
> He supports a regulation banning lead shot because he cares about wildlife and a healthy environment, and because he knows that banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.
>
> **Support a ban on toxic lead shot in Minnesota's farmland zone.**

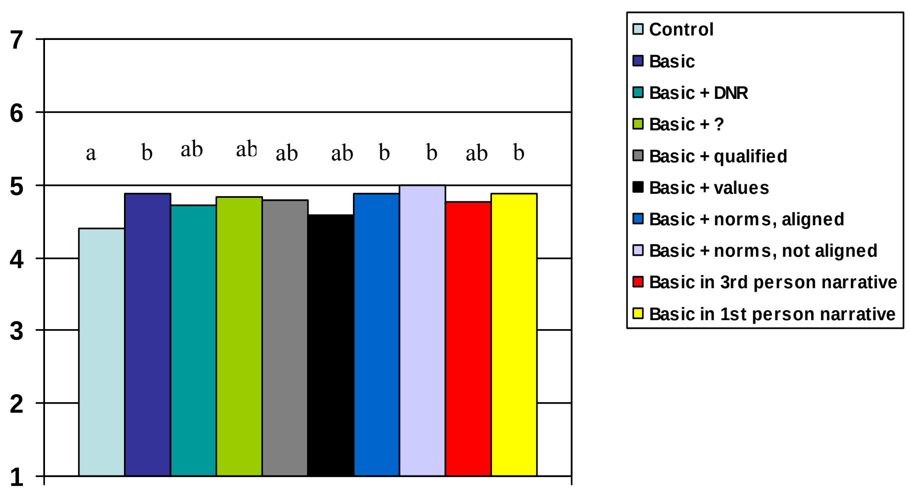
(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

The final treatment adapted the third-person narrative to first person by substituting 'you' for 'Joe' throughout the message.

Message Quality

Respondents agreed slightly that all messages, including the control message, were believable, convincing, compelling, logical, and conveyed in a straightforward way. Respondents disagreed slightly that the reasoning in the messages was unsound. Compared to all of the treatment messages, the control message was rated significantly less believable, convincing, compelling, logical and using more reasoning that was more unsound. Using a scale of message quality, which included whether the message was believable, convincing, compelling, and logical, we found that the control message had significantly lower message quality, while the basic factual, aligned social-adjustive message, non-aligned social-adjustive message, and first-person narrative message had higher message quality (Figure S-1).

Figure S-1: Message quality by treatment.

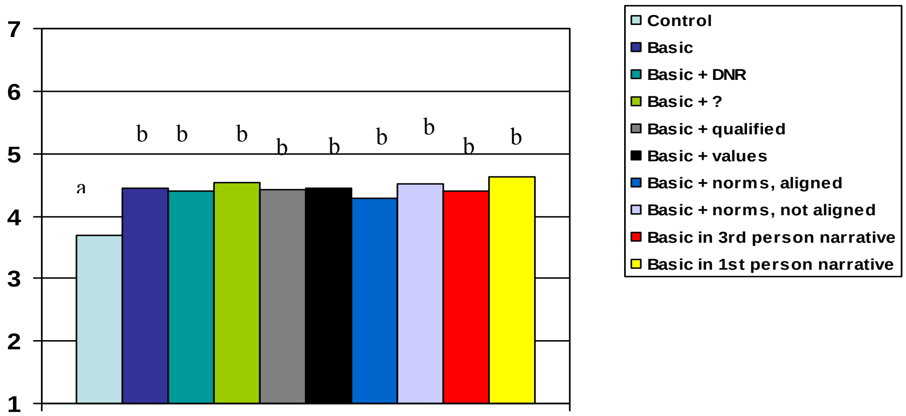


Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=3.906, p<0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Message Type

Respondents agreed slightly that all treatment messages were (a) persuasive, (b) conversational, (c) fact-oriented, (d) dramatic, and (e) telling a story. The control message was rated significantly less persuasive, conversational, fact-oriented, dramatic, and 'telling a story.' Based on research conducted by Polyorat (2007), we constructed a scale to test the narrative manipulation of the messages, which included whether the message was dramatic, and 'telling a story' (r = 0.490). The control message was perceived as having significantly lower narrative quality compared to all treatment messages (Figure S-2), but we found no difference between factual and narrative treatment messages in perception of narrative quality.

Figure S-2: Perceived narrative quality of message by treatment

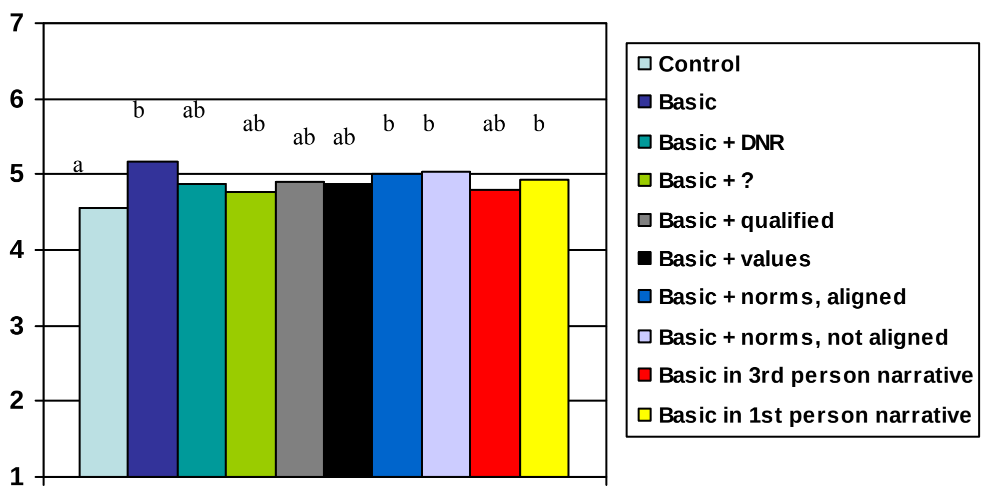


Notes: 1=non-narrative, 7=extremely narrative
F=16.277, p<0.001
Letters a, ab, b indicate significant differences in SNK post-hoc test.

Message Involvement

Five questions were asked to evaluate respondents' involvement with the messages. Respondents agreed slightly that all messages were (a) conveyed clearly, (b) easy to understand, (c) interesting, (d) involving, and (e) credible. The control message was perceived as having significantly lower message involvement compared to all treatment messages. The basic factual message, two social-adjustive treatment messages, and the first-person narrative message were rated to have greater message involvement (Figure S-3).

Figure S-3: Message involvement by treatment

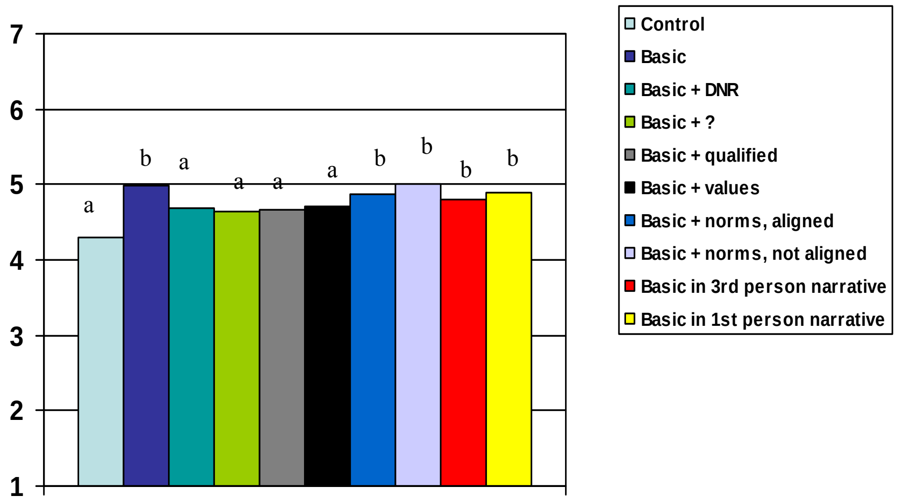


Notes: 1=non-narrative, 7=extremely narrative
F=5.055, p<0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Message Evaluation

Six questions were asked to measure respondents' evaluation of a ban on lead shot in the farmland zone of Minnesota. On average, respondents agreed just slightly that a ban was: (a) beneficial, (b) good, (c) wise, (d) worthwhile, (e) appealing, and (f) important. Respondents who received the control message felt that a ban would be less beneficial, good, wise, worthwhile, appealing and important. Using a scale of six evaluation items, we found that respondents who received the control message had a lower evaluation of a ban compared to respondents who received the treatment messages. Respondents who received the basic factual message, the two normative treatment messages, and the two narrative messages rated a ban more positively (Figure S-4).

Figure S-4: Message evaluation by treatment.

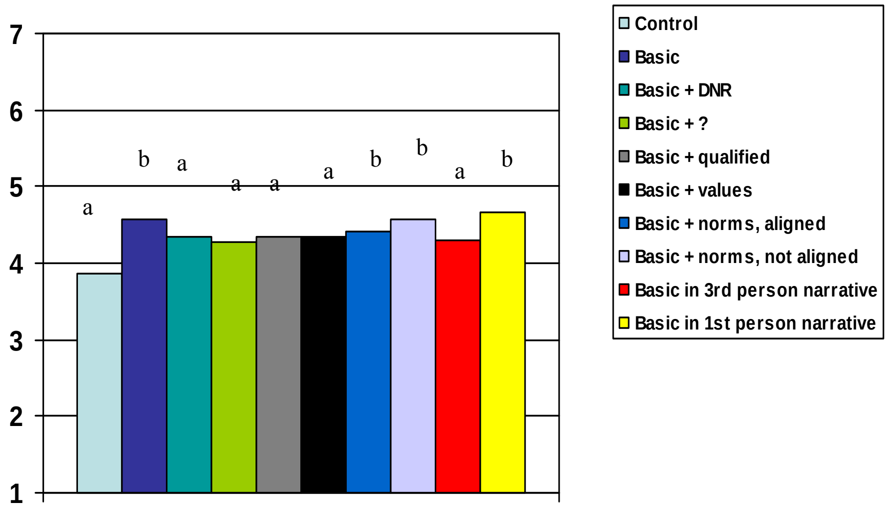


Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=4.412, p<0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Agreement With Message Recommendations, Outcome Involvement, Behavioral Intentions

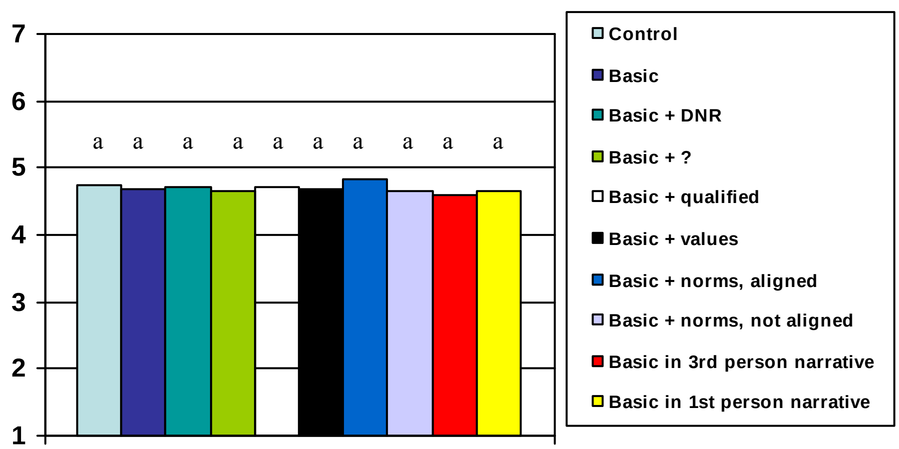
We constructed three scales to measure overall agreement with message recommendations, outcome involvement, and behavioral intentions. We found that respondents who received the control message agreed less with the message recommendations, while respondents who received the basic factual and first-person narrative messages agreed more (Figure S-5). We found no significant differences among the control and treatment groups in outcome involvement (Figure S-6). Respondents who received the basic factual, non-aligned social-adjustive, and first-person narrative messages reported stronger intentions to support a ban on lead shot in the farmland zone, while those who received the control message reported weaker intentions, compared to other treatment groups (Figure S-7).

Figure S-5: Agreement with message recommendations by treatment.



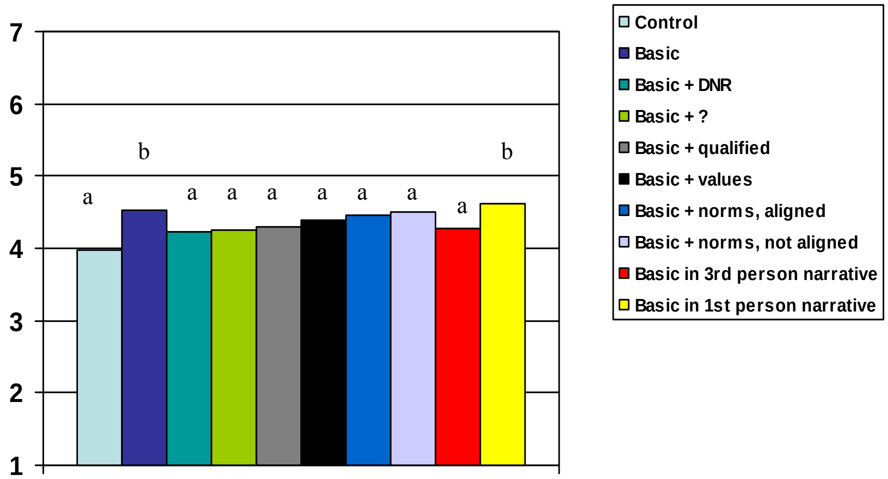
Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=4.112, $p<0.001$, $\eta=0.132$
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure S-6: Outcome involvement by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.574, n.s., $\eta=0.050$
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure S-7: Behavioral intentions by treatment.

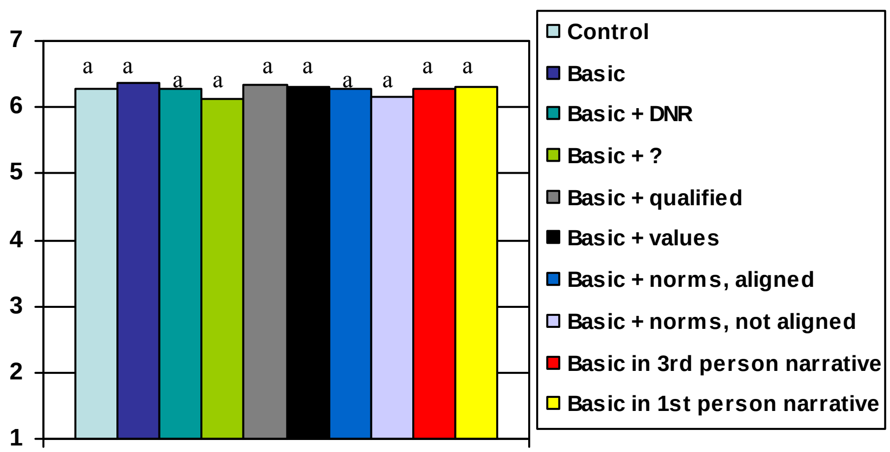


Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=2.691, $p<0.01$, $\eta=0.107$
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Values

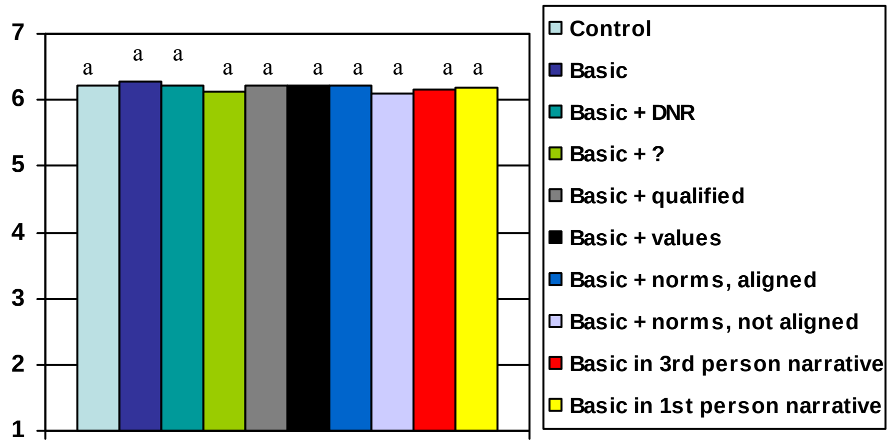
Survey recipients were asked to respond to nine items derived from Hullett and Boster (2001) addressing values related to conformity and self direction. We found no significant differences among the control and treatment groups in the importance of conformity (Figure S-8) or self-direction (Figure S-9) values. Unlike Hullett and Boster (2001), we did not find significant relationships between self-direction values and message quality for the values-expressive message, nor conformity values and message quality for the social adjustive message with norms aligned. We found significant positive relationships between both self-direction values ($r = 0.234^{**}$) and conformity values ($r = 0.262^{**}$) with the message quality for the social adjustive messages with non-aligned norms.

Figure S-8: Importance of conformity value by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.795, n.s., $\eta=0.059$
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure S-9: Importance of self-direction value by treatment.



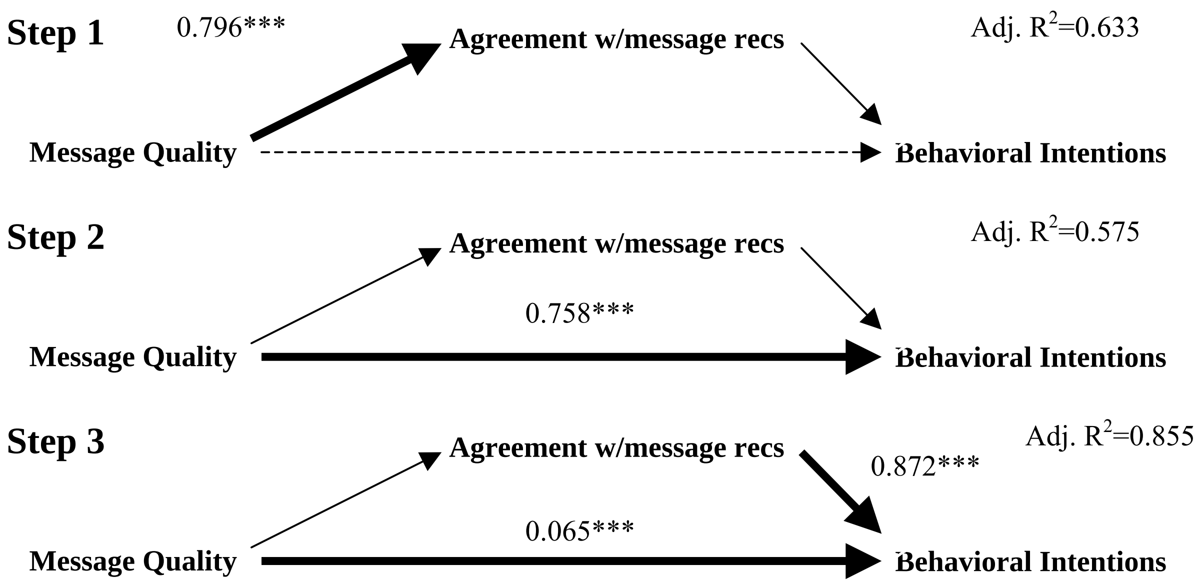
Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.437, n.s., η=0.043
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Modeling the Effectiveness of Communications on Support for a ban on Lead Shot in Minnesota's Farmland Zone

Based on the research of Hullett and Bolster (2003) and Polyorat (2007), we examined the factors associated with persuasive messages that may relate to support for a ban on lead shot in the Minnesota farmland zone. We found that message quality (r = 0.758***), perception of the narrative quality of the message (r = 0.334***), message involvement (r = 0.598***), product evaluation (r = 0.875***), agreement with message recommendations (r = 0.923***), conformity values (r = 0.070**), and self-direction values (r = 0.069**) were positively correlated with our scaled measure of intention to support a ban on lead shot in the Minnesota farmland zone. Outcome involvement (r = -0.147***), years hunting small game (r = -0.126***), age (r = -0.074**), and increased use of lead shot for hunting small game (r = -0.470***) were negatively correlated with intent to support a ban. Respondents who had hunted for small game in the Minnesota farmland zone in the past 5 years were significantly less likely to support a ban ($\bar{x} = 4.143$) than those who had not hunted in the area in the past 5 years ($\bar{x} = 4.741$) (F=36.47***, η = 0.131).

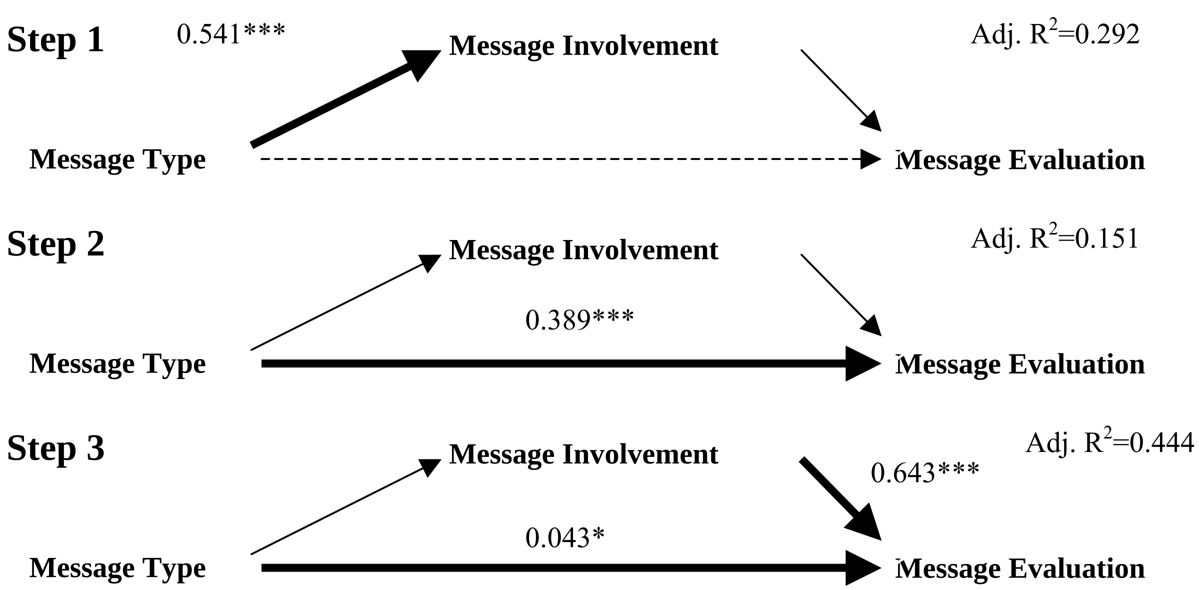
We conducted mediation analyses to examine the relationships first among (a) message quality, (b) agreement with message recommendations, and (c) intention to support a ban, then among (a) message type, (b) message involvement, and (c) message evaluation. We followed Baron and Kenny's (1986) recommendations for mediation analysis, which involved computing a series of three models. Agreement with message recommendations partially mediated the relationship between message quality and behavioral intentions (Figure S-10).

Figure S-10: Mediation Analysis of Message Quality, Agreement With Message Recommentations, and Behavioral Intentions to Support a Ban on Lead Shot in the Farmland Zone.



Message involvement partially mediated the relationship between message type (i.e. perception of narrative nature of the message) and product evaluation (Figure S-11).

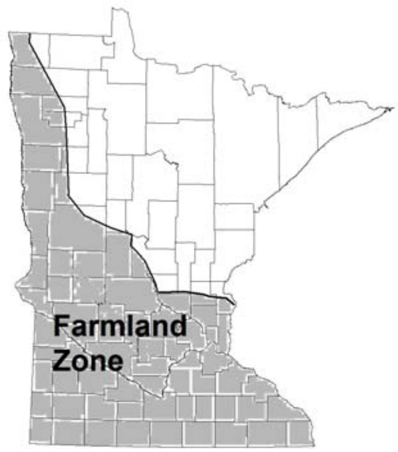
Figure S-11: Mediation Analysis of Message Type, Message Involvement, and Message Evaluation.



Conclusions

Our results suggest that persuasive messages may increase support for a ban on lead shot in Minnesota's farmland zone. Compared to respondents who received the control message, respondents who received treatment messages reported more positive attitudes about, higher evaluations of, and stronger support for a possible ban on lead shot. Results suggest that basic factual, first-person narrative, and social-adjustive messages mentioning Ducks Unlimited may be more persuasive than messages that use: (a) declarative statements from the Minnesota Department of Natural Resources, (b) concession questions, (c) qualifiers (i.e. counterarguments), (d) value-expressive messages about hunting heritage, or (e) third-person narrative.

Small Game Hunter
Lead Shot Communication Study



Appendices

A cooperative study conducted by:

Minnesota Cooperative Fish and Wildlife Research Unit
Minnesota Department of Natural Resources

Small Game Hunter
Lead Shot Communication Study

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Acknowledgements

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Appendix A: Methodology

Introduction

Study Purpose and Objectives

In a recent report to the Minnesota Department of Natural Resources, the Nontoxic Shot Advisory Committee (NSAC) agreed that further restrictions on the use of lead shot are inevitable at some future time. While no consensus on specific regulations was reached, the NSAC did agree that more restrictive regulations on the use of lead shot in shotgun hunting are warranted. Five viable options were identified as deeming further consideration. Currently, there is potential legislation that would restrict the use of lead shot on public and/or private land in the farmland/prairie zone of Minnesota in the next few years.

The NSAC recognized that for more restrictive regulations to be implemented successfully, the impacted public must be well-informed and accepting of such regulations. The purpose of this study was to provide information about small game hunter perceptions and knowledge of using toxic/non-toxic shot and help identify appropriate message points for information and education programs addressing the issue of restricting the use of lead shot. Specific objectives of this study were to:

1. Identify levels of use of lead and non-toxic shot in the farmland zone by small game hunters;
2. Identify attitudes toward restrictions on toxic shot;
3. Identify support/opposition for restrictions on the use of toxic shot;
4. Identify the key beliefs affecting attitudes toward restrictions on toxic shot;
5. Identify the influence of conservation/stewardship values in shaping attitudes and beliefs about restricting the use of toxic shot;
6. Develop and test the effectiveness of targeted messages in changing attitude, beliefs, and behaviors concerning restrictions on the use of toxic shot.

These appendices relate to the sixth objective.

Methods

Treatments

Based on a review of the literature on persuasive messaging, we developed one control and nine treatment messages (Appendix B). Previous research suggested that more persuasive messages might include those that: (a) were validated by a respected source, (b) used aligned descriptive and injunctive norms, (c) used narrative messages rather than statistical or factual ones, (d) used qualifiers when message recipients were predisposed to counter-argue a claim, (e) expressed personal values, or (f) activated social and/or personal norms (Areni, 2003; Cialdini, 2003; Eisend, 2007; Hullett & Boster, 2001; Paracchio & Meyers-Levy, 1997; Pechmann, 1990; Polyorat, et al., 2007; Weber et al., 2006). Therefore, we developed messages including: (a) control message, (b) basic factual message, (c) basic factual message with declarative statement from the Minnesota Department of Natural Resources, (d) basic factual message with concession question, (e) basic factual message with a qualifier statement, (f) value-expressive message, (g) social-adjustive message with aligned norms, (h) social-adjustive message with non-aligned norms, (i) third-person narrative message, and (j) first-person narrative message.

Sampling

The population of interest in this study included all Minnesota residents who hunt small game. The sampling frame used to draw the study sample was the Minnesota Department of Natural Resource's

(DNR) Electronic Licensing System (ELS). A random sample of Minnesota resident small game hunters in the ELS was drawn. The initial study sample included 4,800 individuals. The sample was divided into a control group and nine treatment groups. The control communication and survey was mailed to 1,200 people and each of the nine treatment communications with surveys was distributed to 400 people. The target sample size was n = 300 for the control and n = 100 for each of the treatments. (n = 1,200 overall).

Data Collection

Data were collected using a mail-back survey generally following a process outlined by Dillman (2000). We constructed a relatively straightforward questionnaire and created personalized cover letters describing the purpose of the study. Potential study respondents were contacted once in January 2008. Business-reply envelopes were included in the mailing. We made only one contact with potential respondents to minimize the influence of outside information and dosage effects to the persuasive messages on reported attitudes.

Survey Instrument

The data collection instrument was an 8-page self-administered survey with the control or treatment communication on the cover page, 5 pages of questions, a page for comments, and contact information on the back cover (Appendix C). The questionnaire addressed the following topics:

- Message quality,
- Narrative versus factual nature of the message,
- Message involvement,
- Evaluation of the message,
- Likelihood of supporting a ban on lead shot in the Minnesota farmland zone,
- Agreement with message recommendations, outcome involvement, and behavioral intentions,
- Importance of values associated with conformity and freedom, and
- Background hunting small game.

Data Entry and Analysis

Data were keypunched and the data were analyzed on a PC using the Statistical Program for the Social Sciences (SPSS for Windows 15.0). We computed basic descriptive statistics and frequencies for the overall results and by treatment. Treatments were compared using one-way analysis of variance and cross-tabulations.

Several statistics presented in the report are used to show the association between variables. Pearson product moment correlations are used to show the linear relationship between two measured (interval-level) variables. Pearson correlations range from -1.0 (perfect negative association) to 1.0 (perfect positive association), with 0 indicating no linear association (Norusis, 2002). The chi-square statistic is used to test whether two categorical variables are independent. The chi-square statistic is not a good measure of association (Norusis, 2002), so the Cramer's V statistic is provided to show the strength of the relationship. Values for Cramer's V range from 0.0 (no association) to 1.0 (perfect association) (Norusis, 2002). Analysis of variance (ANOVA) is used to test hypotheses about differences in two or more population means (Norusis, 2002). In this report ANOVA is used to compare: (a) the means of measured (interval-level) variables based on one multiple-category (polytomous) variable, or (b) the means of multiple interval-level variables. ANOVA produces the F ratio. Large values for the F ratio indicate that the sample means vary more than you would expect (Norusis, 2002). The Games-Howell post-hoc test is used associated with ANOVA to compare multiple means. Toothaker (1993) recommends using the

Games-Howell post-hoc test over other tests for the situation of unequal (or equal) sample sizes and unequal or unknown variances. The correlation ratio (eta) is calculated for one-way ANOVA calculations in this report, to indicate the strength of the relationship. Like the Cramer's V statistic, eta (η) ranges from 0.0 (no association) to 1.0 (perfect association) (Norusis, 2002).

Scales of multiple items (i.e. questions) were included in the survey to measure constructs like message involvement. The reliability of items that make up a scale indicates the extent to which the scale yields consistent results over repeated observations (Eagly and Chaiken, 1993). Other ways of thinking about the reliability of a measure are: (a) "the extent to which it is free from random error" (Eagly and Chaiken, 1993, p. 64), or (b) "how well scores on the measuring instrument correlate with themselves" (Eagly and Chaiken, 1993, p. 64). We use Cronbach's alpha (α) to report the reliability of the scales in this report.

Survey Response Rate

Of the 4,800 questionnaires mailed, 106 were undeliverable, one was sent to a deceased person, and 12 were sent to people who had moved out of the state. Of the 4,694 remaining surveys, a total of 2,127 were returned before the cut-off date for response, resulting in an overall response rate of 45.4%. An additional 184 surveys were returned after the cut-off date for a total response rate of 49.4%. Surveys were collected through March 28, 2008. Response rates for the different treatments are summarized in Table I-1.

Table I-1: Response rates by treatment

	Initial sample size	Number invalid	Valid sample size	Number of full surveys returned	Response rate %	Number of late surveys returned	Total surveys returned	Total response rate %
Control	1,200	30	1,170	541	46.2%	45	586	50.1%
Treatment 1	400	13	387	163	42.1%	18	181	46.8%
Treatment 2	400	12	388	186	47.9%	15	201	51.8%
Treatment 3	400	11	389	170	43.7%	13	183	47.0%
Treatment 4	400	10	390	168	43.1%	17	185	47.4%
Treatment 5	400	5	395	183	46.3%	13	196	49.6%
Treatment 6	400	9	391	204	52.2%	20	224	57.3%
Treatment 7	400	5	395	168	42.5%	11	179	45.3%
Treatment 8	400	10	390	175	44.9%	15	190	48.7%
Treatment 9	400	14	386	169	43.8%	17	186	48.2%
Total	4,800	119	4,681	2,127	45.4%	184	2,311	49.4%

Appendix B: Tables of Survey Results

Section 1: Message Quality

Respondents agreed slightly that all messages, including the control message, were (a) believable (Table 1-1), (b) convincing (Table 1-2), (c) compelling (Table 1-3), (d) logical (Table 1-4), and (e) conveyed in a straightforward way (Table 1-6). Respondents disagreed slightly that the reasoning in the messages was unsound (Table 1-5). There were significant differences in the mean rating of message quality for all items. Through post-hoc analysis, we found that the control message was rated significantly less believable, convincing, compelling, logical and using reasoning that was more unsound.

Based on research conducted by Hullett & Bolster (2003), we constructed a scale of message quality, which included whether the message was believable, convincing, compelling, and logical ($\alpha = 0.941$). Using this scale we found that the control message had significantly lower message quality, while the basic factual, aligned social-adjustive message, non-aligned social-adjustive message, and first-person narrative message had higher message quality.

Section 1: Message Quality

Table 1-1: The message is believable.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremel y agree	Mean
Control	518	7.7%	9.1%	8.7%	13.5%	18.0%	32.2%	10.8%	4.65[a]
Basic	158	5.1%	5.7%	7.6%	7.0%	19.0%	40.5%	15.2%	5.11[ab]
DNR declaration	180	7.2%	8.3%	6.1%	10.0%	18.3%	36.1%	13.9%	4.88[ab]
Concession question	159	2.5%	9.4%	9.4%	8.2%	15.1%	38.4%	17.0%	5.07[ab]
Qualifier	161	6.8%	9.3%	6.2%	6.2%	15.5%	39.8%	16.1%	4.98[ab]
Value expressive	177	10.7%	7.9%	7.9%	6.8%	19.2%	33.9%	13.6%	4.72[ab]
Social adjustive – norms aligned	197	5.6%	7.1%	6.6%	8.6%	15.7%	40.1%	16.2%	5.07[ab]
Social adjustive – norms not aligned	163	3.1%	4.3%	5.5%	12.9%	20.2%	39.3%	14.7%	5.20[b]
3rd person narrative	170	5.9%	5.3%	6.5%	9.4%	19.4%	41.8%	11.8%	5.04[ab]
1st person narrative	165	4.8%	8.5%	7.9%	9.1%	13.9%	38.8%	17.0%	5.03[ab]
	χ^2=59.298 n.s.; Cramer's V = 0.069								F=2.848** η=0.111

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 1-2: The message is convincing.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Control	513	7.4%	11.5%	11.9%	20.1%	19.1%	22.2%	7.8%	4.30[a]
Basic	158	7.0%	6.3%	8.9%	11.4%	21.5%	32.9%	12.0%	4.81[b]
DNR declaration	177	9.0%	7.9%	9.0%	14.7%	18.6%	27.7%	13.0%	4.61[ab]
Concession question	159	5.7%	8.2%	8.8%	12.6%	21.4%	31.4%	11.9%	4.78[ab]
Qualifier	161	8.7%	6.2%	9.9%	9.3%	18.0%	36.6%	11.2%	4.76[ab]
Value expressive	177	9.6%	10.2%	8.5%	12.4%	17.5%	30.5%	11.3%	4.55[ab]
Social adjustive – norms aligned	196	5.6%	8.7%	4.6%	16.8%	15.8%	36.2%	12.2%	4.86[b]
Social adjustive – norms not aligned	163	2.5%	3.7%	9.2%	17.2%	28.2%	30.7%	8.6%	4.91[b]
3rd person narrative	168	5.4%	4.8%	11.9%	15.5%	23.2%	28.6%	10.7%	4.75[ab]
1st person narrative	164	4.3%	11.0%	4.3%	11.0%	26.8%	31.1%	11.6%	4.85[b]
	χ^2=96.389***; Cramer's V = 0.089								F=3.926*** η=0.131

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 1: Message Quality

Table 1-3: I find the message to be compelling.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Control	510	9.4%	10.8%	9.6%	30.4%	17.5%	14.9%	7.5%	4.10[a]
Basic	154	7.8%	7.8%	6.5%	24.0%	22.7%	18.8%	12.3%	4.52[ab]
DNR declaration	178	7.9%	7.3%	8.4%	23.6%	21.9%	20.2%	10.7%	4.48[ab]
Concession question	160	5.0%	13.1%	7.5%	25.0%	18.8%	23.1%	7.5%	4.39[ab]
Qualifier	160	9.4%	6.9%	11.9%	18.8%	18.1%	23.8%	11.3%	4.46[ab]
Value expressive	177	10.2%	10.7%	7.3%	23.7%	20.9%	18.1%	9.0%	4.25[ab]
Social adjustive – norms aligned	196	5.6%	10.2%	7.1%	26.0%	19.9%	21.9%	9.2%	4.47[ab]
Social adjustive – norms not aligned	160	3.8%	7.5%	8.8%	24.4%	27.5%	21.3%	6.9%	4.56[b]
3rd person narrative	169	7.1%	7.7%	11.2%	25.4%	19.5%	21.9%	7.1%	4.37[ab]
1st person narrative	164	7.9%	7.9%	7.3%	22.0%	20.1%	25.6%	9.1%	4.52[ab]
	χ^2=59.362 n.s.; Cramer's V = 0.070								F=2.249* η=0.100

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 1-4: The message seems logical.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Control	509	9.0%	10.6%	8.1%	12.8%	22.0%	26.7%	10.8%	4.51[a]
Basic	156	7.1%	5.1%	6.4%	7.7%	15.4%	34.6%	23.7%	5.18[ab]
DNR declaration	175	8.0%	5.1%	6.9%	13.1%	20.0%	31.4%	15.4%	4.88[ab]
Concession question	158	3.2%	7.6%	8.9%	5.1%	22.2%	38.0%	15.2%	5.10[b]
Qualifier	160	10.0%	6.3%	6.9%	6.9%	20.6%	29.4%	20.0%	4.90[ab]
Value expressive	174	8.6%	8.0%	8.6%	9.2%	20.1%	28.7%	16.7%	4.77[ab]
Social adjustive – norms aligned	196	6.1%	6.1%	7.1%	10.2%	15.8%	33.7%	20.9%	5.08[b]
Social adjustive – norms not aligned	161	1.2%	5.0%	8.1%	12.4%	17.4%	37.9%	18.0%	5.25[b]
3rd person narrative	167	7.2%	5.4%	6.6%	12.0%	21.0%	34.1%	13.8%	4.92[ab]
1st person narrative	164	4.3%	6.7%	6.7%	12.8%	15.9%	36.0%	17.7%	5.08[b]
	χ^2=83.825**; Cramer's V = 0.083								F=4.658*** η=0.143

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 1: Message Quality

Table 1-5: The reasoning used in the message was unsound.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Control	514	8.8%	19.3%	15.8%	26.8%	11.7%	11.3%	6.4%	3.73[a]
Basic	157	12.7%	28.7%	15.3%	16.6%	11.5%	9.6%	5.7%	3.37[ab]
DNR declaration	175	10.3%	20.6%	13.7%	24.6%	12.0%	10.3%	8.6%	3.73[ab]
Concession question	160	7.5%	31.3%	14.4%	20.0%	12.5%	11.9%	2.5%	3.44[ab]
Qualifier	161	11.2%	26.1%	12.4%	24.2%	8.1%	11.2%	6.8%	3.53[ab]
Value expressive	176	12.5%	22.7%	10.2%	22.7%	12.5%	13.1%	6.3%	3.64[ab]
Social adjustive – norms aligned	193	8.3%	26.4%	14.5%	18.7%	11.9%	14.5%	5.7%	3.66[ab]
Social adjustive – norms not aligned	161	9.3%	28.0%	18.6%	23.0%	8.7%	8.1%	4.3%	3.35[ab]
3rd person narrative	168	12.5%	25.6%	15.5%	20.8%	7.7%	9.5%	8.3%	3.48[ab]
1st person narrative	166	11.4%	31.3%	13.3%	22.3%	11.4%	6.0%	4.2%	3.26[b]
	χ^2=58.702 n.s.; Cramer's V = 0.069								F=2.041* η=0.095

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

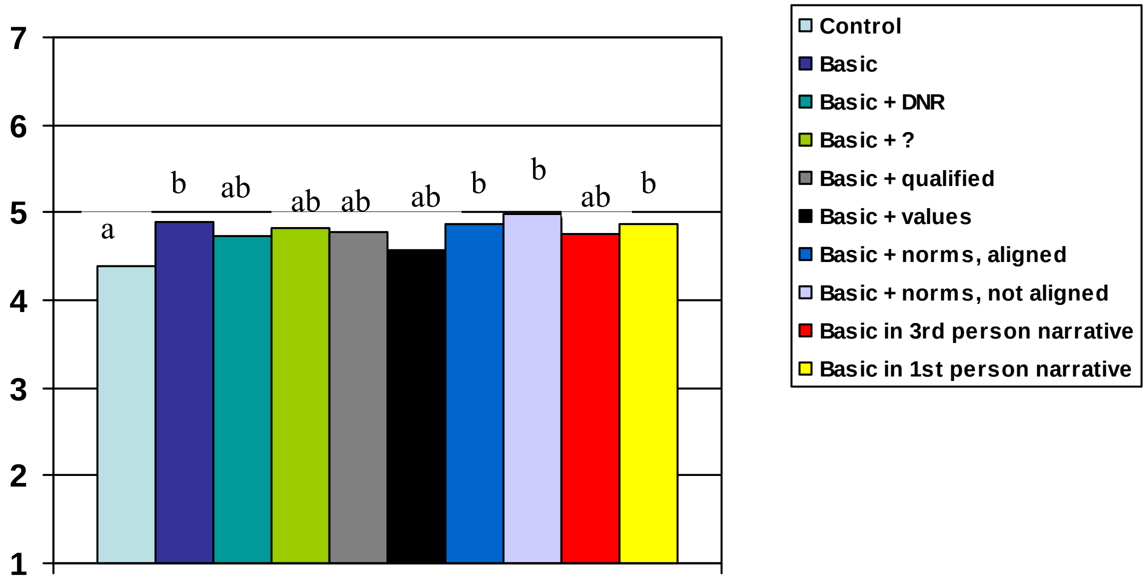
Table 1-6: The message conveyed the key information in a straightforward way.

	N	Extremely disagree	Quite disagree	Slightly disagree	Neutral	Slightly agree	Quite agree	Extremely agree	Mean
Control	514	5.8%	8.4%	8.9%	17.1%	20.6%	30.2%	8.9%	4.65[ab]
Basic	160	5.0%	5.6%	7.5%	10.6%	16.3%	37.5%	17.5%	5.10[ab]
DNR declaration	176	7.4%	3.4%	8.0%	14.8%	16.5%	36.9%	13.1%	4.93[ab]
Concession question	160	3.1%	7.5%	5.6%	13.1%	21.3%	38.8%	10.6%	5.01[ab]
Qualifier	159	2.5%	7.5%	8.8%	13.8%	13.8%	40.3%	13.2%	5.03[ab]
Value expressive	177	7.9%	5.6%	9.0%	13.6%	18.6%	31.1%	14.1%	4.79[ab]
Social adjustive – norms aligned	197	4.1%	7.1%	8.6%	11.7%	15.2%	39.1%	14.2%	5.01[ab]
Social adjustive – norms not aligned	162	1.9%	8.0%	6.8%	14.2%	23.5%	33.3%	12.3%	4.99[ab]
3rd person narrative	168	8.3%	6.5%	10.1%	14.3%	17.3%	33.9%	9.5%	4.65[ab]
1st person narrative	165	6.7%	6.1%	9.1%	10.3%	17.0%	38.8%	12.1%	4.90[ab]
	χ^2=59.671 n.s.; Cramer's V = 0.070								F=2.282* η=0.100

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 1: Message Quality

Figure 1-1: Scaled message quality by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=3.906, p<0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 2: Factual Versus Narrative Communication

Respondents agreed slightly that all treatment messages were (a) persuasive (Table 2-1), (b) conversational (Table 2-2), (c) fact-oriented (Table 2-3), (d) dramatic (Table 2-4), and (e) telling a story (Table 2-5). There were significant differences in the mean rating of narrative quality for all items. Through post-hoc analysis, we found that the control message was rated significantly less persuasive, conversational, fact-oriented, dramatic, and 'telling a story.'

Based on research conducted by Polyorat (2007), we constructed a scale to test the narrative manipulation of the messages, which included whether the message was dramatic, and 'telling a story.' Using this scale ($r = 0.490$), we found that the control message was perceived as having significantly lower narrative quality compared to all treatment messages. Unlike Polyorat (2007), there was no difference in our factual versus narrative messages in perception of narrative quality.

Section 2: Factual Versus Narrative Communication

Table 2-1: The message is NOT PERSUASIVE…PERSUASIVE

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	517	9.1%	14.3%	9.7%	24.0%	25.3%	14.3%	3.3%	3.98[a]
Basic	157	4.5%	7.0%	5.7%	11.5%	35.0%	29.9%	6.4%	4.81[b]
DNR declaration	181	9.4%	8.3%	9.9%	11.6%	26.5%	29.3%	5.0%	4.45[b]
Concession question	160	3.8%	10.0%	7.5%	13.1%	30.6%	30.0%	5.0%	4.67[b]
Qualifier	161	6.8%	6.8%	8.7%	8.7%	36.6%	24.2%	8.1%	4.66[b]
Value expressive	177	9.0%	9.6%	7.9%	17.5%	25.4%	23.2%	7.3%	4.40[ab]
Social adjustive – norms aligned	195	4.6%	6.7%	10.3%	9.7%	32.3%	27.7%	8.7%	4.76[b]
Social adjustive – norms not aligned	162	3.1%	6.2%	13.0%	10.5%	35.8%	27.2%	4.3%	4.69[b]
3rd person narrative	172	5.2%	8.1%	10.5%	14.5%	30.8%	26.7%	4.1%	4.54[b]
1st person narrative	168	3.0%	6.5%	11.3%	10.7%	29.8%	31.5%	7.1%	4.81[b]
	χ^2=149.226***; Cramer's V = 0.270								F=8.813*** η=0.193

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 2-2: The message is NOT CONVERSATIONAL…CONVERSATIONAL

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	515	4.9%	8.2%	9.5%	17.7%	24.1%	27.4%	8.3%	4.63[a]
Basic	158	4.4%	3.2%	7.0%	13.9%	25.9%	29.1%	16.5%	5.07[b]
DNR declaration	182	3.3%	7.1%	8.8%	14.8%	20.9%	30.2%	14.8%	4.93[ab]
Concession question	161	1.9%	6.2%	9.9%	13.7%	32.9%	28.0%	7.5%	4.83[ab]
Qualifier	160	1.9%	6.3%	9.4%	16.9%	28.8%	26.9%	10.0%	4.85[ab]
Value expressive	176	4.0%	8.0%	8.0%	13.6%	26.7%	26.7%	13.1%	4.84[ab]
Social adjustive – norms aligned	196	3.6%	5.1%	10.7%	19.9%	26.0%	25.0%	9.7%	4.73[ab]
Social adjustive – norms not aligned	162	1.9%	.6%	8.0%	14.8%	35.8%	26.5%	12.3%	5.11[b]
3rd person narrative	171	5.8%	3.5%	8.2%	21.6%	25.1%	26.3%	9.4%	4.73[ab]
1st person narrative	166	4.8%	4.2%	7.8%	15.7%	25.9%	31.3%	10.2%	4.89[ab]
	χ^2=65.337 n.s.; Cramer's V = 0.073								F=2.256* η=0.099

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 2: Factual Versus Narrative Communication

Table 2-3: The message is NOT FACT ORIENTED…FACT ORIENTED

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	518	16.6%	13.5%	11.2%	17.4%	20.8%	15.3%	5.2%	3.79[a]
Basic	158	8.2%	10.8%	6.3%	14.6%	19.6%	27.8%	12.7%	4.61[b]
DNR declaration	182	13.2%	11.5%	7.7%	14.3%	28.0%	19.2%	6.0%	4.14[ab]
Concession question	160	7.5%	10.6%	11.3%	12.5%	25.6%	24.4%	8.1%	4.44[b]
Qualifier	157	10.8%	12.7%	8.9%	12.7%	23.6%	21.7%	9.6%	4.29[ab]
Value expressive	174	12.1%	11.5%	8.6%	7.5%	23.0%	25.9%	11.5%	4.41[b]
Social adjustive – norms aligned	196	7.1%	12.8%	12.8%	12.2%	20.9%	25.5%	8.7%	4.38[b]
Social adjustive – norms not aligned	161	8.7%	3.1%	9.9%	11.8%	32.3%	26.7%	7.5%	4.66[b]
3rd person narrative	172	8.7%	12.2%	14.0%	15.7%	23.8%	18.6%	7.0%	4.17[ab]
1st person narrative	167	6.0%	10.8%	13.2%	18.0%	13.8%	31.7%	6.6%	4.44[b]
	χ^2=118.766***; Cramer's V = 0.098								F=6.165*** η=0.163

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 2-4: The message is NOT DRAMATIC…DRAMATIC

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	517	10.1%	16.4%	9.3%	41.0%	14.5%	7.2%	1.5%	3.61[a]
Basic	157	5.7%	6.4%	6.4%	22.9%	33.8%	16.6%	8.3%	4.55[b]
DNR declaration	181	4.4%	6.1%	8.8%	28.2%	28.7%	17.7%	6.1%	4.48[b]
Concession question	161	4.3%	2.5%	8.7%	26.7%	29.2%	20.5%	8.1%	4.68[b]
Qualifier	160	3.8%	2.5%	8.8%	34.4%	30.0%	13.8%	6.9%	4.53[b]
Value expressive	174	1.7%	9.2%	5.7%	29.3%	24.1%	20.1%	9.8%	4.64[b]
Social adjustive – norms aligned	198	3.5%	10.6%	9.1%	32.3%	23.7%	14.1%	6.6%	4.31[b]
Social adjustive – norms not aligned	161	1.2%	5.0%	6.2%	36.0%	32.3%	13.0%	6.2%	4.57[b]
3rd person narrative	171	2.9%	8.8%	13.5%	33.9%	24.6%	9.4%	7.0%	4.25[b]
1st person narrative	168	3.0%	5.4%	8.9%	20.8%	32.1%	22.0%	7.7%	4.71[b]
	χ^2=234.345***; Cramer's V = 0.138								F=19.668*** η=0.283

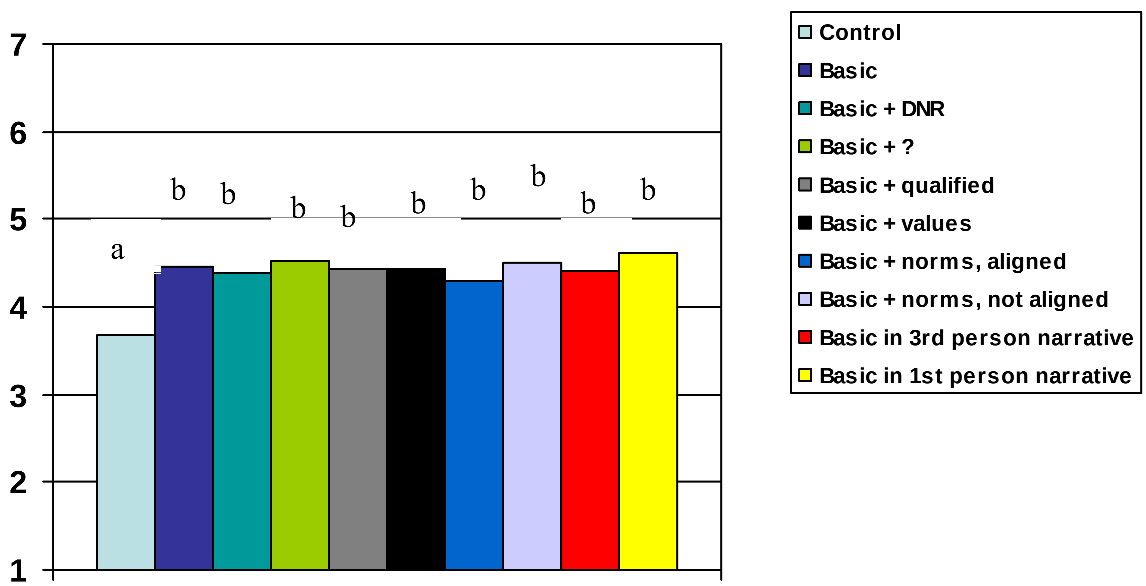
n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 2-5: The message is NOT TELLING A STORY…TELLING A STORY

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	519	11.0%	15.4%	10.8%	27.6%	23.7%	9.2%	2.3%	3.75[a]
Basic	158	8.2%	7.0%	8.9%	24.1%	28.5%	16.5%	7.0%	4.35[b]
DNR declaration	183	8.7%	9.8%	7.7%	22.4%	25.7%	20.2%	5.5%	4.29[b]
Concession question	161	6.8%	9.3%	8.1%	23.0%	25.5%	21.1%	6.2%	4.39[b]
Qualifier	159	5.0%	11.9%	7.5%	26.4%	27.0%	14.5%	7.5%	4.32[b]
Value expressive	176	8.0%	9.1%	8.5%	25.0%	26.7%	17.6%	5.1%	4.27[b]
Social adjustive – norms aligned	196	6.6%	11.2%	10.7%	24.0%	21.9%	17.9%	7.7%	4.28[b]
Social adjustive – norms not aligned	161	4.3%	4.3%	8.1%	32.3%	32.3%	14.3%	4.3%	4.44[b]
3rd person narrative	172	7.0%	4.1%	10.5%	19.8%	28.5%	23.3%	7.0%	4.56[b]
1st person narrative	167	3.0%	9.6%	10.8%	19.8%	28.1%	21.6%	7.2%	4.54[b]
	χ^2=109.031***.; Cramer's V = 0.094								F=7.794*** η=0.182

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure 2-1: Scaled message narrative



Notes: 1=non-narrative, 7=extremely narrative
F=16.277, p<0.001
Letters a, ab, b indicate significant differences in SNK post-hoc test.

Section 3: Message Involvement

Five questions were asked to evaluate respondents' involvement with the messages. Respondents agreed slightly that all messages were (a) conveyed clearly (Table 3-1), (b) easy to understand (Table 3-2), (c) interesting (Table 3-3), (d) involving (Table 3-4), and (e) credible (Table 3-5). There were significant differences in the mean rating all items used to measure message involvement. Through post-hoc analysis, we found that the control message was found to be conveyed less clearly, less easy to understand, less interesting, less involving, and less credible.

Based on research conducted by Paracchio and Levy (1997) and Polyorat (2007), we constructed a scale to test message involvement ($\alpha = 0.862$). This scale included all five items. Using this scale we found that the control message was perceived as having significantly lower message involvement compared to all treatment messages. The basic factual message, two social-adjustive treatment messages, and the first-person narrative message were rated to have greater message involvement.

Section 3: Message Involvement

Table 3-1: The information in the message is: NOT CONVEYED CLEARLY…CONVEYED CLEARLY

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	516	6.8%	7.8%	11.2%	14.7%	24.0%	27.9%	7.6%	4.55[a]
Basic	157	3.8%	5.1%	6.4%	9.6%	21.7%	35.0%	18.5%	5.19[b]
DNR declaration	180	6.7%	9.4%	10.0%	6.7%	18.3%	38.9%	10.0%	4.77[ab]
Concession question	158	2.5%	7.6%	12.7%	11.4%	21.5%	36.7%	7.6%	4.82[ab]
Qualifier	161	3.1%	6.2%	9.3%	10.6%	21.1%	36.6%	13.0%	5.02[b]
Value expressive	174	5.7%	6.9%	6.9%	13.2%	23.0%	29.9%	14.4%	4.88[ab]
Social adjustive – norms aligned	195	3.1%	5.6%	4.6%	12.8%	20.0%	41.5%	12.3%	5.15[b]
Social adjustive – norms not aligned	159	3.8%	2.5%	5.7%	14.5%	23.3%	42.1%	8.2%	5.10[b]
3rd person narrative	173	5.8%	8.1%	8.1%	13.9%	17.3%	38.7%	8.1%	4.77[ab]
1st person narrative	168	1.8%	6.5%	10.7%	8.3%	26.2%	35.1%	11.3%	5.01[b]
	χ^2= 90.940**; Cramer's V = 0.086								F=4.421***; η=0.139

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 3-2: The information in the message is: DIFFICULT TO UNDERSTAND…EASY TO UNDERSTAND

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	516	4.3%	3.1%	8.3%	20.2%	15.9%	35.9%	12.4%	4.97[b]
Basic	157	1.3%	3.2%	3.2%	12.1%	12.1%	36.9%	31.2%	5.66[b]
DNR declaration	181	3.3%	3.3%	5.0%	12.7%	14.9%	41.4%	19.3%	5.34[ab]
Concession question	158	2.5%	4.4%	8.2%	14.6%	15.2%	40.5%	14.6%	5.15[ab]
Qualifier	159	.6%	3.1%	5.7%	15.7%	13.8%	40.3%	20.8%	5.43[b]
Value expressive	177	1.7%	4.5%	5.1%	18.6%	12.4%	35.6%	22.0%	5.31[ab]
Social adjustive – norms aligned	197	.5%	3.0%	5.1%	17.8%	9.6%	41.6%	22.3%	5.47[b]
Social adjustive – norms not aligned	160	.6%	3.1%	7.5%	16.9%	13.1%	40.0%	18.8%	5.34[ab]
3rd person narrative	173	1.7%	2.9%	5.2%	19.7%	11.0%	42.2%	17.3%	5.31[ab]
1st person narrative	168	3.0%	4.2%	6.0%	17.3%	12.5%	34.5%	22.6%	5.26[ab]
	χ^2=77.027*; Cramer's V = 0.079								F=4.436***; η=0.139

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 3: Message Involvement

Table 3-3: The information in the message is: NOT INTERESTING…INTERESTING

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	515	4.1%	6.6%	10.7%	16.9%	26.2%	26.8%	8.7%	4.70[a]
Basic	156	3.2%	3.2%	4.5%	12.8%	26.3%	34.0%	16.0%	5.22[b]
DNR declaration	181	2.8%	4.4%	9.4%	13.8%	24.9%	30.4%	14.4%	5.02[ab]
Concession question	158	3.8%	8.2%	4.4%	17.1%	25.9%	31.6%	8.9%	4.84[ab]
Qualifier	159	2.5%	3.8%	6.9%	20.1%	22.0%	32.7%	11.9%	5.01[ab]
Value expressive	173	2.9%	5.2%	7.5%	14.5%	28.3%	22.5%	19.1%	5.04[ab]
Social adjustive – norms aligned	197	3.6%	4.6%	4.1%	21.8%	20.3%	34.5%	11.2%	4.99[ab]
Social adjustive – norms not aligned	161	3.1%	2.5%	7.5%	14.9%	28.0%	31.7%	12.4%	5.07[ab]
3rd person narrative	173	3.5%	5.2%	8.1%	20.8%	27.7%	27.2%	7.5%	4.76[ab]
1st person narrative	167	3.0%	4.2%	8.4%	16.8%	25.7%	29.3%	12.6%	4.96[ab]
	χ^2=66.665 n.s.; Cramer's V = 0.074								F=2.767** η=0.110

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 3-4: The information in the message is: NOT INVOLVING…INVOLVING

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	515	5.6%	9.5%	9.9%	27.8%	23.3%	17.7%	6.2%	4.31[a]
Basic	157	3.8%	3.8%	4.5%	21.7%	29.9%	24.2%	12.1%	4.91[ab]
DNR declaration	182	4.9%	4.4%	7.7%	19.8%	25.3%	28.6%	9.3%	4.79[ab]
Concession question	158	4.4%	5.1%	7.6%	26.6%	23.4%	27.8%	5.1%	4.63[b]
Qualifier	160	2.5%	4.4%	10.6%	26.3%	23.1%	26.9%	6.3%	4.69[b]
Value expressive	174	3.4%	5.7%	6.9%	26.4%	28.2%	19.0%	10.3%	4.68[b]
Social adjustive – norms aligned	197	3.0%	3.6%	7.6%	27.4%	24.9%	26.9%	6.6%	4.75[ab]
Social adjustive – norms not aligned	159	1.3%	4.4%	6.3%	27.0%	30.2%	22.6%	8.2%	4.81[ab]
3rd person narrative	172	2.9%	4.1%	8.7%	25.6%	25.0%	27.9%	5.8%	4.73[ab]
1st person narrative	168	2.4%	4.2%	11.3%	20.2%	31.0%	24.4%	6.5%	4.73[ab]
	χ^2=77.719*; Cramer's V = 0.080								F=4.286***; η=0.136

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

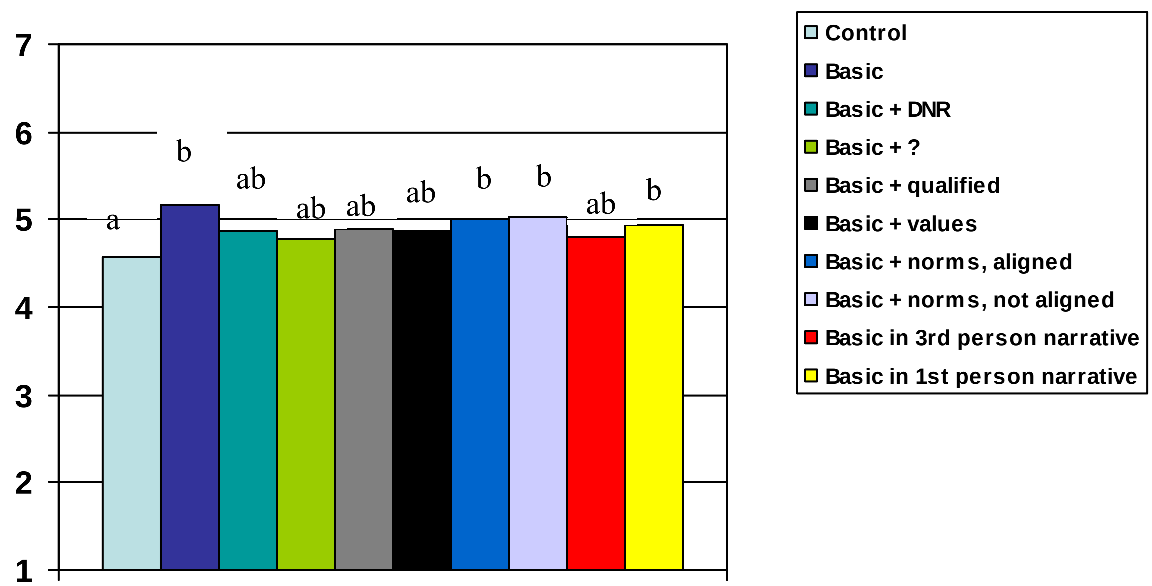
Section 3: Message Involvement

Table 3-5: The information in the message is: NOT CREDIBLE…CREDIBLE

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	516	10.1%	8.9%	8.9%	20.2%	22.1%	23.3%	6.6%	4.31[a]
Basic	158	8.9%	8.2%	5.7%	10.8%	22.2%	25.9%	18.4%	4.80[ab]
DNR declaration	181	9.4%	9.4%	12.7%	13.3%	20.4%	24.3%	10.5%	4.41[ab]
Concession question	158	7.6%	8.2%	8.9%	20.3%	18.4%	30.4%	6.3%	4.50[ab]
Qualifier	160	8.1%	13.8%	8.8%	17.5%	18.8%	26.3%	6.9%	4.31[ab]
Value expressive	173	11.0%	8.7%	6.9%	15.0%	16.8%	30.1%	11.6%	4.54[ab]
Social adjustive – norms aligned	196	7.7%	7.7%	7.7%	15.3%	22.4%	30.6%	8.7%	4.64[ab]
Social adjustive – norms not aligned	159	3.8%	5.0%	9.4%	19.5%	21.4%	32.7%	8.2%	4.81[b]
3rd person narrative	172	11.6%	4.7%	8.7%	20.9%	20.3%	26.7%	7.0%	4.42[ab]
1st person narrative	167	7.8%	6.6%	12.0%	10.8%	22.8%	26.3%	13.8%	4.68[ab]
	χ^2=81.747**; Cramer's V = 0.082								F=2.362* η=0.102

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure 3-1: Scaled message involvement



Notes: 1=non-narrative, 7=extremely narrative
F=5.055, p<0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 4: Message Evaluation

Six questions were asked to measure respondents' evaluation of a ban on lead shot in the farmland zone of Minnesota. On average, respondents agreed just slightly that a ban was: (a) beneficial (Table 4-1), (b) good (Table 4-2), (c) wise (Table 4-3), (d) worthwhile (Table 4-4), (e) appealing (Table 4-5) and (f) important (Table 4-6). There were significant differences in the mean rating all items used to measure message involvement. Through post-hoc analysis, we found that respondents who received the control message felt that a ban would be less beneficial, good, wise, worthwhile, appealing and important.

We constructed a scale, including the six items described, to test the overall evaluation of a ban on lead shot in the farmland zone ($\alpha = 0.977$). Using this scale we found that respondents who received the control message had a lower evaluation of a ban compared to respondents who received the treatment messages. Respondents who received the basic factual message, the two normative treatment messages, and the two narrative messages rated a ban more positively.

Section 4: Message Evaluation

Table 4-1: A ban on lead shot in the farmland zone of Minnesota is: HARMFUL…BENEFICIAL

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	523	6.9%	7.1%	8.4%	25.8%	16.8%	22.6%	12.4%	4.56[a]
Basic	160	3.8%	6.3%	3.1%	16.9%	19.4%	25.6%	25.0%	5.19[b]
DNR declaration	183	8.2%	4.9%	7.1%	14.2%	19.7%	26.8%	19.1%	4.89[ab]
Concession question	161	6.8%	9.3%	5.0%	16.8%	19.3%	24.2%	18.6%	4.80[ab]
Qualifier	162	6.2%	6.8%	6.8%	16.7%	19.8%	24.1%	19.8%	4.88[ab]
Value expressive	177	5.6%	6.2%	6.2%	18.6%	19.8%	24.9%	18.6%	4.90[ab]
Social adjustive – norms aligned	198	4.5%	4.5%	7.1%	15.2%	17.7%	27.8%	23.2%	5.13[b]
Social adjustive – norms not aligned	162	4.9%	1.2%	8.0%	14.2%	21.6%	34.0%	16.0%	5.12[b]
3rd person narrative	173	7.5%	1.7%	3.5%	20.2%	21.4%	30.1%	15.6%	4.99[ab]
1st person narrative	168	6.5%	4.2%	4.8%	18.5%	16.7%	25.0%	24.4%	5.07[b]
	χ^2=86.534**; Cramer's V = 0.084								F=3.861***; η=0.129

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 4-2: A ban on lead shot in the farmland zone of Minnesota is: BAD…GOOD

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	522	9.8%	10.5%	10.7%	18.4%	16.3%	21.5%	12.8%	4.37[a]
Basic	160	6.9%	5.6%	3.8%	15.0%	19.4%	27.5%	21.9%	5.04[b]
DNR declaration	184	10.9%	8.2%	7.1%	12.5%	17.9%	22.8%	20.7%	4.70[ab]
Concession question	161	8.1%	7.5%	8.7%	15.5%	18.0%	24.8%	17.4%	4.72[ab]
Qualifier	161	8.1%	8.7%	5.0%	14.9%	19.3%	23.0%	21.1%	4.82[ab]
Value expressive	176	6.3%	9.1%	9.7%	16.5%	13.1%	26.1%	19.3%	4.77[ab]
Social adjustive – norms aligned	197	6.6%	7.1%	7.6%	14.2%	14.7%	28.9%	20.8%	4.93[b]
Social adjustive – norms not aligned	161	5.6%	2.5%	8.1%	14.3%	21.1%	28.6%	19.9%	5.08[b]
3rd person narrative	173	8.1%	2.9%	5.8%	20.2%	19.1%	29.5%	14.5%	4.86[b]
1st person narrative	168	7.7%	3.0%	8.3%	18.5%	15.5%	20.8%	26.2%	4.98[b]
	χ^2=82.015**; Cramer's V = 0.081								F=4.284***; η=0.136

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 4: Message Evaluation

Table 4-3: A ban on lead shot in the farmland zone of Minnesota is: FOOLISH…WISE

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	521	13.8%	9.4%	9.4%	17.1%	15.7%	21.1%	13.4%	4.29[a]
Basic	160	8.8%	5.6%	5.6%	14.4%	13.8%	25.6%	26.3%	5.01[b]
DNR declaration	184	13.6%	7.1%	4.9%	15.8%	16.3%	22.8%	19.6%	4.61[ab]
Concession question	161	10.6%	8.1%	8.7%	17.4%	13.0%	24.2%	18.0%	4.59[ab]
Qualifier	163	15.3%	6.1%	7.4%	9.2%	18.4%	22.7%	20.9%	4.61[ab]
Value expressive	178	10.1%	9.6%	5.1%	15.2%	14.6%	26.4%	19.1%	4.70[ab]
Social adjustive – norms aligned	196	11.7%	6.1%	6.1%	13.3%	12.8%	26.0%	24.0%	4.83[b]
Social adjustive – norms not aligned	162	5.6%	6.8%	8.0%	15.4%	14.2%	28.4%	21.6%	4.98[b]
3rd person narrative	173	10.4%	2.9%	4.6%	17.3%	21.4%	26.0%	17.3%	4.84[b]
1st person narrative	168	8.9%	5.4%	10.1%	18.5%	10.1%	20.8%	26.2%	4.83[b]
	χ^2=78.821*; Cramer's V = 0.080								F=3.711***; η=0.126

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Table 4-4: A ban on lead shot in the farmland zone of Minnesota is: NOT WORTHWHILE…WORTHWHILE

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	523	15.5%	10.5%	9.8%	12.4%	16.6%	22.0%	13.2%	4.23[a]
Basic	160	8.1%	6.3%	5.0%	12.5%	18.8%	23.8%	25.6%	5.01[b]
DNR declaration	184	13.6%	7.6%	8.7%	8.2%	17.9%	25.5%	18.5%	4.60[ab]
Concession question	161	14.9%	7.5%	6.8%	12.4%	15.5%	23.0%	19.9%	4.55[ab]
Qualifier	162	13.6%	10.5%	7.4%	6.2%	19.1%	23.5%	19.8%	4.56[ab]
Value expressive	176	10.8%	9.7%	5.7%	9.7%	17.0%	25.6%	21.6%	4.76[ab]
Social adjustive – norms aligned	197	10.7%	7.6%	6.6%	11.7%	15.2%	25.9%	22.3%	4.80[b]
Social adjustive – norms not aligned	162	6.2%	6.2%	6.2%	12.3%	19.1%	28.4%	21.6%	5.04[b]
3rd person narrative	173	10.4%	4.6%	7.5%	13.9%	19.7%	27.2%	16.8%	4.76[b]
1st person narrative	168	10.1%	7.7%	9.5%	11.3%	13.7%	19.0%	28.6%	4.82[b]
	χ^2=71.762 n.s.; Cramer's V = 0.076								F=4.357***; η=0.137

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 4: Message Evaluation

Table 4-5: A ban on lead shot in the farmland zone of Minnesota is: UNAPPEALING…APPEALING

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	520	15.0%	10.8%	13.3%	20.2%	13.1%	17.9%	9.8%	3.98^{a}
Basic	160	9.4%	5.6%	10.6%	18.8%	11.3%	23.8%	20.6%	4.71^{b}
DNR declaration	184	12.5%	9.8%	8.2%	16.3%	15.2%	22.8%	15.2%	4.41^{ab}
Concession question	160	13.1%	7.5%	8.8%	16.9%	18.8%	21.3%	13.8%	4.39^{ab}
Qualifier	163	11.7%	11.7%	9.2%	14.1%	16.6%	22.1%	14.7%	4.37^{ab}
Value expressive	176	12.5%	9.7%	9.1%	13.6%	18.2%	23.3%	13.6%	4.40^{ab}
Social adjustive – norms aligned	198	9.6%	7.6%	8.1%	19.7%	14.6%	23.7%	16.7%	4.60^{b}
Social adjustive – norms not aligned	162	5.6%	4.9%	10.5%	14.8%	22.2%	26.5%	15.4%	4.85^{b}
3rd person narrative	172	11.6%	4.1%	9.9%	22.7%	19.2%	22.7%	9.9%	4.41^{ab}
1st person narrative	167	6.0%	7.8%	11.4%	19.2%	12.0%	24.0%	19.8%	4.74^{b}
	χ^2=85.852**; Cramer's V = 0.083								F=5.156***; η=0.149

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

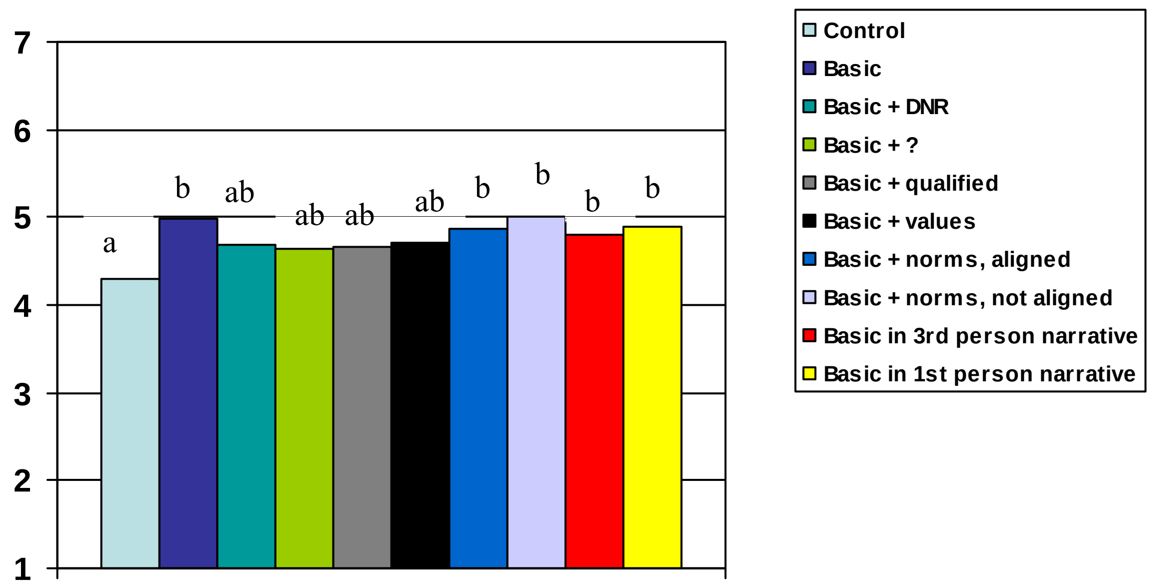
Table 4-6: A ban on lead shot in the farmland zone of Minnesota is: NOT IMPORTANT…IMPORTANT

	N	Extremely	Quite	Slightly	Neutral	Slightly	Quite	Extremely	Mean
Control	522	10.9%	9.6%	9.0%	16.9%	17.2%	22.6%	13.8%	4.43^{a}
Basic	160	9.4%	6.3%	5.6%	10.0%	16.3%	26.3%	26.3%	5.01^{b}
DNR declaration	184	9.2%	7.1%	6.0%	10.9%	19.6%	26.6%	20.7%	4.87^{ab}
Concession question	160	11.9%	6.3%	5.6%	13.8%	16.3%	25.0%	21.3%	4.76^{ab}
Qualifier	163	13.5%	7.4%	8.6%	8.6%	16.0%	26.4%	19.6%	4.64^{ab}
Value expressive	177	9.6%	10.7%	5.6%	9.6%	16.9%	25.4%	22.0%	4.78^{ab}
Social adjustive – norms aligned	196	9.2%	6.1%	7.7%	11.2%	17.9%	25.5%	22.4%	4.89^{ab}
Social adjustive – norms not aligned	161	4.3%	6.8%	6.8%	12.4%	21.1%	26.7%	21.7%	5.06^{b}
3rd person narrative	173	9.2%	6.4%	4.6%	12.1%	20.2%	26.6%	20.8%	4.91^{ab}
1st person narrative	168	8.3%	5.4%	8.9%	11.9%	16.7%	23.2%	25.6%	4.95^{ab}
	χ^2=59.337 n.s.; Cramer's V = 0.069								F=3.057** η=0.115

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 4: Message Evaluation

Figure 4-1: Scaled message evaluation by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=4.412, $p<0.001$
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 5: Agreement With Message Recommendations, Outcome Involvement, Behavioral Intentions

Four questions were asked to measure respondents' agreement with message recommendations (Tables 5-1 to 5-4), four questions were asked to measure respondents' outcome involvement (5-5 to 5-8), and five questions measured behavioral intentions (5-9 to 5-13).

We constructed three scales to measure overall agreement with message recommendations ($\alpha = 0.960$), outcome involvement ($\alpha = 0.618$), and behavioral intentions ($\alpha = 0.942$). Using these scales, we found that respondents who received the control message agreed less with the message recommendations, while respondents who received the basic factual and first-person narrative messages agreed more (Figure 5-1). We found no significant differences among the control and treatment groups in outcome involvement (Figure 5-2). However, respondents who received the basic factual, non-aligned social-adjustive, and first-person narrative messages reported stronger intentions to support a ban on lead shot in the farmland zone, while those who received the control message reported weaker intentions, compared to other treatment groups (Figure 5-3).

Section 5: Agreement With Message Recommendations

Table 5-1: I think that a ban on lead shot in the Minnesota farmland zone is a good idea.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	527	18.8%	14.6%	11.8%	6.6%	16.7%	19.4%	12.1%	3.94
Basic	163	10.4%	8.0%	6.7%	9.8%	19.0%	25.8%	20.2%	4.77
DNR declaration	182	15.9%	8.2%	11.0%	6.0%	16.5%	24.7%	17.6%	4.43
Concession question	165	15.8%	10.3%	8.5%	10.9%	10.9%	26.1%	17.6%	4.39
Qualifier	168	17.9%	8.9%	5.4%	3.6%	20.2%	25.0%	19.0%	4.51
Value expressive	182	16.5%	9.3%	7.1%	7.7%	16.5%	22.5%	20.3%	4.47
Social adjustive – norms aligned	202	14.4%	9.9%	6.9%	9.9%	14.4%	26.2%	18.3%	4.52
Social adjustive – norms not aligned	164	10.4%	11.0%	9.1%	9.8%	10.4%	31.7%	17.7%	4.65
3rd person narrative	175	13.7%	8.6%	5.7%	15.4%	17.1%	26.3%	13.1%	4.45
1st person narrative	167	10.2%	7.8%	7.2%	12.0%	13.2%	28.7%	21.0%	4.80
	χ^2=97.156***; Cramer's V = 0.088								F=4.532***; η=0.139

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-2: I support a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	526	20.2%	15.0%	10.1%	10.1%	13.5%	17.9%	13.3%	3.89
Basic	162	13.0%	6.8%	6.2%	17.9%	13.0%	22.2%	21.0%	4.62
DNR declaration	181	17.1%	8.3%	12.7%	8.8%	12.2%	22.1%	18.8%	4.32
Concession question	166	18.7%	10.8%	8.4%	10.2%	10.2%	24.7%	16.9%	4.24
Qualifier	168	18.5%	11.9%	1.8%	7.1%	17.3%	26.8%	16.7%	4.40
Value expressive	182	19.2%	9.3%	5.5%	11.5%	10.4%	25.8%	18.1%	4.35
Social adjustive – norms aligned	202	16.8%	7.4%	9.4%	6.9%	15.3%	25.7%	18.3%	4.47
Social adjustive – norms not aligned	164	12.8%	9.8%	10.4%	9.1%	11.6%	26.8%	19.5%	4.55
3rd person narrative	174	15.5%	10.3%	6.9%	13.8%	16.1%	24.1%	13.2%	4.30
1st person narrative	167	10.8%	10.2%	10.2%	9.0%	10.2%	26.9%	22.8%	4.69
	χ^2=91.965**; Cramer's V = 0.086								F=3.744***; η=0.126

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Agreement With Message Recommendations

Table 5-3: The Minnesota Department of Natural Resources should ban lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	527	22.0%	15.2%	10.2%	11.0%	12.1%	16.7%	12.7%	3.77
Basic	163	15.3%	8.0%	8.0%	15.3%	10.4%	22.7%	20.2%	4.47
DNR declaration	182	17.6%	9.3%	12.6%	8.8%	9.9%	23.6%	18.1%	4.27
Concession question	165	18.8%	11.5%	9.7%	7.9%	12.7%	21.8%	17.6%	4.20
Qualifier	168	20.8%	9.5%	4.2%	9.5%	15.5%	23.2%	17.3%	4.28
Value expressive	182	20.9%	9.9%	4.4%	10.4%	11.5%	23.6%	19.2%	4.30
Social adjustive – norms aligned	201	20.9%	8.5%	7.5%	9.5%	13.4%	22.4%	17.9%	4.25
Social adjustive – norms not aligned	162	13.0%	12.3%	8.6%	11.7%	9.9%	25.3%	19.1%	4.46
3rd person narrative	175	18.3%	9.7%	6.9%	16.0%	12.0%	24.6%	12.6%	4.18
1st person narrative	168	13.1%	10.7%	8.9%	8.3%	11.9%	24.4%	22.6%	4.59
	χ^2=74.667*; Cramer's V = 0.077								F=3.558*** η=0.123

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-4: I do not think there should be a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	524	14.1%	15.6%	13.9%	8.8%	13.0%	15.3%	19.3%	4.14
Basic	163	19.6%	20.2%	11.7%	14.1%	11.7%	10.4%	12.3%	3.58
DNR declaration	182	22.5%	19.2%	8.2%	12.1%	12.6%	11.5%	13.7%	3.63
Concession question	164	14.0%	30.5%	7.9%	11.0%	9.8%	9.8%	17.1%	3.70
Qualifier	168	21.4%	16.7%	11.9%	10.7%	8.9%	11.9%	18.5%	3.79
Value expressive	181	16.6%	26.0%	8.3%	13.3%	7.7%	7.7%	20.4%	3.75
Social adjustive – norms aligned	202	19.3%	23.3%	12.4%	9.9%	10.4%	10.4%	14.4%	3.57
Social adjustive – norms not aligned	162	24.1%	24.1%	7.4%	12.3%	8.6%	13.0%	10.5%	3.38
3rd person narrative	174	14.4%	23.0%	10.3%	17.8%	8.0%	10.9%	15.5%	3.77
1st person narrative	168	22.6%	23.8%	9.5%	10.1%	11.3%	12.5%	10.1%	3.42
	χ^2=91.380**; Cramer's V = 0.085								F=3.304** η=0.119

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Agreement With Message Recommendations

Table 5-5: Whether or not lead shot is banned in the Minnesota farmland zone is very important to me.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	526	3.6%	6.1%	4.0%	28.3%	22.1%	20.5%	15.4%	4.82
Basic	163	2.5%	4.3%	6.1%	30.1%	18.4%	20.2%	18.4%	4.92
DNR declaration	183	3.3%	3.3%	6.0%	28.4%	20.2%	21.3%	17.5%	4.93
Concession question	166	3.6%	5.4%	6.0%	27.7%	21.1%	19.9%	16.3%	4.82
Qualifier	168	2.4%	4.8%	5.4%	28.6%	20.2%	21.4%	17.3%	4.93
Value expressive	182	3.8%	4.9%	4.9%	30.2%	14.3%	23.6%	18.1%	4.90
Social adjustive – norms aligned	202	2.5%	4.0%	4.0%	26.2%	19.3%	24.3%	19.8%	5.08
Social adjustive – norms not aligned	164	1.8%	6.1%	4.3%	27.4%	20.1%	20.7%	19.5%	4.98
3rd person narrative	174	1.7%	4.0%	8.0%	36.8%	14.4%	19.0%	16.1%	4.79
1st person narrative	167	1.2%	9.0%	5.4%	26.3%	18.6%	23.4%	16.2%	4.87
	χ^2=37.148 n.s.; Cramer's V = 0.054								F=0.680 n.s. η=0.054

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-6: A ban on lead shot in the Minnesota farmland zone directly affects me.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	524	5.5%	8.0%	7.1%	18.9%	20.4%	19.3%	20.8%	4.82
Basic	162	10.5%	7.4%	4.9%	25.9%	14.8%	16.7%	19.8%	4.56
DNR declaration	183	4.4%	7.1%	11.5%	25.7%	19.1%	14.8%	17.5%	4.62
Concession question	165	3.6%	10.9%	6.1%	21.8%	20.6%	18.8%	18.2%	4.74
Qualifier	168	6.5%	6.0%	9.5%	22.0%	17.9%	19.6%	18.5%	4.71
Value expressive	182	5.5%	8.2%	5.5%	24.2%	15.9%	23.1%	17.6%	4.76
Social adjustive – norms aligned	202	5.0%	8.4%	5.4%	22.3%	19.3%	17.8%	21.8%	4.83
Social adjustive – norms not aligned	163	8.0%	5.5%	5.5%	28.2%	22.1%	17.2%	13.5%	4.56
3rd person narrative	174	9.8%	6.3%	8.6%	22.4%	14.4%	19.5%	19.0%	4.60
1st person narrative	168	4.2%	10.1%	4.8%	26.2%	17.3%	20.8%	16.7%	4.71
	χ^2=56.128 n.s.; Cramer's V = 0.067								F=0.733 n.s. η=0.056

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Agreement With Message Recommendations

Table 5-7: The outcome of the decision to ban lead shot in the farmland zone is not relevant to me.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	525	24.4%	22.9%	20.0%	16.2%	9.5%	4.6%	2.5%	2.87
Basic	163	25.2%	20.9%	17.2%	17.2%	8.6%	6.1%	4.9%	3.01
DNR declaration	183	23.5%	19.1%	20.2%	24.0%	7.1%	3.3%	2.7%	2.93
Concession question	165	15.8%	23.6%	23.6%	19.4%	8.5%	4.8%	4.2%	3.13
Qualifier	167	22.8%	24.6%	22.2%	15.0%	7.2%	4.8%	3.6%	2.88
Value expressive	182	18.1%	28.6%	15.9%	23.1%	7.1%	4.4%	2.7%	2.97
Social adjustive – norms aligned	202	23.3%	24.3%	21.8%	19.3%	5.4%	2.5%	3.5%	2.81
Social adjustive – norms not aligned	164	23.2%	17.7%	25.0%	17.7%	6.1%	6.7%	3.7%	3.01
3rd person narrative	174	21.8%	23.0%	17.8%	19.5%	5.7%	6.9%	5.2%	3.06
1st person narrative	168	20.2%	27.4%	17.3%	21.4%	6.5%	5.4%	1.8%	2.90
	χ^2=49.153 n.s.; Cramer's V = 0.063								F=0.724 n.s. η=0.056

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-8: The final decision regarding whether lead shot is banned in the Minnesota farmland zone or not will have an impact on my life.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	525	8.6%	13.5%	9.0%	26.3%	17.5%	14.5%	10.7%	4.17
Basic	163	10.4%	6.7%	11.7%	25.8%	17.8%	18.4%	9.2%	4.26
DNR declaration	183	8.7%	7.7%	12.0%	30.6%	18.0%	13.1%	9.8%	4.20
Concession question	166	7.2%	12.7%	7.2%	27.1%	27.1%	9.6%	9.0%	4.19
Qualifier	167	8.4%	12.0%	11.4%	26.3%	21.0%	10.8%	10.2%	4.13
Value expressive	182	9.3%	15.4%	7.7%	27.5%	14.8%	14.3%	11.0%	4.10
Social adjustive – norms aligned	202	10.9%	10.4%	9.9%	27.2%	14.4%	15.3%	11.9%	4.17
Social adjustive – norms not aligned	165	9.1%	7.9%	12.7%	27.9%	21.8%	15.2%	5.5%	4.13
3rd person narrative	174	12.6%	9.8%	10.3%	27.0%	17.2%	14.4%	8.6%	4.04
1st person narrative	167	9.0%	10.2%	13.8%	33.5%	16.8%	8.4%	8.4%	3.98
	χ^2=56.129 n.s.; Cramer's V = 0.067								F=0.397n.s. η=0.041

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Agreement With Message Recommendations

Table 5-9: Would you be likely or unlikely to support a ban on using lead shot to hunt small game in the farmland zone of Minnesota within the next 5 years?

	N	Extremely unlikely	Quite unlikely	Slightly unlikely	Neutral	Slightly likely	Quite likely	Extremely likely	Mean
Control	502	23.5%	13.3%	9.8%	7.2%	13.5%	18.1%	14.5%	3.86
Basic	157	12.7%	9.6%	8.3%	5.1%	15.3%	25.5%	23.6%	4.71
DNR declaration	181	21.0%	9.4%	9.9%	3.3%	11.0%	23.8%	21.5%	4.31
Concession question	157	18.5%	14.0%	7.0%	6.4%	10.8%	24.2%	19.1%	4.26
Qualifier	159	19.5%	10.7%	3.8%	6.9%	15.7%	27.0%	16.4%	4.35
Value expressive	172	20.9%	9.3%	6.4%	4.7%	12.2%	25.6%	20.9%	4.38
Social adjustive – norms aligned	193	16.6%	9.8%	5.7%	6.2%	14.5%	27.5%	19.7%	4.53
Social adjustive – norms not aligned	152	14.5%	8.6%	8.6%	8.6%	11.8%	28.3%	19.7%	4.59
3rd person narrative	167	17.4%	9.0%	7.8%	12.0%	12.0%	28.1%	13.8%	4.32
1st person narrative	164	13.4%	10.4%	7.3%	7.3%	14.6%	21.3%	25.6%	4.66
	χ^2= 73.372*; Cramer's V = 0.078								F=3.873***; η=0.131

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-10: I intend to support a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	525	22.9%	11.8%	7.6%	17.9%	13.3%	15.0%	11.4%	3.78
Basic	162	13.0%	9.9%	6.8%	20.4%	9.9%	21.6%	18.5%	4.43
DNR declaration	182	19.8%	8.2%	9.9%	16.5%	12.1%	17.0%	16.5%	4.10
Concession question	166	19.3%	12.0%	6.0%	18.1%	10.8%	22.9%	10.8%	4.01
Qualifier	166	19.9%	10.2%	3.6%	12.7%	21.1%	18.7%	13.9%	4.16
Value expressive	181	20.4%	9.9%	3.3%	20.4%	11.6%	20.4%	13.8%	4.09
Social adjustive – norms aligned	202	18.8%	9.9%	4.5%	18.8%	11.9%	23.3%	12.9%	4.16
Social adjustive – norms not aligned	164	13.4%	8.5%	9.1%	17.1%	10.4%	25.6%	15.9%	4.43
3rd person narrative	174	18.4%	6.9%	7.5%	22.4%	12.1%	24.1%	8.6%	4.10
1st person narrative	167	13.8%	9.6%	7.2%	15.6%	14.4%	24.0%	15.6%	4.41
	χ^2=74.427*; Cramer's V = 0.077								F=2.830** η=0.110

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 5: Agreement With Message Recommendations

Table 5-11: I believe I will oppose a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	520	18.8%	13.7%	10.8%	16.5%	9.8%	11.5%	18.8%	3.95
Basic	163	25.2%	14.1%	9.2%	20.9%	6.1%	11.7%	12.9%	3.55
DNR declaration	181	21.5%	15.5%	11.0%	12.2%	11.6%	7.7%	20.4%	3.82
Concession question	166	17.5%	22.3%	8.4%	16.3%	7.8%	10.8%	16.9%	3.75
Qualifier	164	18.9%	20.1%	9.8%	17.1%	2.4%	11.0%	20.7%	3.80
Value expressive	178	22.5%	19.1%	13.5%	14.6%	5.6%	8.4%	16.3%	3.52
Social adjustive – norms aligned	199	22.1%	21.6%	11.1%	14.1%	8.0%	10.1%	13.1%	3.47
Social adjustive – norms not aligned	161	19.3%	21.7%	6.8%	17.4%	11.8%	7.5%	15.5%	3.65
3rd person narrative	174	16.7%	19.5%	10.9%	21.3%	6.9%	6.9%	17.8%	3.74
1st person narrative	164	21.3%	24.4%	9.8%	14.6%	6.7%	9.1%	14.0%	3.45
	χ^2=65.473 n.s.; Cramer's V = 0.073								F=1.641 n.s. η=0.084

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 5-12: I plan to oppose a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	520	20.2%	16.5%	8.5%	19.0%	9.2%	9.0%	17.5%	3.78
Basic	162	26.5%	16.7%	8.0%	22.2%	8.0%	6.2%	12.3%	3.36
DNR declaration	180	25.0%	14.4%	8.9%	20.0%	6.7%	6.1%	18.9%	3.63
Concession question	165	18.2%	26.1%	6.1%	20.0%	7.3%	7.3%	15.2%	3.55
Qualifier	166	20.5%	22.9%	7.2%	17.5%	3.6%	9.0%	19.3%	3.65
Value expressive	181	24.3%	22.1%	7.2%	17.7%	4.4%	9.4%	14.9%	3.44
Social adjustive – norms aligned	201	24.4%	19.9%	8.5%	17.4%	8.5%	7.0%	14.4%	3.44
Social adjustive – norms not aligned	164	22.6%	21.3%	9.8%	17.7%	9.8%	6.1%	12.8%	3.40
3rd person narrative	172	20.3%	20.3%	12.2%	18.6%	5.8%	5.2%	17.4%	3.55
1st person narrative	166	24.7%	25.3%	8.4%	18.1%	6.0%	7.8%	9.6%	3.17
	χ^2=52.589 n.s.; Cramer's V = 0.065								F=1.664 n.s. η=0.085

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

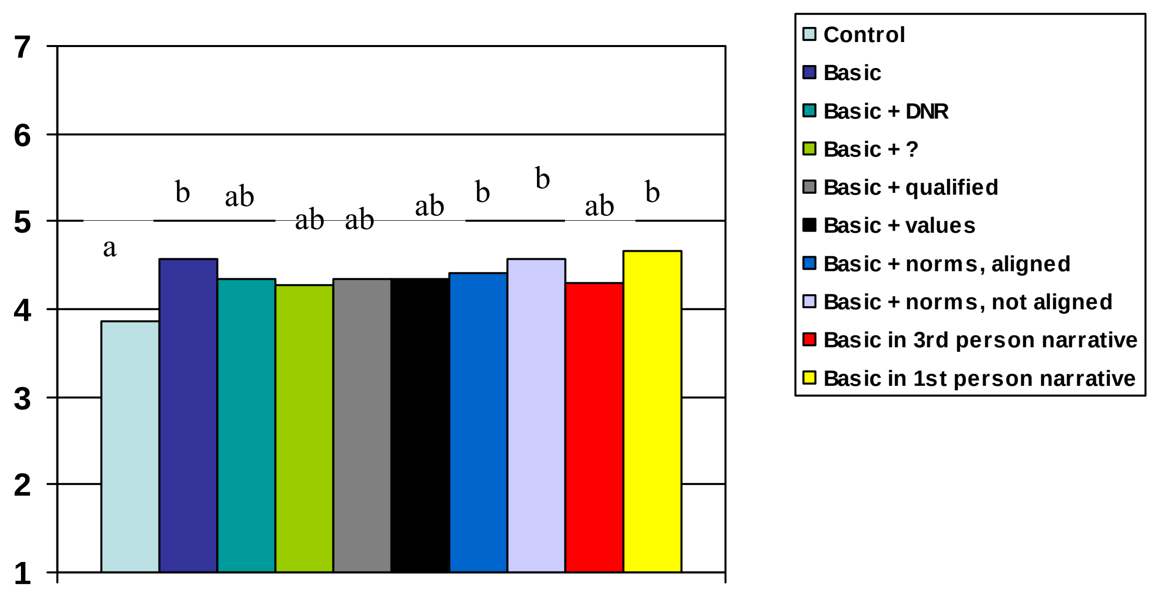
Section 5: Agreement With Message Recommendations

Table 5-13: I will support a ban on lead shot in the Minnesota farmland zone.

	N	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely agree	Mean
Control	527	21.4%	13.7%	8.0%	17.3%	12.0%	15.2%	12.5%	3.80
Basic	162	14.8%	8.0%	9.9%	17.3%	10.5%	21.0%	18.5%	4.38
DNR declaration	183	16.9%	6.6%	10.4%	17.5%	13.1%	17.5%	18.0%	4.28
Concession question	166	21.1%	9.0%	7.2%	15.7%	10.2%	24.1%	12.7%	4.08
Qualifier	168	19.0%	10.7%	3.0%	14.9%	18.5%	17.9%	16.1%	4.21
Value expressive	182	18.7%	10.4%	5.5%	16.5%	10.4%	20.9%	17.6%	4.23
Social adjustive – norms aligned	202	19.3%	6.4%	6.4%	14.4%	13.9%	23.3%	16.3%	4.32
Social adjustive – norms not aligned	165	12.1%	9.7%	9.1%	17.0%	9.7%	24.2%	18.2%	4.48
3rd person narrative	175	20.0%	8.0%	8.0%	20.6%	9.1%	23.4%	10.9%	4.05
1st person narrative	167	12.6%	10.8%	9.0%	13.8%	12.0%	24.6%	17.4%	4.45
	χ^2=72.335*; Cramer's V = 0.076								F=3.002** η=0.113

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

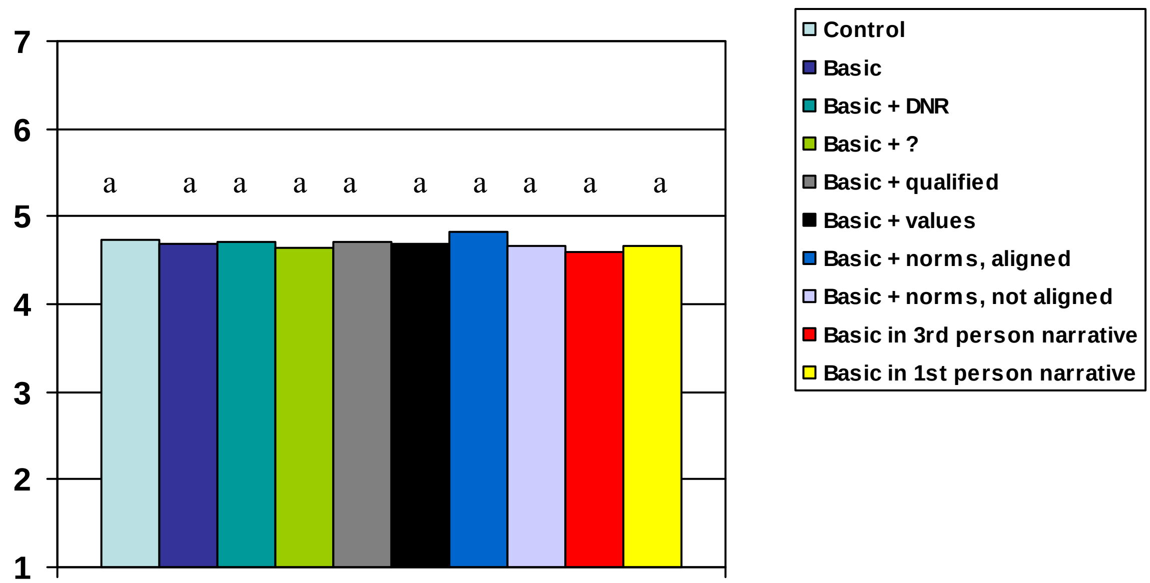
Figure 5-1: Scaled agreement with message recommendations by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=4.112, p<0.001, η=0.132
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

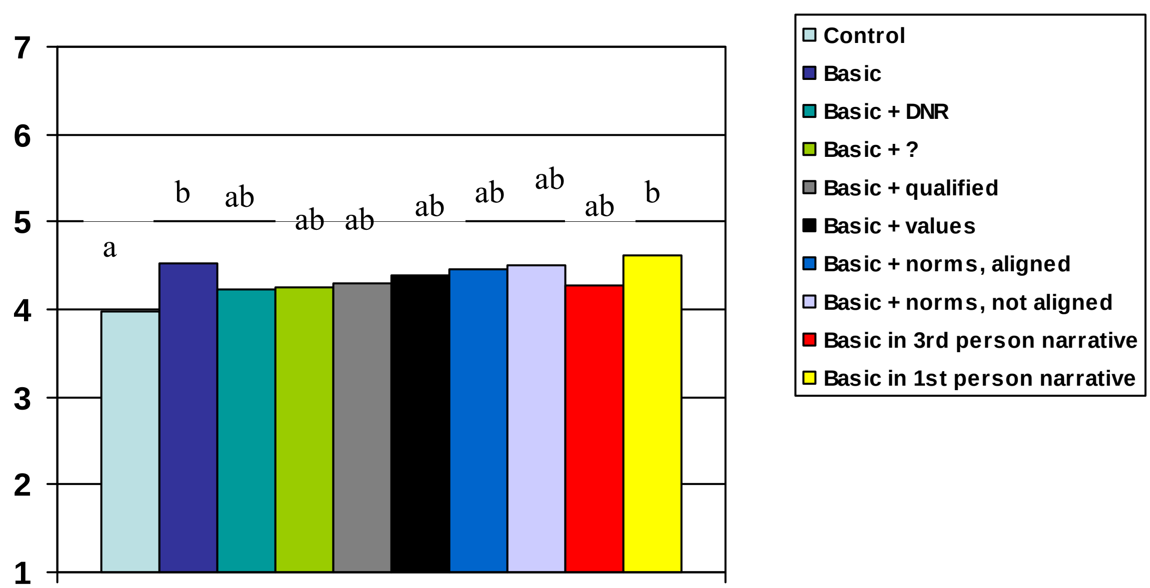
Section 5: Agreement With Message Recommendations

Figure 5-2: Scaled outcome involvement by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.574, n.s., η=0.050
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Figure 5-3: Scaled behavioral intentions by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=2.691, p<0.01, η=0.107
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 6: Values

Survey recipients were asked to respond to nine items derived from Hullett and Boster (2001) addressing values related to conformity and self direction. Three items addressed conformity (Tables 6-1 to 6-3), and six items addressed self direction (Tables 6-4 to 6-9). On average, respondents rated all of the items quite important.

We constructed two scales to measure the importance of conformity ($\alpha = 0.946$) and self-direction ($\alpha = 0.954$). We found no significant differences among the control and treatment groups in the importance of conformity (Figure 6-1) or self-direction (Figure 6-2) values. Unlike Hullett and Boster (2001), we did not find significant relationships between self-direction values and message quality for the values-expressive message, nor conformity values and message quality for the social adjustive message with norms aligned. We found significant positive relationships between both self-direction values ($r = 0.234^{**}$) and conformity values ($r = 0.262^{**}$) with the message quality for the social adjustive messages with non-aligned norms.

Section 6: Values

Table 6-1: How important is the following value to you: politeness (being courteous, having good manners)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	527	2.5%	1.3%	0.6%	0.4%	3.6%	44.8%	46.9%	6.23
Basic	161	1.9%	0.6%	0.0%	0.0%	5.0%	40.4%	52.2%	6.35
DNR declaration	182	1.1%	1.1%	0.0%	1.6%	4.9%	45.6%	45.6%	6.27
Concession question	166	1.2%	4.8%	0.6%	1.2%	5.4%	41.0%	45.8%	6.11
Qualifier	164	0.0%	1.8%	0.0%	1.8%	3.7%	46.3%	46.3%	6.32
Value expressive	182	1.6%	2.2%	0.5%	1.6%	2.7%	38.5%	52.7%	6.28
Social adjustive – norms aligned	202	2.0%	0.5%	0.5%	1.5%	4.5%	41.6%	49.5%	6.29
Social adjustive – norms not aligned	163	1.8%	1.8%	1.8%	1.2%	4.3%	41.1%	47.9%	6.19
3rd person narrative	174	1.1%	0.6%	0.0%	4.0%	1.1%	48.9%	44.3%	6.27
1st person narrative	167	0.6%	3.6%	0.6%	0.0%	5.4%	41.9%	47.9%	6.23
	χ^2=68.520 n.s.; Cramer's V = 0.074								F=0.660 n.s.; η=0.053

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 6-2: How important is the following value to you: Honoring of parents and elders (showing respect)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	527	2.7%	0.8%	0.2%	0.2%	3.0%	35.9%	57.3%	6.37
Basic	161	1.9%	0.6%	0.0%	0.6%	1.9%	32.3%	62.7%	6.48
DNR declaration	181	1.1%	1.1%	0.0%	0.6%	6.1%	39.2%	51.9%	6.35
Concession question	166	3.6%	2.4%	0.0%	1.8%	5.4%	26.5%	60.2%	6.23
Qualifier	165	0.6%	1.2%	0.0%	2.4%	2.4%	31.5%	61.8%	6.47
Value expressive	182	3.3%	0.5%	0.5%	0.5%	3.8%	29.1%	62.1%	6.37
Social adjustive – norms aligned	202	2.5%	0.0%	0.0%	1.5%	3.5%	34.2%	58.4%	6.40
Social adjustive – norms not aligned	165	2.4%	1.8%	1.2%	2.4%	1.8%	33.9%	56.4%	6.27
3rd person narrative	175	1.1%	1.1%	0.0%	3.4%	2.3%	34.9%	57.1%	6.38
1st person narrative	167	2.4%	1.8%	0.0%	0.0%	5.4%	26.9%	63.5%	6.39
	χ^2=71.912 n.s.; Cramer's V = 0.076								F=0.738 n.s.; η=0.056

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 6: Values

Table 6-3: How important is the following value to you: Obedience (being dutiful, meeting obligations)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	525	2.1%	1.1%	0.0%	1.0%	5.0%	41.7%	49.1%	6.27
Basic	160	1.3%	1.3%	0.0%	0.6%	5.6%	40.0%	51.3%	6.33
DNR declaration	182	1.1%	1.1%	0.0%	1.6%	8.8%	46.7%	40.7%	6.19
Concession question	165	1.2%	5.5%	0.0%	2.4%	8.5%	37.0%	45.5%	6.04
Qualifier	164	0.0%	1.8%	0.0%	4.3%	9.1%	40.9%	43.9%	6.19
Value expressive	181	2.2%	2.2%	0.0%	1.1%	5.5%	33.1%	55.8%	6.28
Social adjustive – norms aligned	201	2.5%	0.5%	0.0%	3.5%	6.0%	42.8%	44.8%	6.17
Social adjustive – norms not aligned	165	1.2%	3.6%	1.8%	3.6%	4.2%	41.2%	44.2%	6.07
3rd person narrative	175	1.1%	0.6%	0.6%	4.6%	4.6%	46.9%	41.7%	6.18
1st person narrative	166	1.2%	2.4%	0.6%	0.6%	3.6%	39.2%	52.4%	6.30
	χ^2=96.109***; Cramer's V = 0.088								F=1.338 n.s.; η=0.076

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 6-4: How important is the following value to you: Freedom (freedom of action and thought)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	524	2.5%	0.8%	0.0%	0.8%	4.4%	26.5%	65.1%	6.44
Basic	160	1.3%	1.3%	0.0%	1.9%	1.9%	30.6%	63.1%	6.46
DNR declaration	181	1.7%	0.0%	0.6%	1.7%	5.0%	27.1%	64.1%	6.46
Concession question	165	3.0%	1.8%	1.2%	1.2%	1.8%	27.9%	63.0%	6.33
Qualifier	164	0.6%	1.2%	0.0%	3.0%	3.0%	32.3%	59.8%	6.43
Value expressive	182	2.2%	1.6%	0.5%	1.1%	3.3%	22.5%	68.7%	6.44
Social adjustive – norms aligned	201	2.5%	0.5%	0.0%	2.0%	3.0%	25.9%	66.2%	6.45
Social adjustive – norms not aligned	164	2.4%	1.8%	0.6%	1.8%	3.0%	23.2%	67.1%	6.39
3rd person narrative	175	1.1%	0.6%	0.6%	4.6%	5.7%	31.4%	56.0%	6.31
1st person narrative	167	2.4%	1.8%	0.0%	0.0%	6.6%	25.7%	63.5%	6.38
	χ^2=58.681 n.s.; Cramer's V = 0.069								F=0.405 n.s.; η=0.042

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 6: Values

Table 6-5: How important is the following value to you: Self-respect (belief in one's own worth)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	522	2.3%	1.0%	0.0%	0.2%	3.4%	32.6%	60.5%	6.41
Basic	160	1.9%	0.6%	0.0%	0.6%	1.9%	30.6%	64.4%	6.49
DNR declaration	181	1.7%	0.0%	0.0%	1.1%	6.1%	34.3%	56.9%	6.40
Concession question	166	1.8%	4.2%	0.0%	1.8%	1.2%	28.3%	62.7%	6.32
Qualifier	164	1.2%	0.6%	0.6%	1.8%	4.3%	34.1%	57.3%	6.39
Value expressive	182	3.3%	1.1%	0.5%	1.6%	3.8%	25.3%	64.3%	6.35
Social adjustive – norms aligned	202	2.0%	0.5%	0.0%	2.0%	4.0%	33.7%	57.9%	6.38
Social adjustive – norms not aligned	162	2.5%	1.2%	1.9%	1.2%	3.7%	31.5%	58.0%	6.29
3rd person narrative	175	1.1%	0.6%	0.0%	5.1%	4.0%	32.0%	57.1%	6.35
1st person narrative	167	2.4%	1.8%	0.0%	0.0%	6.0%	32.3%	57.5%	6.32
	χ^2=89.465**; Cramer's V = 0.085								F=0.493 n.s.; η=0.046

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 6-6: How important is the following value to you: Creativity (uniqueness, imagination)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	525	1.9%	1.3%	0.8%	3.2%	16.6%	43.2%	33.0%	5.93
Basic	161	0.6%	1.9%	0.6%	3.1%	12.4%	45.3%	36.0%	6.05
DNR declaration	182	1.6%	0.0%	1.6%	3.8%	15.4%	41.2%	36.3%	6.00
Concession question	165	1.2%	4.8%	1.2%	5.5%	11.5%	37.0%	38.8%	5.87
Qualifier	165	0.6%	1.2%	1.2%	4.8%	15.8%	39.4%	37.0%	6.00
Value expressive	181	1.7%	1.7%	1.1%	6.6%	12.7%	32.6%	43.6%	5.99
Social adjustive – norms aligned	202	2.5%	0.0%	0.5%	5.0%	15.8%	42.6%	33.7%	5.94
Social adjustive – norms not aligned	163	0.6%	3.7%	1.8%	3.7%	24.5%	32.5%	33.1%	5.78
3rd person narrative	175	0.0%	1.1%	1.1%	7.4%	17.7%	43.4%	29.1%	5.89
1st person narrative	166	1.2%	3.0%	0.6%	3.0%	9.6%	45.2%	37.3%	6.02
	χ^2=76.670*; Cramer's V = 0.078								F=0.823 n.s.; η=0.060

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 6: Values

Table 6-7: How important is the following value to you: Independence (being self-reliant, self-sufficient)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	526	2.3%	1.1%	0.0%	1.1%	6.3%	35.7%	53.4%	6.29
Basic	161	1.9%	0.6%	0.0%	0.6%	3.7%	38.5%	54.7%	6.38
DNR declaration	182	1.6%	0.0%	0.0%	2.7%	7.7%	35.7%	52.2%	6.31
Concession question	166	3.0%	1.8%	0.6%	1.8%	3.6%	34.3%	54.8%	6.23
Qualifier	165	0.6%	1.2%	0.0%	3.6%	7.9%	38.2%	48.5%	6.25
Value expressive	181	2.2%	1.7%	0.0%	1.1%	7.2%	26.5%	61.3%	6.34
Social adjustive – norms aligned	202	2.0%	0.5%	0.0%	2.0%	7.4%	33.7%	54.5%	6.31
Social adjustive – norms not aligned	164	1.8%	2.4%	0.6%	1.8%	6.7%	37.8%	48.8%	6.18
3rd person narrative	175	0.6%	1.1%	0.0%	5.7%	5.1%	37.7%	49.7%	6.26
1st person narrative	167	2.4%	1.8%	0.0%	0.6%	6.0%	34.1%	55.1%	6.29
	χ^2=59.449 n.s.; Cramer's V = 0.069								F=0.426 n.s.; η=0.043

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 6-8: How important is the following value to you: Choosing own goals (selecting own purposes)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	524	2.1%	1.1%	0.2%	1.1%	6.3%	37.0%	52.1%	6.28
Basic	161	1.9%	.6%	0.0%	1.2%	5.6%	41.6%	49.1%	6.29
DNR declaration	182	1.6%	0.0%	0.5%	1.1%	7.7%	45.1%	44.0%	6.24
Concession question	166	2.4%	2.4%	0.6%	2.4%	4.2%	37.3%	50.6%	6.18
Qualifier	165	0.0%	1.8%	0.0%	2.4%	9.1%	40.0%	46.7%	6.25
Value expressive	182	2.2%	2.2%	0.0%	2.7%	6.6%	32.4%	53.8%	6.22
Social adjustive – norms aligned	202	2.5%	0.0%	0.0%	2.0%	5.9%	40.6%	49.0%	6.27
Social adjustive – norms not aligned	165	2.4%	1.2%	0.6%	2.4%	5.5%	39.4%	48.5%	6.19
3rd person narrative	175	0.6%	1.1%	0.0%	5.7%	6.9%	41.7%	44.0%	6.18
1st person narrative	167	2.4%	1.8%	0.0%	3.6%	3.6%	34.7%	53.9%	6.24
	χ^2=54.388 n.s.; Cramer's V = 0.066								F=0.260 n.s.; η=0.034

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

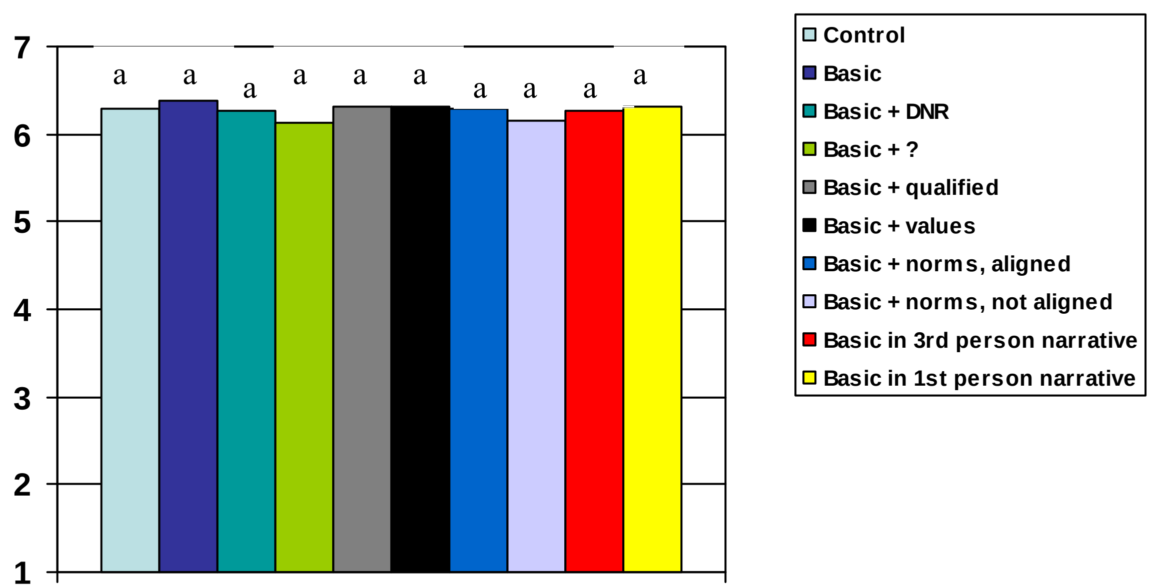
Section 6: Values

Table 6-9: How important is the following value to you: Curiosity (being interested in everything, exploring)

	N	Extremely Un-important	Quite Un-important	Slightly Un-important	Neutral	Slightly Important	Quite Important	Extremely important	Mean
Control	526	1.9%	1.5%	0.8%	2.9%	16.3%	43.3%	33.3%	5.93
Basic	161	0.6%	1.2%	0.6%	3.7%	16.1%	39.8%	37.9%	6.04
DNR declaration	182	1.1%	0.5%	2.2%	4.9%	17.0%	41.2%	33.0%	5.92
Concession question	166	0.6%	4.8%	1.8%	4.2%	17.5%	31.9%	39.2%	5.86
Qualifier	165	0.0%	2.4%	1.8%	4.8%	15.2%	42.4%	33.3%	5.93
Value expressive	182	2.2%	1.6%	1.1%	7.7%	10.4%	36.8%	40.1%	5.93
Social adjustive – norms aligned	202	1.5%	.5%	1.0%	4.5%	16.8%	40.1%	35.6%	5.98
Social adjustive – norms not aligned	165	1.2%	2.4%	1.8%	6.1%	19.4%	35.2%	33.9%	5.81
3rd person narrative	175	0.0%	1.1%	1.1%	8.0%	18.9%	39.4%	31.4%	5.89
1st person narrative	167	0.6%	3.6%	1.2%	3.6%	16.2%	35.3%	39.5%	5.95
	χ^2=60.413 n.s.; Cramer's V = 0.069								F=0.487 n.s. η=0.046

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

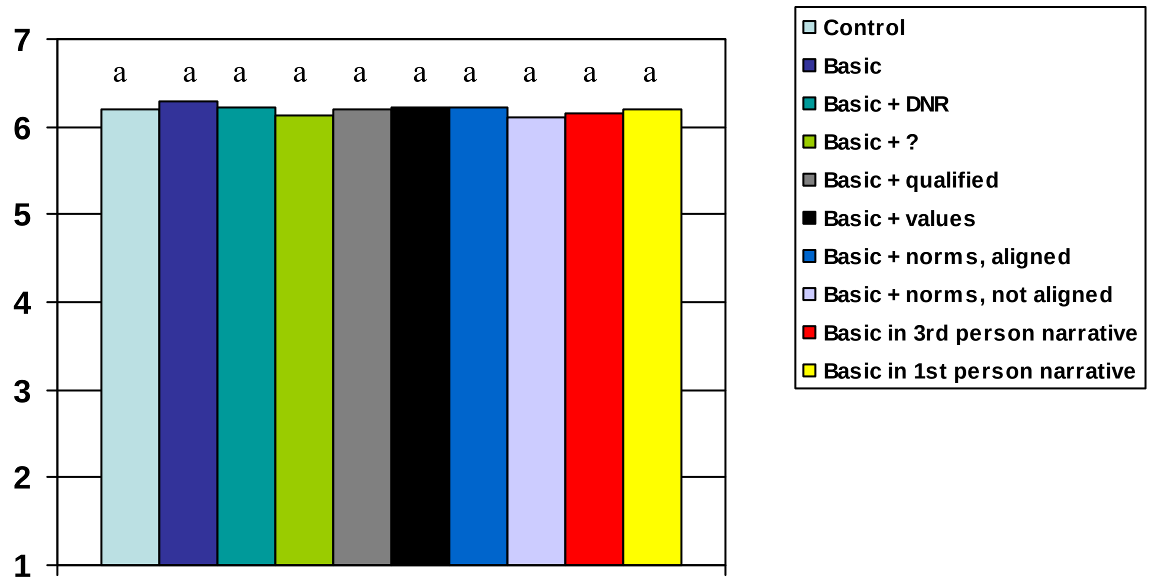
Figure 6-1: Scaled importance of conformity value by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.795, n.s., η=0.059
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 6: Values

Figure 6-2: Scaled importance of self-direction value by treatment.



Notes: 1=extremely low evaluation, 7=extremely high evaluation
F=0.437, n.s., η=0.043
Letters a, ab, b indicate significant differences in Games-Howell post-hoc test.

Section 7: Background Information

We gathered background information on the individuals who received the control and treatment messages. On average, respondents had been hunting for small game for 33.5 years. There were no significant differences among the control and treatment groups in the number of years hunting small game (Table 7-1). Similarly, there were no significant differences among the groups in the proportion of respondents who had hunted for small game in Minnesota in the past 5 years ($\bar{x} = 97.1\%$) (Table 7-2), nor in the proportion of respondents who had hunted for small game in the farmland zone in the past 5 years ($\bar{x} = 75.4\%$) (Table 7-3). Likewise, there were no significant differences among the groups in typical use of lead shot. About 60% of respondents used non-lead shot at least some of the time, compared to about 40% of respondents who always used lead shot (Table 7-4). Finally, there was no statistically significant difference in the age of respondents to the different treatments ($\bar{x} =$ 46 years) (Table 7-5).

Section 7: Background Information

Table 7-1: Years hunting small game

	N	Mean
Control	529	33.45
Basic	157	33.59
DNR declaration	178	34.09
Concession question	165	33.80
Qualifier	165	31.72
Value expressive	175	33.75
Social adjustive – norms aligned	200	32.20
Social adjustive – norms not aligned	164	34.13
3rd person narrative	172	33.83
1st person narrative	166	34.64
	$F=0.558$ n.s. $\eta=0.049$	

n.s. = not significant, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 7-2: Did you hunt for small game in Minnesota at anytime during the past 5 years?

	N	% Yes
Control	536	97.0%
Basic	162	97.5%
DNR declaration	183	97.8%
Concession question	167	97.6%
Qualifier	166	97.6%
Value expressive	180	97.8%
Social adjustive – norms aligned	202	97.0%
Social adjustive – norms not aligned	168	95.8%
3rd person narrative	175	96.0%
1st person narrative	169	96.4%
	$\chi^2=2.952$ n.s.; Cramer's V = 0.037	

n.s. = not significant, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Section 7: Background Information

Table 7-3: Did you hunt for small game in the farmland zone of Minnesota at anytime during the past 5 years?

	N	% Yes
Control	536	77.1%
Basic	161	72.0%
DNR declaration	182	76.4%
Concession question	166	74.7%
Qualifier	167	74.3%
Value expressive	181	78.5%
Social adjustive – norms aligned	202	74.8%
Social adjustive – norms not aligned	168	75.0%
3rd person narrative	174	70.7%
1st person narrative	169	76.3%
	χ^2=5.141 n.s.; Cramer's V = 0.049	

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Table 7-4: Do you typically use lead shot or non-lead shot (steel, bismuth) when you hunt small game?

	N	Never use lead	Occasionally use lead	Mostly use lead	Always use lead
Control	533	10.5%	16.9%	26.5%	46.2%
Basic	162	14.8%	25.9%	23.5%	35.8%
DNR declaration	181	13.3%	21.0%	26.0%	39.8%
Concession question	165	9.1%	24.8%	28.5%	37.6%
Qualifier	165	10.3%	26.7%	22.4%	40.6%
Value expressive	180	12.2%	18.9%	27.2%	41.7%
Social adjustive – norms aligned	202	14.9%	26.2%	23.3%	35.6%
Social adjustive – norms not aligned	165	15.2%	28.5%	18.8%	37.6%
3rd person narrative	175	10.9%	21.1%	27.4%	40.6%
1st person narrative	169	14.8%	21.3%	30.8%	33.1%
	χ^2=39.633 n.s.; Cramer's V = 0.079				

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

Section 7: Background Information

Table 7-5: Current age

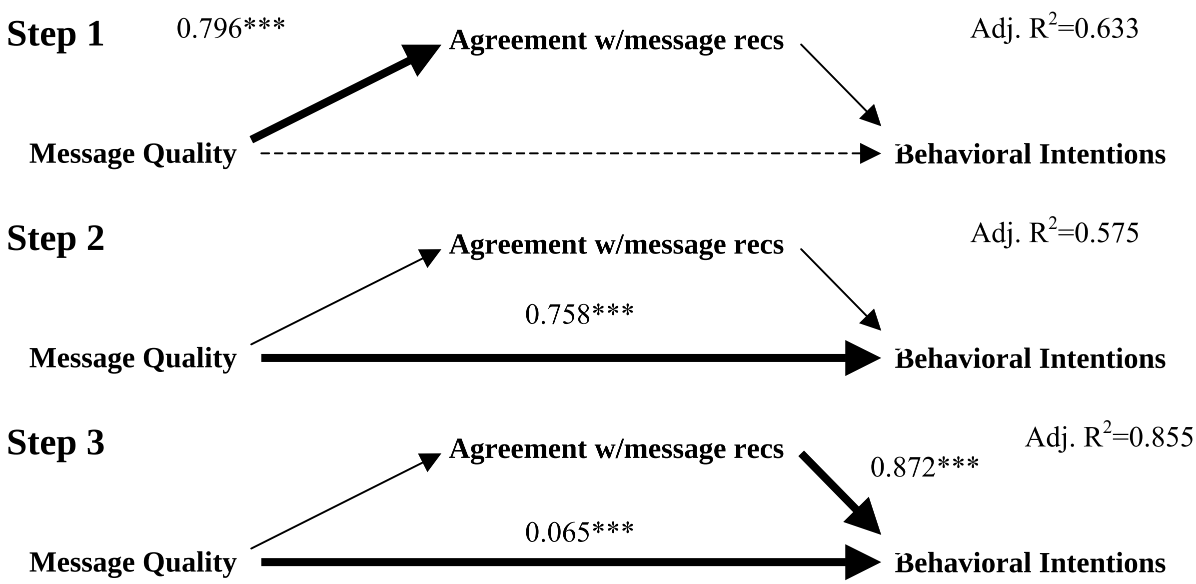
	N	Mean
Control	535	45.63
Basic	162	45.68
DNR declaration	183	46.85
Concession question	166	46.63
Qualifier	164	44.51
Value expressive	179	46.04
Social adjustive – norms aligned	201	44.82
Social adjustive – norms not aligned	167	46.23
3rd person narrative	175	46.65
1st person narrative	169	47.18
	F=0.652 n.s. η=0.053	

n.s. = not significant, *p < 0.05, **p< 0.01, ***p< 0.001

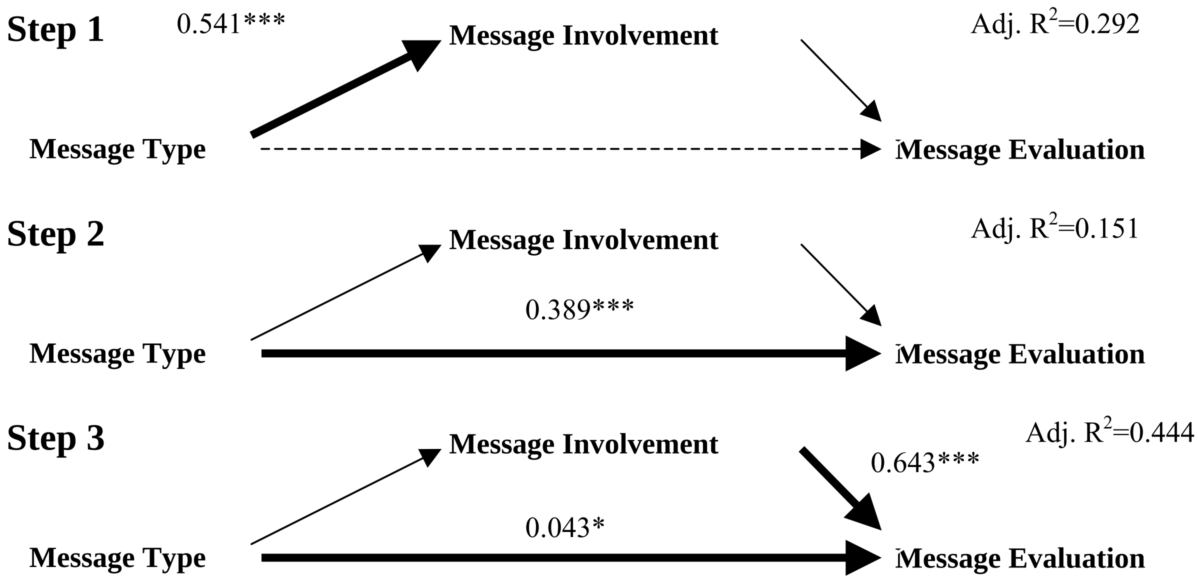
Section 8: Model Development

Based on the research of Hullett and Bolster (2003) and Polyorat (2007), we examined the factors that may relate to support for a ban on lead shot in the Minnesota farmland zone. We found that message quality (r = 0.758***), perception of the narrative quality of the message (r = 0.334***), message involvement (r = 0.598***), product evaluation (r = 0.875***), agreement with message recommendations (r = 0.923***), conformity values (r = 0.070**), and self-direction values (r = 0.069**) were positively correlated with our scaled measure of intention to support a ban on lead shot in the Minnesota farmland zone. Outcome involvement (r = -0.147***), years hunting small game (r = -0.126***), age (r = -0.074**), and increased use of lead shot for hunting small game (r = -0.470***) were negatively correlated with intent to support a ban. Respondents who had hunted for small game in the Minnesota farmland zone in the past 5 years were significantly less likely to support a ban ($\bar{x} = 4.143$) than those who had not hunted in the area in the past 5 years ($\bar{x} = 4.741$) (F=36.47***, η = 0.131).

We conducted mediation analyses to examine the relationships first among (a) message quality, (b) agreement with message recommendations, and (c) intention to support a ban, then among (a) message type, (b) message involvement, and (c) message evaluation. We followed Baron and Kenny's (1986) recommendations for mediation analysis, which involved computing a series of three models. Agreement with message recommendations partially mediated the relationship between message quality and behavioral intentions.



Message involvement partially mediated the relationship between message type (i.e. perception of narrative nature of the message) and product evaluation.



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Appendix C: Treatment Messages

Appendix C: Treatment Messages

Control Message: Nationwide there is concern about the effects of using lead shot while hunting small game. Although lead is the primary component of shot and has been used for a couple of centuries, there are environmental concerns associated with its continued use. The use of lead shot for waterfowl hunting has been banned nationwide since 1991.

The Minnesota Department of Natural Resources is examining the issue of further restricting the use of lead shot in the state. Some other states are also examining this issue and some have already taken action. One recommendation of an advisory committee to the DNR is to phase out the use of lead shot for all small game species in the farmland zone on all public and private lands.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 1—Basic factual message: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 2—Basic factual with DNR declarative statement: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

The Minnesota Department of Natural Resources would like your support of a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Appendix C: Treatment Messages

Treatment 3—Basic factual with concession question: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Why would you oppose regulations banning the use of toxic shot?

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 4—Basic factual with qualifier: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

Although it means additional government regulation, a regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 5—Value expressive: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

You love nature and the outdoors and value your hunting heritage. You want future generations to enjoy hunting and outdoor experiences like you do now. A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Appendix C: Treatment Messages

Treatment 6—Social adjustive, norms aligned: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

You know that a growing number of hunters have voluntarily switched from lead to non-toxic shot and that sportsmen's groups like Ducks Unlimited support the use of non-toxic shot. A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 7—Social adjustive, norms not aligned: Twenty six states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Lead is a toxin that can kill humans and wildlife when it is eaten. Recent news reports have described concerns related to lead in children's toys and discussed how doves, loons, and trumpeter swans have died from lead poisoning.

You know that many hunters are still using lead shot even though sportsmen's groups like Ducks Unlimited support the use of non-toxic shot. A regulation banning lead shot will protect wildlife and support a healthy environment. Banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Treatment 8—Third-person narrative: Joe is listening to the radio on his way out to hunt pheasants. He hears a story about how 26 states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

Joe knows that lead is a toxin that can kill humans and wildlife when it is eaten. Indeed, he has heard recent news reports about concerns related to lead in children's toys and about doves, loons, and trumpeter swans dying from lead poisoning.

He supports a regulation banning lead shot because he cares about wildlife and a healthy environment, and because he knows that banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Appendix C: Treatment Messages

Treatment 9—First-person narrative: You are listening to the radio on your way out to hunt pheasants. You hear a story about how 26 states have begun regulating the use of lead shot beyond existing restrictions for waterfowl hunting.

You know that lead is a toxin that can kill humans and wildlife when it is eaten. Indeed, you have heard recent news reports about concerns related to lead in children's toys and about how doves, loons, and trumpeter swans have died from lead poisoning.

You support a regulation banning lead shot because you care about wildlife and a healthy environment, and because you know that banning lead shot will improve the image of hunters, safeguard hunting opportunities, and preserve our hunting heritage.

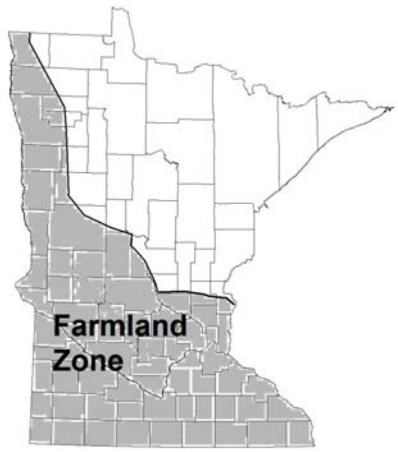
Support a ban on toxic lead shot in Minnesota's farmland zone.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

Appendix D: Survey Instrument

Appendix D: Survey Instrument

Small Game Hunter Lead Shot Study



Please read the information enclosed in the box below. Then complete the survey on the following pages.

Nationwide there is concern about the effects of using lead shot while hunting small game. Although lead is the primary component of shot and has been used for a couple of centuries, there are environmental concerns associated with its continued use. The use of lead shot for waterfowl hunting has been banned nationwide since 1991.

The Minnesota Department of Natural Resources is examining the issue of further restricting the use of lead shot in the state. Some other states are also examining this issue and some have already taken action. One recommendation of an advisory committee to the DNR is to phase out the use of lead shot for all small game species in the farmland zone on all public and private lands.

(The farmland zone includes a large area in southern and western Minnesota that was historically prairie and has now been largely converted to row crops and pasture. The farmland zone generally does not include the forested areas in central and northern Minnesota.)

C

Appendix D: Survey Instrument

Q1. Please indicate how much you agree or disagree with the following statements about the message that you just read. (*Please circle one response for each.)*

	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely Agree
The message is believable.	1	2	3	4	5	6	7
The message is convincing.	1	2	3	4	5	6	7
I find the message to be compelling.	1	2	3	4	5	6	7
The message seems logical.	1	2	3	4	5	6	7
The reasoning used in the message was unsound.	1	2	3	4	5	6	7
The message conveyed the key information in a straightforward way	1	2	3	4	5	6	7

Q2. The message is… ***(Circle one response for each pair of words below.)***

	1	2	3	4	5	6	7	
NOT PERSUASIVE	extremely	quite	slightly	neither	slightly	quite	extremely	**PERSUASIVE**
NOT CONVERSATIONAL	extremely	quite	slightly	neither	slightly	quite	extremely	**CONVERSATIONAL**
NOT FACT ORIENTED	extremely	quite	slightly	neither	slightly	quite	extremely	**FACT ORIENTED**
NOT DRAMATIC	extremely	quite	slightly	neither	slightly	quite	extremely	**DRAMATIC**
NOT TELLING A STORY	extremely	quite	slightly	neither	slightly	quite	extremely	**TELLING A STORY**

Appendix D: Survey Instrument

Q3. The information in the message is… ***(Circle one response for each pair of words below.)***

	1	2	3	4	5	6	7	
	extremely	quite	slightly	neither	slightly	quite	extremely	
NOT CONVEYED CLEARLY	1	2	3	4	5	6	7	**CONVEYED CLEARLY**
DIFFICULT TO UNDERSTAND	1	2	3	4	5	6	7	**EASY TO UNDERSTAND**
NOT INTERESTING	1	2	3	4	5	6	7	**INTERESTING**
NOT INVOLVING	1	2	3	4	5	6	7	**INVOLVING**
NOT CREDIBLE	1	2	3	4	5	6	7	**CREDIBLE**

Q4. Would you say supporting a ban on lead shot in the farmland zone of Minnesota is… ***(Circle one response for each pair of words below.)***

	1	2	3	4	5	6	7	
	extremely	quite	slightly	neither	slightly	quite	extremely	
HARMFUL	1	2	3	4	5	6	7	**BENEFICIAL**
BAD	1	2	3	4	5	6	7	**GOOD**
FOOLISH	1	2	3	4	5	6	7	**WISE**
NOT WORTHWHILE	1	2	3	4	5	6	7	**WORTHWHILE**
UNAPPEALING	1	2	3	4	5	6	7	**APPEALING**
NOT IMPORTANT	1	2	3	4	5	6	7	**IMPORTANT**

Appendix D: Survey Instrument

Q5. Would you be likely or unlikely to support a ban on using lead shot to hunt small game in the farmland zone of Minnesota <u>within the next five years</u>? *(Circle one response below.)*

	1	2	3	4	5	6	7	
UNLIKELY	extremely	quite	slightly	Neither	slightly	quite	extremely	**LIKELY**

Q6. Please indicate how much you agree or disagree with the following statements about the message that you just read. (*Please circle <u>one</u> response <u>for each.)</u>*)

	Extremely Disagree	Quite Disagree	Slightly Disagree	Neutral	Slightly Agree	Quite Agree	Extremely Agree
I think that a ban on lead shot in the Minnesota farmland zone is a good idea.	1	2	3	4	5	6	7
I support a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
The Minnesota Department of Natural Resources should ban lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
I do not think there should be a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
Whether or not lead shot is banned in the Minnesota farmland zone is very important to me.	1	2	3	4	5	6	7
A ban on lead shot in the Minnesota farmland zone directly affects me.	1	2	3	4	5	6	7
The outcome of the decision to ban lead shot in the farmland zone is not relevant to me.	1	2	3	4	5	6	7
I intend to support a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
I believe I will oppose a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
I plan to oppose a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7
The final decision regarding whether lead shot is banned in the Minnesota farmland zone or not will have an impact on my life.	1	2	3	4	5	6	7
I will support a ban on lead shot in the Minnesota farmland zone.	1	2	3	4	5	6	7

Appendix D: Survey Instrument

Q7. Please indicate how important the following values are to you. (*Please circle one response for each.*)

	Extremely unimportant	Quite unimportant	Slightly unimportant	Neutral	Slightly important	Quite important	Extremely important
Politeness (being courteous, having good manners)	1	2	3	4	5	6	7
Honoring of parents and elders (showing respect)	1	2	3	4	5	6	7
Obedience (being dutiful, meeting obligations)	1	2	3	4	5	6	7
Freedom (freedom of action and thought)	1	2	3	4	5	6	7
Self-respect (belief in one's own worth)	1	2	3	4	5	6	7
Creativity (uniqueness, imagination)	1	2	3	4	5	6	7
Independence (being self-reliant, self-sufficient)	1	2	3	4	5	6	7
Choosing own goals (selecting own purposes)	1	2	3	4	5	6	7
Curiosity (being interested in everything, exploring)	1	2	3	4	5	6	7

Appendix D: Survey Instrument

BACKGROUND INFORMATION

Q8. In what year did you first hunt for small game?

______ year

Q9. Did you hunt <u>for small game in Minnesota</u> at anytime during the <u>past 5 years</u>?

❒ YES
❒ NO

Q10. Did you hunt <u>for small game in the farmland zone of Minnesota</u> at anytime during the <u>past 5 years</u>? *(See map on the front cover that identifies the farmland zone.)*

❒ YES
❒ NO

Q11. Do you typically use lead shot or non-lead shot (steel, bismuth) when you hunt small game? *(Check one.)*

❒ NEVER USE LEAD
❒ OCCASIONALLY USE LEAD
❒ MOSTLY USE LEAD
❒ ALWAYS USE LEAD (EXCEPT FOR WATERFOWL)

Q12. What is your current age?

______ years

Appendix D: Survey Instrument

Please make any comments on this page.

Thanks for your help! Please return your survey in the enclosed, self-addressed, stamped envelope.

Please return your completed questionnaire in the enclosed envelope. The envelope is self-addressed and no postage is required. Thanks!

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TEMPERATURE MEDIATED SURVIVAL IN NORTHEASTERN MINNESOTA MOOSE[1]

Mark S. Lenarz, Michael E. Nelson[2], Michael W. Schrage[3], and Andrew J. Edwards[4]

ABSTRACT

The earth is in the midst of a pronounced warming trend and temperatures in northern Minnesota are projected to increase. Moose (*Alces alces*), a species restricted to northern Minnesota, are intolerant of heat and increase their metabolic rate to regulate their core body temperature. We hypothesized that moose survival rates would be a function of the frequency and magnitude that ambient temperatures exceeded the upper critical temperature of moose. We collected data on annual and seasonal moose survival in northeastern Minnesota between 2002 and 2008 and compared these data with a temperature metric. We found that models based on January temperatures consistently explained greater than 78% of the variability in spring, fall, and annual survival. Models based on late spring temperatures also explained an equally high proportion of survival during the subsequent fall. Warm season temperatures were important in explaining survival during the subsequent winter. Based on these results we believe that as temperatures continue to rise, the distribution of moose could shift northward out of Minnesota.

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[1] Abstract of paper submitted to Journal of Wildlife Management

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MOOSE POPULATION DYNAMICS IN NORTHEASTERN MINNESOTA

Mark S. Lenarz, Michael W. Schrage[1], Andrew J. Edwards[2], and Michael Nelson[3]

SUMMARY OF FINDINGS

We captured and radiocollared a total of 116 adult moose (*Alces alces*) (55 bulls and 61 cows) between 2002 and 2005. As of 1 March 2008, 85 collared moose (44 bulls and 41 cows) have died. Annual mortality rates varied among years, and generally were higher than found elsewhere in North America. Regression analysis indicated that a large proportion of the variability in annual and seasonal survival was explained by the frequency and magnitude of days when physiological temperature thresholds were exceeded. Using logistic regression analysis we developed a model to correct for sightability bias on the aerial survey. We found that this bias was substantially larger than previously estimated. The sightability model has now been incorporated into our annual moose survey. Several manuscripts are in preparation or submitted.

INTRODUCTION

Moose formerly occurred throughout much of the forested zone of northern Minnesota, but today are restricted to the northeastern-most counties including all of Lake and Cook counties, and most of northern St. Louis county. Aerial surveys in the late 1990s suggested that the population was relatively stable, despite a conservative harvest. We initiated a research project in 2002 to better understand the dynamics of this population and evaluate the rigor of our aerial survey technique. Fieldwork on the first phase of this projected ended in early 2008 and we are in the process of analyzing data and preparing manuscripts that discuss results of the study. The following report will discuss some of the preliminary findings.

The project was a partnership between the Minnesota Department of Natural Resources (MNDNR), the Fond du Lac Band of Lake Superior Chippewa, and the 1854 Treaty Authority. A second research project was initiated in February 2008 with funding secured by the Fond du Lac band. The Minnesota Department of Natural Resources and 1854 Treaty Authority will provide in-kind support and limited funding for this second phase of research.

METHODS

We captured a total of 116 moose in southern Lake county and southwestern Cook county between 2002 and 2005, attached radiocollars, and collected blood, hair, fecal and tooth samples. We monitored a sample of up to 78 radiocollared moose weekly to determine when mortality occurred and conducted necropsies in an attempt to determine the cause of mortality. We calculated annual non-hunting mortality rates using the Kaplan-Meier procedure (Kaplan and Meier 1958) modified for a staggered-entry design (Pollock et al. 1989) and censored all moose killed by hunters, those that died from capture mortality, and moose still alive as of 1 March 2008. Survival analyses were conducted using Cox Proportional Hazard (CPH) models (Cox 1972, SAS PROC PHREG, SAS Institute 2008).

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[3] United States Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, 58401, USA

We developed a sightability model (Anderson and Lindzey 1996, Quayle et al. 2001), which is used to correct for visibility bias, the number of moose not detected by observers in the survey aircraft. We identified test plots that contained 1 or more radiocollared moose and surveyed these plots using procedures identical to those used in the operational survey. If we observed the collared moose within the plot, we recorded a suite of covariates including environmental conditions, group size, and the amount of visual obstruction. If we didn't observe the collared moose, we located them using telemetry, and recorded the same set of covariates. We used logistic regression to determine which covariates were most important in determining whether moose were observed.

RESULTS AND DISCUSSION

Eighty-five of the 116 radiocollared moose (44 bulls and 41 cows) died by 1 March 2008. In addition, 1 moose slipped its collar and we lost contact with another one. Moose that died within 2 weeks of capture (5) were designated as capture mortality. Hunters killed 15 moose, 2 were poached, and 8 were killed in collisions with vehicles (cars, trucks, or trains). The remaining mortality (55) was considered to be non-anthropogenic and causes included wolf predation (5), bacterial meningitis (1), or unknown (49).

The unknown mortality appeared to be largely non-traumatic. In 50% of the cases, the intact carcass was found with only minor scavenging by small mammals or birds. Wolves and bears were the primary scavengers in 35% of the remaining cases. We were unwilling to attribute predation as the cause of death in these cases because there was little evidence that a struggle had preceded death. In 14% of the cases, we were unable to examine the carcasses or only found a collar with tooth-marks.

Annual non-hunting mortality rates for adult bull and cow moose averaged 18% (SE=6, *n*=6, 0 to 35%) and 22% (SE=4, *n*=6, 6 to 34%), respectively. In both sexes, non-hunting mortality was substantially higher than documented for populations outside of Minnesota (generally 8 to 12%) (Peterson 1977, Mytton and Keith 1981, Bangs 1989, Larsen et al. 1989, Ballard, 1991, Kufeld and Bowden 1996, Bertram and Vivion 2002) and similar to that observed for adult moose in northwestern Minnesota (Murray et al. 2006). The CPH model indicated that sex did not contribute to the prediction of survival (χ^2_1=0.01, P=0.92), which implies that there was no difference in survival rates (non-hunting) between adult bull and cow moose. A more complete analysis of moose survival is underway for a manuscript in preparation.

Moose increase their metabolic rate when ambient temperatures increase beyond a seasonally dependent upper critical temperature (Renecker and Hudson 1986). We hypothesized that moose survival would be a function of the frequency and magnitude that summer and winter threshold temperatures were exceeded. Using regression analyses we found that January temperatures consistently explained a high proportion of the variability in both annual and seasonal survival. Models based on late spring temperatures also were important in explaining survival during the subsequent fall. A manuscript discussing these analyses and results has been submitted to the Journal of Wildlife Management.

A total of 171 radiocollared moose were located on test plots during 4 annual surveys between 2004 and 2007. Eighty-six moose were observed from transects in the test plots and the remaining 85 had to be located using telemetry. Logistic regression indicated that the best model to estimate the probability of detection (π) included only 1 covariate, the amount of visual obstruction. Theta (θ) is the inverse of π and is used to correct each moose observation during the helicopter surveys. The mean annual value for θ approximates the sightability correction factor (SCF), which was used prior to 2004 as a measure of sightability bias. Between 1998 and 2003 the mean SCF was 1.4, which implies that 40% of the moose were not detected by observers. In contrast, the mean annual θ for surveys from 2005 to 2007 ranged from 1.70 to 2.10 ($\bar{x}$ =1.9), which implies that moose numbers were approximately 90% higher than the number detected. The sightability model created from these analyses was used in the 2008 aerial survey. Manuscripts discussing the sightability model and assessing the switch to using helicopters for moose surveys are in preparation.

ACKNOWLEDGMENTS

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AN INCIDENTAL TAKE PLAN FOR CANADA LYNX AND MINNESOTA'S TRAPPING PROGRAM

Glenn D. DelGiudice, Michael DonCarlos, and John Erb

SUMMARY

A Habitat Conservation Plan (HCP) has been developed in association with an application from the Minnesota Department of Natural Resources (MNDNR) to the U. S. Fish and Wildlife Service (USFWS) for a Section 10 Incidental Take Permit (ITP) under the Endangered Species Act (ESA) of 1973 to absolve the Department and its employees from liability in the event of incidental take of Canada lynx (*Lynx canadensis*) in Minnesota that result from otherwise lawful activities. The MNDNR agreed to file an ITP application with the USFWS as part of a joint stipulation in U. S. District Court, District of Minnesota, to settle a legal complaint. Incidental take permitted within the scope of a Section 10 permit issued to the MNDNR would include primarily direct injury or mortality of Canada lynx as the result of being captured during the legal trapping season in Minnesota and under the terms and limitations of a trapping license issued by Minnesota. Additionally, this Section 10 permit would also cover incidental take of Canada lynx resulting from trapping activities conducted by MNDNR employees as part of their position duties authorized by Minnesota Statutes and MNDNR permits. Some of these terms and limitations are designed to minimize the probability of taking endangered or threatened species. The MNDNR is seeking full, statewide coverage of all aspects of "take" related to trapping under the terms and limitations of the Department's licenses. The permit requested is for incidental take of Canada lynx and not for other listed species or species that may be listed in the future. The Department is seeking a Section 10 permit through 2028 or 20 years from the date of acceptance of the application for an ITP.

The ESA, administered by the Department of Interior's USFWS, is considered by many to be one of the most comprehensive wildlife conservation laws worldwide. Its purpose is to conserve "the ecosystems upon which endangered and threatened species depend" and to recover populations of listed species (U. S. Congress 1988). As amended, Section 9 of the ESA prohibits "take" of any fish or wildlife species listed under the ESA as endangered. Under Federal regulation, take of fish or wildlife species listed as threatened is also prohibited unless specifically authorized by regulation. According to the ESA, "take" includes "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." In 1982 Congress revised Section 10 via amendments to the ESA that allows for "incidental take" of endangered and threatened species of wildlife by non-federal entities. The ESA defines incidental take as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." Prior to 1982, such activities by non-federal entities risked violating the Section 9 prohibition, but no legal recourse for exemption was available. Only take associated with scientific research or other conservation activities could be authorized under the ESA. The ITP process was established under Section 10(a)(2)(B) of the ESA to provide a legal recourse when activities occurred outside this realm. Section 10(a)(2)(A) of the ESA requires an applicant for an ITP to submit a "conservation plan" (also known as a habitat conservation plan) "…that specifies, among other things, the impacts that are likely to result from the taking and the measures the permit applicant will undertake to minimize and mitigate such impacts" (Maine Department of Inland Fisheries and Wildlife 2007).

The complete HCP describes in some detail Minnesota's environmental setting and biological resources, including geographic location, area, vegetative ecological composition (e.g., Laurentian Mixed Forest and Prairie Parkland provinces), diverse natural resources (e.g., cover types), climate, topography and geology, hydrology, wildlife, and land use. The document discusses the distribution, habitat (Figures 1 and 2), natural history, and ecology of Canada lynx from North American, regional (i.e., northern Great Lakes), and Minnesota perspectives, and in-so-doing, it highlights the more relevant findings of past and current research of the lynx within Minnesota and elsewhere (Mech 1973, 1977, 1980; Moen et al. 2004a,b, 2006a,b). The full HCP also addresses: forest management and limiting factors relative to lynx survival and persistence in Minnesota; the state's trapping zones and program (Figure 3); furbearer harvests and how they relate to lynx; documented takes of lynx since 2001 (Tables 1 and 2); goals and objectives of the MNDNR's Plan (see below); proposed measures to minimize incidental take by trapping; future anticipated and projected incidental take of lynx; and an adaptive management strategy.

Section 10 Permit Goals:

To ensure that Minnesota's trapping program does not pose a threat to lynx, the MNDNR proposes the following goals for its plan:

- Limit the incidental take of lynx associated with *legal* trapping activities during the State's furbearer trapping seasons to the greatest extent possible, while maintaining recreational trapping opportunities;
- Minimize injuries and mortalities to the greatest extent that is practical, where incidental takes occur; and
- Employ an adaptive management strategy, which includes implementation of new trapping regulations and enhanced educational and communication tactics/strategies; monitoring the success of these efforts through investigation of incidental takings; evaluation of minimization activities/strategies; and if necessary, implementation of new, additional tactics/strategies to decrease the incidental take of lynx by *legal* trapping activities.

Section 10 Permit Objectives:

- Limit incidental captures of lynx by licensed trappers associated with *legal* trapping activities to no more than 4 per year, averaged over a 5-year period (i.e., running average);
- Limit lynx mortalities directly related to *legal* trapping to 1 over any 5-year period;
- Limit serious injuries directly related to *legal* trapping to 1 in any 5-year period; and
- Provide appropriate veterinary care for lynx incurring a debilitating injury associated with incidental trapping.

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Table 1. Incidents of Canada lynx takings in Minnesota recorded by the U. S. Forest Service and U. S. Fish and Wildlife Service, 2001 to 2007. Takings include captures by trapping where there was no apparent injury to the animal.

Year	Number incidentally trapped[a,b]	Trapping mortality[a,b]	Vehicle mortality	Train mortality	Poaching[c]	Unknown
2001	0	0	0	1	0	0
2002	2	0	0	0	0	0
2003	4	2	2	0	1	1
2004	4	2	2	0	0	0
2005	3	1	1	1	2	7
2006	0	0	0	0	0	3
2007	0	0	0	0	0	0

[a]One female and 1 male lynx were incidentally trapped and died in snares set for fox in Koochiching and Clearwater counties in 2003. Also in 2003, a radiocollared male lynx was incidentally trapped in St. Louis County and released alive; another released alive after being caught in a leghold set (for bobcat) in Cook County, sex unknown, was uncollared. In 2004, a radiocollared female was incidentally trapped by a leghold trap set for a fox and died in Cook County, and an uncollared male died in a snare set for a fox in Lake County. Two lynx, a radiocollared male and an uncollared female, were accidentally caught in snare (set for fox/coyote) and body-gripping trap (intended for fisher) sets, respectively, in St. Louis Country, but both were released alive. In 2005, in St. Louis County, 1 radiocollared male lynx died in a snare, another was released alive, and a third lynx (uncollared, unknown sex) was released alive from a body-gripping #120 trap after getting its leg caught.

[b]3 of these incidental takes were associated with violations of MNDNR trapping regulations; 2 of these resulted in the death of the lynx.

[c]Lynx poached included 1 of unknown sex shot and buried, exact date unknown; 1 male and 1 female were shot during the firearm season (2005) for white-tailed deer, both in St. Louis County.

Table 2. Categorization of incidentally trapped lynx by trap type in northern Minnesota, 2001 to 2007 (USFWS 2007 *lynx incidental take database*).

	Number incidentally caught		
Trap type	Release	Killed	Total (%)
Snare	3	4	7 (53.8)
Foothold	3	1	4 (30.8)
Body gripping trap (#120 & #200)	2	0	2 (15.4)
Total	8	5	13 (100.0)

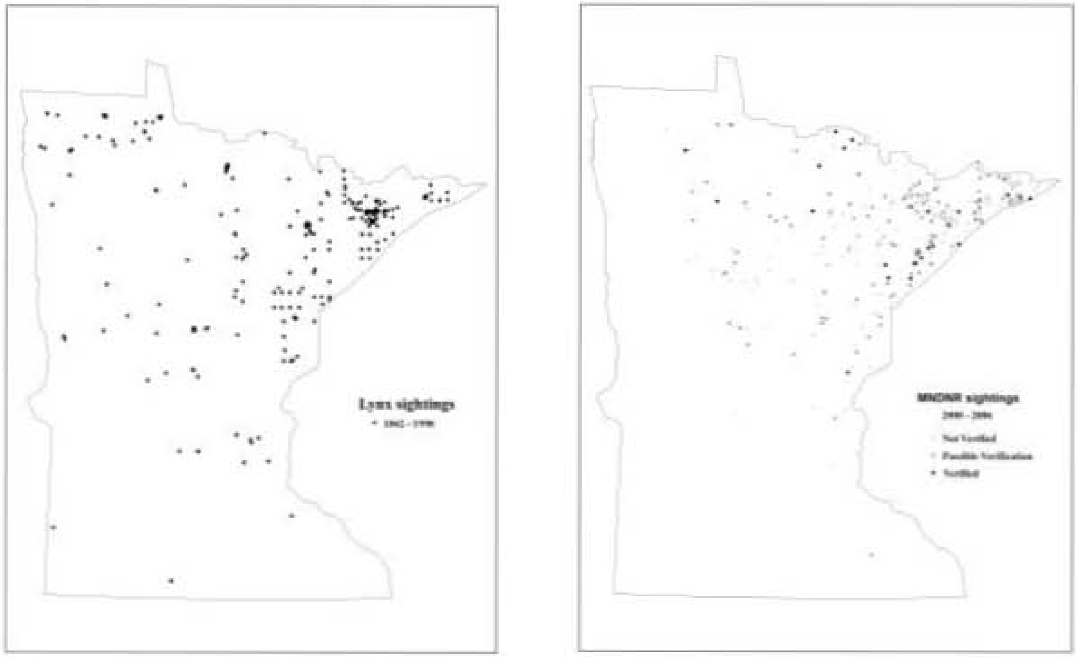

Figure 1. Historic (1842-1988) and current (2000-2006) distribution of Canada lynx in Minnesota. Current lynx primary ("core") range is based on lynx sightings, snowtrack surveys, and locations of radiocollared lynx (McKelvey et al. 2000; Moen et al. 2006a,b; MNDNR 2006 *lynx sightings database*); historic range is based on records compiled by Henderson (1978, as cited in McKelvey et al. 2000).

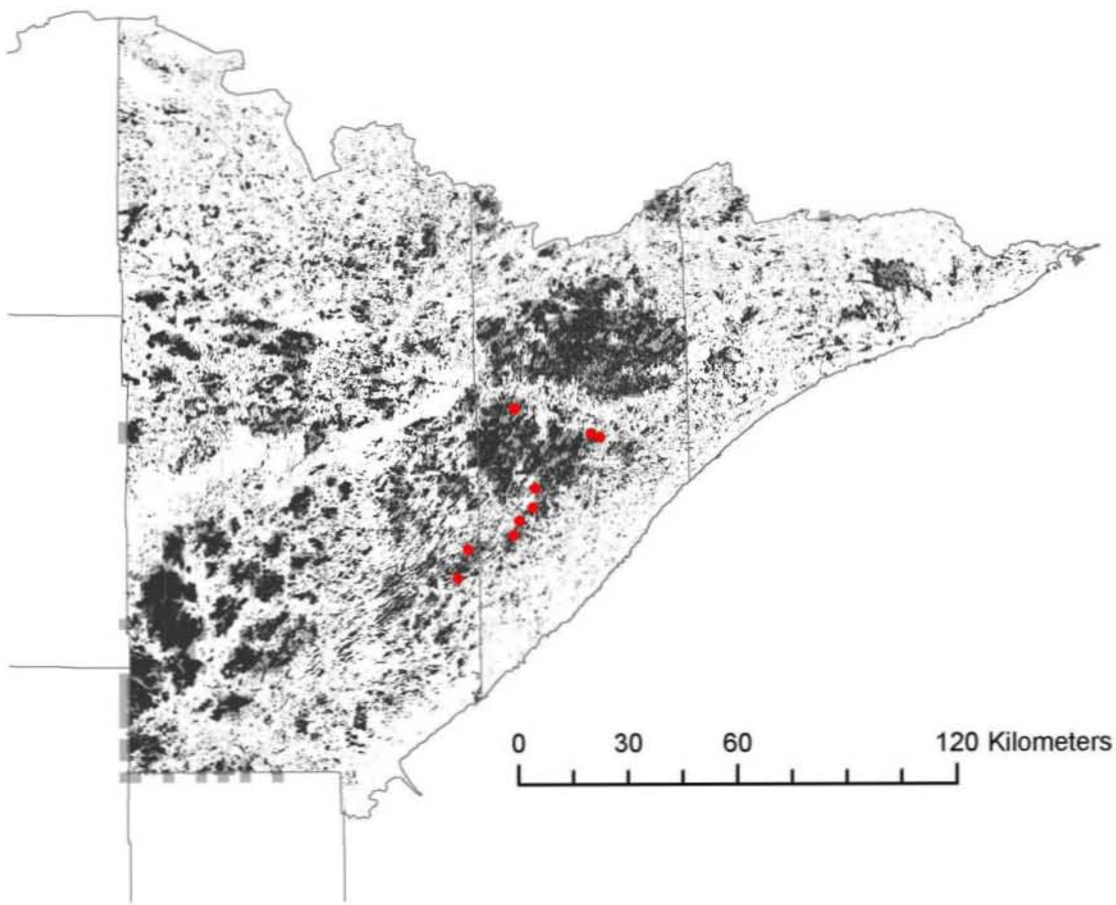

Figure 2. Refinement of critical habitat based on predicted suitable Canada lynx denning habitat in northeastern Minnesota. Darker colors indicate higher quality denning habitat, based on the assumption that females currently selecting den sites are selecting among the suitable habitats that are available (from Moen et al. 2007).

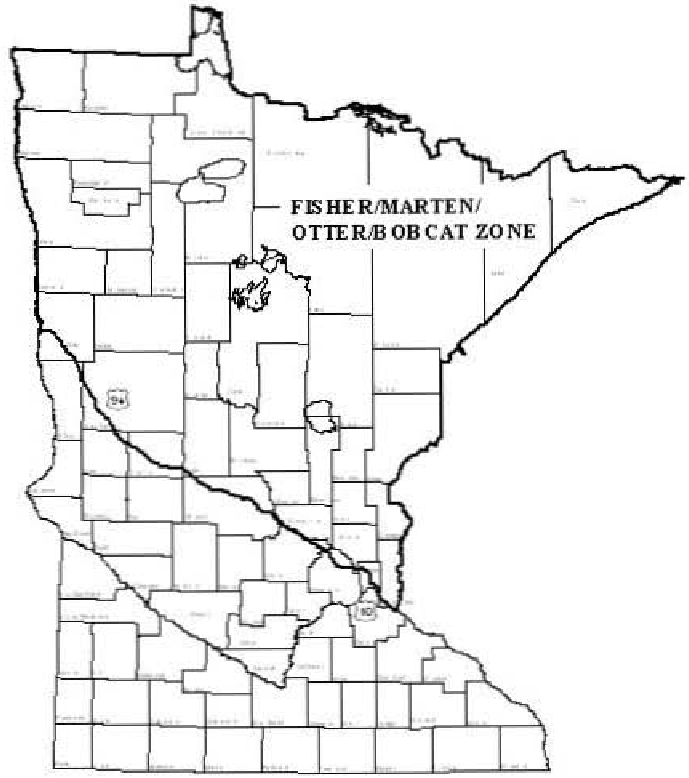

Figure 3. Minnesota's 2006 furbearer trapping zones. Other furbearers are trapped statewide.

ECOLOGY AND POPULATION DYNAMICS OF BLACK BEARS IN MINNESOTA

David L. Garshelis and Karen V. Noyce

SUMMARY OF FINDINGS

During April 2007–March 2008, we monitored 45 radiocollared black bears (*Ursus americanus)* at 4 study sites representing different portions of the bear's geographic range in Minnesota: Voyageurs National Park (VNP, northern), Chippewa National Forest (CNF; central), Camp Ripley (southern), and a new site at the northwestern edge of the range, where we collared 19 bears (14 with Global Positioning System (GPS) collars). Mortality data were obtained through collars turned in by hunters or collars tracked to carcasses. Hunting continues to be the largest source of mortality of collared bears, even though hunters were asked not to shoot bears with bright orange radiocollars, and even though 2 study sites are closed to hunting (bears were killed when they wandered outside these areas during the fall). The rate of hunting mortality among radio-collared bears during the past 5 years is not sustainable population-wide. Reproductive output was highest in the southern study site and declined northward in response to diminishing food availability. Our objective in the new study site is to ascertain food availability per bear in a highly fragmented (agricultural) habitat, and from this, to make predictions about future range expansion.

INTRODUCTION

A lack of knowledge about bear ecology and effects of harvest on bear populations spurred the initiation of a long-term telemetry-based bear research project by the Minnesota Department of Natural Resources (MNDNR) in the early 1980s. For the first 10 years, the study was limited to the Chippewa National Forest (CNF), near the center of the Minnesota bear range. After becoming aware of significant geographic differences in sizes, growth rates, and productivity of bears across the state, apparently related to varying food supplies, we started other satellite bear projects in different study sites. Each of these began as graduate student projects, supported in part by the MNDNR. After completion of these student projects, we continued studies of bears at Camp Ripley Military Reserve, near the southern fringe of the Minnesota bear range, and in Voyageurs National Park (VNP), on the Canadian border.

These study sites differ enormously. The CNF is one of the most heavily hunted areas of the state, with large public (national, state, and county), heavily-roaded forests dominated by aspen (*Populus tremuloides, P. grandidentata)* of varying ages. Camp Ripley is unhunted, but bears may be killed by hunters when they range outside, which they often do in the fall, as the reserve is only 6–10 km wide. Oaks are far more plentiful here than in the 2 study sites further north. VNP, being a national park, is also unhunted, but again bears may be hunted when they range outside. Soils are shallow and rocky in the park, and foods are generally less plentiful than the other sites.

This year we also initiated a project in a new area at the northwestern edge of the Minnesota bear range (henceforth NW). This area differs from the other 3 areas in a number of respects: (1) it is largely agricultural, interspersed with MNDNR Wildlife Management Areas, a National Wildlife Refuge, and small private woodlots; (2) the bear range in this area appears to be expanding and bear numbers increasing; and (3) hunting pressure in this area is unregulated (it is within the no-quota zone, so there is no restriction on numbers of hunting licenses, and each hunter can kill 2 bears).

OBJECTIVES

- Monitor temporal and spatial variation in cub production and survival;
- Monitor rates and sources of mortality;
- Compare body condition indices across sites and years (not covered in this report);
- Assess habitat requirements for bears in an agricultural fringe area; and
- Predict range expansion of bears in northwestern Minnesota.

METHODS

We attached radiocollars with breakaway and/or expandable devices to bears either when they were captured during the summer or when they were handled as yearlings in the den of their radiocollared mother. We trapped bears this year only in the NW study site, using barrel traps baited with raw bacon, and anesthetized them with ketamine-xylazine. In this area, we used principally GPS collars, programmed to collect locations every 2-4 hours. These data will be used to assess fine-scale movements and habitat use in this highly fragmented landscape.

During December–March, we visited all radio-instrumented bears once or twice at their den site. We immobilized bears in dens with an intramuscular injection of Telazol, administered with a jab stick or Dan-Inject dart gun. Bears were then removed from the den for processing, which included changing or refitting the collar (removing GPS collars for downloading data), attaching a first collar on yearlings, measuring, weighing, and obtaining blood and hair samples. We also measured biolelectrical impedance (to calculate percent body fat) and vital rates of all immobilized bears. Additionally, with the cooperation of investigators from the University of Minnesota (Dr. Paul Iaizzo) and Medtronic (Dr. Tim Laske), heart condition was measured with a 12-lead EKG and ultrasound on a select sample of bears in early and late winter. Bears were returned to their den after processing.

We assessed reproduction by observing cubs in dens of radiocollared mothers. We sexed and weighed cubs without drugging them. We evaluated cub mortality by examining dens of radio-collared mothers the following year: cubs that were not present as yearlings with their mother were presumed to have died.

During the non-denning period we monitored mortality of radio-instrumented bears from an airplane periodically through the summer. We listened to their radio signals, and if a pulse rate was in mortality mode (no movement of the collar in >4 hours), we tracked the collar on the ground to locate the dead animal or the shed radiocollar. If a carcass was located, we attempted to discern the cause of death. During the hunting season, hunters routinely reported collared bears that they had killed.

We conducted food sampling on plots in various woodlands in the NW study site, representing all the principle forest types in that area. Experience in our previous studies indicated that fruit production is often high at the forest edge, so we situated plots such that we sampled both the edge and interior of the woodlot. We sampled 12 circular plots, each 3-m radius, per stand. Within each plot, we separately estimated the percent areal coverage and productivity of all principle fruiting species that bears consume. We visually rated fruit production on a 0-4 scale, with 0 = no fruit, 1 = below average fruit production, 2 = average fruit production, 3 = above average fruit production, and 4 = bumper crop. We picked samples of fruits representing each of these categories so that we could convert these subjective scorings to food biomass estimates.

We sampled acorns differently because they are difficult to reliably score and convert to biomass from observations of the tree canopy; furthermore, as bears tend to feed on acorns after they have fallen, plots on the ground more accurately reflect their availability to bears. We sampled 15 1-m^2 plots in each of several stands with oaks, again with some plots along the forest edge. The leaf litter was brushed away and all the acorns and caps counted and collected. Using these data on food availability and GPS collar data on bear movements and home range size, we will ascertain food biomass available per bear's home range at different times throughout the year.

RESULTS AND DISCUSSION

Since 1981 we have handled >800 individual bears and radiocollared >500. As of April 2007, the start of the current year's work, we were monitoring 27 collared bears: 6 in the CNF, 10 at Camp Ripley, 8 in VNP, and 3 in the new NW study site (which we collared in their dens).

Trapping

We trapped in the NW study site from late May through July, and sporadically during August. A total of 1,254 trapnights (typically 18-20 traps set per night) yielded 19 captures of 17 individual bears (1 new bear per 74 trapnights). Trapping success was higher in May-June than later, when an abundance of Juneberries and other fruits reduced the effectiveness of our baits (Figure 1). Trapping success also was reduced by interference (capture or consumption of the bait) by non-target animals: we caught 30 raccoons, 9 skunks, 6 fishers, and 1 domestic cat.

Of the 17 captured bears, 11 were fitted with GPS collars, 5 with VHF collars, and 1 was released without being handled (judged to be a cub). The trapping sample was biased toward males (12M:4F; Figure 1), but we preferentially put GPS collars on females (7M:4F, plus 3F collared in their den).

Mortality

Legal hunting has been the predominant cause of mortality among radiocollared bears from all study sites; 78% of mortalities that we observed were due, or likely due to hunting (Table 1). In earlier years of this study, 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 radio-collared bears, and we fitted these bears with bright orange collars so hunters could more easily see them in dim light conditions. Nevertheless, 12 of 36 bears (33%) with functional radiocollars were killed during this year's hunt (September-October 2007). We observed similarly high harvest rates for radiocollared bears each year since 2003.

In the NW study site, where our research was widely publicized by local media and wildlife managers, we learned that several hunters took greater precautions in not shooting collared bears (e.g., noticing collars on photos from trail cameras). Conversely, 4 of 8 collared bears from VNP were shot by hunters in a small area just outside the park boundaries. These bears were apparently attracted by hunters' baits and also an abundant supply of wild plums in that area. All of these bears were adult females (10, 14, 18, and 22 years old), 3 of which had cubs with them. The remaining 4 radiocollared bears in VNP were all subadults. We do not know whether they remained within the park boundaries during the hunting season.

Two other mortalities occurred this year: an 18 year-old Camp Ripley female died of unknown causes (when we located her body it was too decomposed to ascertain cause of death) and 1 NW bear was killed in a collision with a vehicle. Vehicle kills and nuisance kills have been equivalent in terms of mortalities of radiocollared bears (Table 1), although few nuisance kills have occurred in the past 10 years.

Reproduction

Of 11 mature bears checked in dens during March 2008, 7 (64%) had cubs and 4 had yearlings. Additionally, a 34-year-old has been post-senescent since 1999, when she was 25 years old.

Bears at Camp Ripley, where hard mast (especially oak) is abundant, grow faster and thus have an earlier age of first reproduction than at CNF and VNP (data not yet available for NW). This is reflected in the reproductive rates (cubs born/female) of 4–6 year-old females, which was nearly twice as high at Camp Ripley as at VNP (where no bears produced cubs at 4 years old), and intermediate at CNF (Table 2). This north-south gradient was also apparent in the reproductive rates of older bears, due to fewer missed reproductive opportunities in Camp Ripley and more whole-litter losses and skipped litters at VNP (Table 2). If no bears skipped litters, all would be on a 2-year reproductive cycle, and thus 50% of females would have cubs, on average, per year. The proportion of females with cubs was lowest in VNP and highest in Camp Ripley (where it exceeded 50% as an artifact of sampling; Table 2).

Mean litter size was somewhat higher in the central CNF site (2.6 cubs/litter; Table 3) than at the other sites (2.3–2.4 cubs/litter; Tables 4–5; data insufficient in NW, Table 6). However, counting only litters where at least 1 cub survived 1 year, litter sizes were remarkably similar across areas for 7+ year-old bears (mainly multiparous mothers; Table 2). In all areas, litter size was smaller for younger females, nearly all of which were first-time mothers (Table 2). Notably, 2 collared bears produced litters of 5 cubs last year and 2 produced litters of 4 this year, which is unusual given our small sample.

Average sex ratio of cubs shortly after birth was slightly, but consistently male-biased (52–53%) at all study sites. Observed year-to-year variation in cub sex ratios (Tables 3–6) was likely attributable to sampling error. In all areas, the mortality rate of male cubs was higher than (1.5-2x) that of females. Overall, cub mortality appeared to be lower in CNF (18%; Table 3) than in the other sites (23–28%; Tables 4–5). The difference, though, was not statistically significant.

Cub production and cub mortality did not show an upward or downward trend during our 27 years of monitoring. However, statewide bear harvests have shown an increasing proportion of yearlings, suggesting a changing statewide age structure, or possibly changing selectivity by hunters (with varying numbers of hunters).

Fruit Sampling

From July 9 to August 15, we sampled 78 stands for soft mast and hazelnut production in the NW study site, including: 28 aspen, 21 oak, 9 balsam poplar, 6 lowland hardwood, 5 conifer, 4 lowland conifer, 2 lowland shrub, and 2 hardwood stands. Sampling of lowland shrub and lowland conifer stands was discontinued when it became apparent that they contained little bear forage. We sampled acorns in 21 oak and 12 mixed stands.

Juneberry (*Amelanchier* sp.), chokecherry (*Prunus virginiana*), sarsaparilla (*Aralia nudicaulis*), American hazel (*Corylus americana*), and beaked hazel (*C. cornuta*) were all widely distributed in the study area and had exceptional fruit production in 2007. Wild plum (*Prunus* sp.) and hawthorn (*Crataegus* sp.) were largely restricted to sandy oak beach ridges and also had bumper crops. Nannyberry (*Viburnum lentago*) was restricted to the southern and western edges of aspen stands and produced well. Highbush cranberry (*V. trilobum*) was mostly restricted to lowland areas and also produced well. Raspberry (*Rubus idaeus*) produced well but was largely limited to the few scattered conifer stands in the study area. Other bear foods encountered in the study area included pin cherry (*P. pensylvanica*), red-osier dogwood (*Cornus sericea*), grey dogwood (*C. racemosa*), downy arrowwood (*V. rafinesquianum*), *Ribes* spp., swamp buckthorn (*Rhamnus* sp.), and blueberry (*Vaccinium angustifolium*), none of which were common or produced much fruit.

FUTURE DIRECTION

We plan to continue monitoring bears on these 4 study sites, although sample sizes have been greatly diminished by the exceedingly high harvest of collared bears for the past few years. Our main emphasis in the next few years will be at the new study site in northwestern Minnesota. Our goal there is to assess the factors that may limit range expansion, including highly fragmented forested habitat, availability of agricultural crops that bears can eat, and human-related mortality.

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Table 1. Causes of mortality of radiocollared black bears ≥1 year old from the Chippewa National Forest (CNF), Camp Ripley, Voyageurs National Park (VNP), and Northwestern (NW) Minnesota, 1981–2007. Bears did not necessarily die in the area where they usually lived (e.g., hunting was not permitted within Camp Ripley or VNP, but bears were killed by hunters when they traveled outside these areas).

	CNF	Camp Ripley	VNP	NW	All combined
Shot by hunter	220	11	14	3	248
Likely shot by hunter[a]	8	1	0	0	9
Shot as nuisance	22	2	1	0	25
Vehicle collision	12	7	1	1	21
Other human-caused death	9	0	0	0	9
Natural mortality	7	3	4	0	14
Died from unknown causes	3	2	0	0	5
Total deaths	281	26	20	4	331

[a] Lost track of during the hunting season.

Table 2. Reproductive rates (cubs/female), mean litter size, and proportion of females with cubs (in all cases, counting only litters in which at least 1 cub survived 1 year) in winter dens (March) in VNP (1997–2008), CNF (1981–2008) and Camp Ripley (1991–2008) (*n* = 4+ year-old female-years of observation). Reproduction increased from north (VNP) to south (Camp Ripley). Data from the new study site in the northwest are as yet too sparse to add to the table.

	VNP (*n* = 56)			**CNF** (*n* = 403)			**Camp Ripley** (*n* = 45)		
Age of female	Repro rate	Litter size	Prop w/ cubs	Repro rate	Litter size	Prop w/ cubs	Repro rate	Litter size	Prop w/ cubs
4–6 yrs	0.59	2.0	0.29	0.84	2.3	0.37	1.04	2.2	0.48
7–25 yrs	1.15	2.7	0.44	1.34	2.8	0.48	1.50	2.7	0.55
4–25 yrs	0.98	2.5	0.39	1.15	2.6	0.44	1.24	2.4	0.51

Table 3. Black bear cubs examined in dens of radiocollared mothers in or near the Chippewa National Forest during March, 1982–2008. High hunting mortality of radiocollared bears has reduced the sample size in recent years to the extent that the data are no longer suitable for monitoring.

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%	0%
2004	5	13	2.6	46%	33%
2005	6	18	3.0	33%	28%
2006	2	6	3.0	83%	33%
2007	2	6	3.0	67%	17%
2008	1	3	3.0	100%	—
Overall	173	452	2.6	52%	18%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cubs were born to collared females.
[b] Excluding 1 cub that was killed by a hunter after being translocated away from its mother.

Table 4. Black bear cubs examined in dens of radiocollared mothers in Camp Ripley Military Reserve during March, 1992–2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
1992	1	3	3.0	67%	0%
1993	3	7	2.3	57%	43%
1994	1	1	1.0	100%	—
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%	33%
2004	1	2	2.0	50%	—
2005	3	6	2.0	33%	33%
2006	2	5	2.5	60%	—
2007	3	7	2.3	43%	0%
2008	2	5	2.5	60%	—
Overall	25	59	2.4	53%	23%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cubs were born to collared females or collared mothers with cubs died before the subsequent den visit. Presumed deaths of orphaned cubs are not counted here as cub mortality.

Table 5. Black bear cubs examined in dens of radiocollared mothers in Voyageurs National Park during March, 1999–2007. All adult collared females were killed by hunters in fall 2007, so there are no data for 2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
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%	8%
2004	0	0	—	—	—
2005	5	13	2.6	46%	20%
2006	1	2	2.0	50%	0%
2007	3	9	3.0	44%	—
Overall	24	54	2.3	52%	28%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cub mortality data because no cubs were born to collared females.

Table 6. Black bear cubs examined in dens of radiocollared mothers in Northwestern Minnesota during March, 2007–2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
2007	2	6	3.0	33%	100%[b]
2008	4	12	3.0	67%	—
Overall	6	18	3.0	56%	—

[a] Cubs that were absent from their mother's den as yearlings were considered dead.
[b] Only one 5-cub litter was monitored, and all the cubs died (mother produced a litter of 4 cubs the next year).

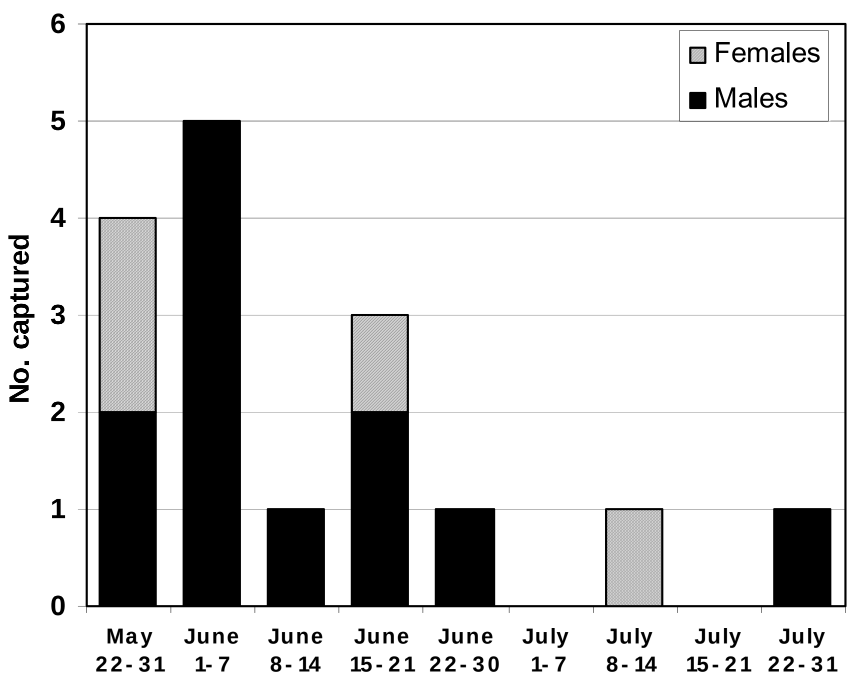

Figure 1. Trapping success in new study area in Northwestern Minnesota, May-Aug, 2008.

RESPONSE IN SKELETAL GROWTH AND BODY MASS OF JUVENILE AMERICAN BLACK BEARS TO PERIODS OF SEVERE FOOD SHORTAGE[1]

Karen V. Noyce, David L. Garshelis, and John Fieberg

SUMMARY OF FINDINGS

Across much of their range, American black bears (*Ursus americanus*) experience periodic and sometimes severe food shortages due to stochastic variation in wild fruit and nut production. Adult bears typically show little or no lasting effect from year-to-year fluctuations in food abundance, though females may sacrifice reproduction following years of particularly poor foods. However, young bears must maintain skeletal and muscular growth through unpredictable times, in addition to building fat reserves each year for hibernation; their ability to do so certainly affects their age of maturity (Noyce and Garshelis 1994) and may have longer-term repercussions. Hence, food conditions may have both short and long term effects on population growth and dynamics.

Captive studies have shown that young bears gain lean body mass in direct proportion to their protein intake, whereas they accumulate fat in proportion to total calories ingested (Felicetti et al. 2003). In north-central Minnesota, most protein-rich bear foods (e.g. emergent greens, insects, deer fawns) are reliably available every year, particularly in the spring and early summer. In contrast, high-calorie fruit and nuts are typically not available until mid-late summer and are notoriously inconsistent in production (Noyce and Coy 1990). We postulated that if growth in stature occurs mostly before mid-summer, then age-specific growth should be relatively consistent from year to year, independent of mast availability. In contrast, weight gain from fat accumulation should more closely reflect year-specific mast availability. If skeletal growth continues through the summer, however, it also should reflect mast abundance, as late summer protein-poor foods like berries can meet the dual requirements of growth and fattening only if consumed in large enough quantities.

We investigated the impact of 3 years of severe food shortage (1985, 1990, 1995) on growth and weight gain in juvenile black bears during a 2+-decade study of black bear population dynamics in north-central Minnesota. We trapped and radio-collared bears during May-July most years and handled radiocollared individuals in their winter dens in December and/or February-March each year. We measured total length, skull length, zygomatic girth, and length of humerus and ulna. We report results here for skull length, which appeared to be the most precise of the measurements and the one least affected by the fatness of the bear. We used a mixed model approach to derive population growth curves (Pinheiro et al. 2007), incorporating effects of sex, individual variation among bears and habitat (upland or lowland). We modeled separate growth curves for males and females living in upland habitats, where foods tended to be more abundant, and neighboring lowlands, where foods were typically less available. We documented abundance of natural foods via an annual survey of wildlife managers and other field personnel, in which they rated the productivity, relative to average, of 14 types of wild berries and nuts each year.

[1]Summary of oral paper presented at the 18th International Conference on Bear Research and Management, Monterrey, Mexico, November 2007.

Bone growth and weight gain were depressed in juvenile bears during 3 years of severe food shortage. Age-specific population means for body mass and skull length did not reflect this effect, due to large variation in age-specific size among juveniles. However, longitudinal data from individual bears showed that rates of bone growth and mass gain were both lower than expected during years of food shortage, when compared with sex-specific growth curves for the population. Weight gain was more profoundly affected; some bears gained almost no weight from one year to the next, despite modest growth in stature. Both size and weight rebounded the following year with average-to-good food abundance, compensating for temporary slowdown and returning bears to a normal growth trajectory. About half the growth observed in yearlings occurred during early summer and half during late summer; in 2-4-year-olds, more than half the growth observed occurred in early summer.

Modeled growth curves indicated that across the population, 95% of males reached full size (full skull length) by 7 years of age and 99% by 10 years, whereas 95% of females completed growth by 4 years of age and 99% by 7 years. Bears reached similar adult size in upland and lowland habitats, despite large differences in food availability, however, lowland bears grew slower and required more time to reach adult size.

In conclusion, despite temporary slowdown in growth, there was no difference in the adult size achieved by bears that experienced a severe food shortage during their growing years. Rebound was quick once food availability returned to normal. Instead, small size in adulthood appeared to stem from pre- and peri-natal nutrition related to maternal age and condition. Bears display a physiologic resiliency that enables them to withstand periodic famine with minimal lasting effect.

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MAPPING BEAR DISTRIBUTIONS: MESHING HARD DATA AND EXPERT OPINION[1]

David L. Garshelis, Karen Minkowski[2], and Eric W. Sanderson[3]

ABSTRACT

Delineating the geographic range of species and populations is fundamental to understanding ecological and human-imposed limits on distribution, planning coordinated range-wide conservation efforts, and monitoring effects of conservation initiatives, or the lack thereof. Beginning in late 2006, we collaborated with 67 national experts (on bears and other wildlife) from throughout Asia on a project to demarcate the past and current ranges of 4 species of Asian bears (*Ursus arctos, U. thibetanus, Melursus ursinus, Helarctos malayanus*) using a modified version of the range-wide priority-setting methodology that has been previously applied to a number of other species. Published maps and expert knowledge were utilized to define the historic ranges of these species, which spanned 35 countries. We then asked the experts to provide known, recent point locations of bears (from sightings, photos, kills, definitive sign, etc.) from their geographical area of expertise, and from these, delineate areas of definite occupied range, probable range, extirpated range, and remaining "unknown" areas within the historic range, following definitions that we provided. A workshop was subsequently convened where the experts could confer with others from their own and neighboring countries to revise their preliminary range maps. After the workshop, we produced revised maps, which were sent back to the experts for review, clarification, and further revision. Ultimately, an up-to-date range map was created, including metadata for each point location and expert-derived range polygon. What became clear and interesting, however, is how differently experts treated their own data and interpreted the defined range categories. On one extreme, definite range was ascribed only to specific reserves where bears were known to occur, whereas all areas outside reserves without recent point observations were considered extirpated. On the other extreme, some experts filled in large areas of probable or even definite range well beyond the extent of their point data. Only a few experts made use of the "unknown" category. These disparities may well be real, as countries differ enormously in suitability of habitat in the areas outside reserves, and also in the extent of existing knowledge about these areas. But it is also apparent that the mapping was influenced by differing personalities of the experts, their level (or self-perceived level) of expertise, and their culture. We discuss the implications of these factors in terms of ecological understanding and conservation monitoring, and compare the pros and cons of expert-based range mapping to a habitat modeling-based mapping approach.

[1]Presented at 18th International Conference on Bear Research and Management, Monterrey, Mexico, November 4–11, 2007
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FISHER AND MARTEN DEMOGRAPHY AND HABITAT USE IN MINNESOTA

John Erb, Pam Coy, and Barry Sampson

SUMMARY OF FINDINGS

During winter 2007-08, we began work on a study of fisher (*Martes pennanti*) and marten (*Martes americana*) ecology in northern Minnesota. The primary goal this winter was to radiocollar a sample of animals to allow us to evaluate various field methods. A total of 18 martens (11M, 7F) were captured. Five martens (1M, 4F) appear to have slipped their collars in the first 6 weeks after capture. Of the remaining 13 martens, 3 (2M, 1F) were killed by raptors, 1 female dispersed, traversing ~ 15 miles (now missing), and 9 are currently being monitored. We radiocollared 9 fishers (2M, 7F), but 3 collars, all on females, fell off after the collar material broke (1 was later re-collared). Prior to the collar breaking, 1 female fisher dispersed 13 miles. Of the 7 fishers that remained collared, 1 female appears to have been accidentally or illegally trapped after the season closed, 1 female is missing, and 5 are currently being monitored. Only 2 of the currently monitored animals (1 fisher, 1 marten) are suspected to be adult females, but neither appears to have established a den and given birth. During winter, we opportunistically located 5 winter resting sites used by marten, including 1 in a rock pile, 1 in a slash/debris pile, and 3 in underground tunnels in the mossy substrate of lowland conifer forest. Since spring, we have also documented 2 above-ground marten rest sites, both in tree cavities. During winter, we also opportunistically located 5 fisher resting sites, including 2 in tree cavities, 1 in a slash pile, 1 in a beaver (*Castor canadensis*) dam, and 1 in an abandoned muskrat (*Ondatra zibethicus*) or beaver bank den. Since spring, 2 additional fisher rest sites were located, 1 in a red squirrel (*Tamiasciurus hudsonicus*) nest and 1 in a tree cavity. We have begun establishing prey sampling transects in the study areas, and are preparing to measure vegetative characteristics in animal home ranges. Full-scale trapping and collaring will begin in winter 2008-09.

INTRODUCTION

American marten and fisher are native to Minnesota, but reliable documentation of their historic distribution is limited. Undoubtedly, northeastern Minnesota was a stronghold for the marten population, though notable numbers likely occurred in the northern border counties as far west as Roseau county. Limited information suggests they occurred as far south and west as Crow Wing and Polk counties. As a result of over-harvesting, marten were considered rare in Minnesota by 1900, and extensive logging and burning around the turn of the century further contributed to the near extirpation of marten from Minnesota by the 1930s (Swanson et al. 1945). Fishers in Minnesota appear to have historically occupied a larger geographic area than martens, extending further south and west into the hardwood dominated transition zone, and also into southeast Minnesota (Swanson et al. 1945, Balser and Longley 1966). The impacts of over-harvest and habitat alteration were equally as detrimental to fisher, with populations substantially reduced by the 1930s.

Legally, fisher and marten were unprotected in Minnesota prior to 1917, after which harvest season length restrictions were implemented. These protections were removed in the mid-1920s, and remained so until all harvest was prohibited in 1929. Seasons remained closed until 1977 for fisher and 1985 for marten, when limited harvests were reinstated. Since then, trapping zones and quotas have periodically increased to the current combined quota of 5 fisher/marten per trapper. Recent harvest levels have been near 3,500 and 2,500 for marten and fisher, respectively. While harvest is legal in ~ the northern 50% of the state, most marten harvest occurs in counties bordering Canada, particularly in northeast and north-central Minnesota. Fisher harvest occurs in most of the northern 50% of the state, though harvest is comparatively low in extreme northeast Minnesota (Lake and Cook counties), and rare, though perhaps increasing, in the Red River Valley (western Minnesota) and the highly fragmented transitional forests in central Minnesota.

While both species appear to have naturally re-colonized a significant portion of their historic range, Minnesota-specific information on species biology and ecology is limited. Except for carcass data obtained from harvested fisher and marten, we are aware of only 1 published field study in Minnesota. Specifically, Mech and Rogers (1977) opportunistically radiocollared 4 marten and reported survival and home range information for those animals. This information is now nearly 30 years old, and based on a very limited sample size. While fisher and marten populations appear to be 'healthy' based on current occupied range and recent harvest levels, their lower reproductive potential, lower density, and comparatively narrow habitat requirements make them more susceptible to over-harvest and the negative effects of human development and habitat alteration.

The primary objectives of this study are to: (1) estimate survival rates and causes of mortality for fisher and marten in Minnesota; (2) describe and quantify features of natal den sites used by females; (3) directly estimate parturition rates and, if possible, litter sizes of radio-marked females; (4) evaluate how survival or reproduction varies as a function of forest attributes, prey abundance and weather conditions; and (5) to evaluate the design of winter track surveys.

Winter 2007-08 marked the pilot year of the study, with efforts focused on evaluating trapping and handling methods, radiocollar designs, aerial relocation efficacy, and den confirmation and inspection methods. Herein we present only those methods and results pertinent to field methods employed during the pilot year. Other objective-specific methods will be detailed in future years as results become available.

STUDY AREA

Marten research is focused on 1 study area located in northeastern Minnesota (Figure 1; Area 1). The area (~ 700 km^2) is composed of ~ 69% mixed forest, 15% lowland conifer or bog, 5% upland coniferous forest, 4% gravel pits and open mines, 3% regenerating forest (deciduous and coniferous), 2% shrubby grassland, 1% marsh and fen, 1% open water, and 0.4% deciduous forest. The area is ~ 90% public ownership, including portions of the Superior National Forest and state and county lands. Fishers are also present in this area at low to moderate density.

Fisher research will take place in 3 areas (Figure 1; Areas 1, 2, and 3), though the study in Area 3, a collaborative effort between Camp Ripley Military Reservation, Central Lakes Community College, and the Minnesota Department of Natural Resources, is not discussed in detail in this report. Area 2 (1075 km^2), our primary fisher study area, is composed of ~ 74% deciduous forest, 11% open water, 5% lowland conifer or bog, 5% marsh and fen, 2% regenerating forest (deciduous and coniferous), 1% coniferous forest, 1% grassland, and 1% mixed forest. Area 2 is ~ 67% public ownership, including portions of the Chippewa National Forest and State and county lands. Extremely few martens occupy Area 2.

METHODS

Our goal the first winter was to capture 15 martens and 15 fishers to evaluate numerous field techniques. We used cage traps to capture both fishers (Tomahawk Model 108) and martens (Tomahawk Model 106 or 108) during winter. Traps were baited with either deer or beaver meat, with commercial lure placed in or above the traps. We enclosed traps inside white plastic 'feed sacks' or burlap bags and further covered traps with snow or vegetation. All traps were checked daily.

To immobilize animals, we used metal 'combs' to restrict the animal to a small portion of the trap, or restrained the animal against the side of the trap by pulling its tail through the cage mesh. Animals were injected with a hand-syringe using a 10:1 mixture of ketamine and xylazine (fisher: 30 mg/kg ketamine and 3 mg/kg xylazine; marten: 20 mg/kg ketamine, 2 mg/kg xylazine) (Kreeger et al. 2002). After processing, the xylazine was reversed with yohimbine at a dosage of 0.1 mg/kg (marten) or 0.15 mg/kg (fisher). We ear-tagged fisher with a monel # 3 tag in one ear (National Band and Tag Co., Newport, KY) and a 2-piece plastic mini-tag (Dalton I.D. Systems, UK) in the other ear. Marten were ear-tagged with a monel #1 tag (National Band and Tag Co., Newport, KY) in each ear. Passive Integrated Transponder (PIT) tags or lip tattoos may be used in the future if ear-tag retention is low.

During processing, animals were placed on either chemical hand warmers or heating pads connected to a power inverter and 12 volt battery. We monitored respiration, pulse, and rectal temperature during anesthesia. We weighed and sexed animals and removed a first pre-molar for aging. Morphological measurements taken included body length, tail length, hind foot length, and chest, neck, and head circumference. We removed guard hair samples for subsequent genotyping, and for evaluating the use of stable isotope analysis for deciphering food habits (Ben-David et al. 1997). To determine which females were pregnant in mid-winter, and eventually the percent of those that failed to produce a litter in spring, we planned to draw blood samples from either the jugular or femoral vein to measure serum progesterone levels (Frost et al. 1997). We were unsuccessful at drawing blood, but hope additional experience or training will allow us to do so in the future. Antibiotics were administered subcutaneously to all animals prior to release.

During the pilot year, we deployed several radiocollar models to compare overall performance. Fishers were collared with an ATS M1585 zip-tie collar (~ 43 g), an ATS M1930 collar (~ 38 g; deployed on females only) with a 16on/8off duty cycle, or a Lotec SMRC-3 collar (~ 61 g; deployed on adult males only). Martens were collared with an ATS M1565 zip-tie collar (~ 32 g), an ATS M1930 collar (~ 38 g; deployed on males only) with a 16on/8off duty cycle, or a Holohil MI-2 collar (~ 31 g). All radiolocations, except for some taken during the den-monitoring period, will be obtained from fixed-wing aircraft at approximately weekly intervals. During the pilot year, and periodically thereafter, we will test the accuracy of aerial radiolocations by placing transmitters in known locations of varying forest structure, and compute the mean distance between known and estimated locations. Detailed information on radiolocation methods and analysis will be presented in future years.

While data is absent for Minnesota, nearly all reported fisher natal dens have been in elevated tree cavities (Powell et al. 2003). Marten natal dens are also frequently in tree cavities (Gilbert et al. 1997), but may occur in more varied features (e.g., under-ground burrows, exposed root masses of trees, rock piles, large downed logs; Ruggiero et al. 1998). Confirmation of parturition and den location can often be accomplished by monitoring female movements and behavior. When necessary to help confirm exact den location, and to monitor female den attendance and kit emergence, we will also utilize remotely triggered cameras positioned near suspected dens (Jones et al. 1997). After den locations are confirmed, we will wait ~ 2 weeks and attempt to obtain counts of litter size using video inspection equipment. For viewing underground and tree cavity dens, we are evaluating use of a modified Aqua-Vu Scout SRT black and white video camera (Nature Vision Inc., Brainerd, MN), or an MVC2120-WP color video camera (Micro Video Products, Bobcaygeon, Ontario) connected to a laptop computer. Dens will only be examined when radio-marked females are not present. After initial den and litter confirmation, we will re-examine dens at 30-day intervals (up to 120 days) to determine which females recruit at least 1 offspring to the fall population.

RESULTS AND DISCUSSION

A total of 18 martens (11M, 7F) and 9 fishers (2M, 7F) were radiocollared during the first winter (Table 1). Tooth aging has not yet been completed. Of the 18 martens collared, 3 individuals (1M, 2F) were able to subsequently slip the collars off. Two additional females are presumed to have slipped their collars as well, but we have not yet been able to access the collar location to confirm (1 in a rock pile, 1 in a white pine tree cavity). No fishers have slipped their collars, but 3 females lost collars when the collar attachments broke (ATS M1585 zip-tie attachment collars). One female was recaptured shortly thereafter, and a new collar was attached.

While we have yet to compute the number of captures per trap night, capture rate was considered high for marten in Area 1, with 18 individuals, plus 1 fisher, being captured in approximately 12 days of trapping by 1 trapping crew. While additional fisher captures would likely have occurred in Area 1, trapping was terminated after reaching our goal for marten capture. Fisher capture success was low in Area 2, with only 7 fisher being captured over ~ 10 weeks of trapping. While the low capture success appears due in part to a recent decline in fisher numbers, we believe it is also attributable to our decision to utilize only 1 trapping crew this first winter, which necessitated moving traps more frequently than desired in an attempt to examine or trap all portions of both study areas.

Three marten mortalities have been confirmed, all from raptor predation. Two males were killed within ~ 100 m of each other, but neither were consumed. Both were found along a forest edge (open power line corridor) and appeared to have escaped the initial attack, but puncture wounds penetrating the heart or lungs caused death shortly thereafter. One female marten was killed, likely carried a distance to a perch, and 'plucked', with only the head, fur, and collar remaining at the site. No human-related marten mortalities have been documented, but radiocollaring efforts began after the close of the harvest season. Only 1 fisher death has been documented, a female that appears to have been accidentally or illegally trapped after the harvest season closed.

One female fisher, we suspect a juvenile, dispersed 13 miles before her collar attachment broke and fell off. One female marten traversed ~ 15 miles since capture, though the maximum distance she was ever located from her original location center was ~ 6 miles. She is currently missing. Two other martens, both males, have moved 4-6 miles from their original location.

Of the 7 female martens captured, 4 slipped collars and 1 was killed by a raptor. For the remaining 2, 1 suspected juvenile is missing and 1 suspected adult does not appear to have established a natal den. Of the 7 female fishers captured, 3 lost collars when the collar attachment broke (1 was subsequently re-collared), 1 was accidentally or illegally trapped, and 1 is missing. For the 3 females currently collared, only 1 was suspected as being an adult, and she does not appear to have established a natal den.

Because no natal dens were confirmed, we have been unable to fully evaluate our video and camera methods for confirming dens, ascertaining litter size, or monitoring den attendance by females. However, as part of collar retrieval and ground checks on potentially denned females, we have had opportunity to document and examine various resting/den sites. Throughout winter, all resting sites we located for marten were either on or below ground, including 1 in a rock pile, 1 in an old slash/debris pile, and 3 underground in the mossy substrate of lowland conifer stands. During spring, we have also confirmed 2 marten resting sites in above ground tree cavities (1 in a live white pine, 1 in a black spruce snag), and another resting site in a slash/debris pile. While this sparse and opportunistic sample of resting sites is inadequate to draw any strong conclusions, it appears that martens may primarily use on- or below-ground dens in winter, with increasing use of above-ground sites in other seasons.

We confirmed 5 fisher resting sites used in winter, including 2 in tree cavities in large-diameter snags (1 trembling aspen (*Populus tremuloides*), 1 sugar maple (*Acer saccharum*)), 1 in a slash pile, 1 in a beaver dam, and 1 in an abandoned muskrat or beaver bank burrow on the edge of an old beaver pond. During spring, 1 collared female fisher has also been located in a red squirrel nest, and 1 non-radioed animal was followed to a tree cavity in a sugar maple snag.

Both video systems we are evaluating appear adequate for viewing details inside tree cavities and underground dens. Numerous slipped or broken collars were observed in such dens with the use of the portable video systems. We continue to experiment with improved (sufficiently sturdy, yet lightweight) poles for elevating the video probe to higher tree cavity entrances, and better underground attachments that are sufficiently sturdy to advance the video probe into the den, yet flexible and maneuverable enough for turning in more complex dens.

We also deployed a Reconyx PC85 remotely triggered camera (Reconyx LLP, Holmen, Wisconsin) at several potential natal den sites. While we did obtain pictures of a fisher near a suspected den site, we did not confirm repeated fisher or marten use at any of the monitored locations (i.e., they were not natal dens). Cameras also captured activity of other species, including squirrels, raccoons (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus*), and the cameras obtained sufficiently rapid sequences of pictures (~ 1 per second) necessary to detect quick movements to and from potential den sites.

FUTURE PLANS

Full-scale radiocollaring of fishers and martens will begin in December 2008, with a goal of annually collaring 40 martens (Area 1) and 30-40 fishers (~ 10 fisher in Area 1, 20 in Area 2, and 5-10 in Area 3). The project is currently planned as a 6-year study. Throughout this summer and fall, prey and vegetation sampling will commence, as will establishment of weather monitoring locations. More detailed description of these methods will be presented in subsequent years. Here, we outline basic sampling plans.

Prey sampling transects are being established in both study areas. Transects (n = 200 in each study area) will consist of 10 sampling locations spaced 20m apart, distributed in various cover types throughout the study area. Transects will generally be oriented perpendicular to roads or trails, with the first plot 30m off the trail. In spring, we will count snowshoe hare (*Lepus americanus*) pellets in a 1-m^2 plot at each sampling station (McCann et al. 2008). During fall, small mammal snap-trapping will occur for 2 consecutive days at the same sampling stations, similar to protocol used on an existing small mammal survey in Minnesota (Olson 2006). During both spring (hare pellet sampling) and fall (small mammal trapping), we will also count the number of red squirrels observed or heard along each transect. Rather than using 10-min point counts (Mattson and Reinhart 1996, Bayne and Hobson 2000), with our small mammal/hare pellet stations as the sampling points, we will simply record the number of unique squirrels observed/heard along each transect while checking pellet plots and small mammal traps. Information on white-tailed deer and ruffed grouse (*Bonasa umbellus*) populations may be available from existing surveys or population models.

Throughout summer, we will collect vegetative information from individual fisher and marten home ranges. Sampling will occur in randomly located plots, stratified by cover type within each home range. We will collect quantitative data on: (1) tree DBH and height, and ultimately basal area and volume of trees, by species; (2) % canopy cover (deciduous and coniferous); (3) sapling density; (4) understory cover density; (5) density and volume of snags; (6) density, volume, and other characteristics of coarse woody debris; and (7) density and volume of exposed root masses.

Weather sampling stations will be established within different cover types throughout the study area. At each station we will monitor daily temperature throughout the year, and weekly snow depth and snow density from ~ December 1 – May 1. Depending on the amount of spatial variability in temperature and snow conditions within a study area, we will either assign a study area specific average to all animals, or assign home-range specific results based on data from the nearest cover type appropriate stations.

Prey sampling data will be summarized by cover type, and, along with vegetative data from home ranges and pertinent weather information, will be used to help elucidate any observed differences in survival and reproduction across individuals or years, and to evaluate the reliability or applicability of existing fisher or marten habitat models/recommendations developed elsewhere (e.g., Allen 1982, 1983, Carroll et al. 1999, Naylor et al. 1999, Payer and Harrison 2004, Fuller and Harrison 2005, Bowman and Robitaille 2005, Zielinski et al. 2006). We will also continue to collect tissue samples from prey species to quantify species-specific stable isotope ratios. If prey-specific chemical signatures are sufficiently distinct, it may be possible to describe late-summer/fall food habits for fisher and marten based on chemical analysis of guard hair samples. In addition, we will examine whether animal-specific isotope ratios are correlated with home range habitat characteristics (e.g., cover type) or prey population indices, and whether there is any correlation between isotope ratios (food habits) and survival or reproductive success.

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Table 1. Sex, weight, and status of fishers and martens radiocollared during winter 2007-08.

Study Area	Species	ID	Sex	Weight (kg)	Status
Area 1	fisher	F08-304	F	2.50	Alive
Area 1	marten	M08-140	F	0.65	Alive
Area 1	marten	M08-162	F	0.60	Disperser, now missing
Area 1	marten	M08-206	F	0.61	Raptor predation
Area 1	marten	M08-202	F	0.50	Slipped collar
Area 1	marten	M08-188	F	0.62	Presumed slipped collar – not yet retrieved
Area 1	marten	M08-138	F	0.52	Slipped collar
Area 1	marten	M08-213	F	0.61	Presumed slipped collar – not yet retrieved
Area 1	marten	M08-161	M	0.82	Alive
Area 1	marten	M08-184	M	0.89	Alive
Area 1	marten	M08-136	M	0.79	Alive
Area 1	marten	M08-134	M	0.89	Alive
Area 1	marten	M08-204	M	0.82	Alive
Area 1	marten	M08-215	M	1.07	Alive
Area 1	marten	M08-217	M	1.06	Alive
Area 1	marten	M08-219	M	0.81	Alive
Area 1	marten	M08-211	M	1.05	Raptor predation
Area 1	marten	M08-209	M	0.90	Raptor predation
Area 1	marten	M08-132	M	0.71	Slipped collar
Area 2	fisher	F08-375	F	2.70	Collar attachment broke, re-collared, now missing
Area 2	fisher	F08-353	F	2.95	Alive
Area 2	fisher	F08-351	F	2.70	Accidentally or illegally trapped
Area 2	fisher	F07-002	F	2.60	Collar attachment broke
Area 2	fisher	F08-374	F	2.70	Collar attachment broke
Area 2	fisher	F08-077	M	2.50	Alive
Area 2	fisher	F08-373	M	4.70	Alive
Area 3	fisher	F07-326	F	2.7	Alive

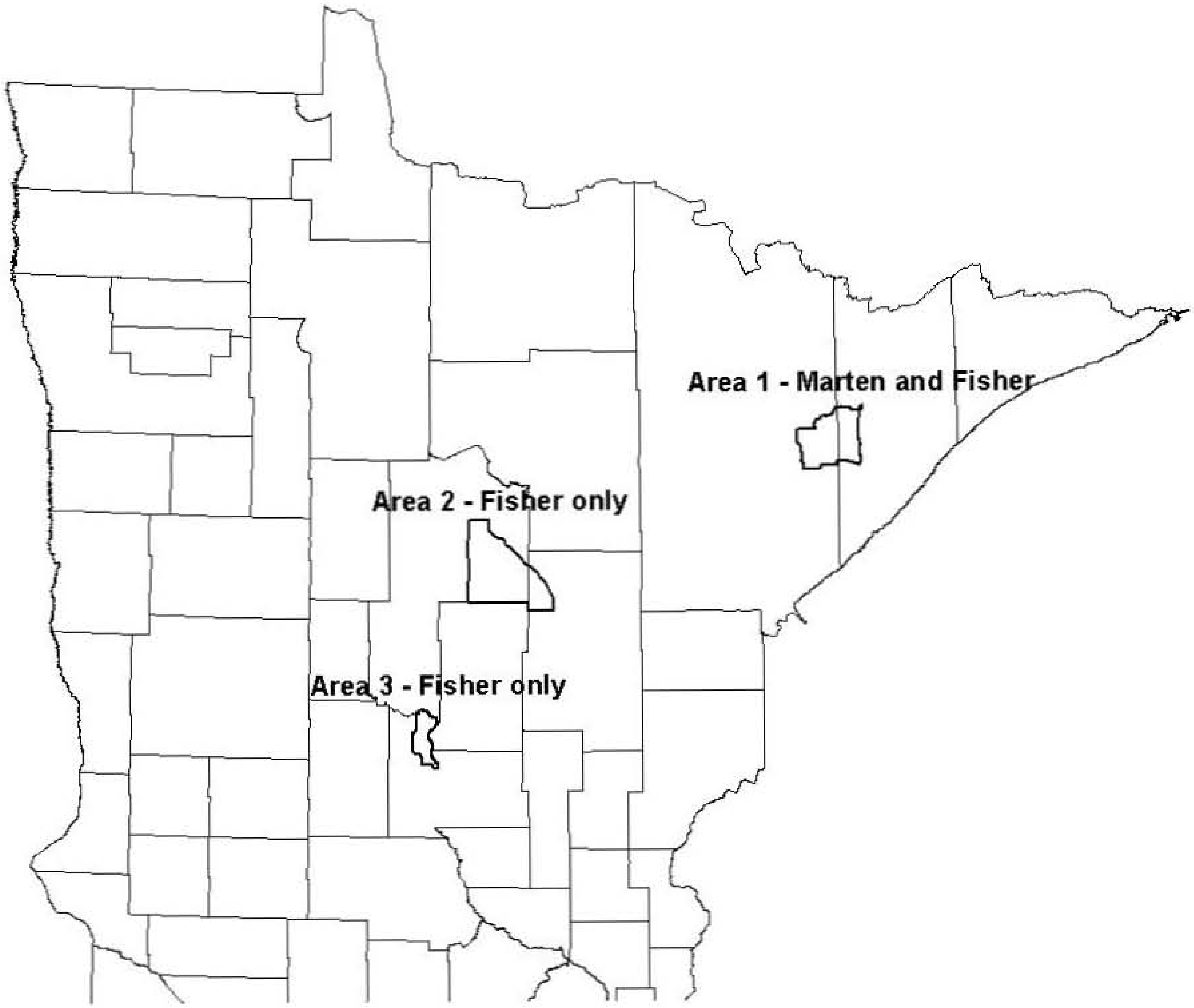

Figure 1. Fisher and marten study areas.

IDENTIFYING PLOTS FOR SURVEYS OF PRAIRIE-CHICKENS IN MINNESOTA

Michael A. Larson and J. Wesley Bailey

SUMMARY OF FINDINGS

To explore potential improvements in surveys of greater prairie-chickens (*Tympanuchus cupido pinnatus*) in Minnesota, we developed this study to determine landscape-scale characteristics associated with plots of land occupied by prairie-chicken leks and to evaluate potential within-year sources of variation in the probability of detecting a prairie-chicken lek, if one is present. The study area consisted of nearly the entire range of prairie-chickens in northwestern Minnesota. Observers visited randomly selected Public Land Survey (PLS) sections (~259 ha) 3 times during April and early May of 2005 to detect leks. Confirmatory analyses indicated that wind speed and cloud cover were negatively correlated with the probability of detecting a lek. Road density was positively correlated with the probability of detection, but it was negatively correlated with the probability of a section being occupied by a lek. Exploratory analyses also revealed positive correlations between occupancy and both grass cover as a proportion of area and the area of all cover types considered as habitat and a negative correlation between occupancy and distance to the nearest known lek from the previous year. Comparing only models that included only covariates for which data are available for all plots within prairie-chicken range (i.e., uncorrected GAP data and other Geographic Information System (GIS) based landscape characteristics), models that included covariates measured at the plot scale fit better than those that included covariates measured at a larger landscape scale in the exploratory analysis, but there was no difference in fit in the *a priori* analysis. Approximately 13% of sections in the study area were occupied by a lek, but the precision of the estimated abundance of occupied sections was low ($\hat{Y}$ = 420, SD = 270).

INTRODUCTION

Nearly all methods for monitoring populations of greater prairie-chickens, including those currently employed by the Minnesota Department of Natural Resources (MNDNR), depend upon locating leks, or concentrations of the birds at their arenas for breeding displays (i.e., booming grounds) during spring. Surveying a statistically valid sample of leks requires identifying all areas where leks may occur and then sampling to find a number of plots occupied by active leks. The range of prairie-chickens in Minnesota covers approximately 10,000 km^2, so a major limitation to monitoring leks of prairie-chickens is determining where to survey within that range.

The availability of GIS technology and databases of spatially explicit land cover have made it feasible to use landscape-scale habitat criteria to identify areas where leks may occur. Although land cover associated with prairie-chicken leks in Minnesota and Wisconsin have been quantified during previous studies (Merrill et al. 1999, Niemuth 2000, 2003), interpretation and application of those data are problematic. In particular, the previous studies were based on a case–control sampling design, which does not allow inferences about relative probabilities of occurrence (Keating and Cherry 2004). In addition, they did not select active leks randomly or verify nonuse at the randomly selected control locations.

Inferences about trends in the abundance of grouse throughout the state require statistically valid samples of survey locations from defined areas in which the species may occur. This study builds upon existing knowledge of landscape-scale habitat criteria that may be useful for identifying plots where prairie-chicken leks may occur, thereby dramatically reducing the area needed to be included in monitoring programs. It also serves as a pilot project for a new survey design that may prove to be more efficient than current survey methods for detecting changes in the abundance of prairie-chickens. Results of this study may benefit management programs for prairie-chickens by improving the quality of inferences drawn from spring surveys and developing resource selection functions for using landscape characteristics to estimate the relative probability of an area being occupied by a lek.

OBJECTIVES

- To determine landscape-scale characteristics associated with plots of land occupied by prairie-chicken leks in Minnesota; and
- To evaluate potential within-year sources of variation in the probability of detecting prairie-chicken leks in Minnesota.

METHODS

Study Area

Prairie-chickens occur in 3 distinct ranges in Minnesota. A study area was established in the northwest prairie-chicken range because the northwest range contained the largest population of prairie-chickens, was where the hunting permit areas were, and was the focus of all recent prairie-chicken monitoring efforts by the MNDNR. The study area included the northern 96% of the northwest range as defined by Giudice (2004) based upon land type associations of the Ecological Classification System (Figure 1). The size of the study area was limited only by a maximum distance of 90 km to the southeast of Moorhead, where the southernmost field technicians resided.

Notation

Methods for this study were based on analytical techniques for estimating the probability of site occupancy (MacKenzie et al. 2002). Throughout this report notation follows that of MacKenzie et al. (2002): ψ, probability that a sample plot is occupied by a lek; *p*, probability of detecting a lek within a sample plot, given that the plot is occupied; N, number of sample plots in a study area; T, number of surveys, or distinct sampling intervals during which all plots are visited once; the "hat" character (e.g., $\hat{\psi}$) denotes the estimated value of a quantity; and *c*, the probability of detecting a lek during visits that occur after a lek already has been detected within a plot (i.e., recapture).

Sampling Design

A sampling unit, or plot, was defined as a PLS section, most of which were 1.6- $\times$ 1.6-km squares (i.e., 259 ha = 1 mi^2). In portions of the prairie-chicken range in Minnesota some PLS sections were rectangular and much smaller than 259 ha. Variability in the size of plots was accounted for by the possible inclusion of habitat area within a plot as a covariate for ψ. The size of plots roughly corresponded to home range sizes of prairie-chickens during spring (<400 ha; Robel et al. 1970).

We applied a dual frame sampling design in which samples were drawn from a list frame consisting of plots known to have been occupied by a lek during 2004, and a much larger area frame consisting of the statistical population of plots to which the estimate of occupancy can be inferred (Haines and Pollock 1998). The area frame completely overlapped the list frame, so inferences were based upon the mutually exclusive overlap and nonoverlap domains. Dual frame sampling was appropriate for this study because an area frame was necessary for sample plots to be representative of other plots in the population, and the list frame was useful for focusing adequate sampling effort in plots where leks were known to have occurred recently. The locations of leks, especially those attended by more than a few males, are relatively consistent among years (Schroeder and Braun 1992), which makes them amenable to the use of a list frame.

Data Collection

An observer visited each sample plot once during each of T=3 consecutive biweekly periods from 4 April 2005 until 15 May 2005 (Svedarsky 1983). A visit consisted of a 20-minute interval between 0.5 hours before and 2 hours after sunrise (Cartwright 2000) during which a plot was surveyed with the purpose of detecting the presence of a lek (i.e., ≥2 male prairie-chickens) by sight or sound. The value of time-dependent covariates of *p* (e.g., wind speed, time of day) were recorded during each visit.

The value of all covariates of ψ and some covariates of *p* varied among plots but not among visits (i.e., they varied spatially but not temporally). We measured these landscape characteristics at 2 different spatial scales—within the boundaries of the plot and also within a 1,600-m buffer of the plot centroid. The larger scale roughly corresponded to areas of nesting and brood-rearing, which usually occur within 1,600 m of a lek (Schroeder and Braun 1992, Ryan et al. 1998). For land cover data we used the GAP level 4 database and combined all cover types not likely to be used by prairie-chickens into a single nonhabitat category. Observers corrected the GAP data at the plot scale in the field, thereby creating a third set of land cover covariate data.

Occupancy models often require an assumption that *p* is homogeneous (i.e., does not vary among plots). Using covariates of *p* in the model may ameliorate the negative effects of potential heterogeneity in *p*, but to prevent the sampling design from introducing heterogeneity, each observer visited a different set of plots during each biweekly survey period. Differences among observers in their ability to detect leks, therefore, would not be correlated with specific plots.

Data Analysis

We transformed the value of the covariates of ψ and *p* so they were within the interval [-9.9, 9.9], which precluded problems with numerical optimization that occur occasionally when using a logit link function. We developed sets of 8 and 14 *a priori* models to represent hypotheses about which covariates contributed to variation in *p* and ψ, respectively. Included in the set of models for ψ were 2 supported by previous studies (Table 1; Merrill et al. 1999, Niemuth 2003). We used Program MARK to fit occupancy models to the detection-nondetection survey data (MacKenzie et al. 2002). We used Akaike's Information Criterion adjusted for sample size (AIC_c) to calculate the Akaike weight (w), which is a relative weight of evidence for a model, given the data. We based inferences on parameter estimates averaged over the best models that accounted for ≥95% of the Akaike weights (Burnham and Anderson 2002:150, 162). To estimate uncertainty in $\hat{p}$ and $\hat{\psi}$ given specific values of covariates we calculated limits of 95% confidence intervals on the logit scale then transformed them to the real scale (Neter et al. 1996:603). We combined estimates of $\hat{\psi}$ across sampling domains to estimate the number of plots occupied by prairie-chicken leks in the northwest range of Minnesota (Haines and Pollock 1998). Finally, we conducted an exploratory analysis by fitting models that were not specified *a priori*.

RESULTS AND DISCUSSION

We randomly selected n_{Area}=135 plots from the area frame (N_{Area}=3,137 plots), but 2 were excluded because they were not accessible by passable public roads and were not visited by observers (Figure 1). Inferences, therefore, were limited to portions of the study area that were accessible by public roads during spring. We randomly selected n_{List}=135 plots from the list frame (N_{List}=181 plots), 1 of which was excluded due to inaccessibility. Six of the plots selected from the area frame were also on the list frame, so $n_{nonoverlap}$=127 plots were in the nonoverlap domain (i.e., 127=135–2–6), and $n_{overlap}$=140 plots were in the overlap domain (i.e., 140=135–1+6).

The AIC-best *a priori* model for *p* was the "global" model, which contained all 16 covariates (i.e., 5 for observers, recapture, day of the study, time of day, temperature, wind speed, presence of precipitation, proportion of the sky obscured by clouds, road density, density of interior roads, proportion of suitable land cover types that were visible from roads, and proportion of suitable land cover types that were under snow or temporary water). It accounted for 97% of the AIC weight in the model set for p.

The 4 best *a priori* models for occupancy, which accounted for 93% of the AIC weight, included covariates measured at the plot scale and land cover data that was corrected in the field (Table 2). Although they contained 21–25 parameters, only 6 model-averaged parameter estimates had confidence intervals that did not include 0 (Table 3). Wind speed, cloud cover, road density, and an observer effect were correlated with *p* (Figure 2; $\hat{\bar{p}}$ = 0.45, 95% CI=0.34–0.56). Road density was also correlated with occupancy (Figure 3). No land cover covariates, however, were correlated with occupancy within each sampling frame. In the *a priori* analysis, models fit equally well at both spatial scales when using uncorrected GAP land cover data (Table 2).

The probability of occupancy based on model-averaged *a priori* models was 0.83 (95% CI=0.31–0.98) for plots in the overlap domain (i.e., from the list frame) and 0.09 (95% CI=0.01–0.46) for plots in the nonoverlap domain (i.e., from the area frame but not the list frame). Therefore, $\hat{\psi}$ = 420 (SD=270) plots in the study area were occupied by a lek. The lack of precision of $\hat{\psi}$ was acceptable, given the objectives of the study. The results, however, will be useful for evaluating the level of sampling effort necessary to estimate $\hat{\psi}$ with adequate precision at range-wide scales in the future.

We started the exploratory analysis by simplifying the model for *p* to include only the dominant 4 covariates rather than all 16 and by using combinations of covariates for ψ that may not have been included in the *a priori* set of models. The AIC-best occupancy model then included domain, habitat area, density of all roads, and density of paved roads as covariates for ψ. There was still much model-selection uncertainty, and the combined-1 and disturbance-1 models for ψ were only 2.0 and 3.1 AIC-units away from the best model.

We further refined the exploratory analysis by removing the domain covariate because it appeared to be an excellent discriminator between occupied and unoccupied plots and therefore potentially masking relationships between ψ and more informative landscape characteristics. Using a reduced model for *p* (K=5) and no domain covariate for ψ resulted in 3 models that accounted for 98% of the AIC-weight in the new exploratory model set (Table 4). As in the *a priori* analysis, the best-fitting models included covariates measured at the plot scale and land cover data that was corrected in the field. The model-averaged parameter estimates whose confidence intervals did not include 0 were those for the proportion of the plot covered in grass, distance to the next nearest lek observed the previous year, area of habitat in the plot, and density of roads (Figure 4).

A goal of this project was to be able to predict the probability of occupancy for any or perhaps all plots in the prairie-chicken range. That would require applying an occupancy model that only included covariates that are available for all plots in the range. The sets of models based on uncorrected data for landscape characteristics meet that criterion. Comparing only models that included covariate data that is available for all plots in the range, those that included measurements at the plot scale fit much better than those that included measurements at the landscape scale (Table 4).

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Table 1. *A priori* models for explaining variation in the probability (ψ) of a sample plot being occupied by a prairie-chicken lek in Minnesota during spring of 2005.

Name	Covariates included
Habitat-1	Grass[a], Prairie[a], Sedge[a], Forest[a,b], Crop[a], Edge[c], Tree[d], Lek distance[e]
Habitat-2	Grass, Prairie, Forest, Edge, Lek distance
Habitat-3	Grass, Forest, Lek distance
Habitat-4	Grass
Disturbance-1	Homes[f], Road density, Density of interior roads[g], Density of paved roads[g]
Disturbance-2	Homes, Road density
Combined-1	Grass, Forest, Lek distance, Habitat area, Homes, Road density
Combined-2	Grass, Forest, Lek distance, Homes, Road density
Combined-3	Grass, Forest, Lek distance, Habitat area
Lek distance	Lek distance
Forest	Forest
Habitat area	Habitat area
Niemuth	Grass, Sedge, Forest, Lek distance
Merrill	Forest, Homes

[a] Proportion of area in this cover type.
[b] Forest cover was estimated in the field. This was replaced by the nonhabitat category when we used uncorrected GAP data.
[c] Edge between forest and nonforest cover types or between nonhabitat and all other cover types when we used uncorrected GAP data.
[d] Presence of trees within suitable cover types; not available in the uncorrected GAP data.
[e] Distance from the nearest known lek during the 2004.
[f] Number of occupied human residences counted in the field; not available in the uncorrected GAP data.
[g] These covariates were observed in the field and were not measured for uncorrected data sets.

Table 2. Ranking of the best *a priori* models of occupancy of PLS sections by leks of greater prairie-chickens in northwest Minnesota during spring of 2005. Models with $\Delta AIC_c \geq 12$ are not shown.

LC data source[a]	Spatial scale[b]	Model[c]	K[d]	ΔAIC_c[e]	AIC-weight
Corrected	Plot	Disturbance-1	23	0.0	0.524
Corrected	Plot	Combined-1	25	2.1	0.181
Corrected	Plot	Disturbance-2	21	2.5	0.147
Corrected	Plot	Combined-2	24	3.9	0.074
Uncorrected	Plot	Combined-2	23	7.1	0.015
Uncorrected	Landscape	Combined-2	23	7.2	0.014
Uncorrected	Landscape	Disturbance-1	20	7.9	0.010
Uncorrected	Plot	Disturbance-1	20	9.0	0.006
Uncorrected	Plot	Combined-1	24	9.5	0.004
Corrected	Plot	Habitat-2	24	9.8	0.004
Corrected	Plot	Habitat-1	26	10.4	0.003

[a] Source of land cover data was either corrected or uncorrected GAP level 4.
[b] Scale-dependent covariates were measured within PLS sections (Plot) and within 1,600 m of the plot centroid (Landscape).
[c] Models for the probability of occupancy described in Table 1. All models included sampling domain as a covariate and the global model for the probability of detection, p.
[d] K = number of parameters, which includes 2 intercept terms—1 for the p portion of the model and 1 for the ψ portion.

[e] The difference In AIC_c values between a given model and the best model in the set.

Table 3. Parameter estimates averaged over the best 4 models of the occupancy of sample plots by leks of greater prairie-chickens in Minnesota during spring of 2005 and unconditional confidence intervals on the logit scale.

Probability	Parameter[a]	Estimated value	95% confidence limits Lower	Upper
Detection	Intercept	-2.269	-6.213	1.675
	Observer 1	-0.474	-1.310	0.362
	Observer 2	-0.363	-1.183	0.457
	Observer 3	-0.201	-0.925	0.522
	Observer 4	-0.749	-1.563	0.065
	Observer 5	1.187	0.359	2.015
	Recapture	0.211	-0.562	0.984
	Day	-0.150	-0.424	0.124
	Time	-0.081	-0.638	0.476
	Temperature	-0.028	-0.083	0.026
	Wind speed	-0.885	-1.253	-0.516
	Precipitation	0.106	-0.720	0.932
	Cloud cover	-0.768	-1.438	-0.098
	Road density	0.469	0.044	0.894
	Interior roads	-0.114	-1.223	0.995
	Proportion visible	2.705	-1.318	6.728
	Ground cover	0.388	-5.925	6.701
Occupancy	Intercept	0.180	-2.368	2.728
	Overlap domain	3.861	2.420	5.302
	Homes	-0.511	-3.793	2.772
	Road density	-1.373	-2.289	-0.456
	Paved roads	-1.062	-2.848	0.725
	Grass	0.276	-0.722	1.273
	Forest	0.259	-1.681	2.200
	Lek distance	-0.349	-1.577	0.878
	Habitat area	0.221	-0.556	0.998

[a] Parameter names for models for p, the probability of detection, are described in the text; parameter names for models for ψ, the probability of occupancy, are explained in Table 1.

Table 4. Ranking of the best exploratory models of occupancy of PLS sections by leks of greater prairie-chickens in northwest Minnesota during spring of 2005. Models with $\Delta AIC_c \geq 27$ are not shown.

LC data source[a]	Spatial scale[b]	Model[c]	K[d]	ΔAIC_c[e]	AIC-weight
Corrected	Plot	Grass+Lek distance+Habitat area+Road density	10	0.0	0.432
Corrected	Plot	Grass+Lek distance+Habitat area+Road density +Density of paved roads[f]	11	0.4	0.346
Corrected	Plot	Combined-1	12	1.5	0.206
Corrected	Plot	Combined-2	11	6.6	0.016
Uncorrected	Plot	Combined-2	10	14.9	<0.001
Uncorrected	Plot	Grass+Lek distance+Habitat area+Road density	10	16.8	<0.001
Uncorrected	Plot	Combined-1	11	16.9	<0.001
Corrected	Plot	Combined-3	10	17.7	<0.001
Corrected	Plot	Habitat-1	14	17.9	<0.001
Corrected	Plot	Habitat-2	11	18.3	<0.001
Corrected	Plot	Habitat-3	9	18.4	<0.001
Uncorrected	Landscape	Combined-2	10	19.7	<0.001
Corrected	Plot	Niemuth	10	20.0	<0.001
Uncorrected	Landscape	Grass+Lek distance+Habitat area+Road density	10	20.1	<0.001
Uncorrected	Landscape	Habitat-2	11	26.9	<0.001

[a] Source of land cover data was either corrected or uncorrected GAP level 4.
[b] Scale-dependent covariates were measured within PLS sections (Plot) and within 1,600 m of the plot centroid (Landscape).
[c] Models for the probability of occupancy described in Table 1. All models excluded sampling domain as a covariate and the model for the probability of detection, p, included wind speed, cloud cover, road density, and 1 observer effect.
[d] K = number of parameters, which includes 2 intercept terms—1 for the p portion of the model and 1 for the ψ portion.
[e] The difference In AIC_c values between a given model and the best model in the set.
[f] This covariate was observed in the field and was not measured for uncorrected data sets.

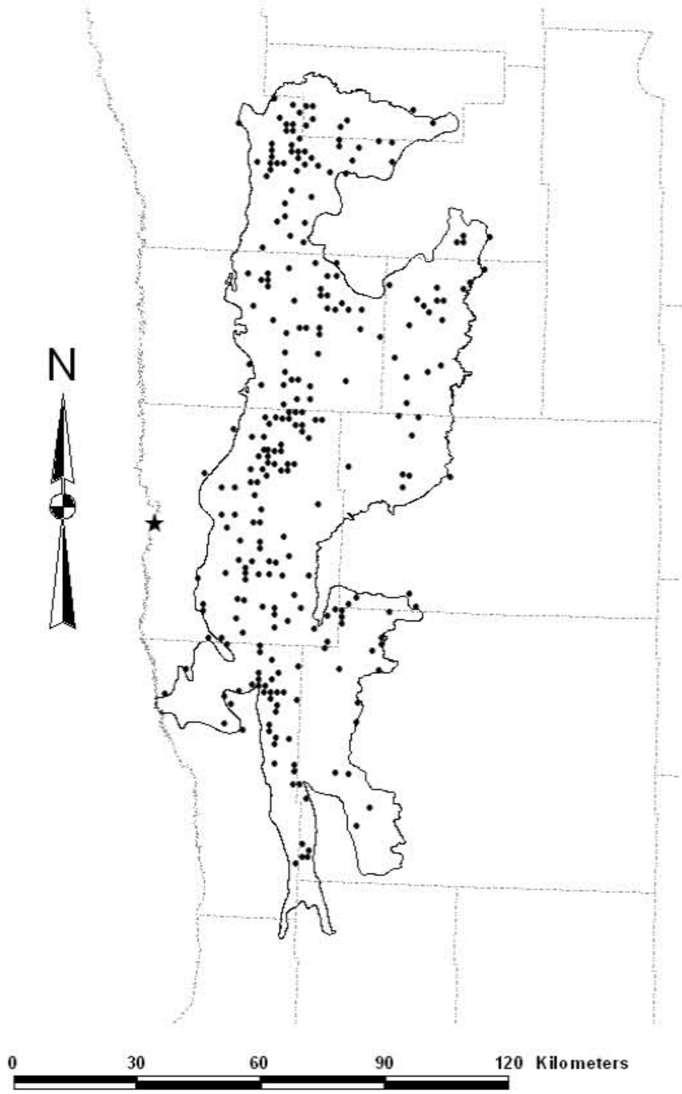

Figure 1. The northwest prairie-chicken range based on land type associations of the Ecological Classification System (solid line) relative to county boundaries (dashed lines) in western Minnesota. Sample plots (dots) were not selected from areas >90 km southeast of Moorhead (star).

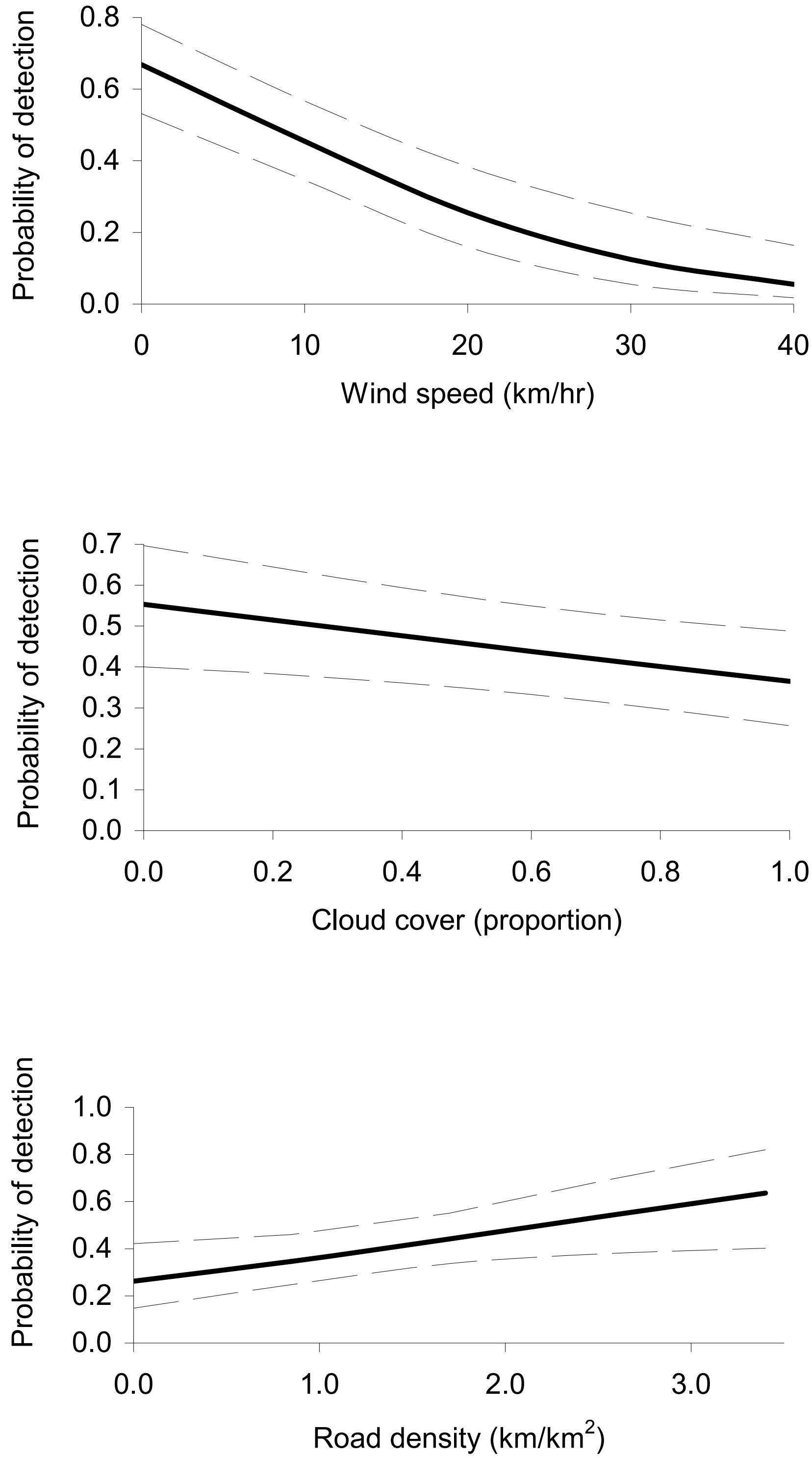

Figure 2. Model-averaged probabilities (and 95% confidence intervals) of detecting a prairie-chicken lek in sample plots in Minnesota during spring of 2005 over the range of observed values of 3 selected model parameters based on *a priori* models.

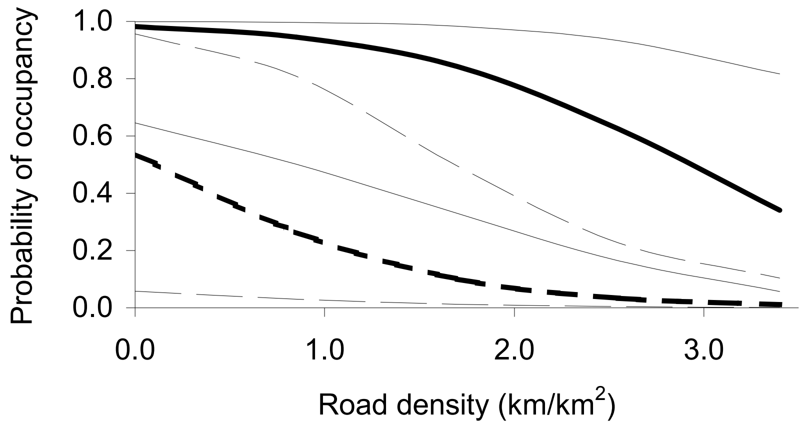

Figure 3. Model-averaged probabilities (heavy lines) and 95% confidence intervals (light lines) of a sample plot in Minnesota being occupied by a prairie-chicken lek during spring of 2005 over the observed range of road densities in the overlap domain (i.e., plots known to have contained a lek during 2004; solid lines) and nonoverlap domain (i.e., all other plots in the study area; dashed lines) based on *a priori* models.

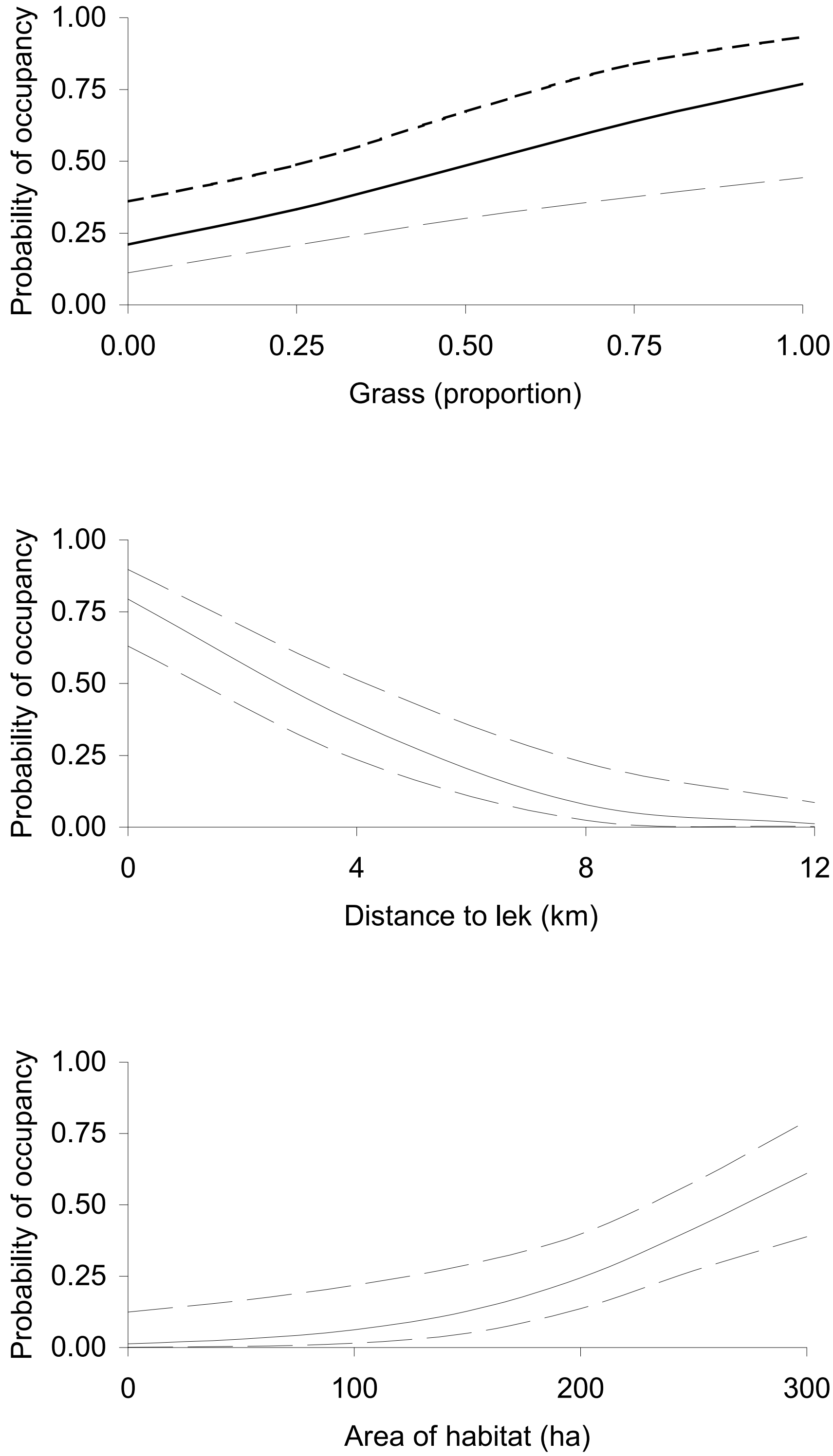

Figure 4. Model-averaged probabilities (and 95% confidence intervals) of detecting a prairie-chicken lek in sample plots in Minnesota during spring of 2005 over the range of observed values of 3 selected model parameters based on an exploratory analysis.

IDENTIFYING PLOTS FOR SURVEYS OF SHARP-TAILED GROUSE IN MINNESOTA

Michael A. Larson and J. Wesley Bailey

SUMMARY OF FINDINGS

The justification, objectives, and methods for this project are identical to those for the prairie-chicken project, which is summarized separately. Study areas for sharp-tailed grouse (*Tympanucgus phasianellus campestris*) covered the core of the eastern and northwestern portions of the species' range in Minnesota (Figure 1). Detection–nondetection surveys for sharp-tailed grouse were completed during 2006 and 2007. Land cover data associated with sample plots have been summarized at 2 different spatial scales. Analyses of the data are in progress. Therefore, results for sharp-tailed grouse are not available at this time.

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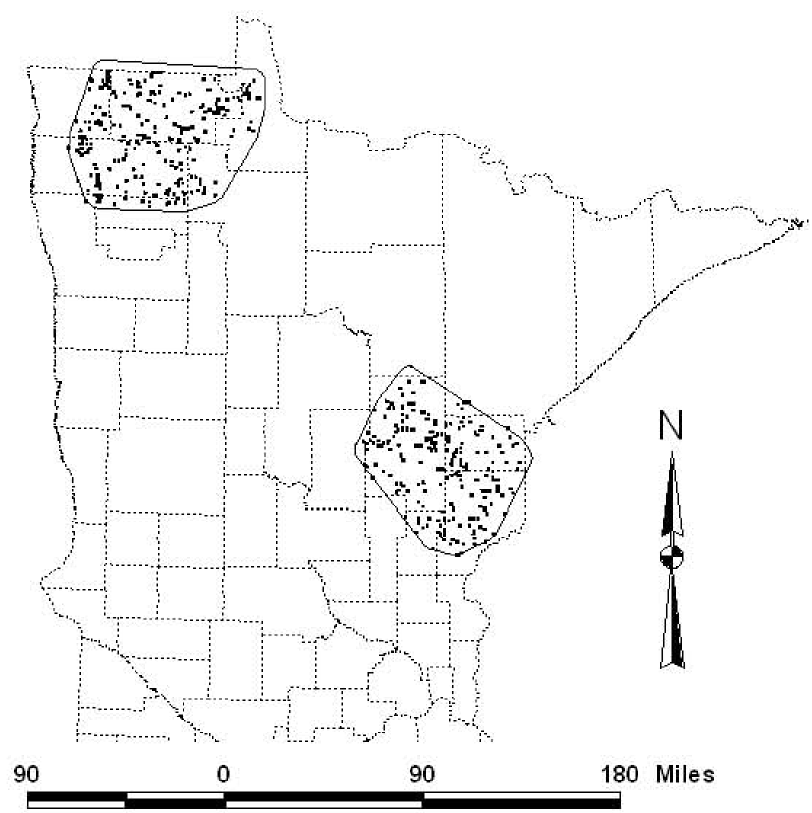

Figure 1. Sharp-tailed grouse study areas (solid lines) relative to county boundaries (dashed lines) in northern Minnesota. Sample plots (dots) were selected randomly after screening for road access and minimum habitat availability.

TRANSLATING BAIT PREFERENCE TO CAPTURE SUCCESS OF NORTHERN WHITE-TAILED DEER[1]

Meredith A. Barrett, Sabrina Morano, Glenn D. DelGiudice, and John Fieberg

ABSTRACT

Wildlife management and research have depended upon trapping as an essential tool for decades. Although deer (*Odocoileus* spp.) capture by Clover traps remains a basic technique that has changed little over time, researchers use it as an integral part of field operations to support increasingly sophisticated and costly project objectives. Despite reports of deer preference for certain baits, no study has determined if bait preference can effectively increase capture success of free-ranging deer. By supplementing corn bait with salt, peanut butter, or molasses, we tested effects of these bait treatments on capture success of free-ranging white-tailed deer (*O. virginianus*), as well as levels of non-target animal disturbance in Clover traps, during February–March 2005. With 1,446 adjusted trap-nights and a 6.5% capture success rate, the probability of capture increased over time and varied among 4 study sites (df = 3, P < 0.001); however, we did not detect a significant effect of bait supplementation on capture success (df = 3, P >0.8). Non-target animal activity in the trap varied by site (df = 3, P < 0.001), bait treatment (df = 3, P = 0.04), and Julian date (df = 3, P < 0.001). Our results are the first to suggest that bait preference may not translate into actual improved capture success of free-ranging deer. Future research should focus on testing additional baits or bait supplements to determine if an increase in trapping success and a minimization of trap disturbance by non-target species occurs.

[1]Journal of Wildlife Management (2008) 72: 555-560.

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 and Barry A. Sampson

SUMMARY OF FINDINGS

The goal of this long-term investigation is to assess the value of conifer stands as winter thermal cover/snow shelter for white-tailed deer (*Odocoileus virginianus*) at the population level. Over the course of the 15-year study period, we radiocollared and monitored a total of 452 female deer, including 43 female newborn fawns. During the past 12 years, data generated from this study provided the basis for scientific and popular articles addressing supplemental feeding effects on winter food habits of white-tailed deer; age-specific survival and reproduction; cause-specific mortality; seasonal migration; safe capture, chemical immobilization and handling; wolf predation; bait selection and capture success; and disease of deer; as well as progress in applied geographic information system (GIS) technology. These papers allowed us to explore new, more scientifically rigorous analytical approaches to viewing the diverse data sets we were accumulating. During the past year, we've been concentrating our efforts on: (1) examining annual variation in seasonal migration of deer and influential factors, as well as determining the most relevant and informative time origins and scales in survival analyses relative to the goals and objectives of our study; (2) using global positioning system (GPS) collars in field trials to determine the effects of habitat composition, body posture of deer and associated collar position on location acquisition performance; and (3) determining the effects of vegetative succession during the study period on classification of habitat types on the 4 study sites as the study progressed. These last 2 tasks are important to accurate determinations of habitat use by radiocollared deer throughout the study. All are described in more detail below.

INTRODUCTION

The goal of this long-term investigation is to assess the value of conifer stands as winter thermal cover/snow shelter for white-tailed deer at the population level. Historically, conifer stands have declined markedly relative to the increasing numbers of deer in Minnesota and elsewhere in the Great Lakes region. The level of logging of all tree species collectively, 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* animal level, indicating the seasonal value of this vegetation type to white-tailed deer and other wildlife species. However, agencies have anticipated increased pressure to allow more liberal harvests of conifers in the future. Additional information is needed to assure that 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.

OBJECTIVES

The null hypotheses in this study are that conifer stands have no effect on the survival, movement, or distribution of female 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 have been to:

- monitor deer movements between seasonal ranges by aerial radio-telemetry, and more importantly, within winter ranges, for determination of home range size;
- determine habitat composition of winter home ranges and deer use of specific vegetation types;

- monitor winter food habits;
- monitor winter nutritional restriction and condition via serial examination of deer body mass and composition, blood and bladder-urine profiles, and urine specimens suspended in snow (snow-urine);
- monitor age-specific survival and cause-specific mortality of all study deer; and
- 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 their survival.

STUDY DESIGN AND PROGRESS

This study employed a replicated manipulative approach, which is a modification of the Before-After-Control-Impact design (BACI; Stewart-Oaten et al. 1986; see DelGiudice and Riggs 1996). The study involves 2 control (Willow and Dirty Nose Lakes) and 2 treatment sites (Inguadona and Shingle Mill Lakes), a 5-year pre-treatment (pre-impact) phase, a 4-year treatment phase (conifer harvest serves as the experimental treatment), and a 6-year post-treatment phase. The 4 study sites located in the Grand Rapids-Remer-Longville area of north-central Minnesota are 13.0-23.6 km^2 (5.0-9.1 mi^2) in area. The study began with the Willow and Inguadona Lakes sites during winter 1990-1991. The Shingle Mill and Dirty Nose Lakes sites were included beginning in winter 1992-1993. The objective of the experimental treatment (impact) was to reduce moderate (40-69% canopy closure) and optimum (≥70% canopy closure) conifer thermal cover/snow shelter to what is considered a poor cover class (< 40% canopy closure).

Data collected on all 4 study sites included the following: (1) descriptive quantification of deer habitat by color infrared air photointerpretation, digitizing, and application of a geographic information system (GIS); (2) monitoring of ambient temperature, wind velocity, snow depth, and snow penetration (index of density) in various habitat types (e.g., openings versus dense conifer cover) by automated weather data-collecting systems, minimum/maximum thermometers, and conventional hand-held measurements; (3) deer capture, chemical immobilization, and handling data; (4) age determination by last incisor extraction and cementum annuli analysis; (5) physiological samples collected during captures and recaptures of radiocollared female deer and data generated by laboratory analyses, including complete blood cell counts (i.e., CBCs), serum profiles of about 20 characteristics, (e.g., reproductive and metabolic hormones, chemistries), urine chemistry profiles, and partial and complete body composition determination by isotope-dilution and visual ultrasound; (6) morphological measurements; (7) physiological assessment of winter nutritional restriction by chemical analysis of urine in snow; (8) seasonal migrations and other movements via very high frequency (VHF) and global positioning system (GPS) radiocollars; (9) habitat use; (10) annual and seasonal cause-specific mortality; (11) age-specific survival rates; (12) winter food habits; and (13) movements, territory size, survival, and cause-specific mortality of radiocollared wolves.

The 15th and final winter of data collection was 2004-2005. Over the course of the study period, we radiocollared and monitored a total of 452 female deer, including 43 female newborn fawns. During 1991 to 2006, in annual issues of the Minnesota Department of Natural Resources' (MNDNR) "Summaries of Wildlife Research Findings" we've presented summary data describing the winter weather conditions (e.g., weekly snow depths, monthly mean daily minimum and maximum ambient temperatures, winter severity index); live-capture success; and age distribution, pregnancy and fecundity (i.e., number of fetuses:doe) rates of the female cohort recruited for this study. Additionally, in those summaries we've addressed winter and annual mortality rates (and their relations to the varying severities of winter weather conditions), specific causes of mortality, and how the underlying age-specific hazard function (i.e., instantaneous probability of death) drove age-specific, seasonal, and annual survival rates of these females from birth to old age (up to 17.5 years old). To varying degrees we've presented preliminary descriptions of seasonal migration patterns of the collared deer; margins of safe capture, chemical immobilization, and handling; food habits; assessments of winter nutritional restriction and condition; as well as the territory sizes, survival, and specific fates of wolves ranging over the study sites.

Additionally, during the past 12 years, we've published a number of scientific and popular articles that have delved into supplemental feeding effects on *natural* winter food habits of white-tailed deer; age-specific survival and reproduction; cause-specific mortality; seasonal migration; safe capture, chemical immobilization and handling; wolf predation; bait selection and capture success; and disease of deer; as well as progress in applied GIS technology, in much greater detail than appropriate for the annual research summaries (Doenier et al. 1997; DelGiudice 1998; DelGiudice et al. 2001, 2002, 2005, 2006, 2007a; Carstensen et al. 2003, 2008; Carstensen Powell and DelGiudice 2005; Carstensen Powell et al. 2005; Raizman et al. 2005; Sampson and DelGiudice 2006; Barrett et al. 2008; Fieberg et al. 2008). Importantly, often as a result of collaborations with our Research Unit's biometricians (M. Riggs, J. Fieberg), these scientific articles and their associated in-depth analyses have allowed us to explore new, more scientifically rigorous and illuminating analytical approaches to viewing the diverse data sets we were accumulating during this long-term study (DelGiudice and Riggs 1996; DelGiudice et al. 2002, 2006; Fieberg and DelGiudice 2008a,b). These large data sets, analyses, and articles facilitated not only an increased understanding of numerous aspects of white-tailed deer ecology that we've been able to share with the scientific and management communities, but ultimately served as preparation for our most important upcoming data analyses relative to the long-term study's BACI design, primary goals, and objectives (described above). The many popular articles and presentations also allowed us to share current, interesting information synthesized from the data with numerous, diverse special interest groups, academic (K-12 and college-level) audiences, and the general public over the years.

During the past year, we've been concentrating our efforts on several tasks, including: (1) examining annual variation in seasonal migration of deer and influential factors, as well as determining the most relevant and informative time origins and scales in survival analyses relative to the goals and objectives of our study (see abstracts elsewhere in this issue of "Summaries of Wildlife Research Findings"); (2) using GPS collars in field trials to determine the effects of habitat composition, behavior and body posture of deer and associated collar position on location acquisition performance; and (3) determining the effects of vegetative succession on classification of habitat types on the 4 study sites as the study progressed. This final task is important to accurate determinations of habitat use by radiocollared deer throughout the study. Below we describe how we are assessing vegetative succession and the types of changes we've observed on our study sites. We also discuss how we have begun to examine GPS collar performance on study deer and the potential effects of "missed locations" (i.e., masking) on determinations of habitat importance.

Habitat Analyses and Updates

Detailed baseline habitat analyses using mirror stereoscope interpretation of color infrared air photos (1:15,840) and GIS (Arc/Info, ArcView) were completed early in the study. Forest stand types were classified according to their dominant 2-3 tree species, height and winter canopy closure. Open habitat types, water sources, and roads were also delineated. Our classification system was developed with the specific intent that it would facilitate an examination of potential relations between use of habitat types by white-tailed deer and their winter biological requirements.

During the 15-year study period there was potential for natural and human-induced changes of the vegetation/habitat to occur. Because we are examining habitat use by study deer (via radio-telemetry) during each year, it was important to update the classification of the habitat layers of the 4 study sites to account for vegetative succession, as well as habitat destruction (e.g., by flooding). This was particularly important for types that were openings when the study began, as well as for conifer types with canopies that may have succeeded from a less dense closure class (A [< 40%] or a B [40-69%]) to a more dense class (B or a C [≥70%]).

We had current air photo coverage taken and rectified by the MNDNR's Resource Assessment Laboratory during fall 2006, again at a scale of 1:15,840. We then were able to compare specific habitat types from the initial interpretation with the current coverage and determine whether significant change, particularly in conifer canopy closure and height classes or dominant species had occurred. Overall, on the Willow Lake control site, conifers increased 22.6% due to succession, with increases specifically in canopy closure classes A, B, and C of 29.7, 26.9, and 16.5%, respectively (DelGiudice et al. 2007b, Table 1). Conversely, on the Dirty Nose Lake control site, conifers declined 22.7%, with specific changes of 20.5, 30.8, and 23.7% in canopy closure classes A, B, and C, respectively. At the Inguadona Lake treatment site, conifers were reduced by 18.2% (primarily associated with the mid-study treatment harvests); A and C classes had decreased by 19.0 and 65.5%, respectively. Overall, there was a net increase of 39.7% in the B canopy closure class. Finally, at the Shingle Mill Lake site, decreases in all classes (A, 8.2%; B, 27.5%; and C, 7.5%) accounted for an overall decrease in area of conifers of 12.9%. Net changes in conifer canopy closure classes were attributable primarily to a combination of natural and human-induced sources: (1) destruction of stands by natural seasonal flooding; (2) planned, mid-study, treatment conifer harvests; (3) non-study, planned timber harvests committed to by cooperators (primarily U. S. Forest Service) prior to initiation of the study; and (4) gradual natural succession during the 13–15 years each site was part of the long-term study. Based on comparisons of the initial and final habitat analyses by color infrared photo-interpretations, we have recently completed extensive field measurements of stand heights for pre-selected habitat types, which had changed or were considered most likely to have changed, over the course of the study period. Based on linear regression analyses, these measurements and study-long changes in canopy closure classes, will permit us to estimate when (i.e., specific year) during the 15-year study period a given habitat type changed (e.g., based on stand height) from one type to another (T. Burke, Department of Forest Products, University of Minnesota, personal communication). This determination will facilitate more accurate assessments of deer use of habitat types throughout the study period.

Detailed spatial and temporal analyses of annual deer use of habitat types on the study sites relative to specific winter weather conditions and overall winter severity will begin during the current year. A preliminary analysis has shown that during phases of the study associated with mild to average winter conditions, deer distribution over the study sites was more dispersed and use of vegetative cover was more variable, whereas when influenced by severe winter conditions, deer locations were more concentrated in dense conifer cover. Location data sets from 32 GPS-radiocollared deer (programmed to collect data at 1–4-hour intervals over 24-hour daily periods) during 2001–2006, will be used to augment analyses of data collected by aerial location (from fixed-wing aircraft) of VHF-radiocollared deer and to enhance our understanding of deer use of winter cover types relative to varying weather conditions.

Evaluating GPS Collar Performance and Accounting for "Masking"

A second important prerequisite to accurately assessing winter use of habitat by deer is to evaluate and understand performance in the field of the GPS collar technology being used and to account for "masking," which is the effect that *failed* attempts, relative to pre-programmed location-sampling and specific habitat types, can have on determinations of their use and importance to deer. We have been applying ourselves to this effort using a 3-prong approach, which included examining indicators of technical performance (e.g., percent success, 2- versus 3-dimensional [D] locations, position dilution of precision [PDOP] values) for: (1) GPS collars fitted to our free-ranging female deer; (2) GPS collars placed (e.g., upright or on a side) within various pre-selected habitat types during controlled performance trials; and (3) a GPS collar fitted to an intact deer carcass, which allowed us to test the potential effects of body posture and head/neck position on collar performance within different habitat types (Sampson and DelGiudice 2008).

Data collection is complete and analyses are ongoing. However, we already have learned much about the performance of our GPS collars relative to habitat type and deer behavior and body posture. Herein, we provide several highlights. Overall mean fix success rate for our collared deer on their winter range was 72.4% (SE = 3.5, range = 25.0-99.0%, *n* = 32) versus 95.5% for the test collars (SE = 1.7, range = 46.0-100.0%, *n* = 34, Table 1). Because the GPS trials included collars placed in the same variety of habitat or vegetation types (e.g., open, dense conifer stands, aspen (*Populus* spp.) regeneration) used by deer during winter, without any significant variation in fix success rate ($\geq$90% for 31 of 34 collars, $\geq$95% for 25 of these), these combined data sets indicate that vegetative characteristics associated with structure (e.g., canopy closure, stem density) were not primary factors affecting fix success rate. Additionally, simply placing the GPS collar on its side had no apparent effect on the fix success rate. In the trials we did note a significant linear relation between percent of 3-D locations and percent success (r^2 = 0.73, P < 0.0001) and between percent locations with PDOP values of 0-5 and percent success (r^2 = 0.30, P = 0.0008).

These findings prompted us to consider whether position of the GPS collar on the deer, particularly relative to behavior of the animal and associated body posture (e.g., bedding), affected the fix success rate. We observed that the frequency of "missed locations" was greatest during the middle of the day (Figure 1) when white-tailed deer tend to be least active (Kammermeyer and Marchinton 1977, Marchinton and Hirth 1984). To explore this possibility, we fitted a recently road-killed deer with a GPS collar and placed it in a curled up, bedded position within vegetation types similar to those used by our GPS-collared free-ranging deer on their winter ranges (e.g., aspen regeneration, conifer stands with moderate to dense canopy closures). The collar was programmed to sample 1 location per hour over 1 to 5 days with the receiver position being either "in" (i.e., facing the deer's body) or "out" (i.e., facing away from the deer's body by varying degrees). What we noted was that when the GPS collar receiver was turned in, the mean fix success rate was only 16.8% (SE = 11.0, range = 0-60%, number of trials = 6), whereas, when it was even *slightly* exposed, the mean fix success rate was 95.8% (SE = 2.3, range = 89-100%, number of trials = 5). We will be performing additional analyses and further details will be presented elsewhere (Sampson and DelGiudice 2008), but thus far, evidence indicates that body posture and the associated position of the GPS collar receiver may be the primary factor influencing the fix success rate of the collar. These results will assist us in subsequent rigorous analyses of habitat use by our collared deer during winter, including how to account for missed locations in the data sets of each deer.

Our primary analytical approach during the coming year will include examination of survival and cause-specific mortality, migration, habitat use, physiological condition/status, and food habits data relative to the multi-year pre-treatment, treatment, and post-treatment phases of the study for deer inhabiting the control and treatment sites.

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Table 1. Mean (± SE) location-sampling success and indicators of performance for global positioning system (GPS) collars fitted to free-ranging female white-tailed deer and during controlled trials in the same habitat as the collared deer, near Grand Rapids, MN, winters 2000-2001 to 2006-2007.[a]

Deer/Trial	*n*[b]	% success 1 location/hr	% success 1 location/4 hr	Overall % success	% 3-D locations[c]	% PDOP values[d] 0-5	6-10	>10
Deer	32	72.0	70.7	71.0	64.4	78.6	14.8	7.0
		(4.0)	(4.2)	(3.9)	(1.8)	(1.2)	(0.6)	(0.7)
Trials	34	95.6	94.5	95.6	89.0	86.1	11.3	2.6
		(1.6)	(2.5)	(1.6)	(2.2)	(1.1)	(0.8)	(0.4)

[a]Trials involved setting GPS collars upright or on their side in various winter habitat types for several days, programmed to sample a location at 1 location per hour or 1 location per 4 hours.
[b]Sample size varied from 25 to 32 and 31 to 34 for the above performance indicators of collars fitted on deer or used in trials, respectively, depending on whether the sampling schedule included 1 location per hour or per 4 hours, or both. Additionally, on rare occasion, collar malfunction did not allow recording of data for an indicator.
[c]Three-D locations are 3-dimensional, which requires 4 satellites to simultaneously fix the location.
[d]PDOP is the position dilution of precision; lower values have been associated with more accurate location determination.

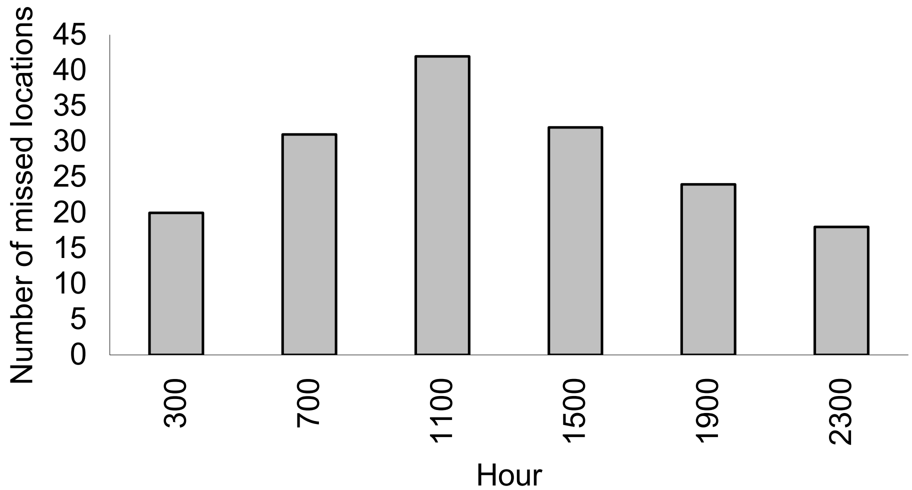

Figure 1. Typical temporal distribution of missed locations for adult, female white-tailed deer (no. 709) fitted with global positioning system collars programmed to sample 1 location per hour or 1location per 4- hour interval, near Grand Rapids, Minnesota, winter 2001-2002. Percent success for this deer was 60% (243 of 404 possible locations) at 1 location per 4-hour interval.

UNDERSTANDING VARIATIONS IN AUTUMN MIGRATION OF NORTHERN WHITE-TAILED DEER BY LONG-TERM STUDY[1]

John Fieberg, David W. Kuehn, and Glenn D. DelGiudice

ABSTRACT

Much of our present knowledge of mixed migration strategies of northern white-tailed deer (*Odocoileus virginianus*) comes from short-term studies, which limits the observed variation of winter severity, its potential influence on the migration behavior of study cohorts, and our understanding. From 1991 to 2006, we assessed: (1) the incidence of autumn migratory versus non-migratory behavior of 335 adult (>1.0 years old) females; (2) what proportion were conditional versus obligate migrators; (3) the importance of winter severity as a factor affecting the migratory response; and (4) the effect of winter severity and study length on the classification of deer as conditional or obligate migrators and the overall composition of the study populations. Annual winter conditions ranged from historically mild to severe. The annual estimated proportion of deer migrating from spring-summer-autumn range to winter range was positively related to winter severity, and the cumulative probability of deer migrating tracked accumulating snow depths as winters progressed. However, the relationship was highly variable, largely attributable to the annual variation in migratory behavior of individuals radio-monitored for 2-7 years. Importantly, due to the variability of autumn-winter weather conditions, we noted that the proportion of deer we classified as obligate migrators was inversely related to the number of years individuals were monitored. Further, the composition (non-migratory, conditional and obligate migrators) of the study cohort was strongly influenced by the severity of winter conditions in the year of capture, as well as in subsequent winters of monitoring.

[1]Journal of Mammalogy (2008) 89: In Press.

MANAGEMENT-FOCUSED RESEARCH NEEDS OF MINNESOTA'S WILDLIFE MANAGERS – FOREST MANAGEMENT ACTIVITIES

J. Wesley Bailey

SUMMARY OF FINDINGS

Because Minnesota Department of Natural Resources (MNDNR) wildlife managers requested help with evaluating the effectiveness of habitat management techniques, MNDNR Habitat Evaluation Biologists sent 65 research-needs surveys to all area wildlife, assistant area wildlife, regional, and assistant regional managers from all MNDNR regions during January 2008. Of the 65, 33 respondents answered the forest management activities section, with 9, 14, 9, and 1 responses received from Regions 1, 2, 3, and 4, respectively. I asked respondents whether a series of forest management activities and associated practices needed evaluation. When I pooled all responses, 93.9%, 69.7%, 69.7%, 63.6%, and 42.4% respondents stated that forest stand improvements, forest stand burns, brush-openland management, brush-openland burns, and forest openings, respectively need evaluation. Within forest stand improvements, 83.9% of managers ranked regeneration as needing the most evaluation. Regional priorities differed slightly from the pooled results. Region 1 selected brush-openland management as the most important habitat management activity whereas Regions 2 and 3 indicated forest stand improvements need most evaluation. Although these 2 regions selected forest stand improvements, Region 2 and 3 differed in their practice ranking. Region 2 selected thermal cover whereas Region 3 selected regeneration as evaluation priority. Overall, pooled and regional responses indicate forest stand improvements need the most evaluation, specifically those practices that affect regeneration and thermal cover.

INTRODUCTION

The MNDNR Section of Wildlife created 3 half-time Habitat Evaluation Biologist positions tasked with evaluating and monitoring wildlife habitat across Minnesota. Each research group houses 1 Habitat Evaluation Biologist position: Molly A. Tranel (Farmland), J. Wesley Bailey (Forest), and David P. Rave (Wetland). Because MNDNR wildlife managers requested help with evaluating the effectiveness of habitat management techniques, MNDNR Habitat Evaluations Biologists designed and conducted a survey of management-focused research needs. Our chief objective of this survey was to determine habitat management activities that managers believed warranted evaluation.

METHODS

MNDNR Habitat Evaluation Biologists designed a survey to determine habitat evaluation priorities of wildlife managers across Minnesota. Recipients (n =65) of the survey included all area wildlife managers, assistant area wildlife managers, regional managers, and assistant regional managers from across MNDNR regions. Microsoft Word format allowed participants to type in their responses and return the completed survey as an e-mail attachment. M. Tranel attached the survey to an e-mail message on 15 January 2008 that briefly explained the purpose and survey completion procedure. After a 2-week period, survey recipients received a reminder e-mail message encouraging completion of the survey. Respondents answered questions individually or as a group (usually no more than 3 people); therefore, some surveys may reflect the opinion of an area office rather than one person. The survey contained 3 sections: forest management activity, prairie management activity, and wetland management activity (Appendix 1). I report forest management results in this summary.

The forest management activities section contained 5 broad habitat management activities. Each of these contained practices for managers to rank. I also included a write-in practice ("other") for each forest management activity so that managers could type in techniques they felt needed evaluation but that are not included in the list. First, managers determined whether each broad management activity required evaluation within their management area by typing either "Yes" or "No". For management activities marked "Yes" managers then ranked the provided practices or ranked the practice they wrote in under "other" by using numbers with '1' as the most important. The broad habitat management activities are those that the Section of Wildlife developed for use by operations staff as expenditure categories.

I asked respondents to rank each practice within a management activity and assigned each unranked (i.e., blank) practice the lowest rank. This ensured that the sum of ranks was the same for all observers. I then calculated a mean rank for each practice within a forest management activity by averaging the ranks across respondents.

I used a 2-step process to analyze responses in the write-in category ("other"). First, I calculated their mean rank and noted the written response by each observer. I then compared this score to the other practices within the associated forest management activity. If "other" ranked highest overall, I categorized the written responses into groups and ranked each according to the total number of times each response was provided. I considered the category with the most responses priority for evaluation. I first report the mean rank for "other", which indicates how well the write-in responses as a whole compared to the other practices. I then report the most supported written category within "other" for the associated management activity.

I also calculated frequencies of responses to each management activity and practice. This frequency is the percentage of respondents that stated a given activity needs evaluation from the total number of respondents and represents the percentage of managers that responded to that activity; I calculated the same frequency for each practice within each forest management activity.

RESULTS

Of the 65 managers that received the survey, 67.7% (n = 44) responded. Of the 44, 75.0% (n = 33) answered questions in the forest management section. The majority (42.4%; n = 14) of responses came from Region 2, while Region 1 and 3 each sent in 9 surveys; only 1 respondent from Region 4 answered the forest management section. Because only 1 respondent answered forest questions from Region 4, I dropped these data from the analysis

Pooled Responses

When I pooled all responses, 93.9%, 69.7%, 69.7%, 63.6%, and 42.4% respondents stated that forest stand improvements, forest stand burns, brush-openland management, brush-openland burns, and forest openings, respectively need evaluation (Table 1, Figures 1 and 2). Within forest stand improvements, 83.9% of respondents ranked regeneration as priority for evaluation. Overall, regeneration scored higher than any of the practices within forest stand improvements with a mean score of 2.76 (Table 2). Timber harvest and thermal cover tied as second priority with a mean score of 3.61 each (Table 2). Vegetation response, mowing, and timing of burns ranked highest from the written responses in forest stand burns, brush-openland management, and brush-openland burns, respectively (Table 1 and 2). Overall, forest openings ranked last with 42.9% of respondents ranking this activity (Table 1), which indicates openings are not a priority for evaluation.

Regional Responses

Regional priorities differed slightly from the pooled results. Regions 2 and 3 indicated forest stand improvements need the most evaluation (Tables 1, Figures 1 and 2) with 100.0% and 88.9% of respondents respectively, ranking this category as priority. Although these 2 regions ranked forest stand improvements highest, Region 2 and 3 differed in their practice ranking. Region 2 selected thermal cover whereas Region 3 selected regeneration as priority activities of forest stand improvements (Tables 1 and 3). Region 1 ranked forest stand improvements second (Tables 1 and 3) with 75.0% of respondents ranking regeneration as in need of most evaluation.

All 9 respondents from Region 1 selected brush-openland management as the most important habitat management activity, with 77.8% of respondents ranking mowing and combined treatments (Tables 1 and 3) as top priority for evaluation. Region 2 and 3 ranked brush-openland management as fourth priority with the practice of shearing in need of the most evaluation (Table 1 and 3).

Region 2 and 3 selected brush-openland burning and forest stand burning, respectively as second priority, although both regions ranked timing and frequency of burns as in most need of evaluation (Table 3). All remaining forest management activities varied in ranking among regions although forest openings ranked last in Regions 2 and 3 (Tables 1 and 3).

DISCUSSION

Overall, forest stand improvements consistently ranked highest in evaluation need among regions. Almost 94.0% of managers from Regions 1, 2, and 3 agreed forest stand improvements need the most evaluation. Forest stand improvements include many interrelated habitat management practices that when implemented at multiple spatial and temporal scales, these activities likely affect a variety of wildlife species especially across the broad forested landscape. However, of the stand improvement techniques, managers believe regeneration needs the most evaluation. Tree cover regeneration is complicated because management objectives, including desired future conditions, prescriptions, site preparation, stand age, harvest treatments, and area affected, vary among cover-types and individual stands thus limiting our understanding of how to best improve wildlife habitat while meeting timber harvest goals. Subsection Forest Resource Management Plans (SFRMP) aid in developing long-term vegetation management plans on forest lands administered by the Division of Forestry and Section of Wildlife; however, the use of well-designed observational and manipulative experiments to evaluate factors affecting regeneration should help improve forest stand improvement information gaps.

Region 2 selected practices that influence thermal cover as needing the most evaluation. Tree cover-type and age-class may affect use of a stand as a thermal refuge. MNDNR and national forests in Minnesota plan to reduce aspen (*Populus* spp.) and convert these stands to conifer. How wildlife will respond is unclear, although white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*) may benefit as these animals seek refuge from winter and summer temperatures respectively, within conifers.

The majority of MNDNR wildlife managers do not consider evaluation of brush-openland management a current priority; only Region 1 placed high priority on this activity. Although managers indicated that they have sufficient information regarding brush-openland management, studies of how brush-openland wildlife and plant species respond to various types of management treatments are lacking. Brush-openland management practices may warrant evaluation, especially given the increased interest in using brush as a source for bio-fuels.

ACKNOWLEDGMENTS

I thank all the area and assistant area managers that responded to this survey. I thank M. A. Tranel who initially developed the survey for the farmland region; she also managed outgoing and incoming surveys and distributed completed surveys to each respective research group. I am grateful to M. A. Larson who suggested an alternative approach to analyze these data.

Table 1. Forest management activities and practices that wildlife managers ranked as in most need of evaluation based on frequency of response during January 2008 from wildlife work areas across Minnesota, USA.

Respondents	Management activity	Needs evaluation	Highest ranked practice[a]	Mean score	Frequency scored	n scored
Pooled (n = 33)	Forest stand improvements	93.9	Regeneration	2.76	83.9	26
	Forest stand burns	69.7	Other (Vegetation response)	1.17	91.3	21
	Brush-openland management	69.7	Other (Mowing)	1.89	65.2	15
	Brush-openland burns	63.6	Other (Timing of burn)	1.12	95.2	21
	Forest openings	42.4	Maintenance	1.86	78.6	11
Region 1 (n = 9)	Brush-openland management	100.0	Other (Mowing & combined treatments)	1.56	77.8	7
	Forest stand improvements	88.9	Regeneration	2.19	75.0	6
	Brush-openland burns	66.7	Other (Compare to mechanical)	1.17	100.0	6
	Forest openings	66.7	Maintenance	2.17	66.7	6
	Forest stand burns	55.6	Other (Vegetation response)	1.30	80.0	4
Region 2 (n = 14)	Forest stand improvements	100.0	Thermal cover	2.19	71.4	10
	Brush-openland burns	71.4	Other (Frequency & timing)	1.10	90.0	9
	Forest stand burns	71.4	Other (Frequency & timing)	1.15	90.0	9
	Brush-openland management	64.3	Shearing and mowing	1.89	66.7	6
	Forest openings	42.9	Maintenance	1.50	100.0	6
Region 3 (n = 9)	Forest stand improvements	88.9	Regeneration	2.19	87.5	7
	Forest stand burns	77.8	Other (Frequency & timing)	1.14	100.0	7
	Brush-openland burns	55.6	Other (Frequency & timing)	1.00	100.0	5
	Brush-openland management	55.6	Shearing and dozing	2.10	55.6	5
	Forest openings	22.2	Maintenance	1.67	50.0	2

[a] The write-in category ‘Other’ ranked highest within management activity; however, the practice in parenthesis ranked highest among the written responses within ‘Other’ and is considered priority for evaluation.

Table 2. Forest management activities and practices that wildlife managers ranked as in most need of evaluation based on pooled mean scores and frequencies during January 2008 from wildlife work areas across Minnesota, USA.

Management activity and practice	Mean score	Rank	n
Forest stand improvements			
Regeneration	2.76	1	26
Timber harvest	3.61	2	19
Thermal cover	3.61	2	19
Mast enhancement	3.97	3	18
Browse	4.11	4	19
Oak wilt	5.15	5	13
Other[a]	6.10	6	9
Categories within ‘other’[b]	Frequency	Rank	n
Diversity and site preparation	22.2	1	2
Invasive exotic control	22.2	2	2
All of the above	11.1	3	1
Direct seeding	11.1	3	1
Fencing-enclosure use	11.1	3	1
Herbicide use	11.1	3	1
White-tailed deer impacts	11.1	3	1
Forest stand burns	Mean score	Rank	n
Other	1.17	1	21
Fire break development	2.20	2	11
Categories within ‘other’	Frequency	Rank	n
Vegetation response	57.1	1	12
Timing and frequency	19.0	2	4
Forestry tool	9.5	3	2
Invasive exotic control	9.5	4	2
Compare to mechanical	4.8	5	1
Brush-openland management	Mean score	Rank	n
Other	1.89	1	15
Shearing	2.13	2	14
Dozing	2.65	3	11
Herbicide	3.33	4	2
Categories within ‘other’	Frequency	Rank	n
Mowing-hydroaxe	33.3	1	5
Combination of treatments	20.0	2	3
Biomass harvest	13.3	3	2
Timing and frequency	13.3	3	2
Wildlife response	13.3	3	2
Grazing	6.7	4	1
Brush-openland burns	Mean score	Rank	n
Other 1	1.12	1	20
Fire break development	2.05	2	17

Table 2 continued.

Categories within ‘other’	Frequency	Rank	n
Timing of burns	35.0	1	7
Control of regenerating brush	30.0	2	6
Compared to non-burn treatments	15.0	3	3
Combined treatments	5.0	4	1
Effects of fire on non fire-dependent plants	5.0	4	1
Invasive exotic control	5.0	4	1
Wildlife use of burned area	5.0	4	1
Forest openings	Mean score	Rank	n
Maintenance	1.86	1	11
Seeding	2.46	2	10
Slash clearing	2.68	3	10
Other	2.71	4	6
Categories within ‘other’	Frequency	Rank	n
Wildlife value	14.3	1	2
Deer value/use	7.1	2	1
Necessity	7.1	2	1
Opening burns	7.1	2	1
Wildlife use	7.1	2	1

[a] The write-in category ranked in comparison to practices within the management activity.
[b] Categorized responses within the write-in category of ‘Other’ ranked by the total number of responses to each category.

Table 3. Forest management activities and practices that wildlife managers ranked as in most need of evaluation by region based on mean scores and frequencies during January 2008 from wildlife work areas across Minnesota, USA.

Response group	Management practice	Score	Rank	n
Forest opening management				
Region 1	Maintenance	2.17	1	4
	Slash clearing	2.17	1	4
	Seeding	2.67	2	4
	Other[a]	3.00	3	2
	Categories within ‘other’[b]	Frequency	Rank	n
	Wildlife use	50.0	1	1
	Overall benefit	50.0	1	1
Region 2	Maintenance	1.50	1	6
	Seeding	2.40	2	5
	Other	2.50	3	3
	Slash clearing	3.42	4	5
	Categories within ‘other’	Frequency	Rank	n
	Value and necessity	66.6	1	2
	Opening burns	33.3	2	1
Region 3	Maintenance	1.67	1	2
	Seeding	2.33	2	2
	Slash clearing	3.00	3	2
	Other	3.00	4	1
	Categories within ‘other’	Frequency	Rank	n
	Value to deer	50.0	1	1
Forest stand burns				
Region 1	Management practice	Score	Rank	n
	Other	1.30	1	4
	Fire break development	2.10	2	2
	Categories within ‘other’	Frequency	Rank	n
	Vegetation response	100.0	1	4
Region 2	Other	1.15	1	9
	Fire break development	2.10	2	6
	Categories within ‘other’	Frequency	Rank	n
	Vegetation response	66.6	1	6
	Frequency and timing	16.6	2	1
	Evaluate burn	16.6	2	1
	Benefit as forestry tool	16.6	2	1
Region 3	Other	1.14	1	7

Table 3 continued.

	Fire break development	2.29	2	3
	Categories within 'other'	Frequency	Rank	n
	Vegetation response	57.1	1	4
	Frequency and timing	28.6	2	2
	Stand improvement	14.3	3	1
Forest stand improvements				
Region 1	Management practice	Score	Rank	n
	Regeneration	2.19	1	7
	Timber harvest	2.31	2	6
	Browse	3.44	3	5
	Thermal cover	4.13	4	5
	Mast enhancement	4.56	5	4
	Oak wilt	5.56	6	2
	Other	5.81	7	0
	Categories within 'other'	Frequency	Rank	n
	None suggested	0.0		0
Region 2	Thermal cover	2.19	1	10
	Regeneration	3.04	2	11
	Timber harvest	3.64	3	9
	Browse	4.07	4	10
	Mast enhancement	4.18	5	8
	Other	4.18	5	5
	Oak wilt	5.50	6	6
	Categories within 'other'	Frequency	Rank	n
	Site preparation effects	60.0	1	3
	Deer effects	20.0	2	1
	Fencing-enclosure use	20.0	2	1
Region 3	Regeneration	2.81	1	7
	Mast enhancement	3.38	2	5
	Oak wilt	3.88	3	4
	Other	3.88	3	3
	Thermal cover	4.13	4	3
	Browse	4.88	5	3
	Timber harvest	5.06	6	3
	Categories within 'other'	Frequency	Rank	n
	Invasive-exotic species control	66.6	1	2
	Evaluate all practices	33.3	2	1
Brush-openland burns				
Region 1	Management practice	Score	Rank	n
	Other	1.17	1	6

Table 3 continued.

	Fire break development	1.92	2	4
	Categories within 'other'	Frequency	Rank	n
	Frequency and timing	50.0	1	3
	Burning and mechanical combined	33.3	2	2
	Wildlife use post-burn	16.6	3	1
Region 2	Other	1.10	1	9
	Fire break development	1.90	2	8
	Categories within 'other'	Frequency	Rank	n
	Frequency and timing	44.4	1	4
	Evaluate burn	22.2	2	2
	Vegetation response	22.2	2	2
	Effect on non-fire dependent plants	11.1	3	1
Region 3	Other	1.00	1	5
	Fire break development	2.00	2	5
	Categories within 'other'	Frequency	Rank	n
	Frequency and timing	40.0	1	2
	Compare to not burning	20.0	2	1
	Invasive-exotic species control	20.0	2	1
	Brush control	20.0	2	1
<u>Brush-openland management</u>				
Region 1	Management practice	Score	Rank	n
	Other	1.56	1	7
	Shearing	2.39	2	4
	Dozing	2.72	3	4
	Herbicide	3.33	4	0
	Categories within 'other'	Frequency	Rank	n
	Brush mowing	28.6	1	2
	Combined treatments	28.6	1	2
	Biomass harvest	14.3	2	1
	Frequency and timing	14.3	2	1
	Wildlife response	14.3	2	1
Region 2	Shearing	1.89	1	7
	Other	1.89	1	6
	Dozing	2.89	2	4
	Herbicide	3.33	3	2
	Categories within 'other'	Frequency	Rank	n
	Brush mowing	50.0	1	3
	Biomass harvest	16.6	2	1
	Frequency and timing	16.6	2	1
	Wildlife response	16.6	2	1

Table 3 continued.

Region 3	Shearing	2.10	1	3
	Dozing	2.10	1	3
	Other	2.50	2	2
	Herbicide	3.30	3	0
	Categories within ‘other’	Frequency	Rank	n
	Combined treatments	50.0	1	1
	Patch-burn grazing	50.0	1	1

[a] The write-in category ranked in comparison to practices within the management activity.
[b] Categorized responses within the write-in category of ‘Other’ ranked by the total number of responses to each category.

Appendix 1. Survey of management-focused research needs consisting of 3 management sections sent to Minnesota Department of Natural Resources wildlife managers across Minnesota, USA.

Does it Need Evaluation? (Yes / No)	**Forest management activity**	**Rank (1 is Highest)**
________	**Forest opening management** (Developing, improving, and maintaining forest openings for wildlife, created during normal timber harvest management.)	
	• Slash clearing	_____
	• Seeding of log landings, logging roads, & trails to legumes for wildlife habitat	_____
	• Periodic or regular maintenance to maintain openings, etc.	_____
	• Other: ________________________	_____
________	**Forest stand burns** (Prescribed burning to enhance and restore forest communities and related wildlife habitat including openings.)	
	• Firebreak development	_____
	• Other: ________________________	_____
________	**Forest stand improvement** (All efforts relating to forest stand improvement.)	
	• Timber harvest	_____
	• Regeneration	_____
	• Mast enhancement	_____
	• Thermal cover establishment	_____
	• Browse regeneration	_____
	• Oak wilt control	_____
	• Other: ________________________	_____
________	**Openland/brushland burns** (The use of prescribed burning to enhance and restore brushland communities and related wildlife habitat.)	
	• Firebreak development	_____
	• Other: ________________________	_____
________	**Openland/brushland management** (The use of non-prescribed burn efforts relating to the restoration of brushland habitats and related complexes.)	
	• Shearing	
	• Dozing	_____
	• Herbicide	_____
	• Other: ________________________	_____

Does it Need Evaluation? (Yes / No)	**Prairie management activity**	**Rank (1 is Highest)**
________	**Prairie/grassland burns** (Prescribed burning to enhance/restore native prairie and other grassland communities and related wildlife habitat.)	
	• Firebreak development	_____
	• Seasonal timing of burns (spring, summer, or fall)	_____
	• Frequency of burns (how long between burns?)	_____
	• Other: ________________________	_____
________	**Prairie/grassland management** (All efforts related to the initial planting of native prairie/cool season grasslands as well as efforts to improve existing stands of grass.)	
	• Converting cool season stands to native grass	_____
	• Species diversity (% grass/forbs)	_____
	• Grazing	_____
	• Patch-burn techniques	_____
	• Exotic species removal and/or prevention	_____
	• Other: ________________________	_____
________	**Food plot establishment/maintenance** (All efforts related to food plot establishment and maintenance.)	
	• Providing seed to landowners	_____
	• Food plot maintenance	_____

Appendix 1 continued.

	• Necessity of plots • Other: ______________________	_____ _____
________	**Woody cover development** (All efforts to establish and maintain woody cover for the improvement of farmland wildlife habitat.) • Planting techniques • Effectiveness of plantings • Other: ______________________	

Does it Need Evaluation? (Yes / No)	**Wetland management activity**	**Rank (1 is Highest)**
________	**Wetland enhancement** (All activities that enhance wetland habitats for wildlife.) • Management of Aquatic vegetation • Cattail/Exotic species management • Aquatic seeding • Bog removal at basin outlets • Removal of unwanted fish (i.e., carp, bullheads) • Other: ______________________	_____ _____ _____ _____ _____ _____
________	**Wetland habitat maintenance** (All efforts to maintain wetland wildlife habitat.) • Fish barrier maintenance • Water level management • Minor dike/structure maintenance • Other: ______________________	_____ _____ _____ _____
________	**Wetland impoundment development** (The development of a new wetland where none historically existed by constructing a dike and water control structure in the appropriate topographic area.) • Dugouts/scrape outs • Other: ______________________	_____ _____
________	**Wetland restoration** (The restoration of a drained wetland by the plugging of drainage ditches or removal of drain tiles. Note: may include the restoration of part of an original basin where full restoration is not possible.) • Historical vs. current ecological functions • Species diversity of restored wetlands • Other: ______________________	_____ _____ _____
________	**Wetland water controls** (The addition or rehabilitation of water control structures, fish barriers, dikes and related inlets and outlets that enhance the value of existing wetland habitat.) • Impacts on aquatic wildlife • Impacts on non aquatic wildlife • Other: ______________________	_____ _____ _____

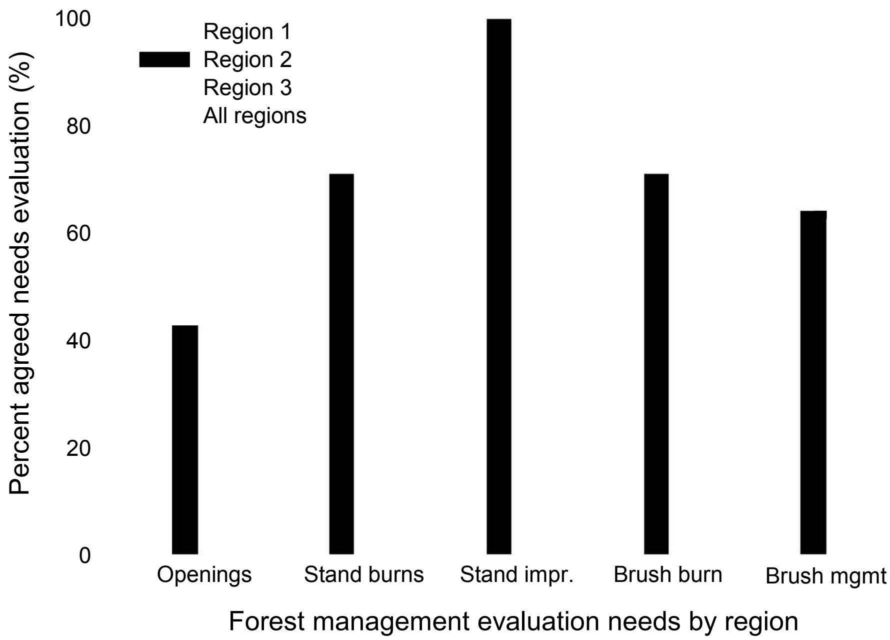

Figure 1. Percentage of wildlife managers that agreed each forest management activity needs evaluation based on frequency of response during January 2008 from wildlife work areas across Minnesota, USA.

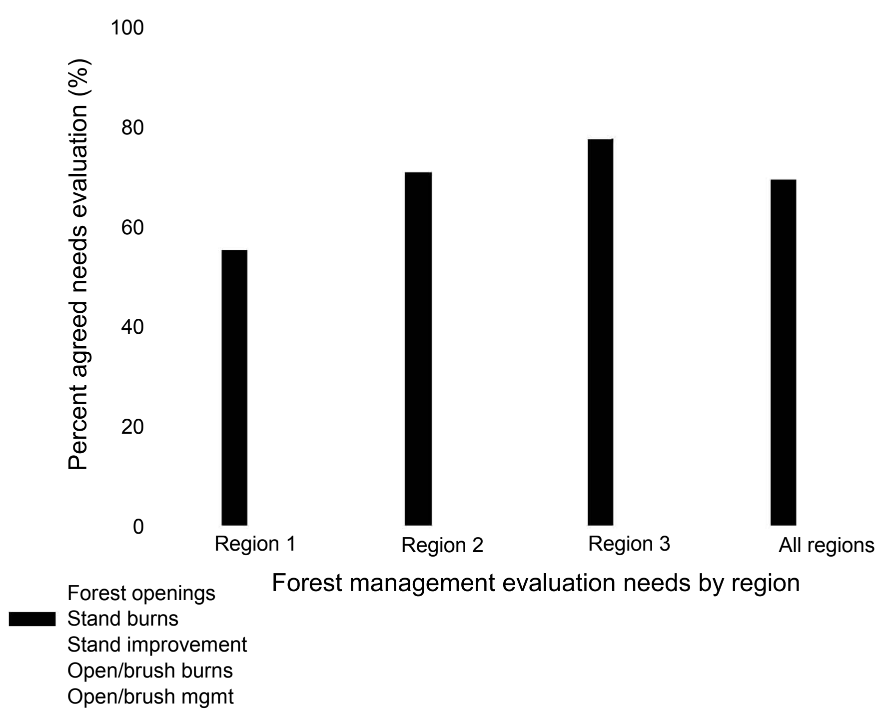

Figure 2. Percentage of wildlife managers within each region that agreed each forest management activity needs evaluation based on frequency of response during January 2008 from wildlife work areas across Minnesota, USA.

Climate Change:
Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources

Prepared by the
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EXECUTIVE SUMMARY

The Intergovernmental Panel on Climate Change (IPCC), in their latest assessment report, concluded that "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures…" (IPCC 2007:30), and "Most of the observed increase in global average temperatures since the mid-20th century is very likely [>90% probability] due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations" (IPCC 2007:39). Some of the impacts of recent warming on the Earth's biota have been documented (Parmesan and Galbraith 2004), and projected climate change will have implications for wildlife in particular (Inkley et al. 2004). In recognition of the importance and urgency of developing approaches to deal with climate change, senior managers in the Minnesota Department of Natural Resources' Division of Fish and Wildlife convened a working group within the Section of Wildlife during August 2007. The purpose of the Wildlife Climate Change Working Group was to guide the Division of Fish and Wildlife in describing (1) climate change in Minnesota, (2) its effects on wildlife species and habitat, and (3) the development of wildlife management and monitoring actions needed to respond to this unprecedented wildlife management challenge. The goal was to produce this summary document by spring of 2008.

During the next 100 years average temperatures in Minnesota are projected to increase by 6–10 ^{o}F (3–5.5^{o}C) in winter and 7–16 ^{o}F (4–9^{o}C) in summer (Kling et al. 2003, IPCC 2007). Precipitation is projected to decline by 0–15% during summer but increase by 5–30% overall (Kling et al. 2003, IPCC 2007). The frequency of extreme precipitation events is projected to increase by 50–100% (Kling et al. 2003), which will result in greater surface runoff and less percolation into the soil. Increasing temperatures and declining soil moisture during summer will have dramatic effects on plant communities. The boundary between grassland and deciduous forest biomes will shift. Tree species composition in forests will change. Specific effects of climate change, however, are difficult to predict because of uncertainty in future precipitation patterns and because climate change will interact in complex ways with changes in other disturbances like human land use and invasive species. Climate change may affect forest disturbances by changing the frequency, duration, and severity of fires, tornadoes, outbreaks of insects and pathogens, thunderstorms, and drought (Dale et al. 2001). Due to differences among species in sensitivity to temperature and precipitation, rates of dispersal, and vulnerability to various disturbances and threats, biological communities with which we are familiar may not remain intact. New biological communities may be dominated by plant and animal species best able to disperse, including many of the invasive species we are currently managing.

Climate change will be beneficial for some species, but it is likely to be detrimental for many species. In response to climate change, plants and animals can adapt, migrate (i.e., shift their range), or become extirpated or extinct (Noss 2001). In Minnesota, it is likely that ranges of some species will shift generally from south to north with increasing temperatures and perhaps from west to east if summers become drier. It is predicted that ranges of many wildlife species may become smaller (Parmesan and Galbraith 2004). As the spatial distributions of species change, some species will become extirpated from Minnesota and others will move into Minnesota (Price and Glick 2002). Several wildlife species have expanded into northern Minnesota from the south during recent decades, presumably due to warmer temperatures and mild winters. Examples include mourning doves, northern cardinals, and opossums. Wildlife associated with near-boreal forests in northern Minnesota may be under the greatest threat of extirpation from the state due to climate change.

Rising interest in and development of renewable sources of energy, partially due to desires to mitigate for climate change, are influencing land-use decisions that affect wildlife. For example, in western Minnesota commercial wind turbine projects and planting feedstocks for ethanol fuel and biomass (e.g., corn, switchgrass) are becoming more common. Opportunities exist, however, to produce biofuels, sequester carbon from the atmosphere, and provide other ecosystem services using high-diversity plantings of native grassland perennials (Tilman et al. 2006).

We in the Wildlife Climate Change Working Group believe that communicating and establishing a clear, shared vision within the Section of Wildlife (or higher level within MNDNR) about climate change is important. A critical aspect of the vision should include being proactive in identifying and implementing responsible, science-based strategies for mitigating climate change and adapting to unavoidable climate changes. We also believe that the significance of climate change to the management and conservation of wildlife warrants making it an explicit priority of the Section, Division, and Department to develop and implement a proactive response to climate change.

In general, we in the Section of Wildlife should (1) focus on objectives that help the Section accomplish its mission and mandates; (2) acknowledge uncertainty when making decisions and confront it in a logical, productive manner; and (3) strive to work effectively with colleagues and stakeholders to achieve wildlife management goals. Furthermore, the Section of Wildlife as a whole should address climate change using mitigation and adaptation strategies. The following lists highlight some of our recommendations for how to approach climate change:[1]

Mitigate climate change:

- Accomplish gubernatorial mandates to reduce energy consumption and increase efficiency of energy use by staff (Pawlenty 2004*a*,*b*; 2005; 2006).
- Develop recommendations for personal choices that result in mitigation.
- Seek carbon sequestration opportunities that do not conflict with or diminish wildlife conservation.

Adapt to unavoidable consequences of climate change:

- Develop, utilize, and communicate transparent decision processes.
- Identify important decisions and decision thresholds, so management and monitoring objectives can be specified.
- Establish interdisciplinary teams to collaborate on climate change issues.
- Provide specific guidance to staff about whether or how to address climate change in management actions and planning efforts (USGAO 2007).
- Dedicate 1 new FTE position at the Program level in the Section of Wildlife or the Division of Fish and Wildlife to lead and coordinate climate change efforts.
- Link monitoring programs to specific management decisions or scientific hypotheses.
- Continue to acquire and manage land for wildlife purposes.
- Maintain ecological structures and functions (e.g., biodiversity, water quality).
- Reduce nonclimate stressors that we can influence now (e.g., habitat loss; Inkley et al. 2004:18).
- Proactively choose where and when to resist climate-induced changes, encourage resilience of systems to change, or enable climate-induced changes (Millar et al. 2007).

[1] The suggestions and recommendations in this report are intended primarily for the Division Management Team and, therefore, do not represent a statement of policy by the Section of Wildlife, Division of Fish and Wildlife, or any other unit within the Minnesota Department of Natural Resources.

1. INTRODUCTION

The most comprehensive research on climate change is summarized by the Intergovernmental Panel on Climate Change (IPCC). The IPCC, comprised of many scientists from around the world, was created by the World Meteorological Organization and the United Nations Environment Programme to provide an objective source of climate change information for policymakers. In their latest assessment report, the IPCC made the following conclusions: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (IPCC 2007:30); "Most of the observed increase in global average temperatures since the mid-20th century is very likely [>90% probability] due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations" (IPCC 2007:39); and "It is likely [>66% probability] that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica)" (IPCC 2007:39).

Some of the impacts of recent warming on the Earth's biota have been documented (Parmesan and Galbraith 2004), and projected climate change will have implications for wildlife in particular (Inkley et al. 2004). In recognition of the importance and urgency of developing approaches to deal with climate change, senior managers in the Division of Fish and Wildlife of the Minnesota Department of Natural Resources (MNDNR) started 2 initiatives. First, a group in Fisheries Research redesigned its long-term lake survey program to detect early climate change impacts. The new program is called Sustaining Lakes in a Changing Environment (SLICE, Valley 2008). The second initiative was to form a short-term working group within the MNDNR Section of Wildlife. Three Advisors, who provided direction and oversight, convened the Wildlife Climate Change Working Group during August 2007. The purpose of the working group was to guide the MNDNR Division of Fish and Wildlife in describing (1) climate change in Minnesota, (2) its effects on wildlife species and habitat, and (3) the development of wildlife management and monitoring actions needed to respond to this unprecedented wildlife management challenge. The goal was to produce this summary document by spring of 2008.

The organization of this report follows directly from our 3-point statement of purpose. Knowledge of climate change as it relates to Minnesota is summarized in Section 2. Observed and potential effects of climate change on wildlife and habitats are described in Section 3. Our suggestions for how to approach the challenges posed by climate change and ideas for next steps are presented in Section 4.

This report is intended primarily for the Division Management Team of the MNDNR Division of Fish and Wildlife and the Advisors of the working group. The efforts and products of the working group, including this report, are simply the Section of Wildlife's first step in considering how to approach the issue of climate change. The suggestions and recommendations in this report do not represent a statement of policy by the Section of Wildlife, Division of Fish and Wildlife, or any other unit within the MNDNR. Furthermore, there is no expectation for implementation of any of our recommendations unless or until they are requested by the Director of the Division of Fish and Wildlife or the Commissioner of the MNDNR and specified in a separate document.

2. CLIMATE CHANGE IN MINNESOTA

2.1. Climate predictions

2.1.1. How are climate change predictions made?

First, it is important to distinguish between weather and climate. Weather is the state of the atmosphere (e.g., temperature, wind speed, pressure, water vapor content) over a relatively short period of time (e.g., minutes to months). Climate is the average weather over a longer period of time (e.g., seasons to many years). Importantly, average conditions are often easier to predict than specific temporal and spatial patterns. For example, gross changes in climate (averaged across space) can be predicted by considering overall changes in solar and terrestrially emitted radiation resulting from increases in the concentration of greenhouse gases, decreases in surface reflectivity (or albedo) following snow and ice melt, variation due to the Earth's orbit, etc. (Thorpe 2005). More detailed predictions, however, are usually made with global circulation models (GCMs).

Similar to weather prediction models, GCMs forecast changes in atmospheric conditions using classic laws of physics (Thorpe 2005). This process requires modeling complex interactions between the atmosphere, oceans, land, and sea ice. Importantly, changes in climate may result from changes in external forces (e.g., solar radiation, volcanic activity), human actions (e.g., emission of greenhouse gases), and complicated feedback loops involving the climate system itself (NRC 2003), such as:

- melting sea ice reduces the Earth's albedo, which in turn increases average temperatures;
- warming air and sea temperatures influence ocean circulation patterns, which in turn influence heat and carbon uptake by the world's oceans;
- higher temperatures lead to more water vapor in the air, which in turn traps more energy radiated from the Earth's surface; and
- increased greenhouse gas concentrations may lead to changes in the amount and distribution of cloud cover, which in turn changes the reflective properties of the atmosphere.

Vegetation can also have a strong influence on climate (e.g., due to carbon uptake, evapotranspiration, and albedo effects) and vice versa. Plants typically assimilate more carbon with warmer temperatures, but changes in precipitation patterns and soil moisture levels may lead to large changes in the amount and distribution of vegetation. Wide-spread changes in land use that alter the amount of vegetation and the reflective properties of the Earth's surface are also expected in the future (see Section 2.2.2 below).

2.1.2. Model uncertainty

Weather and climate projections both require the solution to partial differential equations, which describe continuous changes in measurements through time and space. These solutions are approximated at a set of grid points using numerical methods. In the case of climate models, this grid is fairly coarse. As a result, effects on scales smaller than the grid cannot be accounted for directly in the models and must be predicted by linking historic regional data with GCMs of the Earth's climate system. Sub-grid predictions are typically more uncertain, particularly for climatic variables that vary substantially across space and that are difficult for GCMs to predict with a coarse grid (e.g., rainfall). Although predictions should improve over time with advances in computing power, considerable uncertainties result from limited understanding of the complex physical processes that influence climatic variables (e.g., the feedback loops discussed in Section 2.1.1) and inadequate parameterization of model sub-components. Forecasts must also consider a range of future greenhouse gas emissions that reflect uncertainty in future development trends, energy systems, and societies' responses to climate change. As with weather predictions, the range of possible outcomes is captured by making multiple projections starting at different initial conditions and using slightly different parameter values in the models. The end result is an ensemble of forecasts that can be used to describe predictive uncertainty.

2.1.3. Model validation

Climate models have been subjected to an extensive series of validation tests (IPCC 2007:Chapter 8), and have largely been able to reproduce accurate descriptions of the following:

- spatial distribution of observed climatic conditions on global and regional scales,
- explosive volcanic events leading to short-term perturbations in global climate,
- 150-year mean annual global temperature record,
- 50-year record of oceanic heat gain or loss,
- 1,000-year northern hemispheric surface temperature record, and
- 10,000-year reconstructed record of northern hemispheric surface temperatures.

However, these models cannot account for recent temperature increases without including emissions of greenhouse gases by humans (Stott et al. 2000, IPCC 2007). In its fourth assessment report, the IPCC concluded, "most of the observed increase in global average temperatures since the mid-20th century is very likely [>90% certainty] due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations" (IPCC 2007:39).

2.1.4. Summary of current predictions

The following are projections for the next 100 years, generated by linking GCM predictions from IPCC (2000) emission scenarios to past historic data from Minnesota (Kling et al. 2003):

- Average temperatures in Minnesota are projected to increase by 6–10 ^{o}F (3–5.5^{o}C) in winter and 7–16 ^{o}F (4–9^{o}C) in summer. The number of days with extreme temperatures (e.g., >95^{o}F) is expected to increase.
- Average annual precipitation for the Great Lakes region may increase, decrease, or stay about the same, but precipitation levels are expected to increase in the winter (15–40%) and decrease in the summer (up to 15%).
- Frequency of extreme precipitation events is expected to increase. Projections suggest 24-hour and multi-day heavy rainstorms will increase in frequency (50–100% higher than current values).

- With precipitation concentrated in fewer storm events of shorter duration, longer intervening periods of more intense drought and increased risk of wildfires may be expected.
- Duration of seasonal ice cover on the Great Lakes and inland lakes is expected to continue to decline (see also Austin and Colman 2007).

Projections from the latest set of climate models (IPCC 2007, Table 1) differ slightly from those above. Although the projections in Table 1 do not attempt to link coarse scale GCM results to historic data, they are based on more recent climate models.

Table 1. Differences in mean values of climate parameters for Minnesota during the 100 years between the periods 1980–1999 and 2080–2099 (IPCC 2007).

Climate parameter	Dominant change	Exception	Location of exception
Surface temperature (°C)			
Annual	+4	+3.5	Extreme south
Summer	+3.5	+4	Southwest
Winter	+4	+4.5	Extreme north
Precipitation (%)			
Annual	+5 to +10		
Summer	0 to -5	0 to +5	Extreme north

2.1.5. Summary of the potential impact of climate change in Minnesota

- Possibly reduced summer water levels will result in loss of wetlands and lower lake levels unless precipitation offsets losses.
- Pollution in the water supply is expected to increase (e.g., due to increased runoff associated with a greater frequency of larger storm events).
- Agriculture will see a longer growing season but may be constrained by a decline in soil moisture and an increase in soil acidity.
- Increased frequency of severe weather events (e.g., storms, floods) will place heavier burden on emergency management, with increased costs in clean-up and rebuilding.

- Native aquatic plant and animal species will be affected by warming waters, oxygen depletion, possibly lower water levels, and increases in invasive species.
- Boreal forests will shrink, causing some terrestrial wildlife species' ranges to move northward.
- Recreation and tourism will be affected by loss of habitat, possible changes from pines to hardwoods, shifts in migratory bird populations, and reduced winter sporting opportunities.
- Warmer minimum winter temperatures will result in range expansions for some plant and animal species.
- Warmer nighttime summer temperatures will stress both humans and wildlife.
- The costs of suppressing wildfires are increasing rapidly and will likely account for an even greater portion of future natural resource budgets if anticipated changes in climate occur.

2.2. Other trends to consider with climate change

Addressing climate change in Minnesota will require consideration of large time scales, and the context in which we practice wildlife conservation is likely to change over time. It will be important, therefore, to consider potential impacts of trends in other major influences on wildlife, particularly those associated with human activities (Vitousek et al. 1997).

2.2.1. Human demographics

The following list of projections of future population demographics are from the Minnesota State Demographic Center < www.demography.state.mn.us >:

- Minnesota's population will increase by 2.7 million by 2060 (to 7.1 million total). Population gains are achieved by both natural increase (more births than deaths) and by immigration (internationally and from other states).
- Substantial growth in the Twin Cities suburbs and the Rochester and St. Cloud regions. The lakes area of northcentral Minnesota is also projected to have a considerable increase. Western Minnesota and the urban neighborhoods of the Twin Cities are projected to experience a slow growth or decline.
- "Baby boomers," born between 1946 and 1964, will produce a doubling of the number of people ages 55–69 by 2035 (623,200 in 2005 to 1,400,000). The population under age 65 will grow only 10%. The number of very old in Minnesota will surge after 2025 as baby

boomers begin to pass their 85th birthdays. Increasing longevity contributes to the predicted gains for this age group.

- Households in Minnesota will change. As the population grows older, more people will be living in small, one- or two-person households instead of in larger families (a projected decrease of more than 22% in the number of households with a married couple and children by 2035).
- Minnesota is one of the least diverse states in the nation (in 2000, minorities in Minnesota were 14% of the population vs. 33% for the U.S. average). However, Minnesota's non-white and Latino populations are projected to grow substantially faster than the white population. By the period 2025–2030, the non-white population will account for more than half of the total population gain. The Latino population is projected to almost triple over 30 years, due to a combination of international immigration, immigration from other states, and a high birth rate. Non-white and Latino populations are younger than the white population, and this will continue in the future.
- Levels of education have risen sharply in Minnesota. In the last 40 years, the number of people >25 years old having completed high school (high school graduation or GED) increased by 52% while the number having completed college rose by 75%. Levels of educational attainment are influenced by social and economic factors, but it is reasonable to expect this trend will continue.

Projected demographic changes are likely to influence societal values, attitudes, and beliefs about natural resource management issues. This may result in changes in outdoor recreation and support for wildlife management programs. For example, Minnesota's movement toward a population that is older, more urban/suburban, and comprised of increased numbers of non-white and Latino members suggests that rates of outdoor recreation will be lower in the future. Although overall sales of hunting licenses in Minnesota did not decline during 2000–2005, it is likely they will decline in the future because rates of hunting participation by younger adults (ages 16 to 44) is declining (Kelly 2005).

2.2.2. Land use conversion and intensification

Loss of habitat is the greatest immediate threat to wildlife populations (Czech et al. 2000). Habitat loss and fragmentation are often driven by changes in land use by humans. The most obvious and detrimental changes are conversions of land to uses that are not compatible with maintaining wildlife habitat, such as expansion of new infrastructure (e.g., houses, retail stores, roads; Radeloff et al. 2005) and conversion of small farms with crop fields, grasslands, and woodlots to suburban developments.

Intensifying particular land uses may have substantial negative impacts on wildlife conservation. For example, pressures to produce more energy from renewable sources is changing land uses in agriculture and forestry (Westcott 2007). There is concern that perennial grasses (e.g., on lands enrolled in the Conservation Reserve Program, or CRP) will be replaced by additional row crops or other feedstocks for ethanol production (Bies 2006). Burning biomass to produce heat and electricity will lead to collection of additional woody debris after timber cuts and the harvesting of shrubs from brushlands. Whereas the effect on wildlife habitat of specific land use changes may differ, the net effect of intensifying land use could be detrimental. On the other hand, special attention to bioenergy derived from low-input, high-diversity native grasslands (Tilman et al. 2006) could conceivably be managed to expand wildlife habitat while providing biofuel and other ecosystem services.

2.2.3. Costs of energy

Costs of energy are increasing and will continue to do so as fossil fuels, particularly conventional oil, become more scarce and transitions to alternative energy sources and technologies occur (EIA 2007), barring some unforeseeable event. This trend has already resulted in plans within the MNDNR to investigate ways in which we can use energy more efficiently (e.g., using more fuel-efficient vehicles) and reduce energy consumption (e.g., turning off lights and computers when they are not being used). Predictions about future energy availability vary widely, but it may become necessary to dramatically reduce even further the rates and overall amount of energy we consume, which may require changes in how we conduct our work. Another important consideration is that the increasing scarcity of oil and major shifts in energy production and use are likely to have even broader impacts on the economy (Cleveland et al. 1984, Hallock et al. 2004) and levels of future greenhouse gas emissions (Brandt and Farrell 2007).

3. EFFECTS OF CLIMATE CHANGE ON LANDSCAPES AND WILDLIFE IN MINNESOTA

Climate changes and their effects on wildlife and other natural resources have been observed and documented already (Parmesan and Galbraith 2004). Based on these observations, broad climate change predictions, and ecological theory, we can describe potential impacts on Minnesota's biological communities and wildlife populations. Models that can be used to predict specific outcomes of climate change at small spatial scales, however, do not exist yet.

3.1. General responses of plant and animal species to climate change

3.1.1. Adaptation

Species may adapt to climate change in various ways, including acclimatization, genetic evolution, and shifts in geographic distribution (i.e., range) to suitable sites (Noss 2001). Failure to adapt may result in population declines and extinction. Most species responded to past climate changes primarily by shifting their ranges (Noss 2001). However, current climate change is predicted to occur faster than previous changes during the Quaternary Period (1.8 million years ago to present), so it is uncertain whether rates of range shifts will be sufficient. Furthermore, range shifts may be difficult for species with poor dispersal abilities such as plants with large seeds, small forest vertebrates, and flightless invertebrates (Noss 2001).

Peters and Darling (1985) also believed that range shifts may be too slow for predicted climate changes, especially considering barriers to dispersal and migration. Even if native species can migrate, the high fecundity of invasive species makes it highly probable that invasives will be the first to arrive and dominate new sites. Habitat fragmentation, especially by agricultural and urban development, has created many barriers to movements of plants and animals (Noss and Csuti 1997, Iverson et al. 1999). Lack of appropriate soils, including moisture conditions, may be another barrier for plants. The Great Lakes pose a formidable barrier to species movements from the U.S. into Canada.

In Minnesota, it is likely that ranges of some species will shift generally from south to north with increasing temperatures and perhaps from west to east if summers become drier. It is predicted that ranges of many species may become smaller (Parmesan and Galbraith 2004). As the spatial distribution of species change, some species will become extirpated from Minnesota and others will move into Minnesota (Price and Glick 2002). More locally, especially in southeastern Minnesota and the North Shore where topographic relief is relatively pronounced, north slopes may act as refugia, allowing individuals and populations to remain in suitable microclimates by moving from south to north slopes.

Genetic adaptation in response to warming temperatures has been demonstrated by some species (Nowak et al. 1994, Hughes 2000) and depends on generation time as well as adequate levels of genetic variation within and among populations (Noss 2001). Species whose range and populations increase under climate change, such as many insects, may adapt well. For other species, however, genetic adaptation will be limited by anticipated declines in abundance and genetic variation as a consequence of selection imposed by climate change (Noss 2001).

Some wildlife species are distributed throughout most or all of Minnesota (Appendix A). These habitat generalists will be affected by climate change, but the effects may be less severe or more difficult to monitor than effects on species that are habitat specialists. Many habitat generalists demonstrate great adaptability to different levels of human development, including urban landscapes. Some of these species, however, may require management attention if climate change causes their populations to exceed acceptable levels. For example, managing white-tailed deer populations within goals will continue to be important (scientific names are provided in Appendix B). Survival of white-tailed deer is related to the frequency and severity of winter weather (DelGiudice et al. 2002) and could increase due to climate change. Impacts on deer may depend on specific moisture regimes. For example, increased winter precipitation may cause deeper snow pack, which reduces deer survival. As a large herbivore, deer have the potential to impact plant communities and species diversity. Over-wintering populations greater than 9.7–13.5 deer/mi^2 (25–35 deer/km^2) in fragmented forests result in local extirpation of trillium and other understory forbs and inhibit plant and forest restoration efforts (Augustine and Frelich 1998).

3.1.2. Biodiversity and new biological communities

Moisture, minimum and maximum temperatures, soils, and length of the growing season largely determine the composition and distribution of biological communities in Minnesota. Natural and human-induced disturbance regimes also influence our present and future natural environment.

Currie (2001) and Hansen et al. (2001) compared the predictions of various climate change models to known relationships between climate and species richness for the continental U.S. They noted that species richness of both endothermic and ectothermic species is strongly correlated with temperature. Endothermic species richness is greatest in moderately warm areas and decreases in hotter areas, suggesting that bird and mammal species richness may decline in temperate regions in response to global warming. Ectothermic species richness increases with temperature, and the richness-temperature relationship is even stronger than it is for endotherms. Species richness of ectotherms, therefore, may increase throughout the continental U.S. It is uncertain, however, whether temperature increases alone will be sufficient for amphibian populations to overcome recent population declines, numerous threats (e.g., disease, habitat loss), and potentially drier surface conditions due to climate change.

Changes in moisture and temperature associated with global climate change are likely to affect reproduction and survival in amphibians and reptiles. Rain and temperature trigger chorusing in some frogs, which is an important component of breeding (Busby and Brecheisen 1997). Temperature and water levels also affect predation on amphibians by affecting the length of vulnerable larval stages (Manjarrez 1996, Moore and Townsend 1998) and periods of activity (Bider and Morrison 1981). Temperature is related to sex ratios in some reptiles, and it is related to sexual maturation rate, overwinter survival, metamorphosis size (Werner 1986, Smith 1987), and mating success as it relates to body size and fecundity in amphibians (Berven 1981).

In response to climate change, some of the biological communities we currently manage will cease to exist, and new combinations of plant and animal species will emerge (Schugart et al. 2003, Inkley et al. 2004). The new communities may be simpler (e.g., contain fewer species) than the communities they replace and communities that develop as better competitors arrive (Hansen et al. 2001). Species' responses to climate change will depend on the specific characteristics, favoring generalists that can disperse effectively and adapt rapidly. In a few cases, species with similar characteristics and environmental requirements could occur in assemblages similar to those seen in current native plant communities. However, there will likely be unpredicted interactions between microbes, plants, and animals that create challenging management scenarios.

New biological communities may be dominated by plant and animal species best able to disperse, including many of the invasive species we are currently managing. Climate change will likely increase the number of invasive species in Minnesota, but it will also increase the reproductive capacity, survival, and competitiveness of existing invasive species and some non-native species that have been innocuous. It is likely that invasive species will disperse faster than the rate of climate change and be better able than other species to disperse in human-dominated and climate-altered landscapes (Hansen et al. 2001, Kusler 2006). A combination of climate change, invasive species, and decreased area of native habitats will likely promote homogenization of native plant communities, ultimately favoring the invasive species. Negative effects of invasive non-natives on native species, especially endangered species, are well documented (Pimentel et al. 2000) and can be expected to increase.

Changes in the relationships among pests and their hosts and predators can be expected, which may amplify the magnitude of natural disturbance regimes and hasten large scale community changes. Modeling by Logan et al. (2003) indicated that all aspects of insect outbreak behavior would intensify as the climate warms. Warmer temperatures are providing the opportunity for additional breeding cycles within a year. Price (2002) suggested that spruce budworm outbreaks can be expected to become more significant because of the species' response to warmer temperatures and a northward shift in the ranges of several of its major avian predators (e.g., wood warblers). Coupled with the expected increases in drought and fire, this asynchrony between predator and prey could hasten the loss of the southern boreal forest.

3.2. Potential effects of climate change on ecological provinces and systems in Minnesota

Following a national framework, the MNDNR and the U.S. Forest Service developed an Ecological Classification System (ECS) for ecological mapping and landscape classification in Minnesota (MNDNR 2008*a*). The system uses associations of biotic and abiotic environmental factors, including climate, geology, topography, soils, hydrology, and vegetation. There are 8 hierarchical levels of ECS units in the United States. Map units for 6 of these levels occur in Minnesota. In order from least to most specific (i.e., from top to bottom), they are Provinces, Sections, Subsections, Land Type Associations, Land Types, and Land Type Phases. Provinces are units of land defined using major climate zones, native vegetation, and biomes such as prairies, deciduous forests, or boreal forests (MNDNR 2008*a*). There are 4 provinces in Minnesota—Laurentian Mixed Forest, Eastern Broadleaf Forest, Tallgrass Aspen Parklands, and

Prairie Parkland (Figure 1, MNDNR 2006). This section of our report (3.2) is organized by provinces of the ECS.

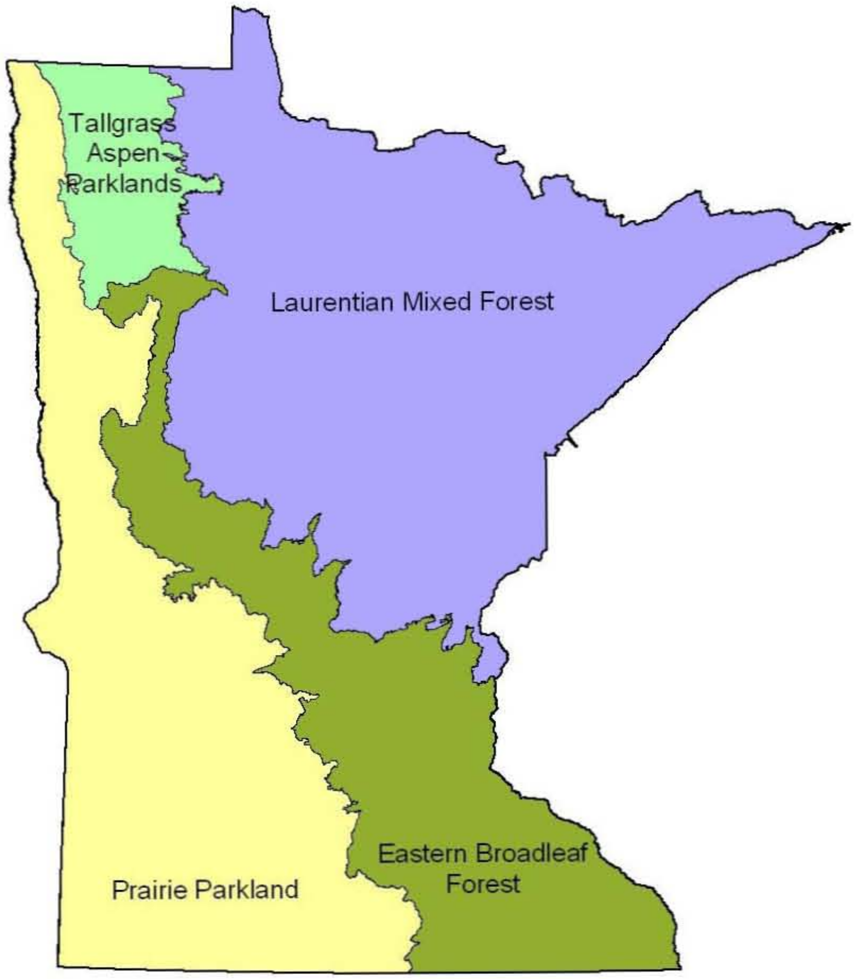

Figure 1. Provinces of the Ecological Classification System of Minnesota.

Nearly all ecological systems occur in more than 1 province. We tried to minimize redundancy, however, by discussing some of the main ecological systems in the context of only 1 province. We discuss upland coniferous forests, mixed coniferous-deciduous forests, and lowland coniferous forests in Section 3.2.1 (*Laurentian Mixed Forest Province*). We discuss deciduous forests and oak savannas in Section 3.2.2 (*Eastern Broadleaf Forest Province*). Our main treatment of lakes and wetlands is also in Section 3.2.2, but we discuss wetland issues in the sections for other provinces as well.

Minnesota DNR ecologists recently completed a new classification of the native vegetation of Minnesota (MNDNR 2008*b*). The new classification is intended to provide a framework and common language for management of native vegetation in Minnesota. The classification is hierarchical, with vegetation units described at levels ranging from broad landscape-level ecological systems to local communities. One of the most important features of the new classification is the inclusion of ecological processes as an organizing principle. The classification has 6 levels. In order from least to most specific (i.e., from top to bottom), they are System Group, Ecological System, Floristic Region, Native Plant Community (NPC) Class, NPC Type, and NPC Subtype (MNDNR 2003). The NPC classification system levels are referenced in the following discussion on impacts to ecological systems. We used plant and community descriptions contained in the Field Guides to Native Plant Communities of Minnesota (MNDNR 2003; MNDNR 2005*a*, *b*), especially fire dependence and soil characteristics, to make predictions of potential range shifts. The data and plant community knowledge acquired to develop the NPC classification system and the implementation of the system will be helpful as the MNDNR continues to analyze the potential effects of climate change on natural resources. In describing how provinces and ecological systems might be affected by climate change, we based our discussion on the available literature and our best professional judgment.

Many models of the effects of climate change exist, with some emphasizing impacts on particular ecological systems [e.g., DISTURB (Iverson and Prasad 2001), WETS (Johnson et al. 2005)] and others focusing on coarser scale changes in temperature and precipitation [e.g., Hadley Center model, Canadian Climate Center model (MacCracken et al. 2000)]. Models are simplified representations of reality and rely on assumptions that may limit their applicability and testability. For example, most of the ecological impacts models assume that habitat suitability is characterized by a few key parameters and that all available habitats will be colonized (Iverson and Prasad 2001).

3.2.1. Laurentian Mixed Forest Province

The Laurentian Mixed Forest Province is the largest of Minnesota’s 4 provinces, covering two-fifths of the state (Figure 1). This province is characterized by broad areas of conifer forest, mixed coniferous-deciduous forests, and conifer bogs and swamps. The landscape ranges from rugged lake-dotted terrain with thin glacial deposits over bedrock, to hummocky or undulating plains with deep glacial drift. The highest and lowest elevations in Minnesota both occur in this province (MNDNR 2006). The province supports many industries, including recreation, tourism, mining, and forestry. While the majority of the land remains forested, the age and species composition of trees have changed.

A distinct suite of boreal forest species inhabits this province. Animal species include great gray owl, Connecticut warbler, boreal owl, boreal chickadee, black-backed woodpecker, northern goshawk, spruce grouse, moose, gray fox, pine marten, and Canada lynx (scientific names are provided in Appendix B). Species of greatest conservation need (SGCN) are “animals whose populations are rare, declining, or vulnerable to decline and are below levels desirable to ensure their long-term health and stability.” The Laurentian Mixed Forest Province is home to 171 SGCN, 47 of which are found only in this province (Table 2). Habitat loss (75%) and degradation (83%) are the greatest immediate threats to these species (MNDNR 2006).

Table 2. Animal species in greatest conservation need (SGCN) in the ecological provinces of Minnesota (MNDNR 2006).

Province	Number of species	Number unique to province	Percent unique to province
Laurentian Mixed Forest	171	47	27
Eastern Broadleaf Forest	205	51	25
Tallgrass Aspen Parklands	85	2	2
Prairie Parkland	139	13	9

3.2.1.1. Upland forests in the Laurentian Mixed Forest Province

Warmer temperatures associated with climate change will clearly affect forest and woodland systems. Changes in precipitation will also have great impacts, but they will be more difficult to predict (see Section 2 above). Brush cover types may increase as the climate changes (Iverson et al. 2007). Climate change may alter the frequency and intensity of forest disturbances (Dale et al. 2001). Predictions include changes in the frequency, duration, and severity of fires, tornadoes, outbreaks of insects and pathogens, thunderstorms, drought, and ice storms. A higher frequency or intensity of disturbances could alter the way that forests recover from disturbances (Dale et al. 2001).

Of particular importance as a source of forest disturbance are insects, whose geographic ranges are largely determined by temperature. Short generation times and high reproductive rates result in rapid responses by insects to changing conditions, more rapid than those of their slow-growing tree hosts (Logan et al. 2003). Thus, insects will likely expand into forest communities that have previously been outside their range. This may disrupt the synchrony and associations between forest plant communities and forest pests that have formed over long periods of time, which may cause infestations to become persistent rather than episodic (USGAO 2007). Adverse effects of insects or other forest pests can appear suddenly, occurring when a temperature limit or other climatic threshold is passed and can include changes out of proportion to the relatively small climatic change that induced the effect.

3.2.1.1.1. Coniferous forests

Coniferous forests in Minnesota occur almost exclusively in the Laurentian Mixed Forest Province. Dominant conifer species in the province include white, jack, and red pines in uplands, where fire was the main historical disturbance, and black spruce, tamarack, and white cedar in lowlands, where small-scale blowdown was the main historical disturbance (MNDNR 2006).

Changes in plant species abundance and distribution will depend on species dispersal ability and moisture regimes, which are determined not only by precipitation but also by temperature, topography, evapotranspiration, and soils. Fire dependent forest systems (many pine types) will be particularly sensitive to a change in moisture regimes that result in wetter conditions and less frequent or less intense fires. If this scenario is realized, fire dependent forest systems will become less abundant in the Laurentian Mixed Forest Province. Mesic hardwood systems (e.g., red oak-sugar maple types) would likely experience a range expansion. Generally, a shift northward for spruce-fir forests is predicted (Hansen et al. 2003, Iverson and Prasad 2001). Tree species associated with lowland coniferous forests are predicted to decline in abundance and may convert to lowland hardwood forests (Hogg and Hurdle 1995). New combinations of plant and animal communities should be anticipated as species' ranges (described here primarily as tree species) shift. It is likely that global warming will cause the southern boundary of the near-boreal forest to migrate northward out of Minnesota.

If conditions in the Laurentian Mixed Forest Province are warmer and drier, fire dependent hardwood systems (e.g., bur oak) will likely increase with a range shift to the north and east. Jack and red pine woodland types (fire dependent on dry, nutrient poor soils) may persist or expand. The likely increase in fire frequency and intensity with warmer, drier conditions will influence fire dependent forest systems, both coniferous and deciduous. It is possible, however, that site specific characteristics (e.g., slope, aspect, soil type) and their influence on moisture availability will be particularly significant under this scenario. New associations of plants and animals are likely with the potential for dominance by invasive species.

Declines of coniferous forests will have negative impacts on the plant and animal communities associated with them. For example, spruce grouse feed on pine or spruce needles during much of the year (Boag and Schroeder 1992). Moose populations are declining (Lenarz 2008), perhaps due to heat stress (Murray et al. 2006). Habitat changes in northeastern Minnesota induced by climate change may also negatively affect moose populations. Wildlife associated with coniferous forests may be under the greatest threat of extirpation from Minnesota due to climate change.

3.2.1.1.2. Mixed coniferous-deciduous forests

Mixed coniferous-deciduous forests of Minnesota are located primarily within the Laurentian Mixed Forest Province. Typical trees in these forests include pine, spruce, balsam fir, oak, aspen, and maple. The mix of tree species and their relative importance within the canopy vary with the age, disturbance history, soil, and geographic location of the forest stand.

Warmer, drier conditions will likely favor fire dependent deciduous trees such as oaks and hickory (more commonly associated with the Eastern Broadleaf Forest Province) over aspen and birch. Jack pine woodlands may expand under this scenario, depending on how dry it becomes and how rich the soils are. Shifts in plant species’ ranges, diseases, pests, disturbances, and invasive species may contribute to the emergence of new and unpredictable species associations.

Warmer, wetter conditions would likely favor mesic hardwood types, which currently occur in but are not relatively abundant in the Laurentian Mixed Forest Province. Fires would likely be less frequent and intense under wetter conditions. Species that favor wetter sites include aspen, birch, and sugar maple. Soil characteristics and nutrients will also change species associations. Emerging combinations of plant and animals may be quite new and strongly influenced by invasive species, disease, and pests.

Global warming will likely cause some animal species associated with the mixed coniferous-deciduous forests to move northward and others to enter the province from the south. Because of the significant amount of public forestland in the Laurentian Mixed Forest Province, connectivity to the north is likely adequate but needs to be specifically maintained as part of forest management activities. Connectivity to the south likely is not as secure due to changes in ownership patterns, land use, and human population densities. Changes in distributions of plants and animals, as well as functional relationships among them, may take centuries to develop.

The impact of climate change on wildlife species will depend upon many factors, especially changes in plant communities with which they are associated. Ruffed grouse and snowshoe hares may decline in abundance and distribution as climate change reduces the dominance and shifts the ranges of aspen, birch, and balsam fir (Iverson and Prasad 2001). Breeding American woodcock also favor young aspen and paper birch stands (MNDNR 2006). The persistence of lynx in Minnesota, especially during low periods of the lynx–hare population cycles, may be less likely due to changes in habitat and snow depth patterns associated with climate change. Several wildlife species have expanded into the Laurentian Mixed Forest Province from the south during recent decades, presumably due to warmer temperatures and mild winters. Examples include mourning doves, ring-necked pheasants, northern cardinals, and opossums.

3.2.1.2. Lowland forests and wetlands in the Laurentian Mixed Forest Province

Wetlands within the boreal and near-boreal forests play an important role in the carbon cycle due to large accumulations of peat (Burkett and Kusler 2000), which are estimated to contain the equivalent of nearly 100 times the annual emissions of carbon dioxide from burning fossil fuels (Bridgham et al. 1995). Decomposition of peat is expected to accelerate under warmer, drier conditions, which will result in the release of carbon from these historical carbon sinks (Burkett and Kusler 2000). Climate change is also likely to alter water flow in peatlands, which influences water chemistry, peat accumulation and decay, and the species of trees that can grow (Heinselman 1970). Cash et al. (2007) pointed out that lakes contain 15% of the boreal carbon pool and should not be overlooked when considering the carbon cycle. Release of this carbon may have important feedback effects on climate change.

Lakes and wetlands in the boreal forest are the second most important area for breeding ducks (14 million waterfowl, USFWS 2002), yet survival and reproductive rates of ducks and other breeding birds in the boreal forest are poorly understood. Other species dependent on these wetlands in Minnesota include mink frogs, northern bog lemmings, and four-toed salamanders. The way these species will be affected by climate change is still unknown.

Non-boreal forested wetlands are also common in the Laurentian Mixed Forest Province. These wetlands and associated wildlife are also susceptible to drying under warmer, drier conditions. Wetlands dominated by ash trees, however, are also at risk of future infestations by the emerald ash borer, an exotic beetle from China that has killed >30 million ash trees in Michigan (USFS 2006).

Lowland conifers occur in the Laurentian Mixed Forest Province and the Tallgrass Aspen Parkland Province. Many ecologically important lowland conifers or bogs associated with large Scientific and Natural Areas (SNAs) may be affected by temperature increases more slowly than adjacent uplands due to their microclimate. Similarly, forest reserves and corridors closely associated with the microclimate of Lake Superior may be affected more slowly than forests further inland. These areas may serve as refugia from climate change and may support some species that might otherwise be extirpated.

3.2.2. Eastern Broadleaf Forest Province

The Eastern Broadleaf Forest Province is a transition zone between the prairie to the west and the mixed coniferous-deciduous forest to the northeast (Figure 1). The deciduous forests of this province are a species-rich extension of the eastern U.S. deciduous forest. Topography varies from level plains to steep blufflands along the Mississippi River, with major landforms of outwash plains, end moraines, ground moraines, and drumlin fields (MNDNR 2006).

The Eastern Broadleaf Forest Province coincides roughly with the part of Minnesota where precipitation approximately equals evapotranspiration. It seems likely that this aspect of climate has an important influence on plants because many forest species reach their western range limits and several prairie species reach their eastern range limits within the province. Precipitation in the province increases from about 24 inches (60 cm) annually in the northwestern portion to 35 inches (90 cm) in the southeast. Normal annual temperatures range from 38°F (3°C) in the northwest to 46°F (8°C) in the southeast (MNDNR 2003). Row crop agriculture is one of the major land uses in this province. Recreation and tourism are important industries, especially surrounding the many lakes and wetlands. Most Minnesotans live in this province, which encompasses the Twin Cities, St. Cloud and Rochester (MNDNR 2006).

The Eastern Broadleaf Forest Province is home to many wildlife species, including the red-shouldered hawk, cerulean warbler, Louisiana waterthrush, wild turkey, ruffed grouse, American woodcock, wood duck, and Blanding's turtle (scientific names are provided in Appendix B). Species of greatest conservation need in this province number 205, with 51 unique to the province (Table 2). Fourteen of the unique SGCN occur in the blufflands of southeastern Minnesota. Habitat loss (82%) and degradation (88%) are the greatest immediate threats to these species (MNDNR 2006).

3.2.2.1. Upland forests in the Eastern Broadleaf Forest Province

Site-specific characteristics such as soil type, evapotranspiration rates, aspect, and slope may be significant in determining climate-induced shifts in plant communities in this province, where fire disturbance is less widespread, primarily due to human influence. The western boundary of the Eastern Broadleaf Forest Province is sharply delineated with non-forested areas, whereas the northeastern edge is a diffuse transition from deciduous to mixed forests. Warmer, wetter conditions would likely favor mesic hardwood tree species, which are currently common in the Eastern Broadleaf Forest Province. Fires would likely be less frequent and intense under wetter conditions. Species that favor wetter sites include aspen, birch, and sugar maple. Soil characteristics and nutrients will also change species associations. Emerging combinations of plant and animals may be new and strongly influenced by invasive species, diseases, and pests.

Several climate change models predict warmer, drier conditions for existing deciduous forests. Under this scenario, deciduous forests will tend toward savanna types (fire dependent hardwood systems), if managed with fire, and the range of mesic hardwood forests will likely contract. If not managed with fire, these areas will likely become brushlands or become dominated by non-native woody invasive species. Iverson and Prasad (2001) predict expansions of oak-hickory and oak-pine forests (fire dependent-drier forest types) as well as reductions in aspen-birch forests (a mesic hardwood type).

Animal species associated with mesic hardwood systems (e.g., wood thrush, ovenbird, and red-backed salamanders) will likely decline. Birds such as cerulean warblers and red-shouldered hawks generally require large areas of contiguous mature or old growth hardwood forest and may be negatively impacted by climate change. An expansion of drier deciduous forests may result in an expansion in the ranges of animal species dependent upon them, provided the transition and climax forests include adequate habitat. The eastern hognose snake is an example of a species that may benefit from expanding dry oak forests.

Minnesota's deciduous forests have been severely fragmented by agriculture and urban/suburban expansion. They are at risk of further fragmentation and habitat degradation, especially near urban centers. Lack of habitat corridors and ongoing land development may compromise the ability of many species in deciduous forests to adapt to climate change. Furthermore, competition for groundwater resources may affect soil moisture regimes.

3.2.2.2. Oak savannas

Oak savanna plant communities occur in the Eastern Broadleaf Forest, Tallgrass Aspen Parklands, and Prairie Parkland Provinces. Oak savannas exist between forests and prairies and support biological communities from both adjacent biomes. Oak savannas, which have 10–70% canopy closure, are dominated by big and little bluestem, porcupine grass, Indian grass, bur oak, northern pin oak, and black oak in Minnesota (Taft 1997, Anderson 1998, MNDNR 2006). So few of the historical oak savanna NPCs remain (MNDNR 2006) that changes in land use are more likely than climate change to affect this biological community. Over 80% of the former oak savanna in Minnesota is now farmed, and the Minneapolis-St. Paul metro area is at its northern boundary (MNDNR 2006).

As in other prairie-forest transition communities, moisture is the most important limiting factor and fire is the most important disturbance (MNDNR 2008*c*). Warmer temperatures and wetter conditions could allow expansion of more mesic hardwood species at the expense of bur, northern pin, and black oak associated with oak savannas. This conversion is already occurring due to the lack of fire. Greater soil moisture would favor woody plants over herbaceous plants associated with oak savannas. New and more homogenous biological communities may emerge.

If the change is toward a warmer, drier climate in Minnesota, the oak savanna range may shift to the north and east, expanding further into the Eastern Broadleaf Forest Province and moving out of the Prairie Parkland Province. Drought conditions in general would favor growth of herbaceous rather than woody plants. Under warmer, drier conditions the frequency and intensity of fires would likely increase (Schwarz and Wein 1990). Depending on how fire is used as a land management tool, burning could contribute to conversion of forest to savannas and prairie. Without fire, there will likely be a slow transition to brushland systems potentially dominated by non-native species. Although oaks favoring drier sites may shift into historic mesic hardwood regions, it is unknown whether native herbaceous plants associated with oak savannas will also be able to shift in the presence of fast dispersing invasive plants. New combinations of species that are strongly influenced by invasive species, disease, and pests should be anticipated. One of the few animals linked closely with oak savannas is the red-headed woodpecker (Brawn 2006). Expansion of oak savanna range would likely benefit this bird.

3.2.2.3. Lakes and wetlands

Minnesota is at the latitude where the greatest impacts of climate change on aquatic ecosystems are predicted to occur (Stefan et al. 1996). Meyer et al. (1999) emphasized that these impacts must be assessed in the context of the massive anthropogenic changes in land and water use that will be occurring simultaneously.

Projected temperature increases will likely result in soil moisture deficits throughout Minnesota due to increased rates of evaporation and transpiration (Johnson et al. 2003, Kling et al. 2003, Johnson et al. 2005), although predictions of changing precipitation patterns are somewhat uncertain. Moisture deficits would reduce groundwater recharge, wetland area and water quality, and dry small streams (Hostetler and Small 1999, Johnson et al. 2003, Kling et al. 2003). Semi-permanent wetlands could be reduced in size and number (Johnson et al. 2005, Kusler 2006). Warmer average temperatures could also result in changes in native wetland communities through new opportunities for invasive species (both native and exotic) to expand their range northward (Kusler 2006). These changes could result in the loss of rare or range-restricted native species or regional losses of entire wetland communities.

Wetlands sequester large amounts of carbon, primarily as organic sediment and methane (Burkett and Kusler 2000). The net effect of climate change on carbon sequestration in wetlands, however, is still uncertain. Increases in atmospheric CO_2 concentrations will likely increase the primary productivity of wetlands, unless other factors such as moisture or temperature are limiting (Kusler 2006). Where moisture deficits occur, wetlands—especially peatlands—may become sources rather than sinks for atmospheric carbon due to increased decomposition (Burkett and Kusler 2000, Camill and Clark 2000).

The impacts of climate change on Minnesota lakes are expected to vary with latitude, trophic state, and lake morphometry (Stefan et al. 1996, Hostetler and Small 1999, Kling et al. 2003, Magnuson et al. 2003). In general, though, climate change will result in warmer, more productive waters, and eutrophication has implications for overall fish community integrity (Drake and Valley 2005). Temperature increases could increase annual evaporative water losses by as much as 30 cm (Stefan et al. 1996) and reduce summer water levels. Predicted increases in water temperatures, stratification (Stefan et al. 1996), and anoxic conditions would cause pronounced changes in aquatic habitats. Estimates of the increase in the ice-free season range from 40 to >100 days (Hostetler and Small 1999, Magnuson et al. 2003), and the frequency of winterkill of fish in some lakes will decline. Cold-water fish are predicted to lose habitat while cool- and warm-water fish gain habitat (Stefan et al. 1996). Cool- and warm-water fish, however, may actually realize a net loss of productivity if more favorable temperatures are not accompanied by increased food availability (Hostetler and Small 1999, Kling et al. 2003, Shuter et al. 2003).

3.2.3. Tallgrass Aspen Parklands Province

The Tallgrass Aspen Parklands Province in northwestern Minnesota is characterized by low, flat topography that was once part of Glacial Lake Agassiz (Figure 1). The portion of this province that is in Minnesota is the southern end of a much larger area that stretches north and west into Canada and serves as the transition zone between the prairie and forest, much like the Eastern Broadleaf Forest Province to the south. Historically, fire created a complex mosaic of prairie, brushland, and forest in the Tallgrass Aspen Parklands Province. Extensive peatlands occur in this province as well (MNDNR 2006). Over 60% of the province is used for agriculture (MNDNR 2006). Recreation, especially wildlife viewing, is an increasing industry. Large state and federal wildlife areas exist, which facilitates wildlife-related recreation.

Wildlife species of the Tallgrass Aspen Parkland Province include the sharp-tailed grouse, elk, moose, marbled godwit, bobolink, and upland sandpiper (scientific names are provided in Appendix B). Breeding waterbirds occurring here include the horned grebe, Franklin's gull, American white pelican, yellow rail, Forster's tern, trumpeter swan, and American bittern. A total of 85 species of greatest conservation need can be found in this province. Two of these are unique to the province (Table 2). Habitat loss (90%) and degradation (95%) are the greatest immediate threats to these species (MNDNR 2006). Common plant species in Tallgrass Aspen Parklands Province include aspen, paper birch, bur oak, black spruce, tamarack, big and little bluestem, cattail, and smooth brome (MNDNR 2005*b*, Appendix B).

3.2.3.1. Uplands in the Tallgrass Aspen Parklands Province

Moisture is the most important limiting factor and fire is the most important disturbance in forest-prairie transition zones (MNDNR 2008*d*). Climate change, therefore, may have dramatic impacts in these zones. Warmer temperatures coupled with wetter conditions could allow expansion of deciduous forests (Iverson and Prasad 2001) and brushlands into the remnant prairies and grasslands of the province. Greater soil moisture would favor growth of woody over herbaceous plants, resulting in canopied systems rather than open systems. Wetter conditions may reduce the frequency and intensity of fires. Higher rates of evapotranspiration under warmer temperatures will also be a factor influencing plant communities. Wildlife species that depend upon grasslands, including the chestnut-collared longspur, Baird's sparrow, and several species of butterflies, would be negatively affected by additional losses of grasslands in the Tallgrass Aspen Parklands Province (MNDNR 2006).

If changes are toward a warmer, drier climate, the impacts on wildlife in forest-prairie transitions would be different but still substantial. Deciduous forests in the Tallgrass Aspen Parkland Province would likely decline as the landscape becomes drier. Deciduous trees, especially aspens, would be subject to drought stress (Hogg and Hurdle 1995) and potentially more abundant insect defoliators and fungal diseases (Ives 1981, Zoltai et al. 1991, Peterson and Peterson 1992). Drought conditions in general would favor growth of grasses and other herbaceous plants rather than woody species. Under warmer, drier conditions the frequency and intensity of fires may increase and contribute to conversion of forest to prairie, especially if fire is used as a land management tool (Schwarz and Wein 1990).

Warmer, drier conditions could exclude wildlife that require cool, moist conditions, such as northern bog lemmings. Species like sharp-tailed grouse and white-tailed jackrabbits, however, would benefit from more open landscapes. In the Tallgrass Aspen Parkland Province large blocks of wildlife habitat exist that may facilitate the northward range shift of wildlife populations due to a warming climate.

3.2.3.2. Wetlands in the Tallgrass Aspen Parklands Province

Specific information on the impacts of climate change on aspen parkland wetlands is limited. Larsen (1995) modeled the relationship between climate variables and the percentage of wet basins and found that aspen parklands may be much more vulnerable to increased temperatures than either Canadian or U.S. grasslands. Camill and Clark (2000) argued that the complex ecological dynamics of the prairie-forest interface may include lags and thresholds that make it subject to sudden large responses that are difficult to discern from current vegetation.

3.2.4. Prairie Parkland Province

The Prairie Parkland Province stretches across most of southern and western Minnesota (Figure 1). Before European settlement the area was mostly covered by tallgrass prairies and wetlands, including sparsely vegetated sand dunes, vast expanses of tallgrass prairie, sedge meadows and marshes, and short-grass prairies on the Prairie Coteau. Major land forms of lake plains and ground moraines exist across land that is mostly level to gently rolling. Much of the flat, fertile land has been plowed for agriculture. Less than 1% (about 150,000 acres) of the original 18 million acres of prairie remains, and many grasses that persist are not native. Agriculture is the primary industry in the province (MNDNR 2006).

Ring-necked pheasants, gray partridge, and greater prairie-chickens occur in mixed crop-grass landscapes in Minnesota. Pheasants and partridge tolerate greater proportions of crop fields, whereas prairie-chickens and many grassland songbirds (e.g., bobolink) require more grass in larger patches. Other grassland wildlife species include the marbled godwit, upland sandpiper, Sprague’s pipit, chestnut-collared longspur, western meadowlark, Franklin’s and Richardson’s ground squirrels, and badger (scientific names are provided in Appendix B). Waterfowl and shorebirds that breed in the province include the trumpeter swan, Canada goose, mallard, northern pintail, canvasback, blue-winged teal, gadwall, redhead, northern shoveler, western grebe, Wilson's snipe, American bittern, sora, and Virginia rail. Species of greatest conservation need total 139 for the province, with 13 being unique to this province only (Table 2). Habitat loss (88%) and degradation (92%) are the greatest immediate threats to these species (MNDNR 2006).

3.2.4.1. Grasslands and agricultural lands in the Prairie Parkland Province

Hansen et al. (2003) reviewed potential effects of climate change on grasslands around the world. Where precipitation is likely to decline grasslands may experience decreased productivity and increased vulnerability to invasive species and wildfires. Populations of many wildlife species in the Prairie Parkland Province have responded to changes in agricultural policies and land-use practices (e.g., the Conservation Reserve Program). Given the intensive use of land by humans and paucity of native vegetation in this part of Minnesota, such policies and practices are likely to continue being the primary force affecting wildlife habitat. Climate change is unlikely to cause a dramatic change in potential native vegetation (e.g., from grass and forbs to trees) or a reduction in the proportion of land allocated to production of agricultural commodities in this province.

Rising interest in and development of renewable sources of energy, partially due to desires to mitigate for climate change, are influencing land-use decisions that affect wildlife. For example, commercial wind turbine projects and planting feedstocks for ethanol fuel and biomass (e.g., corn, switchgrass) are becoming more common. As mentioned in Section 2 above, however, opportunities exist to produce biofuels, sequester carbon from the atmosphere, and provide other ecosystem services using high-diversity plantings of native grassland perennials (Tilman et al. 2006).

3.2.4.2. Wetlands in the Prairie Parkland Province

The Prairie Pothole Region (PPR) is an area within central North America that is defined by glacially formed wetlands within a matrix of grassland and agriculture. The PPR, also called the "duck factory," is the most important area for breeding ducks. Currently, western Minnesota is the most eastern extent of the PPR. Climate change, however, is expected to bring drier conditions to the western PPR and shift the distribution of moisture in the PPR to the east into Minnesota. Nearly all models suggest soil moisture declines, fewer wetlands, shorter hydroperiods for temporary wetlands, more variation in the extent of surface water, and changes in depth, salinity, temperature, and aquatic plants in the PPR (Poiani and Johnson 1991, Larsen 1995, Poiani et al. 1995, Clair et al. 1998, Johnson et al. 2005).

Changes for prairie wetlands in Minnesota are difficult to predict because changes in precipitation are uncertain in climate models. If precipitation decreases, wetland conditions are expected to be too dry to provide good breeding habitat for waterfowl in most years (Johnson et al. 2005). Dry conditions have been linked to smaller clutch sizes, less reproductive effort, and reduced offspring survival and recruitment in waterfowl (Dzus and Clark 1998, Anderson et al. 2001). If precipitation increases, habitat conditions for waterfowl may improve in western Minnesota (Johnson et al. 2005).

Wetland losses in the western portion of the PPR, however, are not likely to be offset by gains in the east because many wetlands in western Minnesota have been drained for agriculture. As a result, duck distributions on the landscape are expected to change and duck populations are anticipated to decline (Bethke and Nudds 1995, Sorenson et al. 1998). Wetland protection and restoration in Minnesota are even more urgent in light of expected changes in wetland conditions in the PPR associated with climate change.

Climate change may affect other wildlife species associated with prairie wetlands. Wetland birds may experience mismatches between the timing of breeding and the availability of prey for offspring (Visser et al. 1998). Murphy-Klassen et al. (2005) documented that the first spring sightings of 27 of 96 migrant bird species at Delta Marsh, Manitoba, were significantly correlated with a trend of increased spring temperatures.

4. SUGGESTIONS FOR THE SECTION OF WILDLIFE'S APPROACH TO CLIMATE CHANGE

4.1. Organization transitions

Future climate conditions will present dramatic social, ecological, and economic changes for both individual Minnesota citizens and agencies mandated with management of Minnesota's natural resources. Individual adjustments to life-changing events or processes have been recognized to occur in a sequence of stages manifested as denial, anger, bargaining, depression, and finally acceptance (Kubler-Ross 1969). In discussions with staff and stakeholders about changing conditions, it will be important to understand and accept that individuals are at different stages along this continuum.

Bryson (2004) advises that organizations need to respond to dramatic changes or challenges in order to "survive, prosper and do good and important work." Organizational responses to challenges range from maintaining the status quo, maintaining previous approaches but increasing the intensity or volume of work, to shifting focus and strategies, or a combination of the latter 2. Organizational responses to dramatic and rapid changes can produce anxiety and decrease effectiveness in accomplishing the organization's mission. To be successful in realizing its mission, vision, and goals, an organization must also be aware of and manage these periods of transition.

Managing organizational change has been described as an 8-step process (Kotter 1996). The initial 4 steps focus on revisiting the status quo and energizing the organization around a new vision. The last 4 steps move the organization to the desired state, implements new practices, and reinforces changes in the organizational culture (Figure 2). A first step for Minnesota DNR was creating a Wildlife Climate Change Working Group to guide the Division of Fish and Wildlife in describing climate change in Minnesota, its effects on wildlife species and habitat, and the development of wildlife management and monitoring actions needed to respond to this unprecedented wildlife management challenge. The recommendations in this report begin to articulate a vision and strategies for conserving wildlife populations and habitats in the face of changing climate conditions.

4.2. Vision statement

As presented in Kotter's step 3 (Kotter 1996; Figure 2 here), creating a shared vision of a desirable future is a critical aspect of organizational change. Costanza (2000) discussed the importance of visioning in the context of conserving natural resources. The Wildlife Climate Change Working Group believes that communicating a clear vision and establishing a shared vision within the Section of Wildlife (or higher level within MNDNR) about climate change is important. We suggest the following vision statement to help guide the Section of Wildlife's approach to climate change:

The Minnesota Department of Natural Resources Section of Wildlife will continue to accomplish its mission[1] *in the face of climate change. Despite uncertainties about the future, staff within the Section will be proactive in identifying and implementing responsible, science-based strategies for mitigating climate change and adapting to unavoidable climate changes. Staff, others in public service, stakeholders, and the general public will understand the unprecedented challenges to wildlife conservation posed by climate change, and they will support the Section's decisions and initiatives related to climate change. Populations of diverse wildlife species will continue to be a critical component of the high quality of life of the citizens of Minnesota.*

4.3. Recommendations to Section and Division leaders

First and foremost, we in the Wildlife Climate Change Working Group think the significance of climate change to the management and conservation of wildlife—and natural resources in general—warrants making a proactive response to climate change an explicit priority of the Section, Division, and Department based upon our missions and legal mandates.

A few guiding principles—sufficiently important and general to be useful in most or all situations—provide a good place to start when considering additional ideas and priorities for approaching the unique challenge of climate change. The Section of Wildlife should:

(1) focus on objectives that help the Section accomplish its mission and mandates;

(2) acknowledge uncertainty when making decisions and confront it in a logical, productive manner; and

(3) strive to work effectively with colleagues and stakeholders to achieve wildlife management goals.

Options for addressing climate change fall into 2 broad categories—mitigation and adaptation. Climate change mitigation includes actions taken to avoid or minimize the change. Most directly, mitigation actions reduce emissions of greenhouse gases or reduce concentrations of greenhouse gases in the atmosphere (e.g., carbon sequestration). Adaptation refers to actions

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[1] The mission of the Section of Wildlife is "*to work with the people of Minnesota to conserve and manage wildlife populations and habitats, to provide wildlife-related recreation, and to preserve Minnesota's hunting and trapping heritage.*"

Step 1. Establish the Priority
- Examine the natural resource and recreational realities
- Identify and discuss crises, potential crises, or major opportunities in the context of risk

Step 2. Develop Scientific Guidance
- Charge a group to develop biological and social science based guidance
- Identify network of experts and resources

Step 3. Develop a Vision and Strategy
- Create a vision to help direct the change effort
- Develop strategies for achieving vision

Step 4. Communicate the Change Vision
- Use multiple venues to communicate the new vision and strategies with staff and stakeholders
- Provide opportunities for staff and stakeholders discussion of new vision and strategies

Step 5. Empower Broad-Based Action
- Charge Operations, Programs, and Research with next steps
- Utilize biennial budget and annual spending plans to incorporate approaches
- Encourage risk taking and nontraditional ideas, activities, and actions

Step 6. Take Initial Implementation Steps
- Identify objectives
- Implement steps

Step 7. Evaluate, Adjust, and Expand Change Efforts
- Evaluate and adapt existing and new approaches, programs, projects, and policies
- Communicate findings and status
- Use increased credibility to change all systems, structures, and policies that don't fit together and don't fit the transformation vision
- Consider needs in workforce planning (i.e., new hires, promotions, and training)
- Reinvigorate the process with new projects, themes, and change agents

Step 8. Operationalize Approaches
- Create better performance through customer- and productivity-oriented behavior, more and better leadership, and more efficient management
- Articulate the connections between new behaviors and organization success
- Develop means to ensure leadership development and succession

Figure 2. A process for creating major organizational change [adapted from Kotter (1996) for wildlife professionals].

taken to manage the unavoidable impacts of climate change. We classified our remaining recommendations as either mitigation or adaptation.

4.3.1. Mitigation

- Accomplish gubernatorial mandates to reduce energy consumption and increase efficiency of energy use by staff (Pawlenty 2004*a*,*b*; 2005; 2006). Consider and educate others about potential impacts of the production of renewable transportation fuels on wildlife and other natural resources. To reduce fuel consumption, staff should first try to reduce the number of miles they drive, then try to use the most fuel-efficient vehicle for a particular task. We should also continue to identify and prioritize specific actions, in addition to those related to fleet and facilities management.
- Develop recommendations for personal choices by staff, those participating in wildlife-related recreation, and the general public to reduce direct and indirect consumption of fossil fuels (e.g., strategies for driving fewer miles, reducing use of electricity). We should encourage the use of fuel-efficient and low-emission vehicles for personal travel by the millions of hunters, trappers, and wildlife watchers in Minnesota. Specifically for staff, we should consider evaluating and drafting policies regarding telecommuting from home rather than driving to work every day, use of telephone and video conferencing for meetings, and the net effect on climate change of various practices.
- Develop more wildlife-related recreational opportunities near urban population centers to reduce travel distance or the need to travel (Schultz et al. 2003).
- Seek carbon sequestration opportunities that do not conflict with or diminish wildlife conservation.
- Use the Division's outreach capacity to inform constituents and other citizens about how they can reduce their contributions to climate change.

4.3.2. Adaptation

4.3.2.1. Administration

- Develop, utilize, and communicate transparent decision processes. This will be important for documenting climate-related decisions and ensuring support for the decisions from staff and stakeholders. We must confront uncertainty in a logical, productive manner when making decisions (e.g., employ adaptive management when appropriate; Inkley et al. 2004:20, Williams et al. 2007). In the face of uncertainty about climate change, preserve future options and be cautious by anticipating threats to natural resources, acting to conserve resources despite the uncertainty, and explicitly valuing long-term benefits. Consider risk management to identify risk potential and consequences for habitat and population management actions. Consider triage—a decision framework for classifying relative priorities during emergencies—when appropriate (Millar et al. 2007). Although triage decisions may affect single species, multiple species (i.e., competing priorities) should be considered explicitly during the decision process.

- Identify important decisions and decision thresholds, so management and monitoring objectives can be specified.
- Establish interdisciplinary teams to collaborate on climate change issues. For example, we encourage initiation of a Department-wide team to address climate change and seek participation on interagency climate change teams. Unified approaches and sharing of information and other resources among a wide variety of organizations [e.g., MNDNR divisions, state and federal agencies, universities, and nongovernmental organizations (NGOs)] will be necessary to manage wildlife successfully in the face of climate change.
- Provide specific guidance to staff, programs, and projects about whether or how to address climate change in management actions and planning efforts (USGAO 2007).
- Complete a more comprehensive assessment of recent and on-going initiatives and research related to climate change and wildlife impacts.
- Communicate with public, stakeholders, and elected officials about habitat and population impacts and management implications (using practical examples).
- Improve communication and coordination (as distinct from collaboration) among disciplines and organizations.
- Assign specific staff to stay abreast of the large and growing body of literature on climate change.
- Consider desirable expertise and staffing plans during workforce planning.
- Consider reducing workloads related to short-terms goals to focus sufficient effort on climate change and other long-term issues (USGAO 2007).

- <u>Dedicate 1 new FTE position</u> at the Program level in the Section of Wildlife or the Division of Fish and Wildlife to lead and coordinate climate change efforts. This person should chair a standing committee to address climate change issues and develop strategic approaches for responding to climate change impacts.
- <u>Address funding needs</u> through reallocation of existing appropriations or new state/federal appropriations and grants.
- <u>Support a review and update of Minnesota's Comprehensive Wildlife Conservation Strategy</u> in terms of climate changes.

4.3.2.2. Research and Policy

- <u>Link monitoring programs to specific management decisions or scientific hypotheses</u> (Yoccoz et al. 2001, Inkley et al. 2004:20). Interest in and ideas for monitoring will likely exceed the available resources. It will be imperative, therefore, to carefully identify and prioritize monitoring needs based on the potential impact on future decisions and management activities.
- <u>Identify species, communities, and ecosystems</u> that are most vulnerable to climate change or are the best indicators of climate change effects (Noss 2001), identify ecological thresholds at which significant climate-induced changes may be particularly abrupt (Halpin 1997), and identify species and communities that may migrate into Minnesota.
- <u>Expand the focus of habitat management evaluation biologists in Wildlife Research</u> to include consideration of carbon sequestration and energy footprint for land management practices.
- <u>Support the development and use of models</u> to provide local projections of expected changes.
- <u>Develop new tools and approaches</u> for determining the appropriate type and amount of resource management efforts. For example, a decision tree may help staff determine the best management practices for systems in transition.

4.3.2.3. Operations and Programs

- <u>Continue to acquire and manage land for wildlife purposes</u> as part of the Outdoor Recreation System to "protect those lands and waters which have a high potential for wildlife production" as directed by Minnesota Statute 86A.

- Maintain ecological structures and functions (e.g., water quality, biodiversity), not just specific components (e.g., individual species; Inkley et al. 2004:20). For example, individual wildlife species have great value, but conserving the ecosystem processes upon which humans and wildlife depend is more fundamental and important. We will need a better understanding of ecological systems to be successful. We will need to improve our understanding of community ecology and the likely succession of communities through climate change (Noss 2001). Managing communities and ecosystems requires working with large areas, so we will need to develop programs to manage habitat at the landscape level with multiple land ownership types (e.g., state, federal, county, private, NGO).
- Maintain connected, diverse populations of wildlife, so they can adapt and migrate. This should include ensuring that land acquisition policies consider climate change and support biodiversity and connectivity now and in the future (Inkley et al. 2004:19). Subsection Forest Resource Management Plans and the Forest Resource Council's Landscape Teams should consider and address habitat connectivity issues. Bioreserve programs such as the Wildlife Management Area (WMA), Aquatic Management Area, and SNA programs should be expanded because, in addition to protecting native biodiversity, these parcels may contribute to potential migration corridors.
- Reduce nonclimate stressors that we can influence now (Inkley et al. 2004:18). For example, we can minimize habitat loss, degradation, and fragmentation near WMAs and other public lands, thereby conserving more habitat for wildlife adapting to a changing climate. We should focus on major disturbance agents that we can influence now, such as preventing and controlling catastrophic fire and invasive species (Inkley et al. 2004:19, MNDNR Operational Order #113). More specifically, we should continue to manage deer for population goals that do not negatively impact plant communities.
- Proactively choose where and when to resist climate-induced changes, encourage resilience of systems to change, or enable climate-induced changes (Millar et al. 2007). Resist climate-induced changes only temporarily and only for resources of high value (e.g., endangered species). Interdisciplinary work is needed to identify management practices (e.g., elimination of invasive species versus integration into habitat frameworks) that contribute to resilient systems and functions with the objective of maintaining or increasing resilience where and when it's appropriate (e.g., site prep for forest stand regeneration, reducing

contributions to shallow lake eutrophication). In most cases, strongly consider enabling community transitions (e.g., planting trees north of their current distribution).

- Prepare to manage for more frequent "extreme" events (e.g., flood, drought; Inkley et al. 2004:18).
- Do not rely solely on the historical range of variability to plan or make predictions. The future range of variability may be quite different and have no historical analogs (Inkley et al. 2004:18).
- Identify and discuss climate change in long-term management plans, programs, and policies where appropriate.
- Revisit management plans and population goals more frequently (Inkley et al. 2004:19).

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APPENDIX A: Key Species

This is a list of plant and animal species that the MNDNR Division of Fish and Wildlife manages for recreational harvest and nongame wildlife species that have restricted ranges in Minnesota and are being monitored by the Division of Ecological Resources. The 4 provinces are the Laurentian Mixed Forest (LMF), Eastern Broadleaf Forest (EBF), Tallgrass Aspen Parklands (TAP), and Prairie Parkland (PP) Province. SGCN = Species in Greatest Conservation Need (MNDNR 2006).

Scientific Name	Common Name	LMF Province	EBF Province	TAP Province	PP Province	Northern Part of Range	Southern Part of Range	Eastern Part of Range	Western Part of Range	Habitat Generalist	SGCN
Accipiter gentilis	Northern Goshawk	x					x				x
Aegolius acadicus	Northern Saw-whet Owl	x					x				
Aix sponsa	Wood Duck	x	x	x	x					x	
Alces alces	Moose	x		x			x		x		
Anas acuta	Northern Pintail			x				x			x
Anas americana	Widgeon			x			x				
Anas clypeata	Northern Shoveler		x	x				x	x		
Anas discors	Blue-winged Teal			x					x		
Anas platyrhynchos	Mallard	x	x	x	x					x	
Anas strepera	Gadwall				x					x	
Aythya collaris	Ring-necked Duck	x					x				
Aythya valisineria	Canvasback			x				x			
Bonasa umbellus	Ruffed Grouse	x	x	x			x			x	
Branta canadensis	Canada Goose	x	x	x	x					x	

Scientific Name	Common Name	LMF Province	EBF Province	TAP Province	PP Province	Northern Part of Range	Southern Part of Range	Eastern Part of Range	Western Part of Range	Habitat Generalist	SGCN
Bucephala clangula	Common Goldeneye	x					x				
Bufo cognatus	Great Plains Toad				x			x			
Buteo lineatus	Red-Shouldered Hawk		x			x					x
Canis latrans	Coyote	x	x	x	x					x	
Canis lupus	Gray Wolf	x		x					x	x	x
Capella gallinago	Snipe	x	x	x	x						
Castor canadensis	Beaver	x	x	x	x					x	
Cervus canadensis	Elk			x	x					x	x
Corvus brachyrhynchos	Crow	x	x	x	x					x	
Dendroica cerulea	Cerulean Warbler		x						x		x
Didelphis marsupialis	Opossum	x	x		x					x	
Falcipennis canadensis	Spruce Grouse	x		x			x				x
Fulica americana	Coot			x				x			
Gavia immer	Common Loon	x					x				x
Hemidactylium scutatum	Four-toed Salamander	x					x				x
Hesperia dacotae	Dakota Skipper Butterfly				x			x			x
Larus pipixcan	Franklin's Gull		x				x				x
Lepus americanus	Snowshoe Hare	x		x			x			x	
Lepus townsendii	White-tailed Jackrabbit				x			x			

Scientific Name	Common Name	LMF Province	EBF Province	TAP Province	PP Province	Northern Part of Range	Southern Part of Range	Eastern Part of Range	Western Part of Range	Habitat Generalist	SGCN
Lontra canadensis	River Otter	x	x	x	x					x	
Lophodytes cucullatus	Hooded Merganser	x	x							x	
Lynx canadensis	Lynx	x					x				x
Lynx rufus	Bobcat	x	x	x			x		x	x	
Martes americana	Pine Marten	x		x	x		x		x	x	
Martes pennanti	Fisher	x		x					x	x	
Meleagris gallopavo	Wild Turkey	x	x			x				x	
Mephitis mephitis	Striped Skunk	x	x	x	x					x	
Microtus ochrogaster	Prairie Vole				x			x			x
Mustela erminea	Short-tailed Weasel	x	x	x	x					x	
Mustela frenata	Long-tailed Weasel	x	x	x	x					x	
Mustela rixosa	Least Weasel	x	x	x	x					x	x
Neovison vison	Mink	x	x	x	x					x	
Odocoileus virginianus	White-tailed Deer	x	x	x	x					x	
Ondatra zibethicus	Muskrat	x	x	x	x					x	
Panax quinquefolius	Ginseng	x	x							x	
Perdix perdix	Gray Partridge				x	x					
Phasianus colchicus	Ring-necked Pheasant	x	x		x	x				x	
Porzana carolina	Sora Rail	x	x	x	x						
Procyon lotor	Raccoon	x	x	x	x					x	
Rallus limicola	Virginia Rail				x					x	x
Rana palustris	Pickerel Frog		?			x					x
Rana septentrionalis	Mink Frog	x					x				

Scientific Name	Common Name	LMF Province	EBF Province	TAP Province	PP Province	Northern Part of Range	Southern Part of Range	Eastern Part of Range	Western Part of Range	Habitat Generalist	SGCN
Sciurus carolinensis	Gray Squirrel	x	x	x	x					x	
Sciurus niger	Fox Squirrel	x	x	x	x					x	
Scolopax minor	American Woodcock	x	x	x			x		x	x	x
Seiurus mutacilla	Louisiana Water Thrush		x			x					x
Spilogale putorius	Eastern Spotted Skunk	x	x		x						x
Sterna huryndo	Common Tern		x				x				x
Sylvilagus floridanus	Cottontail	x	x	x	x	x				x	
Synaptomys borealis	Northern Bog Lemming	x					x				
Tamiasciurus hudsonicus	Red Squirrel	x	x	x	x					x	
Taxidea taxus	Badger	x	x	x	x					x	x
Tympanuchus cupido	Greater Prairie-Chicken				x						x
Tympanuchus phasianellus	Sharp-tailed Grouse	x		x					x	x	x
Urocyon cinereoargenteus	Gray Fox	x	x	x	x	x		x		x	
Ursus americanus	Black bear	x	x	x			x		x	x	
Vulpes fulva	Red Fox	x	x	x	x					x	
Zenaida macroura	Mourning Dove	x	x	x	x					x	
Zizania palustris	Wild Rice	x	x	x	x		x		x	x	

APPENDIX B: Scientific Names of Species

The following species are mentioned by common name in the report.

<u>Mammals</u>

Badger	*Taxidea taxus*
Canada lynx	*Lynx canadensis*
Elk	*Cervus canadensis*
Franklin's ground squirrel	*Spermophilus franklinii*
Gray fox	*Urocyon cinereoargenteus*
Moose	*Alces alces*
Northern bog lemming	*Synaptomys borealis*
Opossum	*Didelphis marsupialis*
Pine marten	*Martes americana*
Richardson's ground squirrel	*Spermophilus richardsonii*
Snowshoe hare	*Lepus americanus*
White-tailed deer	*Odocoileus virginianus*
White-tailed jackrabbit	*Lepus townsendii*

<u>Birds</u>

American bittern	*Botaurus lentiginosus*
American white pelican	*Pelecanus erythrorhynchos*
American woodcock	*Scolopax minor*
Baird’s sparrow	*Ammodramus bairdii*
Black-backed woodpecker	*Picoides arcticus*
Blue-winged teal	*Anas discors*
Bobolink	*Dolichonyx oryzivorus*
Boreal chickadee	*Poecile hudsonicus*
Boreal owl	*Aegolius funereus*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cerulean warbler	*Dendroica cerulea*
Chestnut-collared longspur	*Calcarius ornatus*
Connecticut warbler	*Oporornis agilis*
Forester’s tern	*Sterna hirundo*
Franklin’s gull	*Larus pipixcan*
Gadwall	*Anas strepera*
Gray partridge	*Perdix perdix*
Great gray owl	*Strix nebulosa*
Greater prairie-chicken	*Tympanuchus cupido*

Horned grebe	*Podiceps auritus*
Louisiana waterthrush	*Seiurus mutacilla*
Mallard	*Anas platyrhynchos*
Marbled godwit	*Limosa fedoa*
Meadowlark	*Sturnella neglecta*
Mourning dove	*Zenaida macroura*
Northern cardinal	*Cardinalis cardinalis*
Northern goshawk	*Accipiter gentilis*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Ovenbird	*Seiurus aurocapillus*
Redhead duck	*Aytha americana*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Red-shouldered hawk	*Buteo lineatus*
Ring-necked pheasant	*Phasianus colchicus*
Ruffed grouse	*Bonasa umbellus*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Sora rail	*Porzana carolina*
Sprague's pipit	*Anthus spragueii*
Spruce grouse	*Falcipennis canadensis*
Trumpeter swan	*Cygnus buccinator*
Upland sandpiper	*Bartramia longicauda*
Virginia rail	*Rallus limicola*
Western grebe	*Aechmophorus occidentalis*
Wild turkey	*Meleagris gallopavo*
Wilson snipe	*Gallinago gallinago*
Wood duck	*Aix sponsa*
Wood thrush	*Hylocichla mustelina*
Wood warblers	Family Parulidae
Yellow rail	*Coturnicops noveboracensis*

Reptiles

Blanding's turtle	*Emydoidea blandingii*
Eastern hognose snake	*Heterodon platyrhinos*

Amphibians

Four-toed salamander	*Hemidactylium scutatum*
Mink frog	*Rana septentrionalis*
Red-backed salamander	*Plethodon cinereus*

Insects

Emerald ash borer	*Agrilus planipennis*
Spruce budworm	*Choristoneura fumiferana*

Plants

Aspen	*Populus spp.*
Balsam fir	*Abies balsamea*
Basswood	*Tilia americana*
Beech	*Fagus spp.*
Big bluestem	*Andropogon gerardii*
Birch	*Betula spp.*
Black oak	*Quercus velutina*
Black spruce	*Picea mariana*
Bur oak	*Quercus macrocarpa*
Cattail	*Typhus spp.*
Fir	*Abies spp.*
Hickory	*Carya ovata*
Indian grass	*Sorghastrum nutrans*
Jack pine	*Pinus banksiana*
Little bluestem	*Schizachyrium scoparium*
Maple	*Acer spp.*
Northern pin oak	*Quercus ellipsoidalis*
Oak	*Quercus spp.*
Paper birch	*Betula papyrifera*
Pine	*Pinus spp.*
Porcupine grass	*Stipa spartea*
Red oak	*Quercus rubra*
Red pine	*Pinus resinosa*
Smooth brome	*Bromus inermis*
Spruce	*Picea spp.*
Sugar maple	*Acer saccharum*
Switchgrass	*Panicum virgatum*
Tamarack	*Larix laricina*
Trillium	*Trillium spp.*
White cedar	*Thuja occidentalis*
White pine	*Pinus strobus*

MINNESOTA'S RING-NECKED DUCK BREEDING PAIR SURVEY

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SUMMARY OF FINDINGS

A pilot study was conducted in 2004-2006 to develop a survey for Minnesota's ring-necked duck (*Aythya collaris*) breeding population because little was known about its distribution and relative abundance. We employed the survey design and methods developed during the pilot study (Zicus et al. 2006) to estimate the size of the population in 2007. The helicopter-based counts (5–13 June 2007) entailed 11 flight days between 2 crews, and included the portion of Minnesota considered primary breeding range. The combined population was estimated to be ~14,500 indicated breeding pairs (~30,300 birds) which is similar to the estimates during the pilot years of the study.

INTRODUCTION

Staff members in the Minnesota Department of Natural Resources (MNDNR) Wetland Wildlife Populations and Research Group have been developing a forest wetlands and waterfowl initiative. The status of ring-necked ducks has been among the topics considered because the species has been identified as an indicator species for the Forest Province (Minnesota Department of Natural Resources. 2003. A Vision for Wildlife and its Use – Goals and Outcomes 2003 – 2013 (draft). Minnesota Department of Natural Resources, unpublished report, St. Paul). However, little is known about the current distribution and abundance of breeding ring-necked ducks in Minnesota. A 3-year pilot study was used to develop a breeding pair survey (Zicus et al. 2006), and 2007 represented the first year of an operational ring-necked duck breeding pair survey.

METHODS

Two separate surveys, identical to those used in 2006 (Zicus et al. 2006), were conducted in 2007. We used a stratified random sampling design with 2 stratification variables: (1) Ecological Classification System (ECS) sections; and (2) presumed nesting-cover availability (i.e., a surrogate for predicted breeding ring-necked duck density) to estimate population size in the best ring-necked duck habitat. We used a 2-stage simple random sampling design to estimate population size in the remainder of the survey area. We used a helicopter for the survey because visibility of ring-necked ducks from a fixed-wing airplane is poor in most ring-neck breeding habitats. We considered pairs, lone males, and males in flocks of 2 – 5 to indicate breeding pairs (IBP; J. Lawrence, Minnesota Department of Natural Resources, personal communication). The total breeding population in the survey area was considered to be twice the IBP plus the number of birds in mixed sex groups and lone or flocked females.

Statistical Population, Sampling Frame, and Sample Allocation

The surveys were restricted to an area believed to be primary breeding range of ring-necked ducks for logistical efficiency (Zicus et al. 2005). We used the same habitat class definitions that were used for stratification in the last pilot year (i.e., 2006) (Table 1). Habitat class 1 and 2 plots were presumed to represent the best habitat whereas habitat class 3 and 4 plots represented the remainder of the survey area. Public Land Survey (PLS) sections at the periphery of the survey area that were <121 ha in size were removed from the sampling frame to reduce the probability of selecting these small plots.

A stratified sampling design was used to estimate breeding ducks in habitat class 1 and 2 plots, and the sampling frame consisted of 12 strata (i.e., 6 ECS sections x 2 habitat classes). We proportionally allocated 200 plots to the 12 strata (Zicus et al. 2005). We used a 2-phase sampling process to sample 50 plots in habitat classes 3 and 4. The phase-1 sample consisted of 1,000 habitat class 3 and 4 plots, disregarding ECS sections. These plots were visually inspected using 2003 Farm Services Agency (FSA) true color aerial photography and classified as to their ring-necked duck potential (i.e., possible breeding pairs vs. no pairs). PLS sections containing open water except for small streams were considered potential ring-necked duck plots. The proportion of plots classified as potentially having pairs was used as an estimate of the proportion of all class 3 and 4 plots that had potential for breeding pairs. We then randomly selected 50 plots (phase-2 sample) from those having the potential for ring-necked duck pairs in order to estimate the mean number of breeding pairs in these plots.

Data Analyses

Estimated population size

We used SAS PROC SURVEYMEANS (SAS 1999) to estimate population totals for habitat class 1 and 2 plots in each ECS section and the entire survey area. In this analysis, PLS sections were the primary sampling unit in a stratified random sampling design. For the second survey, we estimated population size (τ) for habitat class 3 and 4 plots in the entire survey area as follows:

$$\hat{\tau} = \hat{P} * \bar{x} * N \text{ ,}$$

where $\hat{P}$ = proportion of phase-1 plots classified as habitat-class 3,
$\bar{x}$ = mean breeding ducks detected on phase-2 sample plots, and
N = total habitat-class 3 and 4 plots in sampling frame.

The variance of $\hat{\tau}$ was estimated using the delta method as:

$$\text{var}(\hat{\tau}) = N^2 ((\hat{P}^2 * \text{var}[\bar{x}]) + (\bar{x}^2 * \text{var}(\hat{P}))).$$

Estimates from the 2 surveys were combined to produce an overall population estimate for the survey area.

Data acquisition

The 2005 and 2006 survey utilized an ArcView 3.x extension (DNRSurvey) in conjunction with a GPS receiver and MNDNR Garmin program (real time survey technique) to collect the survey data. This approach allowed us to display the aircraft's flight path over a background of aerial photography and the survey plots. The flight path and ring-necked duck observations were recorded directly to ArcView shapefiles, all in real time (R. Wright, Minnesota Department of Natural Resources, personal communication). We planned to use an updated version of DNRSurvey for the 2007 survey, however, the updated version was not ready, thus DNRSurvey was not used this year. In 2007, location, date, and time was recorded on data sheets for all ring-necked ducks seen on study plots from the helicopter. Locations of these birds were also plotted on aerial photos.

RESULTS

In 2007, plots were well distributed throughout the study area (Figure 1). Most plots (77) were located in the Northern Minnesota Drift and Lake Plains section, while the fewest plots (8) were located in the Lake Agassiz, Aspen Parklands section (Table 2). The highest and lowest sampling rate again occurred in the Lake Agassiz, Aspen Parklands section and Northern Superior Uplands section, respectively. The survey was conducted 5–13 June and entailed 11 survey-crew days. Observed pairs represented 56% of the indicated pairs tallied during the 2007 survey compared to 44% in 2006, 36% in 2005, and 57% in 2004 (Table 3).

Estimated Pair Density

Mean pair density on habitat class 1 and 2 plots ranged from a high of 2.65 pairs/plot in the Lake Agassiz, Aspen Parklands section to a low of 0.30 pairs/plot in the Western and Southern Superior Uplands section (Table 4). Indicated pair densities were greatest in the Lake Agassiz, Aspen Parklands section with lowest pair densities in the Western and Southern Superior Uplands and the Northern Minnesota and Ontario Peatlands sections. Estimated indicated breeding pairs on habitat class 1 and 2 plots ranged from a high of 5,686 in the Northern Minnesota Drift and Lake Plains section to a low of 671 in the Western and Southern Superior Uplands section (Table 5).

Estimated Population Size

The estimated population of ring-necked ducks on habitat class 1 and 2 plots ranged from a high of 11,651 in the Northern Minnesota Drift and Lake Plains section to a low of 1,342 in the Western and Southern Superior Uplands section (Table 6). The number of estimated indicated breeding pairs on habitat class 3 and 4 plots was 1,721 (90% confidence interval = 267 – 3,176), while the estimated breeding population on class 3 and 4 plots was 4,304 (90% confidence interval = 1,117 – 7,491, Table 7).The estimated number of indicated breeding pairs for the entire survey area in 2007 was 14,508 (90% confidence interval = 10,514 – 18,503), and the estimated ring-necked duck population was 30,330 (90% confidence interval = 22,203 – 38,457, Table 7).

Observed Distribution

The survey was not designed explicitly to describe the distribution of breeding ring-necked ducks, but observations accumulated thus far have improved our knowledge of ring-necked duck distribution in the survey area. Indicated pair observations in 2005–2007 shifted somewhat to the east compared to 2004 (Figure 1). Estimates from 2004–2007 suggest that some ECS subsections or portions of a section might have substantial numbers of breeding ring-necked ducks even though few birds were observed in the ECS section (Figure 2). For example, pairs/plot and total estimated pairs were relatively high in the Northern Superior Uplands, yet few plots in the section had indicated breeding pairs (Tables 5 and 6).

DISCUSSION

Survey dates in 2007 appeared appropriate because 56% of the indicated pairs were counted as paired birds, and survey timing is considered optimal when most birds are counted as pairs and not in flocks (Smith 1995). The stratified random sampling design that we employed was adequate for plots in habitat classes 1 and 2, while the second survey based on a simple random sample of plots in habitat classes 3 and 4 again provided an estimate for the survey area that was unbiased (i.e., included all potential breeding habitat). Detection rates appeared to be relatively high in all habitats, suggesting that any bias probably would be minor.

MN-GAP land cover data provided a convenient way to stratify the survey area, but they have shortcomings as well as strong points. They provided a consistent statewide source of land use/cover data that was available in an easy to use raster format. However, the data are derived from 1991 and 1992 satellite imagery, which makes them dated. Further, the data exist at 4 levels of resolution, and classification accuracy of cover types is diminished at the level that we used. Nearly 50% (487 of 1,000) of habitat class 3 and 4 plots were incorrectly classified when compared to conditions that existed in 2003 (based on FSA photography). Misclassifications resulted from MN-GAP data missing small wetland areas capable of supporting ring-necked duck pairs or from wetland conditions that changed between 1991 and

2003. We improved the stratification in 2006 and 2007 by eliminating emergent shoreline-vegetation associated with larger lakes containing fish from our definition of potential ring-necked duck nesting cover. Ring-necked ducks do not occupy these types of lakes during the breeding season.

Recommendations

- Identify the most important management needs to be addressed by the survey through discussions within the MNDNR Wetland Group and the Waterfowl Committee. Rationale: The current survey is a compromise allowing both population size estimation and definition of population distribution. As such, it is not optimal for either objective. If one objective is deemed more important than the other, the survey could be modified to achieve the priority objective more efficiently.

- Continue using the design and methods arrived at in the pilot study if the current survey objectives meet management needs. Rationale: MN-GAP land cover data has provided a convenient way to stratify the survey area, and population estimates based on 2 surveys using PLS-section sampling units are relatively efficient (Giudice, unpublished data). Further, beginning the survey as soon after 5 June as possible is appropriate because it allows the survey to be done while most ring-necked ducks are still paired.

- Decide whether the sampling frame needs to be modified through discussions within the MNDNR Wetland Group and the Waterfowl Committee. Rationale: Obtaining population estimates for the entire primary breeding range would be ideal. However, the information gained by surveying some areas such as the Northwest Angle and the Arrowhead region that are logistically difficult to reach, are dangerous to sample, or that have few ring-necked ducks, might not be worth the added cost.

- Update the habitat files or change the definition of nesting cover. Rationale: We defined ring-necked duck cover as: MNGAP class 10, 14, and/or 15 cover **within** 250 m of **and adjacent to** that patch of MNGAP class 12 and/or 13 cover. The habitat layer that we used in 2004 and 2005 defined nesting cover in this way. However, the habitat layer that we used in 2006 and 2007 included some MNGAP class 10, 14, and/or 15 cover that was **within** 250 m **but not** necessarily **adjacent** to that patch of MNGAP class 12 and/or 13 cover. Geographic Information System work needs to be done to correct this problem, or the definition of ring-necked duck nesting cover needs to be changed.

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Table 1. Habitat classes assigned to Public Land Survey section plots in the Minnesota ring-necked duck breeding pair survey area, June 2004 – 2007.

	Definition[a]		%[b]		
Habitat class	2004	2005 - 2007[c]	2004	2005	2006-2007
1	Plots with ≥ the median amount of MNGAP class 14 and/or 15 cover within 250 m of and adjacent to MNGAP class 12 cover (i.e., high pair potential).	Plots with ≥ the median amount of MNGAP class 10, 14, and/or 15 cover within 250 m of and adjacent to MNGAP class 12 and/or 13 cover (i.e., high pair potential).	15.3	24.5	21.5
2	Plots with < the median amount of MNGAP class 14 and/or 15 cover within 250 m of and adjacent to MNGAP class 12 cover (i.e., moderate pair potential).	Plots with < the median amount of MNGAP class 10, 14, and/or 15 cover within 250 m of and adjacent to class 12 and/or 13 cover (i.e., moderate pair potential).	15.3	24.5	21.5
3	Plots with no MNGAP class 14 and/or 15 cover that include MNGAP class 12 cover that is within 250 m of a shoreline (i.e., low pair potential).	Plots with no MNGAP class 10, 14, and/or 15 cover that include class 12 and/or 13 cover that is within 100 m of a shoreline (i.e., low pair potential).	25.2	7.7	13.5
4	Plots with no MNGAP class 14 and/or 15 cover and no MNGAP class 12 cover within 250 m of a shoreline (i.e., no pair potential).	Plots with no MNGAP class 10, 14, and/or 15 cover and no class 12 and/or 13 cover within 100 m of a shoreline (i.e., no pair potential).	44.2	43.3	43.5

[a]Plots are Public Land Survey sections. MNGAP = Minnesota GAP level 4 land cover data. Class 10 = lowlands with <10% tree crown cover and >33% cover of low-growing deciduous woody plants such as alders and willows. Class 12 = lakes, streams, and open-water wetlands. Class 13 = water bodies whose surface is covered by floating vegetation. Class 14 = wetlands with <10% tree crown cover that is dominated by emergent herbaceous vegetation such as fine-leaf sedges. Class 15 = wetlands with <10% tree crown cover that is dominated by emergent herbaceous vegetation such as broad-leaf sedges and/or cattails.

[b]Percent of the survey area.

[c]Habitat class definitions in 2005, 2006 and 2007 were the same, but MNGAP class 10, 14, and 15 cover associated with lakes having a General or Recreational Development classification under the Minnesota Shoreland Zoning ordinance was not considered nesting cover in 2006 and 2007.

Table 2. Sampling rates by Ecological Classification System section for Minnesota's ring-necked duck breeding- pair survey, June 2004 – 2007.

		~Area[a]			Sampling rate (%)		
Ecological Classification System section	Habitat classes	2004	2005	2006-2007	2004	2005	2006-2007
W & S Superior Uplands[b]	1,2	1,638	2,461	2,218	1.1	0.9	0.9
Northern Superior Uplands	1,2	1,810	4,648	4,209	0.7	0.8	0.8
N Minnesota & Ontario Peatlands	1,2	1,817	2,737	2,389	1.4	1.3	1.3
N Minnesota Drift & Lake Plains	1,2	5,048	8,383	7,145	1.5	1.1	1.1
Minnesota & NE Iowa Morainal	1,2	3,510	4,033	3,561	1.4	0.9	0.9
Lake Agassiz, Aspen Parklands	1,2	316	363	340	4.7	2.2	2.4

[a]Number of Public Land Survey sections in the ECS section(s).
[b]Western and Southern Superior Uplands sections combined due to the small area of the Southern Superior Uplands occurring in the survey area.

Table 3. Social status of the indicated pairs observed in the Minnesota ring-necked duck breeding pair survey area, June 2004-2007.

				Indicated pairs			
Year	Habitat class	No. of plots	Total ducks	*n*	% Pairs	% Lone males	% Flocked males
2004[a]	1,2	200	278	160	57.5	18.1	24.4
2005[b]	1,2	230	147	92	35.9	28.2	35.9
2005	3,4	21	11	7	57.1	0.0	42.9
2006[c]	1,2	200	279	167	43.7	27.6	28.7
2006	3,4	50	4	3	33.3	66.7	0.0
2007[d]	1,2	200	152	137	57.7	25.5	16.8
2007	3,4	50	13	6	16.7	16.7	66.7

[a]Survey conducted 6 – 17 June.
[b]Survey conducted 12 – 24 June.
[c]Survey conducted 6 – 16 June.
[d]Survey conducted 5 – 13 June.

Table 4. Estimated indicated breeding pairs per plot in the habitat class 1 and 2 strata in the Minnesota ring-necked duck breeding pair survey area, June 2005-2007.

	2005			2006			2007		
Ecological Classification System section	Plots	Mean pairs/plot	SE	Plots	Mean pairs/plot	SE	Plots	Mean pairs/plot	SE
W & S Superior Uplands[a]	22	0.181	0.179[b]	20	0.302	0.178	20	0.302	0.301
Northern Superior Uplands	36	0.252	0.118	33	0.636	0.215	33	0.640	0.297
N Minnesota & Ontario Peatlands	35	0.087	0.045[b]	30	0.658	0.228	30	0.300	0.139
N Minnesota Drift & Lake Plains	94	0.416	0.138	77	0.887	0.279	77	0.796	0.207
Minnesota & NE Iowa Morainal	35	0.228	0.010	32	0.590	0.318	32	0.595	0.231
Lake Agassiz, Aspen Parklands	8	3.403	1.365[b]	8	4.160	1.463	8	2.652	1.086

[a]Western and Southern Superior Uplands sections combined due to the small area of the Southern Superior Uplands occurring in the survey area.
[b]Standard error estimate is biased low because no birds were observed in one of the Ecological Classification System section's strata.

Table 5. Estimated indicated breeding pairs in the habitat class 1 and 2 strata in the Minnesota ring-necked duck breeding pair survey area, June 2005-2007.

	2005				2006				2007			
Ecological Classification System section	Pairs	LCL[a]	UCL[a]	CV(%)	Pairs	LCL	UCL	CV(%)	Pairs	LCL	UCL	CV(%)
W & S Superior Uplands[b]	444	0	1,207	99.5[c]	669	0	1,355	59.1	671	0	1,829	99.6
Northern Superior Uplands	1,169	244	2,095	46.8	2,679	1,148	4,210	33.7	2,694	571	4,816	46.5
N Minnesota & Ontario Peatlands	239	20	457	54.1[c]	1,572	644	2,499	34.7	717	150	1,284	46.5
N Minnesota Drift & Lake Plains	3,490	1,577	5,404	33.0	6,334	3,011	9,657	31.5	5,686	3,227	8,144	26.0
Minnesota & NE Iowa Morainal	918	241	1,595	43.6	2,102	178	4,026	53.9	2,118	724	3,512	38.8
Lake Agassiz, Aspen Parklands	1,235	273	2,198	40.1[c]	1,414	448	2,381	35.2	902	184	1,619	40.9

[a]Estimates were based on a stratified random sample of Public Land Survey (PLS) sections in habitat classes 1 and 2 and 6 ECS sections. LCL = lower 90% confidence level. UCL = upper 90% confidence level.
[b]Western and Southern Superior Uplands sections combined due to the small area of the Southern Superior Uplands occurring in the survey area.
[c]Variance estimate for the Ecological Classification System section is biased low because no birds were observed in one of the section's strata. As a result, the confidence interval is too narrow and the CV is optimistic.

Table 6. Estimated ring-necked ducks in the habitat class 1 and 2 strata in the Minnesota ring-necked duck breeding pair survey area, June 2005-2007.

Ecological Classification System section	2005 Birds	2005 LCL[a]	2005 UCL[a]	2005 CV(%)	2006 Birds	2006 LCL	2006 UCL	2006 CV(%)	2007 Birds	2007 LCL	2007 UCL	2007 CV(%)
W & S Superior Uplands[b]	889	0	2,415	99.5[c]	1,338	0	2,710	59.1	1,342	0	3,658	99.6
Northern Superior Uplands	2,339	488	4,190	46.8	5,357	2,295	8,419	33.7	5,388	1,143	9,633	46.5
N Minnesota & Ontario Peatlands	477	40	915	54.1[c]	4,076	1,141	7,012	42.3	1,434	301	2,568	46.5
N Minnesota Drift & Lake Plains	6,981	3,154	10,808	33.0	14,816	7,504	22,127	29.6	11,651	6,721	16,581	25.4
Minnesota & NE Iowa Morainal	4,122	187	8,057	56.4	4,204	375	8,052	53.9	4,236	1,448	7,024	38.8
Lake Agassiz, Aspen Parklands	2,471	545	4,396	40.1[c]	2,829	896	4,762	35.2	1,976	352	3,600	42.3

[a]Estimates were based on a stratified random sample of Public Land Survey (PLS) sections in habitat classes 1 and 2 and 6 ECS sections. LCL = lower 90% confidence level. UCL = upper 90% confidence level.
[b]Western and Southern Superior Uplands sections combined due to the small area of the Southern Superior Uplands occurring in the survey area.
[c]Variance estimate for the ECS section is biased low because no birds were observed in one of the ECS section's strata. As a result, the confidence interval is too narrow and the CV is optimistic.

Table 7. Estimated indicated breeding pairs and breeding population size in the Minnesota ring-necked duck breeding pair survey area, 2004-2007.

Year	Habitat classes	Indicated breeding pairs: Pairs	LCL[a]	UCL[a]	CV(%)	Breeding population: Birds	LCL[a]	UCL[a]	CV(%)
2004	1,2[b]	9,443	6,667	12,220	17.8[d]	20,321	14,248	26,395	18.1[d]
2005	1,2[b]	7,496	5,022	9,971	20.0[d]	17,279	11,156	23,402	21.5[d]
2005	3,4[c]	3,832	0	9,269	86.3	7,664	0	18,539	86.3
2005	All	11,328	5,359	17,298	32.0[d]	24,943	12,476	37,411	30.4[d]
2006	1,2[b]	14,770	10,465	19,075	17.6[d]	32,621	23,231	42,010	17.4[d]
2006	3,4[c]	861	0	1,908	74.0	1,721	0	3,816	74.0
2006	All	15,631	11,221	20,041	17.2[d]	34,342	24,766	43,918	17.0[d]
2007	1,2[b]	12,787	9,049	16,525	17.7	26,026	18,514	33,539	17.5
2007	3,4[c]	1,721	267	3,176	51.4	4,304	1,117	7,491	45.0
2007	All	14,508	10,514	18,503	16.7	30,330	22,203	38,457	16.3

[a]LCL = lower 90% confidence level. UCL = upper 90% confidence level.
[b]Population estimates were based on a stratified random sample of habitat class 1 and 2 Public Land Survey (PLS) sections in 12 strata (2 habitat classes and 6 ECS sections).
[c]Population estimates were based on a simple random sample of Public Land Survey (PLS) sections in habitat classes 3 and 4.
[d]Variance estimate is biased low because no birds were observed in one or more strata. As a result, the confidence interval is too narrow and the CV is optimistic.

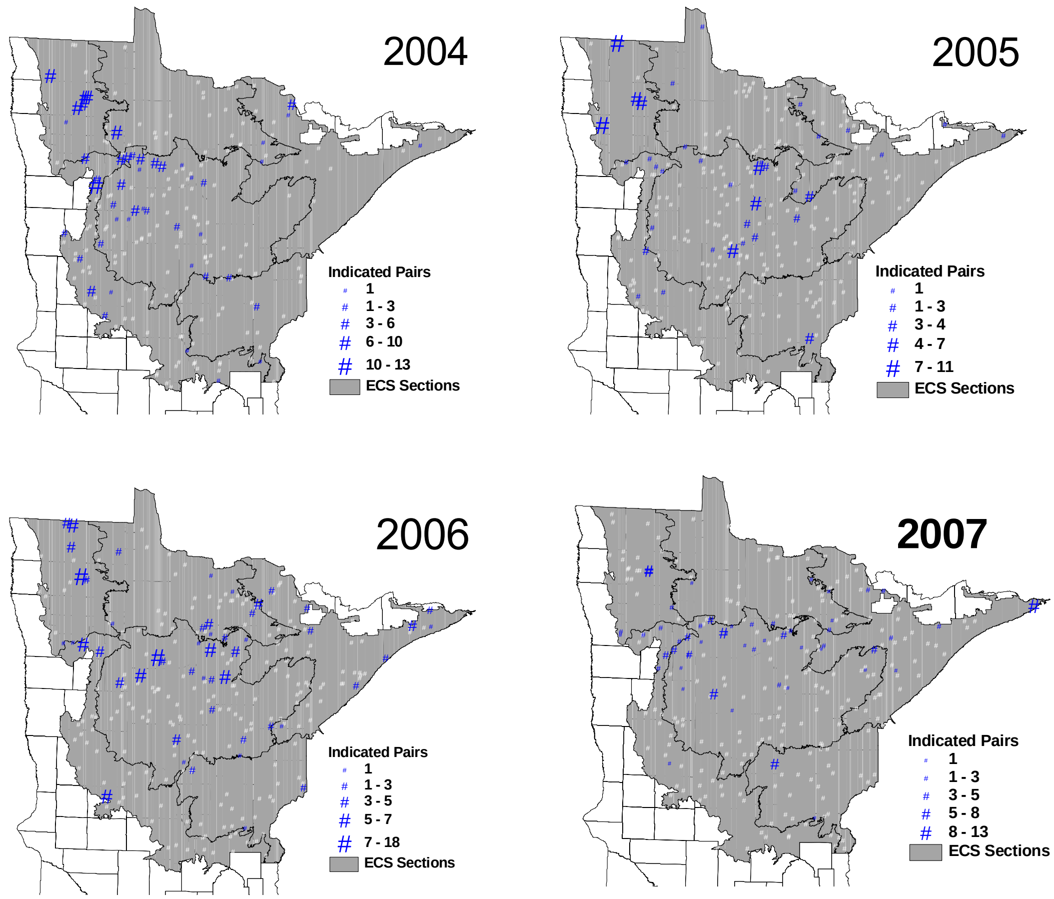

Figure 1. Plot locations and numbers of indicated breeding pairs of ring-necked ducks observed on survey plots in the Minnesota survey area in June 2004 (top left), 2005 (top right), 2006 (bottom left), and 2007 (bottom right). White circles indicate plots where no indicated pairs were seen.

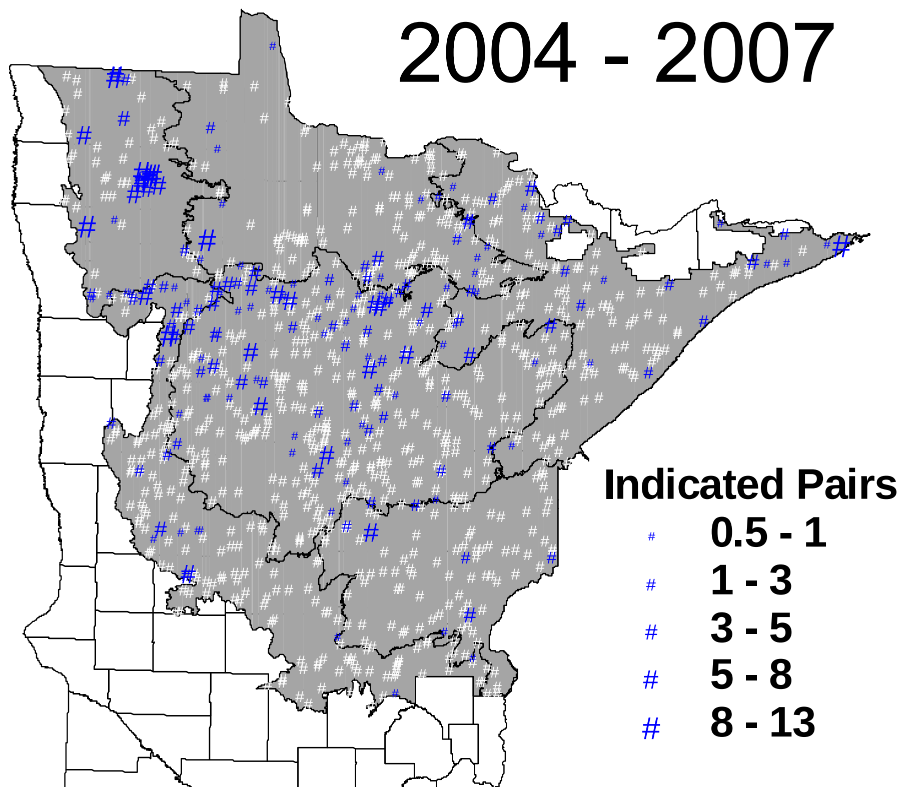

Figure 2. Plot locations and numbers of indicated breeding pairs of ring-necked ducks observed on survey plots in the Minnesota survey area, June 2004-2007. White dot indicates a plot where no birds were seen.

MOVEMENTS, SURVIVAL, AND REFUGE USE BY LOCALLY PRODUCED POST-FLEDGING RING-NECKED DUCKS IN MINNESOTA

Charlotte Roy, David Rave, Wayne Brininger[1], and Michelle McDowell[2]

SUMMARY OF FINDINGS

The Wetland Wildlife Populations and Research Group of the Minnesota Department of Natural Resources (MNDNR) initiated a study in 2006 to examine the use and survival benefits of waterfowl refuges to locally produced ring-necked ducks (*Aythya collaris*). The fall of 2007 was the 2nd year of this 4-year study. During 2007, we successfully captured and implanted 52 ring-necked ducks with radio-transmitters before fledging. Ducks were tracked weekly by aircraft and from telemetry receiving stations on 14 waterfowl refuges. Locally produced ring-necked ducks used state and federal waterfowl refuges, but use was not evenly distributed among refuges; 4 refuges received the majority of use and 7 refuges were never used by marked birds. Refuge use also increased markedly during hunting season. Additional data collection in 2008 and 2009 will be aimed at addressing survival benefits of refuge use to young birds.

INTRODUCTION

The MNDNR Fall Use Plan recognized sizable populations of resident breeding ducks as a cornerstone to improving fall duck use. Although breeding ring-necked duck populations have been increasing continentally, they appear to be declining in Minnesota (Zicus et al. 2005). Further, hunter harvest of ring-necked ducks has declined in the last 20 years in Minnesota even as numbers of these birds staging in fall on most traditional ring-necked duck refuges (Federal and State) have increased in the state (Wetland Wildlife Populations and Research Group, unpublished data).

Factors influencing resident populations of ring-necked ducks are poorly understood, and efforts to better understand their status began in 2003 with development of a breeding-pair survey. Minnesota's Fall Use Plan identified the need to better understand the role of refuges in duck management. The influence of north-central Minnesota refuges on the distribution and welfare of resident ring-necked ducks is unknown, as well as the influence that the distribution of the resident population might have on that of migrant ring-necked ducks staging in the fall. Post-fledging ecology of many waterfowl species has not been documented, and this study provides information for an important Minnesota species.

The intent of this project is to determine whether refuges benefit locally produced ring-necked ducks and increase survival. Understanding movements and refuge use by locally raised ring-necked ducks in the fall may provide valuable insights into the distribution of refuges required to meet management objectives for ring-necked ducks in Minnesota.

OBJECTIVES

1. Characterize post-fledging movements of local ring-necked ducks prior to their fall departure.
2. Estimate survival of locally raised birds during this period.
3. Relate the survival of locally raised birds to their relative use of or proximity to established refuges (federal and state) in north-central Minnesota.

[1] U.S. Fish and Wildlife Service, Tamarac National Wildlife Refuge, Rochert, MN
[2] U.S. Fish and Wildlife Service, Rice Lake National Wildlife Refuge, McGregor, MN

STUDY AREA

The study area lies in the heart of the Laurentian mixed forest province of Minnesota which is characterized by a mixed coniferous and hardwood forest landscape pocked with lakes, many of which are dominated by wild rice. The study area encompasses a significant portion of the core of the ring-necked duck breeding range in Minnesota and 14 important ring-necked duck refuges (Figure 1, Table 1). These state and federal refuges are closed to public hunting, thus providing security areas for ducks during the fall migration.

METHODS

Night-lighting techniques were employed to capture pre-fledging ring-necked ducks throughout the study area during August. Ducklings were aged and their sex was determined at the time of capture (Gollop and Marshall 1954). Radio-transmitters were implanted dorsally and subcutaneously on flightless ring-necked ducks following techniques developed by Korschgen et al. (1996). The ducks were then allowed several hours to recover from surgery before release at their capture location. These methods were similar to those employed during the pilot study in 2006, except that in 2007 we attached mesh to the back of transmitters to increase retention rates (D. Mulcahy, USGS, Alaska Science Center, personal communication). We also marked ducklings with nasal saddles to allow examination of natal philopatry in the spring, which was a new objective in 2007.

By early September, radiotelemetry stations were established at each refuge as a means of quantifying refuge use. These stations consisted of a tower with a four-element yagi antenna pointed toward the primary waterfowl use areas of each lake within the refuges. In some cases, more than 1 antenna was used so that more area could be covered. The receivers were programmed to scan all transmitter frequencies each hour and were equipped with data-loggers to store the data (Advanced Telemetry Systems DCC II Model # D5041). The data were downloaded weekly from the data-loggers from mid-September through early November. The data were then immediately examined to determine presence/absence of radio-marked birds. Reference radio-transmitters were stationed permanently at each refuge to ensure that receivers and data loggers functioned properly. Flights with telemetry equipment were also done twice weekly throughout the fall to document the locations and survival of radio-marked birds within the study area.

RESULTS

We captured 52 ducklings with night-lighting techniques between 4 August and 3 September 2007. Capture locations were distributed throughout the study area, but more ducklings were captured on the western half of the study area (33 in western counties compared to 19 in eastern counties, Table 2).

Prior to opening of the hunting season on 29 September, 91% of birds were located each week from aerial surveys or telemetry tower locations. The week that hunting opened, 89.5% of birds were located, but success rapidly dropped thereafter. Success in locating birds declined over the field season as birds began moving more in preparation for migration. Transmitter signals could be detected from a distance of about 2 miles.

By the end of the tracking season, 17 radio-marked birds were known to have died, of which 5 were harvested by hunters. Four of the 5 hunter-harvested birds were shot during the first 2 days of the season. The remaining hunter-shot bird was harvested on 20 October. Natural sources of mortality based on evidence at the site where the transmitter was found included predation by mink (*Mustela vison*) and other mammals (7), great-horned owls (*Bubo virginianus*) or other raptors (3), and unknown sources (2). During hunting season, hunters may have crippled some of these birds before predators consumed them. Losses to predation (6) prior to hunting season were similar in number to those (3 predation + 2 unknown causes) after the opening, though formal survival analyses have yet to be performed. Three birds were harvested after the tracking period (2 in Louisiana, 1 in Illinois). Four radios were thought to have dehisced because they were retrieved from open water, but only 2 of these occurred before the end of the tracking season.

Refuge use was documented for 20 radio-marked birds during the fall migration period; however, not all refuges were used equally. The most heavily used refuges were Mud Goose, Drumbeater, and Tamarac National Wildlife Refuge (NWR). Seven radio-marked birds were located on Tamarac NWR. No radio-marked birds were documented at Rice Lake NWR this year, but this refuge was outside the capture area and we expected use of this refuge by radio-marked birds to be less than for refuges located within the capture area. However, Rice Lake NWR is an important staging area for ring-necked ducks in the fall, so we will continue to monitor this refuge throughout this study. Several state refuges also received no documented use by radio-marked birds this year (Table 1). Refuges were rarely used before hunting season, but use increased markedly with the onset of hunting (Figure 2).

DISCUSSION

Two field seasons remain. In 2008, field methods will be similar to those in 2007. Transmitter range in 2007 was less than expected, but it was sufficient to meet study objectives. Therefore, we will continue to use the same transmitters in 2008. In 2008, we will also attempt to locate ring-necked ducks that received nasal saddles as post-fledging birds in 2007. If few birds are resighted, we will discontinue marking with nasal saddles in 2008. However, if we are able to resight birds, we will continue these methods until the end of the study to document the degree of natal philopatry in young ring-necked ducks. This study will conclude in 2009. More formal analyses will be conducted at the conclusion of the study. Results and discussion of these analyses will be included in future Summaries of Wildlife Research Findings.

ACKNOWLEDGMENTS

M. Zicus was instrumental in planning, development, and initiation of this project. J. Berdeen helped with planning, surgeries, night-lighting, and hiring interns. S. Bischof, P. Christensen, B. Ferry, and J. Kennedy helped set up remote towers, capture, and radio-track birds. S. Cordts, J. Lawrence, K. Noyce, and B. Sampson helped with surgeries. J. Lawrence and S. Cordts also helped in the field, especially with aerial telemetry. J. Heineman flew telemetry flights, and A. Buchert flew us to Drumbeater Lake and helped set up the remote tower. J. Fieberg provided statistical advice. Dr. A. Pillar and M. Kelly of Bemidji Veterinary Hospital ordered surgical equipment and gave technical advice. Dave Brandt, United States Geological Survey Northern Prairie Research Center, loaned us 2 pairs of crimping pliers. John Finn, Leech Lake DNR, guided us into Drumbeater Lake, and retrieved equipment from Drumbeater Lake. R. Lego allowed access to the Leech River, and D. Barrett, North Country Regional Hospital Surgery Department, sterilized transmitters.

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Table 1. National Wildlife Refuges and Minnesota State Refuges included in the study area, approximate location of the refuges, number of recording telemetry stations established on each refuge and the use of each refuge by radio-marked post-fledging ring-necked ducks.

Refuge	Location	Receivers	Activity
Rice Lake National Wildlife Refuge	5 mi SSW of McGregor	4	No
Tamarac National Wildlife Refuge	16 mi. NE Detroit Lakes	3	Yes
Donkey Lake	6 mi. SW Longville	1	Yes
Drumbeater Lake	2 mi. N of Federal Dam	1	Yes
Fiske and Blue Rock Lakes	8 mi. SE Northhome	1	Yes
Gimmer Lake	10 mi. SE Blackduck	1	No
Hatties and Jim Lakes	13 mi. SE Blackduck	1	No
Hole-in-the-Bog Lake	2 mi. SW Bena	1	No
Mud Goose Lake	4 mi. SSW of Ballclub	1	Yes
Lower Pigeon Refuge	4 mi. S Squaw Lake	1	Yes
Pigeon River	6 mi. S Squaw Lake	1	No
Preston Lakes	22 mi. ENE of Bemidji	1	No
Round Lake Waterfowl Refuge	8 mi. N Deer River	1	No
Rice Pond	9 mi. E of Turtle River	1	Yes

Table 2. Ring-necked duckling captures per county, 2007.

County	Captures
Aitkin	1
Becker	6
Beltrami	17
Cass	9
Clearwater	5
Hubbard	3
Itasca	9
Koochiching	2

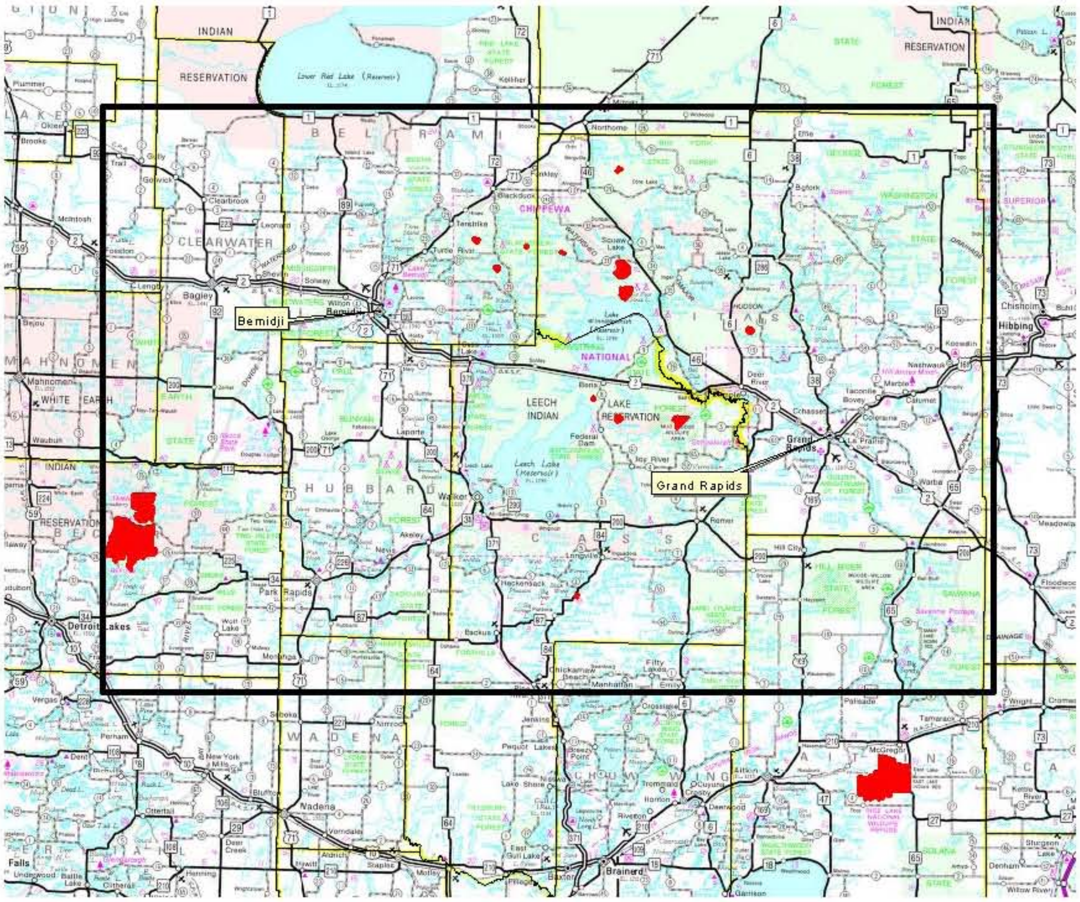

Figure 1. Ring-necked duck study area depicting 12 state waterfowl refuges and 2 National Wildlife Refuges in red.

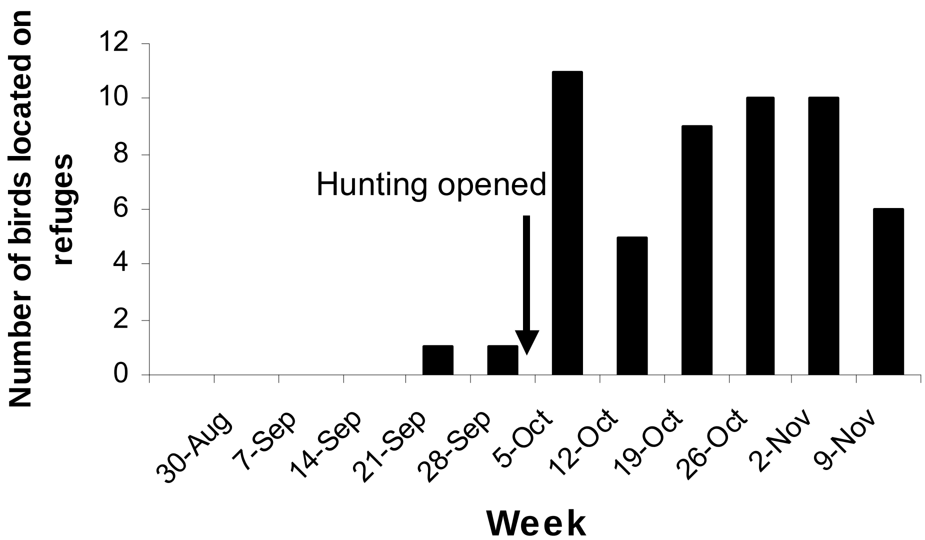

Figure 2. Use of refuges by post-fledging ring-necked ducks before and during hunting season in 2007.

INFLUENCE OF FISH, AGRICULTURE, AND BIOME ON ALGAL ABUNDANCE IN SHALLOW LAKES[1]

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We measured algal abundance in 72 shallow lakes across 2 biomes (prairie and deciduous forest) in western Minnesota during July 2005-06. We also determined type of fish community and fish biomass present in each site, and used Geographic Information Systems to estimate the proportion of agriculture and other cover types within each lake's watershed. We used a model-selection approach to assess the relationships between algal abundance and a) biome, b) proportion agriculture and other cover types at the watershed scale, c) lake and watershed morphometry, and d) relative biomass of benthivorous + planktivorous fish. Our best models included terms for biome, benthivorous + planktivorous fish biomass, and extent agriculture, and explained 66% and 48% of the variance in algal abundance during 2005-06, respectively. Model averaging reflected stronger influence of fish biomass and biome than proportion of agriculture. Our results indicated that management of Minnesota's shallow lakes should include management of fish populations along with surrounding land use.

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ASSESSING CHARACTERISTICS OF KENOGAMA LAKE, A SHALLOW WATERFOWL LAKE IN NORTHERN MINNESOTA: PRELIMINARY FINDINGS

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SUMMARY OF FINDINGS

Kenogama Lake (Kenogama) is a shallow lake in western Itasca County, MN, contained within the boundaries of the Laurentian Mixed Forest. The lake is believed to be of considerable importance to migrating diving ducks, especially Lesser Scaup (*Aythya affinis*). During the past 15 years, anecdotal evidence indicates that fall use of Kenogama by diving ducks has diminished. Mechanisms responsible for these declines are unknown but may include changes in duck migration patterns, weather or precipitation dynamics, or changing availability of aquatic invertebrates or other food resources important in diets of migrating Lesser Scaup and other ducks. Of particular interest is whether historical use of Kenogama as a site for rearing of walleye (*Sander vitreus*) fry is related to changes in lake characteristics and habitat suitability for migrating ducks. During 2007, we monitored relative abundance of fish and aquatic invertebrates, water transparency, phytoplankton abundance, major nutrients, submerged macrophytes, and other characteristics of Kenogama. Fish were relatively abundant, with golden shiners (*Notemigonus crysoleucas)* and walleyes comprising most biomass in our samples. We observed sparse populations of macroinvertebrates such as aquatic insects and amphipods. Zooplankton were abundant, but only small taxa were numerous, probably reflecting high predation by zooplanktivorous fish. Water quality data and relative abundance of submerged aquatic plants were indicative of a shallow lake in a "clear-water state" with a lighted substrate and rooted aquatic plants present in most areas throughout the lake. Walleye stomach contents indicated considerable consumption of aquatic invertebrates. However, it is not yet known whether this consumption is responsible for apparent low density of macroinvertebrates throughout the lake. We plan additional monitoring efforts at Kenogama during 2008 and future data may help clarify influences of walleye and other fish in relation to Kenogama's ecological characteristics and suitability for waterfowl.

INTRODUCTION

Kenogama Lake holds considerable interest to wildlife managers in north central Minnesota due to its history of fall use by migrating diving ducks. Located in the Laurentian Mixed Forest, Kenogama also represents a type of shallow lake that has received little study, particularly within North America. In Minnesota and elsewhere, shallow lakes are believed to exhibit a bimodal distribution of characteristics, tending toward 1 of 2 opposite regime conditions along a continuum of water clarity and extent of submerged macrophyte development (Scheffer 2004). These "alternative states" are typically characterized by clear-water lakes containing abundant submerged macrophytes, and alternatively, by lakes with turbid water and sparse submerged macrophyte communities. In each alternative state, shallow lakes are believed to exhibit stability and resist changes toward the opposite extreme, especially at either very high or very low levels of background nutrients. However, at intermediate nutrients, shallow lakes in either stable state can shift to the opposite state in response to water level changes, winter hypoxia and resulting "winterkill", chemical fish kills, introduction of fish, and other perturbations. For example, shifts to a turbid state often follow increased density of planktivorous/benthivorous fish populations, prolonged increases in water depth, or increased nutrient loading (although we have fewer examples of the latter). Complete removal of fish from shallow Minnesota lakes has been shown to induce transitions toward clear-water states (Hanson and Butler 1994 a, Zimmer et al. 2002), but even then, regime shifts may be temporary.

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Mechanisms structuring characteristics of shallow lakes in forested regions of Minnesota and elsewhere are not well understood. At least some shallow northern lakes seem to follow the general pattern of alternative regimes (Bayley 2003, Zimmer et al. in prep). Minnesota's shallow lakes program has compiled data from 375 shallow lakes statewide, yet these efforts target relatively few lakes east of the transition zone from "parkland" to forested environment (Nicole Hansel-Welch, Personal Comm.). Data from Minnesota also indicate that patterns of shallow lake characteristics and behavior differ dramatically between prairie and transition ecoregions, perhaps indicating importance of different structuring mechanisms across regional gradients (Herwig et al. 2006).

Previous studies of shallow "parkland" lakes in north central Minnesota indicated that these sites often supported diverse fish communities (Herwig et al. 2006). Thus, we expected that Kenogama Lake might also contain a rich fish community. This seemed especially likely given the lake's size, history of angler interest, and the recent pattern of mild winters. Limited previous reports from Kenogama indicated that water clarity was good, that abundance of submerged aquatic plants was relatively high, and that plants were not limited by low water clarity (Hansel-Welch et al., unpublished data). Kenogama has been used to rear walleye since 1983 (MNDNR, unpublished data). Walleye fry are stocked in spring; juveniles (age-0) are removed during fall. Some unharvested walleye are known to survive over-winter because, at times, summer and winter angling was popular, at least during the past decade.

Recent research evaluating stocking of walleye fry in shallow prairie lakes indicated that adding juvenile (age-0) walleye to sites containing moderately dense cyprinid populations actually bolstered abundance of macroinvertebrates and zooplankton, and favored clear water shifts (Potthoff et al. 2008). However, it is currently not possible to predict long-term consequences of walleye fry stocking in a shallow lake with an unknown fish community, or where adult fish are removed at low rates (and do not winterkill). These are interesting questions for which good limnological monitoring at Kenogama might improve the general understanding of shallow lakes in forested landscapes in Minnesota and elsewhere.

During May 2007, we initiated a 2-year monitoring effort at Kenogama. Our objectives were to: (1) document current ecological conditions within the lake; (2) assess characteristics of the lake's current fish community; (3) characterize the invertebrate community, with special emphasis on selected taxa known to be important for water quality and as waterfowl food; and (4) draw broad comparisons between Kenogama and other shallow MN lakes recently studied. This interim report summarizes our efforts during May-September 2007; we also discuss some of our preliminary findings and offer some hypotheses about current characteristics of the lake. Interpretations may change with additional data gathering during 2008 and further data analyses.

METHODS

During May 2007, we chose 6 transects by randomly selecting 6 compass bearings (0-360 from north) from the approximate center of the lake. Two sampling stations were established along each of the 6 transects (total of 12), one 20 meters from the edge of the emergent vegetation and the second, at a location one-half the distance from the shoreline to the center of the lake. All sampling for aquatic invertebrates, fish, and water quality parameters was conducted at 2 locations along each of these transects.

Fish Community

Relative abundance and species composition of Kenogama's fish population was assessed using 3 gill nets, 12 mini-fyke (small trap) nets, and 12 minnow traps during 13-15 June and 7-9 August. For each sampling effort, a single mini-fyke net and a minnow trap were deployed along the shore, or at the deep margin of emergent vegetation along all 6 transects.

Gill nets were set concurrently; 1 at the deepest location along transects 2, 4, and 6. Sampling gear was deployed in the morning and checked approximately 24 hours later. All fish were identified to species, and wet weights (g) and total lengths (mm) were determined in the field. Random samples of stomachs and otoliths were taken from walleye. Because we were especially concerned with population characteristics and functional influences of walleye, we also examined walleye length at age distribution, length frequency, relative weights (Wr, Pope and Carter 2007), and stomach contents.

Aquatic Invertebrates

Aquatic invertebrates were sampled at approximately 2-3-week intervals using column samples (CS) (Swanson 1978) and vertical activity traps (AT) after the design of Muscha et al. (2001). CS and AT samples were gathered concurrently from deep and shallow collecting locations, respectively. CSs were concentrated by passage through a 64 μm-mesh funnel. ATs were deployed for approximately 24 hrs, then collected and condensed by passage through a 80 μm-mesh funnel. Both CS and AT samples were preserved in 70% ethanol.

Invertebrates were identified to the lowest feasible taxonomic group (mostly family, sometimes genus) and were counted in the lab at Bemidji State University. To facilitate analyses, we pooled organisms into the following eleven groups: all insects, all Diptera (Chaoboridae, Chironomidae, Culicidae), Corixidae, Ephemeroptera, Amphipoda, large cladocera (mainly *Daphnia, Ceriodaphnia, Simocephalus,* and Sididae), small cladocera (Chydoridae, Bosminidae, and *Diaphanosoma*), cyclopoid copepods, calanoid copepods, and *Leptidora*. Because we were interested primarily in assessing relative abundance and seasonal trends, we combined results of all CS and AT samples on each sampling date to develop a relative abundance estimate for each of the 11 groups listed above. We assessed trends in major taxa graphically, although we expect to perform statistical analyses as more data become available.

Plant Community

Relative abundance of submerged macrophytes was assessed on 2 August using methods of Deppe and Lathrop (1992) (an approach generally similar to that currently used by MNDNR Section of Wildlife Shallow Lakes Program staff and by researchers from MNDNR Wetland Wildlife Group). We selected 8 transects, with 5 sampling locations equidistant from one another and from shorelines. At each location, we collected plants using 2 casts of a weighted plant rake. We recorded presence/absence of all submergent species retained on each cast. We estimated relative abundance of each species as the number of occurrences (of a possible 40) that a species was sampled on at least 1 rake cast per sampling location. A maximum score of 40 would indicate that a species was present at all sampling stations.

Given our interest in comparing Kenogama to other shallow MN lakes, we applied 2 additional procedures using plant data. First, we constructed a plant relative-abundance matrix by combining Kenogama plant survey results with similar data from a recent (2006) study of 74 shallow lakes in MN (Herwig et al. 2006). We then used Principal Components Analysis (PCA) to identify patterns in presence and abundance of plant species, and especially, to assess similarity between plant communities of Kenogama and other shallow lakes in Minnesota. Second, we compared plant (% vegetated points) and water clarity characteristics (average Secchi/average lake depth) of Kenogama with other shallow lakes in a large data set supplied by the MNDNR Section of Wildlife Shallow Lakes Program (Nicole Hansel-Welch, unpublished data). These approaches allowed us to compare Kenogama with other shallow lakes statewide in terms of submerged plants and water clarity relationships.

Chemical Properties and Water Quality Features

We assessed water clarity, phytoplankton abundance (indexed using chlorophyll a (Chl *a*)), and concentrations of major nutrients at approximately 2-3 week intervals during 31 May-1 August. Chemical analyses were performed using surface-dip water samples collected at 3 central locations within the lake. Secchi disk transparency was measured at these 3 sites using a standard (20-cm) circular disk. We also measured turbidity directly using a LaMotte turbidity meter following transport of water samples back to the lab. Water samples collected for determination of total phosphorus (TP), total nitrogen (TN), and nitrate (NH_3) were frozen and transported to laboratory facilities. Water samples were also collected and later analyzed for total dissolved phosphorus (TDP) and phytoplankton abundance (Chl *a*). Previous work in shallow lakes indicated TDP is sometimes much more useful than TP for evaluating ecological change in shallow lakes (Potthoff et al. In press.). TDP samples were prepared by filtering lake water through GF/F glass fiber filters (0.7 µm nominal pore size) and immediately freezing the filtered water. Chl *a* samples were prepared by filtering lake water through a GF/F glass fiber filter; filters were then wrapped in tin foil and immediately frozen. TDP concentrations were determined using high-temperature persulfate digestion followed by ascorbic-acid colorimetry. Chl *a* was measured via fluorometric analysis following a 24 h, alkaline-acetone extraction of photosynthetic pigments. All chemical procedures for analysis of Chl *a*, TP, TDP, TN, and NH_3 were performed using laboratory facilities at the University of St. Thomas (St. Paul, MN). Preliminary evaluation of data trends was done graphically.

Relative Water Depth

Relative water level readings were recorded approximately biweekly from 31 May-15 August by reading a depth gauge near the boat access. On 8 June, using a Lowrance sonar unit, we also measured water depth at various locations around the lake.

RESULTS

Fish Community

Fourteen species of fishes were captured during the 2007 sampling period (Table 1). Based on results of mini-fyke (trap) nets, golden shiner, fathead minnow (*Pimephales promelas*) and walleye were the most abundant fishes (highest relative mass, Table 1). Walleye were the most abundant species captured in gill nets, although some were also sampled in mini-fyke nets. Golden shiners from several size (year) classes were captured in mini-fyke nets. Gill nets also collected golden shiners but only larger sizes (135-185 mm) representing older year classes.

We observed 3 peaks in length frequency of walleye collected during 2007 (Figure 1). Lengths of the walleye collected shifted between June and August sample dates, reflecting summer growth (Figure 1). Age-assignment based on otoliths confirmed the 3 (or more) year-classes indicated by length-frequencies in Figure 1. We observed that randomly selected walleye ranging from 230–300 mm were age-1 (2006 year class), fish ranging from 360–430 mm were age-2 (2005 year class), and larger walleye ranged from ages 3-5.

Walleye appeared to be in fair-good condition, with an average relative weight (W_r) ranging between 0.8 and 1.0 (Figure 2). Smaller fish demonstrated the highest W_r during the June sampling period, whereas the larger fish appeared healthier during August. In general, W_r values were negatively associated with total length during the first sample period, perhaps indicating that food availability most benefited smaller fish. During the second sampling period, feeding conditions probably favored larger fish, and this may have been reflected in a positive correlation between W_r and length.

Summer diet of adult walleye consisted largely of aquatic invertebrates (Table 2). Amphipods comprised the major percentage of food found in walleye stomachs during June (32.7% wet mass, N=8) and August (58.3% wet mass, N=9). Minnows (cyprinids) were absent in walleye stomachs examined during June, but occurred in 16.7 % of stomachs examined in August (31.3% wet mass, N=9). Other food items present in walleye stomachs were Decapoda (crayfish), Hirundea (leeches), and larval insects. Almost one-fourth of walleye stomachs were empty, and considerable proportions of stomach contents (19.4%) were decomposed, thus were unidentifiable.

Aquatic Invertebrates

Zooplankton samples during late May–September were numerically dominated by small bodied cladocerans and copepods. Small cladocerans occurred consistently and persisted through mid-September, but density peaked on 9 July (Figure 3a). Large cladocerans occurred in relatively low numbers throughout the summer, but peaked briefly on 1 August, when they increased by a factor of 4 (Figure 3a). *Leptodora* (large, predatory cladocera) were absent in samples from the first 3 sampling dates, but appeared in samples gathered on 9 July. *Leptodora* persisted only for a short period, with low densities by mid-September (Figure 3a).

Calanoid copepods persisted throughout the sampling period, but were highly variable throughout the summer (Figure 3b). In general, Calanoid densities followed a bimodal distribution, peaking during early July and early August (Figure 3b). Cyclopoid copepods were also common in samples from Kenogama, but with a slight decrease from late July through late September (Figure 3b). In general, calanoid copepods were more abundant than were cyclopoids.

Amphipods were captured in very low numbers throughout the sampling year. Lake-wide catches of amphipods (all traps combined) ranged from 0 (31 May and 1 August) to 4 individuals (23 July) (Figure 4b). As with amphipods, Corixidae (water boatmen) were periodically captured, but densities in our samples remained very low (< 5 individuals, lake-wide) (Figure 4a). Ephemeroptera (mayflies) occurred periodically in our samples, ranging from 0 (7 June and 1 August) to 18 (20 June) individuals during the sampling year, with a peak during June, then steadily decreasing during the remainder of the study period (Figure 4a).

Water Clarity, Phytoplankton, and Major Nutrients

Water clarity followed a typical summer pattern, decreasing from seasonal highs in May and June, to its lowest level in early August (Figure 5a). Because the annual ratio of mean Secchi/depth values falls far to the right of Figure 7b (and well above a ratio of 0.5, a theoretical limit of the photic zone), most of the substrate in Kenogama was sufficiently lighted to support submerged aquatic plants.

TP values in Kenogama remained relatively low throughout late May-early August, ranging from slightly below, to slightly above 25 *u*g L^{-1} (Figure 5b). Throughout late May–early August, TDP comprised >50 % of the TP pool in Kenogama (Figure 3b).

Phytoplankton abundance also remained very low during late May-early August, with mean values ranging from approximately 5.5 – 8.5 *u*g L^{-1} (Figure 6a). Seasonal patterns in ratios of Chl *a*:TP were also consistently low, indicating that considerable phosphorus was probably not associated with phytoplankton (Figure 6a).

Relative Water Depth

Lake depth generally decreased as the sampling season progressed (by approximately 0.5 ft (0.15 m)) during late May–15 August (Figure 6b). We assessed depths lake-wide only once on 8 June, when depth ranged from 3.1 – 4.9 ft (0.94 – 1.49 m) in various locations.

Submerged Aquatic Plants

Submerged aquatic plants were present at 100 % of sites sampled during 2007. However, only 3 species were widespread; these included Robbins' pondweed (*Potamogeton robbinsii*, collected at 100 % of sites), bushy pondweed (*Najas flexilis*, collected at 65 % of sites), and large-leaf pondweed (*Potamogeton amplifolius*, collected at 43 % of sites). Flatstem pondweed (*Potamogeton zosterformis)*, whitestem pondweed (*Potamogeton praelongus*), 1 *Sagittaria* spp., and 1 unidentified pondweed (*Potamogeton spp.*) were also collected, but these were far less abundant.

DISCUSSION

Kenogama supported a diverse fish community during 2007. Similar fish community data from shallow lakes in MN are scarce, but comparisons with results of recent studies of 74 lakes provide some general insight, especially since data from these broader studies were collected using identical gear. Species richness in Kenogama's fish community (14 taxa) was similar to the upper range of values reported from shallow parkland lakes in north central Minnesota (Herwig et al. 2006, Herwig et al. in prep.). Total fish mass captured (relative abundance) in Kenogama was within the range of values observed in the broader MN study (Table 1, Zimmer et al. In Prep.). In spite of Kenogama's high fish species diversity, the community was comprised of mostly planktivorous species and walleye. Excepting walleye, piscivores were absent, and benthivores were uncommon [low mass of only white sucker (*Catostomus commersoni*) and yellow bullhead (*Ameiurus natalis*)].

Kenogama's fish community differed sharply from other shallow lakes recently studied in MN in at least 2 ways. First, Kenogama supported a relatively robust walleye population that included fish from at least 3 year-classes. Second, Kenogama's golden shiner population is higher than we have previously observed in any shallow lakes in MN. Certainly Kenogama's walleye population results directly from operational walleye rearing activities here, and from incomplete recovery and removal of these fish during fall netting efforts. It is plausible that the dense population of golden shiners results, in part, from angling activities, as golden shiners are a popular regional bait fish, especially during winter months. This combination of abundant golden shiners (planktivores) concurrent with a well-established population of walleye (piscivores) is unusual and seems at odds with recent studies indicating that walleye stocking has potential to limit abundance of planktivores in shallow lakes (Potthoff et al., In Press). Different trophic relationships at Kenogama probably result from several things. First, previous research demonstrated that walleye fry sharply reduce fathead minnows; adult walleye apparently do not limit minnow abundance. Second, golden shiners may resist depredation by walleye to greater extent than did fathead minnows in previous work, especially since shiners are longer-lived and reach larger sizes than do fathead minnows. Finally, it is plausible that extensive stands of submerged macrophytes in Kenogama provide refuge areas for golden shiners and other planktivores, thus uncoupling predator and prey densities.

Comparison of Kenogama plant community characteristics with similar data from 74 other shallow MN lakes indicates considerable dissimilarity (Figure 7a). This is not unexpected and probably results from high densities of Robbins pondweed, bushy pondweed, and large-leaf pondweed, all of which were rare or absent at other shallow lakes in MN (Herwig et al. 2006). As is often the case, a large proportion of the submerged plants were senescent by mid-August.

Trophic relationships in Kenogama suggest that consumption of macroinvertebrates and zooplankton was very high during summer 2007. Surprisingly, amphipods comprised a major percentage of food found in walleye stomachs during June and August; minnows were absent in walleye stomachs examined during June and were only a minor food item in August. However, these results should be viewed cautiously because sample sizes were small (total of 17 stomach examined) and high water temperatures resulted in decomposition of some food items prior to dissection. Dominant planktivores (golden shiners and fathead minnows) were not dissected for diet analysis, but we expect that predation on zooplankton and macroinvertebrates by cyprinids was intense. This was reflected in the sparse zooplankton community, low levels of macroinvertebrates, and, perhaps, by the lack of amphipods in activity traps.

It is tempting to conclude that Kenogama's walleye population is responsible for the sparse macroinvertebrate community, especially given the high occurrence of macroinvertebrates in walleye stomachs. However, we urge caution in interpretation of these data because they were collected on 2 dates during a single summer. It is also likely that golden shiners and other planktivores are consuming a considerable proportion of available zooplankton and macroinvertebrates, although it is presently impossible to estimate consumption by various functional groups of fish. It would not be surprising if walleye depredation were a significant constraint on macroinvertebrates in Kenogama as Reed and Parsons (1999) concluded similar influences of walleye were operating in large prairie wetlands in west-central MN.

In general, Kenogama appears in a clear-water state with widespread submergent (or emergent) macrophytes (Figure 7b). This is consistent with our estimates that average lake depth is considerably less than that at which light availability becomes insufficient to maintain photosynthesis. However, during May–September 2007, the lake supported a relatively sparse invertebrate community. Zooplankton were dominated by small-bodied taxa known to be inefficient filter-feeders on phytoplankton, and macroinvertebrate relative abundance also appeared to be low (Hall et al. 1976). From the standpoint of zooplankton and macroinvertebrates, the lake seems to exhibit characteristics similar to a shallow lake in a turbid state. This probably underscores the need for better understanding of basic ecological characteristics of shallow lakes in forested regions of MN and elsewhere. Specifically, managers need to know what ranges of conditions are typical for shallow lakes statewide, and whether these lakes always provide good habitat for invertebrates and wildlife species simply because they exhibit clear water and moderately abundant submergent plants.

We are puzzled by relationships among water-column phosphorus concentrations, phytoplankton biomass (Chl *a*), likely zooplankton filter-feeding rates, and water clarity patterns. During all dates on which we measured water quality parameters, Chl *a* concentrations were always low (lake-wide average <10 ug L^{-1}). At the same time, dissolved phosphorus (TDP concentrations) comprised approximately 50 percent (or more) of the TP pool. This probably indicates that a very large portion of the phosphorus pool was available for plants (phytoplankton, periphyton, perhaps macrophytes), but remained unutilized. In other words, nutrient availability was not limiting phytoplankton growth. Given the predominance of small-bodied zooplankton in our samples (*Bosmina*, *Chydorus*, cyclopoid copepods, etc.) grazing rates were also not likely limiting phytoplankton. It seems plausible to expect that dissolved organic compounds might occur at high concentrations in Kenogama, thus limiting phytoplankton growth (Williamson et al. 1999), especially since the lake probably receives considerable inflows from peatland areas. However this too seems unlikely given relatively good water clarity in the lake. We are unable to explain the combination of high nutrient availability and low phytoplankton abundance, along with small-bodied zooplankton and clear water. However, if these patterns persist next year, we will consider this an important information need for shallow lakes in forested regions of MN.

Historical duck-use patterns at Kenogama are poorly documented. Anecdotal reports suggest limited interest in duck hunting here prior to the decade of the 1980s, probably due to abundant opportunity in nearby areas (Robert Jessen and Leon Johnson, personal comm.). However, hunting pressure on Kenogama increased during the 1980s and early-mid 1990s. High fall use by migrating Lesser Scaup was well documented during the early 1990s and hunting pressure on the lake was high. Duck use apparently declined during the later 1990s and appeared to remain relatively low during the period of 2000-2007.

At a broad scale, wetland and shallow lake quality certainly influences food availability and habitat suitability for migrating diving ducks (Anteau and Afton 2008). It is also obvious that high-density fish populations can (directly and indirectly) influence invertebrate abundance and water quality and, in some cases, these effects are reflected in habitat suitability for foraging ducks (Hanson and Butler 1994 a,b, Bouffard and Hanson 1997, Cox et al. 1997). Presently, available data are insufficient to determine reasons for apparent low abundance of aquatic invertebrates, or for the unusual patterns of phytoplankton abundance and nutrient availability observed in Kenogama. Waterfowl use sometimes increases following water quality (and invertebrate community) improvements in shallow lakes (Hanson and Butler 1994 a), however this is not always the case. Weather, annual recruitment, and other things work together to determine whether food resources are actually utilized in a potential waterfowl feeding lake. However, our results are consistent with the notion that food resources for some waterfowl (amphipods, for example) are relatively low in Kenogama and this may influence patterns of fall use, at least by Lesser Scaup.

We expect to repeat methods described here during spring-summer 2008. In addition, we plan to explore suitability of additional sampling methods for aquatic macroinvertebrates, with attention to whether relative abundance estimates of amphipods can be improved. Also, we anticipate collecting golden shiner stomachs for diet analysis, to develop a better understanding of factors constraining invertebrates. Finally, we hope it will be possible to include Kenogama in a core group of forest lakes to be used as sites for upcoming shallow lakes research. We believe that only by conducting multi-year studies of numerous lakes across regional gradients can we hope to clarify important mechanisms and influences structuring shallow lake communities in MN.

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Table 1. Relative abundance (mean weight (g) of catch per overnight set, standard error in parentheses) of fishes in Lake Kenogama, Minnesota, during summer 2007.

		14-Jun-07			9-Aug-07		
		Trap net	Gill net	Activity trap	Trap net	Gill net	Activity trap
Species	Common name	*N* = 12	*N* = 3	*N* = 12	*N* = 12	*N* = 3	*N* = 12
Cyprinidae							
Hybognathus hankinsoni	brassy minnow	0.4(0.4)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
Notemigonus crysoleucas	golden shiner	3759.8(791.6)	277.3(17.3)	0.0(0.0)	26.5(9.7)	150.2(93.0)	0.0(0.0)
Notropis heterolepis	blacknose shiner	23.5(5.1)	0.0(0.0)	0.0(0.0)	4.4(2.5)	0.0(0.0)	0.0(0.0)
Phoxinus eos	northern redbelly dace	68.5(27.8)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
Phoxinus neogaeus	finescale dace	11.3(5.4)	0.0(0.0)	0.0(0.0)	0.4(0.4)	0.0(0.0)	0.0(0.0)
Pimephales promelas	fathead minnow	292.6(129.6)	0.0(0.0)	0.3(0.3)	6.9(2.7)	0.0(0.0)	0.0(0.0)
Catostomidae							
Catostomus commersoni	white sucker	0.0(0.0)	720.0(361.2)	0.0(0.0)	0.0(0.0)	412.3(296.7)	0.0(0.0)
Ictaluridae							
Ameiurus natalis	yellow bullhead	48.3(48.3)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
Umbridae							
Umbra limi	central mudminnow	3.0(1.6)	0.0(0.0)	1.0(0.8)	17.9(13.5)	0.0(0.0)	0.5(0.5)
Gasterosteidae							
Culaea inconstans	brook stickleback	38.3(16.6)	0.0(0.0)	3.4(2.2)	0.2(0.2)	0.0(0.0)	0.2(0.1)
Percidae							
Etheostoma exile	Iowa darter	1.7(1.1)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
Etheostoma nigrum	johnny darter	0.3(0.2)	0.0(0.0)	0.0(0.0)	0.0(0.2)	0.0(0.0)	0.0(0.0)
Perca flavescens	yellow perch	0.0(0.0)	0.0(0.0)	0.0(0.0)	3.3(3.3)	303.7(303.7)	0.0(0.0)
Sander vitreus	walleye	260.5(180.5)	9445.7(1304.6)	0.0(0.0)	214.2(94.2)	11447.7(2868.0)	0.0(0.0)

Table 2. Percent by weight and prevalence (percent of stomachs containing a food item) of stomach contents of walleyes in Lake Kenogama, Minnesota, summer 2007.

	6/14/2007 *N* = 8 stomachs examined Empty stomachs = 1 (12.5%)		8/9/2007 *N* = 9 stomachs examined Empty stomachs = 3 (33.3%)		Overall *N* = 17 stomachs examined Empty stomachs = 4 (23.5%)	
Food	Percent by weight	Prevalence	Percent by weight	Prevalence	Percent by weight	Prevalence
Hirudinea	28.2	25			9.4	11.8
Crustacea						
Amphipoda	32.7	25	58.3	66.7	40.7	35.3
Decapoda	15.5	12.5			10.7	5.9
Insecta						
Odonata	9.3	12.5	2.1	16.7	7.1	11.8
Ephemeroptera			8.3	33.3	2.6	11.8
Diptera	0.1	12.5			0.3	5.9
Pisces						
Cyprinidae			31.3	16.7	9.7	5.9
Unidentified	28.2	37.5			19.4	17.6

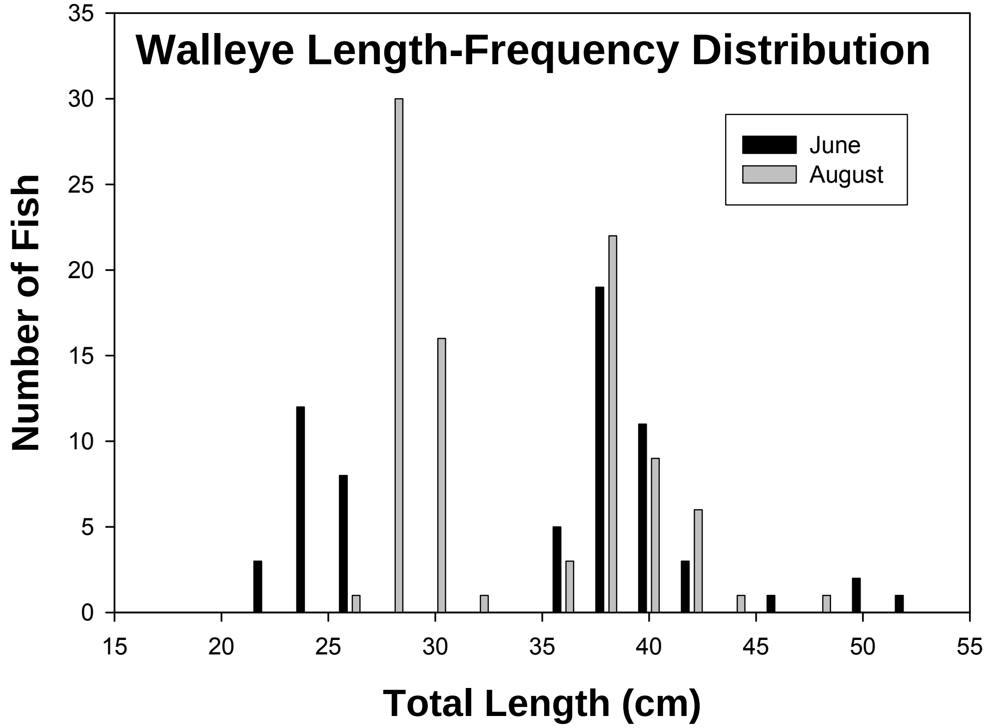

Figure 1. Length-frequency distribution of walleye captured in gill and mini-fyke nets during June and August 2007 in Kenogama Lake.

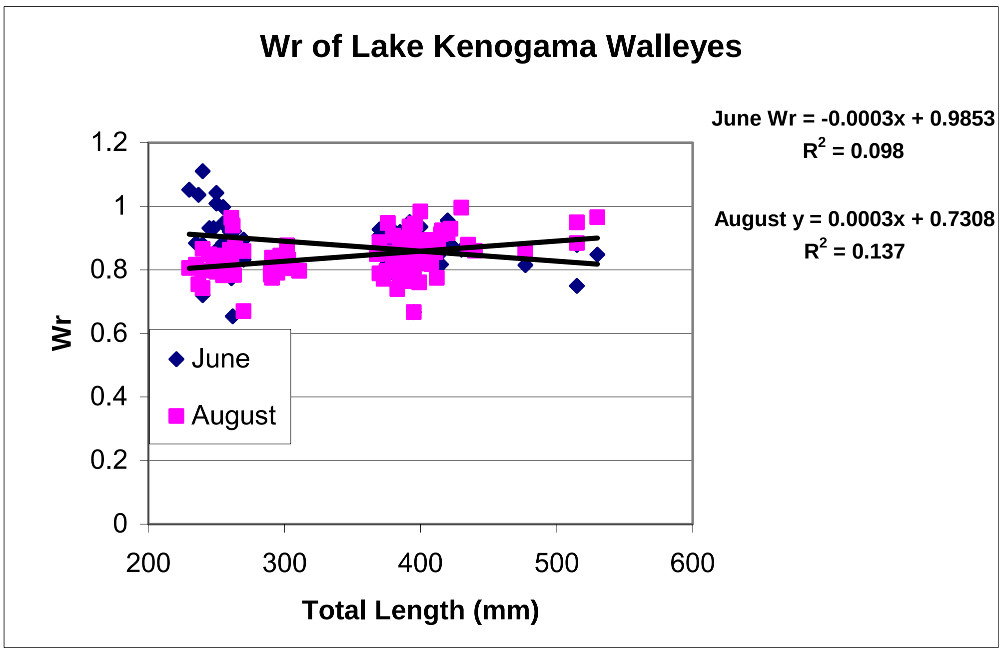

Figure 2. Relative weights (W_r) of walleyes sampled in Kenogama Lake during June and August 2007.

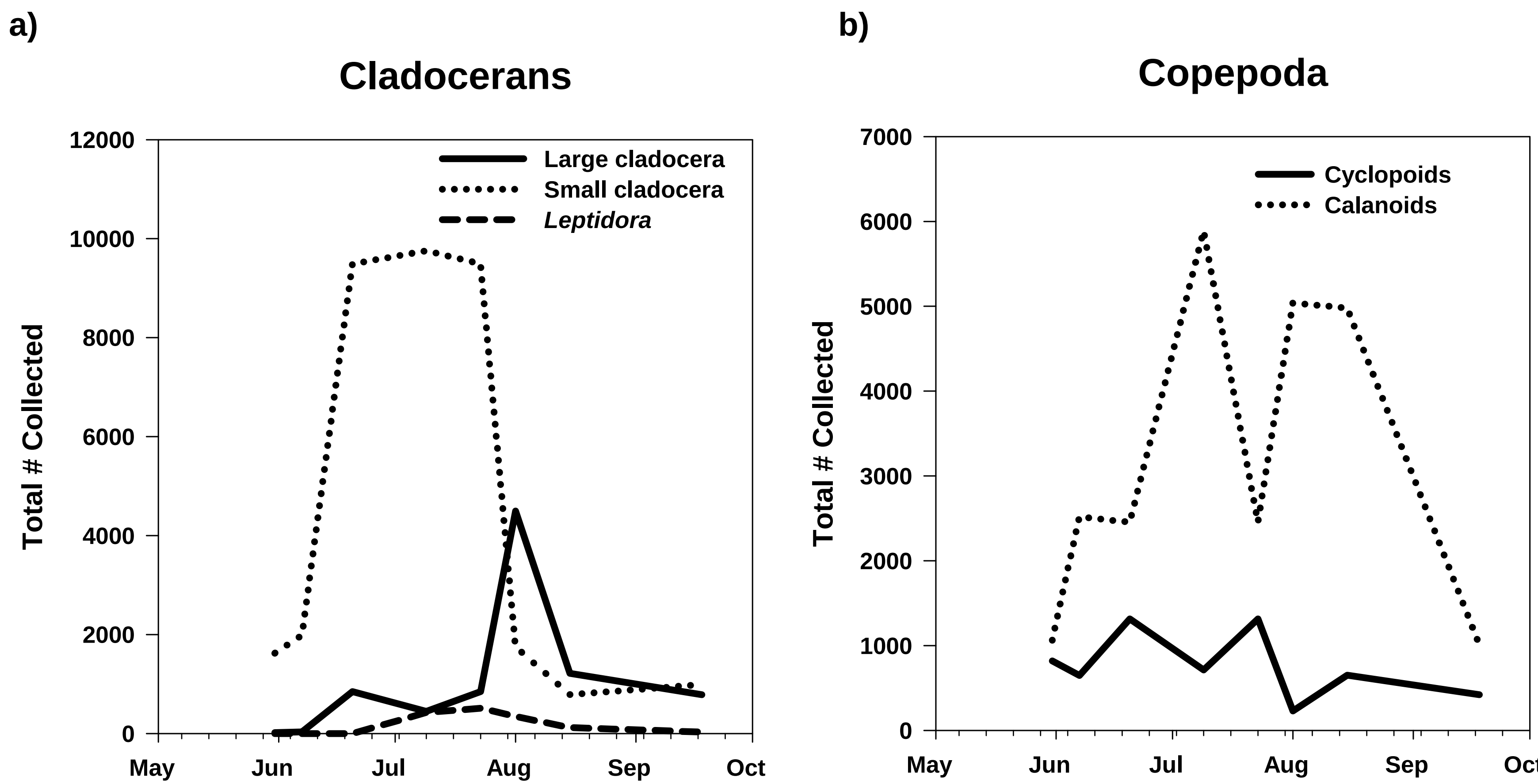

Figure 3. Seasonal patterns in total numbers of organisms captured in both activity traps (n=12) and vertical column sampler (n=12) on each sampling date. Large cladocerans (panel a) include *Daphnia, Ceriodaphnia,* Sididae, and *Simocephalus*; small cladocerans include Bosminidae, Chydoridae, and *Diaphanosoma*. Copepoda (panel b) were classified only to suborder.

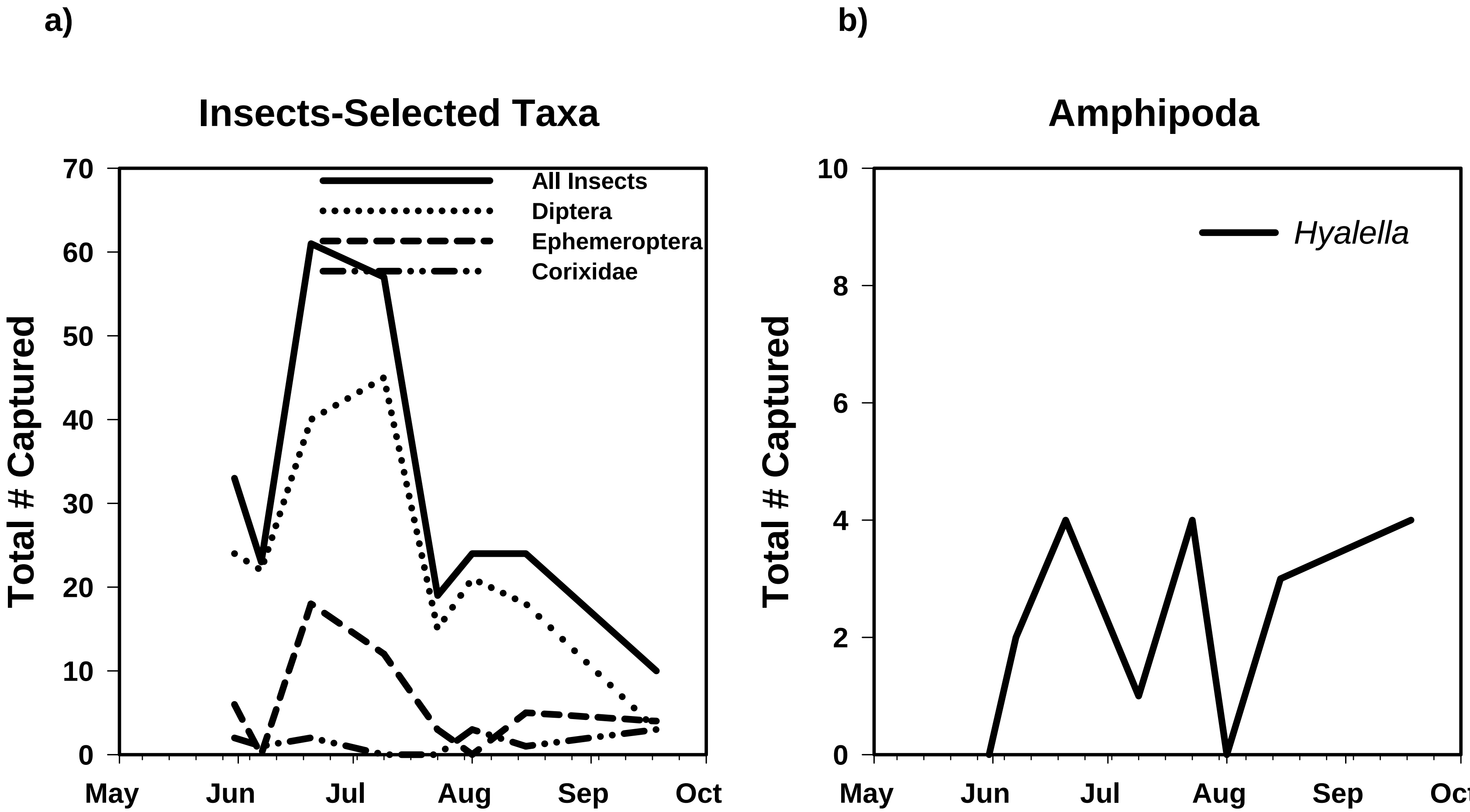

Figure 4. Seasonal patterns in total numbers of macroinvertebrates captured in Kenogama Lake during May-September 2007. Trend lines include total numbers of organisms captured in both activity traps (n=12) and vertical column sampler (n=12) on each sampling date.

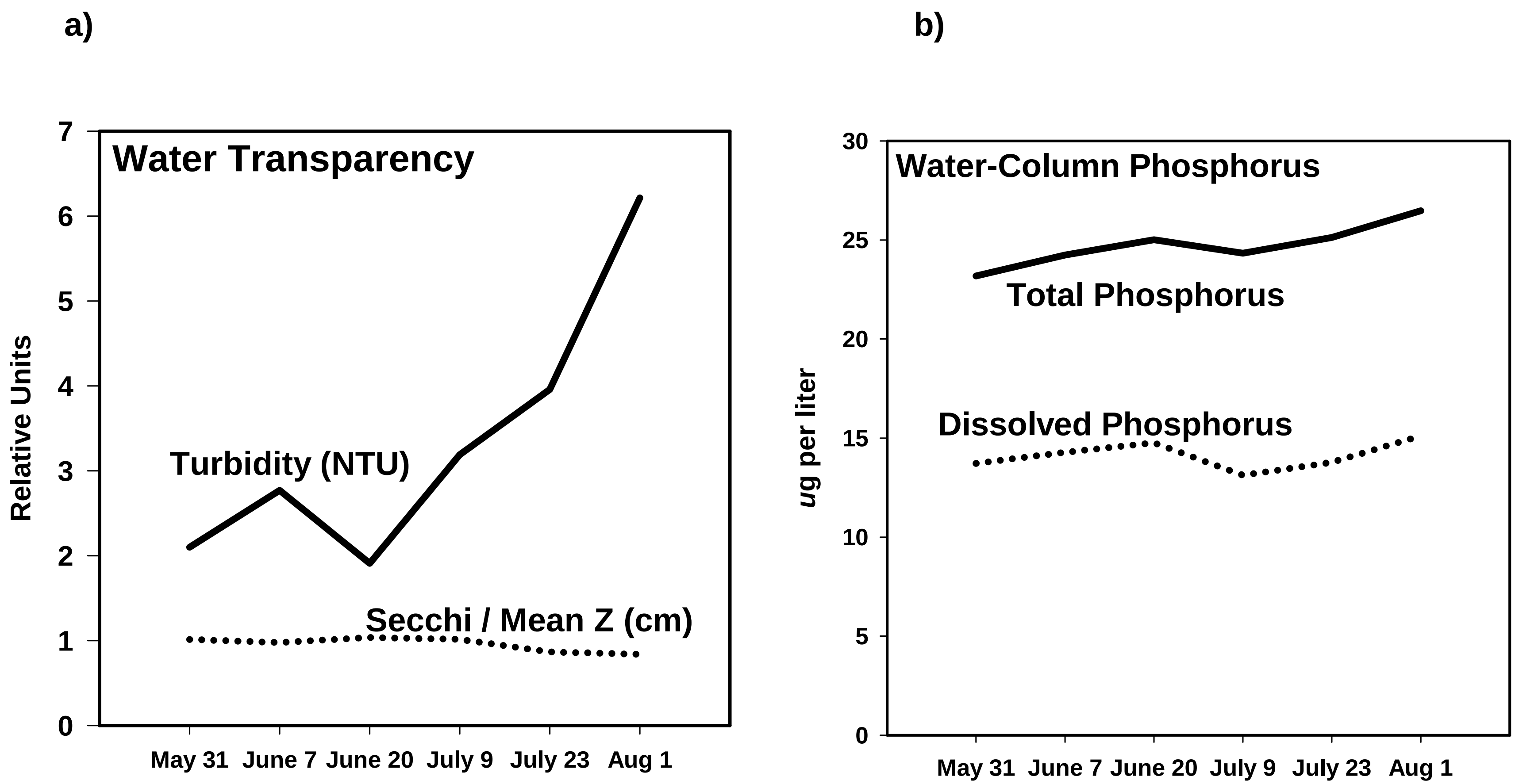

Figure 5. Water transparency patterns at Kenogama Lake during 2007 (a, left panel) depicted by ratio of Secchi disk transparency:mean lake depth, and turbidity measured using nephelometer. Total and dissolved phosphorus concentrations (2007) are summarized on right (panel b).

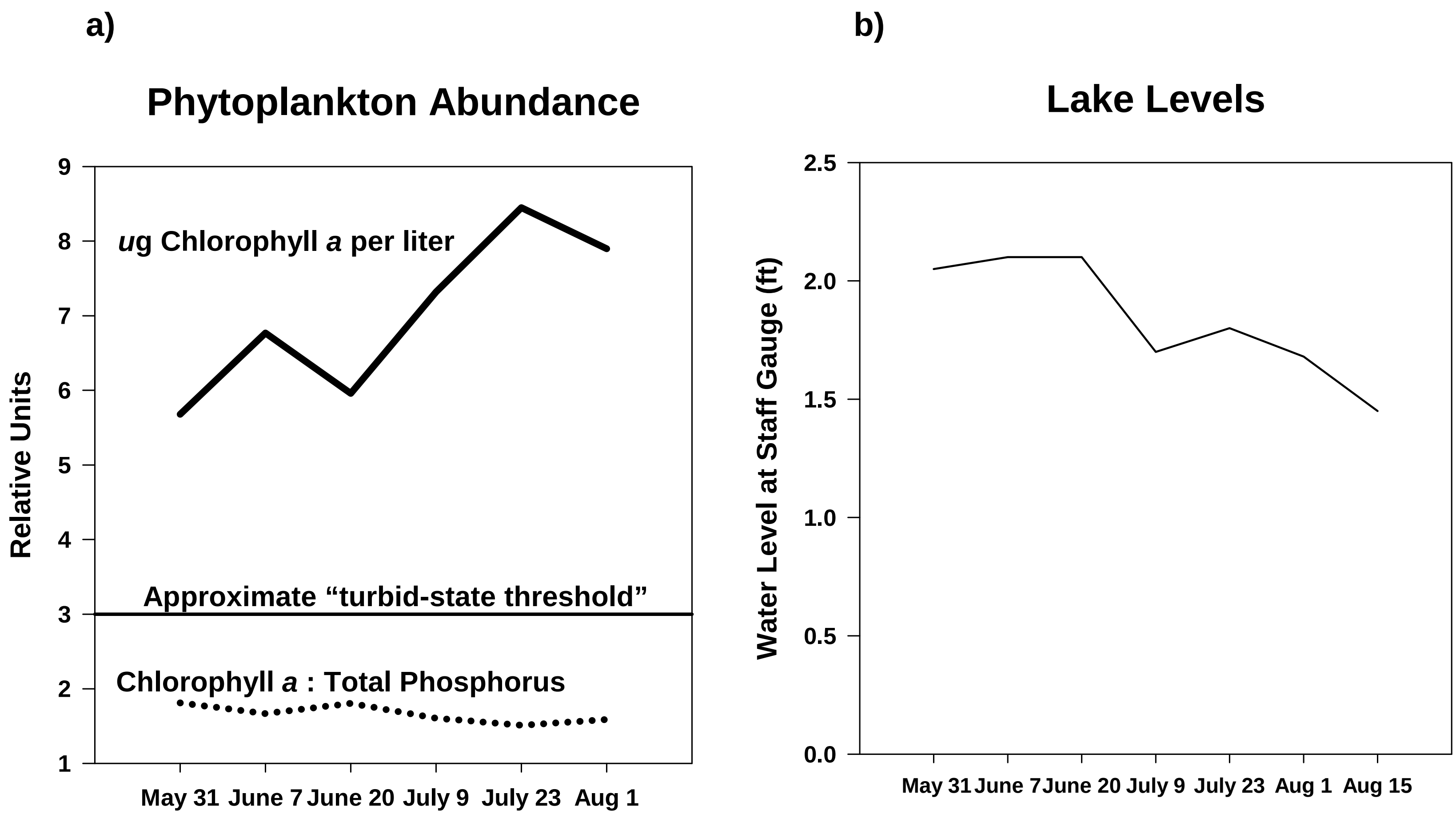

Figure 6. Phytoplankton abundance as indicated by water-column chlorophyll a concentrations (top line) at Kenogama Lake during 2007. Bottom (dashed) line depicts ratios of Chlorophyll a:Total phosphorus; values below theoretical threshold are usually associated with lakes in a clear-water state (Dokulil and Teubner 2003, panel a). Relative lake levels shown on right (panel b)

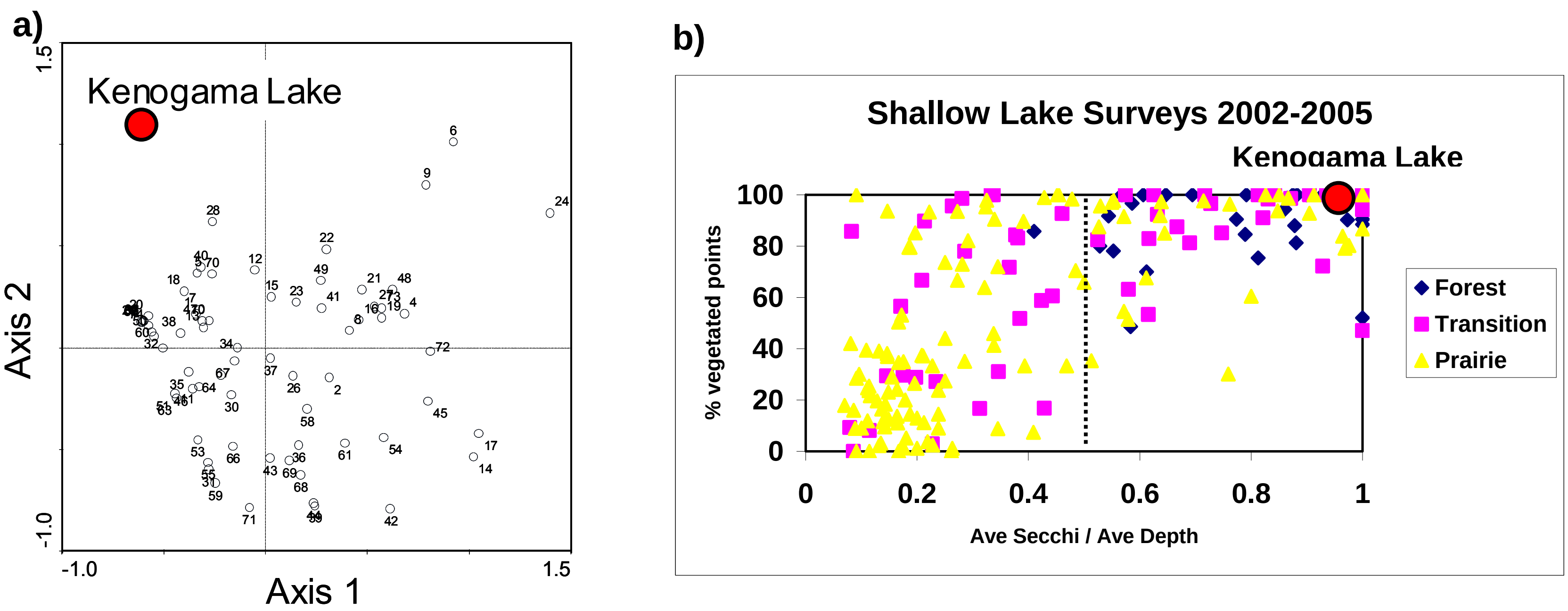

Figure 7. Plant community characteristics depicted by Principal Components Analysis (panel a, upper left; PCA) based on scores from a combined species matrix containing 74 shallow lakes (as numbered) in western and central MN, and Kenogama Lake. Panel b compares (upper right) water clarity and macrophyte relationships between Kenogama and other shallow lakes recently surveyed by MNDNR Shallow Lakes Program (data provided by Nicole Hansel-Welch et al.). Dashed line on right (panel b, Secchi/depth value = 0.5) indicates approximate threshold depth where light penetration is sufficient to support rooted plants at mean lake depth. Separation in PCA space and water clarity/plant relationships indicates extent of similarity in abundance and species composition of Kenogama and water transparency relative to other shallow lakes recently studied in MN.

THRESHOLDS AND STABILITY OF ALTERNATIVE REGIMES IN SHALLOW PRAIRIE-PARKLAND LAKES OF NORTH AMERICA[1]

Kyle D. Zimmer,[2] Mark. A. Hanson[3], Brian R. Herwig[4], and Melissa L. Konsti[5, 6]

Numerous studies have demonstrated alternative regimes in shallow lake ecosystems around the world, with 1 state dominated by submerged macrophytes and the other by phytoplankton. However, the stability of each regime, and thresholds where lakes shift to the alternative regime, are poorly known. We used a cross-sectional analysis of 72 shallow lakes in Minnesota, USA, over 2 years to assess the frequency of regime shifts and to estimate corresponding phytoplankton and macrophyte abundance thresholds. Thresholds were low and varied among lakes, likely due to differences in lake depths. Upper bounds on confidence intervals for thresholds were 29 ug L^{-1} chlorophyll *a* for phytoplankton and 398 g $sample^{-1}$ for macrophytes. Lakes crossing 1 or both of these bounds shifted regimes between years, as evidenced by greater changes in macrophyte and phytoplankton abundance relative to all other lakes. Thirty-three lakes were dominated by macrophytes and 17 lakes were dominated by phytoplankton in both years, while 22 sites shifted regimes. Benthivore biomass was intermediate in shifting lakes relative to clear and turbid lakes, and change in biomass was higher in shifting and turbid lakes relative to clear lakes. This suggests a threshold at moderate benthivore abundance. Our results indicated that shallow lakes may switch regimes at relatively low levels of phytoplankton and macrophyte abundance, and that natural changes in abundance of benthivorous fish may be an important trigger. Specific thresholds were variable among lakes, perhaps due to other important influences, indicating that lakes will be best managed on a case by case basis.

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FACTORS INFLUENCING FISH DISTRIBUTIONS AND COMMUNITY STRUCTURE IN SHALLOW LAKES WITHIN PRAIRIE AND PRAIRIE-PARKLAND REGIONS OF MINNESOTA, USA[1]

Brian R. Herwig[2,3], Kyle D. Zimmer[4], Mark A. Hanson[5], Melissa L. Konsti[6], Jerry A. Younk[2], Robert W. Wright[7], Sean R. Vaughn[8], and Mitchell H. Haustein[9]

Fish populations exert strong, but variable, influences on prairie shallow lakes in Minnesota. Consequently, shallow lake managers would benefit from empirical models predicting the distribution of fish populations at landscape scales. We used indirect and direct gradient analysis, classification and regression tree analysis (CART), and simple linear regression to predict fish presence/absence (P/A), species richness, and community composition in 82 shallow lakes. A CART model for fish P/A that included 2 variables, downstream connections to surface waters capable of supporting fish and lake maximum depth, correctly classified 100% and 92% of our training and validation sites, respectively. Fish richness was positively related to both lake size and watershed size in both study areas. Distinct patterns in community composition were also evident, ranging from planktivore-only sites to sites with planktivores, benthivores, and piscivorous fish all present. Community composition varied by study region, and reflected both isolation (lake watershed area, connections to upstream and downstream fish sources) and extinction features (lake size). Negative associations between abundance of soft-rayed minnows (e.g., fathead minnows) and piscivores suggested piscivory was also an important extinction process. Fishless sites were quite rare and tended to be isolated or shallow. Managers interested in minimizing distributions and abundance of fish should focus on protecting shallow, isolated basins, maintaining existing barriers, or breaking up connectivity among basins (e.g., fish screens and velocity barriers) as anthropogenic-induced connectivity (culverts, drainage ditches) repeatedly appeared as an important mechanism supporting persistent fish populations, including detrimental species such as native black bullhead, and invasive common carp. Many of our sites contained only minnows, thus represent candidate sites where piscivore additions could be used to reduce prey fish populations, particularly when combined with installation of fish barriers.

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[1] Abstract of paper submitted to Canadian Journal of Fisheries and Aquatic Sciences

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MANAGEMENT-FOCUSED RESEARCH NEEDS OF MINNESOTA'S WILDLIFE MANAGERS – WETLAND MANAGEMENT ACTIVITIES

David Rave

SUMMARY OF FINDINGS

In order to determine areas of habitat management that Minnesota Department of Natural Resources (MNDNR) wildlife managers believed warranted research, the Habitat Evaluations Biologists conducted a survey of research needs. The majority of the managers who responded indicated that there was a need for research pertaining to wetland enhancement. In particular, they felt that there is a need to examine the effects of exotic species, such as narrow leafed cattail (*Typha angustifolia*) encroachment in wetlands.

INTRODUCTION

In response to requests from Wildlife Managers for help in evaluating the effectiveness of habitat management techniques, the MNDNR Section of Wildlife created a half-time position devoted to habitat evaluation and monitoring in each of the Farmland, Forest, and Wetland Wildlife Populations and Research Groups. Molly Tranel, Habitat Evaluations Biologist with the Farmland Wildlife Populations and Research Group, developed the original draft of the survey. Wes Bailey, Habitat Evaluations Biologist with the Forest Wildlife Populations and Research Group, and I helped with later drafts of the survey.

METHODS

The Management Focused Research Needs survey was sent to MNDNR wildlife managers, assistant wildlife managers, regional managers, and assistant regional managers by electronic mail on January 15th 2008 and reminders were e-mailed on January 31st. Managers were encouraged to fill the survey out alone or with their area office staff. This resulted in some surveys reflecting the opinion of one person, and others reflecting the opinion of an entire office (up to 3 people). All returned surveys were received by February 14th, 2008.

The survey consisted of a table outlining major management activities divided into wetland (Table 1), prairie, and forest habitat management activities. These activities were derived from the major expenditure categories that managers use to appropriate funds. Managers were asked to indicate ("Yes" or "No") whether each activity required evaluation in their management area. A list of specific examples was provided beneath each activity, with a space listed as "other" for respondents to fill in if they felt that techniques other than those listed needed evaluation. For each activity that respondents indicated required evaluation, they were asked to rank the provided examples starting with 1 as the most important. Molly Tranel will report on results of the prairie management activities section of the survey, Wes Bailey will report on results of the forest management activities section, and I report here on the wetland management activities section.

RESULTS

A total of 45 surveys was returned. Some offices filled out a single survey for the entire office, whereas each individual within an office filled others out. We used each returned survey as a respondent, with 1 to 3 individuals per respondent. Thirty-nine (87%) of the respondents indicated that at least one of the 5 wetland management activity categories needed evaluation (Table 2). Most respondents selected the wetland enhancement category (92%) as needing evaluation, followed by wetland habitat maintenance (74%), wetland restoration (62%), wetland water controls (59%), and wetland impoundment development (31%, Table 2). The most highly ranked management examples in each of the 5 wetland categories were cattail/exotic species management

(1.9), water level management (1.3), dugouts/scrape outs (1.4), species diversity of restored wetlands (1.5), and impacts on aquatic wildlife (1.6, Table 2).

Respondents were asked to provide "other" management activities that they felt required evaluation. Thirty-six responses were provided, some with more than one suggestion. The "other" management practice topics suggested for evaluation were: cost benefit/value of management treatments (8), moist soil unit/vegetation management (7), beaver (*Castor canadensis*) control (6), water control structures (5), impoundment management (4), unwanted fish control (3), overall waterfowl use/non-use (3), best management practices (2), invertebrate response to agricultural chemicals (1), upland waterfowl habitat in the forest (1), private lands wetland mitigation(1), removal of accumulated sediment in restored basins (1), and bog restoration (1).

DISCUSSION

Most of the managers who responded to the survey believed that there was a need for research on wetland enhancement. In particular, there is a need to examine exotic species, such as narrow leafed cattail (*Typha angustifolia*), encroachment in wetlands. Many managers also wanted to learn more about moist soil, water level, and impoundment management. There was an interest in evaluating cost/benefits of management techniques, concerns about beaver and fish problems in wetlands, as well as questions about water control structures, and waterfowl use versus non-use of wetlands.

The survey allowed the 3 new Habitat Evaluations Biologists to learn from wildlife managers which of the wide range of habitat management issues in the state they would like evaluated. This will allow for informed discussions within the research groups as to where to focus evaluation efforts.

ACKNOWLEDGMENTS

We appreciate the effort of all of the wildlife management staff that completed the survey.

Table 1. Survey questions for wetland management activities with examples assigned to four activities.

Does it Need Evaluation? (Yes / No)	Wetland management activity	Rank (1 is the Highest)
________	**Wetland enhancement** (All activities that enhance wetland habitats for wildlife.)	
	• Management of Aquatic vegetation	_____
	• Cattail/Exotic species management	_____
	• Aquatic seeding	_____
	• Bog removal at basin outlets	_____
	• Removal of unwanted fish (i.e., carp, bullheads)	_____
	• Other: __________________________	_____
________	**Wetland habitat maintenance** (All efforts to maintain wetland wildlife habitat.)	
	• Fish barrier maintenance	_____
	• Water level management	_____
	• Minor dike/structure maintenance	_____
	• Other: __________________________	_____
________	**Wetland impoundment development** (The development of a new wetland where none historically existed by constructing a dike and water control structure in the appropriate topographic area.)	
	• Dugouts/scrape outs	_____
	• Other: __________________________	_____
________	**Wetland restoration** (The restoration of a drained wetland by the plugging of drainage ditches or removal of drain tiles. Note: may include the restoration of part of an original basin where full restoration is not possible.)	
	• Historical vs. current ecological functions	_____
	• Species diversity of restored wetlands	_____
	• Other: __________________________	_____
________	**Wetland water controls** (The addition or rehabilitation of water control structures, fish barriers, dikes and related inlets and outlets that enhance the value of existing wetland habitat.)	
	• Impacts on aquatic wildlife	_____
	• Impacts on non aquatic wildlife	_____
	• Other: __________________________	_____

Table 2. Mean rank and frequency of wetland management activities and provided examples for each activity from the 2008 Management Research Needs Survey. A rank of 1 is most important, and 5 is least important. Frequency is the number of respondents that answered "Yes" for the Management practice divided by the total number of respondents who ranked each provided example.

Management Activity & Response		Provided Example	Mean Rank	Frequency
Wetland enhancement				
		Manage aquatic vegetation	2.4	72.20%
# Respondents	**39**	Cattail/Exotic species management	1.9	83.33%
# answered Yes	**36**	Aquatic seeding	3.3	58.33%
Percentage Yes:	**92.3%**	Bog removal at basin outlets	4.1	52.77%
		Removal of unwanted fish	2.4	66.67%
		Other		16.67%
Wetland habitat maintenance				
		Fish barrier maintenance	2.1	55.17%
# Respondents	**39**	Water level management	1.3	82.76%
# answered Yes	**29**	Minor dike/structure maintenance	2.5	58.62%
Percentage Yes:	**74.4%**	Other		20.69%
Wetland impoundment development				
		Dugouts/scrape outs	1.4	66.7%
# Respondents	**39**	Other		75.0%
# answered Yes	**12**			
Percentage Yes:	**30.8%**			
Wetland restoration				
		Historical vs. current ecological functions	2.0	70.83%
# Respondents	**39**	Species diversity of restored wetlands	1.5	79.17%
# answered Yes	**24**	Other		29.17%
Percentage Yes:	**61.5%**			
Wetland water controls				
		Impacts on aquatic wildlife	1.6	78.3%
# Respondents	**39**	Impacts on non aquatic wildlife	2.2	69.6%
# answered Yes	**23**	Other		34.8%
Percentage Yes:	**58.97%**			

VARIANCE OF STRATIFIED SURVEY ESTIMATORS WITH PROBABILITY OF DETECTION ADJUSTMENTS[1]

John Fieberg and John H. Giudice

ABSTRACT

Estimates of wildlife population sizes are frequently constructed by combining counts of observed animals from a stratified survey of aerial sampling units with an estimated probability of detecting animals. Unlike traditional stratified survey designs, stratum-specific estimates of population size will be correlated if a common detection model is used to adjust counts for undetected animals in all strata. We illustrate this concept in the context of aerial surveys, considering 2 cases: 1) a single-detection parameter is estimated under the assumption of constant detection probabilities; and 2) a logistic regression model is used to estimate heterogeneous detection probabilities. Naïve estimates of variance formed by summing stratum-specific estimates of variance may result in significant bias, particularly if there are a large number of strata, if detection probabilities are small, or if estimates of detection probabilities are imprecise.

[1]Journal of Wildlife Management (2008) 72(3):837-844.

EXPLORING MIGRATION DATA USING INTERVAL-CENSORED TIME-TO-EVENT MODELS[1]

John Fieberg and Glenn D. DelGiudice

ABSTRACT

Ecologists and wildlife biologists rely on periodic observation of radiocollared animals to study habitat use, survival, movement, and migration, resulting in response times (e.g., mortality and migration) known only to occur within an interval of time. We illustrate methods for analyzing interval-censored data using data on the timing of fall migration (from spring-summer-fall to winter ranges) for white-tailed deer (*Odocoileus virginianus*) in northern Minnesota during years 1991-1992 and 2005-2006. We compare both nonparametric and parametric methods for estimating the cumulative distribution function of migration times, and we suggest a parametric (cure rate) model that accounts for conditional (facultative) migrators as a potential alternative to traditional parametric models. Lastly, we illustrate methods for exploring the effect of environmental covariates on migration timing. Models with time-dependent covariates (snow depth, temperature) were sensitive to the treatment of the data (as interval-censored or known event times), suggesting the need to account for interval-censoring when modeling the effect of these covariates.

[1]Journal of Wildlife Management (2008) 72: In Press.

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