ELK-AGRICULTURE CONFLICTS IN THE GREATER RIDING MOUNTAIN ECOSYSTEM:

Building Bridges between the Natural and Social Sciences to Promote Sustainability

by

Ryan K. Brook

A thesis submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfillment of the degree of

DOCTOR OF PHILOSPHY

Department of Environment and Geography
University of Manitoba
Winnipeg, Manitoba R3T 2N2

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

*****

COPYRIGHT PERMISSION

ELK-AGRICULTURE CONFLICTS IN THE GREATER RIDING MOUNTAIN ECOSYSTEM:

Building bridges between the Natural and Social Sciences to Promote Sustainability

BY

Ryan K. Brook

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirement of the degree

DOCTOR OF PHILOSOPHY

"Complex problems have simple, easy to understand wrong answers."

Grossman's Law

ABSTRACT

Successful mitigation of human-wildlife conflicts requires an approach that incorporates both the ecological aspects of wildlife and the social considerations of the affected stakeholders and these must be considered in an integrated fashion at multiple temporal and spatial scales. In this dissertation, I examine the relationship between farmers around Riding Mountain National Park (RMNP) in southwestern Manitoba and the regional elk (*Cervus elaphus*) population, in order to better understand and resolve these long-standing conflicts more effectively. Local perspectives were documented throughout this study, initially through 40 community meetings in 2000 and 2001 prior to formal data collection, then through a mail-out survey in 2002, and later through participatory mapping exercises from 2003 to 2006. A longitudinal analysis of historical information regarding elk-agriculture conflicts using the interviews and government letter files indicated that diverse types of conflicts have occurred annually for the last 127 years. Issues related to bovine tuberculosis (TB) in elk in the last 15 years have been some of the most intense conflicts ever occurring, but these are based on previous conflicts and they have further undermined the already strained relationship between farmers and RMNP. The most important factor associated with high concern regarding bovine TB was the frequency that farmers observed elk on their land. To examine the biophysical aspects of elk interactions with agriculture, 212 wild elk were captured from 2002-2005 using a net-gun fired from a helicopter and given a GPS satellite collar (n=25) or VHF transmitter (n=187). Overlap in space use between elk and cattle was high in summer and low in winter based on both the collar data and local knowledge, though farmers identified higher levels of overlap throughout the year. During the spring elk

calving period, the home ranges of 73% of the parturient elk remained entirely within protected areas, while 6% were exclusively on farmland, and 21% included both. The proportion of the elk population calving on farmland continues to increase from near zero in the 1970s. Hay yard barrier fences are the most effective and widely accepted management tool in use to mitigate elk-agriculture conflict, but modifications to the process of allocating and monitoring fences are needed. Indeed, all aspects of the management of elk-agriculture interactions require greater levels of communication and collaboration between government agencies and local stakeholders. I also advocate taking an adaptive, science-based approach to managing human-wildlife conflicts that focuses on both the social and natural sciences as mutually contributing to our understanding of the problems and generating meaningful solutions. This is one of few studies that makes use of local knowledge and conventional ecological data together, and demonstrates the contributions of both in better understanding the temporospatial aspects of wildlife-human conflicts and their socioeconomic and conservation implications.

ACKNOWLEDGEMENTS

"The easiest way for me to grow as a person is to surround myself with people smarter than I am." – ***Andy Rooney***

I humbly thank the many, many people that made this project so successful. For some, the contribution was an idea, a bit of advice, or help with securing funding, while others helped with what seemed at times like never ending data collection. To all of you, I give much thanks.

My advisor, Stef McLachlan is a mentor in the very best sense because he teaches with caring and genuine interest, but perhaps more importantly, teaches by example. I have learned through experience that it is one thing to talk in vague terms about the value of working with communities, but it is quite another to really do it well. He has inspired the approach that I have taken in this thesis and will continue to influence the ways that I interact with communities for the rest of my life. His primary role in the evolution of this thesis was acting as a voice of reason, which seemed to be in great demand, particularly in the first year. The chapters of this thesis reflect long discussions we have had over the past five years and his many editorial revisions.

I am truly grateful to my advisory committee, Drs. Paul Paquet, Marc Cattet, and Norm Kenkel for setting the bar high. The patience, kindness, and enthusiasm that Paul radiates represent the very ideal that I consider necessary to be a great scientist and great person. The contribution of Marc has been both as an academic committee member and as the key person overseeing the capture and handling of the elk. For anyone reading this that might mistakenly think that Marc's contribution was minor, please imagine flying in a helicopter with no doors at temperatures below minus thirty and wrestling hundreds of elk over the course of three years. I thank Marc for his advice in general and for challenging my perspectives on local knowledge. Were it not for Norm, it is unlikely I would have survived my masters, never mind tackling a PhD, so I give many thanks to him for serving on both of my graduate committees and for inspiring me, 'big time'. I also greatly appreciate the input of my external examiner, Dr. Michael Quinn from the University of Calgary for reviewing this dissertation and providing unique and valuable insights.

When I came to Riding Mountain, I was warned that the farmers are 'difficult' to work with, but nothing could be further from the truth. I have worked closely with many local farmers over the last six years and their contribution to all aspects of this thesis and my training as a scientist cannot be overstated and I thank particularly John Whitaker, Ray Armbruster, Calvin Pawluk, and Bengt Schmidt who contributed to this research immeasurably.

More than forty individuals contributed their time and energy into a combined force that conducted over seven thousand hours of data collection, much of which involved long hours spinning in air planes, wrestling elk, freezing fingers at four a.m., stuffing envelopes until their fingers bled, and conducting long and sometimes repetitive interviews. My initial thought was to thank you all generally, but that would not sufficiently recognize the unbelievable contribution that many have made.

My pilots, Patty and Bob Simpson have provided incredible support for this project, making themselves available continuously for the last three years. Their strong commitment has kept the data consistent and accurate, but most importantly, their commitment to safety was extraordinary. I also thank Tom Gibbs who sometimes helped with the telemetry flights. The primary aerial telemetry crew was composed of Rob Watson, Gord Pylipuik, Tim Sallows, Pat Rousseau, Astrid Vik Stronen, and Glen Schmidt. Unless you have actually done at least a full day of aerial telemetry yourself, you cannot fully appreciate the effort these folks put in. Ground telemetry was conducted by Roger Baird, Greg Boughen, Nicole Lavalee, Ian Kitch, Sean Frey, Paul Friesen, and Murray Lungal. Mortality retrievals were conducted by Pat Rousseau, Tim Sallows, Gord Pylipuik, Sean Frey, Blair Fyten, Paul Friesen, and Greg Boughen. Thank you to "Obi-Wan" Tim Sallows for teaching me a lot about telemetry and life. Also thanks to Bighorn Helicopters for efficient and safe handling of the elk, they too, endured some incredibly tough days while getting the collars onto the elk.

Special thanks to Jessie MacDonald and Ginger Arnold for assistance in conducting interviews, to Nicole Lavalee for helping to get the surveys delivered, to Andrea Thorgilsson, Amber Jays, Rob Watson, and Julie Preston for assisting with data entry. Photographs used in the project were provided by Murray Gillespie, Patty Simpson, Parks Canada, Manitoba Conservation, many local farmers, Nick Fiarchuk, Bob Inouye, Tim Sallows, US Department of Agriculture, and the Animal and Plant Health Inspection Service.

During this entire process, whenever I ran into a brick wall, I typically turned to one of my "four wise men", Rob Watson, Ken Kingdon, John Whitaker, and Celes Davar, who 'unofficially' were my community science advisors, providing advice, support and often performing the all important role of cheerleading squad. I also appreciate the support and perspectives of Murray Gillespie, who has taught me more than anyone else about managing ecosystems. I also thank Murray for his conceptual and editorial input into this dissertation. To you all, I thank you for your teachings and your advice, sometimes sought, sometimes not.

My colleagues at the University of Manitoba helped make the experience enjoyable and have challenged me with some unique ideas. Rick Riewe has been an important mentor to me through my entire time here and I appreciate his support through it all. The folks in the Environmental Conservation Lab have contributed much to my learning experience and I particularly thank Ian Mauro for shaping my thinking and helping with many aspects of this thesis.

The government agencies involved in managing bovine TB have contributed important insights into the research and I particularly thank Ken Kingdon, Jack Dubois, Shelagh Copeland, Terry Whiting, and Dan Chranowski for working with me. Paul Tarleton was instrumental in helping get this study initiated and Doug Bergeson helped process the funding arrangements with Parks Canada and co-ordinate the fieldwork.

Financial support for this project was provided by Riding Mountain National Park, Manitoba Conservation, Manitoba Agriculture, Food and Rural Initiatives, University of Manitoba, Riding Mountain Biosphere Reserve, Louisiana Pacific, Nature Conservancy of Canada, Rocky Mountain Elk Foundation, Manitoba Wildlife Federation, Prendiville Industries Ltd., Shur-Gro Farm Services Ltd., Eastlands Wildlife Association, Westlake Wildlife Association, Earth Rhythms Inc., Seven Oaks Game and Fish, Friends of Riding Mountain National Park, Natural Science and Engineering Council, and the Social Science and Humanities Research Council. I am safe in saying the study could not have happened without this support.

Music has played an important role in getting me through this project during long midnight drives and all-nighter computer session, so many thanks to Simple Plan, The Tragically Hip, Garth Brooks, the Ramones, Dixie Chicks, and all of you other musicians who kept me awake and kept me sane.

A warm thank you to my favourite elk, who taught me much about ecology and the interface with agriculture; Moxie for being wise and crafty and being a wonderful mother, Sneaky Pete for, well, for being sneaky, Zipper for reminding me there are always exceptions, Blues Traveller for confirming that three years is not long enough, Daffy and Donald for good times in the Duck Mountains, Waldo for teaching me patience, Miller Time for some nice evening flights, Smiley for being consistent, Goldilocs for the great bear sightings, old Three-Sixty-Six for running the gauntlet, and Kubesaw for outrunning the wolves.

Finally, I thank my family, all of whom have been wildly supportive throughout my many (many) years at university. I am really done!

"Setting an example is not the main means of influencing others, it is the only means of influencing others." ***–Albert Einstein***

DEDICATION

To Kellie, you make everything possible and bring meaning to everything that I do.

To Evan, my son, you are the future of the world and show me what is really important.

To Mom, because more than any other person, you made me who I am.

To Dad, for teaching me a respect for animals that no other I person that I know has, and for common sense and hard work.

To Deanna, for being the strongest person I will ever know.

To Shawn, I wanted to be just like you for as long as I can remember and I like to think that I am, at least a bit.

To Grandpa and Grandma Brook, for putting that chicken egg in the first nest I built when I was four. I wonder how my life would be different if the nest had stayed empty.

"What would you do if you knew you could not fail?" **-Author Unknown**

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

DISSERTATION INTRODUCTION:
REGIONAL PROBLEMS NEED INTEGRATED SOLUTIONS

"The world we have made as a result of the level of thinking we have done thus far creates problems that we cannot solve at the same level of thinking at which we have created them. We shall require a substantially new manner of thinking if humankind is to survive."

--Albert Einstein

Introduction

Human life ultimately relies on ecosystem services provided by the biosphere, including agricultural production, recreational opportunities, and spiritual connections with the land (Egri 1997, Johnston *et al.* 2007). Producing sufficient food resources while maintaining biodiversity and ecosystem functions is one of the greatest challenges currently facing the world population (Ehrlich *et al.* 1993). Agricultural lands currently occupy more than one third (37%) of the earth's land surface and this area continues to expand (Food and Agriculture Organization of the United Nations 2002). Conversion of native prairie and forested habitats to agricultural fields has resulted in dramatic changes to the landscape including forest fragmentation , reduction in the size of native habitat patches, increased isolation of the remaining 'pristine' patches and an overall reduction in forest cover (Merriam 1988, Wiens 1994, Jaeger 2000). Livestock grazing has also significantly altered native habitats and introduced non-native species (Vance 1976, Herkert 1994). Because of these large-scale changes, much of the agricultural areas of the world exist as a mosaic of native habitat patches within a matrix of agricultural fields.

Protected areas have been set aside to be devoted primarily or exclusively to preserve natural ecosystems in the face of human development. According to the classification system used by the World Conservation Union, national parks are the most restricted of these protected areas (Synge 2004). Historically, national parks were largely managed as islands of natural habitat, in isolation from the surrounding landscape. A paradigm of command and control, often referred to as 'fortress conservation', has prevailed within protected areas management whereby the parks have been managed with a strong authoritarian approach that excluded local use, often employing armed guards and complex regulations (Brockington 2003). In North America, human populations have normally not been allowed to live permanently within national park boundaries in large numbers, but at the same time human use has been strongly encouraged (Hough 1988). Parks and protected areas are faced with many challenges but perhaps the most significant are the internal challenges of both mitigating and facilitating human use while addressing the complex interdependent relationship that parks have with the surrounding landscape and people.

While protected areas play a critical role in maintaining wildlife habitat and ensuring populations of wildlife remain viable (Janzen 1983), few are large enough to be self-contained (Miller and Harris 1977). The movement of wildlife across jurisdictional boundaries and out of parks can create management challenges since no one agency has full or continued jurisdiction over them (Forbes and Theberge 1996). Furthermore, wildlife that move beyond park boundaries can create significant impacts for people living along the edge. Cross-boundary issues will continue to become more pronounced as landscape alteration increases, as protected areas become more isolated, and as the scale of environmental pressures such as global climate change and human development continue to increase (Schonewald-Cox 19923).

Cross-boundary issues around protected areas are particularly important to farmers because of the complex range of benefits and costs associated with wildlife that leave protected areas and use agricultural lands. Local people may acquire benefits through hunting and tourism opportunities but the wildlife may cause significant impacts to crops and livestock, damage to infrastructure, and even risks to human health and safety (Conover 1998, 2001, Aguirre and Starkey 1994).

While agricultural landscapes have fundamentally changed the earth, farming communities have also been dynamic. There are still millions of farmers throughout North America, although this number continues to decline because of an ongoing rural crisis and an associated depopulation of rural areas (Reich 1988). Progress in farming technology – the so called "green revolution" – has increased the capacities of many nations to feed itself. This progress has been associated with dramatic changes in farming in Canada in the last century, with farm sizes increasing sharply, while net income declines and farmers are working more on outside employement to subsidize the farm (Todd and Brierly 1982, Statistics Canada 2002). The effects of unprecedented climate change and global population growth will have dramatic, though poorly understood, effects on farming communities.

Although there have been some important successes, the overall record of accomplishment of humankind in contemporary wildlife management and agricultural policy has been generally very poor. As the scale and scope of global human impacts becomes increasingly evident, scientists and managers are recognizing the complex interrelationships among these impacts that further obscure our understanding of an already complicated world.

Some individuals have suggested that a more interdisciplinary approach to addressing these 'wicked' problems is needed, that adequately reflects both the complexity and the interactions between the environmental and social components Rittel and Webber 1973, Daily and Ehrlich 1999). While many, or even most, scientists and resource managers seem to acknowledge the value and importance of an interdisciplinary approach, few have embraced it (Pickett *et al.* 1999). Diverse practical and philosophical barriers to interdisciplinary research and management have been identified (Campbell 2005), but most of these barriers ultimately are defined by the process by which knowledge is produced, legitimized, and applied. As such, interdisciplinary research that supports resource management will require an approach that attends to these practical issues but also addresses the power dynamics and social constraints that exist.

Scope of the Thesis

The intent of this thesis is to examine the biophysical and social factors that influence elk-agriculture interactions in the Greater Riding Mountain Ecosystem using two parallel approaches, documenting local farmer knowledge and expert-based scientific research. Elk-agriculture conflicts are a result of complex interactions among numerous factors. Both environmental factors and farm management practices are influencing elk use of agricultural areas. This project focuses on the biophysical factors and farm management practices that influence the use of agricultural lands by elk. The relative contribution of biophysical and farm management practices in influencing overall vulnerability to elk-agriculture interactions is examined by comparing farms that have high elk interaction with those having little or no interactions (*sensu* Mech 2000, Kaneene 2002). Social aspects of elk-agriculture interactions focus on characterizing local farmer knowledge, and identifying factors that influence concerns and priorities of farmers mitigating these conflicts.

While the social and biophysical approaches to understanding elk-agriculture interactions are each valuable in their own right, using them together provides new opportunities to produce a richer, more holistic description of the factors that influence farm use by elk. The biophysical and social aspects are then linked spatially to characterize and map risk, which includes the likelihood of elk using agricultural areas, the perceived risk associated with it, and a description of the types of impacts that occur. This research provides an opportunity to explore the challenges of linking local farmer knowledge with an expert-based scientific management paradigm. Together, this information provides valuable insights into the nature of the problems and will ultimately facilitate the development of more effective management solutions.

This research is based on the premise that both local farmer knowledge and expert-based science provide a way of understanding the environment, which is embedded within a specific cultural context. Both forms of knowledge are useful, important, and they may even be complementary. This thesis ultimately will attempt to incorporate two knowledge systems. The process provides an opportunity for farm operators to participate in research and allows them to generate their own solutions to wildlife problems . This is important because, currently, much of the information regarding elk-agriculture interactions has been collected by scientific 'experts', is expressed in a technical language, has limited accessibility, and reflects the priorities of scientists and managers, not farmers.

Thesis Objectives

The primary objective of this thesis was to develop an approach to characterizing and resolving human-wildlife conflicts in a manner that effectively incorporates both the ecological aspects of wildlife with the attitudes, knowledge, and actions of the affected stakeholders, in order to ensure equity between the conservation of native animals and their habitats and the socioeconomic needs of local people.

Interactions between farmers living around Riding Mountain National Park and the regional elk population have involved some of the most intense conflicts in the region since farming began in the region in the 1880s, related initially to crop damage. The impetus for this research comes from recent conflicts associated with the perceived transmission of bovine tuberculosis from wild elk to cattle. The presence of bovine TB in cattle and wildlife has been well established through on-going testing. However, despitethe absence of compelling evidence that transmission is occurring from elk to cattle and the disease, it has been widely assumed that this is the primary route of transmission. Although the mechanism of transfer between potential hosts remains unclear, the presence of bovine TB in cattle herds has resulted in important direct and indirect social and economic impacts to farmers. The presence of bovine TB in the elk herd has seriously strained the relationship between local farmers and RMNP and may ultimately influence wildlife conservation actions of the farmers and their relationship with the national park.

Practical outcomes from the thesis contribute to understanding the relationship between elk and agriculture around RMNP in order to support farmer decision making at the local level and federal and provincial interagency management of TB within the regional ecosystem and the national arena. Recommendations from these results are intended to of direct value to farmers and government agencies in addressing these important conflicts. The applied case studies that address these practical problems also illustrate the interdependence between parks and local communities and provide further support for the need for better communication and cooperation. The primary theoretical contributions of the dissertation are to develop rigorous and ethical ways of using ecological and social methods in an integrated approach to understanding the nature of risk and the resolution of human-wildlife conflicts.

Specific objectives of the study were to:

I. Characterize the biophysical aspects of the risks associated with elk-agriculture interactions

- What is the relationship between elk use of areas outside of RMNP and forest cover?
- What crop types and combinations attract elk to agricultural areas?
- How do hay management practices at the farm level influence elk-agriculture interactions?

II. Characterize the social aspects of the risks associated with elk-agriculture interactions

- What are the primary concerns of farmer's regarding elk-agriculture interactions?
- How are farmers' subjective risk perceptions regarding elk-agriculture interactions influenced by demographic and farm characteristics?
- What are the most acceptable management practices to reduce elk-agriculture contact?

III. Characterize and explain the differences that underlie objective descriptions and subjective perceptions of the risks associated with elk-agriculture interactions

- To what degree are the objective descriptions and the subjective perceptions of risk similar and how are they different?
- To what degree are farmer knowledge and expert-based knowledge complementary?
- What are the main institutional and social barriers to incorporating farmer knowledge into the existing expert-based paradigm?
- What differences exist between the attitudes and management approaches of farmers and management agencies?

Overview of Research Approach

My overall approach toward this project focused on working collaboratively with the local communities and management agencies during the entire process, from idea generation through to the final reports and recommendations. Throughout the six-year course of this study, information regarding the purpose and methodologies used were shared openly with community members, including non-participants in the study.

In order to develop a research methodology that reflected community concerns and to establish on-going communication with local stakeholders and government agencies, I attended 36 community meetings in 2000 and 2001 before collecting any data, including Riding Mountain Biosphere Reserve, Riding Mountain Regional Liaison Committee, Riding Mountain National Park Ecological Integrity Study Group, local Rural Municipality offices, local and regional hunting clubs, Riding Mountain National Park Visitor Centre, regional meetings of the Manitoba Agriculture and Food staff, and the Manitoba Wildlife Federation Annual Conventions. In addition, I participated in seven town hall meetings throughout the study area between January and April 2002, where comments of over 500 local agricultural producers were documented. This provided an opportunity to listen to local people and to hear their concerns and research priorities from their own perspective. Important research themes were initially identified through these interactions and many other informal discussions with local people and management agency staff.

Community meetings provided me with opportunities to share details regarding my research methodology and make the development of the research protocol an iterative process that included local knowledge from the beginning. Once the data collection began in 2002, and throughout the project, meetings continued with local groups to listen to their perspectives, including the bovine TB Stakeholders Advisory Committee, which was established in 2003, and local First Nations. In total, I made 166 presentations regarding this project. Efforts were also made to incorporate other learning opportunities for tourists, teachers, and students into the study and provide meaningful opportunities for engaging Canadians in the study.

The data collected for this study were obtained using four primary approaches that included two separate but complementary ecological studies (VHF and GPS collared elk) and two unique but complementary social science studies (a regional mail survey and participatory mapping interviews). In addition, existing independent datasets collected by government agencies were also used, including aerial survey data, hunter killed wildlife locations, and Manitoba Crop Insurance Corporation damage claims.

This project was conducted under the authorization of University of Manitoba Animal Care Utilization Protocol No. F01-037, Manitoba Conservation Wildlife Scientific Permit No. WSP 02001, Riding Mountain National Park Research/Collecting Permit No. RMNP-000321, and Riding Mountain National Park Environmental Assessment Screening Report No. #RMNP 000321. The aspects of community participation through a mail survey and interviews have been approved under the authorization of the Joint-Faculty Human Subject Research Ethics Board Protocol #J2002:043 at the University of Manitoba.

Thesis Structure

The thesis is arranged so that each chapter is in the form of a publishable manuscript. First, I set up the conceptual framework of the research related to wildlife-agriculture conflict risk analysis (Chapter Two). I then critically evaluate the role and use of local ecological knowledge (LEK) in the ecological literature (Chapter Three) and explore the historical aspects of elk-agriculture conflicts throughout the history of farming around Riding Mountain National Park (Chapter Four). I examine the drivers of farmer concern related to the presence of bovine TB (Chapter Five) and the complex interactions of habitat attributes with farmer attitudes and actions that influence movements and ultimate survival of elk and other large mammals moving through agriculture-dominated landscapes (Chapter Six), elk-cattle interactions (Chapter Seven), and natality site selection by parturient cow elk (Chapter Eight). The barrier-fencing program is then evaluated as part of the bovine tuberculosis management program, and arguably the most successful of any program in the region to mitigate elk-agriculture conflicts in the last 127 years (Chapter Nine). In the concluding chapter (Chapter Ten), I outline how the analysis and outreach aspects of the overall study provide insights into the practical, moral, and theoretical aspects of using local ecological knowledge with conventional ecology. Within the context of understanding the risks associated with elk-agriculture interaction and mitigating the resulting conflicts, I provide practical recommendations for farmers and government agencies to address the existing conflicts.

Study Area

The study area includes Riding Mountain Biosphere Reserve (RMBR), which is composed of Riding Mountain National Park (RMNP) as the core area and surrounding rural municipalities (RM's) as the zone of co-operation (http://www.unesco.org, 2002). It represents a broad transition zone between the Canadian prairie ecosystem and the Boreal Plains (Caners and Kenkel 1998). RMNP is 2,974 km^2, extending approximately 115 km from east to west and 60 km from north to south. It is elevated up to 475 metres above the surrounding agricultural landscape due to the Manitoba Escarpment. The park represents a core area of relatively undisturbed wilderness surrounded by lowland agriculture. Much of the region is dominated by glacial topography and is poorly drained. The prairie ecosystems were influenced heavily over thousands of years by large herbivores, particularly bison (*Bison bison*) (Bradley and Wallis 1996).

Aboriginal Peoples have inhabited the region for at least 6,000 years, including Assiniboine, Cree and Ojibwa societies. More recently, the Ojibway and Nakota Peoples have used the area extensively for subsistence harvesting. Several First Nation communities are now in the region including Waywayseecappo, Keeseekowin, Valley River, and Rolling River First Nations.

In the early 1800's RMNP was used extensively as a source for timber in the construction of railways and farm buildings. Land in the region was opened to European settlement in the 1880's (Lehr 1996) and by 1885, settlement in the Grandview and Dauphin region was underway. In 1895, the Dominion Government set aside what is now RMNP as a forest reserve as an attempt to limit the production of lumber to a more sustainable level. By 1904, much of the available land outside of the protected area had been purchased. The majority of existing forest cover in the region remained intact until after the Second World War, when the introduction of the bulldozer significantly increased the rate of forest clearing. Since that time, extensive areas of upland forest have been cleared, leaving behind small forest refugia along rivers and wetlands and on unproductive land (Bird 1961, Stadel 1996).

Approximately 25,000 people currently live within the RMBR (Statistics Canada 2002), across 1,272,000 ha (http://www.unesco.org). The major agricultural products of the region are cereal and oil crops, hay, and livestock. Farms are managed on an individual basis and so typically are highly variable in their size, structure, number of livestock raised and crops produced (Brook and McLachlan 2006).

The termination of grain freight subsidies previously provided under the Western Grain Transportation Act (WGTA) has resulted in a shift from grain to increased forage production. Beef cattle production occurs throughout the study are on agricultural lands, particularly on marginal land types. Cattle production in the Grandview area is well above the provincial average, with up to 80% of farmed land in the region under pasture. Cattle grazing was permitted within RMNP until 1970, with between 1,375 head (1950's) and 4,500 head (1919) of cattle present. Grazing by cattle opened up the vegetation in many areas of the park by removing understory, and caused of deterioration of many native fescue prairie sites in RMNP (Blood 1966). Road density inside RMNP and Duck Mountain Provincial Park and Forest is low and the trails that are present in the backcountry typically have low use, particularly in the winter months. In contrast, most of the privately owned land in the study area has a high number of roads (Figure 3).

Five major vegetation types comprise the study area: northern boreal forest, aspen parkland, bur oak savannah, grassland, and eastern deciduous forest (Rowe 1972, Caners and Kenkel 1998). Important tree species include trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), white spruce (*Picea glauca*), black spruce (*Picea mariana*) bur oak (*Quercus macrocarpa*), and balsam fir (*Abies balsamea*). The vegetation reflects the region's transitional climatic position between subhumid coniferous forest and semiarid cool steppe (Bird 1961). A range of factors have influenced the structure and dynamics of natural vegetation in the region, including post-climatic change, physiography, edaphic conditions, fire disturbance, herbivory, and human activity.

Fire scar and stand age data indicate that large fires occurred in 1822, 1853-1855, 1889-1891, and 1918-1919 (Rowe 1955). Fires were most prevalent during European settlement (1885-1889) and were often set purposely by settlers and loggers burning hay meadows and clearing land (Tunstell 1940, Sentar 1992). Historically, wildfires were common in the prairie grasslands of southern Manitoba. These fires would occasionally burn into the forested areas of RMNP (Trottier 1986). Fire suppression policies of the federal and provincial governments, along with the increased efficiency of fire fighting and patrolling techniques and eqiupment, have greatly reduced the extent and frequency of fires with the region (Bailey 1968, Hirsch 1991). This fire suppression has resulted in inceased tree and shrub encroachment. In RMNP, the removal of cattle grazing, forestry, and hay cutting, in conjunction with fire suppression, has led to a significant increase in understory development in many areas. Haying, pasturing, and logging, which were permitted inside RMNP until the mid-1960's, have also influenced secondary plant succession (Bailey 1968).

Large and meso-carnivores in the region include wolf (*Canis lupus*), coyote (*C. latrans*), red fox (*Vulpes vulpes*), black bear (*Ursus americanus*), and lynx (*Lynx lynx*). Ungulates include elk, white-tailed deer (*Odocoileus virginianus*), moose, are present in high numbers. Mule deer (*O. hemionus*) are rare.

Literature Cited

Aguirre, A. A. and E. E. Starkey. 1994. Wildlife disease in U.S. National Parks: historical and coevolutionary perspectives. Conservation Biology 8:654-661.

Bailey, R.H. 1968. Notes on the vegetation of Riding Mountain National Park, Manitoba. National Parks Forest Survey No. 2, Department of Forestry and Rural Development, Ottawa, Ontario.

Bird, R.D. 1961. Ecology of the Aspen parkland of western Canada. Department of Agriculture, Ottawa, Ontario.

Bradley, C. and Wallis, C. 1996. Prairie ecosystem management: an Alberta perspective. Prairie Conservation Forum, Occassional. Paper No. 2. Alberta Environmental Protection, Lethbridge, Alberta.

Brockington, D. 2003. Fortress Conservation. James Currey. Oxford, UK.

Brook, R. K. and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 80:156-166.

Campbell, L. M. 2005. Overcoming obstacles to interdisciplinary research. Conservation Biology 19:574-577.

Caners, R. T. and N. C. Kenkel. 1998. Modeling landscape-level vegetation dynamics in Riding Mountain National Park. Final Report to Parks Canada. University of Manitoba, Winnipeg, Manitoba.

Conover, M. R. 1998. Perceptions of American agricultural producers about wildlife on their farms and ranches. Wildlife Society Bulletin 26:597-604.

Conover, M. R. 2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29:521-532.

Daily, G. C. and P. R. Ehrlich. 1999. Managing earth's ecosystems: an interdisciplinary challenge. Ecosystems 2:277-280.

Egri, C. P. 1997. Spiritual connections with the natural environment. Organization and Environment 10:407-431.

Ehrlich, P. R., A. H. Ehrlich, and G. C. Daily. 1993. Food security, population and environment. Population and Development Review 19: 1-32.

Food and Agriculture Organization of the United Nations. 2002. World agriculture: towards 2015/2030. Rome, Italy.

Forbes, G.J. and Theberge, J.B. 1996. Cross-boundary management of Algonquin Park wolves. Conservation Biology 10:1091-1097.

Herkert, J. R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. Ecological Applications 4:461-471.

Hough, J. L. 1988. Obstacles to effective management of confl icts between national parks and surrounding human communities in developing countries. Environmental Conservation 15: 129-136.

Jaeger, J. A. G. 2000. Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. Landscape Ecology 15:115-130.

Janzen, D. H. 1983. No park is an island: increase in interference from outside as park size decreases. Oikos 41:402–410.

Johnston, P., M. Everard, D. Santillo, and K. H. Robert. 2007. Reclaiming the definition of sustainability. Environmental Science and Pollution Research 14:60-66.

Lehr, J.C. 1996. Settlement: the making of a landscape. IN: J.Welsted, J, Everitt, and C. Stadel. The geography of Manitoba. University of Manitoba Press, Winnipeg, Manitoba.

Merriam, G. 1988. Landscape dynamics in farmland. Trends Ecology Evolution 3:16-20.

Miller, R.I. and L. D. Harris. 1977. Isolation and extirpations in wildlife reserves. Biological Conservation 12:311-315.

Pickett, S., T. A. Burtch Jr., and J. M. Grove. 1999. Interdisciplinary research: maintaining the constructive impulse in a culture of criticism. Ecosystems 2:302-307.

Reich, R.B. 1988. The rural crisis, and what to do about it. Economic Development Quarterly 2:3-8.

Rittel H, Webber M. 1973. Dilemmas in a general theory of planning. Policy Sci 4:155–69.

Rowe, J. S. 1955. Factors influencing white spruce reproduction in Manitoba and Saskatchewan. Technical note no. 3. Department of Northern Affairs and National Resources, Forestry Branch. Ottawa, Ontario.

Schonewald-Cox, C. M., M. Buechner, R. Sauvajot, and B. A. Wilcox. 1992. Cross-boundary management between national parks and surrounding lands: A review and discussion. Environmental Management 16:273-282.

Stadel, C. 1996. The non-metropolitan settlements of southern Manitoba. IN: J.Welsted, J, Everitt, and C. Stadel. Pp. 152-166. The geography of Manitoba. University of Manitoba Press. Winnipeg, Manitoba.

Statistics Canada. 2002. 2001 census of agriculture: farm data and farm operator data. Unpublished Statistics Canada Report.

Synge, H. 2004. European models of good practice in protected areas. IUCN, Protected Areas Programme ; IUCN World Commission on Protected Areas, Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management.

Trottier, G.C. 1986. Disruption of rough fescue, Festuca halli, grassland by livestock grazing in Riding Mountain National Park, Manitoba. Canadian Field-Naturalist 100:488-495.

Vance, D.R. 1976. Changes in land use and wildlife populations in southeastern Illinois. Wildlife Society Bulletin. 4:11-15.

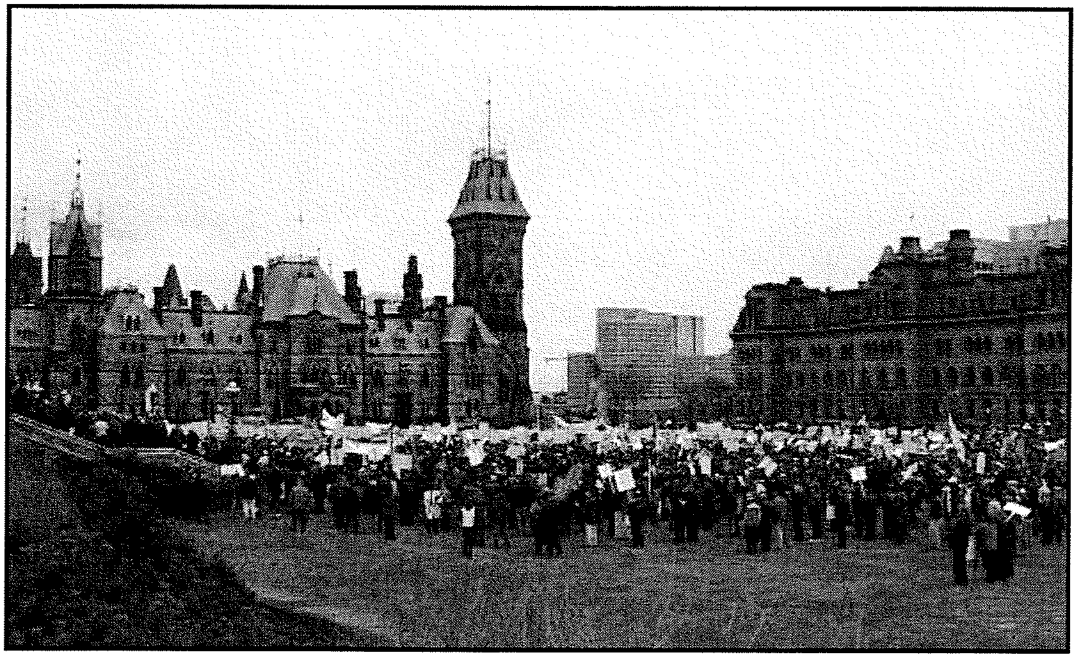
West, P.C. and S. R. Brechin. 1991. Resident peoples and National Parks: Social Dilemmas and Strategies in International Conservation. Tucson, USA: University of Arizona Press 443 pp.

Wiens, J.A. 1994. Habitat fragmentation: island vs. landscape perspectives on bird conservation. Ibis137 :S97-S104.

CHAPTER 2

CONCEPTUAL FRAMEWORK:

RATIONALE FOR AN INTERDISCIPLINARY APPROACH TO HUMAN-WILDLIFE CONFLICTS



"By stepping into rural areas, ecologists abandon their familiar and reassuring natural world and enter a realm long shunned as too unnatural to merit serious academic attention....."

--Western and Wright 1994

Introduction

Conflicts between humans and wildlife by their very nature involve complex interactions between the ecology of the animals and their environment, as well as the attitudes and actions of the affected people (Marker *et al.* 2003, Treves and Karanth 2003). Science-based approaches to these conflicts are diverse, with scientists, resource managers, and stakeholders each contributing unique and sometimes conflicting perspectives on what should constitute the appropriate strategy (Conover 2001). These approaches fall along a gradient, from those that are highly analytical, to those that are highly integrative (Holling 1998).

At its extreme, analytical science is largely experimental, reductionist, and disciplinary, while integrative science at the other extreme is interdisciplinary, takes a broad systems approach, and employs historical, comparative, and experimental approaches (Table 2-1; Holling 1998). Analytical studies are typified by those that document the frequency and impacts of wildlife, particularly those that focus on a single wildlife species (e.g. Conover and Kania 1995). These analytical studies provide accurate and detailed information on the damage done, but few insights into the interactions with the biophysical landscape or the related social perceptions, nor do they contribute to helping elucidate the causes of the problem or derive workable solutions.

In contrast, integrative studies of human-wildlife conflicts are typified by their incorporation of multiple aspects of the issue and they often involve multiple research approaches and may include both the ecological and social sciences (e.g. Treves and Karanth 2003). While there is much diversity in the approaches to scientific study of human-wildlife conflicts, in practice, most projects fall somewhere between these two ends, but characterizing these extremes underscores the variety and options that exist. These diverse approaches have the potential to be complementary and mutually supporting and the only real limitation is the capacity for individuals that advocate these different approaches to work effectively together.

The objective of this chapter is to examine different approaches to studying and mitigating human-wildlife conflicts through a review of the literature, focusing on integrative strategies that incorporate both the social and ecological sciences and build on and incorporate the results from analytical studies. These will form the basis for the remaining data chapters in the thesis.

Interdisciplinary Science-Based Approaches to Risk

Human-wildlife conflicts are influenced by complex environmental and social factors that are generally not well understood, particularly in relation to each other. Much research has examined either the environmental or the social variables separately, but few have considered the two together. The complexity of these higher order interactions at a wide range of temporal and spatial scales creates uncertainty in their timing and nature, as well as uncertainty regarding human responses. Accordingly, interactions between wildlife and humans can be effectively described in terms of risk. This approach integrates the probabilities of interaction with the severity of the outcomes to produce a more holistic understanding of the likelihood and nature of the impacts that occur (Noble Tesh 2000).

Risk is defined here as an exposure to uncertain and potentially unfavourable consequences and the term hazard is used synonymously, following Smith *et al.* (2001). This basic definition, by focusing on the link between uncertainty and adverse outcomes, fits well with the colloquial use and understanding of the term. Much of modern risk analysis is based on the assumption that the probabilities and consequences of adverse events are produced by physical and natural processes in ways that can be objectively quantified. For example, the risk of a cattle herd near RMNP becoming infected with bovine tuberculosis might be modeled using data on contact rates between elk and cattle, along with information on disease prevalence in the elk herd and other pertinent data, if they exist. It is generally assumed that several different studies examining this risk independently will derive similar or identical results. These are often referred to as 'objective risks', although it is now well established that the ways we study and document risks are indeed subjective (Coleman 1993). Much of modern risk analyses have traditionally focused largely on these objective risks, often referred to as 'real risk' (Slovic 1987).

The 'subjective' aspect of risk is often referred to as "perceived risk" since it incorporates human values and unique perspectives (Slovic 1987, Coleman 1993). Studies have shown that the subjective aspects of risk are indeed variable among different individuals, but they are quantifiable and often predictable (Fischhoff et al. 1981, Smith *et al.* 2000). Recent research into the psychology and sociology of risk supports the assertion that most people consistently incorporate cultural criteria into their personal evaluation of risks (Krimsky and Plough 1988). Responses to risk are mediated by social influences transmitted by friends, family, fellow workers, and respected public officials

(Slovic 1987). Individuals have been shown to be more tolerant of risks perceived as voluntary, avoidable, controllable, familiar, and well understood (Slovic 1987, Rescher 1983). Moreover, education, race, societal status may all affect perceptions of risk (Smith *et al.* 2001, Noble Tesh 2000). Thus, risk is spatially and temporally variable and so cannot be generalized across communities. Management efforts that attempt to mitigate the 'objective' aspects of risk but ignore the subjective elements may prove ineffective or even counter-productive.

Conflicts over risk may result from 'experts' and lay people having different definitions of the concept (Slovic 1987). In the case of wolves in North America, it has been established by wolf experts that the risk of a human being attacked by a wild wolf is exceptionally low, with only 19 documented cases of unprovoked wolf aggression toward people in the last hundred years in North America (McNay 2002). Despite these assurances from experts, humans have often expressed extreme levels of fear toward wolves (e.g. Kellert *et al.* 1996, Ponech 1997). From a subjective perspective, these deep anxieties of non-experts are linked to childhood stories, innate fears, and experiences of observing predation on other wildlife and so are not easily changed by new information. Therefore, in the case with wolves, understanding wolf-human conflicts in an area requires information regarding the objective aspects of risk, including the size of the wolf population, the number of documented interactions with humans and any injuries that occur. Of equal importance are the subjective aspects, including human attitudes toward wolves, the level of fear that they have of being attacked and the likelihood that local people will kill or support the lethal control of wolves.

Similarly, nuclear power provides an example of the differences between objective and subjective risk because of the dramatic opposition that exists despite assurances from experts that it is completely safe. Research has shown that people consider the benefits of nuclear power to be low and the risks unacceptably high, while scientific experts have dismissed these fears as irrational (Dupont 1981, Cohen 1983). However, from a subjective perspective, the deep anxieties of non-experts are linked to negative media coverage and a strong association between nuclear power and nuclear weapons. For pastoralists in East Africa, objective descriptions of drought risk from meteorological data were poorly correlated to the subjective perceptions of individuals and groups when mapped using GIS (Smith *et al.* 2001).

If scientific research contradicts or is dismissive of local beliefs and perceptions of risk, the results will likely be rejected by lay people as unreliable, erroneous, or unrepresentative (Slovic 1987). Attempts to characterize, compare, and regulate risks must be sensitive to this broader concept of risk. However, much of the risk literature assumes that increased education regarding risk will inevitably lessen the divide between objective and subjective risk (e.g. Powell 2000). However, beliefs are typically deeply ingrained and perceptions of risk are often slow to change. So in the case of people fearing wolf attacks, it is clear that simply providing additional information about the low probability of wolf problems or other similar information will do very little to alter existing fears. Indeed, providing information about the presence of wolves may may even make people more anxious by stimulating conversations about areas of great concern. Some individuals who are unaware that wolves are even present in their area may be surprised and concerned to learn that there are indeed large numbers present.

An important and often controversial outcome of human-wildlife conflicts is disagreement among individuals or groups of stakeholders regarding the most appropriate way to address these problems. This human-human conflict is directly or indirectly caused by interactions with wildlife, but involve people with differing attitudes, goals, values, wealth, and power (Madden 2004). These individuals may have a history of conflict regarding other issues, with gaps in trust and communication.

In order to move beyond simple descriptive analysis to an understanding of the factors that influence risk, it is useful to recognize that an individual's expression of risk reflects the interactions of the biophysical characteristics of a hazard, and their cognitive understanding of and ability to deal with it (Smith *et al.* 2000). Risk can then be conceptualized as being comprised of four unique components: exposure, perception, mitigation, and coping (Smith *et al.* 2001). Exposure is an objective, measurable component related to space or time, but not to an individual person. In probabilistic terms, exposure is the likelihood that a hazard occurs, for example the probability of a farm being used by elk. Perception is a subjective component that is the specific belief of an individual that he or she might experience a particular hazard and how severe its effects might be, such as fears of a farmer concerned with his or her of cattle herd becoming infected with bovine tuberculosis. The final two components of risk, mitigation and coping, relate to the capacity to reduce the negative effects of a hazard. An individual's ability to mitigate risk increases when objective risk exposure and subjective risk perception are reduced through preemptive behaviors. Coping ability is determined by the individual's ability to respond quickly to and recover from a negative outcome.

Despite the importance of diverse information in understanding human-wildlife conflicts, most of the associated scientific research is limited to a single part of the problem and most is based on a single discipline.

Alternatives to a Conventional Science-Based Approach

While science-based approaches to resolving environmental issues have been embraced by most scientists and many resource managers in North America and beyond, other ways of understanding and managing the world are also implemented widely. Johannes (1998) has advocated a data-less precautionary approach to fisheries management because the ecological and social complexity of these systems ensures that no amount of scientific data will be sufficient to support management. At the same time, other groups choose management decisions based on their own experiences and do not require scientific data.

Farmers, Aboriginal hunters, and indeed many government agency resource managers base their understanding of the environment and make most or all of their decisions using their own experience-based knowledge (Berkes *et al.* 2000, Wilson 2003, Decker *et al.* 2006). They may incorporate science-based information as background information or as part of the decision-making process, but much or all of the information is acquired through personal experience, stories related by ancestors and colleagues, dreams, or ceremonies (McGregor 2000).

The holders of experience-based knowledge are sometimes sceptical of science and frequently question the methods and findings of empirical studies (Neis 1992). For example, hunters in northern Canada collected their own data on caribou kills in an attempt to refute claims by government scientists that caribou populations were lower than local people believed (Anonymous 1980). Similarly, scientists often dismiss experience-based knowledge as anecdotal, unsubstantiated, or inaccurate, particularly the aspects deeply rooted in culture, such as knowledge acquired through dreams or visions (Chambers 1980, Johannes 1993, Hobson 1993, Gilchrist *et al.* 2005).

The rejection of the alternative paradigm by scientists or experienced based knowledge users often occurs even when the two provide similar information. This divergence is largely due to unique institutions governing the interactions between the groups (Wilson 2003). Institutional differences include formal laws, operational rules, social networks, or fora for discussion and decision-making that are structured differently, thus blocking or distorting communications that might otherwise be mutually understood. Linking science-based and alternative approaches to addressing human-wildlife conflicts thus requires a strategy that recognizes the differences between them, while building on the similarities and complementarities, as well as attending to the associated power dynamics and issues of communication (Wilson 2003, Brook and McLachlan 2005). In other words, science and experience-based knowledge are not necessarily mutually exclusive, but much work is still needed if they are to be used together in a way that is acceptable to all concerned.

Human Dimensions of Wildlife Conflicts

Human dimensions of wildlife conflicts refer to how people value wildlife, how they want the conflicts to be managed, and how they affect or are affected by wildlife and the management decisions implemented to mitigate conflicts (Decker *et al.* 2001). Human dimensions research aims to understand human traints and identify means of incorporating that understanding into plans and actions to address conflicts with wildlife. The term 'human dimensions' includes a diverse array of concepts and practices and can include socio-economic values, group and individual behaviours, community participation in decision-making, and communication regarding the risks and outcomes of management.

Social psychology, the study of people's thoughts, feelings, and behaviours, has identified two theoretical approaches that are used extensively in human dimensions research: cognitive approaches and motivational approaches (Decker *et al.* 2001). A cognitive approach considers concepts including attitudes, values, and norms that lead from thought to action. A motivational approach examines why humans do what they do.

The theory of reasoned action (Fishbein and Manfredo, 1992) and theory of planned behavior (Azjen, 199) suggest that human responses to conflicts with wildlife are directed by their attitudes, norms, and perceptions of control (Manfredo and Dyer 2004). An *attitude* is defined by Manfredo and Dyer (2004) as a favorable or unfavorable outlook toward an action, an issue, or an event. Much research has examined how strongly attidues are held because strongly held attitudes are normally difficult to change (Decker *et al.* 2001). *Norms* are standards of behaviour that specify what people should do (Blake and Davis 1964). P*erceived behavioral control* is an appraisal of whether a person possesses the abilities to affect a behavior. Values are fundamental beliefs about desired outcomes and theory suggests that these values develop very early in life, are resistant to changes and are relatively few in number (Rokeach 1973, Gray 1993, Manfredo and Dyer 2004).

A fundamental variable in understanding the nature and potential outcomes of human-wildlife conflicts is how humans perceive themselves in relation to the environment along a gradient from deference toward nature to domination of nature. Human-willdife conflicts research often examines human tolerance for social encounters with wildlife in order to determine three main properties of the interaction: (a) the range of tolerable behaviour; (b) the intensity of the most acceptable or unacceptable extremes; and (c) the amount of agreement that exists (Decker *et al.* 2001).

A fundamental challenge in both theoretical and applied research is how to use human dimensions research that focuses on the social aspects of human-wildlife conflicts, with ecological research that focuses on the biophysical aspects of the conflicts. Research examining human-elephant conflicts have developed approaches for using both social and ecological data together to address the conflicts in a comprehensive manner (Hoare 2000, Sitati et al. 2003). These approaches have focused on linking the perceptions and actions of local people with the crop-raiding behaviour of elephants. However, there remain few studies that explicitly incorporate both social and ecological empirical data.

Adaptive Management of Human-Wildlife Conflicts

The concept of adaptive environmental assessment and management was proposed as means to unify scientists, stakeholders, and resource managers toward a common goal of mitigating risk (Walters 1986, Walters and Holling 1990). This adaptive approach is science-based and involves the development of *a priori* hypotheses before implementing a management action aimed at a specific result (Holling 1978). Given the complexity of ecosystems and social systems, uncertainty regarding the outcome of any management intervention is typically high and the range of potential intended and unintended outcomes is broad (Gunderson and Holling 2002). Thus, the perspectives of scientists, managers, and stakeholders must all be included in order to begin predicting the range of potential outcomes in the face of this uncertainty. Adaptive approaches also rely on learning throughout the process by monitoring the effects of management initiatives and carefully assessing the outcomes on an on-going basis. Perhaps the greatest problem with adaptive management is that the "learning by doing" aspect has been adopted by virtually every management plan produced in recent years, but without any clear definition of what it means or how it will be implemented (Gregory *et al.* 2006). Groups implementing adaptive management also continue to struggle with how to fully comprehend and incorporate the diversity and interconnectedness of ecological and social systems.

The Spatial Ecology of Human-Wildlife Conflicts

While the social aspects of human-wildlife conflicts form important context and drivers for these interactions, the environmental conditions and the ecology of the animals involved are also essential considerations. The ecological aspects of human-wildlife conflicts have been examined in detail at the local scale, but only recently have efforts been made to examine them at the broader landscape scale.

Landscape ecology is based on the notion that environmental patterns strongly influence ecological processes (Turner and Gardner 1991). The habitats in which animals live are spatially structured at a number of different scales and these patterns interact with an animal's perception and behaviour. The concepts and principles of landscape ecology (Burgess and Sharpe 1981, Forman and Godron 1986) provide a framework for the quantitative analysis of landscape structure (O'Neill *et al.* 1997). Applying these principles to interpret wildlife interactions with human dominated landscapes can provide important insights into the risks associated with wildlife-human conflicts.

Habitat fragmentation is a process involving the breaking up of large blocks of habitat into smaller, more isolated patches, with a new habitat becoming the matrix (Fahrig and Merriam 1985). Although fragmentation has been cited as one of the most important threats to species conservation (Andren 1994) its effects are poorly documented, despite their theoretical and applied interest.

Landscapes are dynamic mosaics of natural and human-influenced patches that vary in size, shape, and arrangement (Urban *et al.* 1987). The components of landscape pattern can be described in several ways: (1) patch type diversity (number of different patch types), (2) number of patches, (3) patch type distribution across the landscape, (4) association and dispersion relationships between types, and (5) patch complexity, or size and shape (Forman and Godron 1986). From these components, various indices and models of landscape structure can be constructed and related to movements of wildlife. A commonly used model for conceptualizing and representing the spatial elements of a landscape in a categorical map pattern is the *patch-corridor matrix model* (Forman 1995). This model recognizes three major landscape elements: patch, corridor, and matrix.

A patch represents a relatively discrete area of relatively homogenous environmental conditions, where the patch boundary is distinguished by discontinuities in environmental character states from its surroundings, as perceived by or relevant to the animal under consideration (Weins 1976). Patches are spatially and temporally dynamic, varying with each animal's perceptions (Weins 1976, 1989). At any given scale, each patch has an internal structure that reflects patchiness at finer scales (Kotliar and Wiens 1990) so a landscape is composed of a hierarchy of patch mosaics across a range of scales. From an animal-centred perspective, the smallest scale at which an organism perceives and responds to patch structure is its "grain" (Kotliar and Wiens 1990). "Extent" refers to the coarsest scale of heterogeneity that an animal responds to (Kolasa and Rollo 1991). At the level of the individual, extent is determined by the lifetime home range of the individual (Kotliar and Wiens 1990) and varies among individuals and species. Patch boundaries are artificially imposed and are only meaningful when referenced to a particular scale (i.e. grain size and extent).

In human-dominated landscapes, it has been suggested that an animal's move through the matrix across 'hostile' areas that represent sub-optimal habitats (Keymer *et al.* 2000) and that patches of habitat ('stepping stones') are required to move (Andren 1994, Collingham and Huntley 2000). Connectivity represents the critical features of landscape structure that affect an animal moving among habitat patches (Taylor *et al.* 1993). Landscape connectivity is a fundamental characteristic of the movements and dispersal of animal populations (Fahrig and Merriam 1985). It represents the degree to which the landscape facilitates or impedes the movement of individuals among habitat patches and is dependent on the spatial distribution of habitats across the landscape and on the scale at which organisms interact with landscape pattern (Kotliar and Wiens 1990). However, there are few empirical data that quantify key parameters of landscape connectivity, including habitat-specific movement patterns, rates, or capabilities of animals. Even less data are available that compare movement behaviours among landscapes that differ in structure, such as the amount or configuration of suitable habitats (Wiens 1997).

Spatially explicit models thus have been developed to simulate animal movement and dispersal across heterogeneous landscapes, including grid-based diffusion-like algorithms, Geographic Information System (GIS) models of landscape resistance, random walks, neutral landscape models, and individual-based local-rule models (Johnson *et al.* 1992, Schippers *et al.* 1996, Brooker *et al.* 1999).

Tischendorf and Fahrig (2000) identify two separate approaches to assessing connectivity. "Structural connectivity" is measured without reference to any particular animal species, whereas "functional connectivity" considers the behaviour of a particular species and overall success in moving through the matrix. The composition of habitats on a landscape, their spatial configuration, and the movement behaviour of the animal are critical components of functional connectivity (Taylor *et al.* 1993). Gap tolerance is an important characteristic of a species because it defines how far it will move across unsuitable areas to reach suitable sites. However, in reality, gap tolerance is rarely known with accuracy since animal movements are influenced by a range of factors including a prior knowledge of the landscape, travelling companions, conspecific attraction, and predator avoidance.

The Challenge of an Interdisciplinary Approach

The majority of scientific research is conducted within the established boundaries of its specific discipline. When discussing research that crosses these disciplinary boundaries, the terms 'multidisciplinary' and 'interdisciplinary' are used frequently. Multidisciplinary studies involve separate theories, skills, and data in examinging a research question, whereas interdisciplinary studies bering people and ideas together from several different disciplines using a common methodological approach (Golde and Gallagher 1999). While this is a laudable goal, the primary challenge of this approach is bringing together all of these unique languages, research methods, personal objectives, and datasets and determining a means of making them work effectively.

The development of an integrative, interdisciplinary approach to human-wildlife conflicts is thus fraught with practical and theoretical challenges. The value of interdisciplinary research and the strong need for an integration of social and biological sciences to address conflicts has been widely recognized (Wilson 1998, Pickett et al. 1999). It is also evident that complex issues such as resolving human-wildlife conflicts requires an integration of approaches that together elucidate the biophysical and social aspects (Wear 1999). Indeed, this need has been recognized in human ecology (Burch 1988) and the biological sciences (Golde and Gallagher 1999). However, this integration is challenged by unique spatial and temporal scales of analysis, different data formats, and the level of accuracy obtained by different disciplines and approaches (Nyhus *et al.* 2002).

The overall approach of this dissertation is to address the challenges of interdisciplinary research by integrating data from the ecological and social sciences, using the resulting information as both complementary and as a means of triangulating different methods (Madsen and Adriansen 2004). Inspiration for development of critical realism as a methodology and implementing it for practical research comes from Pratt (1995).

Literature Cited

Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos 71:355-366.

Anonymous. 1980. Inuit dispute biologist's caribou count. Musk-Ox 26:14.

Berkes F, J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251–1262.

Blake, J. and K. Davis. 1964. Norms, values, and sanctions. P.456-484. In. R. E. L. Faris, (ed.) Handbook of modern sociology. Rand McNally, Chicago, Illinios, USA.

Brook, R. K., and S. M. McLachlan. 2005. On using expert-based science to "test" local knowledge. Ecology and Society 10, r3. http://www.ecologyandsociety.org/vol10/iss2/resp3/

Burgess, R.L. and D. M. Sharpe. 1981. Forest island dynamics in man-dominated landscapes. Springer-Verlag, New York, New York.

Brooker, L., M. Brooker, and P. Cale. 1999. Animal dispersal in fragmented habitat: measuring habitat connectivity, corridor use, and dispersal mortality. Conservation Ecology [online] 3(1):4. Available on the Internet. URL:http://www.consecol.org/vol3/iss1/art4.

Burch, W. R. 1988. Human ecology and environmental management. In Ecosystem management for parks and wilderness, eds J. K. Agee and D. R. Johnson, 145±159. Seattle: University of Washington Press, Washington, D.C., USA

Chambers, R. 1980. The small farmer is a professional. Ceres March-April:19-23.

Cohen, B.L. 1983. Before It's Too Late: A Scientist's Case for Nuclear Energy. Plenum, New York.

Coleman, C.L. 1993. The influence of mass media and interpersonal communication on societal and personal risk judgements. Communication Research 20:611-628.

Collingham, Y. C., and B. Huntley. 2000. Impacts of habitat fragmentation and patch size upon migration rates. Ecological Applications 10:131-144.

Conover, M. R., and G. S. Kania. 1995. Annual variation in white-tailed deer damage in commercial nurseries. Agriculture, Ecosystems and Environment 55:213-217.

Conover, M. R. 2001. Resolving human-wildlife conflicts: The science of wildlife damage management. Lewis Publishers, USA.

Decker, D. J., T. L. Brown, and W. F. Siemer. (eds.) 2001. Human dimensions of wildlife management in North America. The Wildlife Society, Bethesda, Maryland, USA.

Decker, D. A., M. A. Wild, S. J. Riley, W. F. Siemer, M. M. Miller, K. M. Leong, J. G. Powers, and J. C. Rhyan. 2006. Wildlife disease management: A manager's model. Human Dimensions of Wildlife 11: 151-158.

Fahrig, L., and H. G.Merriam. 1985. Habitat patch connectivity and population survival. Ecology 66:1762-1768.

Fischhoff, B., S. Lichtenstein, P. Slovic, S. L. Derby, and R. L. Keeney. 1981. Acceptable risk. Cambridge University Press, New York, New York, USA.

Forman, R. T. T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, England.

Forman, R. T. T., and M. Godron. 1986. Landscape ecology. John Wiley and Sons, New York, New York.

Fahrig, L., and H. G. Merriam. 1985. Habitat patch connectivity and population survival. Ecology 66:1762-1768.

Gilchrist, G., Mallory, M. & Merkel, F. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. Ecology and Society 10: 20. (15 August 2006, www.ecologyandsociety.org/vol10/iss1/art20/).

Golde, C. G., and H. A. Gallagher. 1999. The challenges of conducting interdisciplinary research in traditional doctoral programs. Ecosystems 2:281-285.

Gray, G. G. 1993. Wildlife and people: the human dimensions of wildlife ecology. University of Illinois, Urbana.

Gregory, R., D. Ohlson, and J. Arvai. 2006. Deconstructing adaptive management: Criteria for applications to environmental management. Ecological Applications 16:2411-2425.

Gunderson, L., and C. S. Holling, editors. 2002. Panarchy: understanding transformations in human and natural systems. Island Press, Washington, D.C., USA.

Hobson, G. 1993. Traditional knowledge is science. Northern Perspectives 20:2-3.

Holling, C. S., editor. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York, New York, USA.

Holling, C. S. 1998. Two cultures of ecology. Conservation Ecology 2 (2): 4. [online] URL: http://www.consecol.org/vol2/iss2/art4

Johannes R. E. 1993. Integrating traditional ecological knowledge and management with environmental impact assessment. Pages 33-41 in Inglis JT, ed. Traditional Ecological Knowledge: concepts and cases. Canadian Museum of Nature, Ottawa, Ontario, Canada.

Johannes R. E. 1998. The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends in Ecology and Evolution 13:243-246.

Johnson, A. R., J. A. Weins, B. T. Milne, and T. O. Crist. 1992. Animal movements and population dynamics in heterogeneous landscapes. Landscape Ecology 7:63-75.

Kellert, S. R., M. Black, C. R. Rush, and A. J. Bath. 1996. Human culture and large carnivore conservation in North America. Conservation Biology 10:977-990.

Kolasa, J., and C. D. Rollo. 1991. Introduction: the heterogeneity of heterogeneity: a glossary. In: Kolasa, J. and Pickett, S.T.A. (eds.) Pages 1-23. Ecological Heterogeneity. Springer-Verlag, New York, New York, USA.

Keymer, J.E., P. A. Marquest, J. X. Velaco-Hernandez, and S. A. Levin. 2000. Extinction thresholds and metapopulation persistence in dynamic landscapes. American Naturalist 156:478-494.

Kotliar, N.B. and J. A. Wiens. 1990. Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. Oikos 59:253-260.

Krimsky, S., and A. Plough. 1988. Environmental hazards: communicating risks as a social process. Auburn House Publishing, Dover, Mississippi, USA.

Madden, F. 2004. Creating coexistence between humans and wildlife: Global perspectives on local efforts to address human-wildlife conflict. Human Dimensions of Wildlife 9:247-257.

Madsen, L. M., and H. K. Adriansen. 2004. Understanding the use of rural space: the need for multi-methods. Journal of Rural Studies 20: 485–497.

Marker, L. L., M. G. Mills, and D. W. Macdonald. 2003. Factors influencing perceptions of conflict and tolerance toward Cheetahs on Namibian farmlands. Conservation Biology 17:1290-1298.

McNay, M. E. 2002. Wolf-human interactions in Alaska and Canada: a review of the case history. Wildlife Society Bulletin 30:831-843.

McGregor, D. 2000. The state of traditional ecological knowledge research in Canada: a critique of current theory and practice. Pages 436-458 in Laliberte R, Settee P, Waldram J., R. Innes, B. Macdougall, L. McBain, and F. Barron, eds. Expressions in Canadian native studies. Saskatoon: University of Saskatchewan Extension Press.

Neis, B. 1992. Fishers' ecological knowledge and stock assessment in Newfoundland. Newfoundland Studies 8:156-178.

Nyhus, P. J., F. R. Westley, R. C. Lacy, and P. S. Miller. 2002. A role for natural resource social science in biodiversity risk assessment. Society and Natural Resources 1:923-932.

O'Neil, R.V., C. T. Hunsaker, K. B. Jones, K. H. Riiters, J. D. Wickham, P. M. Schwartz, I. A. Goodman, B. L. Jackson, and W. S. Baillargeon. 1997. Monitoring environmental quality at the landscape scale. BioScience 47:513-519.

Ponech, C. 1997. Attitudes of area residents and various interest groups towards the Riding Mountain National Park wolf population. Master's Thesis, Faculty of Graduate Studies, University of Manitoba, Canada.

Powell, D. A. 2000. Food safety and the consumer—perils of poor risk communication. Canadian Journal of Animal Science 80:393-404.

Pratt, A.C. 1995. Putting critical realismto work: the practical implications for geographical research. Progress in Human Geography 19: 61–74.

Rescher, N. 1983. Risk: a philosophical introduction to the theory of risk evaluation and management. University Press of America, Washington, D.C.

Rokeach, M. 1973. The nature of human values. Free Press, New York, New York, USA.

Schippers, P., J. Verboom, J. P. Knappen, and R. C. van Apeldorn. 1996. Dispersal and habitat connectivity in complex heterogeneous landscapes: an analysis with a GIS-based random walk model. Ecography 19:97-106.

Slovic, P. 1987. Perception of risk. Science 236:280-285.

Smith, K., Barrett, C.B., and Box, P.W. 2000. Participatory risk mapping for targeting research and assistance: With an example from East African pastoralists. World Development 28:1945-1959.

Smith, K., Barrett, C.B., and Box, P.W. 2001. Not necessarily in the same boat: Heterogeneous risk assessment among East African Pastoralists. Journal of Development Studies 37:1-30

Taylor, P. D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos 68:571-573.

Tesh, S.N., 2000. Uncertain hazards: environmental activists and scientific proof. Cornell University Press, Ithaca, New York.

Tischendorf, L., and L. Fahrig. 2000. On the usage and measurement of landscape connectivity. Oikos 90:7-19.

Treves, A., and K. U. Karanth. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17:1491-1499.

Turner, M. G. and R. V. Gardner. 1991. Quantitative methods in landscape ecology. The analysis and interpretation of landscape heterogeneity. Springer-Verlag, New York, New York.

Urban, D. L, R. V. O'Neil, and H. H. Shurgart Jr. 1987. Landscape ecology: A hierarchical perspective can help scientists understand spatial patterns. BioScience 37:119-127.

Walters, C. 1986. Adaptive management of renewable resources. McMillan, New York, New York, USA.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems.Conservation Ecology, 1(1), [on-line:] http://www.consecol.org/vol1/iss2/art1.

Walters, C., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71:2060–2068.

Wear, D. N. 1999. Challenges to interdisciplinary discourse. Ecosystems 2:299±301.

Weins, J. A. 1976. Population responses to patchy environments. Annual Review of Ecology and Systematics 7:81-120.

Wiens J. A. 1997. Metapopulation dynamics and landscape ecology. In: Hanski I. A. and Gilpin M.E. (eds), Metapopulation biology: ecology, genetics, and evolution. Academic, New York, New York, USA, pp. 43–62.

Wilson, D. C. 2003. Examining the two cultures theory of fisheries knowledge: The case of Bluefish management. Society and Natural Resources 16:491-508.

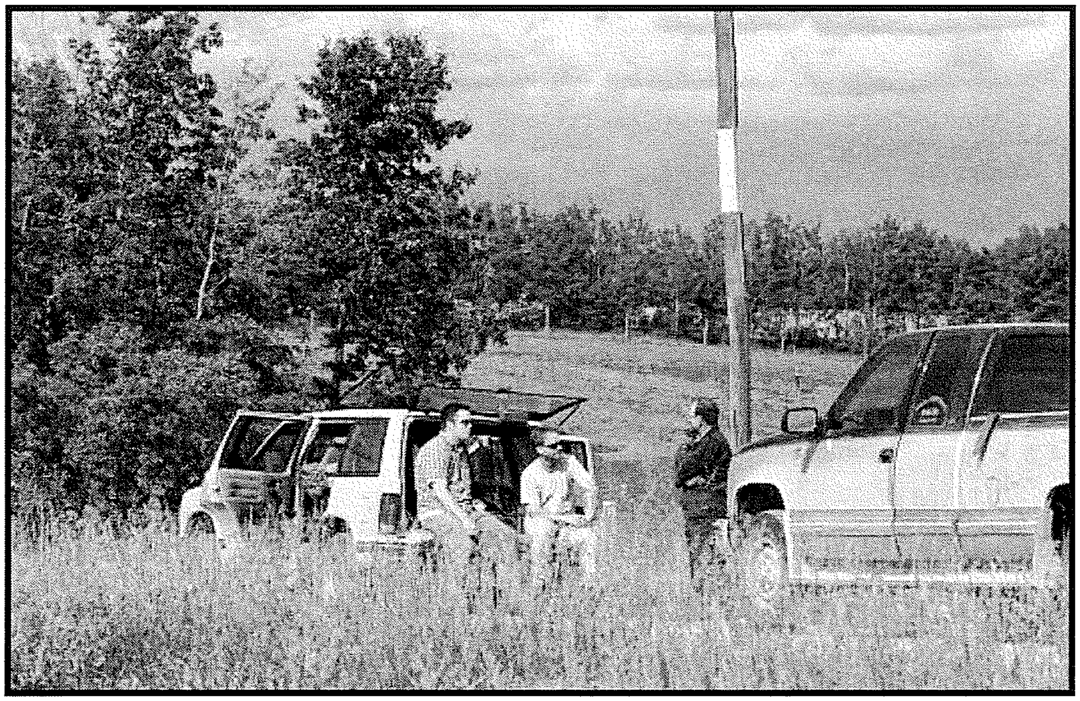
Table 2.1. Contrasting extremes in the cultures of science (after Holling 1998).

ATTRIBUTE	*ANALYTICAL*	*INTEGRATIVE*
Philosophy	-narrow and targeted -disproof by experiment -parsimony by rule	-broad and exploratory -multiple lines of converging evidence -requisite simplicity the goal
Perceived Organization	-biotic interactions -fixed environment -single scale	-biophysical interactions -self-organization -multiple scales with cross-scale interactions
Causation	-single and separable	-multiple and only partially separable
Uncertainty	-eliminate uncertainty	-incorporates uncertainty
The danger	-Exactly right answer for the wrong question	-Exactly right question but a useless answer

CHAPTER 3

KNOWING BY DOING:

THE ROLE FOR LOCAL KNOWLEDGE IN ECOLOGICAL RESEARCH



"The best way to conserve the diversity of cultures and nature is through the empowerment of the people whose local knowledge and experiences form the foundations that conserve much of the earth's remaining biological and ecological diversity."

--Posey 1999

Chapter Summary

Local ecological knowledge (LEK) of those who earn livelihoods from natural resources has long been recognized as providing far-reaching insights into ecological processes. I characterize how LEK has been used in the ecological literature over the last 25 years by broadly examining 360 journals and by evaluating 12 prominent ecological journals in greater detail. Over this period, only 0.01% of papers in the broad and 0.42% of those in the more detailed evaluation incorporated LEK. Despite this slow increase, LEK-based publications remain nearly absent from the longstanding and relatively prestigious theoretical literature and are largely restricted to more recent and less established applied and interdisciplinary journals. Most LEK studies used interviews, but they generally failed to include community members effectively in the research process. These shortcomings and the broader issues of power and influence in the sciences should be addressed if local knowledge holders are expetected to continue participating in ecological research.

Introduction

The use of experience-based knowledge by scientists represents an important emerging area of ecological research (Huntington 2000, Kendrick *et al.* 2005, Brook and McLachlan 2005, Bart 2006). Variously referred to as Indigenous Knowledge, Traditional Ecological Knowledge, or, more generally, Local Ecological Knowledge (LEK), these rich insights are held by lay people working in and making their livelihoods from natural environments.

The concept of documenting and using LEK is not new to the sciences. In the sixteenth century, botanists from Holland and Portugal used Indigenous Knowledge to locate and classify plant species from Asia (Ellen and Harris 1999). Boas (1888) later conducted seminal anthropological research to understand the complex relationship among Inuit, sea ice, and ringed seals. Important in and of-itself, LEK can also be linked with more conventional empirical research to provide a richer understanding of ecological processes (Bart 2006). As large-scale anthropogenic and natural impacts on the environment become apparent, it is increasingly recognized that conventional ecological research cannot always be conducted quickly enough and over large enough areas to understand associated complex, long-term changes (Tesh 2000), and that LEK may thus provide valuable insights for researchers, managers, and policymakers (Mauro and McLachlan accepted).

While researchers seek new approaches to understanding and managing complex environmental problems, society increasingly questions the outcomes of conventional ecological research, especially when the science conflicts with existing local knowledge, concerns, and values (Tesh 2000). The documentation of local knowledge can provide important avenues for discussion and building dialogue between scientists and the communities in which they work (Turner *et al.* 2000), and grounding studies in the realities of non-experts throughout the research process. Importantly, the application of local knowledge to environmental and resource management-related problems has the potential to provide a voice and influence for resource-dependent communities that might otherwise be excluded from decision-making (Brook and McLachlan 2005).

What is local ecological knowledge?

There is no universally accepted definition of LEK, nor does it appear that one is forthcoming or even desirable (Brook *et al.* 2006). This is perhaps not surprising given the complexities of these knowledge systems, the diversity of environments and cultures that they reflect, and the myriad ways that they are viewed, documented, and used (e.g. Berkes 1999, McGregor 2000). Many different approaches and terms are used to describe these diverse knowledge systems (Table 3.1), and for the purposes of this paper, I will use the most inclusive term, Local Ecological Knowledge (LEK).

Most descriptions of LEK emphasize the importance of practical skills and wisdom developed through experience in and earning livelihoods from the environment (Berkes 1999). LEK is largely orally transmitted, is cumulative in nature, is typically local in scale, and builds on the experiences of past and present generations through mentoring, storytelling, and cooperative work (McGregor 2000). Researchers use many different approaches when characterizing experience-based knowledge and often interact with knowledgeable individuals and Elders residing in resource-dependent communities (Ferguson *et al.* 1998, Brook and McLachlan 2006) (Figure 3.1). These knowledge systems continually evolve, responding to changing environmental and societal conditions (Davis and Wagner 2003). Indeed, LEK can readily incorporate technology and scientific discoveries where appropriate, such that the distinctions between LEK and conventional science often become blurred (Agrawal 1995). As such, LEK provides a rich, spatially and temporally explicit, and long-term body of knowledge.

The application of local knowledge has many obvious advantages in understanding and responding to ecological problems (Bart 2006), yet its use remains sometimes controversial. It has been rejected by some scientists as 'anecdotal', 'imprecise', 'unsubstantiated', or 'inaccurate' (Johannes 1993, Hobson 1993, Gilchrist *et al.* 2005). Some even question whether it has any meaningful place in ecological research, labelling it as pseudo-science or even anti-science (e.g. USNC/IUHPS 2001, Howard and Widdowson 1996, Widdowson and Howard 2002). In turn, these criticisms receive measured responses from those whom see it as a viable field of inquiry (e.g. Berkes and Henley 1997, Stevenson 1997, Brook and McLachlan 2005). In my experience, most scientists and other experts seem open to the idea that LEK can contribute meaningfully to their research area, but are often hesitant to begin incorporating local knowledge into their studies because it normally requires a completely different approach than most other types of ecological research. At the same time, many researchers remain unclear as to how local knowledge might contribute to their area of study.

Perhaps the most challenging aspect of LEK for individuals trained in the ecological sciences to absorb is the cultural context for and spiritual aspects of local knowledge, including creation myths and cosmologies used to explain the origin of earth and its people and the codes of ritual and behaviour that govern relationships with their environments (AFN and NAFA 1995). This knowledge may be acquired through dreams, ceremonies, self-knowledge, and learning-by-doing; especially for Indigenous and Aboriginal Peoples (McGregor 2000, Simpson 2001a). These aspects may initially be viewed as irrelevant or inconvenient, since university-based science education often stresses an objective approach that is dissociated from this cultural background.

Publishing Local Ecological Knowledge Research

As LEK has become more widely known as a concept in recent decades, some have suggested that the number of peer-reviewed publications that utilize local ecological knowledge is increasing (e.g. Duerden and Kuhn 1998, McGregor 2000). Neither these changes, nor the body of ecological literature as a whole has yet to be characterized or critically evaluated. My goal here is to assess how and to what degree LEK is used by scientists in the peer-reviewed ecological literature. Ecologists that are not constrained to publishing only in ecological journals will find a wide range of options in the anthropological journals (e.g. Current Anthropology, American Anthropologist) or those that focus entirely on LEK research (e.g. Journal of Ethnobiology). While these types of journals are viable options for researchers within those fields, many ecologists prefer, or are required to, publish their work in ecology journals. Since the publication list of an individual researcher is a critical part of an application for appointment, promotion, and research grants, ecologists generally must publish within ecological journals or their work risks being overlooked within their field. At the same time, within the ecological literature, most researchers strive to publish in journals with the greatest impact and prestige. Journals are often selected based on their impact factor score, which is calculated as the average number of times that articles published in a specific journal in the two previous years were cited in a particular year (Sutherland 1999). At the same time, a manuscript that incorporates both LEK and conventional ecological data such as radio-collared wildlife data would be most appropriately published in an ecological journal. Thus, for my analysis, I focused on the use of LEK within the ecological literature. I also provide a case study from my own research that incorporates LEK to illustrate what I consider important issues and appropriate approaches for documenting and using LEK.

Temporal Trend in LEK use within the Ecological Literature

In order to assess patterns in the publication of experience-based local knowledge within the ecological literature, I used a bibliometric analysis, which involves a systematic examination of the number and type of publications within a discipline which are interpreted based on a coding scheme developed *a priori* (Prichard 1969). In total, all of the 360 environmental, conservation, and ecology journals representing approximately 7.5 million papers within the Biological

Abstracts digital database were searched in each year from 1980 to 2004 (Thomson Corporation 2006). Searches were based on key terms for LEK (Table 3.1) and other key words that could identify papers that employed local knowledge (ethnobotany, ethnoecology, interview, participant observation). Boolean operators were used for terms that included more than one word and searches included the title and abstract when it was available. The searches were run individually for each of the 25 years examined using the same search approach to ensure that the results were directly comparable among years.

Approaches to Utilizing LEK in Ecology

While the key term search provided a general trend in the publications that utilize LEK across the ecological literature as a whole, I was also interested in examining a subset of these journals in more detail to a) provide insights into the methods that were used and how the researchers interacted with the communities they working in; and b) validate the observed temporal trend observed in the broader analysis. This finer scale analysis examined 12 ecological journals in much greater detail over the same 25-year period as the broader analysis. I then use these results to critically examine the ways in which LEK is used within the ecological literature and provide suggestions regarding how ecologists might address the challenges of designing, implementing, and publishing studies that utilize local knowledge.

The journals within the ecological literature that largely cater to a North American readership were stratified by journal impact factor and were categorized within each of three broad classes (theoretical, interdisciplinary, and applied) according to their mission statements. Four journals were randomly selected for each class: i) theoretical (i.e. Canadian Journal of Botany, Canadian Journal of Zoology, Ecological Monographs, and Ecology), ii) interdisciplinary (i.e. Agriculture, Ecosystems and Environment (previously Agro-Ecosystems), Arctic, Ecology and Society (previously Conservation Ecology), and Trends in Ecology and Evolution), and iii) applied (i.e. Canadian Journal of Fisheries and Aquatic Sciences, Canadian Journal of Forest Research, Conservation Biology, and Ecological Applications). Eight of these journals had been published before 1980 and four had been subsequently created, the latter group including Trends in Ecology and Evolution (1986-2004), Conservation Biology (1987-2004), Ecological Applications (1991-2004), and Conservation Ecology/ Ecology and Society (1997-2004). In total, 40,900 articles were screened for the potential use of local knowledge and assessed in detail for these 12 journals and the "methods", "results", "discussion", and "acknowledgement" sections were reviewed for their explicit use of experience-based knowledge and whether the authors acknowledged the participating communities. By going through each article individually, I could identify studies using LEK that might not be captured in the broader key word search. Studies were recognized as using LEK if there was any evidence of it being used in study design, as a source of data, or in the interpretation of results. This detailed analysis allowed me to document the methods used to study LEK in each paper (Table 3.2), as well as the subject of each study, the region it was conducted, and the types of people that were included, using a common coding scheme.

Temporal Trends in LEK Usage

The number of published environment, conservation, and ecology articles using LEK has increased over the last 25 years (Figure 3.2). Through the broader analysis, 421 LEK articles were identified for this period, representing 0.01% of all papers published. I similarly identified 172 articles using LEK in the 12 ecological journals examined in detail, representing 0.42% of papers published from 1980-2004. There is an important body of LEK research within the ecological literature and this continues to grow each year.

Use of LEK varied greatly among the 12 journals examined in detail, being the highest (in descending order of proportional use) in Ecology and Society, Arctic, Conservation Biology, Ecological Applications, and Agriculture, Ecosystems and Environment and were rare or non-existent in the other seven journals (Table 3.3). In each of the journals that incorporated LEK studies, there also seemed to be an overall increase in the proportion of studies using LEK, especially in Ecology and Society and Conservation Biology (Table 3.4). The former likely reflects a change in the mandate, and indeed the name, of the online journal when Conservation Ecology, published by the Ecological Society of America became Ecology and Society, published by the Resilience Network.

The increase in LEK studies in Conservation Biology seems to reflect an increased recognition that resource dependent communities have an important role in conserving biodiversity. In contrast, it seems that the most influential and longstanding journals had the fewest LEK papers and indeed this has not substantially changed over the last 25 years. Although it might be argued that LEK studies go beyond the mandate of these journals, this creates a quandary for researchers whose funding and career advancement is often predicated on publishing in established and high-impact venues. I suggest that the nature of the research objectives should determine the content of publication that journals publish and that LEK studies, if properly formulated, should be supported by all ecological journals.

My analysis was only able to consider the papers that were published in each journal and I did not have any data on papers that were rejected. As a result, it was not possible to determine if LEK papers have been submitted to the theoretical journals but not published. Most LEK research is applied in nature and I am unaware of any completely theoretical ecological studies employing LEK. This likely explains the observed distribution of LEK studies within the different journals. One of the journals that published LEK papers regularly (Conservation Biology) is ranked seventh in the top ten journals in ecology based on journal impact factors (Bergstrom and Bergstrom 2006), and another is ranked very close to the top ten (Ecological Applications).

Embracing Local Knowledge

Some of the key challenges for ecologists using LEK are pragmatic in nature, and reflect a different research culture than many have been exposed to in the past, particularly adopting social research techniques (Huntington 2000). Few ecologists are formally trained in the social sciences, and interdisciplinary studies that combine or integrate both ecological and social research are unlikely outcomes of interdisciplinary team-based research (Brook *et al.* 2006). These skills are still not reflected in most university ecology programs (Berkes 2005) and will likely only be promoted when the need and benefits became readily apparent. Critical needs for LEK have already been identified for areas such as major gaps in data for remote or inaccessible environments such as the Arctic or marine systems, high priority issues such as climate change, and/or when they are required by law. In Nunavut in northern Canada, for example, it is now required that scientists actively involve community members in their research projects.

Most LEK is held by members resource-dependent communities that reflect a wide diversity of cultures and world views, and few residents are formally trained in the sciences. The limited ability of ecological research to capture this diversity is especially evident when addressing the spiritual nature of LEK (Simpson 2001a). It is likely seen as either irrelevant or forbidding to researchers trained in the western and quantitative sciences, where the importance of objectivity and value-neutral approaches remain ubiquitous. Moreover, many of these communities have been subjected to many centuries of oppression, and thus the knowledge that attracts ecologists cannot be viewed in isolation from this history (Simpson 2001b). Unfortunately, the required background, openness, and sensitivity required to address these issues are underemphasized, if reflected at all, in most university-level ecology programs.

Remuneration and Acknowledgement

While many studies (42%) acknowledged the communities and individuals that shared their knowledge and some (6%) included them as co-authors, more than half of all studies (52%) did not explicitly recognize the contribution of study participants within the publications (Figure 3.3). It might be argued that publications in the peer-reviewed literature are of little interest to communities so acknowledgment and co-authorship is irrelevant, but I recommend including acknowledgement as an important part of the process as it is reflective of the overall importance researchers place on ethical research. Similarly, only 24% of studies indicated that any feedback was obtained from the community. I recommend that each research proposal should include at least one preliminary meeting with the community to establish dialogue and communicate the study objectives and methods that will be used. Prior to publication of results, another set of meetings to confirm the study findings is a critical step in ensuring the results are valid and that participants find the outcomes acceptable.

Obtaining community input is a critical step in the research process before proceeding with final reports and peer-reviewed submissions. I have found that while this does require some additional time and financial cost to go back to the communities, it has been invaluable for leaving the local people with a feeling that their input was valued. This step also provides an important validations step where all participants review their submissions, either individually or as a group discussion and I have also received important novel insights from these meetings that were invaluable in helping interpret the results. Some of my earlier attempts at more formal interactions focused on giving PowerPoint presentations of the results, but I have found that less formal and more interactive communication is more effective.

Most of the data in the papers that I examined were communicated in the voice of the researchers, and only 12% of the empirical studies included direct quotes from study participants. Incorporating quotes provides another meaningful way of acknowledging study participants as well as important qualitative information that is lost when paraphrased or coded by the researcher. In the papers reviewed that did use quotes; there was a median of 9 quotes in each. While the length limitation of most ecological journals might discourage extensive quotations, their use does allow participants to speak directly to the research, especially when their cultural origins contrast with those from the researchers.

Only one study that I reviewed explicitly indicated that participants were compensated for their contribution. In my own research, I typically cover any costs that participants incur such as travel, and meals are normally provided during or after the interviews are conducted. Choosing whether to remunerate participants for their time or as an inducement to participate with cash and gifts can be difficult and is often limited by available funding. Indeed some funding agencies will not allow research money to be used to pay study participants. In my experience, many participants will refuse the offered gift, but most appreciate the respect that is implicit in the offer.

Communities as Research Collaborators

There is a growing number of ecological publications that actively involve LEK and this is providing important success stories that encourage other ecologists to embrace LEK. However, the nature of local knowledge research that includes humans as research subjects requires a careful consideration of the political implications of the entire research process. Indeed, some communities and individuals have become frustrated with researchers documenting and applying their knowledge inappropriately and some are reluctant to participate in LEK studies, especially if there are no tangible benefits associated with the research outcomes (Nadasdy 1999). In order to document LEK meaningfully, it requires a considerable investment by scientists working collaboratively with communities, including repeat visits to discuss study design, data collection, and to synthesize and share results (Brook *et al.* 2006). My analysis of the literature suggests that few communities were meaningfully consulted with respect to the research. This, in turn, raises questions about how appropriate the resulting depictions of LEK are and indeed, leads to concerns regarding intellectual property rights and the ownership and control of the resulting data (Brush 1993, Simpson 2001b).

My analysis also revealed that many LEK publications lack a detailed methodology (Figure 3.3). As a result, participants could not be characterized (occupation, gender, and age) for more than one third of all studies examined. Only 11% of the empirical papers explicitly recognized or discussed a spiritual component to the local knowledge in the study since they generally focused on the more practical aspects of LEK. LEK studies involved a wide range of participants and their livelihoods, but most relied on farmers and hunters (Figure 3.4).

Power and knowledge

Are there limitations to LEK? It is impossible to address this question without first considering the power relationship between Science, scientists, and most resource-dependent communities. Some ecologists have argued that documentation of LEK should be verified by expert scientists using their ecological field data (e.g. Gilchrist *et al.* 2005). I agree that if LEK information is to be accepted by the scientific community, it needs to be collected and validated using a rigorous approach. However, assuming that the scientific data are 'truth' to be used to test LEK is a poor approach in that it assumes the scientific data to be absent of biases or limitations (Brook and McLachlan 2005). At the same time, it creates a power imbalance whereby the scientific data take a dominant role. I have suggested that perhaps it is more appropriate to use LEK and scientific data to evaluate each other and assess the differences that exist. Since the two ways of viewing the same world are based on unique perspectives, differences between them that may initially appear to be errors in LEK or the scientific data may actually represent issues of spatial or temporal scale. It is also valuable to include the knowledge holders themselves in any analysis of the limitations of their LEK (Brook and McLachlan 2005). For example, one group of cattle farmers that I worked with felt that the area they were most knowledgeable about was between 50-100 km^2 in size, while Aboriginal hunters in another region indicated their area of knowledge was between 8,000-13,000 km^2.

Case Study: Farmer knowledge in Rural Canada

Despite the widespread distribution of millions of farmers throughout Canada, and indeed much of North America, and their intimate relationship with their land, there have been a surprisingly small number of studies that incorporate their ecological knowledge. More than 25%

of LEK studies that I examined relied on farmers (Figure 3.4), but only four were from North America and none of these were located in Canada. Farms in the US and Canada are currently much larger than ever before and continue to grow and incorporate novel technology. These advances significantly shape farmer relationships with their land and the nature of their observations (Mauro and McLachlan accepted). Replacement of small family farms with large-scale industrial farms is changing, and perhaps eroding, decades of accumulated farmer knowledge, this aggravated by the loss of farmers from the landscape (Mauro *et al.* 2005).

My on-going research in rural Manitoba, Canada represents one of few studies incorporating farmer knowledge within North America. The accumulated experience of farmers observing elk (Brook and McLachlan 2006) and wolves (Stronen *et al.* 2007) on their land contributes meaningfully to ecological research and natural resource management. My research partners have contributed rich observations of wildlife movements, behaviours, and reproductive activities. At the same time, they have also shared their understanding of long-term spatiotemporal dynamics across the landscape and in wildlife populations, spanning over 125 years. In contrast, the aerial ungulate surveys flown in the winter are the longest continuous ecological monitoring program in the region, yet they only occur 75% of the time and only during a period of three weeks in the winter over the last 45 years.

Farmers that I interviewed all had strong connections to the land, often spanning more than four generations and were able to relate detailed observations of wildlife movements and behaviour. Perhaps most importantly, farmers also discussed their attitudes, providing the rich context from which these observations were obtained (Brook and McLachlan 2003). Throughout, I have maintained that the research *process* is as important as the outcomes themselves and have emphasized the importance of maintaining trust-based relationships with the farming communities I work in.

Future directions

There is an increasing number of ecologists actively employing LEK and working collaboratively with communities, which helps accumulate a critical mass of evidence for and support of the value of this knowledge (Kimmerer 2002, Berkes 2004). However, there remains a further need for research that applies local knowledge to ecological problems (Bart 2006). There is also an ongoing need for studies incorporating LEK to be systematically evaluated to ensure that they are theoretically and ethically sound, and, further, that they have met the expectations of local communities. More detailed documentation of the methods used is needed in published LEK papers and more meaningful collaboration with communities, including acknowledgement of their contribution in publications and compensation where appropriate.

Although the recently published LEK-based studies represent important first steps, they typically fail to obtain input from the community on study design or feedback on results. Experience-based knowledge needs to be treated differently from other data, such that the knowledge remains the property of the participants in the research (Brook and McLachlan 2005). Finally, and perhaps most significantly, the spiritual and political aspects of local knowledge were not included in most of the studies I examined. The most effective way to optimize the LEK research process is to meaningfully involve resource-dependent communities throughout the entire study in order to better and more explicitly reflect their concerns and, ultimately, their true expertise (Uriarte *et al.* 2007). As suggested by Stevenson (1998), we need to begin thinking of LEK not so much as a commodity but as a process to be developed and nurtured.

Literature Cited

Agrawal, A. 1995. Indigenous and scientific knowledge: some critical comments. Indigenous Knowledge Develop Monitor 3(3):3-6.

Assembly of Fist Nations, National Aboriginal Forestry Association. 1995. The feasibility of representing Traditional Indigenous Knowledge in cartographic, pictorial or textual forms. Ottawa, Canada.

Bart, D. 2006. Integrating local ecological knowledge and manipulative experiments to find the causes of environmental change. Frontiers in Ecology and Environment 4:541-546.

Benedict, S. M. 1996. The Naturalized Knowledge Systems of Indigenous communities. IDRC Reports. Ottawa: International Development Research Centre. (28 March 2006, ww.idrc.ca/books/reports/1996/06-01e.html).

Bergstrom C. T. and T. C. Bergstrom. 2006. The economics of ecology journals. Frontiers in Ecology and Environment 4:488-495.

Berkes, F. and T. Henley 1997. Co-management and traditional knowledge: Threat or opportunity? Policy Options 18:29–31.

Berkes F. 1999. Sacred Ecology – Traditional Ecological Knowledge and Management Systems. Philadelphia: Taylor and Frances.

Berkes F, J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251–1262.

Berkes, F. 2004. Rethinking community-based conservation. Conservation Biology 18:621-630.

Berkes, F. 2005. The scientist as facilitator or adaptive co-manager? Common Property Resource Digest No. 75:4-5.

Boas F. 1888. The Central Eskimo. Sixth Annual Report of the Bureau of American Ethnology for the Years 1884-1885. Washington: Bureau of American Ethnology.

Brook, R. K. and S. M. McLachlan. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. (12 May 2005, http://umanitoba.ca/environment/ecl/)

Brook, R. K. and S. M. McLachlan. 2005. On using expert-based science to "test" local knowledge. Ecology and Society 10:r3. (14 June 2006; www.ecologyandsociety.org/vol10/iss2/resp3/).

Brook, R. K., M. M'Lot, and S. M. McLachlan. 2006. Pitfalls to avoid when linking Traditional and scientific knowledge. Pages 13-20 in R. Riewe and J. Oakes, eds. Climate Change: Linking Traditional and Scientific Knowledge. Winnipeg: Aboriginal Issues Press.

Brook, R. K. and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 80:156-166.

Brush, S. B. 1993. Indigenous knowledge of biological resources and intellectual property rights: The role of anthropology. American Anthropologist 95:653-671.

Davis, A. and J. Wagner. 2003. Who knows? On the importance of identifying "experts" when researching local ecological knowledge. Human Ecology 31:463–489.

Duerden, F. and R. G. Kuhn. 1998. Scale, context, and application of traditional knowledge of the Canadian north. Polar Record 34:31-38.

Ellen, R. and H. Harris. 1999. Embeddedness of indigenous environmental knowledge. Indigenous knowledge at home in the West. Pages 180-185 in Posey DA, ed. Cultural and spiritual values of biodiversity. London: United Nations Environment Programme.

Ferguson, M. A. D., R. G. Williamson, and F. Messier. 1998. Inuit knowledge of long-term changes in a population of Arctic tundra caribou. Arctic 51:201–219.

Fishbein, M., and M. J. Manfredo. 1992. A theory of behavior change. In M. J. Manfredo (Ed.), Influencing human behavior: Theory and applications in recreation, tourism, and natural resources management pp. 29–50. Sagamore Publishing, Champaign, Illinois.

Gilchrist, G., M. Mallory, and F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. Ecology and Society 10:20. (15 August 2006, www.ecologyandsociety.org/vol10/iss1/art20/).

Hobson, G. 1993. Traditional knowledge is science. Northern Perspectives 20:2-3.

Howard, A., and F. Widdowson. 1996. Traditional knowledge threatens environmental assessment. Policy Options 17:34–36.

Huntington, H. P. 2000. Using traditional ecological knowledge in science: Methods and applications. Ecological Applications 10:1270-1274.

Johannes, R. E. 1993. Integrating traditional ecological knowledge and management with environmental impact assessment. Pages 33-41 in J. T. Inglis, ed. Traditional Ecological Knowledge: concepts and cases. Ottawa: Canadian Museum of Nature.

Kendrick, A., P. O'B. Lyver, and Lutsel K'E Dene First Nation. 2005. Denesoline (Chipewayan) knowledge of barren-ground caribou (*Rangifer tarandus groenlandicus*) movements. Arctic 58:175-191.

Kimmerer, R.W. 2002. Weaving Traditional Ecological Knowledge into biological education: A call to action. Bioscience 52:432-438.

Kothari B. 2002. Theoretical streams in marginalized peoples' knowledge(s): Systems, asystems, and subaltern knowledge(s). Agriculture and Human Values 19:225-237.

Manfredo, M. J. and A. A. Dayer. 2004. Concepts for exploring the social aspects of human-wildlife conflict in a global context. Human Dimensions of Wildlife 9:317-328.

Mauro, I and S. M. McLachlan. Farmer experiences and attitudes toward risks associated with genetically modified crops, in Manitoba, Canada. Agriculture and Human Values; Accepted.

Mauro I, S. M. McLachlan, and J. Sanders. 2005 Seeds of change: Farmers, biotechnology, and the new face of agriculture. (21 September, 2006 http://seedsofchangefilm.org)

McGregor, D. 2000. The state of traditional ecological knowledge research in Canada: a critique of current theory and practice. Pages 436-458 in R. Laliberte, P. Settee, J. Waldram, R. Innes, B. Macdougall, L. McBain, and F. Barron, eds. Expressions in Canadian native studies. Saskatoon: University of Saskatchewan Extension Press.

Nadasdy, P. 1999. The politics of TEK: power and the "integration" of knowledge. Arctic Anthropology 36:1-18.

Obua, J. and G. Muhanguzi. 1998. Farmers' knowledge of indigenous tree cultivation around Bwindi Impenetrable Forest National Park, Uganda. Indigenous Knowledge Monitor 6(2):11-13.

Popescu, I. I. 2003. Science journal ranking by average impact factors, version 2003. (12 April 2006; www.geocities.com/iipopescu).

Posey., D. A. and G. Dutfield. 1996. Beyond intellectual property: Toward traditional resource rightes for Indigenous Peoples and local communities. International Development Research Centre, Ottawa, Ontario, Canada.

Prichard A. 1969. Statistical bibliography or bibliometrics. Journal of Documentation 25:348-349.

Shiva, V. 1997. Western science and its destruction of local knowledge. Pages 161-167 in Rahnema, M and Bawtree V, eds. The post-development reader. New Jersey: Zed Books.

Simpson, L. 2001a. Traditional Ecological Knowledge: marginalization, appropriation and continued disillusion. (12 March 2004; www.snowchange.org/views/indigenous/leanne_trad_en.html)

Simpson, L. 2001b. Listening to our ancestors: rebuilding Aboriginal Nations in the face of environmental destruction. (12 March 2004; http://www.snowchange.org/snowchange/content/view/29/2/)

Simpson, L. 2004. Anticolonial strategies for the recovery and maintenance of Indigenous Knowledge. American Indian Quarterly 28:373-384.

Stevenson, M. G. 1997. Ignorance and prejudice threaten environmental assessment. Policy Options 18:25-28.

Stevenson, M. G. 1998. Traditional Knowledge and Environmental Management: From Commodity to Process. Sustainable Forest Management Network Working Paper 1998-14. (17 November 2006; http://sfmnetwork.ca/docs/e/WP_1998-14.pdf)

Stronen, A., R. K. Brook, P. C. Paquet, and S. M. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Sutherland, W. J. 1999. What do impact factors tell us? Trends in Ecology and Evolution 14:382-385.

Tesh, S. N. 2000. Uncertain hazards: Environmental activists and scientific proof. Ithaca: Cornell University Press.

Thomson Corporation. 2006. Biological abstracts. (22 June 2006; www.isinet.com)

Turner, N. J., M. B. Ignace, and R. Ignace. 2000. Traditional ecological knowledge and wisdom of Aboriginal peoples in British Columbia. Ecological Applications 10:1275-1287.

United States National Committee for the International Union of the History and Philosophy of Science. 2001. USNC/IUHPS Position Paper on Science and Indigenous Knowledge. (4 May 2002; www7.nationalacademies.org/usnc-iuhps/Indigenous_Knowledge.html)

Uriarte, M., H. A. Ewing, V. T. Eviner, and K. C. Weathers. 2007. Constructing a broader and more inclusive value system in science. Bioscience 57:71-78.

Widdowson, F. and A. Howard. 2002. The Aboriginal industry's new clothes. Policy Options 23:30-34.

Table 3.1. Terms used to describe experience-based local ecological knowledge.

Term	Citation
Traditional Ecological Knowledge (TEK)	Berkes *et al.* 2000
Indigenous Knowledge (IK)/Indigenous Knowledge Systems (IKS)	Berkes 1999
Local Ecological Knowledge (LEK)	Davis and Wagner 2003
Naturalized Knowledge (NK)	Benedict 1996
Marginalized Peoples' Knowledge (NPK)	Kothari 1999
Subaltern Knowledge (SK)	Kothari 1999
Rural Peoples' Knowledge (RPK)	Kothari 1999
Farmer Knowledge (FK)	Obua and Muhanguzi 1998
Folk Knowledge	Berkes 1999

Table 3.2. Methods of documenting local knowledge.

Focus Group Interviews	Information is obtained from small groups of participants, allowing for meaningful interactive and exploratory discussions over a short period, but may allow dominant participants to influence others.
Journal	Study participants are given a journal to record observations and personal insights. The results are very detailed and may be more accurate than asking participants to recall observations months after they occur, but require a great commitment on the part of participants.
Mail Survey	Questionnaires are sent and returned by mail, providing a low cost approach that allows participants to complete the survey at their own pace, though it provides little opportunity for dialogue, must be kept short, and often suffer from low response.
Participant observation	The researcher spends months actively working with the participants as they practice their livelihoods, providing insights that could not otherwise be experienced, but this approach blurs the distinction between the researchers and the researched and so has been criticized as being unethical.
Personal Interviews	Participants meet in person with the researcher. Although this approach may provide rich and highly detailed information, it requires considerable time and resources.
Telephone Survey	Interviews conducted over the telephone are typically shorter than in-person interviews. They are convenient and cheap, especially in remote areas and for large-scale research, but they are short and often have frequent refusals.
Transect Walk	Participants walk through an area to observe and document the similarities and differences of socioeconomic and biophysical features. This often requires considerable time and cost but can elicit highly detailed and accurate responses.
Video	Interviews are videotaped as a unique source of qualitative data that includes the body language and inflection of each participant. Footage can also be used to communicate research results effectively in ways that are easily absorbed and effectively convey the tone and intent of the participant.

Table 3.3. Overall use of experience-based local knowledge in twelve ecological journals covering a 25 year span from 1980-2004.

Journal	Year of Origin	Number of Articles using Local Knowledge	% of Total	Journal Impact Factor (after ISI 2005 and Popescu 2003)
Theoretical				
Canadian Journal of Zoology	1929	1	0.0%	1.06
Canadian Journal of Botany	1929	2	0.0%	1.19
Ecological Monographs	1931	0	0.0%	5.02
Ecology	1920	0	0.0%	4.10
Mean	*1927*	*0.8*	*0.00%*	*2.84*
Interdisciplinary				
Agriculture, Ecosystems and Environment[a]	1974	48	0.9%	1.50
Trends In Ecology and Evolution	1986	2	0.1%	12.94
Ecology and Society[b]	1997	18	8.6%	1.72
Arctic	1948	41	7.7%	0.67
Mean	*1976*	*27.3*	*4.33%*	*4.21*
Applied				
Canadian Journal of Fisheries and Aquatic Sciences	1901	3	0.1%	1.97
Canadian Journal of Forest Research	1971	0	0.0%	1.45
Conservation Biology	1987	35	5.1%	3.67
Ecological Applications	1991	23	1.2%	3.29
Mean	*1963*	*15.3*	*1.60%*	*2.60*

[a]Formerly Agro-Ecosystems (1974 to 1983)
[b]Formerly Conservation Ecology (1997 to 2000)

Table 3.4. Use of local knowledge in twelve ecological journals in five year blocks covering a 25 year span from 1980-2004.

	PERIOD				
JOURNAL	**1980-1984**	**1985-1989**	**1990-1994**	**1995-1999**	**2000-2004**
Theoretical					
Canadian Journal of Zoology	0.0%	0.0%	0.0%	0.0%	0.1%
Canadian Journal of Botany	0.0%	0.0%	0.0%	0.1%	0.1%
Ecological Monographs	0.0%	0.0%	0.0%	0.0%	0.0%
Ecology	0.0%	0.0%	0.0%	0.0%	0.0%
Mean	*0.00%*	*0.00%*	*0.00%*	*0.03%*	*0.05%*
Interdisciplinary					
Ag., Ecosystems and Env.[a]	0.20%	0.0%	0.4%	1.7%	2.3%
Trends In Ecology and Evolution	-	0.0%	0.0%	0.2%	0.2%
Ecology and Society[b]	0.0%	0.0%	0.0%	5.0%	10.1%
Arctic	0.0%	3.6%	9.1%	14.0%	8.6%
Mean	*0.17%*	*0.20%*	*0.94%*	*2.30%*	*2.87%*
Applied					
Can J of Fish and Aquatic Sci.	0.0%	0.0%	0.0%	0.0%	0.3%
Can J Forest Research	0.0%	0.0%	0.0%	0.0%	0.0%
Conservation Biology	-	1.8%	3.2%	3.7%	10.5%
Ecological Applications	-	-	0.0%	0.7%	2.4%
Mean	0.00%	0.09%	0.21%	0.39%	1.33%

[a]Formerly Agro-Ecosystems (1974 to 1983)
[b]Formerly Conservation Ecology (1997 to 2000)

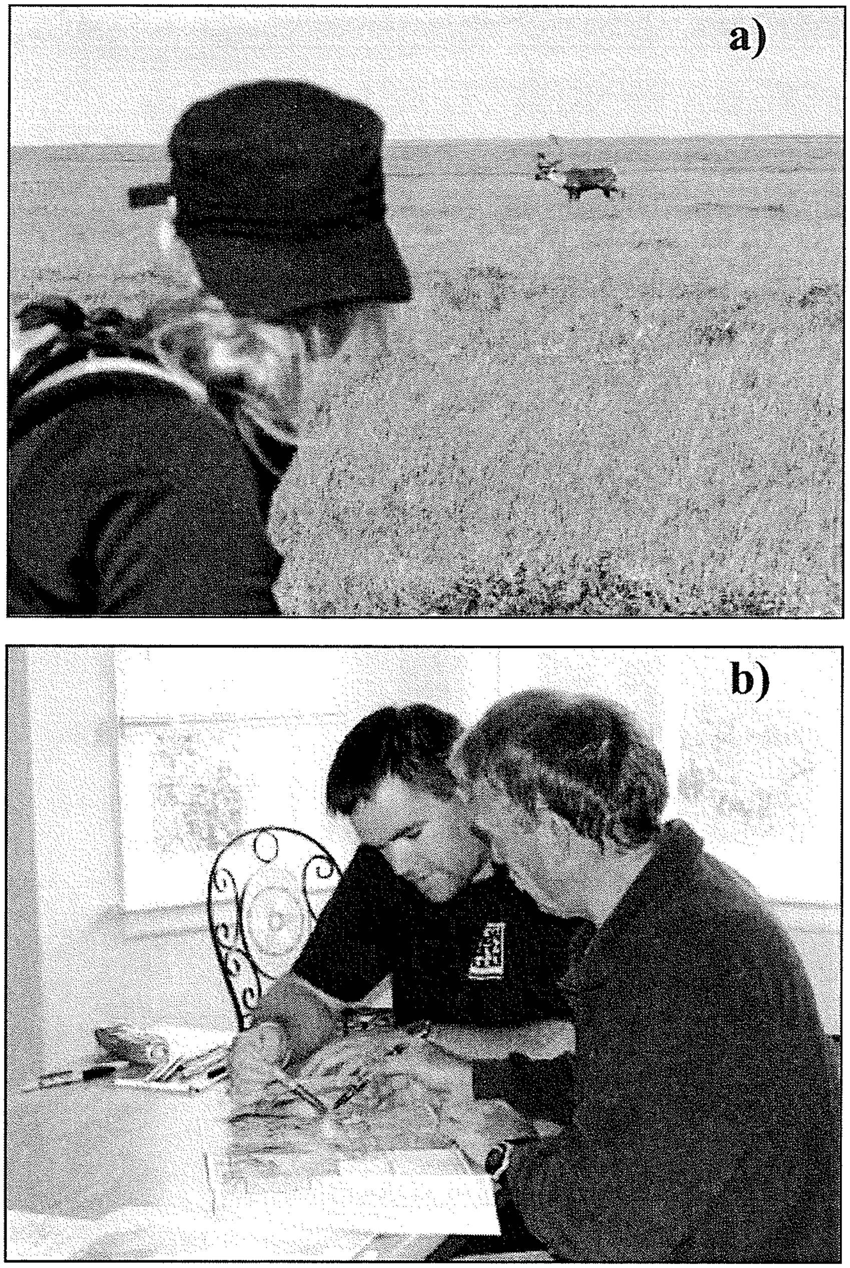


Figure 3.1. Local knowledge is particularly rich for species like caribou that are highly visible and have considerable cultural and economic importance (a). Ryan Brook conducts a participatory mapping interview with park warden Gordon Pylipuik near Riding Mountain National Park in 2005 (b).

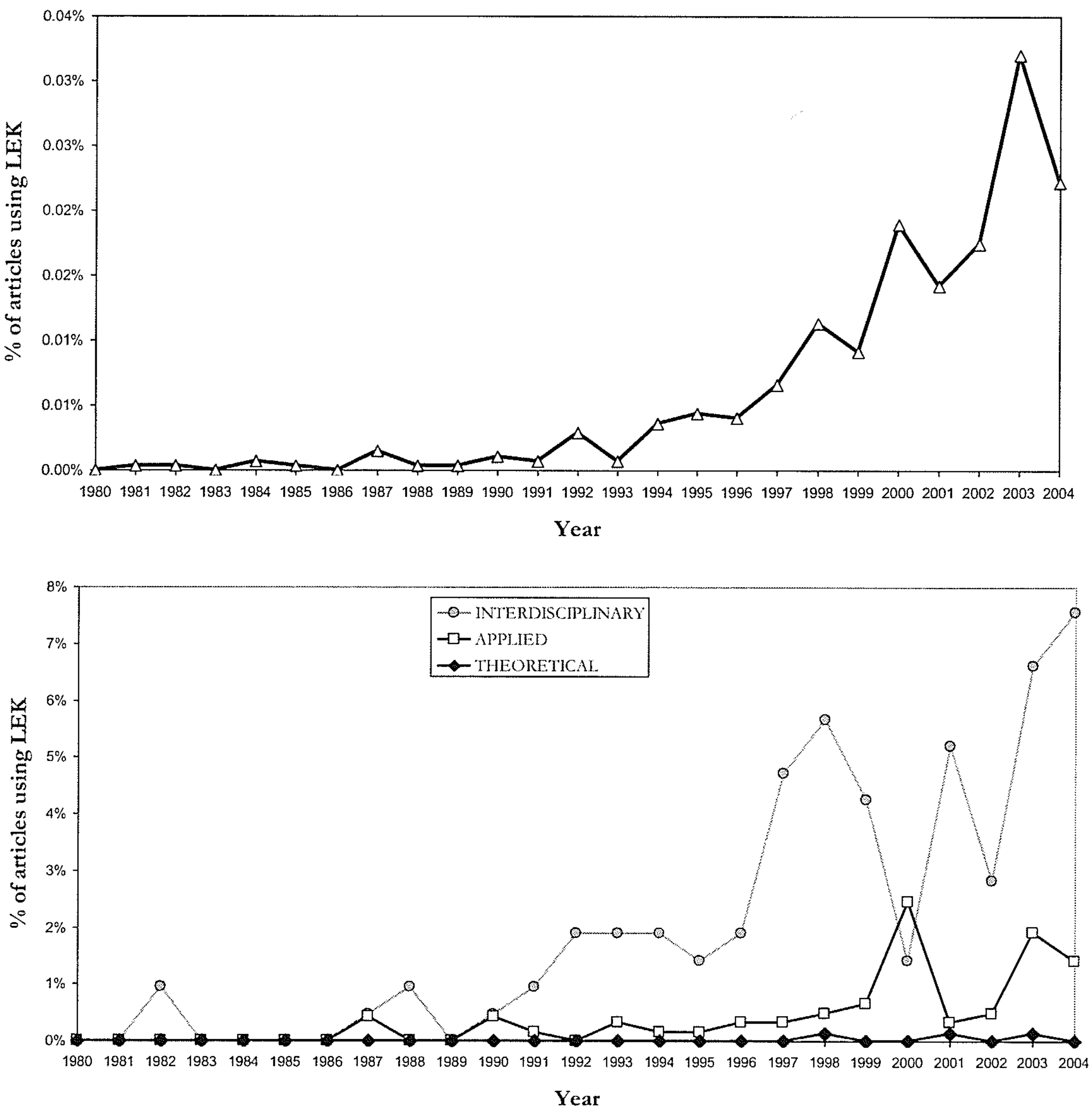


Figure 3.2. Changes in publications using TEK over the last 25 years. a) Percentage of articles in the Biological Abstracts database per year using experience-based local knowledge from 1980 to 2004; b) and percentage of the 40,900 articles in the four theoretical, four applied, and four interdisciplinary journals examined in detail that used LEK.

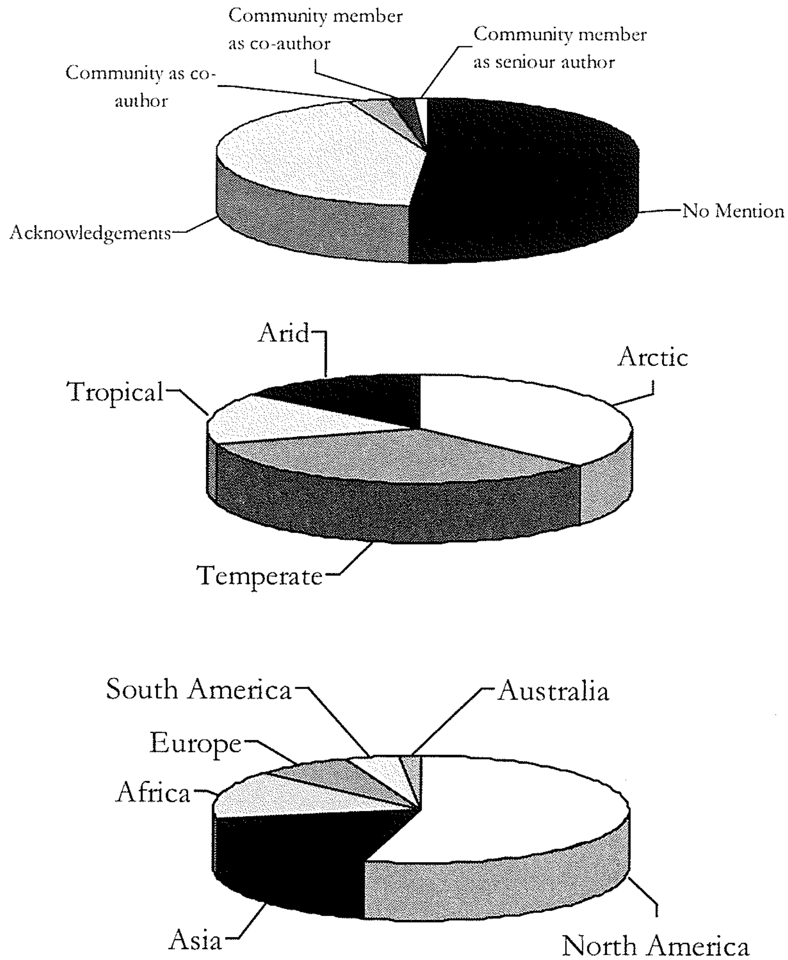


Figure 3.3. Ways that LEK is acknowledged (a) in the ecological literature. Spatial distribution of studies incorporating local ecological knowledge by biome (b) and continent (c).

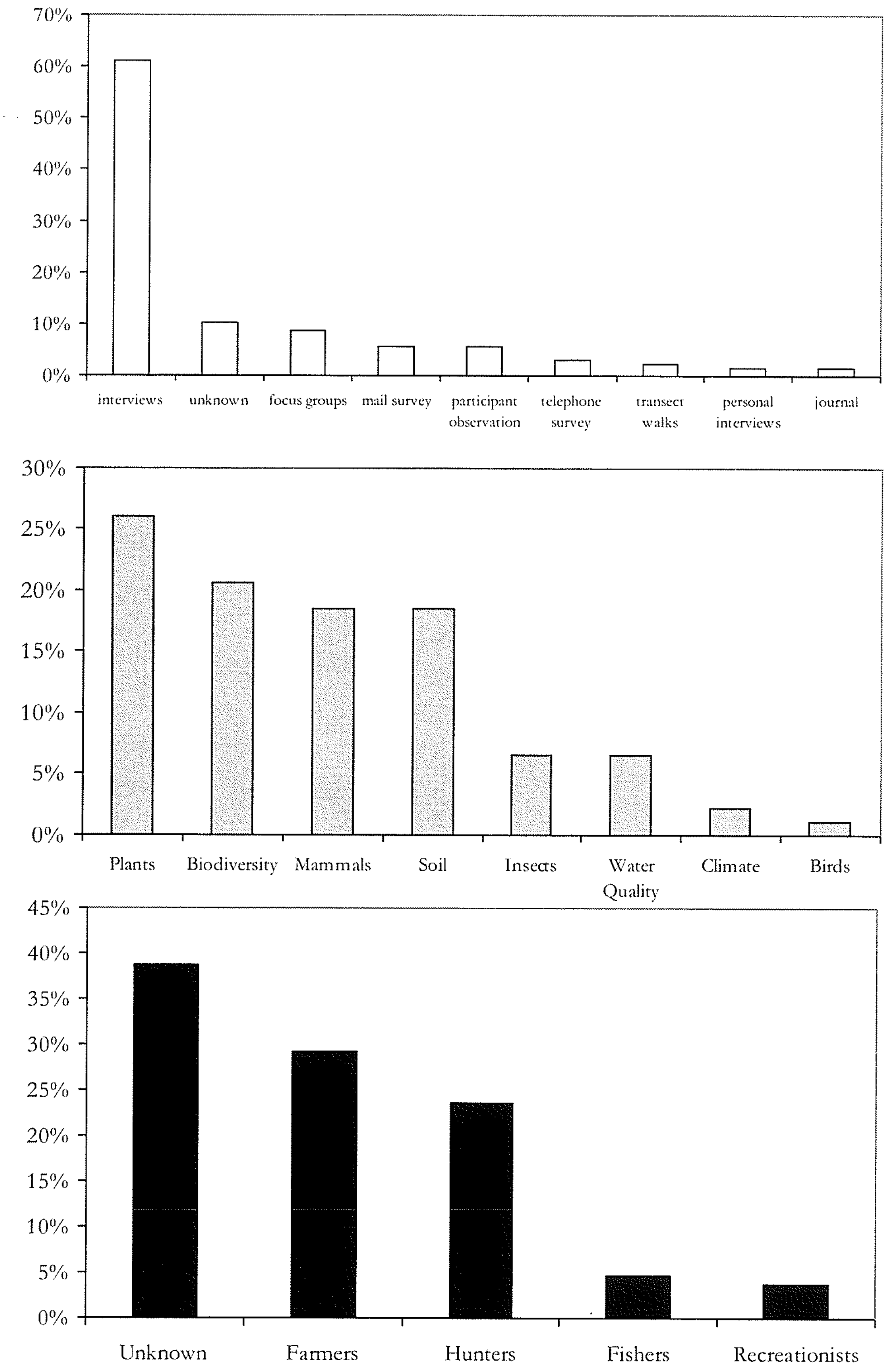


Figure 3.4. Use of different approaches to documenting local ecological knowledge (a); focus of each study (b); and the occupation of study participants (c).

CHAPTER 4

AN HISTORICAL REVIEW OF ELK-AGRICULTURE CONFLICTS IN AND AROUND RIDING MOUNTAIN NATIONAL PARK, MANITOBA, CANADA

"Elk migrated out of the park in 1957 and headed way south. They came right past the farm, going through the field. A big bunch went north to the Duck Mountains too. There were no elk in the Duck Mountains in the 1940's and there were none until those from the Riding Mountain moved up there. They got so damn thick there wasn't room for them all." --Alec Cleland, Riding Mountain Resident since 1911

[1]This chapter is currently 'in review' with the journal Human-Wildlife Conflict and I am the sole author. This chapter has been reformatted slightly from the manuscript here to fit the design of this thesis.

Chapter Summary

Conflicts between elk and farmers have been occurring since agriculture began around what is now Riding Mountain National Park (RMNP) in the 1880s. Initially, the conflicts were related to critically low elk numbers in response to unprotected wildlife populations in the early 20th century. Protection of the Riding Mountain, first as a Dominion Forest Reserve and then as a national park, allowed elk numbers to reach critically high numbers in subsequent years. Since the creation of RMNP in 1930, elk have been documented on surrounding agricultural lands every year and have been associated with considerable damage to fences, standing crops, and stored hay bales, with damage often exceeding $240,000 in damage claims per year. Managing hunting on agricultural lands has been the most commonly used approach to mitigating elk impacts despite the limited successes achieved using this approach. A compensation program was created in 1997, which reimburses up to 80% of the value of any confirmed elk damage. Conflicts associated with elk-agriculture interaction accelerated to a new level, beginning in 1992 with the finding of a hunter killed bovine tuberculosis positive elk in close proximity to infected cattle herds. This has been widely assumed to be evidence that elk were transmitting the disease to cattle herds and causing considerable economic hardship. The disease and damage impacts by elk have resulted in concerns and regular suggestions by some farmers that the elk herd should be eradicated or fenced within the confines of RMNP. However, attitudes toward elk remain largely positive and farmers obtain important economic and non-economic benefits from the elk population. The most severe disputes in the region have been human-human conflicts related to managing the elk and problems that they can cause. Conflicts between farmers and government have been occurring regularly since the early 20th century and have often been characterized by heated debates, poor or non-existent communication and until recently, limited attempts to mitigate the impacts of elk. All of the elk management responses to date have been in reaction to a crisis and there was no evidence of proactive management to address emerging conflicts. Future programs to address these conflicts should focus on collaboration and communication to develop mutually acceptable long-term solutions that are regularly evaluated using both local knowledge and scientific study.

Introduction

Conflicts between wildlife and agriculture are commonplace globally and have important implications for conservation in and around protected areas and influence agricultural economic sustainability (Schonewald-Cox *et al.* 1992, Western *et al.* 1994). Protected areas are largely focused on conservation of wildlife and native habitats, while agricultural lands are working landscapes that have been transformed into crop monocultures and grazing lands interspersed with fragments of native vegetation (Herkert 1994). Farmers living along the borders of protected areas must consider the economic decisions of agricultural production with conservation priorities and thus have a primary influence on conservation outside of protected areas.

Support from farmers for conservation initiatives will ultimately be influenced by the struggle between the economic costs and benefits for farmers living near protected areas, but also the nature of the emotional connection that they have formed (Badola 1998, Jacobson *et al.* 2003). While considerable research has focused on documenting the direct costs of wildlife impacts on agriculture and developing economic incentives for conservation (Western *et al.* 1994, Nyhus *et al.* 2003), much less work has examined the broader social impacts (Fortin and Gagnon 1999). These conflicts are complex in nature due to the synergistic effects of diverse attitudes and socio-economic status of individual farmers combined with characteristically high levels of spatial and temporal variability in occurrence.

Elk-agriculture conflicts around Riding Mountain National Park (RMNP) in southern Manitoba, Canada provide a valuable case study where intensive disputes have been occurring since before the Park was created. RMNP is a core area of deciduous and coniferous native forest and grassland within an agricultural matrix, such that it is often referred to as an "an ecological island in a sea of agriculture" (Bailey 1968, Parks Canada 1987). Indeed, the RMNP boundary is now clearly visible in satellite imagery contrasting sharply with surrounding agriculture right to the edge and this picture is frequently used as an extreme example of an isolated protected area (Noss 1995). This wilderness area and the surrounding agricultural lands support a large population of wild elk (*Cervus elaphus*) which move across the boundary frequently. The elk cause considerable economic losses in the form of hay, crop, and fence damage (Schroeder 1981, Brook and McLachlan 2003) and may be implicated in the spread of bovine tuberculosis to cattle herds (Brook and McLachlan 2006).

Conflicts related to the presence and management of bovine tuberculosis are some of the most intense ever occurring in the region in the last decade and perhaps even the last century (Schroeder 1981, Brook and McLachlan 2006). While considerable efforts have been made to mitigate the biophysical aspects of disease risk, farmers have expressed considerable frustration with the process despite apparent successes in managing the disease. Preliminary research has suggested that an important aspect of this conflict is driven by historical changes in land use and protected areas management, and current conflicts are influenced in important ways by past issues related to elk-agriculture interactions (Brook and McLachlan 2003).

The objective of this study was to characterize conflicts between farmers and elk around Riding Mountain National Park over the last 127 years to understand better the social and biophysical context of current conflicts. This examination also provides important broader insights into the complex relationship between farmers and the National Park itself and other resulting human-human conflicts. At the same time, farmers have a considerable impact on the long-term survival of large mammals such as elk in RMNP since they control the vast majority of land outside of the core protected area, and thus strongly influence the long-term survival of wildlife within the Park. As such, these experiences have much to contribute to other regions with agricultural lands adjacent to a protected area, as a long-term case study to learn from past successes and errors, while highlighting the interconnected nature of diverse conflicts. These analyses are part of a comprehensive study examining wildlife-agriculture interactions around Riding Mountain National Park.

Methods

A longitudinal analysis of historical information regarding elk-agriculture conflicts was conducted using information collected from a wide range of sources including published and unpublished works, provincial hunter questionnaires, provincial and federal letter files, and field reports obtained from a detailed search of federal and provincial libraries. Long-term observations were obtained from farmers around RMNP using a regional mail survey in 2002 (Brook and McLachlan 2003, Brook and McLachlan 2006, Stronen *et al.* 2007) to obtain qualitative observation; semi-directive interviews with 81 knowledgeable long-term residents; and attendance at a series of eleven town-hall meetings regarding current elk-agriculture conflicts from 2002-2007. Long-term changes in regional and farm-scale management strategies and protected area status were also characterized as important context and drivers of conflict. Direct quotes from all data sources were included as an important element of the context and tone of these conflicts (Kreswell 1998). All aspects of community participation through the mail survey and interviews have been approved under the authorization of the Joint-Faculty Human Subject Research Ethics Board Protocol #J2002:043 at the University of Manitoba.

Results

Diverse types of conflicts were identified within the study area (Figure 4.1) over the entire 127-year period of agriculture in the Riding Mountain region (Figure 4.2). These represent distinct periods of development (pre-agriculture, early agriculture, protected area with resource use and extraction, and protected area with conservation status).

Pre-Agriculture

Prior to the arrival of European settlers in the 1880s, archaeological evidence and historical records from the 18th and 19th centuries indicate that elk were common on the mixed aspen/grasslands around what is now RMNP (Green 1933, Jamieson 1974, Parker 1978, Peckett 1999). Elk were culturally important to Cree, Assiniboine, and Ojibwa groups in the region and provided an important source of meat and hides (Green 1933) and local aboriginal people made regular trips into the Riding Mountains to hunt (Peckett 1999). Faunal remains of two elk were located at a pre-historic Assiniboine-Cree campsite in the region occupied between 1000 and 1750 A.D. (Jamieson 1974). The area continued to be used regularly by Cree, Sioux and Ojibwa hunters who provided meat and furs to nearby Hudson's Bay Company posts 1741 to 1880 (Atwood 1970, Tabulenas 1983). Throughout this pre-agricultural period, elk were regarded as an important food and fur source for local people and no conflicts with humans were documented.

Agriculture Development and the Decline of the Elk Population

The flat plains surrounding what is now RMNP were settled extensively during the late 19th and early 20th centuries and large areas of native grassland were converted to farmland (Carlyle 1996). After the rail line reached Brandon in 1881, settlers from Eastern Canada, Europe and the U.S.A. began settling in large numbers (Lehr 1996). By 1904, much of the available land had been purchased, though the forest cover was largely intact until after 1925 (Goldrup 1992, Lehr 1996).

As agriculture began to develop in the latter part of the 19thcentury, the elevated escarpment that is now RMNP was used extensively by elk, particularly during the summer months (Green 1933). It was widely believed by local farmers that elk moved out of the Riding Mountain in large numbers when snow accumulated to high levels (Green 1933). Before 1896, there were few limitations on human activities such as logging, haying, or hunting. Farmers around the Riding Mountain had reported that elk were "plentiful" in those early years (Green 1933), but the population declined in response to unregulated harvest (deVos 1965). The Riding Mountain Timber Reserve was established in 1895 to conserve the remaining forests and wildlife in the region from human settlement (Dickson 1909). This area was then designated as Riding Mountain Dominion Forest Reserve in 1906, but remained under federal jurisdiction. Along with protection from development, forest management and fire protection services were provided (Evans 1923). Forestry Service staff could not interfere with hunting activities except to report abuses (Tabulenas 1983). Although elk harvest was banned until 1900, this did not result in substantive changes to hunting practices (Tabulenas 1983) and it was becoming evident that elk were becoming scarcer. Turner (1906) made an urgent call to save what was left of the elk population:

> *It was plentiful in southern Manitoba, but with the exception of an occasional straggler, it is seldom seen there now. Each year its range shrinks before the advance of settlement, and the constantly increasing number of hunters who pursue it... In its wilder and more inaccessible range of the Riding and Duck Mountains it is reported to be still fairly plentiful, but I have recently been informed that it is steadily decreasing in numbers... In the Riding Mountains district lies an extensive tract of wild country splendidly adapted for the wapiti [elk]. It is practically useless for settlement, and barring some lumbering it will never be of value to the province except as a large and magnificent game and timber preserve.*

Creation of a Protected Area

Establishment of a game reserve in the area after 1907 provided some protection for the elk from over-harvest. It covered approximately nine townships in the south-central portion of the Forest Reserve and hunting was prohibited, but the remaining area was open to provincially regulated elk harvest (Tabulenas 1983). The total effects of sport, subsistence, and illegal harvest combined with normal winter mortalities was that the Riding Mountain elk population was reduced from thousands to an estimated 500 animals by 1914. In 1918, the size of the Forest Reserve was reduced when land was removed from the northwest and southern edges of the reserve to provide a reward for soldiers returning from World War I (Tyman 1972). The Manitoba provincial government prohibited hunting of elk in the entire region between 1917 and 1933, with only one very limited season allowed during this period (Green 1933). During this time, it was an offence to be in possession of elk meat anywhere in Manitoba but despite these regulations, poaching remained a relatively common practice (Hewitt 1921). Conflicts between farmers and government enforcement personnel occurred frequently over elk hunting issues. Farmers argued that they had unregulated access to the elk for decades and they needed to feed their families despite the clear decline in elk. The Riding Mountain elk population rose quickly under this at least partial protection to approximately 2000 animals in 1925 (Rounds 1977). Farmers that were interviewed often observed that local young men leaving for World War I and II resulted in a sharp decline in elk hunting and this was partially responsible for the elk recovery.

Further protection for the elk was provided by the establishment of RMNP in 1930, though the park was 26% smaller than the original Forest Reserve. The elk population continued to increase from 2500 in 1925 to 3500 animals in 1933 (Green 1922, Rounds 1977) and then rose sharply to approximately 7000 animals in 1941 (Banfield 1949), and reached a record high estimate of 16,800 in 1946 (Banfield 1949).
Populations during the growth period were estimated to be 2,500 in 1925, 3,500 in 1933 (Green 1933), and 5,000 to 7,000 in 1941 (Banfield 1949).

Conditions around the park were changing as well. During this period, the human population more than tripled from approximately 15,000 at the turn of the century to 47,000 by the late 1940s (Stadel 1996). Farming gradually became increasingly mechanized.

Following the Second World War, the introduction of the bulldozer drastically increased the rate of forest clearing (Bird 1961). Extensive areas of forest cover were removed, leaving small forest patches along rivers and wetlands and on unproductive land (Bird 1961, Stadel 1996). The elk population appears to have peaked in the 1940s and decreased to 4700 by 1949 in response to declining habitat condition within the Park (Colls 1950). More than half of all farmers interviewed indicated that harvesting elk illegally during the winter months within RMNP was common practice during this period. Many park wardens condoned this practice providing they only took a single animal and used it for personal consumption. The elk population then fluctuated between 2000-6000 animals from 1963 onward, likely in response to changing habitat, predator numbers, as well as hunting effort and success (Figure 4.3).

Agricultural Activities within RMNP

Cattle grazing was allowed within what is now RMNP from 1895 until 1970, with over 4500 head in some years, using approximately 15% of the park area in the 1950s and 1960s (Figure 4.4) (Blood 1966, Dushinsky 1981). Four hundred seventy three (473) cattle were grazed in the reserve in 1914-1915 and the number of cattle peaked in 1919-1920 when 4628 head were present. Indeed cattle grazing was strongly encouraged to reduce the fire hazard (Dushinsky 1981). Cattle grazing led to the deterioration of many of the native fescue prairies within the park (Trottier 1986). Blood (1966) found that cattle grazing on grasslands resulted in important changes in species composition with native rough fescue (*Festuca hallii*) becoming replaced by junegrass (*Koeleria cristata*), bluegrass (*Poa sandbergii*), oatgrass (*Schizachne purpurascens*), wheatgrass (*Agropyron sp.*), and brome

(*Bromus inermus*). However, Blood (1966) felt that there was limited overlap in diet or range use of cattle and elk and he did not believe that either species affected the other. In 1962, 1375 cattle grazed under permit in RMNP, though there were high levels of un-permitted grazing as well. Interviews with local residents indicated that many hundreds of cattle were grazed annually in the park without permit.

Reeve (1951) estimated that 1500 tons of hay were cut and 500 cattle were grazed in the park during the summer and he stated that "I personally, doubt if this number of cattle are a serious menace to the elk's food supply, but I do believe the cutting of so much hay is not wise unless the park officials are prepared to keep the elk herd down to a reasonable level." But he also cautioned that *"the park wardens state that they are afraid of intentionally set fires if grazing and haying permits were to be cancelled."* (Reeve 1951). One farmer interviewed indicated that he indeed did set fires despite regulations opposing them in order to rejuvenate meadows for hay production and cattle grazing. Another interviewee noted that he intentionally started forest fires occasionally to generate paid employment to help put out the blaze.

Malaher (1960) noted that there were impacts from the haying going on:

> *We have complained also that on the one hand Ottawa stress the 'balance of nature' principle on all their National Parks but at the same time very materially disturb that balance by permitting removal of large quantities of hay from the Riding Mountain Park and allowing the summer grazing of large numbers of cattle within the Park. Both these procedures are directly in competition with the elk and their food requirements. Abandonment of haying and grazing by cattle within the Park would enable the area to support more elk and would alleviate the problem of elk doing damage outside the Park in some degree for a short time, but if the elk population was allowed to continue growing we would later be faced with perhaps a bigger problem resulting from insufficient food for a larger number of elk.*

An anonymous RMNP warden report in 1951 had predicted this situation earlier:

I am still surprised to learn that there is a considerable amount of hay cut in areas which are the finest elk range in the Park. The tonnage removed appears to have dropped considerably in the last few years, but it is still a serious problem. I believe that in three of the better districts in the western part of the Park some 1,500 tons of hay were cut during 1950. This amount would support a fair number of elk throughout the critical period, and it would relieve a great deal of pressure on browse species.

The report further underscores the perceived conflict between agriculture and elk interests:

It should be decided as soon as possible whether the greatest need is for this hay cutting or for elk. The two interests should not be competing for food during the critical periods. So far as the general Park area is concerned I am convinced that there would be significant improvement in existing range if the elk herd were reduced to compensate for the hay removal, or if hay cutting were stopped to provide food for elk. (Anonymous 1951).

Logging within RMNP was also allowed until 1964 and farmers relied heavily on Riding Mountain during this entire period as a source of wood for building materials and most fence posts in region were derived from the park. At the same time, many local farmers relied on commercial logging operations for winter employment.

Elimination of cattle grazing, haying, and logging within RMNP by 1970 generated considerable farmer frustration that is still very much present. A town hall meeting participant in 2003 stated that: *"The government sold us out by kicking us out of the park."* Indeed, discussions with farmers about any resource issue typically directly or indirectly implicated the loss of access to RMNP as a cause of other diverse problems and were evident as important context in all modern resource conflicts:

Before RMNP was established my father logged, cut firewood, hunted every winter, as well as all those surrounding the park were doing the same. Now we see millions of dollars worth of timber and firewood rotting. No fires or cutting. So no grass will grow to feed the animals. The tree huggers call this natural but it's a long way from that. (Cattle Producer R814, 2002)

Once farmers stopped using RMNP to extract resources, most never returned at all to use the park. Only 6% of the farmers interviewed made use of the Park for any purpose over the last decade. Of those that did use RMNP in recent years, the most common reasons were to retrieve wounded elk shot on farmland that ran into the park, for recreation on horseback, and to visit the town site.

Potential Disease Transmission

While elk-cattle contact continued to occur around the periphery of RMNP throughout the decades of agriculture (Figure 4.5), it also persisted in the Park, raising concerns about disease transmission. During his research, Green (1933) did not identify any epizootic diseases in the elk, but he warned that monitoring would be necessary since future outbreaks were possible such as anthrax, hemorrhagic septicaemia, brucellosis, and necrobacillosis that could influence the elk population. At the time of Green's study (1933), there was an outbreak of hemorrhagic septicaemia in sheep herds right along the edge of RMNP, which may have infected the nearby elk. Green observed that actions needed to prevent livestock diseases from infecting wild elk were "obvious and worth the effort required to prevent domestic stock invading the range. Once introduced it would be difficult indeed to detect and control..."

An outbreak of blackleg in cattle herds in RMNP in 1956 supported Green's concerns about disease and the risks of transmission to wild elk. Similar concerns were expressed by the biologist D.R. Flook, who made numerous requests to the superintendent of RMNP in the 1950s to eliminate cattle grazing in the park because of disease concerns:

> *I reported last December on the livestock grazing situation as it affected wildlife from a standpoint of competition for forage and wildlife with contagious diseases.*

The situation still exists. I believe that foot rot and lump jaw are more prevalent, indicating that the range is becoming more contaminated with the organisms causing these diseases. Wild ungulates are susceptible to these diseases which can be disastrous in their effects on wild populations. I would suggest that the report of Dr. Cormer and myself be brought to the attention of the Director for further consideration. I recommend <u>again</u> that all livestock grazing in the park be discontinued. (Flook 1956, emphasis in original document)

However, these concerns were not addressed and cattle grazing continued inside RMNP until 1970. During this time, very few elk were tested for disease, so it is not clear if any disease transmission may have occurred among cattle and elk in the park. Banfield (1949) had noted large numbers of sick elk during the winter of 1946-1947 infected with 'verminous pneumonia', but that was attributed to the extreme population size of the elk at the time. Blood (1966) did not identify any diseased elk from the 19 elk that he killed. In 1968, 29 elk were captured in RMNP near the bison compound using baited traps and tested for bovine TB (tuberculin injection) and brucellosis (blood sample). Another 69 elk were captured and tested in the winter of 1970-1971 (Dixon 1971). No disease reactions were identified and all of these animals were transported to the Interlake Region of Manitoba and released in the Mantagao Lake Wildlife Management Area.

Bovine tuberculosis was endemic to cattle in Manitoba until at least the 1960s, but these outbreaks were never formally associated with a wildlife host and bovine TB was generally considered solely a disease of cattle that could infect humans. However, some local people viewed wildlife as a potential source of disease for many decades:

TB was always a factor and concern since day one. In the early 1920s and through to the mid-1950s TB played a role in the lives of almost every family. Pretty well everyone including our past generations here ate elk, moose and deer on a regular basis. The cattle were exposed to these animals in a far greater extent in the past years than they are today. Wild game carried TB at that time as did domestic animals. The percentage of people with TB was also high in consideration of the sparse population. From the mid-1920s to 1955 several families had members sent *to sanatoriums to be treated. The TB at that time was contacted in 3 major ways. Eating contaminated meat (wild and domestic) drinking milk (and cream butter) and water, or from person to person. The spread from person to person was solved by x-ray and early diagnosis. Any positive test was sent to a sanatorium. The spread from domestic animals to humans was solved by having herds tested every 3 years regularly. No one has ever figured out why the TB dropped in the wild life, other than a lot of animals died off of their own accord when populations became too high and we had a rough winter. Roughly this has occurred 4 times since my grandparents and parents and myself have resided in the area from 1912 to present. (Cattle producer R001, 2002).*

In 1986, Manitoba was declared bovine TB-free, but seven beef cattle herds tested positive in 1991 and the source of these was considered to be from near RMNP. The first elk in the region confirmed by laboratory testing to have bovine TB was in 1992 from the same region, however there was virtually no wildlife testing before that, despite an incidental finding of infected wolves in RMNP. Six local farmers interviewed felt that elk they had hunted around RMNP over the last hundred years were infected with bovine TB, though none turned in samples for testing:

As long ago as 1959 I can remember a hunt with two long time local elk hunters (both now deceased) who had hunted elk for 20+ years before me, leaving an elk in the field because of the lumps on the rib cage and in the lungs. ' That elk has TB,' Jack K. said, 'we will leave this elk in the bush.' What really sticks in my memory is how emphatic he was that the elk had TB because of other similar experiences in his past. (Usik 2002)

A very high level of concern was expressed regarding the presence of TB within the region and regarding the risks of transmission to livestock in town hall meetings in the last decade (Brook and McLachlan 2006). In all meetings, at least one participant and often several suggested that the elk herd should be destroyed: *"You need to kill off the wild elk herd. TB is a real problem and something drastic needs to be done."* (Town hall meeting participant, January 2003). When government officials suggested that eradication of the elk was not feasible, participants typically became frustrated that what they viewed as an obvious solution would not be implemented: *"We have given you the solution but you don't have the guts to use it. Kill the elk."* (Town hall meeting participant, January 2003).

Historical Crop Damage around RMNP

Crop damage by elk and damage to fences around RMNP has been a reoccurring problem since farming began (Anonymous 1951, Lundy 1955). Observations from farmers interviewed combined with government records indicated that damage by elk to agricultural crops has occurred in some form every year over the last century. In all years where data were available, >90% of all elk damage occurred within 3km of RMNP (Figure 4.6). The provincial Minister of Game and Fisheries (1950) stated that concerns have been raised about:

> *...damage which elk have been doing to agricultural products such as hay in the farming districts close to the border of the Park. They attribute the exodus of elk from the Park to two main reasons, one being a reported lack of feed for the elk in the Park itself, and the second being an over-abundance of timber wolves and coyotes in the protected area of the Park.*

The concerns about elk damage were also evident in an issue paper that was produced by the Department of Game and Fisheries (1950) in response to the Minister:

> *An RCMP report has also been received wherein it states that a farmer of the Makinak district reported to them he had killed an elk and that they could come pick it up. He further stated that he and other farmers of the area intended shooting all elk they found on their property in the future. All the farmers signed a petition and sent it in to the M.P. for Dauphin, and he took the petition to Ottawa in an attempt to have something done either to prevent the elk doing damage, or to arrange to have farmers paid for damages done by the elk. The petition brought no results. Nothing was done.*

However, Malaher (1952) noted that not all farmers supported such extreme actions:

I asked him if he were given permission to shoot every elk the moment they stepped to his property, would that solve the problem. He said 'no' and stated that he did not wish to see all the elk shot.

In 1952, a memorandum from the provincial Director of Game and Fisheries (Malaher 1952) describes the concerns of a farmer and his neighbours who were having severe elk problems:

His neighbours have suffered material damage from elk. Heavy bush comes right up to the farm fence lines; the farm fence line is also the north boundary of the RMNP. The open hunting season is inadequate in preventing damage. Elk coming out to feeding at night. Farmers cannot protect fields at night in period of intense cold. He has not yet personally suffered damage. He and neighbours have tried every means to keep elk away. He feels that nothing can stop all his crop going before spring. Anticipates elk will reach his fields soon. Suggests the Government buy the crop of himself and neighbours and then let the elk feed on it. If no compensation is granted he is considering suing the Government for damages on behalf of all the group. He thinks the problem is increased by the cutting and removing of hay from the Park by farmers, under permit. This hay should be feed for the elk. Elk seem to have formed the habit of grain eating. Each generation of young now learn habit from the adults. He would not like to see all the elk shot. In normal years there is not much problem as the crops are all off the fields. This year it is critical – only threshed 20 acres. Has no remedy to suggest except perhaps organized feeding in the Park. Insists he and neighbours cannot stand loss.

In response to these concerns, the Director of the federal Department of Resources and Development indicated that: *"the park warden in district opposite the lands of these farmers does not think that the farmers have made any effort to keep elk off their fields"* (Smart 1952). The Director further stated that:

Under the circumstances, it is suggested that any action to be taken should be restricted to areas outside of the park and that, with provincial co-operation, the farmers concerned should endeavour to take effective action to protect their interests.

Farmers typically perceived that RMNP was the source of all elk in the region (Winnipeg Tribune. 1951, Brook and McLachlan 2006) and thus felt any damage was the responsibility of government:

*The crop has been estimated for value at the very least $1500...The wild animals have been feeding in this crop for the past 5 weeks and if they feed until spring there will be no crop left; as you know there are heavy expenses bringing this crop to life. I also have a family to support and I have livestock, too. The matter stands for ruling this way. We pay you for grazing our cattle and horses in the park. This is logical. Good. Now you pay me for pasturing your elk and deer & moose in my crop (*Rogasky 1959).

Intergovernmental Conflicts

Differences of opinion between federal and provincial agencies regarding options to manage elk damage have been commonplace since RMNP was established due to differences in mandate and jurisdiction. An internal provincial memo stated that:

Our main object is to eliminate the elk outside of the Park, as elk and agriculture are not compatible...The root of the trouble lies within the Riding Mountain National Park which is under Federal jurisdiction...This precludes all hunting within the Park boundaries, and apparently, predator control, although this reasoning is not consistent with the present policy of issuing hay and grazing permits within the Park boundaries thereby depriving elk within the Park of feed. (Davey and Reeve 1950)

This conflict is evident in correspondence from the provincial senior game manager to his superior regarding a conversation with the federal director:

We asked him for his viewpoint on the proposal that some system be devised whereby sport hunters could shoot elk inside the Park boundary. Again he was sympathetic but dismissed the idea on the basis that it would be a dangerous precedent. When it was mentioned that possibly a mile to three mile wide strip of the Park periphery could be removed from the Park and designated a game management area, he countered by proposing that the province buy up a one to three mile wide strip adjoining the Park boundary and designate this as a game management area. (Bossenmaier 1960)

Interviews with local farmers also elicited many stories regarding conflicting mandates and objectives between federal and provincial agencies regarding the management of elk and other wildlife. Government employees from both sides also stated that communication among the federal and provincial employees was often rare. One RMNP warden noted that they typically learned about the number of elk tags to be provided to hunters in the upcoming season by obtaining a Manitoba hunting guide, a publication by the provincial government given to all hunters, and that no consultations were held with federal staff before setting seasons. The establishment of a bovine TB management task group in 2001 with representatives from the government agencies and key stakeholders has facilitated increased dialogue, though considerable conflict remains.

Mitigating Elk Damage to Crops

Attempts to manage elk damage on farmland have largely focused on liberalizing hunting seasons and offering farmers kill permits for problem animals (Winnipeg Free Press 1950b, Winnipeg Tribune 1953, Davies 1968, Schroeder 1981). In many years when crop damage was high, the provincial government set open elk hunting seasons around RMNP. The maximum number of elk estimated harvested by hunters in one season was 2298 in 1959-1960 (Carbyn and Flook 1969), though farmers indicated in personal interviews that the actual number was much higher due to poaching and unreported kills by landowners dealing with damage. Elk were frequently killed inside RMNP by park wardens as well and a reduction program was carried out inside RMNP in 1959-1960 when 319 elk were killed (Carbyn and Flook 1969).

On one occasion, the provincial government conducted a trial using a helicopter to herd elk back into the park (Winnipeg Free Press 1950a).

> *However, this attempt ended in failure due to the fact it was found possible to drive elk by this method over open country but once they got into the forested areas and were able to get some protection from the trees, they were no longer concerned with the fact that a helicopter was hovering over them and it was impossible to drive them.* (Malaher 1950)

Since then, both the federal and provincial governments are regularly accused of herding elk back into the park to interfere with hunting success (Winnipeg Tribune 1952b, Dauphin Herald 2004), though government representatives insist that this is not the case.

Some discussion has occurred regarding holding meetings with farmers about crop damage, as was noted by the federal senior game manager:

> *As a means of easing tension among the farmers in the vicinity of the Park, Mr. Coleman speculated about the value of public meetings. It was his thought that if the disturbed land-owners had an opportunity to air their grievances, there might be less grumbling in the future.* (Bossenmaier 1960)

However, there were very few records of meetings being held with farmers to discuss crop damage or mitigation options. One meeting held with local stakeholders and government officials in 1991 to discuss elk management was identified by eleven interviewees as the most intense conflict they have been observed. This was initiated by opening remarks provided by the RMNP superintendent who indicated that:

> *I prefer a buffer concept. Additional lands surrounding the park could be set aside and used on a sustainable yield basis...The land could be designated under new special provincial legislation that would promote sustainable management including, wood cutting, hunting and trapping.* (Estabrooks 1991)

Interviewees frequently referred to these remarks fifteen years later as an example of how they believed the primary goal of RMNP was to expand beyond its boundaries and eliminate farming and all other forms of land use. This issue was raised again in town hall meetings in 2003: *"How long until there is a buffer zone around the park?"* (Town hall meeting participant, 2002).

Elk Hunting

Although hunting was not allowed within RMNP since it was established, most local farmers ignored these rules and harvested elk to feed their families and park wardens did not always enforce the hunting ban: "*We were just feeding our families. The odd guy got caught poaching to sell it. They wanted to catch those guys, but they never bothered us*" (Retired Farmer R801, 2006). Hunting of elk around the periphery of RMNP occurred on all years since farming began both for food procurement and to manage problem elk feeding on stored hay (Krentz 1949, Krentz 1950).

While farmers have regularly raised concerns about elk damage, hunters (who are often also farmers) around RMNP have frequently been frustrated by the lack of available elk and the total ban on elk hunting in the Park (Winnipeg Tribune 1952a, 1952b). Indeed the season length, number of available licences, and the number of elk killed each year has been highly variable (Figure 4.7). In the winter of 1951, a group of 133 hunters signed a petition:

> *We the undersigned hunters of the province of Manitoba in meeting assembled in the village of McCreary in the Rural Municipality of McCreary vigorously protest the action of the game and fisheries branch in accepting the license fee of $10.00 for the privilege of hunting elk in the area bordering on the Riding Mountain National Park. On visiting the area, we find that after two days hunting that no elk venture outside of the park area after the first shot is fired. We have paid our$10.00 and we want a gamblers chance to get an elk. We strongly recommend that the game and fisheries branch give us at least six days hunting within the boundaries of the Riding Mountain National Park, as the lands bordering on the park are privately owned, we do not wish to enter upon same. These elk come out into the open at night and do damage to the farmers crops when it is illegal to shoot them.* (Letter signed, 'Hunters of Manitoba' 1951)

Illegal elk harvest surrounding and inside RMNP has often been considered a problem by government agencies and some farmers (Green 1933, Rounds 1977). However, the numbers of these incidents has been poorly documented. Complaints have also been made by numerous farmers about the actions of licensed hunters shooting from roads and firing too close to houses and children.

Provision of hay to elk on farmland near RMNP has been commonplace since at least the 1940s, though the rationale has sometimes varied. Throughout this period, many farmers have put out hay to sustain elk during the winter, particularly in winters with extreme snowfall and cold temperatures (Trottier and Hutchinson 1982).

According to local people that were interviewed, use of hay bales as bait to concentrate elk for the purposes of hunting began in the 1950s but became commonplace around the RMNP boundary in 1994 and peaked in the early 2000s, and it continues. In 1997 the provincial government enacted baiting regulations but these were never enforced during the first five years they were in place. In response to concerns by local people that elk were transmitting bovine tuberculosis to cattle, the baiting regulations were revised in 2003, and a low to moderate level of enforcement was implemented which reduced, but did not eliminate, the use of bait. These regulations generated considerable frustration with many hunters who had become accustomed to hunting elk over bait. During the period of intensive baiting from 1994 to 2004, elk within RMNP were much closer to the boundary during the winter than they ever were in the previous years, 1963-1992, indicating that it has influenced the overall elk distribution (Figure 4.8).

In 1981, the provincial government established a special landowner-hunting season in the early fall of each year specifically for farmers and other landholders:

> *Landowners were experiencing depredation from elk and this special season was the government's way of saying 'thanks' for putting up with the depredation. Second, it was a way of encouraging landowners to retain habitat on their own land that helped retain elk in the general area. If a landowner retains bush on his property then he would probably have a good chance that elk would be there, when the hunting season started. It gave landowners a chance to hunt elk right on their own land generally before the resident hunter had a chance.* (D. Chranowski, Manitoba Conservation).

The landowner season has been used extensively by local people in the past and is often viewed as a positive contribution to offset elk impacts: *"My wife and I go for the landowner season every year since it started and we usually get an elk for the freezer. If it weren't for this program, we probably wouldn't do nearly as well."* (Cattle Farmer R911, 2007).

While hundreds of farmers participate in the landowner season, there remains conflict over the nature and timing of the program:

> *The landowner elk season should remain open at any time another elk season is open in that area. Many landowners are unsuccessful during their hunting season, which usually occurs during their busy harvest season in the fall. Then they have to put up with the hordes of city slickers that don't have a clue about hunting etiquette and coming out roaring around and sometimes asking permission, then wanting all kinds of assistance when they accidentally harvest an animal – All this when the landowner goes without an animal after trying to be sympathetic towards Elk/Moose – doing damage all year long.* (Cattle producer R711; 2002).

Farmers also felt that the negative impacts of elk should justify a free hunting license:

> *Landowners with wildlife damage yearly should be given an elk tag yearly with no cost to him. I think you would have better relationships with landowners and they in turn should let others hunt on their land. (Cattle farmer R041, 2002).*

Other farmers indicated that they have stopped hunting because of the increasing bureaucracy in the licensing process:

> *The way the hunting is allowed now is ridiculous -applying for a hunting licence in February for hunting in the fall. Put it back like it was years ago. Buy the licence at hunting season!* (Grain farmer R229, 2002).

Farmer-First Nations Conflicts

Relationships between farmers of European descent and the resident Anishinabe people have often been positive and mutually supportive. Farmers cannot legally kill elk that are causing damage to their crops or interacting with their cattle outside of the hunting season without obtaining a special kill permit and these can be difficult to obtain. Seven percent of farmers in the region currently allow local Anishinabe people to harvest elk on their farms and these farmers have indicated this is the most effective means of eliminating problem elk and at the same time the Anishinabe people indicate this provides important hunting opportunities, which are becoming increasingly rare.

Despite these cooperative relationships, there continues to be widespread and often high levels of racism within the study area and considerable conflict regarding access to elk: "*Until there is one law for everybody, you're damned right we are prejudiced and mad that there are so many laws for different peoples.*" (Cattle farmer R809, 2006). Respondents often felt that hunting throughout the year was a form of harassment and that animals needed periods in the year when no hunting occurs:

> *Aboriginal hunters are evident all summer long and their constant over-hunting has seriously depleted numbers. I believe this constant harassment would also force animals to go out of the park to farm areas where they can find some peace. The so called subsistence hunting and fishing has gotten completely out of control and the government doesn't seem to want to deal with it.* (Cattle producer R724, 2006).

Many farmers also explained that their reluctance to allow First Nation hunters on their land is due to damage caused by these hunters to crops or equipment, leaving gates open, or theft of farm items. At the same time, First Nations hunters were often viewed as competitors for the small number of elk that come on their farms, since most of the farmers interviewed also hunted elk. It was also widely believed that it is inequitable that Aboriginal people can hunt throughout the year and are not required to purchase a license while landowners require a license to hunt on their own land:

> *[Aboriginal hunters] are threats to the environment through over-hunting, hunting without permission, damage to property in the process of hunting, not to mention the fishing problem. Hunting and fishing without licenses or permit is out of control!!!* (Grain Farmer R114, 2002).

At the same time, Anishinabe people have expressed frustration over decades of systemic racism and marginalization, having been forced into isolated reserves and banned from using their traditional hunting grounds, which historically focused on what is now Riding Mountain National Park (Peckett 1999). Since only 1% of the region is currently owned by Aboriginal First Nations and most of these areas are distant from RMNP, few elk can be harvested there. The remaining land is either federally protected (11%) with no hunting allowed, provincial crown land (18%) which is open to First Nations and sport hunting, or privately owned farmland (70%), which requires landowner permission to hunt on. Since the majority of farmers (93%) do not allow Aboriginal hunters on their land, this causes considerable tension and frustration for Anishinabe hunters:

> *My ancestors used to hunt this entire area, wherever and whenever they wanted to. Now I can't find a decent place to hunt anywhere. It's not fair that I have to beg permission to get an elk to feed my family.* (Anishinabe hunter, 2003).

Habitat Change

Many areas of the Park are viewed by farmers as overgrown with forest and shrub cover in response to intensive fire control and the discontinuation of haying, forestry, and cattle grazing. These perceived changes in habitat are often considered primary factors associated with elk problems on surrounding agricultural lands. It is often felt that poor quality habitat inside RMNP forces wildlife out of the park:

> *Many years ago when farmers were permitted to cut hay in the park, large meadows were kept treeless and provided good feeding areas for elk ... When cutting hay was no longer permitted these areas became treed in and also because of the explosion in the beaver population, these feeding areas are either grown in or flooded. So I feel the government must improve the habitat for elk in the park and also make sure that the grazing areas are large enough to support the current elk populations.* (Cattle producer R471, 2002)

Changes in farming practices have also influenced elk conflicts:

I've gone from more of a grain crop base, from what my dad had, to a cattle based operation here since a lot of the land is better suited for cattle. So I've been sowing it down, and now I tend to see more elk because of the alfalfa out there. I'll see more during the day than if you would if it was summer fallow or anything else. (Cattle producer R088, 2003).

Habitat change related to beaver activity is frequently identified as the primary cause of elk-agriculture conflict by causing declining elk habitat within RMNP (e.g. Winnipeg Free Press 1981). The word "beaver" was included 141 times in the written responses to the mail survey, even though there were no questions about beavers and the word "beaver" was not used once in the entire questionnaire. One respondent stated:

Major problem with Riding Mountain and surrounding area is the <u>beaver problem</u> everyone wants to protect the park within and wants to leave it natural, well really what happened, beavers have flooded, wasted and screwed up elk and deer feeding areas and habitat so bad, that, elk and deer had to move out of that scrub pile, lake, beaver pond's, where no grass will ever grow and on to farm land for feed on to crops, hay and alfalfa land, and to some grain piles that had to be stored on piles out on the fields. (Grain and cattle producer R047, 2002; emphasis in original survey.)

The concern regarding beaver is exacerbated by the long-standing resentment that Parks Canada reintroduced beaver after being almost completely extirpated from RMNP. During the fur trade and early settlement beaver were heavily harvested and there were only 32 beaver counted in RMNP in 1932 (Green 1933) and these low numbers persisted through the 1940s. In 1947, 28 beavers were brought in and released in RMNP to augment the population and more were added in 1958 (Trottier *et al.* 1982). By 1959 beaver were abundant throughout the park (Trottier 1987) rising to a peak of 4000 colonies in 1983. These beaver disperse often in large numbers onto surrounding farmland and cause considerable flooding in some years (Menzies 1998). One mail survey recipient refused to participate or discuss elk management issues due to long-term frustrations regarding beaver problems.

The initiation of controlled burns within RMNP is seen by most farmers as important for reducing conflicts with elk:

> *The controlled burning in the park over the past few years has benefited the elk habitat; therefore, the elk are staying in the park more. They had nothing to eat before and now they do.* (Grain farmer R510, 2004)

However, this success has then resulted in conflicts with hunters who have complained that the burning program has reduced their success. There were diverse opinions of farmers that were interviewed regarding the future roles and importance of human use in RMNP:

> *You hear locals say that if the Park was used again it would be the place it used to be. You also hear the naturalists say to leave it in the natural state. I disagree with both, for no one will reuse it the way it was before. (Grain farmer R011, 2006).*

Predators

Wolves existed in southern Manitoba at the time of European settlement, but declined dramatically in response to agricultural expansion and intensive predator control programs (Carbyn 1983). Predators were regularly culled within RMNP in the first four decades after park establishment, though their numbers were very low in the 1930s:

> *We were travelling with a park warden to look at some wood that I cut. He always carried a rifle on his cutter. A wolf ran across the road and the warden passed me the gun and told me to shoot it because he was supposed to shoot all of the wolves he could see in the park. Later on we saw a bunch of elk and he was disappointed because he wasn't supposed to shoot elk but he had no meat at home. (Alex Cleland, 2005).*

It was often believed that wolves scared elk out of the park, but support for killing wolves inside RMNP was not always high:

> *Park wardens shoot wolves when the opportunity arises but do not actually hunt them. A few cyanide guns have been issued but no instruction by experienced wolf trappers is available and as far as could be ascertained the wardens have not been*

provided with suitable bait. It seems obvious that there will be no significant reduction in the wolf population unless considerable effort is put into the control program. (Reeve 1951).

These predator management programs were generally seen by farmers as beneficial and were locally supported. However, Carbyn and Flook (1969) noted "*reduction slaughters compromise park ideals and are costly if carried out properly. Hunting is not acceptable in National Parks.*" This change in Park mandate and philosophy resulted in the elimination of wolf kills inside the park.

Benefits of Elk

Despite the many diverse impacts that elk have on farmers, they are also associated with important benefits, particularly as a source of food. Of the 394 diverse stakeholders in the region that were questioned by Beeusaert (1995), all felt that the abundance of large mammals was either very important (84%) or fairly important (16%), while none felt that it was of little or no importance. More than half of all farmers (56%) enjoy seeing elk on their land and many indicated one of the most valuable benefits of living near a national park was the opportunity to observe wildlife (Brook and McLachlan 2003):

The Riding Mountain Park is a treasure for all Canadians to enjoy and protect. The animals, including elk, should not be considered expendable under any circumstances. Over the last 50 years many farmers along the Park have helped a great deal to save habitat for elk and deer. (Grain Producer R588, 2002; emphasis in original).

It was emphasized by many farmers that it was critical to maintain elk and other wildlife over the long term for future generations to enjoy as well: "I have enjoyed having wildlife on and around my land for many years and would like this way of life preserved for the future." (Cattle farmer R431, 2002). Many landowners charge substantial fees for hunters to access their land and for a few, this practice generates more revenue than farming.

Farmer-Park Relationship

The overall relationship between local farmers and Riding Mountain National Park has evolved dramatically since farming began in the 1880s. The most obvious change was the sharp decline in use of RMNP by local farmers between 1880 and 2007. All farmers that were interviewed made extensive use of the park in their youth during trips with their parents to graze cattle, harvest hay, hunt elk, or for recreational purposes like fishing and camping. In contrast, very few enter the park at all in recent years. Most farmers interviewed felt that the impacts associated with living near the national park greatly exceeded the benefits: *"to me, the Park used to be a tremendous benefit, now it is a major liability"* (Calvin Pawluk, cattle producer, 2004). Parks Canada appears to be making some positive measures to work more effectively with local people:

> *I am encouraged by the steps RMNP has taken over the last few years in improving its relationship with the residents that surround the Park* (Calvin Pawluk, cattle producer, 2007).

However, all of the main issues related to information sharing, wildlife conflicts, and the relationships between local people and government that were identified by Schroeder (1981) continue to be concerns and the situation has changed very little since his study 26 years ago.

Discussion

The basis of conflicts that are currently occurring around what is now Riding Mountain National Park are the result of a wide range of cumulative factors that have been operating since farming began in the 1880s. Conflicts related to elk-agriculture interactions such as damage to fences, standing crops, stored hay and perceived disease transmission have occurred annually in some form over the last 127 years. During the first phase of agricultural development (1880-1895), the primary emphasis for European settlers was on survival and there was no protection in place for natural resources. The combined effects of over-hunting and agricultural expansion resulted in a collapse in the elk population. Partial protection was provided by the establishment of the Forest Reserve (1895-1930) and was supplemented by a province-wide ban on elk hunting which ultimately allowed the elk to recover. The period of further protection (1930-1970) began with the creation of RMNP, which eliminated elk hunting within the Park by Aboriginal peoples and farmers but allowed high levels of resource extraction. A dramatic change occurred in the relationship between RMNP and local farmers during the conservation phase (1970-present) when cattle grazing, haying, and forestry were eliminated from the Park. During this period, the long-standing issue of elk damage to crops was addressed somewhat through the provision of barrier fences by government and initiation of a compensation program. However, the presence of bovine tuberculosis has resulted in some of the most intense human-human conflicts ever between farmers and government agencies. These conflicts continued and were indeed exacerbated by government actions to resolve the conflict, since these prescriptive resource management interventions were largely implemented with ineffective communication and collaboration.

The results of this longitudinal analysis serve to underscore that individual conflicts are interrelated and cumulative. In all town hall meetings, interviews and responses to the mail survey, respondents made complex linkages between diverse issues. Perhaps most importantly, they often referred back to issues many years and decades in the past that clearly have not been resolved from their perspective. This was particularly evident with regard to changes in RMNP management planning that excluded resource extraction activity 37 years ago but remains a source of considerable frustration and resentment. Similarly, on-going reference by farmers to a buffer zone around RMNP is reflective of mistrust and fears that the boundaries of the park will expand and displace farms, many of which have been established within a family for five or more generations. Current natural resource management plans and processes in the Riding Mountain region generally do not adequately address the interconnected nature of these diverse conflicts or acknowledge that current conflicts are influenced in large part by the past. My results stress that each management decision and statement can have impacts that linger for many decades.

The long-term nature of these issues was particularly evident with regard to communication and trust between farmers and government agencies. Numerous farmers expressed that government would do whatever it wanted, regardless of what they say or do, so they felt that participation in consultation meetings would be immaterial. As a result, when government agencies do offer opportunities for consultation, they are not always well attended since farmers feel that the process is seriously flawed. This in turn creates frustrations with government staff who feel they have provided valuable opportunities for consultation and question the value of offering future consultations. Similarly, government staff are frequently frustrated by the frequent suggestions by farmers that the conflicts are all the fault of government and many federal and provincial staff feel that farmers are not adequately assuming personal responsibility. These frustrations on both sides need considerable discussion and resolution before attempting to address current elk-agriculture conflicts or initiating further consultation and communication activities. Until farmers begin to feel less marginalized and undervalued, their participation will likely be limited or highly confrontational. This has certainly been the case with bovine TB town hall meetings and information sessions; either very few people attend or many people turn out and the meeting devolves into frustrated shouts of 'kill the elk' or 'fence the damn park'.

The importance of resolving past issues and developing a better approach to conflict management is particularly germane given that RMNP represents a core of wilderness habitat directly adjacent to intensive agriculture; and it seems likely that new, unanticipated conflicts will emerge in the near future. The results of this study suggest that whatever the nature of any future conflicts, they will most likely be influenced by past issues and existing land use and management programs.

Literature Cited

Atwood, M., editor. 1970. In Rupert's Land: Memoirs of Walter Traill. McClelland and Stewart, Toronto, Ontario, Canada.

Badola, R. 1998. Attitudes of local people towards conservation and alternatives to forest resources: A case study from the lower Himalayas. Biodiversity and Conservation 7:1245-1259.

Bailey, R. H. 1968. Notes on the vegetation in Riding Mountain National Park, Manitoba. Canadian Department of Forest Management, National Park Forest Survey Report No. 2.

Banfield, A. 1949. An irruption of elk in Riding Mountain National Park, Manitoba. Journal of Wildlife Management. 13:127-134.

Beeusaert, D. 1995. The non-consumptive values of wildlife in the Riding Mountain area. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada.

Bird, R.D. 1961. Ecology of the Aspen parkland of western Canada. Canada Department of Agriculture, Ottawa, Ontario, Canada.

Blood, D. A. 1966. Range relationships of elk and cattle in Riding Mountain National Park, Manitoba. Canadian Wildlife Service Wildlife Management Bulletin. Series 1, No. 19.

Bossenmaier, E. F. 1960. Visit with Mr. J.R.B. Coleman, Director, National Parks Branch. Manitoba Department of Mines and Natural Resources Wildlife Branch Departmental Memorandum.

Brook, R. K., and S. M. McLachlan. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. University of Manitoba, Winnipeg, Manitoba, Canada.

Brook, R. K. and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 161:156-166.

Carlyle, W. J. 1996. Agriculture in Manitoba. Pages 219-236 *in* J.Welsted, J. Everitt, and C. Stadel. The geography of Manitoba. University of Manitoba Press, Winnipeg, Manitoba, Canada.

Carbyn, L. N. and D. R. Flook. 1969. Riding Mountain National Park: I. Discussions of the wildlife problems as posed at the Federal-Provincial conference held in August 1968. II. Comments on the provisional master plan.

Carbyn, L. N. 1983. Wolf predation on elk in Riding Mountain National Park, Manitoba. Journal of Wildlife Management 47:963-976.

Colls, D. G. 1950. Agricultural damage by elk outside Riding Mountain National Park. Manitoba Game and Fisheries Branch, Winnipeg, Manitoba, Canada.

Conover, M. R. 2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29:521-532.

Cowan, J. G. 1953. Re: Elk Season. Memorandum to G.W. Malahar, Director of Game and Fisheries.

Dauphin Herald. 2004. TB fight continues, Parks Canada hopes to limit effects of flights. January 13, 2004.

Davey, A. P. and A. J. Reeve. 1950. Elk depredation in the agricultural areas surrounding the Riding Mountain National Park. Manitoba Department of Natural Resources, Winnipeg, Manitoba, Canada.

Davies, D. 1968. A brief history of Riding Mountain elk movements and associated problems. Report 14.13. Manitoba Department of Mines and Natural Resources Wildlife Branch, Winnipeg, Manitoba, Canada.

Department of Game and Fisheries 1950. Interoffice memo. Manitoba Department of Mines and Natural Resources Wildlife Branch, Winnipeg, Manitoba, Canada.

deVos, A. 1965. A study of the resources and related problems of RMNP. Documentation Centre, Parks Canada, Ottawa, Ontario, Canada.

Dickson, J. R. 1909. The Riding Mountain Forest Reserve. Canadian Department of Interior Forestry Bulletin No. 6.

Dixon, C. C. 1971. 1970-71 elk release in the Mantagao Lake Wildlife Management Area. Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Dushinsky, R.P. 1981. Haying and livestock grazing in Riding Mountain National Park: past practices, present status, future considerations. Thesis, Carleton University, Ottawa, Ontario, Canada.

Estabrooks, M. H. 1991. Riding Mountain National Park presentation: Elk & moose management. Parks Canada, Wasagaming, Manitoba, Canada.

Evans, S. L. 1923. Report of land classification surveys in part of Riding Mountain Forest Reserve. Canadian Department of Interior, Ottawa, Ontario, Canada.

Flook, D. R. 1956. Range conditions and livestock grazing in RMNP. Canadian Wildlife Service File No. 753.

Fortin, M. J. and C. Gagnon. 1999. An assessment of social impacts of national parks on communities in Quebec, Canada. Environmental Conservation 26:200-211.

Goldrup, C. 1992. An historic overview and analysis of consumptive uses of resources in Duck Mountain Provincial Park. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada Green, H.U. 1933. The wapiti of Riding Mountain Manitoba. An ecological study and commentary. Canadian Field-Naturalist 47(6):105-111 and 47(7):122-132.

Herkert, J. R. 1994. The effects of habitat fragmentation on mid-western grassland bird communities. Ecological Applications 4:461-71.

Hewitt, C. G. 1921. The Conservation of the Wildlife of Canada. Charles Scribner's Sons, New York, New York, USA.

'Hunters of Manitoba'. 1951. A petition submitted to the federal and provincial government. Manitoba Department of Natural Resources, Winnipeg, Manitoba, Canada.

Jacobson, S. K., K. E. Sieving, G. A. Jones, and A. Van Doorn. 2003. Assessment of farmer attitudes and behavioural intentions toward bird conservation on organic and conventional Florida farms. Conservation Biology 17:595-606.

Jamieson, S. M. 1974. A synthesis of archaeological research in Riding Mountain National Park to 1973. Canadian Department of Indian and Northern Affairs, Ottawa, Ontario, Canada

Krentz, H. 1949. Illegal Elk hunting (Ochre River -Laurier. Manitoba Department of Mines and Manitoba Department of Natural Resources, Winnipeg, Manitoba, Canada.

Krentz, H. 1950. Elk damages in the Laurier District. Manitoba Department of Mines and Natural Resources Officer's Report.

Kreswell, J. W. 1998. Qualitative inquiry and research design. Choosing among five traditions. Sage Publications, Los Angeles, California, USA.

Lehr, J. C. 1996. Settlement: the making of a landscape. Pages 92-107 *in* J.Welsted, J. Everitt, and C. Stadel editors. The geography of Manitoba. University of Manitoba Press, Winnipeg, Manitoba, Canada.

Lundy, A. M. 1955. Damage to hay by elk around Riding Mountain. Province of Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Malaher, G. W. 1950. Letter to Mr. Harold Mead. Game Branch, Department of Natural Resources and Industrial Development, Prince Albert, Saskatchewan, Canada.

Malaher, G. W. 1952. Interview with Arthur Schmidt, Birchview, on January 24th, regarding elk depredation. Province of Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Malaher, G. W. 1960. Elk – Riding Mountain National Park. Manitoba Department of Mines and Natural Resources Wildlife Branch, Winnipeg, Manitoba, Canada.

Menzies, C. E. L. 1998. Cooperative beaver management in the Riding Mountain Biosphere Reserve, Manitoba. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada

Noss, R. 1995. Maintaining ecological integrity in representative reserve networks: Discussion Paper. A World Wildlife Fund Canada/World Wildlife Fund United States Discussion Paper.

Nyhus, P., H. Fischer, F. Madden, and S. Osofsky. 2003. Taking the bite out of wildlife damage: The challenges of wildlife compensation schemes. Conservation in Practice 4:37-43.

Parker, J. L. 1978. The Fort Dauphin story. Fort Dauphin Museum, Dauphin, Manitoba, Canada.

Parks Canada. 1987. Riding Mountain National Park management plan. Environment Canada, Ottawa, Ontario, Canada.

Parsons, G. 1952. Post season report on 1951-52 elk season. Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Peckett, M. K. 1999. Anishinabe homeland history: traditional land and resource use of Riding Mountain, Manitoba. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada

Reeve, A. J. 1951. Riding Mountain National Park. Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Rogasky, M. 1959. Re: Elks, Moose, and Deer. Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Rounds, R.C. 1977. Population fluctuations of wapiti (*Cervus elaphus*) and moose (*Alces alces*) in Riding Mountain Park, Manitoba 1950-1976. Canadian Field Naturalist 91:130-133.

Richards, L. K. 1997. Elk/moose population dynamics in the Riding Mountain National Park region. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada

Schonewald-Cox, C. M., M. Buechner, R. Sauvajot, and B. A. Wilcox. 1992. Cross-boundary management between national parks and surrounding lands: A review and discussion. Environmental Management 16:273-282.

Schroeder, R. E. 1981. Factors contributing to resource conflict: a study of Riding Mountain Park in its regional setting. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada

Smart, J. 1952. Letter to Mr. G.W. Malaher. Game and Fisheries Branch, Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba, Canada.

Stadel, C. 1996. The non-metropolitan settlements of southern Manitoba. Pages 152-166 *in* J. Welsted, J. Everitt, and C. Stadel, editors. The geography of Manitoba. University of Manitoba Press. Winnipeg, Manitoba, Canada.

Stronen, A., R. K. Brook, P. C. Paquet and S.M. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Tabulenas, D. T. 1983. A narrative human history of Riding Mountain National Park and area: Prehistory to 1980. Parks Canada, Microfiche Report Series 102.

Trottier, G. C., S. Rollans, and R. C. Hutchinson. 1982. Range, habitat and foraging relationships of ungulates in Riding Mountain National Park. Large Mammal System Study. Canadian Wildlife Service Report No. 14.

Trottier, G. C. and R. C. Hutchinson. 1982. Ungulate-winter severity relationships in Riding Mountain National Park 1977-1980. Final Report. Large Mammal Systems Study. Canadian Wildlife Service, Edmonton, Alberta, Canada.

Trottier, G. C. 1986. Disruption of rough fescue, *Festuca halli*, grassland by livestock grazing in Riding Mountain National Park, Manitoba. Canadian Field-Naturalist 100:488-495.

Trottier, G. 1987. The large mammal system of Riding Mountain - Historical perspective. Canadian Wildlife Service, Edmonton, Alberta, Canada.

Turner, J. P. 1906. The moose and wapiti of Manitoba: A plea for their preservation. Transactions of the Historical and Scientific Society of Manitoba. Winnipeg, Manitoba, Canada.

Tyman, J. L. 1972. By section, township, and range. Brandon University Press, Brandon, Manitoba, Canada.

Usik, R. 2002. TB prevention in cattle-elk transmissions around RMNP "A 100 to one gamble?." Unpublished report presented at the Riding Mountain Biosphere Reserve Meeting, July 25th.

Western, D., R. M. Wright, and S. C. Strum. editors. 1994. Natural connections: perspectives in community-based conservation. Island Press, Washington, D.C., USA.

Winnipeg Free Press. 1950a. Helicopter to round up straying elk. Winnipeg Free Press, February 20, 1950.

Winnipeg Free Press. 1950b. Special season opens Monday on foraging elk. Winnipeg Free Press, December 14, 1950.

Winnipeg Free Press. 1981. Beavers just the tip of a gnawing problem at park. Andy Blicq. September 15. p.2.

Winnipeg Tribune. 1951. Hungry elk crop threat. The Winnipeg Tribune, November 22, 1951.

Winnipeg Tribune, 1952a. Elk play it safe in park. The Winnipeg Tribune, December 15, 1952.

Winnipeg Tribune. 1952b. Hunters charge wardens keep elk in sanctuary. January 9, 1952.

Winnipeg Tribune. 1953. Elk season extended to Feb.27. The Winnipeg Tribune, January 27, 1953.

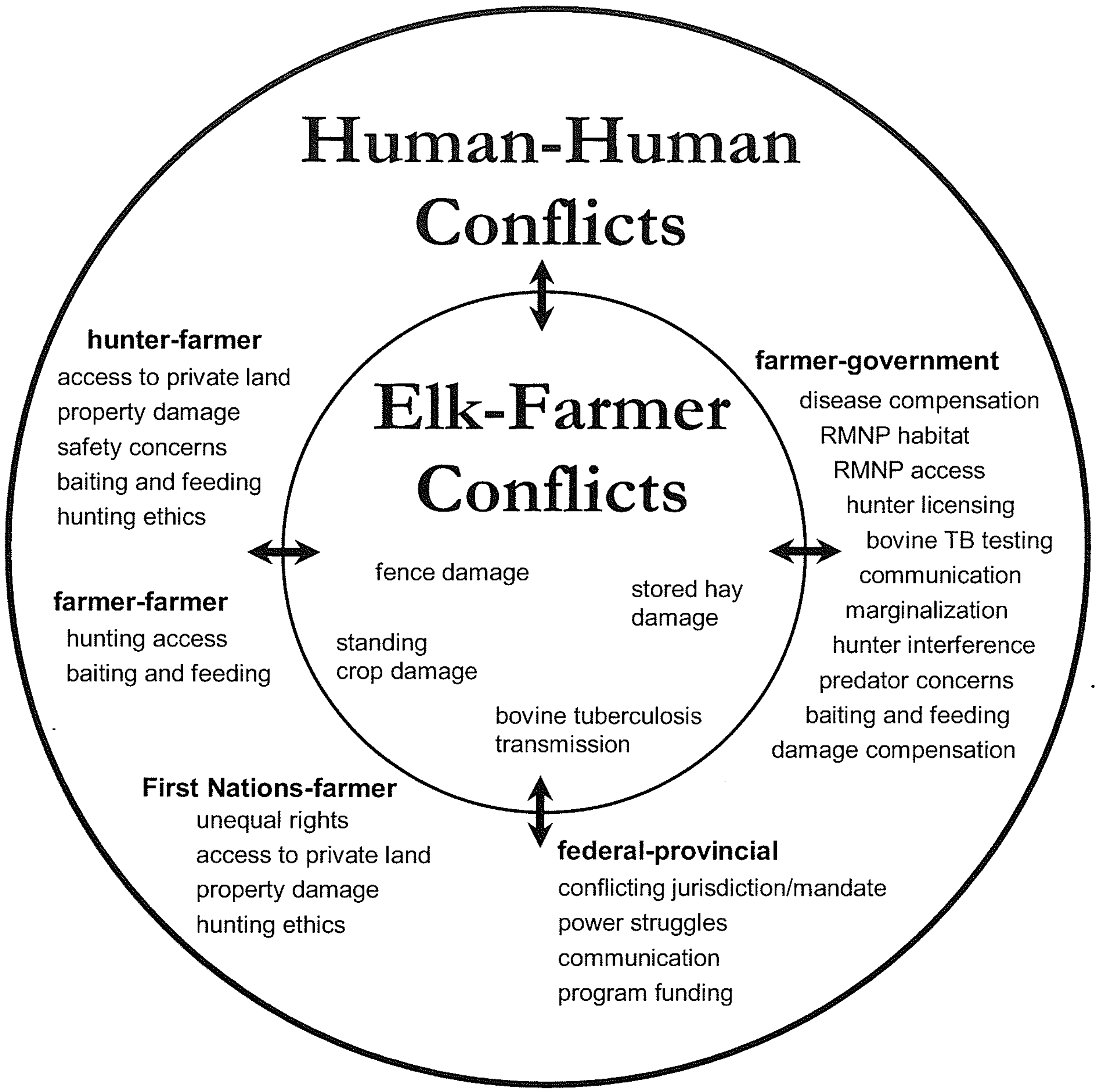


Figure 4.1. Elk-agriculture conflicts in the Riding Mountain region over the last 127 years have been characterized by diverse impacts that drive additional, complex human-human conflicts. The most severe of these have been farmer-government conflicts related to managing elk-farmer conflicts.

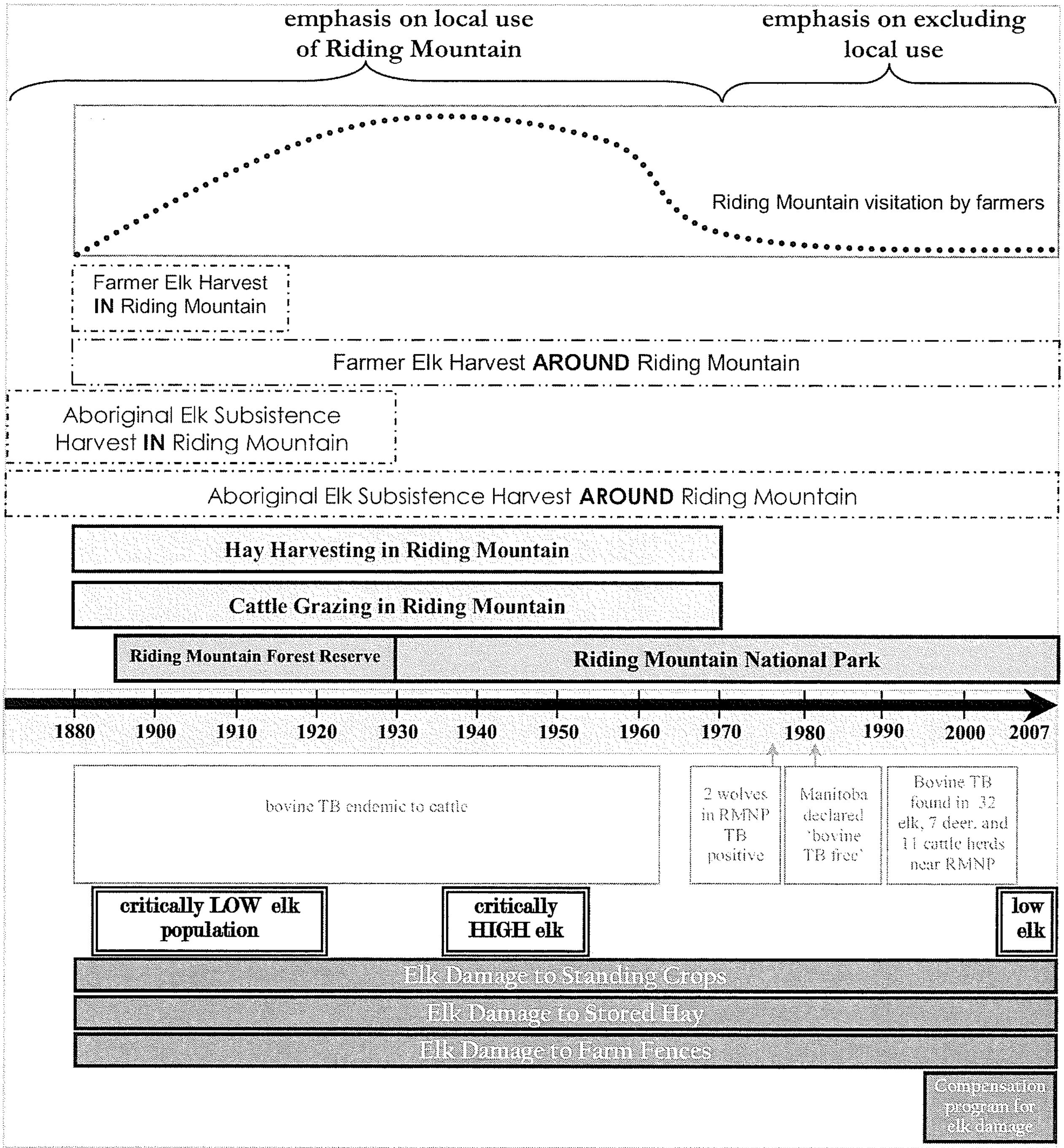


Figure 4.2. Timeline for the evolution of protected area status and use that form the context and primary drivers of elk-agriculture conflicts in and around what is now Riding Mountain National Park.

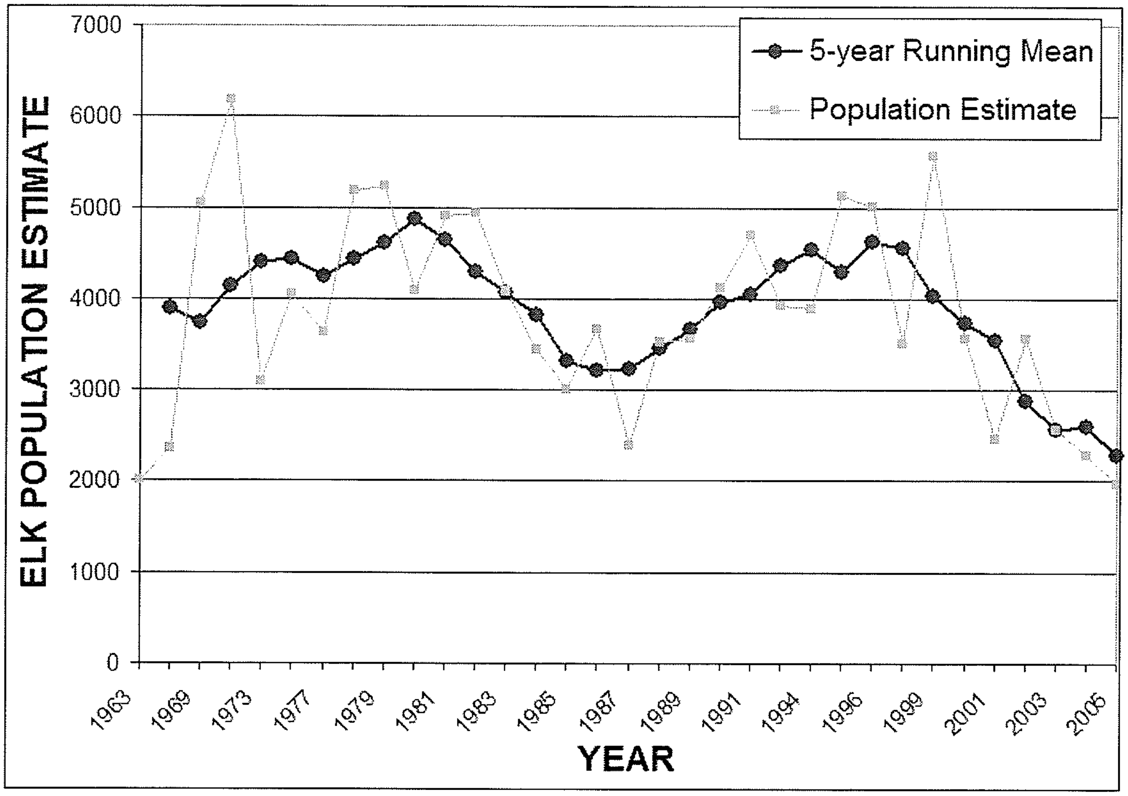


Figure 4.3. Annual estimate of the elk population determined by the RMNP winter aerial ungulate survey (Parks Canada, unpublished data).

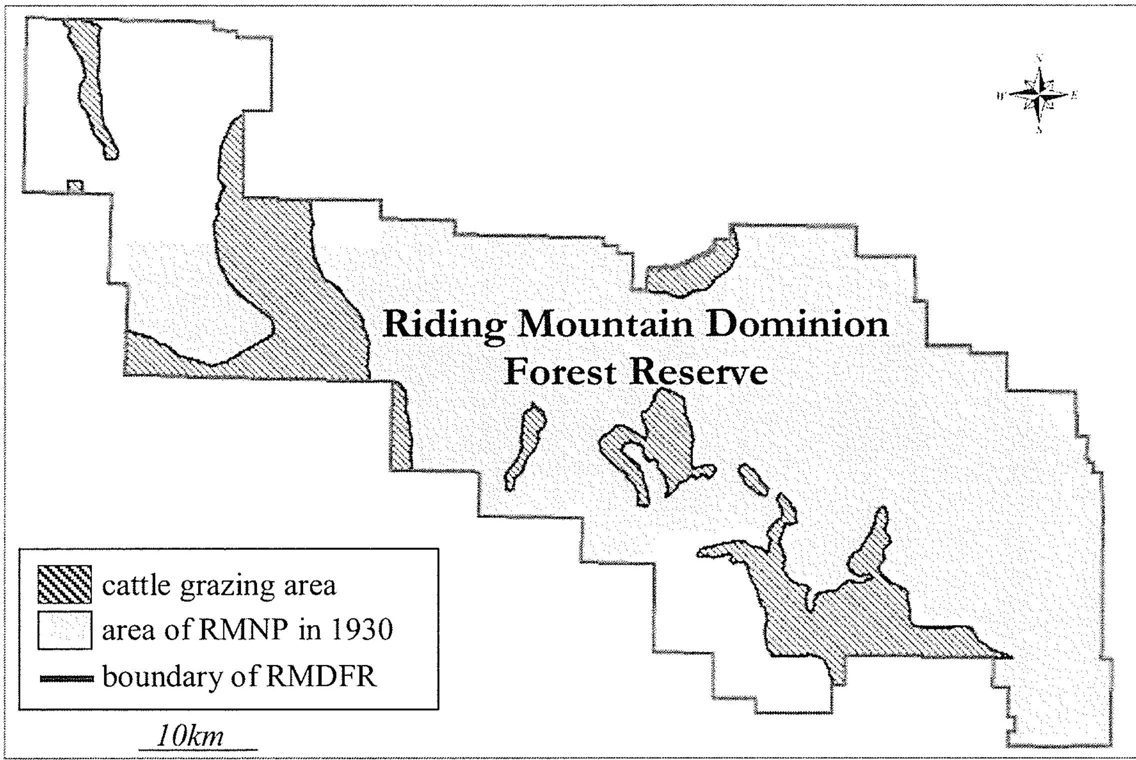


Figure 4.4. Cattle grazing distribution with Riding Mountain Dominion Forest Reserve in 1916 (Parks Canada, unpublished data). The area of what became RMNP in 1930 is shaded grey.

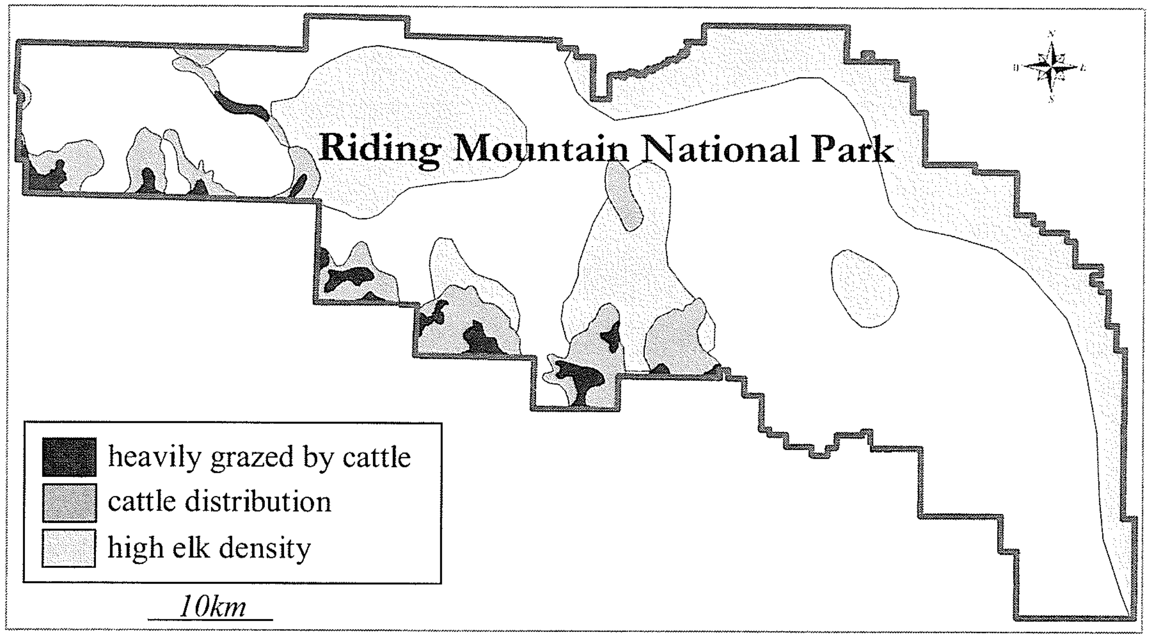


Figure 4.5. Distribution of cattle within RMNP and areas of high elk density in the early 1960's (after Blood 1966). Biologists and local farmers have suggested that this period of high cattle-elk interaction may be responsible for the presence of bovine tuberculosis in the elk population that remains arguably one of the most important conflicts in the region.

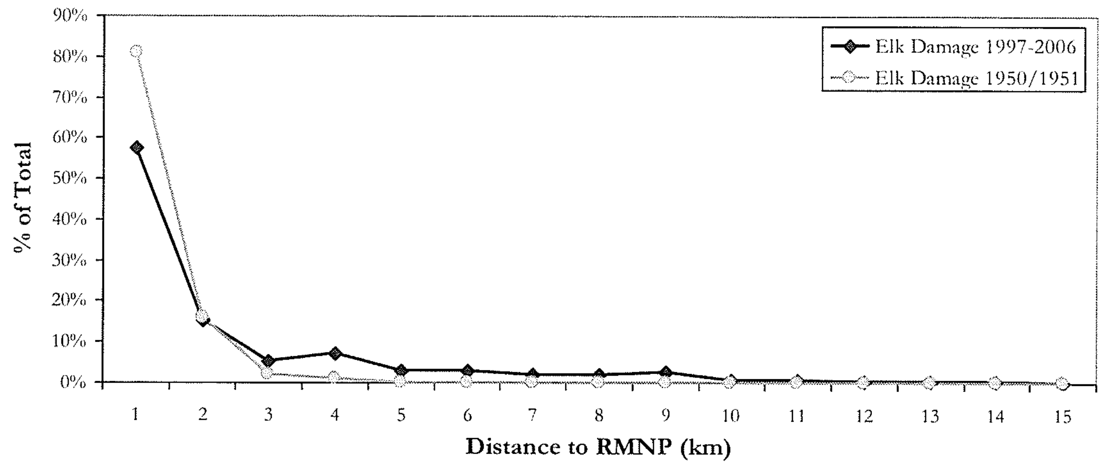


Figure 4.6. Spatial distribution of damage to stored hay by elk during the winter months during 1950/1951 (Manitoba Conservation, unpublished data) and 1997-2006 (Manitoba Crop Insurance, unpublished data; Brook, unpublished data).

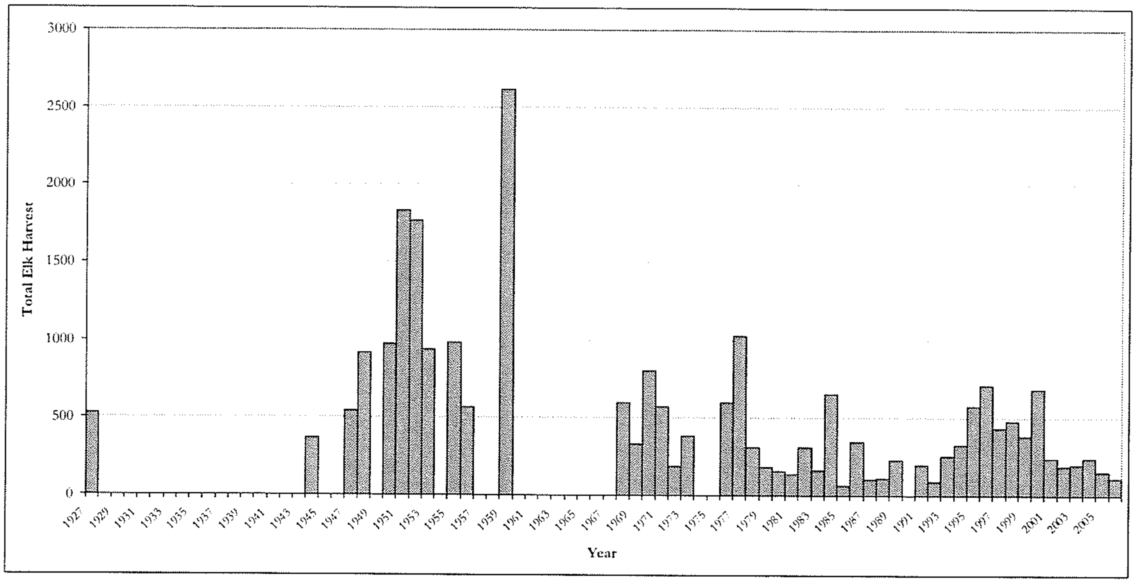


Figure 4.7. Estimates of elk harvest by licensed hunters on the agricultural lands around RMNP. Hunting seasons have been variable in timing, duration, and number of available licences and in some years there was no season, but all have occurred during the winter months and thus provide a minimum estimate for the number of elk moving outside of the RMNP boundary. Data were compiled from diverse sources (Manitoba Conservation, unpublished hunter questionnaires, Malaher 1951, Parsons 1952, Blood 1966, Carbyn and Flook 1969, and Richards 1997). No data are currently available on First Nations subsistence harvest of elk.

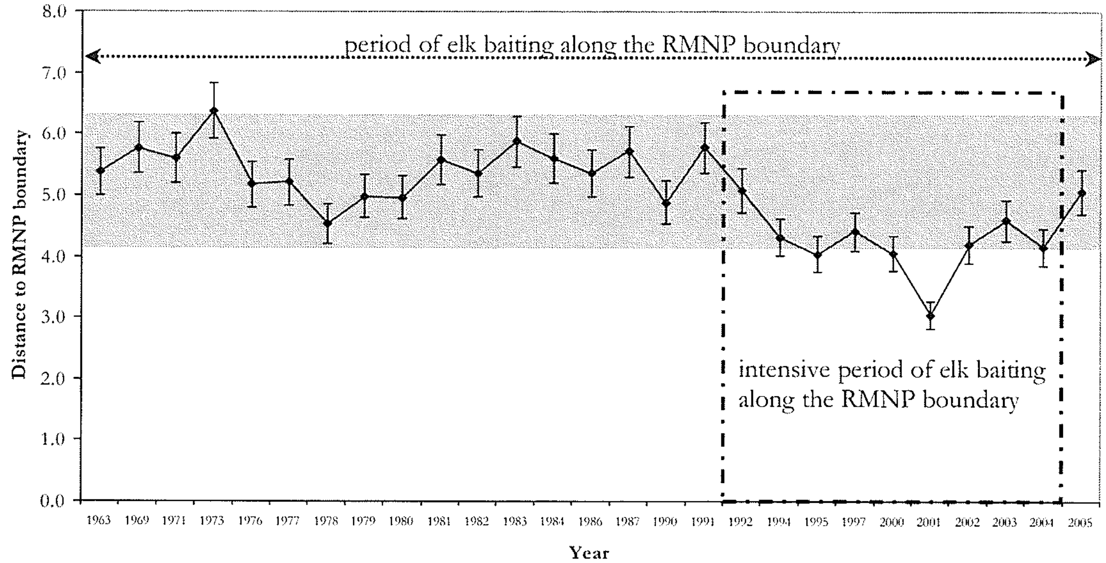
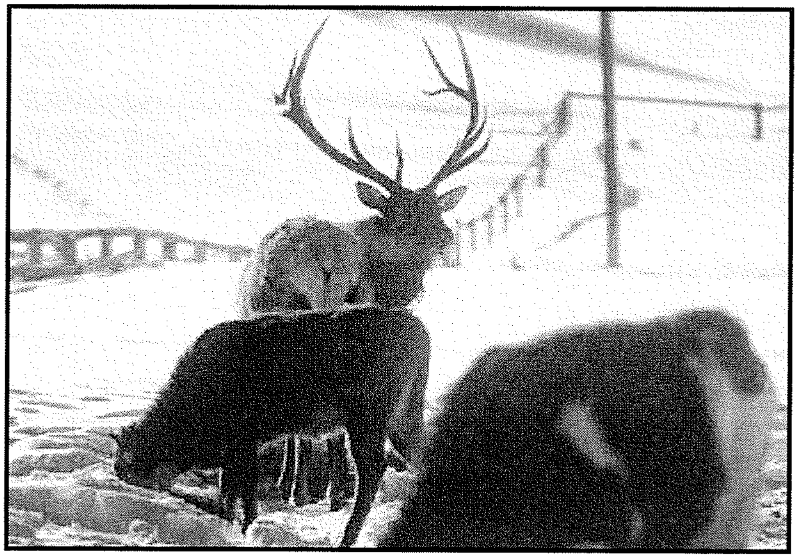


Figure 4.8. Mid-winter distribution of elk inside RMNP (1963-2005) relative to distance from the boundary (mean±SE) based on annual mid-winter aerial surveys (Parks Canada, unpublished data). The 95% confidence interval for locations from 1963-1990 before elk baiting became widespread is shaded grey.

CHAPTER 5

FACTORS INFLUENCING FARMERS' CONCERNS REGARDING BOVINE TUBERCULOSIS IN WILDLIFE AND LIVESTOCK AROUND RIDING MOUNTAIN NATIONAL PARK[1]



"Farming near these tuberculosis positive farms is like having a sniper in the hills, it's like farming with a gun to your head – you never know when it's going to get you."

--Riding Mountain cattle producer (2002)

[1]This chapter has been published in the Journal of Environmental Management in co-authorship with my primary advisor (Brook and McLachlan 2006). While I was responsible for data collection and analysis, Dr. McLachlan provided insights into overall study design, results interpretation, and reviewed multiple drafts. The published paper has been reformatted slightly here to fit the design of this thesis. I use the first person throughout for consistency within the thesis.

Chapter Summary

Despite intensive efforts over the last century to eradicate bovine tuberculosis (TB) in North America, several hotspots of infected wildlife and livestock remain, raising concerns that the disease will never be eradicated. The stress and frustration for a farmer caused by having a herd test positive for TB or living in an infected region can be substantial. The goal of this study was to investigate the concerns of farmers around Riding Mountain National Park (RMNP) regarding the presence of TB in wildlife and livestock and conduct an exploratory analysis of causal factors. Data were collected from 786 farmers within 50 km of RMNP using a mail-back questionnaire. Overall, farmers indicated a high level of concern toward diseases in both wildlife and cattle relative to other concerns. The spatial variables that had the greatest influence on TB concern were both the distance of farms to the RMNP boundary and distance of farms to previous cases of TB. The most important aspatial factor associated with high TB concern was the frequency that farmers observed elk on their land. These results underscore the important differences between "objective" measures of risk, such as epidemiological estimates of disease prevalence, and subjective measures of disease concern, such as risk perception and acceptability of management actions. Written responses suggest that concerns regarding disease may affect how farmers view wildlife on their land and their relationship with neighbouring protected areas. Management activities that reduce the frequency of elk interactions with farms, but also recognize the complex relationship that farmers have with wildlife and protected areas, will be most effective in mitigating farmer concern regarding this important problem.

Introduction

Protected areas have been conventionally managed as "islands" of natural habitat in isolation from the surrounding landscape (Shafer 1999). Although they play a critical role in maintaining biodiversity (Janzen 1983), few are large enough to be self-contained (Newmark 1985, Herrero 1994). Wildlife movements out of parks often generate management challenges as they tend to be cross-jurisdictional (Forbes and Theberge 1996). Wildlife can adversely affect people living near these protected areas by causing economic impacts and creating risks to human health and safety (Hill 1988, Newmark *et al.* 1993, Sekhar 2003). Cross-boundary issues will only become more pronounced as landscapes continue to be altered, as protected areas become more fragmented, and as the scale of environmental pressures continues to increase (Schonewald-Cox *et al.* 1992). These issues have been particularly important in rural areas where wildlife associated with protected areas cause significant agricultural damage (Dudley *et al.* 1992, Sukumar 1995, Naughton-Treves 1998) and where they have been implicated in the spread of diseases that directly affect livestock (Yuill 1987, Aguirre *et al.* 1995, Simonetti 1995).

Bovine tuberculosis (TB) is a bacterial disease (*Mycobacterium bovis*) found in wildlife and livestock throughout much of the world, particularly in regions dominated by agriculture (Barlow 1993, Schmitt *et al.* 1997). Impacts of TB on human health and agriculture have been devastating worldwide for centuries. More than 3.5 million people die annually from TB, with *M. bovis* responsible for approximately 3% of these cases (Cosivi *et al.* 1998). Bovine tuberculosis is now quite rare in humans living in industrialized countries, because of TB control in cattle (Ayele *et al.* 2004), increased hygiene, pasteurization of milk, and improved husbandry practices. TB creates significant challenges for agriculture because apparently healthy animals can be both infected and infectious, making the disease difficult to detect and remove (Radostits *et al.* 2000). In countries where eradication of tuberculosis is the national policy such as the US and Canada, the entire herd of cattle is destroyed when individual animals test positive. Whole herd eradication is necessary due to the difficulties in correctly identifying infected individuals using existing live animal tests and there is currently no economical or efficacious treatment for individual infected cattle. While some compensation is provided, there remains considerable stress and indirect economic impacts on farm communities (Griffore and Phenice 2001). TB presents major challenges for the protection of human and animal health, economic sustainability of agriculture, and, indeed, the conservation of wildlife.

Historically, TB was much more widespread in North American cattle (*Bos taurus*), declining in prevalence from 2.3% to 0.003% in United States cattle in the period from 1916 to 1984 (Black 2004) and following a similar decline in Canada. However, TB continues to be a serious problem in a few isolated areas. The disease was confirmed in 19 cattle herds in Michigan since 1994 (Hickling 2002), 8 cattle herds in Texas (Pillai *et al.* 2000) since 1997, and 11 cattle herds in Manitoba since 1991 (Lees *et al.* 2003), as well as numerous herds in other states and provinces. TB has also been recognized as a significant problem in ranched elk (*Cervus elaphus*) and other captive wildlife (Stumpff 1982, Whiting and Tessaro 1994). While cases of TB in free-ranging wildlife in North America are generally rare, TB has recently been found in isolated groups of wild bison (*Bison bison*), elk, deer (*Odocoileus virginianus*), and a variety of carnivore species including wolves (*Canis lupus*) and coyotes (*C. latrans*) (Clifton-Hadley and Wilesmith 1991, Joly *et al.*

1998, O'Brien *et al.* 2002). It can be spread by direct contact among infected animals, airborne exposure, or through shared foods, milk, urine, and feces (Clifton-Hadley and Wilesmith 1991, Radostits *et al.* 2000).

Risks associated with and responses to TB in North America have largely been science-based and identified using epidemiological models (e.g. McCarty and Miller 1998, Pillai *et al.* 2000, Smith 2001) and managed by government-initiated efforts focused on wildlife and agriculture (e.g. Frye 1995, Lees 2004). However, studies increasingly suggest that the mitigation of wildlife-agriculture conflict improves when the perspectives of local communities and other stakeholders are included in meaningful ways (Selin *et al.* 2000), especially since the majority of wildlife habitat outside of protected areas in human dominated landscapes is often privately owned (Horvath 1976). Landowner concerns about wildlife impacts thus have broad, long-term repercussions for government programs designed to mitigate wildlife interactions on private property (Conover 1994). Indeed, excessive impacts may discourage some private landowners and other stakeholders from managing in ways that benefit wildlife (Conover 1994). There is currently a need for more comprehensive approaches for managing diseases such as TB that include models incorporating stakeholder concerns and experiences, especially those of farmers.

The overall objective of this chapter was to assess the concerns of farmers regarding the presence of TB in wildlife and livestock. More specifically, I examined TB-associated concerns relative to other issues confronting rural communities and conducted an exploratory assessment of the degree to which underlying socio-demographic and environmental variables affected TB-associated concerns. These analyses are part of a comprehensive study examining wildlife-agriculture interactions around Riding Mountain National Park.

Materials and Methods

Study Area

The study area is located in southern Manitoba, Canada and includes the agriculture-dominated area within 50 km of Riding Mountain National Park (RMNP) (Figure 5.1). It represents a broad transition zone between the prairies and the more northern Boreal Plains (Bailey 1968). Much of the region is dominated by glacial topography and is poorly drained. RMNP is 2,974 km^2 (297,746 ha) in size, extending 110 km from east to west and 60 km from north to south. It is dominated by the Manitoba Escarpment, which rises to 475 m above the surrounding, largely flat landscape. The park represents a core area of relatively undisturbed wilderness and is surrounded by land used for agriculture, which is dominated by oilseed and cereal crop, pasture and hay production, interspersed with patches of deciduous and mixed forest. Over 50,000 beef cattle are currently being raised in the region (Statistics Canada 2002). Wildlife is abundant, including a regional population of approximately 2700 elk (*Cervus elaphus*), 2500 moose (*Alces alces*), and more than 5000 deer (Riding Mountain National Park 2004, unpublished data). Large predators include grey wolves (*Canis lupus*), black bears (*Ursus americanus*), lynx (*Lynx canadensis*), and coyotes (*Canis latrans*).

Conflicts among agricultural producers and government agencies in the Greater Riding Mountain Ecosystem are particularly common on matters such as water quality, flooding, wildlife depredation and damage (Dodds and Fenton 1999), hunting seasons, resource extraction (Schroeder 1981), and disease (Brook and McLachlan 2003). Local residents often express dissatisfaction and discontent at how they have to bear costs associated with the movement of wildlife out of protected areas (Schroeder 1981, Brook and McLachlan 2003). Elk-agriculture interactions, particularly related to TB, have recently been associated with some of the most intense conflicts in the region (e.g. Seraphim 2003, Nicoll 2004). Because of the number of recent TB positive cattle herds, the Riding Mountain Eradication Area (RMEA) was created in 2003 by the Canadian Food Inspection Agency around RMNP to try to eradicate the disease through intensive livestock testing and controls on cattle movement (Figure 5.1). Manitoba's TB-free status continues to be threatened by the presence of the disease around RMNP.

Data Collection and Field Techniques

Canada Post mailing lists were used to identify all 4220 rural households within 50 km of RMNP. All households listed by Canada Post as operating a farm were mailed a questionnaire on 18 April 2002. A self-addressed, stamped envelope was enclosed with the survey to facilitate its return. A follow-up letter was sent 18 May 2002. All surveys returned prior to 31 August 2002 were included in subsequent analyses. Overall response rate was calculated by dividing the number of completed questionnaires from farm operators (n=788) by the number of surveys sent out to verified farm operators (n=3148). Study design was approved under the authorization of the Joint-Faculty Human Subject Research Ethics Board Protocol at the University of Manitoba. Seventy-five survey recipients that had not responded to the survey were telephoned and asked five questions subset from the original questionnaire to assess whether a non-response bias existed.

The questionnaire was, in part, designed to determine farmer concerns regarding TB in wildlife and livestock and to identify the influence of socio-demographic and farm management variables on these concerns. Important themes were initially identified by attending seven town hall meetings throughout the study area between January and April 2002, where comments of over 500 local agricultural producers were documented. Insights were also gained from discussions with staff from federal and provincial agencies as well as agricultural and wildlife stakeholder groups. The questionnaire was pre-tested on 15 highly knowledgeable farmers, as well as researchers and government staff. The final version was nine pages long, contained 257 data variables, and took about 30-50 minutes to complete. Respondents rated statements on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree". Farmers were also asked to provide written comments on all aspects of this survey and list any other concerns that they had. One question asked respondents to indicate the location of their farm.

Data Analysis

Farmer Socio-demographic Composition

Socio-demographic variables describing respondents in the region were summarized to characterize farmers and compare cattle producers with non-cattle producers. Data from the 2001 Agriculture Census of Canada for this region (Region 3, Division 15) (Statistics Canada 2002) were compared with survey results in order to assess the representative nature of the questionnaire data from this study using t-tests.

Regional Context of Disease Concern

In order to consider farmers' concerns regarding disease within the context of other regional concerns, factor analysis was used (unweighted least squares method, varimax rotation) to reduce the fifteen questions regarding concerns into conceptually similar groups (SAS Version 8.3, SAS Institute Inc., USA). Items were assigned to factors if the loading on the factor was at least 0.400. Scale reliability was assessed by calculating coefficient alpha (Cronbach 1951). Differences in group means of the factor scores between cattle producers and non-cattle producers were analyzed using t-tests.

Factors Underlying Farmers' Level of Concern Regarding Disease

In order to examine socio-demographic and environmental variables associated with the factor "disease concern" that was identified in factor analysis, a total of 546 surveys from farm operators with no missing responses were sorted into high, medium or low disease concern based on 33rd percentiles of factor scores. Factor scores for 182 respondents in each of the high and low categories were then used as a binary response variable in logistic regression to model the probability that concern would be high. Instead of using a null hypothesis and a single alternative hypothesis, a small meaningful set of multiple competing hypotheses were identified and compared using Akaike's information criterion (AIC) (Anderson and Burnham 2002). Formal statistical inference was based on all of the models in the set (multi-model inference) rather than on the single best model (Anderson *et al.* 2002).

Ten socio-demographic, farm, and wildlife interaction explanatory variables were selected to create a set of candidate models of disease concern. Each of these variables was hypothesized to influence meaningfully farmer's concerns regarding disease according to the literature. These independent variables were first screened for excessive collinearity using a Spearman rank correlation matrix for all possible pairs of independent variables. If any two variables had $r>0.7$, the less important variable was removed. Following Burnham and Anderson (2002), I then developed a global model that included all variables and a set of alternate models that included linear and squared terms as interaction terms between elk use, elk contact, farm size and income that I hypothesized might influence overall disease concern. In order to estimate and graph the relative probability of high disease concern, scaled values from the logistic model were used. Predicted values were standardized to a scale of 0 to 1 following Johnson *et al.* (2004). Many farmers provided the location of their farm in the survey (71%), so spatial aspects of disease concern were analyzed separately from the other independent variables. The minimum distance of each farm to the RMNP boundary and to previous TB outbreaks in wildlife and cattle was measured using Arcview GIS 3.2 (ESRI Inc., USA).

Akaike's information criterion difference with small sample bias adjustment ($\triangle AIC_c$) and Akaike weights (w) were used to evaluate and select the model that includes the fewest number of independent variables to explain the greatest amount of variation (Burnham and Anderson 2002). The model with the lowest $\triangle AIC_c$ is selected as the best from the set. Akaike weights provide a normalized comparative score for all models and are interpreted as the probability that each model is the best model of the set of proposed models (Anderson *et al.* 2000). Substantial support for a model occurs when $\triangle AIC < 2$. Cumulative AICc weights were then calculated for each independent variable thought to influence TB concern by summing the AICc model weights of every model containing that variable (Burnham and Anderson 2002). Variables with the highest cumulative AICc weights have the greatest influence on TB concern.

Qualitative Responses

Farmers were also invited to write their comments on the questionnaire, which were recorded verbatim. Responses were systematically assessed and identified with underlying themes. Comments were incorporated with the quantitative results as complementary information, in that they provide a rich description of the concerns held by farmers and the factors that influence them.

Results

Questionnaire Response

The mail surveys (n=1338) were returned by mail and the overall adjusted response rate was 25%. Questionnaires were received from 27 rural municipalities in Manitoba and one response was received from Saskatchewan. Reasons for refusing to complete the questionnaire, listed in decreasing order of importance, included: respondents did not operate a farm, frustration with government over wildlife management issues, respondents lived outside of study area, and frustration over study design. No differences in concern were identified between respondents and non-respondents.

Farmer Socio-demographic Composition

Nine socio-demographic variables were used to describe farmers in the region (Table 5.1). Slightly more than half (55%) of survey respondents had at least some cattle and 45%

had more than 20 head. Respondents averaged 52 years of age (range 18-85). The 2001 Agriculture Census of Canada for this region (Region 3, Division 15) determined average age of operators to be 50 (Statistics Canada 2002). On average, cattle producers were 3.5 years younger than non-cattle producers ($t = 3.7$; $df = 629$; $p = 0.002$). Overall, there were many more male respondents (91%) than female (9%). While 78% of farmers in the region are male (Statistics Canada 2002), farms are generally operated by both women and men working together. The large majority of respondents (92%) lived at the current location for five or more years and most (81%) were raised on a farm. The highest level of educational achievement varied, with very few having no formal education (<1%), 35% having high school education, and 40% having college, university, or technical training. The mean respondent's farm size was 467 ha (range 16-5666 ha), whereas the overall average farm size is 419 ha for this region (Statistics Canada 2002).

Regional Context of Disease Concern

Three separate factors were identified in the factor analysis that summarized the concerns of farm operators (Table 5.2). Factor 1 represents the level of concern regarding disease in wildlife and livestock, specifically TB in cattle, deer, elk, and moose, but also including concern regarding Chronic Wasting Disease (CWD). Factor 2 represents concern regarding wildlife issues, particularly those associated with elk hunting, as well as elk ranching. Factor 3 represents broader societal issues, including cuts to agricultural subsidies, grain elevator closures, and rural crime. Values of Cronbach alpha for the disease concern, wildlife issues, and societal issues factors were 0.92, 0.80, and 0.66, respectively (Table

5.2). All alpha values are >0.60, which is adequate for variable reduction (Nunnally and Bernstein 1994).

A wide range of disease concern was expressed in the factor scores (range = -3.79 to +1.53). At one extreme, one cattle producer indicated, "The reason I have no concern for TB in cattle is because the cattle industry has a program to deal with TB" (cattle producer, R311, May, 2002). In contrast, many farmers expressed extreme levels of concern regarding TB and its impacts. Another cattle producer indicated its economic ramification

> *I am very concerned about the threat of TB in our area and the economic impact on the beef industry in Manitoba if a widespread outbreak happens. I have lived my entire life on my farm and my family has raised cattle here for nearly fifty years and I do feel threatened by this TB problem north of us. We have bills to pay and debt to service, if cattle prices drop or we can't sell them because of TB in our area we will be forced out of business. I like seeing wildlife on my land, but not if they are threatening our livelihood* (cattle producer, R346, May, 2002, emphasis in original response).

Indeed, many of the written comments indicated a strong feeling that TB could irreparably damage their farm and that disease represents a new type of risk. Some farmers felt it was unlikely that TB would ever be eradicated from the region.

Overall, farmers indicated a high level of concern toward diseases in both wildlife and cattle relative to all concerns listed in the questionnaire (Table 5.2). Predictably, the mean factor score regarding level of concern associated with disease was significantly higher for cattle producers (mean = 0.07, S.D. = 1.01) than for non-cattle producers (mean = -0.08, S.D. = 0.98) (t = 3.7; df = 629; p = 0.035). For cattle producers, concern regarding TB in cattle was highest relative to all other questions retained in the factor analysis (Table 5.2). For non-cattle producers, the three social issues, rural crime, cuts in agriculture subsidies, and grain elevator closures were of greatest concern relative to the other variables, followed by all of the disease issues. All of the issues related to hunting including baiting, feeding, and the length of the hunting season scored relatively low for both cattle producers and non-producers.

The questionnaire was primarily focused on disease issues but the open-ended responses included a broad range of other concerns. One producer felt that

> *There should be better cooperation between the park and its neighbours. It is all right for the elk to come out and eat our hay and crops but we cannot take a stick of dry wood or pick a pail of cranberries (farm operator, R093, May, 2002).*

Farmers also frequently expressed concern regarding beavers (*Castor canadensis*) and their impacts. Indeed, the word "beaver" was included 141 times in the written responses, even though there were no questions about or references to beavers in the questionnaire. However, many farmers made the link between beavers and disease, suggesting that habitat inside RMNP has been significantly degraded by beavers and many felt that this is an important cause of elk movements out of the park. Other concerns included wildlife impacts from bears, geese, and coyotes. Anxiety related to all levels of government and their management actions was also readily apparent.

Factors Underlying Farmers' Level of Concern Toward Disease

I used ten independent variables (Table 5.3) from 364 responding farms to construct nine plausible models to represent aspatial factors influencing disease concern of farmers (Table 5.4). The maximum Spearman rank correlation among the ten variables used was r = 0.619 and the minimum was only r = -0.219, and so all were included in the analyses. The best model included only the frequency of elk observed on the farm (ELKUSE) as a single variable, resulting in a ΔAIC_c value of 0 (Table 5.4). Three models that included the frequency of elk observed on the farm (ELKUSE) along with perceived direct contact between elk and cattle (ELKCON) and perceived indirect contact between elk and cattle (ELKIND), as well as number of beef cattle (BEEFCATL) had moderate support relative to the top-ranked model (i.e. $\Delta AIC_c<4$).

The positive coefficient for ELKUSE indicated that farmers observing elk more frequently on their land were more likely to have higher levels of disease concern (Figure 5.2). Written responses frequently indicated that elk were considered reservoirs of disease that come out of the park and infect cattle herds. Perceiving that elk are central to the TB issue, one cattle producer indicated:

> *The Big ANIMAL in question is elk. What are we going to do with THIS animal? How are we going to stop the spread of this disease within this animal? We have to have a control of some type, monitoring, eradicating some of the animals that carry the disease or are ill. Letting the animals run free and wild is not too acceptable at this moment if they are the ones spreading this disease. Keeping them in the park is a very important factor in controlling this disease outside the park* (farm operator, R427, May, 2002, emphasis in original response).

This comment reflects the frustration and fear that farmers have about disease and suggests that wildlife may not be as welcome on some farms as they once were. It also emphasizes the attitude of many farmers that elk belong inside the park and should not be moving outside of the boundary.

Summation of the Akaike weights (Burnham and Anderson 2002, p.168) for the independent variables results in a value of 0.99 for the frequency of elk observed on the farm (ELKUSE), thus the weight of evidence strongly supports this variable as the most important (Table 5.5). The other nine variables (direct contact between elk and cattle, indirect contact between elk and cattle, gender, direct contact between deer and cattle, indirect contact between deer and cattle, age, education, size of cattle herd, and frequency of deer observed on the farm) were of minimal importance relative to the frequency of elk observations.

In response to the questions regarding the area from which farmers perceived that elk using their land came from, mean response was highest for RMNP (mean = 6.0, SE =0.13) on a scale ranging from "strongly disagree (1)" to "strongly agree (7)". In contrast, few believed these elk originated from private land on or near their farm (mean response = 3.7, SE =0.12) or from the Duck Mountains, a provincial forest and park 20 km to the north (mean response = 2.9, SE =0.12). In their comments, many respondents indicated that they tolerated or even enjoyed seeing wildlife on their land, but also suggested that this could change because of TB:

> *I don't push bush or drain water on my land and if ducks, geese, deer, coyotes and many other animals survive there that's great, but I think it would be silly and stupid to protect any species of wildlife that threatens to ruin the beef industry in Manitoba* (cattle producer, R483, April, 2002).

The feeling that wildlife were directly threatening the survival of farms was common among respondents and many felt that level of concern warranted significant action to reduce or eliminate the disease. One farmer noted that:

> *I grow and sell hay and oats for sale to the horse and cattle trade. My concern is I've had some hay sales rejected because elk and deer were in the bales. The concern was of TB risk* (farmer, R347, May, 2002).

However, the written comments also reflected a broader context to the concerns, in that they viewed disease risk within the scope of impacts on the community as a whole and on future generations. One farmer expressed great concern regarding TB, but felt that:

> *Depleting the elk population is not an option. They must be managed accordingly, so that our children's grandchildren may enjoy the presence of these wonderful creatures in a wild state* (cattle producer, R079, May, 2002).

The two spatial variables, distance to RMNP (DISRMNP) and distance to TB cases (DISTB) (Table 5.3) were used to develop five plausible spatial models using responses from the 381 farmers that included location of their farms in their responses. All of the resulting models were well supported, i.e. ΔAIC <2 (Table 5.6). Two models had ΔAIC = 0; distance to RMNP alone (DISRMNP) and distance to TB cases (DISTB) alone, indicating that both variables influence disease concern (Figure 5.2). Many cattle producers emphasized the relationship between disease risk and proximity to RMNP:

> *Farmers with livestock who live along the park are constantly worried about their animals as elk and deer eat their bales along with their cattle. There is always the risk that the elk and deer may be disease carriers* (cattle producer, R493, May, 2002).

Many respondents indicated that the threat is so serious that their perceptions regarding disease and wildlife are unlikely to change in the future.

Discussion

The results of this study suggest that both cattle producers and non-producers are greatly concerned about disease in livestock (66% of respondents) and wildlife (64% of respondents). Cattle producers were more concerned, in large part because they are more directly threatened by TB, since any infected livestock herd must be destroyed in its entirety. Understanding the subjective nature of perceptions of disease, and the risk that diseases represent, is particularly important in the Riding Mountain region because of the low level of disease and high level of concern. The likelihood of any single cattle farm becoming infected is < 1% per year (Lees *et al.* 2003), yet the impact on any farm testing positive is severe. Farmers are compensated by the federal government with the market value of the cattle if they are destroyed, but the financial and emotional impacts of testing positive remain extremely high. There is typically a significant delay of several months between testing positive for TB and receiving compensation. There are also important indirect impacts related to financial costs of lost sales of forage crops and other livestock from this region due to fear that these products may also carry disease. Of particular concern is the impact of TB positive livestock on Manitoba's TB-free status, which has important implications for national and international beef sales (Lees 2004). Similarly, in Michigan, 58% of livestock producers agreed or strongly agreed that TB in deer is a serious threat to the health of Michigan cattle herds (Dorn and Mertig 2002). Predictably, livestock producers are the most concerned about TB in cattle and hunters are the most concerned about TB in deer (Dorn and Mertig 2002).

The occurrence of positive test results for TB in elk, deer, and cattle near each other and close to the RMNP boundary has intensified concerns that TB is spreading between wildlife and domestic animals and that RMNP is acting as a disease reservoir (e.g., Sopuck 2002). Farmers that see elk more frequently on their farms, those that feel that the elk are coming into direct and indirect contact with cattle, and those that are located close to RMNP and to previously identified TB cases in wildlife and livestock have the highest concern regarding disease. However, it is also important to note that farmer concerns vary widely regarding these impacts and regarding the role of governmental agencies in managing this problem. These results emphasize that farmers cannot be assumed to have a common set of concerns. It is also critical to recognize that these concerns exist within the social and cultural context (Douglas 1985). That context includes a long history with decades of conflict with Parks Canada, and the provincial government regarding natural resource and wildlife issues related to ungulate crop damage, beaver flooding, bear baiting, and hunting regulation (Schroeder 1981, Dodds and Fenton 1999, Brook and McLachlan 2003). Concerns were often associated with anxiety about centralized federal and provincial government decision-making, lack of trust, difficulty in accessing relevant information, and a general sense that decisions were made with little or no farmer input.

National park managers are beginning to realize the strategic value of having good relationships with the people living along their borders (Hough 1988, Schonewald-Cox *et al.* 1992, Parks Canada Agency 2000). However, TB in and around RMNP has emerged in the last decade as an issue that has had serious and adverse impacts on relationships between farmers and the park. Many of the respondents considered the park to be the source of the elk coming onto their farms and believed these elk to be the primary reservoir and vector of TB. This may have long-term ramifications for conservation practices and how wildlife is valued in this region. If these concerns are not adequately addressed, farmers may ultimately conclude that elk and other wildlife are incompatible with farming priorities (Simonetti 1995). Indeed, some farmers around RMNP have called for fencing of the park boundary to keep the wildlife in, and/or the total eradication of elk in order to reduce the risk of TB transmission to cattle (Brook and McLachlan 2003). It has been a point of considerable frustration for many farmers around RMNP that their cattle herds are destroyed if they test positive for TB, yet Parks Canada refuses to eliminate the elk population within RMNP even though it is known to be infected. Conservation attitudes of local people living near protected areas are strongly influenced by their experiences with wildlife (Newmark *et al.* 1993, Conover 2001) and their long-term experiences with management actions that influence wildlife. Since agricultural producers control the majority of wildlife habitat in rural landscapes outside of protected areas, their attitudes toward wildlife can substantially influence the quality and quantity of existing habitat (Horvath 1976) and ultimately the regional viability of these wildlife populations.

Research on risk perception emphasizes that concerns may not be about the objective nature of the risk itself (Douglas 1985, Short 1984, Tesh 2000) and thus, reducing the probability of impact may not diminish concern. Any attempts to characterize, compare, and regulate risks should recognize the broader issues that collectively influence farmer concerns. Indeed, concern regarding TB may actually be a surrogate for other social or ideological concerns (Slovic 2001). Many farmers feel that TB infected elk emanate from RMNP and are the source of the problem. At the same time, many feel that the park is a direct source of other wildlife species such as beaver, black bear, geese, coyotes, and wolves that have significant impacts on their farm operations and in many cases create fears for personal health and safety (Schroeder 1981, Menzies 1998, Dodds and Fenton 1999). Relationships between farmers and the park are also influenced by park-directed changes in management practices that have adversely affected producers, these including the banning of haying, cattle grazing, and logging inside the park, and the re-introduction of beavers (Schroeder 1981). Concerns regarding TB cannot be reduced without understanding and managing these broader issues.

Conclusions and Management Implications

Diseases like bovine TB have important implications for protected areas because they carry significant impacts, particularly for those people living nearby. Some diseases such as brucellosis continue to be a dominant issue after many decades, and affect elk and bison in Yellowstone (Meagher and Meyer 1994) and bison in Wood Buffalo National Parks (Joly *et al.* 1998). Chronic Wasting Disease (CWD) has emerged as an important wildlife disease across North America (Miller 2003) and farmers and rural communities in Canada are currently being devastated by a single occurrence of Bovine Spongiform Encephalopathy (BSE) (Leiss 2004). These disease issues are further negatively influenced by the globalization of the rural economy, increasing farm sizes, climate change, and rural depopulation (e.g. Hinrichs and Welsh 2003). In these rural landscapes, the level of support for protected areas will ultimately be determined by their combined economic and social benefits and costs (Wells *et al.* 1992, Simonetti 1995) as well as the overall social and economic conditions of farmers and their communities.

The long-term viability of protected areas and the wildlife species that use them are dependent on the attitudes and actions of local residents. If TB persists in wildlife and livestock, support for wildlife and protected areas will likely decrease, as will attitudes toward conservation programs aimed at enhancing wildlife habitat and establishing corridors. More intensive pressure to eliminate the Riding Mountain elk population is also an immediate concern. The severe reduction or extirpation of the elk would have broad impacts on local economies as well as ecosystem processes, including reducing grazing and browsing pressure, and eliminating the primary food supply of the wolf population (Estes 1996).

In order to effectively manage TB and reduce farmer concerns, effective partnerships are needed among producers, federal and provincial wildlife and agriculture government agencies, universities, and other stakeholders. These can develop research priorities, risk management strategies, and best practices that meaningfully reduce the likelihood of and stress associated with disease transmission. This approach would facilitate the exchange of skills and knowledge between producers and other stakeholders, while ensuring that these best practices reflect local concerns. In Riding Mountain, the establishment of the TB Stakeholders Advisory Committee (TBSAC) in 2003 represents an important step toward increased communication and cooperation. However, even more encompassing discussions with producers and federal and provincial government funding support will ultimately be required to effect meaningful change because most farmers still feel marginalized from the TB management process and many demand a greater role in decision-making. Modelling efforts to assess the distribution of disease and risks of future transmission should explicitly incorporate the knowledge base and concerns of farmers, acknowledging that there is a strong distinction between "objective" measures of risk (such as epidemiological estimates of disease prevalence) and subjective measures of disease concern (such as risk perception and acceptability of management actions) (Brook and McLachlan 2003).

Better access to information about TB will help farmers reduce their vulnerability to disease. Of particular importance is communicating the ways that TB can be transmitted between elk and cattle. A better understanding of the environmental and farm management variables that influence elk use of the landscape would also help farmers understand the risks involved and help identify best practices appropriate for their operation. For example, farmers indicated a high level of concern regarding baiting and feeding of wildlife. Despite these concerns, a few landowners, some of which are cattle producers, continue to bait and feed elk and deer to increase hunting opportunities. These practices increase elk use of their farms and may inadvertently increase elk concentrations on neighbouring farms and facilitate contact between wildlife and cattle (Brook and McLachlan 2003). Farmers can reduce their vulnerability to TB by eliminating baiting and feeding, which would be facilitated by better communication, as well as more intensive enforcement of the regulations on the part of government. Communication efforts should first be focused in areas directly adjacent to RMNP where concern is generally higher. Greater cooperation and multi-way communication among farmers, government agencies, and other stakeholder will help identify and implement strategies to reduce the risk of TB transmission. In particular, this will help improve the overall relationship between farmers and RMNP, this being an identified priority for national parks in Canada (Parks Canada Agency 2000). As farmers become more aware of TB and its modes of transmission and adapt their farming practices to minimize their vulnerability, their level of concern toward TB may decrease. Ultimately, though, farmers and other stakeholders have to be actively involved in decision-making regarding the disease if it is to be effectively managed in the future.

Literature Cited

Aguirre, A. A, E. E. Starkey, and D. E. Hansen. 1995. Wildlife diseases in national park ecosystems. Wildlife Society Bulletin 23:415-419.

Anderson, D. R., K. P. Burnham, and W. L. Thompson. 2002. Null hypothesis testing: problems, prevalence, and an alternative. Journal of Wildlife Management 64:912-923.

Anderson, D.R. and K. P. Burnham. 2002. Avoiding pitfalls when using information-theoretic methods. Journal of Wildlife Management 66:912-918.

Ayele, W.Y., S. D. Neill, J. Zinsstag, M. G. Weiss, and I. Pavlik. 2004. Bovine tuberculosis: an old disease but a new threat to Africa. International Journal of Tuberculosis and Lung Disease 8:924-937.

Bailey, R. H. 1968. Notes on the vegetation of Riding Mountain National Park, Manitoba. National Parks Forest Survey No. 2. Department of Forestry and Rural Development, Ottawa, Ontario, Canada.

Barlow, N. D. 1993. A model for the spread of bovine TB in New Zealand possum populations. Journal of Applied Ecology 30:156-164.

Black, N. 2004. Animal health: a century of progress, Tuberculosis. United States Animal Health Association. Available on the Internet. URL: http://www.usaha.org/history/chapter4.html. Accessed January 2005.

Brook, R.K., and S. M. McLachlan. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. A Report to Manitoba Agriculture, Food, and Rural Initiatives. University of Manitoba, Winnipeg, Manitoba, Canada.

Brook, R.K. and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 80:156-166.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. Springer-Verlag, New York, USA.

Clifton-Hadley, R. S. and J. W. Wilesmith. 1991. Tuberculosis in deer: a review. The Veterinary Record, July 6.

Conover, M. R.1994. Perceptions of grass-roots leaders of the agricultural community about wildlife damage on their farms and ranches. Wildlife Society Bulletin 22:94-100.

Conover, M. R.2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29:521-532.

Cosivi, O., J. M. Grange, C. J. Daborn, M. C. Raviglione, T. Fujikura, D. Cousins, R. A. Robinson, H. F. A. K. Huchzermeyer, I. de Kantor, and F. X. Meslin. 1998. Zoonotic tuberculosis due to *Mycobacterium bovis* in developing countries. Emerging Infectious Diseases 4:59–70.

Cronbach, L. J.1951. Coefficient alpha and the internal structure of tests. Psychometrika 16:297-334.

Dodds, G., and G. Fenton. 1999. A consensus approach to management planning: an evaluation of effectiveness for Riding Mountain National Park, Manitoba, Canada. Proceedings of the 10th Conference on Research and Resource Management in Parks and on Public Lands.

Dorn, M. L. and A. G. Mertig. 2002. Bovine tuberculosis in Michigan: 2000-2001 Stakeholder Survey: A report to the Michigan Department of Natural Resources Wildlife Division. Michigan State University East Lansing, Michigan, USA.

Douglas, M. 1985. Risk acceptability according to the social sciences. New York, Russell Sage Foundation.

Dudley, J. P., A. Y. Mensah-Ntiamoah, and D. G. Kpelle. 1992. Forest elephants in a rainforest fragment: preliminary findings from a wildlife conservation project in

Estes, J. A. 1996. Predators and ecosystem management. Wildlife Society Bulletin 24:390-396.

Forbes, G. J. and J. B. Theberge. 1996. Cross-boundary management of Algonquin Park wolves. Conservation Biology 10:1091-1097.

Frye, G. H.1995. Bovine tuberculosis eradication: the program in the United States, in: C. O. Thoen and J.H. Steele (Eds). *Mycobacterium bovis* infection in animals and humans, Iowa State University Press, Ames, IA. pp. 119-124.

Griffore, R. J. and L. A. Phenice. 2001. Bovine Tuberculosis: The perspective of farm families. Michigan State University. East Lansing, Michigan, USA.

Herrero, S. 1994. The Canadian National Parks and grizzly bear ecosystems: The need for interagency management. International Conference on Bear Research and Management 9:7-21.

Hickling, G. J. 2002. Dynamics of bovine TB in wild whitetail deer in Michigan. Michigan Department of Natural Resources, Wildlife Division Report No. 3363.

Hill, C. M. 1998. Conflicting attitudes towards elephants around Budongo Forest Reserve, Uganda. Environmental Conservation 25:244-250.

Hinrichs, C. C. and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.

Horvath, W. J. 1976. Habitat programs and recreation opportunities on private agricultural land: opportunities and constraints. Transactions of the North American Wildlife and Natural Resources Conference 41:504-512.

Hough, J. 1988. Obstacles to effective management of conflict between national parks and surrounding human communities in developing countries. Environmental Conservation 15:129-136.

Janzen, D. H. 1983. No park is an island: increase in interference from outside as park size decreases. Oikos 41:402-410.

Johnson, C. J., D. R. Seip, and M. S. Boyce. 2004. A quantitative approach to conservation planning: using resource selection functions to map the distribution of mountain caribou at multiple spatial scales. Journal of Applied Ecology 41:238-251.

Joly, D. O., F. A. Leighton, and F. Messier. 1998. Tuberculosis and brucellosis infection of bison in Wood Buffalo National Park, Canada: preliminary results, in: L. Irby (Ed.), Proceedings of the International Symposium on Bison Ecology and Management in North America, June 1997, Bozeman, Montana, pp. 23-31.

Lees, V. W., S. Copeland, and P. Rousseau. 2003. Bovine tuberculosis in elk (*Cervus elaphus manitobensis*) near Riding Mountain National Park, Manitoba, from 1992 to 2002. Canadian Veterinary Journal 44:831.

Lees, V. W. 2004. Learning from Outbreaks of Bovine Tuberculosis near Riding Mountain National Park: Applications to a Foreign Animal Disease Outbreak. Canadian Veterinary Journal 45:28-34.

Leiss, W. 2004. The mismanagement of BSE risk in Canada. Alberta Beef 44:35-39.

McCarty, C. W. and M. W. Miller. 1998. A versatile model of disease transmission applied to forecasting bovine tuberculosis dynamics in white-tailed deer populations. Journal of Wildlife Diseases 34:722-730.

Meagher, M. and M. E. Meyer. 1994. On the origin of brucellosis in bison of Yellowstone National Park: A review. Conservation Biology 8:645-653.

Menzies, C. E. L., 1998. Cooperative beaver management in the Riding Mountain Biosphere Reserve, Manitoba. Practicum. University of Manitoba, Winnipeg, Manitoba, Canada.

Miller, C. A. 2003. Hunter perceptions and behaviours related to Chronic Wasting Disease in Northern Illinois. Human Dimensions of Wildlife 8:229-230.

Naughton-Treves, L. 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conservation Biology 12:156-168

Newmark, W. D. 1985. Legal and biotic boundaries of western North American national parks: a problem of congruence. Biological Conservation 33:197-208.

Newmark, W. D, N. L. Leonar, H. I. Sariko, and D. M. Garnassa. 1993. Conservation attitudes of local people living adjacent to protected areas in Tanzania. Biological Conservation 63:177-183.

Nicoll, G. 2004. Most elk leaving the park at farmers' invitation. Farmers' Independent Weekly April 8, 2004, 10.

Nunnally, J. C. and I. H. Bernstein. 1994. Psychometric theory. 3rd Edition. New York, McGraw-Hill.

O'Brien, D. J., S. M. Schmitt, J. S. Fierke, S. A. Hogle, S. R. Winterstein, T. M. Cooley, W. E. Moritz, K. L. Diegel, S. D. Fitzgerald, D. E. Berry, and J. B. Kaneene. 2002. Epidemiology of *Mycobacterium bovis* in free-ranging white-tailed deer, Michigan, USA, 1995-2000. Preventative Veterinary Medicine 54:47-63.

Parks Canada Agency. 2000. "Unimpaired for Future Generations"? Protecting Ecological Integrity with Canada's National Parks. Vol. I "A Call to Action." Vol. II. "Setting a New Direction for Canada's National Parks." Report of the Panel on the Ecological Integrity of Canada's National Parks. Ottawa, Ontario, Canada.

Pillai, S. D., K. W. Widmer, L. J. Ivey, K. C. Coker, E. Newman, S. Lingsweiler, D. Baca, M. Kelley, D. S. Davis, N. J. Silvy, and L. G. Adams. 2000. Failure to identify non-bovine reservoirs of *Mycobacterium bovis* in a region with a history of infected dairy-cattle herds. Preventative Veterinary Medicine 43:53-62.

Radostits O. M, C. C. Gay, D. C. Blood, and K. W. Hinchcliff. 2000. Veterinary medicine: A textbook of the diseases of cattle, sheep, pigs, goats and horses, 9th ed. London: WB Saunders.

Schmitt, S. M., S. D. Fitzgerald, T. M. Cooley, C. S. Bruning-Fann, L. Sullivan, D. Berry, T. Carlson, R. B. Minnis, J. B. Payeur, and J. Sikarskie. 1997. Bovine tuberculosis in free-ranging white-tailed deer from Michigan. Journal of Wildlife Diseases 33:749-758.

Schonewald-Cox, C., M. Buechner, R. Sauvajot, and B. Wilcox. 1992. Cross-boundary management between national parks and surrounding lands: a review and discussion. Environmental Management 16:273-282.

Schroeder, R. E., 1981. Factors contributing to resource conflict: a study of Riding Mountain Park in its regional setting. Practicum, University of Manitoba, Winnipeg, Manitoba, Canada.

Sekhar, N. U., 2003. Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India. Journal of Environmental Management 69:339-347.

Selin, S. W., M. A. Schuett, and D. Carr. 2000. Modeling stakeholder perceptions of collaborative initiative effectiveness. Society and Natural Resources 13:735-745.

Seraphim, T. 2003. Producers tell committee about bovine TB concerns. Dauphin Herald August 1, 2003, A14.

Shafer, C. L. 1999. US national park buffer zones: historical, scientific, social, and legal aspects. Environmental Management 23:49-73.

Short, J. F. Jr. 1984. The social fabric at risk: toward the social transformation of risk analysis. American Sociological Review 49:711-725.

Simonetti, J. A., 1995. Wildlife conservation outside parks is a disease-mediated task. Conservation Biology 9:454-456.

Slovic, P., 2001. The perception of risk. Earthscan, London, England, United Kingdom.

Smith, G. C. 2001. Models of *Mycobacterium bovis* in wildlife and cattle. Tuberculosis 81:51-64.

Sopuck, R. D. 2002. Bovine TB crisis at Riding Mountain: spread of disease from elk to cattle creates a wide-ranging threat. Winnipeg Free Press, November 23:7.

Statistics Canada. 2002. 2001 census of agriculture: farm data and farm operator data. Unpublished Statistics Canada Report.

Stumpff, C. C. 1982. Epidemiological study of an outbreak of bovine TB in confined elk herds. Proceedings of the US Animal Health Association 86:524-527.

Sukumar, R. 1995. Elephant raiders and rogues. Natural History 104:52-61.

Tesh, S. N. 2000. Uncertain hazards: environmental activists and scientific proof. Cornell University Press, Ithaca, New York.

Yuill, T. M. 1987. Diseases as components of mammalian ecosystems: Mayhem and subtlety. Canadian Journal of Zoology 65:1061-1066.

Wells, M., K. Brandon, and L. Hannah. 1992. People and parks: Linking protected area management with local communities. World Bank Publications, Washington, D.C., USA.

Whiting, T. L. and S. V. Tessaro. 1994. An abattoir study of tuberculosis in a herd of farmed elk. Canadian Veterinary Journal 35:497-501.

Table 5.1. Comparison of socio-demographic characteristics of cattle producers and non-cattle producers on farms area (% of each category for each variable) based on results of the 2002 mail survey.

Variable	Cattle Producers (n=444)	Non-Cattle Producers (n=340)	All Farmers Combined (n=784)
Gender			
Males (%)	91	90	91
Females (%)	9	10	9
Mean Age			
>55 years	41	51	40
40-55 years	44	37	45
<40 years	15	12	15
Income from farming			
>60 % of total	69	49	60
30-60 % of total	22	20	21
<30 % of total	9	31	19
Education			
college/university	40	45	43
high school	41	33	38
grade school	18	21	20
Farm Size (ha)			
>500 ha	36	23	31
100-500 ha	54	47	51
<100 ha	10	30	18
Cattle Herd Size			
>100 cattle	28	n.a.[a]	28
40-100 cattle	36	n.a.	36
<40 cattle	35	n.a.	35
Distance to RMNP			
>20 km	38	35	40
10-20 km	21	25	23
<10 km	41	40	40
Location Raised			
Farm	92	87	86
non-farm	8	13	14
Hunting Days On Farm			
>50 days	11	12	12
1-50 days	58	46	53
0 days	30	42	35

[a]Not applicable

Table 5.2. Variable reduction of farmer's concerns toward a range of regional issues using factor analysis based on responses to the 2002 mail survey.

FACTOR	Cronbach alpha	Variable	Mean Scores[a] Cattle Producers (s.d.) (n=444)	Mean Scores[a] Non-Cattle Producers (s.d.) (n=340)
Disease	0.92	TB in Cattle	5.9 (1.7)	5.5 (1.8)
		TB in WILD ELK	5.7 (1.8)	5.5 (1.8)
		TB in DEER	5.7 (1.8)	5.5 (1.8)
		Chronic Wasting	5.6 (1.8)	5.6 (1.8)
		TB in CAPTIVE ELK	5.5 (1.9)	5.5 (1.8)
		TB in MOOSE	5.2 (2.0)	5.3 (1.8)
Wildlife	0.80	ELK Baiting by	5.0 (2.2)	4.9 (2.1)
		ELK Ranching	4.7 (2.3)	4.5 (2.2)
		Feeding ELK	4.5 (2.1)	4.2 (1.9)
		Length of Elk hunt	4.2 (2.0)	4.3 (1.9)
		Number of Elk	4.1 (2.0)	4.1 (2.0)
Societal	0.66	Rural Crime	5.8 (1.6)	5.9 (1.6)
		Cuts in Ag Subsidies	5.7 (1.9)	5.9 (1.8)
		Grain elevator	5.6 (1.9)	5.9 (1.7)

[a]Scores were derived from a 7-point scale, with 1 indicating "no concern" and 7 indicating "extremely high concern".

Table 5.3. Spatial and aspatial explanatory variables used in developing the set of models to examine TB concern.

Abbreviation	Variable
GENDER	gender of respondent (male, female)
ELKCON	elk direct physical contact with cattle on the farm (yes, no)
ELKIND	elk indirect contact with cattle on the farm through shared feed (yes, no)
DEERCON	deer direct physical contact with cattle on the farm (yes, no)
DEERIND	deer indirect contact with cattle through shared feed (yes, no)
AGE	age of respondent (years)
EDUCAT	level of education (grade school, high school, college/university)
BEEFCATL	size of cattle herd (0, 1-20, 21-40, 41-60, 61-80......>160)
ELKUSE	elk observations over last 5 years (never, rarely, ..regularly all years)
DEERUSE	deer observations over last 5 years (never, rarely, ..regularly all years)
DISRMNP[a]	minimum distance from farm to RMNP (km)
DISTB[a]	minimum distance to a TB positive wildlife or livestock case (km)

[a]Spatial variables

Table 5.4. Number of model parameters, differences in Akaike information criterion (Δ-AIC_c), and AIC_c weights (w) for candidate aspatial models developed for farmer concern regarding disease around Riding Mountain National Park from the farmer responses to the 2002 mail survey.

Model Structure	-2Log(L)	k	Δ-AIC_c	AIC_c w
ElkUse	489.593	2	0.0	0.586
ElkCon+ElkInd+ElkUse+BeefCattle	486.409	5	2.8	0.143
$ElkUse^2$ +ElkInd+ElkUse* ElkCon	484.512	6	2.9	0.136
$ElkCon^2$ +ElkInd+ElkUse	486.59	5	3.0	0.131
ElkCon+ElkInd+DeerCon+DeerInd+ElkUse+DeerUse+Age +Gender +Education+BeefCattle	482.437	11	10.8	0.003
ElkInd	502.718	2	13.1	0.001
ElkCon	504.611	2	15.0	<0.001
Age+Gender+Education+BeefCattle	502.947	5	19.4	<0.001
DeerCon+DeerInd+DeerUse+Age +Gender+Education+BeefCattle	498.914	8	21.3	<0.001

Table 5.5. Cumulative AICc[a] weights (*w*) for all ten independent variables hypothesized to influence farmer concern regarding TB around Riding Mountain National Park based on the 2002 mail survey.

Variable[b]	Cumulative AICc weight[c]
ELKUSE	0.99
ELKIND	0.07
ELKCON	0.07
DEERCON	0.07
DEERUSE	0.06
EDUCAT	0.06
DEERIND	0.06
GENDER	0.06
AGE	0.06
BEEFCATL	0.06

[a] AICc = Akaike's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).
[b] Variables are described in table 3.
[c] Cumulative AICc weight of a variable = the percent of weight attributable to models containing that particular variable and is calculated by summing the AICc model weights of every model containing that variable.

Table 5.6. Number of model parameters, differences in Akaike information criterion (AIC_c Δ), and AIC_c weights (w) for candidate spatial models developed for farmer concern regarding disease around Riding Mountain National Park from the 2002 mail survey.

Model Structure	*-2Log(L)*	K	AIC_c Δ	AIC_c w
DISRMNP	351.90	2	0.0	0.437
DISTB	351.86	2	0.0	0.445
DISRMNP+ DISTB	350.46	3	0.6	0.330
DISRMNP*DISTB	352.11	3	2.3	0.145
$DISRMNP^2$*DISTB	351.31	4	3.4	0.080

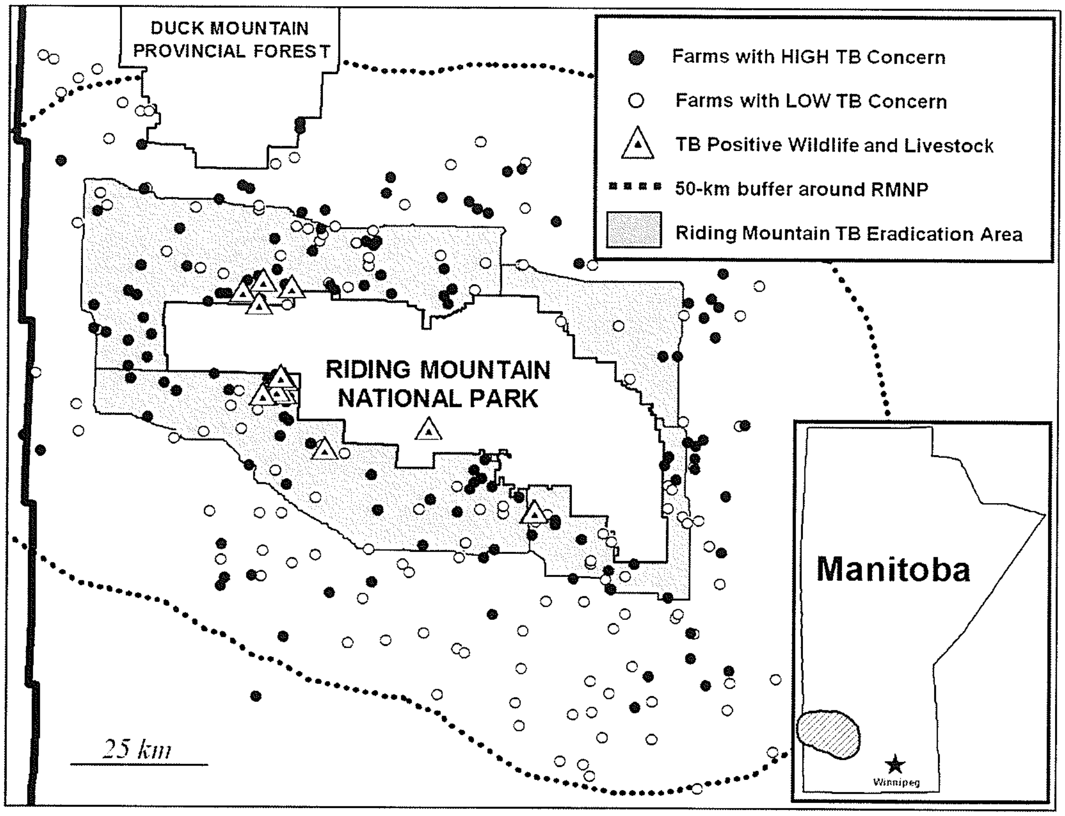


Figure 5.1. The study area including distribution of farm respondents to the 2002 mail survey and TB positive wildlife and livestock relative to Riding Mountain National Park, Manitoba, Canada.

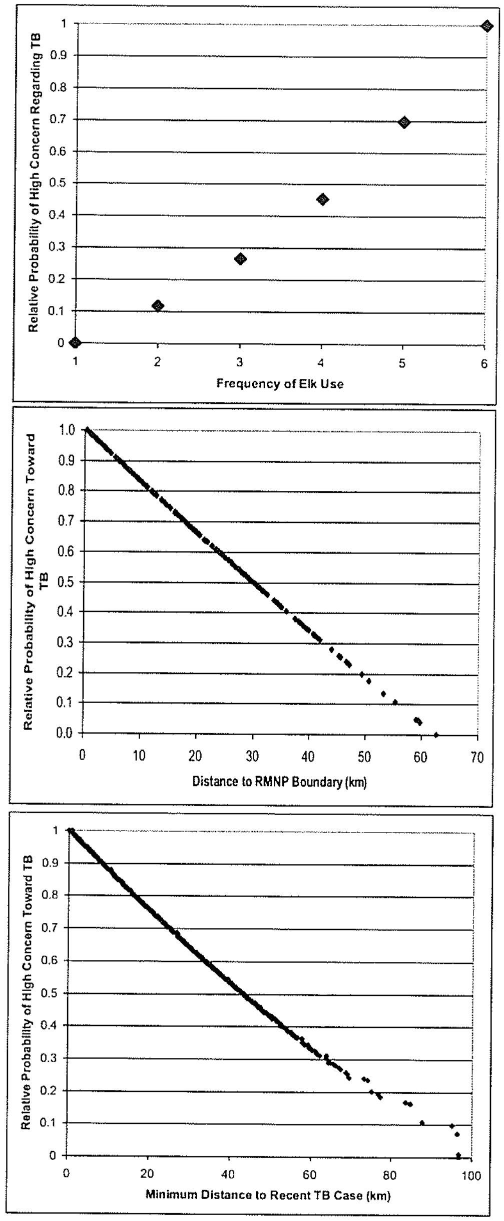
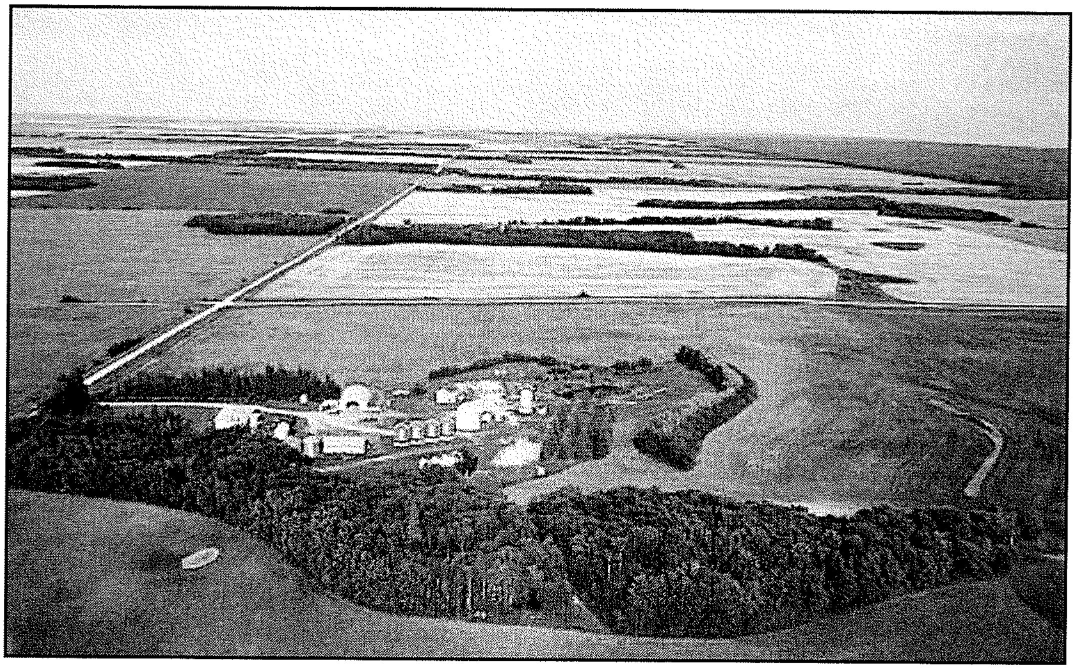


Figure 5.2. Relationship between relative probability of high level of concern regarding TB and (a) frequency of elk use of respondent's farm; (b), distance of the respondent's farm to the RMNP park boundary; and (c)distance of the respondent's farm to the nearest case of TB in livestock or wildlife in the last 15 years. Each figure represents the modeled results using the beta-coefficients that were obtained from the best logistic regression model describing factors influencing farmers' concern regarding TB (Tables 5-3, 5-4 and 5-6).

CHAPTER 6

RETHINKING THE CULTURE OF CORRIDORS:

LINKING UNGULATE AND CARNIVORE HABITAT TO FARMER ATTITUDES AND ACTIONS WITHIN THE AGRICULTURAL MATRIX OF A BIOSPHERE RESERVE



"When elk and wolves enter my property, they don't leave. I encourage my neighbors to kill all wildlife that come onto their farm since they can get away with it."

- Cattle Farmer living in the Riding Mountain-Duck Mountain Corridor

"I have enjoyed having wildlife on and around my land for many years and would like this way of life preserved for the future."

- Cattle Farmer living in the Riding Mountain-Duck Mountain

Chapter Summary

While the importance of landscape connectivity is well established in conservation biology and the value of habitat corridors has considerable support, much less is known about the role of the motivations and behaviour of residents living within these corridors and the adjacent matrix in human-dominated landscapes. I argue that corridor research that focuses solely on habitat ultimately fails to characterize the important drivers of success or failure; the attitudes and actions of humans. At the same time, human dimensions research that ignores the biophysical aspects of wildlife movements and survival are equally limited in their contribution to conservation. Corridors having large areas of intact forest cover but with residents that dislike wildlife and kill all that are seen on their land can create sinks, while landscapes that have relatively poor habitat connectivity but include landowners who value wildlife and allow most or all to survive can be important areas for wildlife movements.

Introduction

Maintaining linkages within human modified landscapes through the establishment or maintenance of habitat corridors are now of central importance in conservation as an approach to facilitating wildlife movement among habitat patches at local, regional, and continental scales (Noss 2003, Chetkiewicz *et al.* 2006). The concept of corridors is based on the widely accepted belief that habitat connectivity is necessary to ensure metapopulations of wildlife in the face of human modification and fragmentation of the landscape (Diamond 1975, Meffe and Carroll 1997, Dixon *et al.* 2006). Without efforts to establish corridors, it is often suggested that animals will be unwilling or unable to travel through, or survive in, the 'hostile' matrix of human dominated landscapes (Zollner 2000). Metapopulation theory suggests that these smaller isolated populations are inherently vulnerable to extinction (Hanski 1999).

Most large mammal populations are indeed susceptible to the diverse negative impacts associated with human activity and associated habitat fragmentation (Hewison *et al.* 2001, Crooks 2002). Direct loss of native habitats can reduce or eliminate access to forage or hiding cover from predators and the habitat change may introduce new predators. But perhaps more important are the disturbances and mortalities associated with exposure to human activities such as hunting, trapping and vehicle traffic (Caro 1999, Setsaas *et al.* 2007). These human activities result in direct mortalities but also, like conventional predation risks, divert both time and energy from feeding and reproduction (Walther 1969, Frid and Dill 2002). Sufficiently large protected areas can provide important refugia from these human impacts and corridors are arguably the most accepted approach to connecting these isolated patches, since few protected areas are large enough to function as intact ecosystems (McNeely 1994, Beier and Noss 1998). While habitat corridors have been generally viewed as providing a route of movements and dispersals, effective corridors may also function as important parts of the annual home range of some individual animals. However, an important criticism of corridors is that they can function as population sinks (Pulliam 1988, Simberloff and Cox 1987).

Within corridors and the associated matrix of human-dominated landscapes, survival of wildlife species is largely determined by the attitudes and actions of the resident human population (Brook et al. 2003, Mascia *et al.* 2003). Human decisions to kill or not kill wildlife, choices of farming techniques, and actions to improve or destroy habitats ultimately determine the success or failure of corridors. However, the biophysical characteristics of the landscape do influence wildlife movements and survival and interact with the social conditions in complex, but poorly understood ways. As a result, it is essential to develop approaches that simultaneously incorporate both ecological aspects of corridor structure and function and the social aspects of corridor use, including the values, attitudes, and concerns of the resident people. There have been several studies that examine the conservation attitudes and actions of people living in and near habitat corridors (e.g. Infield 1988, Badola 1998) and there have been recent discussions promoting the importance of incorporating human dimensions into conservation biology research (Jacobson and McDuff 1998, Nyhus *et al.* 2002, Thornhill 2003). Indeed, Mascia *et al.* (2003) suggest that the question ". . . is not *whether* to integrate the social sciences into conservation but *how* to do so."

Despite the many important discussions that have occurred regarding the relevance and importance of social sciences in conservation, I have been unable to locate any articles related to corridors that bring the suggestions made thus far into practice and quantitatively or qualitatively link conservation biology with human dimensions using empirical research. Indeed, relatively few publications within the entire conservation literature use social and ecological data together (except see Forester & Machlis 1996, Czech *et al.* 2005, Portman 2007).

My main objective in this study was to examine the combined influences of habitat and human attitudes and actions on ungulate and wolf use of corridors and the matrix within human dominated landscapes and assess the relative contribution of these social and biological aspects. I also wanted to assess the similarities and differences in the attitudes toward and habitat use of four different species, wolves, elk, deer, and moose. I then applied this integrated information to identify areas that are effective habitat corridors and assess the social variables that allow us to understand better the 'culture corridors' where local support is high for wildlife survival and dispersal between protected areas may occur.

Study Area

This study was conducted in an agriculture-dominated area of southwestern Manitoba, Canada that is currently 70% privately owned farmland (Brook and McLachlan 2003). Two large protected areas dominated by deciduous and mixed deciduous-coniferous forest, Riding Mountain National Park (RMNP) (2,974 km^2) and Duck Mountain Provincial Forest (DMPF) (3,756 km^2) are embedded within this agricultural matrix. There are approximately 30,000 residents throughout the study area in small towns and on farms. A small number of roads and highways run through the protected areas, but the surrounding farmland is a dominated by a complex network of roads and highways. Although the two protected areas were once connected by more extensive forest cover and native grasslands, agricultural development since 1880 has converted much of this into farmland (Walker 2001).

All hunting has been banned within RMNP since 1930, but all species of ungulates are harvested regularly on adjacent farmland and within DMPF by licensed sport hunters in the fall and winter and by Aboriginal subsistence hunters throughout the year. Since 2001, wolf hunting has not been allowed in areas that surround RMNP, but landowners may shoot wolves in defence of property (Stronen *et al.* 2007). There is an annual wolf-hunting season in and around DMPF and wolves are trapped on registered trap lines within DMPF.

The abundance and distribution of ungulates and carnivores within the study area is not well understood, but ungulate winter surveys are conducted annually in and near RMNP and sporadically within and near DMPF and these indicate that there are populations of elk, deer, and moose and these all make at least some use of the adjacent farmlands (Riding Mountain National Park and Manitoba Conservation, unpublished data). Observations and track counts from RMNP and trapper data from DMPF indicate that wolves are abundant in both areas, though a regional population estimate has never been made (Riding Mountain National Park and Manitoba Conservation, unpublished data).

Methods

Assumptions and Definition of Corridors

There is much discussion and disagreement about how corridors should be defined and evaluated, but for the purposes of this study I consider a corridor to be any space that facilitates the movements and survival of a particular wildlife species over time. The time of these movements can include short periods of minutes, hours, or days; or longer periods of years and multiple generations. My definition of corridor includes both the conventional type that links two otherwise disjunct habitat patches or protected areas, as well as corridors that extend out from a single patch but do not serve a connective function. These may also include continuous corridors and stepping-stone corridors. I then make five key assumptions about these corridors:

1. Effective corridors within human dominated landscapes are determined by some combination of the habitat characteristics (e.g. forage value, hiding cover, connectivity) and the attitudes and actions of the resident human population (e.g.

hunting, trapping, road kills, farm management practices) that influence mortalities, habitat choice and disturbance levels.

2. Species differ in their tolerance of human activity and many receive at least some benefits from associating with human dominated landscapes (e.g. agricultural crops, planted forest cover), but they may also be exposed to impacts that disturb and displace individual animals (e.g. vehicle activity). Conventional least-cost approaches to evaluating corridors fail to incorporate the benefits provided by human activity. Variables that negatively affect one species may be of benefit or of no importance to another.
3. The quality of any individual patch within a corridor is directly related to the frequency that it is used by an animal, combined with the likelihood of that animal being killed there. Corridors are only effective when they facilitate animal movements without also facilitating excessive mortalities.
4. On privately owned land, the quality of the habitat and the types of potential disturbances and mortalities are largely determined by the landowners themselves.
5. Corridors are important conservation tools that can benefit wildlife populations, but the benefits and impacts that they have on humans living in and near them should be a critical consideration in their design and management. Corridors will be generally ineffective and perhaps even short lived or counterproductive without strong local support.

Community Participation and Knowledge Sharing

In order to develop a research methodology that would reflect community concerns and to establish on-going communication with local stakeholders and government agencies, I attended monthly community meetings in 2000 and 2001 before collecting any data. These meetings provided opportunities to share details regarding research methodology and make the development of the research protocol an iterative process that included local knowledge from the beginning. Weekly interactions with local people throughout the research process facilitated two-way communication and sharing of ideas.

Ungulate and Wolf use of the Agricultural Matrix

In order to document farmer observations of wildlife within the agriculture-dominated matrix, I distributed a mail-back questionnaire in the spring of 2002 to all 4220 households identified as operating a farm within 50 km of RMNP. No complete mailing lists of farmers were available for my study area, so surveys were placed in each mailbox identified by Canada Post as a farming household. The questionnaire consisted of Likert-scaled and open-ended questions. Recipients were asked to describe their observations of ungulates and wolves on their farms, their farm management practices, and their attitudes toward wildlife. The adjusted response rate was 25% overall, calculated as the number of completed surveys (n=786) divided by the number of surveys sent out to verified farm operating households (n=3148), as identified by survey respondents indicating if they operated a farm or not (Brook and McLachlan 2006). The potential for non-response bias was assessed by comparing the results with data from the 2001 and 2006 Agriculture Census of Canada for this region (Statistics Canada 2002, 2007). In addition, I contacted 75 non-respondents by telephone and administering five questions from the original survey and compared the results to respondents. The study results were considered representative of the regional population of farmers, as no significant differences were identified in either verification step (Brook and McLachlan 2006).

Variables hypothesized to meaningfully influence ungulate use of farms and having literature support were obtained from questionnaire responses regarding farm size, crop types grown, amount of pasture, forest cover, wetland, number of hunting days on the farm, and spatial analysis of farm locations (Table 6.1). Pasture, crop types, wetland and forest cover were standardized as proportions of the total farm size. Respondents also indicated how they managed hay on the farm, including the proportion of their hay bales that were inside their hay yard at the time of the survey and whether or not they provide hay bales specifically for wildlife. The location of each farm provided by the respondent was used to measure the minimum distance to the RMNP boundary and the density of roads and forest cover within a 3km buffer around each farm; ArcGIS (ESRI Inc., USA). I tested for collinearity among independent variables by calculating correlation coefficients and if any two variables had an $R>0.7$, one of the variables was removed. Resource selection was inferred by comparing used and unused farms to derive resource selection functions that estimate the relative strength of selection of resources and to generate relative probabilities of selection (Manly *et al.* 2002; Boyce 2006), using the formula:

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k) \qquad \text{eqn 1}$$

In this equation, $w(x)$ represents the relative probability of use (RSF) and β_1 is the selection coefficient for resource variable x_1 (Manly *et al.* 2002). I developed RSF models to examine the habitat and farm management variables associated with each species occurrence on farms. From the mail survey responses, the farmers that observed each species "regularly on all years" and "regularly on most years" were considered high use farms and the individuals that "never" or "rarely" saw each species were considered low use farms. The low and high use farms were used as a binary response variable in logistic regression to model the probability that elk, deer, or moose use would be high. For each species, I ran all 8191 possible combinations of binary logistic regression models to calculate Akaike's information criterion with small sample adjustment (AICc) and Akiake weights (*w*) (Chamberlin 1965, Akaike 1973, Anderson and Burnham 2002). Akaike weights provide a normalized comparative score for all models and are interpreted as the probability that each model is the best model of the set of proposed models (Anderson, Burnham and Thompson 2000). Cumulative AICc weights were calculated for each independent variable by summing the AICc model weights for all models containing that variable (Burnham and Anderson 2002). Variables with the highest cumulative AICc weights have the greatest relative influence on ungulate use of farms, allowing the variables to be ranked from most important to least important.

The locations of known ungulate and wolf mortalities were obtained for the 1997-2007 period from wolves killed in defence of property and hunter harvested ungulates (Parks Canada, unpublished data). Locations of ungulates were also obtained from a regional winter ungulate surveys flown during the winter of 2004 (Parks Canada, unpublished data) and these were compared with the mail survey data to assess the regional distribution of wildlife with the agricultural matrix.

Results

Ungulate and Wolf use of the Agricultural Matrix

Wolves, deer, elk, and moose all made widespread use of the agriculture-dominated matrix around the protected areas (Figure 6.1). The frequency that each species was observed on farms was generally similar for elk, moose, and wolves, but deer were much more commonly seen, with 83% of all farms in the region seeing deer regularly on most or all years (Figure 6.2). Based on the observed occurrences of these species, they can be characterized by their ability to function within the farming landscape as an agriculture specialist (deer), habitat generalist that is agriculture adapted (elk, wolves), or boreal specialist poorly adapted to agriculture (moose) and each are exposed to different levels of hunting pressure (Table 6.2).

Attitudes toward all three ungulate species were generally positive with <18% of respondents disagreeing at some level that they enjoyed seeing these species on their farm (8% deer, 15% elk, 10% moose), despite the widespread and often intensive impacts that they often have. Although attitudes were positive, all species were harvested annually by many farmers, resulting in hundreds of mortalities for all ungulate species on most years. Some farmers recognized that hunting did affect the survival and distribution of ungulates:

> *We live south of Riding Mountain National Park and elk never reach our place. Moose and deer come out of the park. Moose come here to calf in May and go back to the park late September but most are shot before they reach the park. There were thirty-three deer last spring but in the fall an outfitter took most of them. This spring only six came back to calve* (cattle producer, R429, 2002).

Local farmers obtain diverse benefits from the ungulate species, utilizing them as a source of food, as well as economic benefits resulting from hunters paying for access to private land. Farmers also widely recognize the ecosystem value of the ungulates and many indicated that the reason they chose to live near a protected area was to have frequent opportunities to observe wildlife, particularly ungulates. However, the perceived transmission of bovine tuberculosis from elk and deer to cattle was seen as critical concern and many farmers indicated that if this issue were not resolved, tolerance of ungulates would decline considerably.

Farmer attitudes toward wolves were generally much more negative than for ungulates, with 42% of farmers disagreeing at some level that they enjoyed seeing wolves on their farm, despite that the economic impacts of wolves was much lower than for any of the ungulate species. However, the nature of the impacts between wolves and ungulates were unique and the qualitative responses frequently indicated that there were concerns regarding personal safety. At the same time, impacts by ungulates were seen largely as economic and lost hay bales could be replaced. Cattle killed by wolves resulted in a gruesome sight that troubled many farmers, particularly in cases where livestock were found partially consumed but still alive. Although there was no hunting season for wolves in the area around RMNP during the mail survey and wolves are supposed to be only killed in defence of property, shooting wolves on sight remains a common practice and these normally go unreported or are recorded as defence kills:

> *Yeah, I mean, if we see a wolf, we kill it. That's the ways it has always been on our farm and that's how it always will be. People try to tell me those wolves are nice and friendly, but they've never seen one feeding on a calf that's still alive, bawling like nothing you've ever heard.* (Farmer R0916, 2006).

While ungulates are generally more abundant on farmland than wolves, farmers observed wolves far away from protected areas:

Our farm is approximately forty miles [64 km] south of Riding Mountain Park, so we only see the occasional stray moose or elk. Lots of deer, coyotes and a few wolves and bears (cattle producer R287, 2002).

There were important differences and similarities between the environmental and farm management variables associated with ungulate and wolf use of farmland around RMNP and DMPF (Table 6.3). The most important variable determining the presence or absence for ungulates was the proximity to a protected area, with elk and moose showing a strong affinity for protected areas and deer strongly avoiding protected areas. Leaving hay bales for elk and deer also increased the likelihood they would enter on to a farm. Forest cover at the farm scale or within a broader buffer around the farm was unimportant for elk, but was critically important for the occurrence of deer and moose. Wolves were unique in that the proximity to protected areas was unimportant in predicting their distribution, but forest cover was of primary importance and forage crop production was of somewhat importance.

The protected areas, RMNP and DMPF are >90% forested, but the proportion of forest cover on the agricultural landscape is much lower for farms farther from these protected areas (Figure 6.3). Overall trends in the distribution of ungulates relative to the RMNP boundary were largely consistent for the mail survey and aerial winter survey datasets (Figure 6.4). Mortalities of ungulates and wolves reported to Parks Canada were mostly within 3km of the park boundary, but some were located as far as 15km from the park boundary (Figure 6.5).

Discussion

Ungulates and wolves make use of agricultural lands for a wide variety of reasons, most notably, access to high quality food resources such as pasture, hay, and grain (Austin and

Urness 1987, Brelsford et al. 1998) in the case of ungulates, and to access these ungulates in the case of wolves. Elk, white-tailed deer, and occasionally moose make use of farms throughout much of North America, can cause considerable damage to fences and agricultural crops, and may be implicated in the spread of diseases to livestock (Yuill 1987, Lacey *et al.* 1993, Conover 1998). Ungulates select habitat at multiple scales (Turner *et al.* 1997, Boyce *et al.* 2003) such that there are regional scale influences on their distribution and abundance, as well as patch scale factors that determine the frequency that individual farmers observe elk, moose, and deer. Hunting (Johnson *et al.* 2004), predators (Laundré *et al.* 2001), forest cover (Cook et al. 1998), forage (Alldredge et al. 2002), and weather conditions (Sweeny and Sweeny 1984) have all been identified as important influences on ungulate occurrence (Cook 2002, Skovlin et al. 2002), but few studies have considered the influences of farm management practices in conjunction with native habitats on wildlife occurrences in agriculture-dominated landscapes (*sensu* Mech *et al.* 2000).

Lesage *et al.* (2002) found that deer avoided agricultural areas during the summer months. In contrast, Kernohan *et al.* (1996) determined that deer selected a range of crop types throughout the year, including corn, grain, and alfalfa, though adjacent grasslands and wetlands were also selected. Similarly, Rouleau *et al.* (2002) found that deer in Quebec used agricultural crops intensively, particularly at night. Nixon *et al.* (1989) found that agricultural crops comprised over half the volume of food eaten by deer throughout the year in Illinois and that deer were located in crops more often than any other habitat in each season except winter. Use of agricultural landscapes by elk and moose has been much less studied, but contrary to our findings, Grover and Thompson (1986) found that elk are often associated with forest edges and prefer to be associated with at least some canopy cover.

Crop damage claims and rumen content analyses have identified alfalfa, wheat, barley, canola, flax, oats, rye, corn, and sunflowers as crops used for forage by elk (Austin and Urness 1987, Garrod *et al.* 1981). Hay bales are also used to manage elk on winter ranges, such as the Jackson elk herd, Yakim, Washington, and Wenaha and White River in Oregon. The purpose there is to supplement elk diets with high-quality forage to control distributions and reduce winter mortality (Robbins *et al.* 1982). Throughout many parts of North America, elk use cattle (*Bos taurus*) grazing areas (Coe et al. 2001, Stewart et al. 2002) and select agricultural crops (Irby *et al.* 1996). Although moose are primarily considered a boreal forest species, they make use of farm fields around Prince Albert National Park in Saskatchewan during the winter months (Goldrup 2000) and introduced moose in Newfoundland do considerable damage to agricultural crops (Wicks 2003). Moose have been observed feeding on forage crops around RMNP and damage claims for moose impacts on stored hay have been made annually.

Clearly, all four species that I examined can thrive within the agricultural landscape, albeit in different ways. A primary determinant of the overall survival of each of these species is the mortality level caused by human hunting. At the same time, hunting creates a unique 'landscape of fear', altering all aspects of the distribution, movements, and reproduction of each of these species (Thomson *et al.* 2006).

I believe that it is time for a major shift in the theory and application of corridors to include the human component, which I have shown here to be a fundamental determinant of the quality of corridors as well as the survival of species that use them. The relationship between the attitudes and actions of people living in and around these corridors is complex; people like elk and kill them, dislike wolves and kill them. However, long-term conservation of these species requires that resource managers simultaneously address the decline in habitat as fragmentation alters the landscape and the ever-changing attitudes and actions of local people. These local people ultimately determine the types of changes that occur to much of the landscape, and influence local wildlife populations by choosing to kill or not kill individual species.

Literature Cited

Badola, R. Attitudes of local people towards conservation and alternatives to forest resources: A case study from the lower Himalayas. Biodiversity and Conservation 7:1245-1259.

Beier P., and R. F. Noss. 1998. Do habitat corridors provide connectivity? Conservation Biology 12:1241–52

Bowman, J.L., B.D. Leopold, F.J. Vilella, D.A. Gill. 2004. A spatially explicit model, derived from demographic variables, to predict attitudes toward black bear restoration. Journal of Wildlife Management 68:223-232.

Brook, A., M. Zint, and R. De Young. 2003. Landowners' responses to an endangered species act listing and implications for encouraging conservation. Conservation Biology 17:1638–1649.

Brook, R.K., and McLachlan, S.M. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. http://www.thegreenpages.ca/tb, accessed 05/09/06.

Brook, R.K. and McLachlan, S.M. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 80:156-166.

Caro, T.M., 1999. Demography and behaviour of African mammals subject to exploitation. Biological Conservation 91:91–97.

Crooks, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488–502.

Chetkiewicz, C.-L. B., C. C. St Clair and M. S. Boyce. 2006. Corridors for conservation: Integrating pattern and process. Annual Review of Ecology, Evolution and Systematics 37: 317-342.

Czech, B., D. L. Trauger, J. Farley, R. Costanza, H. E. Daly, C. A. S. Hall, R. F. Noss, L. Krall, and P. R. Krausman. 2005. Establishing indicators for biodiversity. Science 308:791-792.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural preserves. Biological Conservation 7: 129-146.

Dixon, J.D., M.K. Oli, M.C. Wooten, T.H. Eason, J.W. McCown, and D. Paetkau. 2006. Effectiveness of a regional corridor in connecting two Florida black bear populations. Conservation Biology 20:155-162.

Forester, D. J., and G. E. Machlis. 1996. Modeling human factors that affect the loss of biodiversity. Conservation Biology **10:**1253–1263.

Hanski, I. 1999. Metapopulation ecology. Oxford University Press, Oxford, United Kingdom.

Hewison, A. J. M., J. P. Vincent, J. Joachim, J. M. Angibault, B. Cargnelutti, and C. Cibien. 2001. The effects of woodland fragmentation and human activity on roe deer distribution in agricultural landscapes. Canadian Journal of Zoology 79: 679-689.

Infield, M. 1988. Attitudes of a rural community towards conservation and a local conservation area in Natal, S. Africa. Biological Conservation 45:21-46.

Jacobson, S.K., K.E. Sieving, G.A. Jones, and A. Van Doorn. 2003. Assessment of farmer attitudes and behavioural intentions toward bird conservation on organic and conventional Florida farms. Conservation Biology 17:595-606.

Jacobson, S. K., and M. D. McDuff. 1998. Training idiot savants: the lack of human dimensions in conservation biology. Conservation Biology 12:263-267.

Mascia, M. B., J. P. Brosius, T. A. Dobson, B. C. Forbes, L. Horowitz, M. A. McKean, and N. J. Turner. 2003. Conservation and the social sciences. Conservation Biology **17:**649–650.

McNeely, J. A. 1994. Protected areas for the 21st century: working to provide benefits to society. Biodiversity and Conservation 3: 390-405.

Meffe, G. K., R. F. Noss, and S. K. Jacobson. 1998. Revisiting the human dimension in conservation biology. Conservation Biology **12:**1171–1172.

Naughton-Treves, L. R. Grossberg and A. Treves. 2003. Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. Conservation Biology 17: 1500 – 1511.

Nyhus, P. J., F. R. Westley, R. C. Lacy, and P. S. Miller. 2002. A role for natural resource social science in biodiversity risk assessment. Society and Natural Resources **15:**923–932.

Portman, M. E. 2007. Zoning design for cross-border marine protected areas: The Red Sea Marine Peace Park case study. Ocean and Coastal Management 50:499-522.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652-661.

Sekhar, N.U., 2003. Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India. Journal of Environmental Management 69: 339-347.

Setsaas, T. H., T. Holmern, G. Mwakalebe, S. Stokke, E. Roskaft. 2007. How does human exploitation affect impala populations in protected and partially protected areasÉ – A case study from the Serengeti Ecosystem, Tanzania. Biological Conservation 136:563-570.

Shkedy, Y. and D. Saltz. Characterizing core and corridor use by Nubian Ibex in the Negev Desert, Israel. Conservation Biology 14:200-206.

Simberloff, D., and J. Cox. 1987. Consequences and costs of conservation corridors. Conservation Biology 1:63-71.

Stronen, A., Brook, R.K., Paquet, P.C. and S.M. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Thomson, R. L. J. T. Forsman, F. Sarda-Palomera, and M. Monkkonen. 2006. Fear factor: prey habitat selection and its consequences in a predation risk landscape. Ecography 29:507-514.

Thornhill, A. 2003. Social scientists and conservation biologists join forces. Conservation Biology 17:1476.

Walker, D. 2001. Landscape connectivity and vegetation dynamics in Riding Mountain National Park, Canada. Dissertation. University of Manitoba, Winnipeg, Manitoba, Canada.

Wrigley, R.E. and R.W. Nero. 1982. Manitoba's Big Cat-The Story of the Cougar in Manitoba. Manitoba Museum of Man and Nature, Winnipeg, Manitoba, Canada.

Zeilig, M. 2007. First photos of live, wild cougar in Manitoba. Winnipeg Free Press, January 9th.

Zollner, P.A. Comparing the landscape level perceptual abilities of forest Sciurids in fragmented agricultural landscapes. Landscape Ecology 15:523-533.

Table 6.1. Description of explanatory variables considered to develop the sets of models to examine factors associated with ungulate and wolf use of farms around Riding Mountain National Park.

Abbreviation	Variable
CATTLE	size of beef cattle herd (0, 1-20, 21-40, 41-60, 61-80......>160)
CEREAL	% of farm covered with cereal crops
OILSEED	% of farm covered with oilseed crops
FOREST	% of farm covered with forest
WETLAND	% of farm covered with wetland
FORAGE	% of farm covered with forage crops
PASTURE	% of farm covered with pasture
HAYYARD	% of hay bales in hay yard at time of survey
DISTANCE	minimum distance from farm to protected area (RMNP and DMPF) boundary (km)
LEAVEHAY	does respondent leave hay bales for wildlife? (1=no, 2=yes)
TREEBUFF	% forest cover within a 3km radius buffer around each farm
FARMSZ	size of farm (hectares)
ROADS	% cover of roads within a 3km radius buffer around each farm

Table 6.2. Characteristics of ungulates and wolves within the agricultural matrix around Riding Mountain National Park and Duck Mountain Provincial Forest.

	White-tailed Deer	*Elk*	*Moose*	*Wolves*
Ability to thrive in agricultural environment	Habitat Generalist-Agriculture Specialist	Habitat Generalist-Agriculture Adapted	Boreal Specialist-Poorly adapted to agriculture	Habitat Generalist-Agriculture Adapted
Game Status	Hunted[a]	Hunted[a]	Hunted[a]	Only killed in defense of property around RMNP[a]; Hunted and trapped in and around DMPF
Hunt Days/Farm/Year	20±72	15±71	15±76	n/a
Agricultural Impacts	intensive damage to crops, fences, may transmit bovine tuberculosis to cattle	intensive damage to crops, fences, may transmit bovine tuberculosis to cattle	fence damage	occasional cattle depredation
Estimated Annual $ Damage	$210,000	$144,000	$28,000	$4,500
Direct Economic Benefits to Farmers	meat, charging hunters $ for access	meat, charging hunters $ for access	meat, charging hunters $ for access	none

[a]No hunting is allowed within Riding Mountain National Park.

Table 6.3. Relative importance of the thirteen independent variables hypothesized to influence elk, deer, and moose use of farms around Riding Mountain National Park based on cumulative AICc[a] weights (w_+) from results of the 2002 mail survey. All variables with $w \geq 0.5$ are bolded.

	ELK			*DEER*			*MOOSE*			*WOLVES*		
Variable[b]	w_+	ß	*SE*	w_+	ß	*SE*	w_+	ß	*SE*	w_+	ß	*SE*
DISTANCE	**1.00**	-10.465	0.333	**1.00**	3.584	0.048	**1.00**	-11.281	0.280	0.34	0.17	0.23
FARMSIZE	**0.99**	5.235	0.226	0.26	-0.022	0.037	0.31	-0.381	0.525	0.32	-0.28	0.38
LEAVEHAY	**0.80**	1.300	0.524	**0.56**	0.472	0.416	0.33	0.231	0.309	0.27	-0.04	0.06
ROADS	**0.55**	-1.189	1.066	0.39	0.509	0.620	**0.92**	5.008	0.927	0.32	0.21	0.31
TREEBUFF	0.44	0.577	0.647	**1.00**	2.845	0.133	0.27	-0.056	0.132	**0.52**	0.57	0.55
PASTURE	0.43	-0.431	0.490	0.48	0.392	0.405	**0.78**	-1.627	0.768	0.29	-0.05	0.11
OILSEED	0.34	-0.305	0.401	0.27	0.019	0.071	0.38	-0.509	0.717	0.47	-0.55	0.58
CEREAL	0.30	-0.123	0.181	0.32	-0.113	0.164	0.34	-0.165	0.388	0.36	0.17	0.23
CATTLE	0.28	0.080	0.116	0.28	0.042	0.067	0.34	0.224	0.296	0.33	0.10	0.13
FORAGE	0.28	0.076	0.143	0.36	-0.212	0.272	**0.50**	-0.805	0.825	**0.52**	-0.52	0.51
FOREST	0.27	-0.023	0.078	0.35	0.244	0.316	**0.90**	3.210	0.751	**0.82**	-1.40	0.51
HAYYARD	0.26	0.001	0.023	0.30	-0.056	0.079	0.27	-0.022	0.051	0.29	0.05	0.07
WETLAND	0.26	-0.005	0.044	0.26	-0.028	0.056	0.35	0.566	0.733	0.26	0.01	0.04

[a] AICc = Akaikes's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).
[b] Variables are described in table 1.
[c] Cumulative AICc weight of a variable = the percent of weight attributable to models containing that particular variable and is calculated by summing the AICc model weights of every model containing that variable.

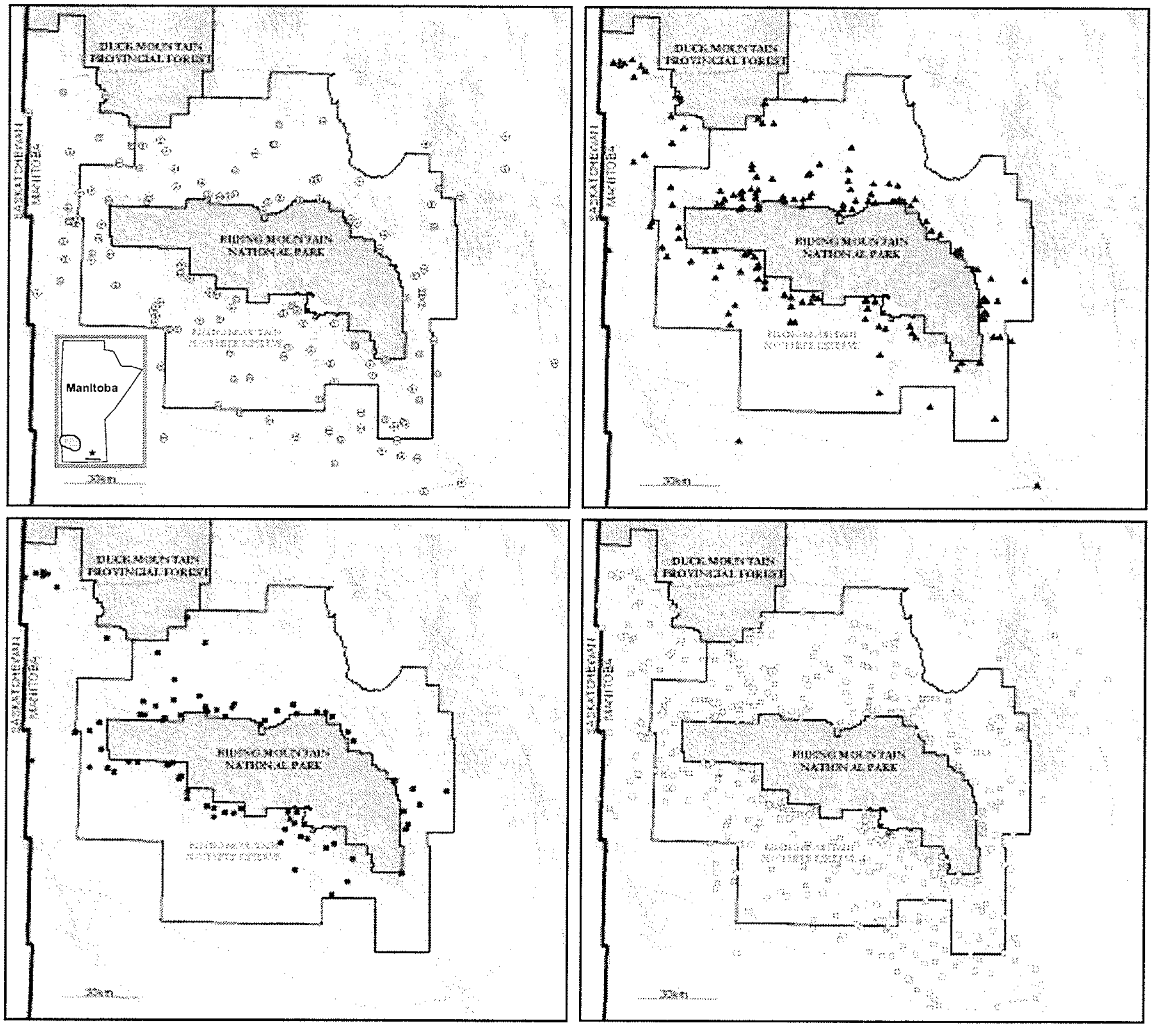


Figure 6.1. Distribution of farms that reported observing (a) wolves (n=132), (b) elk (n=175), moose (n=82) (c), and (d) deer (n=439) regularly on their land over a five year period (1997-2001) around Riding Mountain National Park, based on results from the 2002 mail survey. A 50-km buffer around RMNP is represented by a dashed line and forest cover is shaded grey.

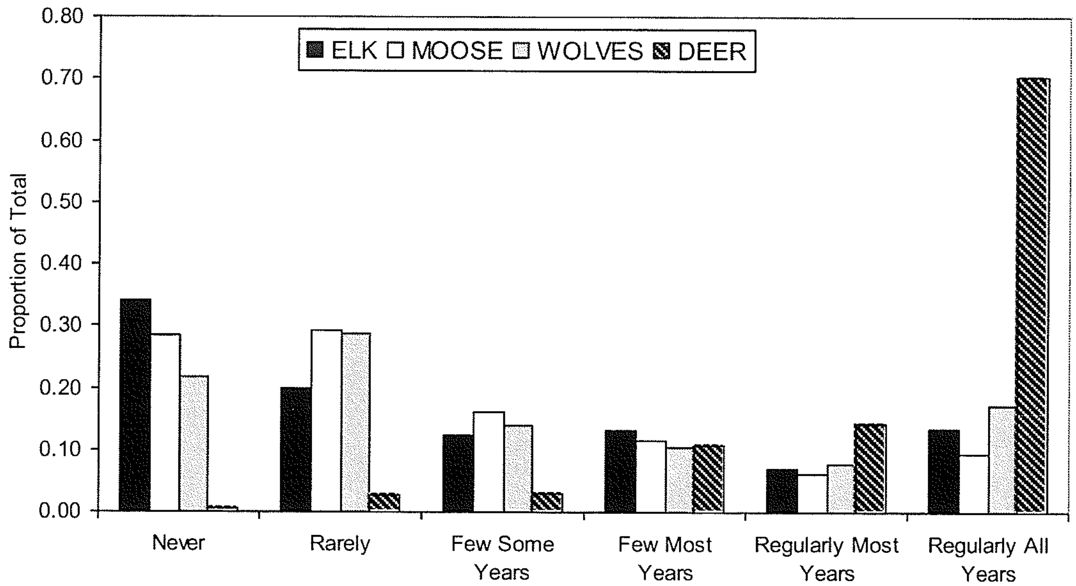


Figure 6.2. Frequency that farm operators reported observing deer, elk, and moose on their farms over a five year period (1997-2001) from responses to the 2002 mail survey.

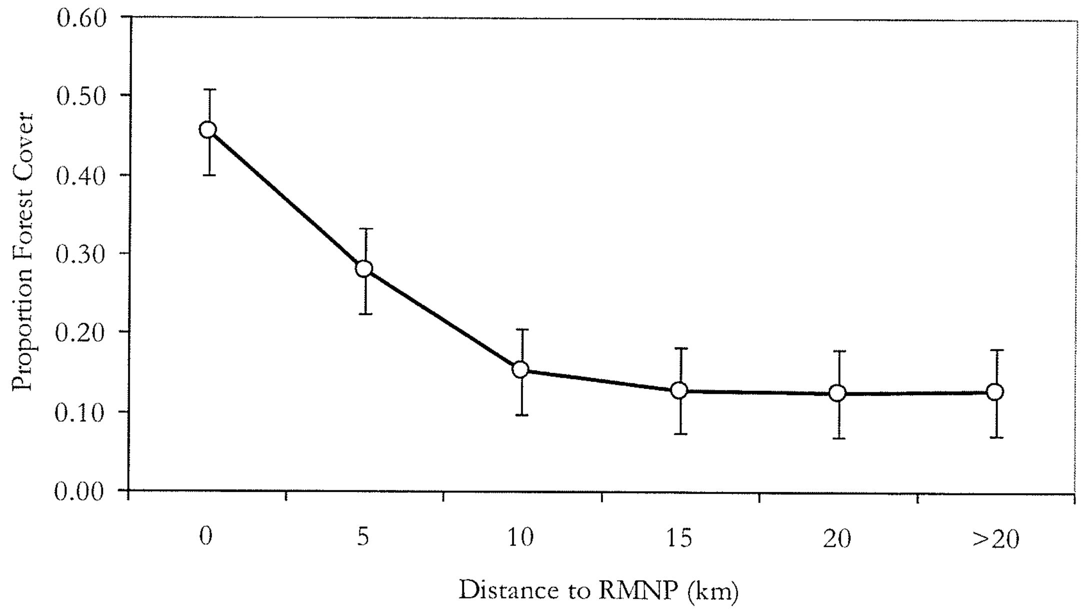


Figure 6.3. Distribution of forest cover within the agriculture-dominated matrix around Riding Mountain National Park based on habitat composition within 1-km wide buffers around RMNP using a 30 m spatial resolution regional land cover map derived from Landsat satellite imagery (Prairie Farm Rehabilitation Administration 1997, unpublished data).

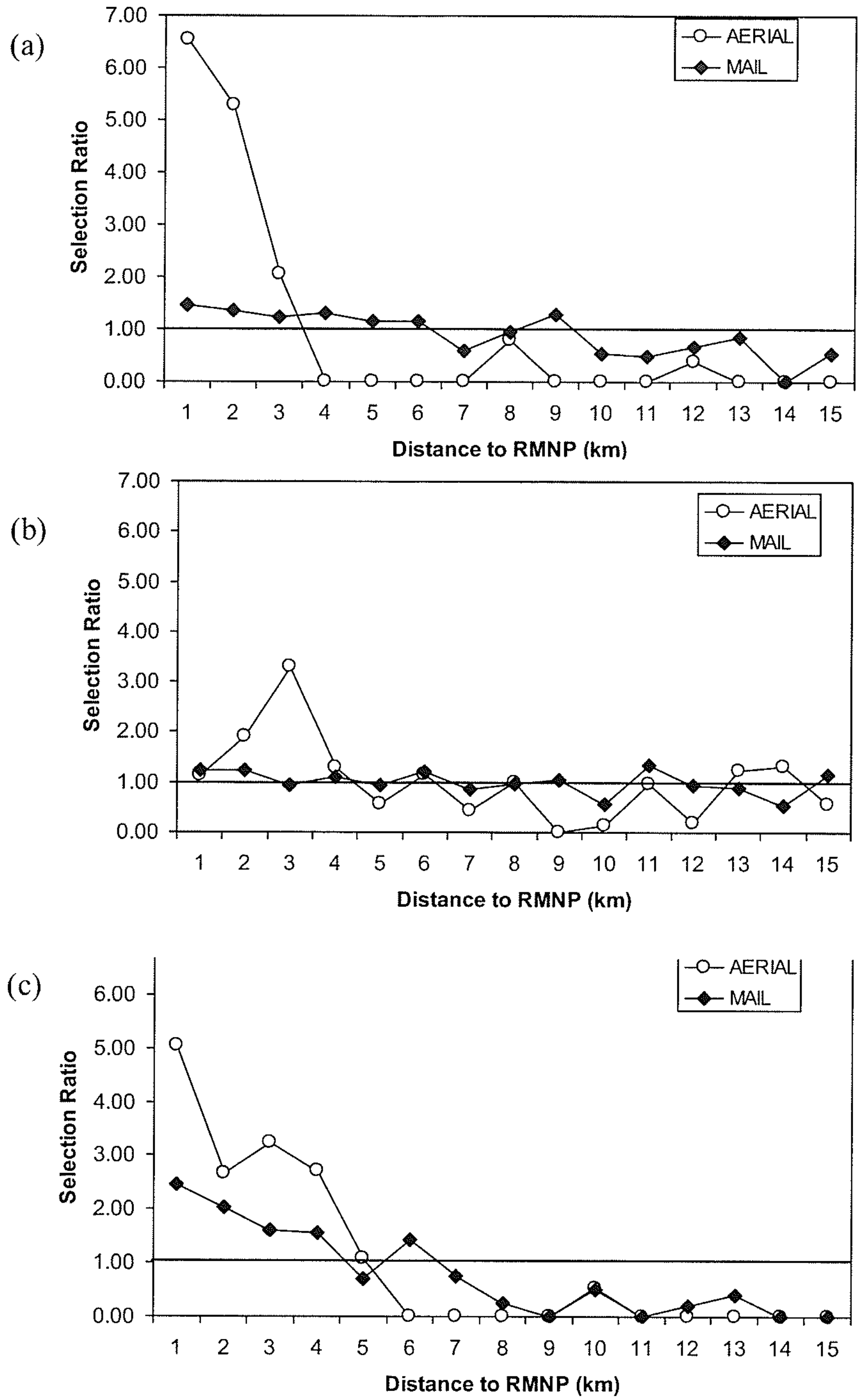


Figure 6.4. Spatial distribution of elk (a), deer (b), and moose (c) relative to distance to RMNP using results obtained from the 2002 regional mail survey and a winter aerial ungulate survey conducted in 2004. Selection ratios >1 show a strong selection and those <1 indicate avoidance.

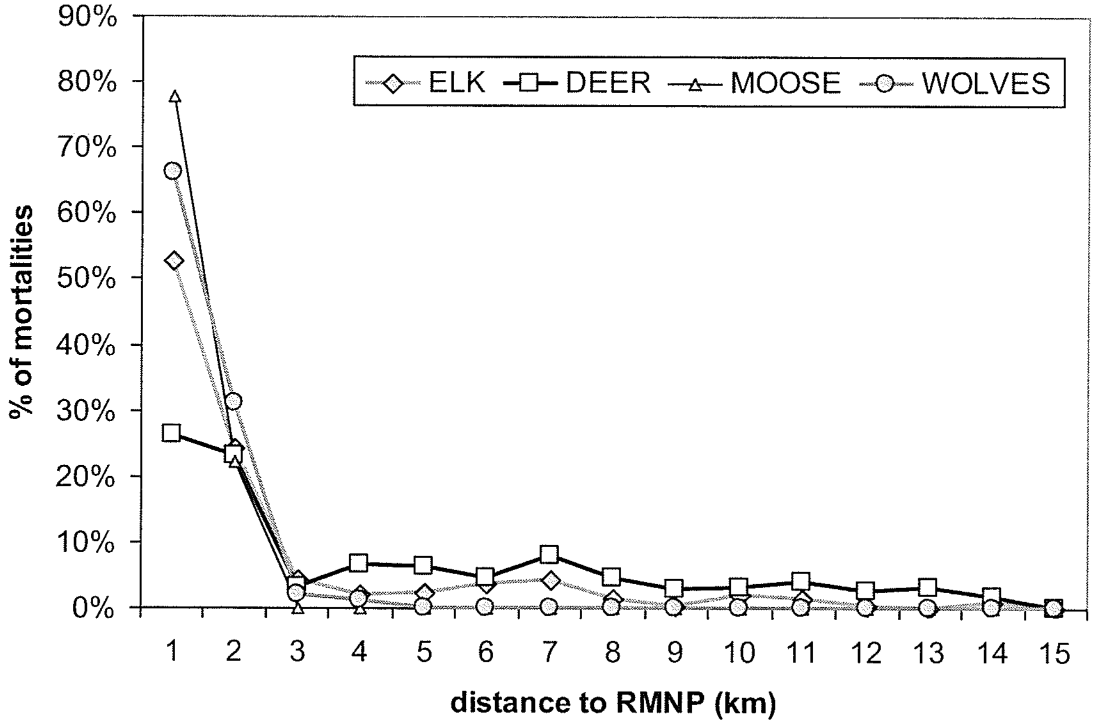
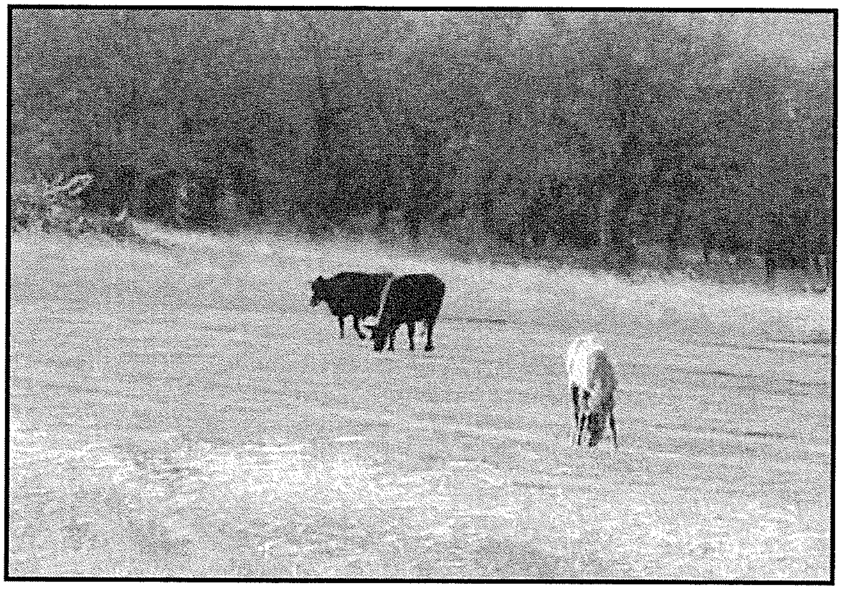


Figure 6.5. Spatial distribution of ungulate and wolf mortalities around Riding Mountain National Park obtained from local reports and turned in carcasses (RMNP unpublished data).

CHAPTER 7

OVERLAP IN ELK AND CATTLE SPACE USE AND RISK OF BOVINE TUBERCULOSIS TRANSMISSION



"We fence our property and we keep our cattle in. You guys fence your park and keep your goddam elk there." --Riding Mountain cattle farmer 2003

Introduction

There is strong evidence of wildlife transmission of bovine tuberculosis (*Mycobacterium bovis*) to livestock in agricultural areas throughout the world. Despite over a century of research, the specific nature of this transmission remains unclear for many species (Briscoe 1912, Phillips *et al.* 2003). The potential for host wildlife species to spread this contact-transmitted disease to livestock depends on patterns of interaction between individual animals (Benham & Broom 1989, Ji *et al.* 2005). Two major routes have been proposed as the means of infection from wildlife to cattle (*Bos taurus*); indirectly through shared pasture, hay, grain, or silage that have been contaminated with saliva, urine or faeces (Hutchings and Harris 1997) or directly through sneezing and coughing (Garnett *et al.* 2002). It is often erroneously assumed that transmission is only one-way from wildlife to livestock (Phillips *et al.* 2003) and the transfer of bovine tuberculosis (TB) from cattle to wildlife has thus received much less attention

Many studies have examined wildlife-cattle interactions to understand better spatiotemporal aspects of bovine TB transmission risk (e.g. Garnett *et al.* 2002, Kaneene *et al.* 2002). However, wildlife-livestock contacts, particularly those that are indirect, are difficult to measure in a natural setting and for nocturnal and cryptic species, and thus limit our understanding of these interactions. In a critique of their own study, Olea-Popelka *et al.* (2005) observed that it was inadequate to examine wildlife-cattle interactions only at the individual farm-scale. Indeed, habitat use by wildlife varies across spatial and temporal scales (Boyce 2006), suggesting that studies of wildlife-cattle interactions must also be examined at multiple scales. Influences of habitat on wildlife use of cattle areas have been assessed using resource selection functions (RSFs) (Coe *et al.* 2001), which represent the probability of resource use by animals (Manly *et al.* 2002, Boyce 2006). However, RSFs have yet to incorporate farm management practices, despite strong evidence that they influence resource use in agriculture-dominated landscapes (Kaneene *et al.* 2002). For the most part these farm management variables can only be documented through dialogue with the farmers themselves.

Including the local ecological knowledge (LEK) of lay people complements and augments research resulting from conventional ecological studies alone (Brook and McLachlan 2005, Berkes and Turner 2006). LEK can be used to generate research hypotheses and identify limitations in scientific research (Jolly *et al.* 2002), address important temporal and geographic gaps in biological data (Johannes 1993), and provide information about local management practices and long-term wildlife occurrences that are otherwise unknown (Berkes and Folke 1998, Brook and McLachlan 2006). While the importance of linking human societies and natural systems is increasingly recognized as an important step in achieving ecological and social resilience, few studies have explicitly compared both in answering complex biological problems (Berkes and Turner 2006).

Wild elk (*Cervus elaphus manitobensis*) are endemic to southern Manitoba, Canada and have used what is now Riding Mountain National Park (RMNP) and the surrounding lowlands continuously for centuries (Green 1933). Over the last century, much of the area around RMNP has been converted to farmland resulting in frequent conflicts between elk and agriculture (Brook and McLachlan 2006). Bovine TB was endemic to cattle in Manitoba until at least 1970, but these outbreaks were never formally associated with a wildlife host. Since 1991, the occurrence of the same strain of bovine TB (Lutze-Wallace *et al.* 2005) in elk (n=32), deer (n=7) and cattle (n=11 herds) in this region has intensified concerns that bovine TB is spreading from wildlife to domestic cattle (Lees *et al.* 2003, Brook and McLachlan 2006). Since 2002, the United States Department of Agriculture (USDA) has been requiring that cattle from Manitoba be bovine TB tested before shipment, creating a considerable cost and stigma for cattle producers in the province. That elk likely represent a primary bovine TB host in the Riding Mountain ecosystem underscores the need to understand better the spatiotemporal nature of their contact with cattle in order to both mitigate potential sites of transmission and protect the integrity of the cattle industry in Canada.

The objectives in this study were to use both conventional radio-collaring and aerial survey data with local farmer knowledge to better characterize elk habitat use and interactions with cattle at multiple spatial scales. Variables associated with spatiotemporal overlap were identified in order to assess the potential risk of bovine tuberculosis transmission. I also contrasted the local knowledge and conventional ecological data to understand better the relative contributions of each in understanding inter-specific shared space use. I then identified ways that these diverse data could be used together to more effectively mitigate risks of wildlife-livestock contact.

Methodology

Study Area

The regional study area is located in southern Manitoba, Canada (Figure 7.1) and includes Riding Mountain National Park (RMNP) and Duck Mountain Provincial Forest (DMPF), which are dominated by aspen, and coniferous forest interspersed with small grasslands and wetlands. Outside of these protected areas, the landscape is dominated by cereal and oilseed crop production, with the marginal lands comprising pasture, hayland, and isolated patches of deciduous forest. Farms in the region are, on average, 467 ha in size, although some exceed 5600 ha (Brook and McLachlan 2006). Half of all farm operations have at least some beef cattle, and 28% have >100 cattle. In response to the recent outbreak of bovine TB in cattle herds, the Canadian Food Inspection Agency (CFIA) created the 8,000-km^2 Riding Mountain Eradication Area (RMEA) around RMNP. The RMEA represents an attempt to eradicate the disease in livestock through intensive testing and controls on cattle movement (Figure 7.1). To examine elk-cattle interactions in detail within the area generally considered at greatest risk for bovine TB transmission, a representative intensive study area (1,750km^2) was delineated, which includes the western quarter of RMNP (750 km^2) and the northwest corner of the TB Eradication Area (1,000 km^2). This area encompassed 75% of the bovine TB outbreaks in cattle and 82% of TB positive elk within the larger regional study area from 2001-2005 (Figure 7.1).

Modelling Approach

Habitat selection by animals is often inferred by comparing used and unused sites to produce resource selection functions that estimate the relative strength of selection of resources and to generate relative probabilities of habitat use that can include multiple spatial scales (Manly *et al.* 2002, Boyce 2006), using the following formula:

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k) \qquad \text{eqn 1}$$

In this equation, $w(x)$ represents the relative probability of use (RSF) and β_1 is the selection coefficient for resource variable x_1 (Manly *et al.* 2002).

I developed RSF models to examine the habitat and farm management variables associated with elk-cattle interaction at the regional scale. The dependent variable was binary, each farm either having or not having elk-cattle interaction. Cattle within the study area are largely confined to individually owned summer pastures and are wintered on smaller fenced areas where they are fed stored hay and grain. Thus, RSFs were also generated for elk-cattle interaction at the patch scale where the dependent variable was binary, each patch being either used or unused by elk.

Monitoring Elk-Cattle Interaction

Radio-collaring and Aerial Surveys

In order to monitor elk movements relative to cattle herds, 212 wild elk (42% bulls; 58% cows) were captured within the regional study area from 2002-2005 using a net-gun fired from a helicopter (Cattet *et al.* 2004). Each animal was given either a GPS satellite collar (n=25), VHF radio-collar (n=136), or a VHF ear transmitter (n=51). Elk locations were obtained daily (8-18 locations per day) from GPS collars for up to one year and VHF collared animals were located using fixed-wing aircraft and ground triangulation (1-8 locations per week) for up to 3.5 years. Aerial VHF locations were collected during daylight hours, usually 0900-1800, whereas ground locations were obtained throughout the 24-hour period. Errors associated with GPS and VHF collars were assessed by locating stationary collars placed on the ground at known points. All elk locations were categorized into either summer (April to November) or winter (December to March) classes. I related overlap in space use of elk and cattle to potential inter-specific transmission of bovine tuberculosis by examining cattle areas used by culture-positive bovine TB-infected collared elk (Parks Canada, unpublished data) as well as elk use of culture-positive cattle farms (Koller-Jones *et al.* 2006). The number of collared elk as well as the number and duration of elk locations on each patch were determined as indices of contact frequency and diversity, both of which can influence disease transmission risk. Winter elk distribution was also determined each year from 2001-2005 using locations obtained from independently conducted winter aerial surveys in February when locations were logged with a GPS unit along transects 1.6 km apart flown with fixed-wing aircraft (Parks Canada, unpublished data).

Local Farmer Knowledge

The use of local knowledge in research is most successful when it occurs as a collaborative and iterative process where ongoing two-way communication occurs between researchers and communities (Brook and McLachlan 2005). Local knowledge was documented throughout this study, initially through community meetings, then a mail-out survey and later through participatory mapping exercises, meetings, and weekly informal discussions with cattle producers.

In the spring of 2002, a questionnaire was mailed to all 4220 households identified as farms by Canada Post within 50 km of RMNP since no comprehensive mailing lists of cattle producers are available for rural Manitoba. The questionnaire consisted of likert-scaled and open-ended questions. Recipients were asked to describe their farm management practices and to indicate if they observed contact between elk and cattle. Adjusted response rate to the mail-out survey was 28%, calculated as the number of cattle producers responding to the survey divided by the number of known cattle operations from CFIA mandatory cattle testing (Brook and McLachlan 2006). In total, 436 usable questionnaires were returned by cattle producers. Seventy-five non-respondents were telephoned and asked five questions selected from the original questionnaire to check for non-response bias. Results were also compared with data from the 2001 Agriculture Census of Canada for this region (Statistics Canada 2002) and were considered representative of the regional population of cattle producers as no significant differences were identified in either verification step (Brook and McLachlan 2006).

Spatial distribution of cattle was determined within the intensive study area using participatory mapping exercises. In total, 86 of the 88 cattle producers in this area participated, amounting to a 98% participation rate. Each participant delineated the boundaries of cattle summer pasture and winter-feeding areas on a 1:5,000 scale orthophoto of their farm. Maps were digitized using ArcGIS 9.0 GIS (ESRI Inc., USA). These farmers also responded to open ended questions regarding cattle-elk interactions, including long-term changes in elk movements and habitat use and the effect, if any, of farm management practices. Direct quotes of respondents were included in the results to provide important context and affirmation of the quantitative results (Kreswell 1998).

Habitat and Farm Management Covariates

Independent predictor variables hypothesized to influence elk-cattle interactions were derived from the literature and discussions with local cattle producers. Farm management variables identified using the mail survey included size of the cattle herd, wildlife and cattle feeding practices, and amount of different crops grown. The minimum distance of each respondent's farm to the nearest protected area was measured using GIS. Size of each cattle use patch was identified with data obtained in participatory mapping interviews and the minimum distance of each to the nearest stream was measured with GIS. Vegetation productivity of each patch was estimated using the Normalized Difference Vegetation Index (NDVI) of a July 2001 LANDSAT-7 satellite image of the region with 30m spatial resolution (Geogratis 2005, unpublished data). Vegetation and water cover was assessed within each pasture patch using a land cover map with 30m spatial resolution developed using LANDSAT-5 satellite imagery collected in 2002 (Manitoba Conservation 2003, unpublished data). Road density for each farm and pasture patch was measured from a detailed provincial GIS road layer (Manitoba Transportation and Government Services 2002, unpublished data).

Habitat and farm management variables associated with elk use were assessed using binomial logistic regression (SAS Institute Inc., USA) to distinguish farms and pastures visited by elk from those that were not. This was assessed using four independently collected datasets: mail surveys (at the regional scale) as well as farmer interviews, VHF collars, GPS collars and combined interview and collar data (at the patch scale). In total, twenty environmental and farm management variables were assessed as potentially influencing elk-cattle co-mingling (Table 7.1). These variables were screened for collinearity using a Spearman rank correlation matrix for all possible pairs of independent variables. Ultimately, 13 were used in each of the regional and patch scale models.

Formal statistical inference was based on all of the RSF models in the set (multi-model inference) rather than on the single best model (Burnham and Anderson 2002). Akaike's information criterion difference with small sample bias adjustment (ΔAIC_c) and Akaike weights (w) were used to evaluate each model (Burnham and Anderson 2002). Cumulative AICc weights ($w+$) were calculated for each independent variable by running all possible combinations of models (n= 8191) for all covariates and summing the AICc weights of every model containing that variable (Burnham and Anderson 2002). Variables with the highest cumulative AICc weights have the greatest influence on elk-cattle co-mingling. Model-averaged coefficients, βi, were then derived for each independent variable and these coefficients were used to derive relative probabilities of elk-cattle interaction. Predicted RSF values were rescaled to a range of 0 to 1 for comparability.

Comparing Local Knowledge With Ecological Data

The diverse datasets used in this study provide valuable insights into the practical problem of understanding the risk of disease transmission among wildlife and livestock, while also providing a unique opportunity to compare explicitly local ecological knowledge with conventional ecological datasets. Patch use by elk was contrasted for all four approaches (farmer interviews, GPS collars, VHF collars, and aerial surveys) using difference matrices. Unlike conventional difference matrices which utilize predictions in comparison with a validation data set, I compared all possible combinations so that each could be validated independently, recognizing that each approach has its own inherent limitations and strengths (Brook and McLachlan 2006). The final stage of the study involved obtaining feedback from cattle producers and other stakeholders within the region regarding the observed interactions of cattle and elk, as well as the way that local knowledge was incorporated with conventional ecological research.

Results

Cattle-Elk Co-Mingling (Regional Scale)

Farmers that were interviewed and responded to the mail survey reported personal observations and stories from their ancestors of elk-cattle contact in the region for the entire period from early settlement in the 1880s to the present. These represent the only available long-term (>10years) data on elk-cattle interactions for the region. Farmer knowledge also confirms the historical cattle testing data that indicates bovine TB has been present in local cattle herds since at least the early 1900s.

Cattle producers responding to the mail survey observed elk-cattle interactions throughout the region; 5% observed direct and 20% observed indirect contact (Figure 7.1) and (66%) observed elk on their farms between 2001 and 2005. Elk were primarily observed during the day, but also at night, and many farmers used the presence of tracks and faeces to confirm the presence of elk. However, some producers (19%) recognized that there were limitations in these observations since they were not always present on the farm.

Farms closer to protected areas and those with larger cattle herds had a higher probability of elk-cattle contact at the regional scale, as determined using cumulative AICc weights (w^+) (Table 7.2). However, farms that were distant from the park could also be at risk, as some producers move their cattle closer to protected areas for the summer:

> *We live 45 miles south of RMNP and our cattle are in open contact with deer at home. In the summer we rent a pasture along the park line where our cattle are also in contact with elk and therefore we've had to have our herd tested for TB.* (R036)

Elk-cattle interaction was inversely correlated with grain production and increased with the use of bale shredding as a cattle-feeding technique. All other variables examined were of minimal importance (i.e. $w^+ < 0.5$) (Table 7.2).

Cattle-Elk Co-Mingling On Summer Pasture (Patch Scale)

In total, 294 summer pasture patches were mapped in the intensive study area (average size = 0.45 km^2; range 0.01 to 5.89; 7.6% of intensive study area). While 34 pastures (12%) were used by VHF collared elk and 37 pastures (13%) were used by GPS collared elk, only 10 pastures were used intensely (each of these pastures representing ≥ 5% of all locations). Cattle summer pastures were significantly larger than cattle winter-feeding areas ($t = -7.36$; $df = 82$; $p < 0.01$). Their use of these pastures was much higher than in winter, as determined by all four elk monitoring methods.

Elk use was observed by cattle farmers on 38% of summer pastures when cattle were present. In contrast, collared elk made relatively little use of summer cattle pastures, and only 2% of the VHF summer collared elk locations occurred on pasture. The large majority (89%) of all VHF locations on pastures were of cow elk, whereas use by juvenile bulls (9%) and adult bulls (2%) was limited. Similarly, only 4% of the GPS collared cow elk locations occurred on pastures. There was no significant difference between the number of summer cattle pastures used by VHF and GPS collared elk ($t = -1.06$; $df = 9$; $p = 0.32$). On average, each pasture used by elk was visited by 1.6 different collared animals (SE = 0.13; Range = 1-6). Counts of collared elk locations on pastures did not vary throughout the day and this pattern was not significantly different from random for GPS collars; chi-square $\chi^2(7, n = 1737) = 12.01$, $p = 0.10$ and VHF $\chi^2(7, n = 145) = 12.16$, $p = 0.09$.

Differences between pastures that had been used and unused by elk were examined using three approaches (farmer interviews, VHF collars, GPS collars) for each dataset and for a combined dataset (Table 7.3). The directions of the RSF coefficients were consistent for the four most important variables in all analyses, though there was some variation in the absolute values (Figure 7.2). Resource selection functions revealed that distance to protected area had a strong negative (i.e. $\beta < -2$) association with elk use for all datasets (Figure 7.2). For the other 12 examined variables, results varied among the different datasets, but overall forest cover was the second and size of the pasture patch was the third most important variable (Table 7.3). When all data sets were combined, road density became an important variable, although less so for both VHF and GPS collar data. Interestingly, distance to stream was ranked highest for GPS collar data, although it was identified as least important for all other data sets.

Cattle-Elk Co-Mingling In Winter (Patch Scale)

In total, 83 winter cattle feeding patches were mapped (average size = 0.06 km^2, range 0.001 to 0.60; 0.3% of intensive study area). In three cases, a single winter-feeding area was shared by two neighbouring farms. Farmers identified seven cattle winter feeding areas used by elk during the winter months, one participant observing:

> *The elk come right up to the cattle fence all the time here in winter. You see the tracks coming right up to it and the cows are on the other side. Some elk come in over the fence as well...Now I haven't actually seen the elk in with the cows because I think most of this goes on in the night, in fact I'm sure of it. I know they are in with the cows because right over here is some elk dung. So the elk are in with them. The cows lay down after eating and the elk come in and eat whatever hay the cows haven't. So there's hard evidence that the elk and the cattle winter together quite nicely.* (R40)

Over the study period, there was little overlap between cattle winter-feeding areas and conventional ecological datasets. Indeed, none of the VHF or GPS collared elk locations occurred on cattle winter areas. With respect to the winter aerial surveys, only one pair of elk was observed on a single cattle winter feeding area out of a total of 6932 recorded elk observations from 2001-2005.

When all datasets were combined, eight cattle winter feeding areas were identified as used by elk (seven by farmers and one by aerial surveys), and this small sample precluded the calculation of RSFs. However, winter feeding areas used by elk were closer to RMNP than those not used were (Mann-Whitney $U = 556$; $n = 8$, $p < 0.01$). In contrast, no significant difference were observed in forest cover ($U = 312$; $n = 8$, $p = 0.38$), patch size ($U = 163$; $n = 8$, $p = 0.80$) or road density ($U = 241$; $n = 8$, $p = 0.36$) between used and unused winter-feeding areas (Figure 7.3).

Comparison of Local Knowledge and Ecological Data

Generally, there were few differences among all of the conventional ecological methods used to assess elk-cattle contact in winter and summer based on the difference matrix, however differences between these and farm interview data were substantial (Table 7.4). The GPS, VHF, and interview data all consistently showed that elk use cattle pastures throughout the spring, summer, and autumn; however, the timing of use varied among data sets (Figure 7.4). Elk with VHF collars had significantly ($p<0.05$) lower use of pastures in June and GPS collars had lower use in July. In October, the estimates of pasture use differed significantly among all three methods, though all datasets showed a large relative decline in use.

There was, however, significant agreement among the relative probabilities of elk occurrence on each pasture patch derived from the coefficients of the RSF models developed using farmer interviews and collaring data ($r_s = 0.77$; $df = 291$, $p < 0.001$). Since these datasets were generally consistent but with each providing unique information, interview and collar data were combined to generate a final integrated RSF map summarizing the probability of elk-cattle contact which emphasizes the level of variability in elk use even for adjacent patches (Figure 7.5). Important benefits and limitations were also identified for each of the five different methods of elk monitoring in this study (Table 7.5). Local knowledge research is considerably cheaper, representing 3-50% of the cost of conventional ecological methods while providing equal or greater spatial coverage and large sample sizes. In contrast, conventional methods provided detailed locations of elk across large areas and sampling equally through all times and seasons.

Elk-Cattle Co-Mingling and Disease

In total, 15 collared elk (9% of all elk collared in the intensive study area) and 3 cattle farms (3% of farms in the intensive study area) were found to be bovine TB culture-positive. Only two of these TB positive elk used cattle pastures during the summer months. One animal was located 1.3% of the time on pastures and used 3 different patches and the other was located 4.4% of the time on pastures and used 4 different patches. Of the three bovine TB infected cattle herds identified during the study, one herd interacted with TB positive collared elk on summer pasture. Infected farms were, on average, significantly closer to RMNP than those testing negative ($U = 150$; $n = 3$, $p = 0.03$). The relative intensity of elk use of pastures was much higher on those with higher proportions of forest cover (Figure 7.6).

Discussion

My results clearly indicate that elk and cattle interact extensively around Riding Mountain National Park, particularly during the summer months. While habitat variables were important predictors of elk-cattle interactions at both the landscape and patch scales, farm management variables also has substantial influence on elk use. Indeed, at the regional scale, three of the four important variables were related to farm management. Larger cattle farms typically have numerous pasture patches and these patches are normally larger so they had a higher probability of elk use. Farms with greater numbers of cattle also produce larger volumes of hay bales which are attractants to elk. Although elk use standing grain crops throughout the summer months, landscapes dominated by grain production lack sufficient security cover to be suitable elk habitat. The practice of shredding hay bales and spreading them widely is a commonly used strategy to simplify manure management by dispersing cattle throughout the paddock, but it also facilitates elk-cattle contact by scattering high quality feed widely.

Since most land outside of the two large protected areas within the study area is privately owned farmland, farmers directly influence the amount and quality of natural habitat in these agriculture-dominated landscapes. Thus, cattle producers have considerable control over the risk of bovine TB transmission to their own herd through their management practices and influence on native habitats (Kaneene *et al.* 2002). Although farm management variables are understandably important in these landscapes, they are rarely incorporated in wildlife studies. However, their importance indicates the need to incorporate socio-economic data and more generally, local ecological knowledge in habitat use and disease studies (Sauter-Louis 2001).

The great majority of the cattle-elk co-mingling occurred on summer pastures at the patch scale in my study. Cattle on pasture feed widely on native and exotic grasses and are not normally supplemented except with minerals. This perhaps explains why habitat variables drive elk-cattle interaction at the patch scale in summer and farm management variables such as crop types grown are relatively unimportant. Elk are opportunistic foragers that utilize the highest quality vegetation that is seasonally available while simultaneously mitigating risk from predation. (Laundré *et al.* 2001) and hunters. However, the forage variables examined were unimportant compared with the need for security cover. The variables most associated with elk use of pastures were security-related, including proximity to RMNP, forest cover, pasture patch size, and road density (all associated with security). In contrast, variables estimating vegetation productivity (i.e. NDVI and wetness) and crop types grown had relatively little influence on pasture use.

RMNP represents a large and relatively intact patch of forest surrounded by an agriculture-dominated matrix and hunting is prohibited within the Park, in large part explaining why it has the most important influence on elk use of cattle holding areas in all seasons and at all spatial scales. The park provides an important refuge from hunters, particularly during the licensed elk hunting season (August – January), as reflected in hunter kills which are clustered on the edges of RMNP. Moreover, there is always risk from hunting as Aboriginal people can harvest elk throughout the year on lands around RMNP. The importance of protected area refuges and forest cover reflects the findings of other studies in North America (e.g. Burcham *et al.* 1999, Coe *et al.* 2001, Stewart *et al.* 2002). My results also indicated that elk avoid roads, in part reflecting the concentration of hunting along roads, or more generally that elk avoid any human activity associated with roads (Coe *et al.* 2001). This was indicated most strongly by the interview data and, secondarily by GPS collar data.

Summer cattle pastures represent the most important areas for shared space use with elk. Summer is characterized by longer periods of intense sunlight (up to 18 hrs/day) and higher temperatures that can kill *M. bovis* (Soparker 1917) and at the same time, cattle are widely dispersed. However, cattle and elk can still infect pastures during the summer by depositing mucus, urine and faeces on vegetation and soil, which can remain infective for >7 weeks (Benham and Broom 1991, Phillips *et al.* 2003). Forest cover may also increase the apparent risks associated with pasture use since diffuse sunlight may take >30 days to destroy the bacilli in contrast to direct sunlight which requires 12h (Soparker 1917). In my study, the cattle pastures used most intensively by elk had four times the forest cover of unused sites, likely allowing *M. bovis* to persist longer during the summer. Elk can also remain on cattle pastures for long periods, indicating that they represent substantial apparent risk for TB transmission.

In contrast to the summer interactions, my results indicate that there was relatively little overlap between elk and cattle during the winter. However, this is a critical period for elk when they are nutritionally stressed after vegetation has senesced, temperatures drop below -30°C, and thick snow limits movements (Jenkins & Starkey 1993). During this period, elk are particularly attracted to stored hay bales, which represent important likely sites for indirect bovine TB transmission, especially since cold temperatures allow *M. bovis* to survive for up to six months in the environment (Phillips *et al.* 2003). During this time, cattle are feeding solely on stored hay. Cattle herds are also more concentrated in winter-feeding areas, which tend to be much smaller than pastures. Thus, winter likely remains an important risk period despite the relatively low incidence of elk-cattle contact.

When confronted with an incomplete understanding of a disease problem, natural resource managers must make decisions based on the best current understanding of potential transmission regardless of uncertainties (Walker 1998). Until there are more reliable diagnostic tests for bovine TB in cattle and elk and more detailed studies of the mechanisms of transmission, it is impossible to prove definitely if bovine TB is actually being spread from elk to cattle or from cattle to elk, or both. However, it is clear that any of these scenarios is possible and undesirable and must be actively managed. My quantitative assessment of shared space use among cattle and elk provides the best proxy for apparent disease transmission risk in the Riding Mountain region and has identified areas of priority for action. A precautionary management approach suggests that elk and cattle should both be considered potential maintenance hosts for *M. bovis* and summer and winter livestock areas should be considered potential sites for transmission, particularly those close to RMNP.

Since a relatively small number of winter cattle feeding areas (10%) have any elk use, these potential contact sites can be efficiently and cost-effectively mitigated using 2.5m tall game wire barrier fences to minimize or even eliminate apparent disease transmission risk (Brook 2005). Cattle summer pastures represent a greater challenge since 41% receive some elk use when livestock are present. Mitigation of the apparent risk should involve encouraging farmers to avoid placing cattle on pastures when elk are present, fencing cattle out of heavily forested parts of pastures, or using livestock guard dogs which can help keep wildlife out of summer pastures. For those pastures used intensively by elk (3% of the total), I recommend that use of these sites by cattle be completely discontinued. Although the use of fencing to eliminate elk use would likely be highly effective, the cost would be prohibitive at >$250,000 CDN per pasture patch for game wire barrier fencing and other fencing designs have proven inadequate for keeping elk out (Brook 2005).

Resource selection functions developed at the patch scale using social (i.e. interview mapping) and ecological (VHF and GPS collar) data resulted in similar outcomes. There was a high level of similarity among the relative importance values of habitat and farm management variables for farmer interviews and VHF collars, as proximity to protected areas, forest cover, and pasture patch size were all important. Distance to protected area was ranked as one of the most important variables for all methods. Although GPS data differed most, for example with respect to the importance of streams, this likely reflects their relatively small sample size. Some differences among all of the different data sets are inevitable since each represent unique sampling strategies, yet there are remarkable similarities in the resulting RSF models and summaries of temporal and spatial trends.

Although comparisons of farmer observations and radio-collar data of elk-cattle interactions showed many similarities regarding the importance of protected areas for elk, they also showed meaningful differences. Local knowledge provided insights into critically important farm management practices that could not be obtained with ecological research alone. This knowledge also reflected cumulative observations of elk-cattle interactions resulting in the only long-term observations of elk-cattle interactions, many of these extending prior to 1900. Despite these findings, throughout the consultations and knowledge sharing with government agencies and other stakeholders the conventional datasets, particularly the radio-collaring results, were typically given much more credence by government agencies and the local knowledge was frequently discounted as 'anecdotal'.

Farmers reported more than three times as many pastures used by elk than were found through radio-collaring during the same period, reflecting differences in sample size and temporal sampling. Collaring studies are limited in that VHF collars were deployed for only four years and on 200 animals (8% of the population) and GPS were attached for two years on 25 animals (2% of the population) but provided hourly locations with high spatial accuracy. Radio-collar data yielded little insight into uncommon or short duration events such as winter elk-cattle contact. However, collars did contribute systematic observations on individual animals, which can be used to quantify the diversity and frequency of elk-cattle contacts on summer pastures. Capturing and collaring provided an opportunity for disease testing, since cattle producers were not able to distinguish visually sick from healthy animals. Although wildlife observations were largely restricted to daylight hours in other studies (e.g. Quinn 1995), farmers in the RMNP region made frequent night observations and were adept at using tracks and faeces when assessing whether elk were mixing with cattle at night. The detail in elk observations by farmers likely reflects their high profile in the region, both as a valued food source and as a significant impact on farms through crop damage and as a potential vector of bovine TB infection (Brook and McLachlan 2006).

This study is one of the first that incorporates ecological and social data in better understanding biological problems, and is certainly the first that uses both to elucidate co-mingling of elk and cattle and the potential spread of disease. Results of this study highlight the benefits of using local ecological knowledge and conventional methods together and this approach is highly recommended for future studies, particularly those addressing issues with high social relevance. The indirect benefits of documenting local knowledge and developing dialogue and trust-based relationships with the local communities are arguably as important as the data themselves, especially for research that has implications for resource-dependent communities and that emerges from controversial and thus often divisive issues (Kirkwood & Dumanski 2003). The building of trust and communication results in the exchange of ideas and outcomes that benefit both researchers and local communities (Brook *et al.* 2006). In this study, the collaborative process produced a more comprehensive understanding of disease risk and increased the acceptability of both the ecological and social results by farmers and other lay people. This, in turn, has facilitated changes in management and policymaking at the farm, regional, and national level that has ultimately benefited both ecological and social systems that are simultaneously threatened by bovine TB.

Literature Cited

Berkes, F., and C. Folke. 1998. Linking social and ecological systems for resilience and sustainability. Linking social and ecological systems: management practices and social mechanisms for building resilience (eds F. Berkes & C. Folke), pp. 1-25. Cambridge University Press, Cambridge, United Kingdom.

Berkes, F., and N. J. Turner. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. Human Ecology 34:479-494.

Benham, P. F., and D. M. Broom. 1989. Interactions between cattle and badgers at pasture with reference to bovine tuberculosis transmission. British Veterinary Journal 14:226–241.

Boyce, M. S. 2006. Scale for resource selection functions. Diversity and Distributions 12:269-176.

Briscoe, C. F. 1912. Fate of tubercle bacilli outside the animal body. Illinois Agricultural Experimental Station Bulletin, Report Number 161.

Brook, R. K., and S. M. McLachlan. 2005. On using expert-based science to "test" local knowledge. Ecology and Society 10, r3. http://www.ecologyandsociety.org/vol10/iss2/resp3/

Brook, R. K. 2005. Riding Mountain hay yard barrier fencing program evaluation final report. http://www.thegreenpages.ca/tb, accessed 05/09/06.

Brook, R. K., and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 161:156-166.

Brook, R. K., M. M'Lot, and S. M. McLachlan. 2006. Pitfalls to avoid when linking traditional and scientific knowledge. Climate Change: Linking Traditional and Scientific Knowledge (eds R. Riewe & J. Oakes), pp. 13-20. Aboriginal Issues Press, Winnipeg.

Burcham, M., W. D. Edge, and C. L. Marcum 1999. Elk use of private land refuges. Wildlife Society Bulletin 27:833-839.

Burnham, K.P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd edn. Springer-Verlag, New York.

Cattet, M. R., N. A. Caulkett, C. Wilson, T. Vandenbrink, and R. K. Brook. 2004. Intranasal administration of xylazine to reduce stress in elk captured by net gun. Journal of Wildlife Diseases 40:562-565.

Coe, P. K., B. K. Johnson, J. W. Kern, S. L. Findholt,J. G. Kie, and M. J. Wisdom. 2001. Responses of elk and mule deer to cattle in summer. Journal of Range Management 54:A51-A76.

Garnett, B. T., R. J. Delahay, and T. J. Roper. 2002. Use of cattle farm resources by badgers (*Meles meles*) and risk of bovine tuberculosis (*Mycobacterium bovis*) transmission to cattle. Proceedings of the Royal Society of London B 269:1487-1491.

Green, H. U. 1933. The wapiti of the Riding Mountain, Manitoba: an ecological study and commentary. Canadian Field-Naturalist 47:105-174.

Hutchings, M. R., and S. Harris. 1997. Effects of farm management practices on cattle grazing behaviour and the potential for transmission of bovine tuberculosis from badgers to cattle. Veterinary Journal 153:149–162.

Jenkins, K. J., and E. E. Starkey. 1993. Winter forages and diets of elk in old-growth and regenerating coniferous forests in western Washington. American Midland Naturalist 130:299-313.

Ji, W., P. C. White, and M. N. Clout. 2005. Contact rates between possums revealed by proximity data loggers. Journal of Applied Ecology 42:595-604.

Johannes R. E. 1993. Integrating traditional ecological knowledge and management with environmental impact assessment. Traditional Ecological Knowledge: concepts and cases (ed J. T. Inglis), pp. 33-41. Canadian Museum of Nature, Ottawa.

Jolly, D., F. Berkes, J. Castleden, T. Nichols, and the Community of Sachs Harbour. 2002. We can't predict the weather like we used to: Inuvialuit observations of climate change, Sachs Harbour, western Canadian Arctic. The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change (eds I. Krupnik and D. Jolly), pp. 93-125. ARCUS, Fairbanks.

Kaneene, J. B., C. S. Bruning-Fann, L. M. Granger, R. Miller, and B. A. Porter-Spalding. 2002. Environmental and farm management factors associated with tuberculosis on cattle farms in northeastern Michigan. Journal of the American Veterinary Medical Association 221:837-842.

Kirkwood, V., and J. Dumanski. 2003. Indicators of sustainability based on expert prairie farmer knowledge. Centre for Land and Biological Resources Research Report. http://paridss.usask.ca/factbook/kirkwood.html

Koller-Jones, M.A., C. Turcotte, C. Lutze-Wallace, and O. Surujballi. 2006. Effect of bovine tuberculosis in wildlife on a national eradication program – Canada.

Mycobacterium bovis infection in animals and humans, 2nd edn (eds C. O. Thoe, J., Stelle, and M. J. Gilsdorf, pp. 226-237. Blackwell Science, Oxford.

Kreswell, J. W. 1998. Qualitative inquiry and research design. Choosing among five traditions. CA: Sage Publications, Inc.

Laundré, J. W., L. Hernandez, and K. B. Altendorf. 2001.Wolves, elk, and bison: Reestablishing the "landscape of fear" in Yellowstone National Park, USA. Canadian Journal of Zoology 79:1401-1409.

Lees, V. W., S. Copeland, and P. Rousseau. 2003. Bovine tuberculosis in elk (Cervus elaphus manitobensis) near Riding Mountain National Park, Manitoba, from 1992 to 2002. Canadian Veterinary Journal 44:830-831.

Lutze-Wallace, C., C. Turcotte, M. Sabourin, G. Berlie-Surujball, Y. Barbeau, D. Watchorn, and J. Bell. 2005. Spoligotyping of *Mycobacterium bovis* isolates founding Manitoba. Canadian Journal of Veterinary Research 69:143-145.

Manly B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Second edition. Kluwer Academic Publishers, Boston.

Millar, J., and A. Curtis. 1999. Challenging the boundaries of local and scientific knowledge in Australia: opportunities for social learning in managing temperate upland pastures. Agriculture and Human Values 16:389-399.

Olea-Popelka, F.J., O. Flynn, E. Costello, G. McGrath, J. D. Collins, J. O'Keeffe, D. F. Kelton, O. Berke, and S. W. Martin. 2005. Spatial relationship between Mycobacterium bovis strains in cattle and badgers in four areas in Ireland. Preventive Veterinary Medicine 71:57–70.

Pearce, J.L., K. Cherry, M. Drielsma, S. Ferrier, and G. Whish. 2001. Incorporating expert opinion and fine-scale vegetation mapping into statistical models of faunal distribution. Journal of Applied Ecology 38:412-424.

Phillips, C. J. C., C. R. W. Foster, P. A. Morris, and R. Teverson. 2003. The transmission of *Mycobacterium bovis* infection to cattle. Research in Veterinary Science 74:1-15.

Quinn, T. 1995. Using public sighting information to investigate coyote use of urban habitat. Journal of Wildlife Management 59:238-245.

Sauter-Louis, C. 2001. The effectiveness of on-farm control programmes against wildlife-derived bovine tuberculosis in New Zealand. PhD thesis, Massey University, New Zealand.

Soparker, M. B. 1917. The vitality of the tubercle bacillus outside the body. Indian Journal of Medical Research 4:627–650.

Statistics Canada. 2002. The 2001 census of agriculture: farm data and farm operator data. Unpublished Statistics Canada Report, Ottawa.

Stewart, K. M., R. T. Bowyer, J. G. Kie, N. J. Cimon, and B. K. Johnson. 2002. Temporospatial distributions of elk, mule deer and cattle: resource partitioning and competitive displacement. Journal of Mammalogy 83:229-244.

Table 7.1. Independent variables used to examine factors associated with elk-cattle interaction at the regional and patch scales to derive resource selection function models.

Scale	Abbreviation	Variable
Regional and Patch	PPATCH	size of pasture patch (hectares)
	DISTANCE	minimum distance to protected area (RMNP and DMPF) (km)
	FOREST	% cover forest
	GRAIN	% cover cropland
	GRASSLAND	% cover grassland
	FORAGE	% cover forage crops
	WATER	% cover water
	WETLAND	% cover wetland
	ROADS	Road density
Patch	STREAM	minimum distance to stream
	MAX NDVI	maximum Normalized Difference Vegetation Index
	MEAN NDVI	mean Normalized Difference Vegetation Index
	WETNESS	derived from the Tasselled Cap Vegetation transformation
Regional	BALESHRED	does respondent shred hay bales to feed cattle? (1=no, 2=yes)
	CATTLE	size of beef cattle herd (0, 1-20, 21-40, 41-60, 61-80......>160)
	PASTURE	% cover pasture
	LEAVEHAY	leave hay bales for wildlife? (1=no, 2=yes)
	LEVCROP	leave crop residue for wildlife? (1=no, 2=yes)
	FEEDFREQ	Cattle feeding frequency (<3, 3, 4, 7, >7x/week)
	DISFEED	Distance of cattle feeding area to farm residence (km)

Table 7.2. Cumulative AICc[a] weights (w^+) for all thirteen independent variables hypothesized to influence elk-cattle interaction at the regional scale around Riding Mountain National Park based on the 2002 mail survey. All variables with $w^+ \geq 0.8$ are bolded.

Variable[b]	Cumulative AICc weight[c]	Elk Selection (+) or Avoidance (-)
DISTANCE	**1.00**	-
CATTLE	**0.82**	+
GRAIN	0.75	-
BALESHRED	0.53	+
PASTURE	0.39	+
FEEDFREQ	0.36	-
LEAVEHAY	0.34	-
WATER	0.34	+
ROADS	0.33	-
LEVCROP	0.32	-
FORAGE	0.28	-
WETLAND	0.28	+
FOREST	0.27	+

[a] AICc = Akaike's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).
[b] Variables are described in table 1.
[c] Cumulative AICc weight of a variable = the percent of weight attributable to models containing that particular variable and is calculated by summing the AICc model weights of every model containing that variable.

Table 7.3. Relative importance of the thirteen independent variables hypothesized to influence elk-cattle interactions around Riding Mountain National Park at the patch scale based on cumulative AICc[a] weights (w_+)[b]. All variables with $w \geq 0.8$ are bolded.

	ALL DATA[c]		FARMER INTERVIEWS		VHF COLLARS		GPS COLLARS	
Variable[d]	Rank	w_+	Rank	w_+	Rank	w_+	Rank	w_+
DISTANCE	**1**	**1.00**	**1**	**1.00**	**1**	**1.00**	**2**	**1.00**
FOREST	**2**	**0.98**	**2**	**0.98**	**2**	**0.97**	3	0.64
PPATCH	**3**	**0.90**	**4**	**0.82**	3	0.61	5	0.54
ROADS	**4**	**0.82**	**3**	**0.88**	13	0.31	7	0.53
WETLAND	5	0.68	5	0.68	8	0.41	11	0.32
WATER	6	0.53	6	0.53	9	0.35	8	0.48
WETNESS	7	0.47	7	0.43	5	0.50	13	0.28
FORAGE	8	0.31	9	0.33	4	0.50	6	0.53
GRAIN	9	0.29	8	0.33	10	0.34	10	0.46
GRASSLAND	10	0.28	10	0.31	7	0.42	9	0.47
MAX NDVI	11	0.28	12	0.28	6	0.44	12	0.31
MEAN NDVI	12	0.27	11	0.30	12	0.31	4	0.61
STREAM	13	0.26	13	0.26	11	0.33	**1**	**1.00**

[a] AICc = Akaikes's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).
[b] Cumulative AICc weight of a variable = the percent of weight attributable to models containing that particular variable and is calculated by summing the AICc model weights of every model containing that variable.
[c] Includes farmer interviews and VHF and GPS collar data combined.
[d] Variables are described in table 1.

Table 7.4. Difference matrices summarizing the level of agreement between different methods used to determine the presence or absence of elk on (a) cattle summer pastures and (b) winter-feeding patches around Riding Mountain National Park (2002-2005).

a)

Commission Error	Omission Error		
	GPS collars	**VHF collars**	**Farmer Interviews**
GPS collars		6.1%	3.4%
VHF collars	5.8%		1.4%
Farmer Interviews	29.3%	27.6%	

b)

Commission Error	Omission Error			
	GPS collars	**VHF collars**	**Farmer Interviews**	**Aerial Surveys**
GPS collars		0.0%	0.0%	1.2%
VHF collars	0.0%		0.0%	1.2%
Farmer Interviews	7.2%	7.2%		7.2%
Aerial Surveys	0.0%	0.0%	0.0%	

Table 7.5. Strengths and limitations of the methods used to assess overlap in space use between elk and cattle around Riding Mountain National Park.

Data Type	Sample Size (%Total)	Spatial Coverage	Spatial Error Estimate	Temporal Coverage	Total Cost[a]	Cost Per Sample[a]
Farmer Mail Survey	436 farms (45%)	22,000km^2	250m	1997-2001; knowledge spans decades	$47,000	$107/completed survey
Farmer Interviews	86 farms (97%)	1,750km^2	45m	2002-2005; knowledge spans decades	$42,000	$488/interview
GPS Satellite Collared Cow Elk	25 elk[b] 55,962 locations (1%)	1,100km^2	14m	2003-2005; individuals located 8-18x/per day for 4-12 months	$215,000	$8,600/elk/year $3.84/location
VHF Collared Cow & Bull Elk	175 elk[b] 9533 locations (7%)	11,000km^2	84m	2002-2005; individuals located 1-6x/week for 4-54 months;	$1,227,000	$5,700/elk/year $128.71/location
Aerial Elk Surveys	6932 elk 3004 locations (~20%/year)	8,000km^2	100m	2002-2005; 1x per year in February	$79,000	$11/elk/year $26.29/location

[a]costs include salaries
[b]some VHF and GPS collars were reused following a mortality and some VHF collars were replaced with GPS

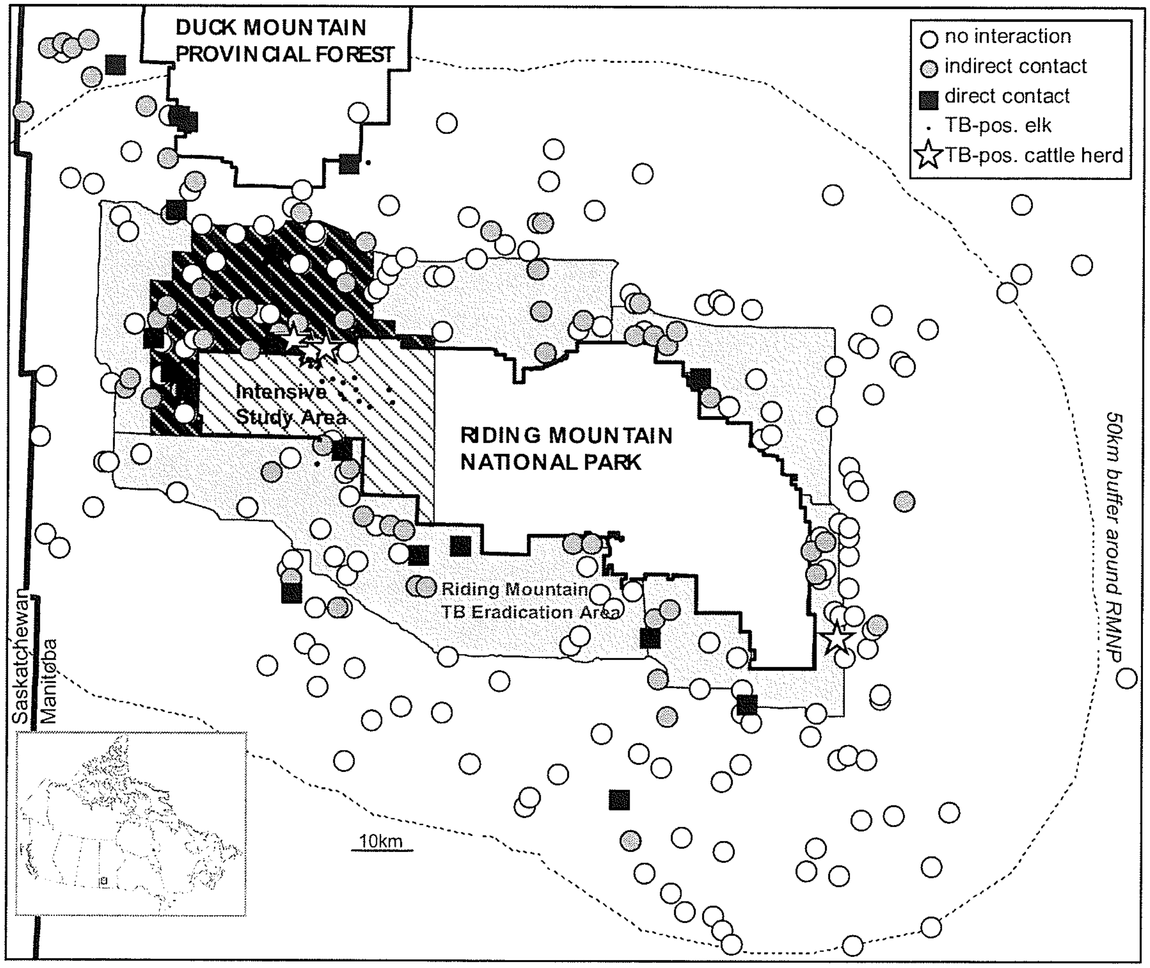


Figure 7.1. Distribution of cattle farms responding to the 2002 mail-out survey that observed direct (5% of respondents) and indirect (20% of respondents) elk-cattle interactions in 2001.

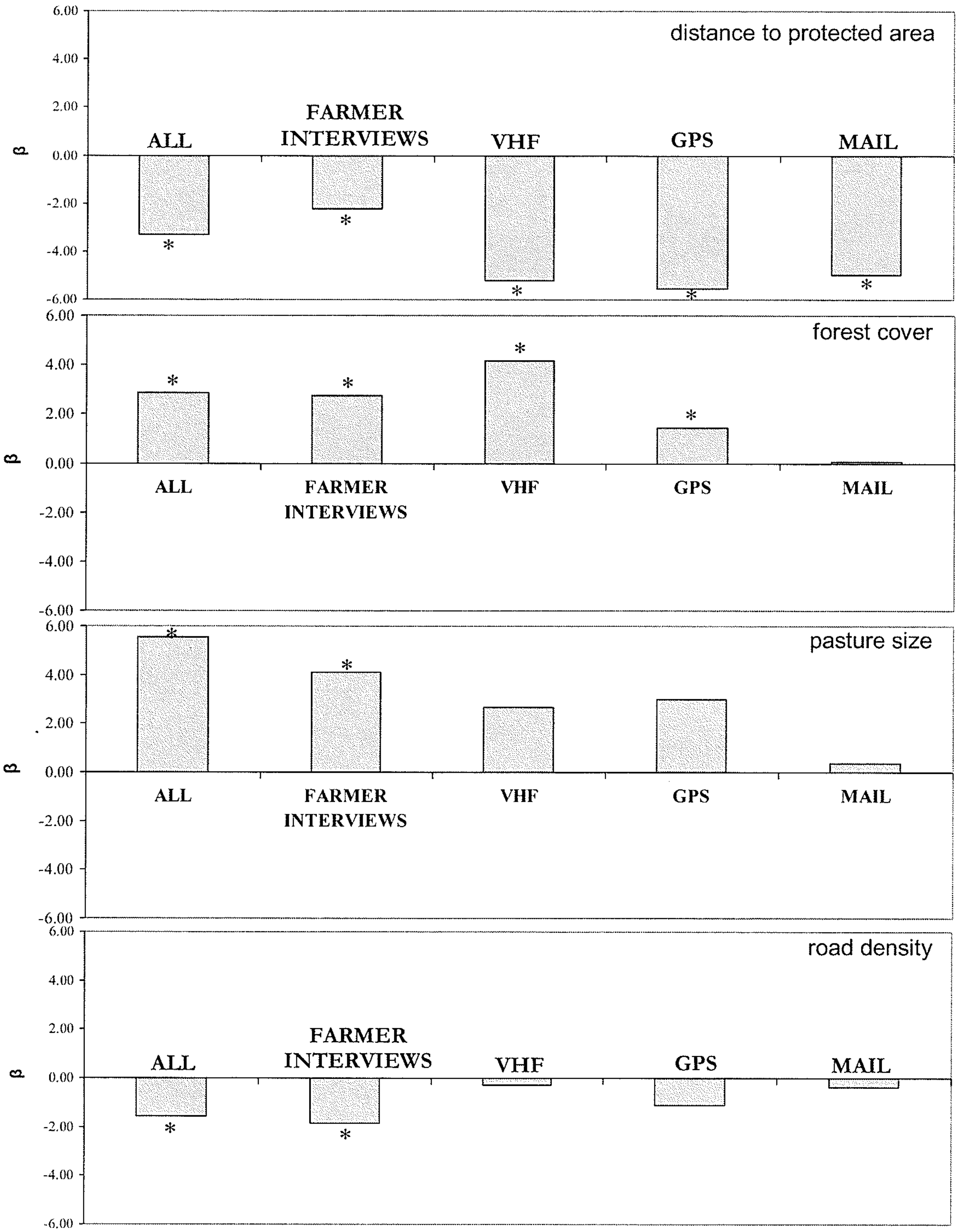


Figure 7.2. Model averaged RSF β coefficients from all possible logistic regression models (n=8191) for elk use of summer cattle pastures. The β estimates that are significantly different from 0 are marked with a * based on a Wald test ($P < 0.05$).

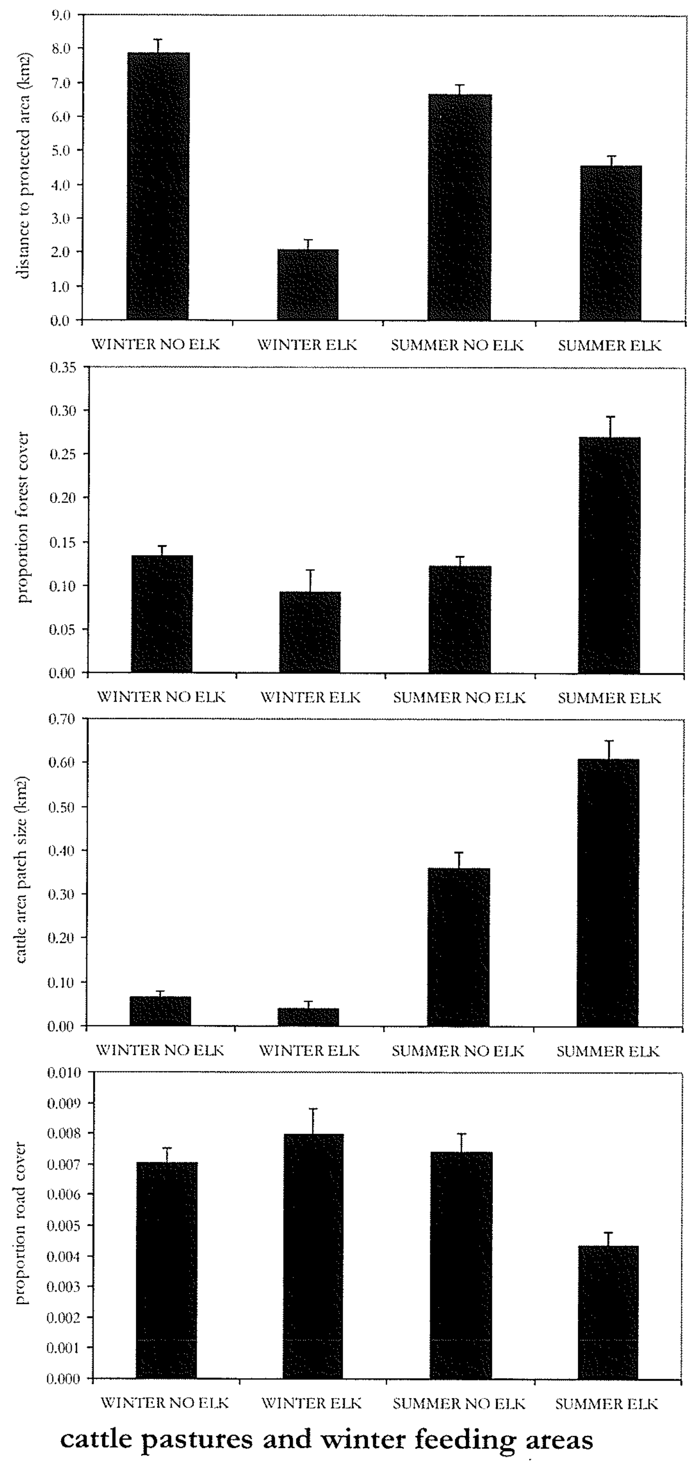


Figure 7.3. Mean values (±SE) for the four most important habitat variables associated with cattle pastures and cattle winter-feeding areas used and not used by elk based on all elk monitoring datasets combined.

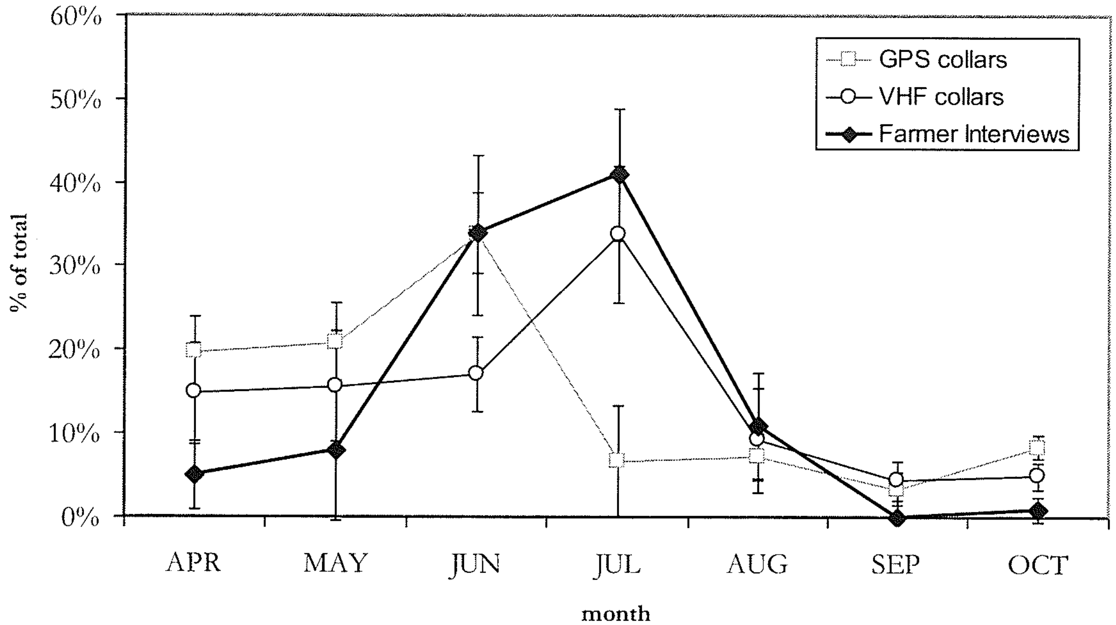


Figure 7.4. Mean percentage of elk locations (±SE) on cattle summer pasture patches during the period when cattle are present around Riding Mountain National Park (2002-2005).

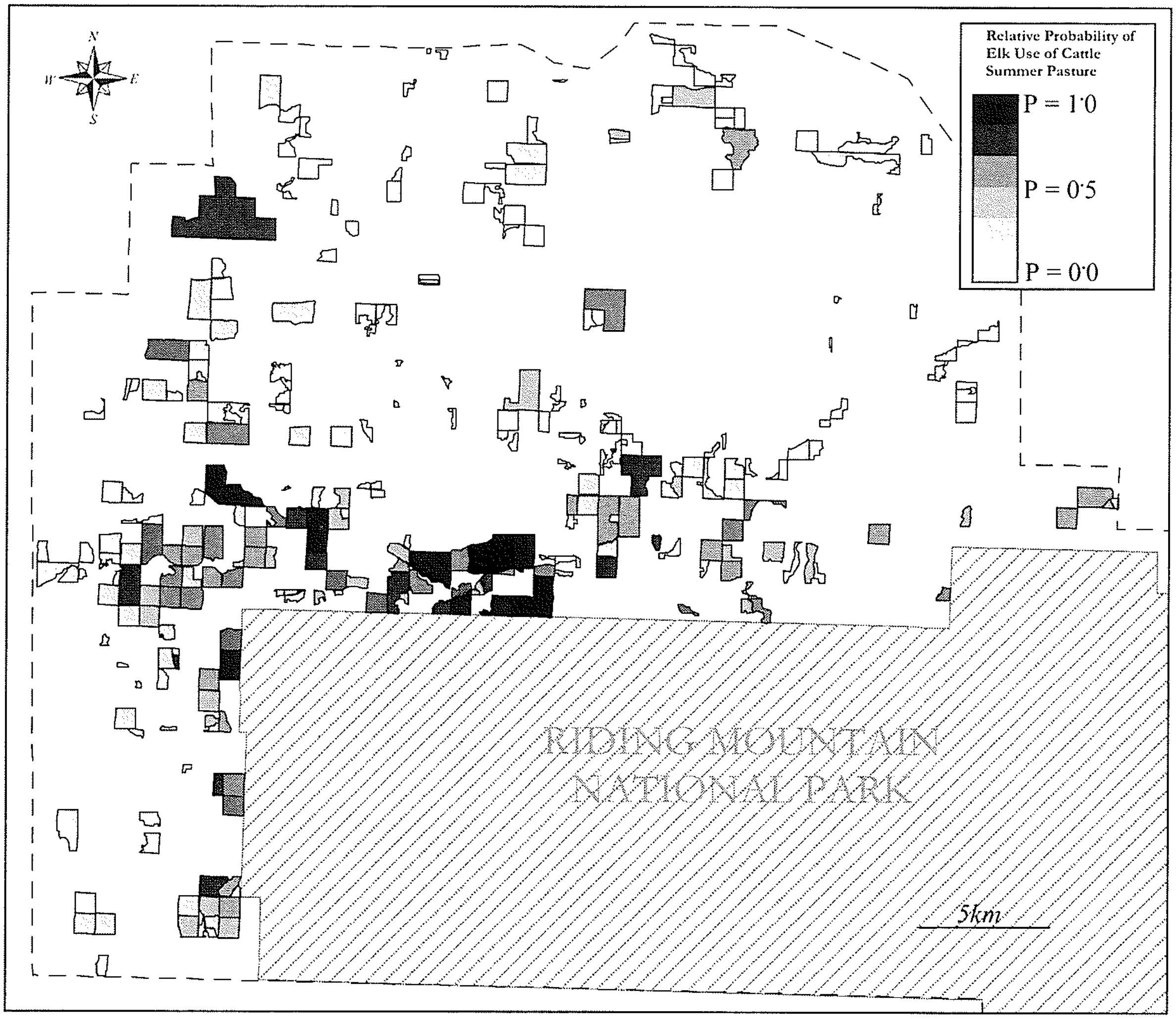


Figure 7.5. Predicted relative probability of elk use of summer cattle pastures (n=294) based on the model averaged resource selection function using patch scale datasets combined around Riding Mountain National Park (2002-2005).

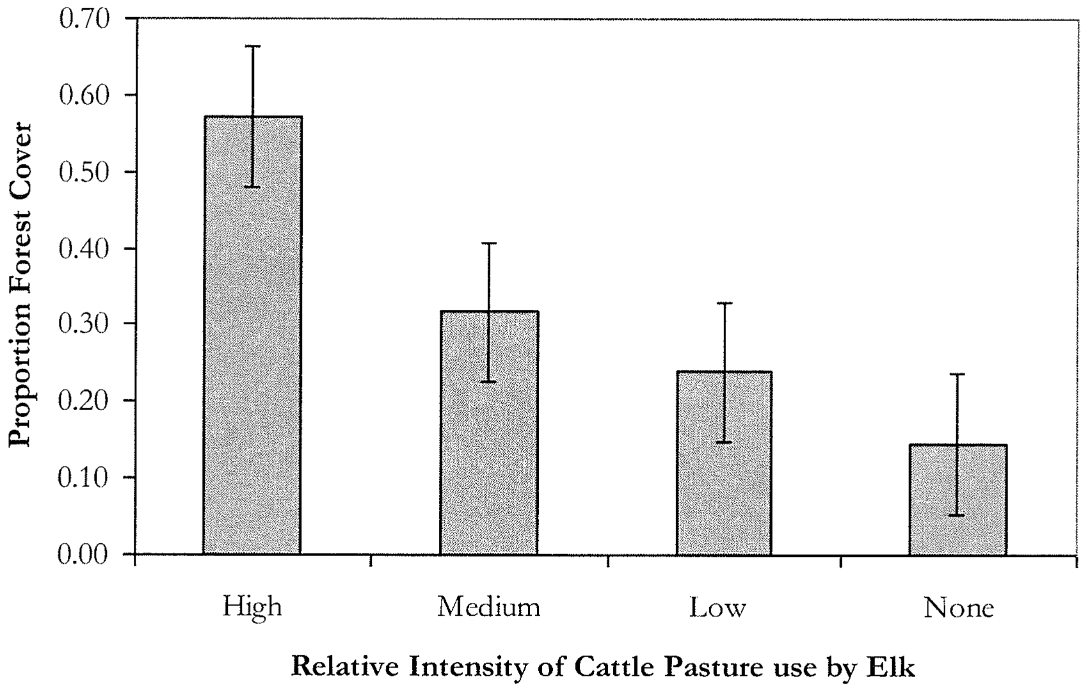


Figure 7.6. Mean proportion of forest cover (±SE) on cattle pastures around Riding Mountain National Park with different intensities of elk use by GPS and VHF collared elk (2002-2005).

CHAPTER 8

Movements and Habitat Selection of Parturient Elk in Agricultural and Forested Landscapes: Implications for Disease Transmission

"Too many scientists are turning their backs on this "dirty business" of natural resource allocation and management. Such is the nation's loss. Yet, it will be increasingly harder for scientists to avoid the arena and to hide from the need and demand for applicable knowledge. This is an exacting, tough, mean, and bruising game. It is not a pastime for wimps." -- Jack Ward Thomas

Chapter Summary

Agriculture has transformed much of the landscape of North America outside of protected areas. Parturient cow elk (*Cervus elaphus*) selecting natality sites in protected areas or on nearby farmland must make trade-offs among access to forage, predation risk, and avoiding human disturbance. I examined movements, habitat use, and location of natality sites of 146 radio-collared breeding age cow elk from 2002 to 2005 combined with the knowledge of 102 farmers obtained through participatory mapping interviews. During the calving period (19 May to 18 June), the home ranges of 73% of the parturient elk remained entirely within protected areas during the calving period, while 6% were exclusively on farmland, and 21% included both agricultural lands and protected areas. Cows exhibited considerable inter-annual home range fidelity during the calving period (mean overlap among years = 26%), with all but one animal having overlapping home ranges in consecutive years. Cow elk remaining solely in protected areas made no use of forage or grain crops and selected deciduous and mixed wood forest as well as marsh and water. Collared elk that exclusively used agricultural areas selected forage crops but showed no selection for any other habitat variables, while avoiding coniferous and mixed wood forest. Of the 102 farmers that were interviewed, 39 identified 67 natality sites, which were associated with deciduous forest cover and avoidance of areas dominated by grain cropland and water. Natality sites were identified for 28 GPS-collared cows and there were no differences between the habitats associated with natality sites identified using GPS collars and farmer interviews, but the local knowledge revealed that calving on agricultural lands had increased substantially in the last two decades, reflecting changes in farming practices and habitat quality within protected areas. This increase in calving on farmland provides insights into the complex trade-off during parturition. Farmland provides high quality forage, areas with reduced predators,

but more human activity. Parturient elk on farmland interacted with cattle frequently and 6.2% of the collared elk were determined to be infected with bovine tuberculosis. Mitigation strategies should focus on excluding cattle from portions of pasture that are near to protected areas and have large remnants of native vegetation.

Introduction

Parturient ungulates make important trade-offs between predation risk and securing quality forage, thereby balancing risks of mortality against increases in reproductive success, as predicted by optimal foraging theory (MacArthur and Pianka 1966, Bowyer *et al.* 1998, Rachlow and Bowyer 1998). Optimal natality sites provide adequate security cover for cows and newborn calves to hide from potential predators as well as high quality forage to support increased energetic demands associated with lactation and recovery from gestation (Carl and Robbins 1988).

Neonatal ungulates are typically immobile during at least the first day following birth and are thus highly susceptible to predation (Lent 1974, Geist 2002). Studies of ungulate-predator interactions have found that ungulates tend to select areas with lower predator density, particularly during the calving season (Mech 1977, Ferguson *et al.* 1988, Hebblewhite and Merrill 2007). Spatial segregation patterns and selection of natality sites by parturient female ungulates significantly influence calf survival during the most dangerous period immediately following birth (Altmann 1952, Ballard *et al.* 1999). Much research has focused on identifying ungulate natality sites to designate them as protected critical areas to prevent human disturbance or habitat changes that may affect calf survival (e.g. Vore and Schmidt 2001, Seward *et al.* 2005, Gustine *et al.* 2006), however there has been little associated research within human-dominated landscapes.

Intensive agriculture drastically alters forest patch size and structure and reduces or eliminates forest, wetland, and grassland cover (Saunders *et al.* 1991, Riiters *et al.* 2000). The resulting mosaic of cropland and natural habitat can change the movement and survival of wildlife (Wegner and Merriam 1979, Bennett *et al.* 1994, Gehring and Swihart 2004) including ungulates (Nixon *et al.* 2007), in turn often compromising genetic diversity and elevating predation rates. Protected areas have been established in North America within these agriculture-dominated landscapes to preserve natural flora and fauna in areas set aside, preventing agriculture and restricting other human activities (Margules and Pressey 2000). Although most fragmentation studies focus on the adverse effects of agriculture-mediated changes on wildlife habitat, some species of ungulates readily adapt to these altered landscapes and benefit from agricultural crops and altered predator distribution and abundance (Burel 1996). White-tailed deer (*Odocoileus virginianus*) are arguably the best adapted to farmed landscapes, as many populations reproduce within intensive agricultural areas and many use these areas exclusively throughout the year (Nixon *et al.* 1991). Although elk (*Cervus elaphus)* have been documented using farmland in diverse regions of North America (Stewart *et al.* 2002), it remains unclear if they are able to effectively reproduce in these areas.

Elk parturition occurs in early summer when forage quality and quantity is at a maximum and most young are born during a short birth season that serves to mitigate risks of predation (Collins and Urness 1983, Sadlier 1987). Despite having access to the highest quality forage, cows still must balance increased energetic demands of parturition with protecting their calves from predators (Carl and Robbins 1988). Primary predators of neonatal elk calves include wolves

(*Canis lupus*), cougars (*Felix concolor*), coyotes (*C. latrans*), and black bears (*Ursus americanus*) (Houston 1978, Carbyn 1983, Gese and Grothe 1995, Smith *et al.* 1996). Most areas where elk are present in North America are exposed to some or all of these carnivores and the cumulative impact of multiple predators on neonates can negatively influence elk population dynamics (Peek 2003).

To minimize risk, parturient elk have evolved a "hider" strategy whereby neonates (<1 month of age) are dispersed widely and are kept hidden until they are sufficiently developed to outrun predators, relying on cryptic coloration, minimal scent, and inactivity to avoid predation (Plate 1) (Johnson 1951, Murie 1951, Geist 2002). Throughout this period, the calf is highly susceptible to predation and thus remains hidden and associates with the cow only for short periods to nurse (Schlegel 1976).

Studies that examine the relationship between predation risk and habitat characteristics for parturient elk and other ungulates have typically been conducted at relatively small spatial scales. These have determined that optimal elk natality sites typically provide security cover for the calf for at least the first week of life and may include forest, ground vegetation, rocks or topographic features (Peek *et al.* 1982, Skovlin 1982, Wallace and Krausman 1991). Security cover must be sufficiently dispersed to avoid attracting predators to localized hiding sites (Schlegel 1976, Vore and Schmidt 2001).

Elk populations frequent landscapes comprising both forest-dominated protected areas and surrounding intensively farmed agricultural lands interspersed with fragmented patches of remaining natural vegetation (Hygnstrom *et al.* 2005). Agricultural landscapes produce large areas of diverse crop with extremely high forage values and typically have reduced populations of predators that avoid areas of human activity (Hayes and Gunson 1995, Bulte and Horan 2003).

These human-dominated areas are also associated with frequent disturbances during the calving period that, like conventional predation risks, divert both time and energy from feeding and parental care (Walther 1969, Frid and Dill 2002). Although human activities influence the regional distribution, habitat selection, and ultimate success or failure of elk calving on human-dominated landscapes (Phillips and Alldredge 2000), elk also have important implications for agriculture, especially regarding disease.

Several important diseases that infect elk and cattle have been identified in North America, including bovine tuberculosis, brucellosis, and anthrax and all of these can be transmitted to humans, making them significant economic and human health concerns (Meagher and Meyer 1994, Dragon and Elkin 2001, Joly and Messier 2004). Changes in the forage characteristics or predator populations in protected areas or farmed landscapes that facilitate greater use of agricultural lands by elk may result in increased opportunities for disease transmission between elk and cattle. These diseases create significant challenges for agencies working to ensure that landscapes support both healthy wildlife and productive agriculture.

Despite the importance of characterizing natality sites for elk and other ungulates, there are few long-term studies that address this need. In part, this reflects challenges in locating natality sites, which generally requires ground searches combined with monitoring cows fitted with radio-collars and/or vaginal-implant transmitters, or more recently, thermal imagery to detect neonates (Seward *et al.* 2005, Butler *et al.* 2006, Johnstone-Yellin 2006). These approaches are all resource and labour intensive, and thus span only one to three years (e.g. Wallace and Krausman 1991, Vore and Schmidt 2001, Seward *et al.* 2005). As such, they provide few insights into long-term fidelity to natality sites or the effects of changing landscapes and choices made to balance predation risk with foraging opportunities. Research that incorporates the local knowledge of lay people has contributed insights into ungulate movements that span decades and even centuries, time periods exceeding all but a few conventional ecological studies (Kendrick *et al.* 2005, R. Brook, *unpublished data*). No such study has ever been conducted on parturient ungulates, much less elk in agricultural landscapes.

The purpose of this study was to examine cow elk movements and habitat selection associated with the spring calving period in forested protected areas and the adjacent agricultural matrix at multiple spatial scales. Specific objectives were: (1) to estimate the relative use of forested protected areas and the nearby agriculture-dominated matrix during the calving period, (2) to determine habitat and crop characteristics associated with elk natality sites on agricultural lands, (3) to assess similarities and differences between natality sites identified using conventional radio-collaring and local farmer knowledge, and (4) to evaluate the implications of calving for the transmission of bovine tuberculosis between elk and cattle.

Methods

Study Area

This study was conducted in southwestern Manitoba, Canada which is dominated by intensive agriculture. Over 50,000 beef cattle are raised on farms in this area, which also includes pasture, hay land and extensive grain cropping of cereals and oilseeds (Statistics Canada 2007). Two large protected areas, Riding Mountain National Park (RMNP) and Duck Mountain Provincial Forest (DMPF) are embedded within this agricultural matrix. These protected areas represent relatively undisturbed natural habitat dominated by deciduous and mixed deciduous-coniferous forest.

Although the two protected areas were once linked by more extensive forest cover in the intervening lowlands, agricultural expansion has fragmented these over the last fifty years, leaving isolated patches of deciduous forest and native grassland (Walker 2001). At the time of the study, 70% of the region was privately owned farmland, 18% was provincial crown land (primarily DMPF, but also smaller wildlife management areas and parcels of agricultural lands), 11% was federal crown land (primarily RMNP but also community pastures) and 1% was Aboriginal First Nations (Brook and McLachlan 2003). Large mammals are abundant in the region, including a regional population of approximately 3700 elk, 3500 moose, and more than 8000 white-tailed deer, most of these closely associated with the protected areas (Riding Mountain National Park and Manitoba Conservation, unpublished data). Large predators in this region include grey wolves (*Canis lupus*), black bears (*Ursus americanus*), lynx (*Lynx canadensis*), cougar (*Felis concolor*), and coyotes (*Canis latrans*).

Elk Capture, Collaring and Disease Testing

One hundred and forty-six breeding age (>2.5 year old) cow elk were captured during the winter months (December-March) of 2002-2005 using a net-gun fired from a helicopter (Cattet *et al.* 2004) and given either Global Positioning System (GPS) satellite collars (n=44), Very High Frequency (VHF) radio-collars (n=86), or VHF ear transmitters (n=16). The VHF instrumented elk were all initially captured in and around RMNP using a stratified sampling approach. The study area was stratified into twelve equal-sized areas and sampling within them reflected the relative distribution of elk within the region based on the last ten years of winter aerial survey counts (Parks Canada, unpublished data). GPS collared elk were initially captured in and near the western quarter of RMNP and were largely captured on adjacent agricultural lands or inside RMNP but within 5km of the park boundary since I was primarily interested in documenting natality sites on agricultural land.

Blood samples of all collared elk were tested to assess the potential for bovine TB exposure and any collared animals testing suspicious on any of the screening tests were subsequently euthanized (Surujballi 2005, Rousseau and Bergeson 2005). All euthanized elk and natural mortalities were examined by necropsy and all lymph nodes and tonsils were collected for histological examination and mycobacterial culture in order to confirm infection with bovine tuberculosis (Rousseau and Bergeson 2005).

Locations of each GPS collared animal were obtained daily (8-18 locations per day) for up to one year. The VHF collared animals were located using fixed-wing aircraft and ground triangulation (1-8 locations per week) for up to 4 years and GPS collared elk were also located and observed during these flights and ground locations. Aerial VHF locations were collected during daylight hours, primarily from 0900-1800, and ground locations were obtained throughout the 24 hour period, primarily from 1800-0900, using roads and trails throughout the region. Location accuracy for VHF (84±61 m) and GPS collars (14±25 m) was assessed using collars placed at known locations on the ground for three-week periods. All adult cows were assumed to be pregnant, as data from necropsies of 67 animals in the region from 2003-2005 found that >90% were pregnant (Parks Canada, unpublished data). This was confirmed with visual observations of collared elk with calf-at-heel during aerial telemetry locations of VHF and GPS collared elk. All animals were captured and handled in accordance with the guidelines of the Canadian Council on Animal Care (2003) and the project was authorized under University of Manitoba Animal Care Utilization Protocol No. F01-037 and federal and provincial research permits.

Home Range and use of Agricultural Lands

The relative importance of agricultural lands and protected areas for parturient cow elk was compared by examining home ranges to determine the proportion that included a protected area. Female elk in the study area have been observed with neonates between 25 May and 14 June, with a mean parturition date of 09 June (Paquet and Brook 2004). A 100% minimum convex polygon (MCP) home range was determined using the Home Range Extension (Rodgers and Carr 1998) for each VHF collared cow elk each year during the calving period from 15 May to 24 June (the calving period defined by Paquet and Brook 2004 ± 10 days). MCPs were used since an average of 12 locations was obtained each year for VHF collared elk.

To assess inter-annual fidelity during the calving period for each VHF cow, I determined percent overlap of the 100% MCP was determined for each year based on the formula by Kernohan *et al.* (2001):

$$HR_{1,2} = A_{1,2} / A_1$$

where $HR_{1,2}$ is the proportion of the home range for year 1 that is overlapped by the home range for year 2, A_1 is the area of the home range for year 1, and $A_{1,2}$ is the area of overlap between the two years. If elk were monitored for >2 years, the area of overlap was calculated among all years.

Farmer Knowledge

Farmer knowledge of elk calving on agricultural lands was documented using an iterative approach. Initial community meetings were held to discuss research objectives and obtain input on study design to ensure it was acceptable to landowners. A questionnaire was then mailed to all farmers within 50km of RMNP in 2002 to document wildlife observations and farmer concerns regarding bovine TB (Brook and McLachlan 2006, Stronen *et al.* 2007).

On-farm participatory mapping exercises were subsequently conducted with 102 farm operators within the study area from 2003 to 2006 to document the locations of elk parturition sites and long-term changes that have been observed in the region. Only four farmers refused to participate due to time constraints, representing a 96% participation rate. Farmers that were interviewed had an average of 32 years of farming experience (range 4-84, S.E.= 2.6). Each participant delineated the movement patterns and known parturition sites of cow elk on a 1:5,000 scale orthophoto of their farm and these data were digitized using ArcGIS 9.0 (ESRI 2004). Locations of all cattle summer pastures were delineated to assess interaction and the potential of disease transmission between elk and cattle. Farmers also responded to open-ended questions regarding elk calving, including long-term changes in movements and habitat use and the potential effects of farm management practices on calving. Survey methodology has been approved under the authorization of the Joint-Faculty Human Subject Research Ethics Board Protocol #J2002:043 at the University of Manitoba.

Natality Sites of GPS-Collared Elk

Date and location of parturition was obtained for GPS collared elk by calculating daily movement rate during the calving period. The parturition date was assumed to be on the day with the shortest distance moved during this period (Waldrip and Shaw 1979, Fancy *et al.* 1989, Rettie and Messier 2001, Vore and Schmidt 2001) and natality site was defined as the centroid of a 100% minimum convex polygon (MCP) home range of the locations for that day. Cows were excluded from the analysis if they lacked a sharp decline in movement rate during the calving period or if they were later confirmed during aerial and ground location flights to be without a calf. Farmers also reported observations of neonatal calf mortalities associated with collared female elk and these cow elk were subsequently removed from analysis of natality sites since they often made large movements (>5km) following calf mortality.

Environmental Covariates

Seven environmental predictor variables hypothesized to influence parturient cow elk selection of natality sites were derived from the literature and discussions with farmers. Vegetation-associated variables included agriculture cropland (cereal and oilseed crops), deciduous forest, grassland, and forage crop (Table 8.1). Water cover was also included, which encompassed lakes, ponds, streams, and rivers. Vegetation and water cover was assessed within each pasture patch using a land cover map with 30m spatial resolution developed using LANDSAT-5 satellite imagery collected in 2002 (Manitoba Conservation 2003, unpublished data) and validated with field visits during telemetry relocations. The proximity of each natality site to the nearest road was measured using a detailed provincial GIS road layer (Manitoba Transportation and Government Services 2002, unpublished data). The road network within the study largely consisted of rural gravel roads, so no distinction was made among road types. Multi-collinearity among independent variables was assessed using Spearman rank correlation, and none had $r>0.7$

Habitat Selection by Parturient Cow Elk

Specific crop types used by adult cow elk were characterized by mapping each agricultural field in the study area and determining overlap with VHF and GPS-collared cow elk. Crop mapping was conducted each year within a GIS using a 1:5,000 scale orthophotos of the region combined with data from aerial and ground field observations and farmer interviews.

Habitat selection associated with birthing sites was determined using a selection ratio (SR) for each environmental variable (Manly *et al.* 2002). Habitat selection was determined using a 150m radius around all natality sites determined from GPS collars and farmer knowledge. The SR was calculated using the ratio of the proportion used to the proportion available (Manly *et al.* 2002):

$w_i = o_i/\pi_i$

where o_i refers to the proportion of the *i*th habitat variable used at natality sites, and π_i represents the proportion available of that same covariate, as determined by 200 randomly generated locations throughout the agricultural lands within the study area. The preference threshold is 1. If use of any given habitat is greater than its availability (i.e. selection is occurring) then the 95% confidence interval (CI) of the SR is >1. If the 95% CI of the SR is <1, the category is used less than available, (i.e. avoided); and if the 95% CI of the SR includes 1, the habitat category is used as a function of its availability and is neither selected nor avoided. Selection ratios for each habitat variable were compared using Bonferroni-corrected confidence intervals for multiple comparisons (Manly *et al.* 2002):

$w_i \pm Z_{\alpha/(2I)}SE(w_i)$

where I is the number of environmental variables (n=5), α=0.05, and SE is the standard error of w_i.

Habitat selection by calving cow elk was further modeled using a resource selection function (RSF) modeling approach. Univariate analyses of environmental variables did not identify significant ($p<0.05$) differences between the habitats associated with natality sites identified using GPS collars and local farmer knowledge. Thus, locations of all natality sites were combined from the GPS collar and farmer knowledge datasets, and used as a dependent binary variable representing the presence or absence of elk natality sites. Availability of habitat was defined by 1000 randomly distributed locations on agricultural lands within the study area. The RSF was estimated using binomial logistic regression (SAS Institute Inc., USA), based on the following formula:

$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)$

where $w(x)$ represents the relative probability of use (RSF) and β_1 is the selection coefficient for environmental variable x_1 (Manly *et al.* 2002).

Modelling was based on all of the RSF models in the set (multi-model inference) rather than on the single best model (Burnham and Anderson 2002). Akaike's information criterion difference with small sample bias adjustment (ΔAIC_c) and Akaike weights (w) were used to assess all models (Burnham and Anderson 2002). Cumulative AICc weights ($w+$) were then calculated for each independent variable by calculating all possible combinations of models (n= 127) for the seven independent variables and summing the AICc weights of all models that included that variable (Burnham and Anderson 2002). Variables having the highest cumulative AICc weights thus have the greatest influence on parturient elk selection of natality sites. Model-averaged coefficients, βi, were then derived for each independent variable and these coefficients were used to derive relative probabilities of elk selection of natality sites.

To display the RSF scores spatially, predicted RSF values were rescaled to a range of 0 to 1 for comparability (Lillesand and Kiefer 1994), extrapolated to the entire study area, and mapped. As scaled values approach 1, the patch is interpreted as having a relatively high likelihood of use by parturient elk as a natality site. Map accuracy was assessed using two independent samples, the 100% MCP home ranges during the calving period of the 24 VHF collared cow elk that used agricultural lands and 24 natality sites identified in farmer interviews that were not employed in model construction. Another 100 sites known not to have calving elk during this period from farmer observations and bi-weekly searches during the calving period were also used as absence sites. Overall map accuracy was determined as the percentage of RSF map pixels within the used sites that had an RSF score >0.8 and the percentage of RSF pixels in the unused sites that had an RSF score <0.2.

Results

Home Range and use of Agricultural Lands

Agricultural lands near protected areas represented an important component of the home ranges of parturient cows during the four summers of this study (2002-2005). When all MCP home ranges of the VHF collared cows (n=116) were examined during the calving period, 27% included some agricultural lands but only 6% were exclusively on farmland. In total, 21% of parturient elk used both agricultural lands and protected areas, whereas 73% of all parturient cows remained entirely within protected areas during the calving period.

I monitored 48 VHF-collared parturient elk over a single calving season and 24 VHF-collared parturient elk for ≥2 consecutive years to obtain a total of sixty-eight 100% MCP home ranges from 2002 to 2006 for the calving period. The home ranges of parturient VHF collared cow elk during the calving period overlapped between years in all cases except one (98% of collared cows) (mean overlap = 26.4%; range 6.5 - 77.5% overlap) The one exception used an overlapping range for three years (2002-2004) then in 2005 dispersed 35km south of RMNP and calved on agricultural lands. This observation was much farther from a protected area than all other recorded natality sites (mean distance to protected area = 4.4km; S.E. = 0.29km; range 0.2 - 10.3 km). The site fidelity of collared elk was consistent with the observations of farmers that elk returned to the same areas on the farm each year to calve:

> *It's usually hard to tell them apart, but there was this one cow elk that had only three legs and she calved on our land for two years in a row so far that we know of.* (Cattle Producer R211)

Habitat selection during the calving period was markedly different among cows that used only agricultural lands, those that used only protected areas, and those that used some combination of both (Figure 8.1). Cows remaining solely in protected areas predictably made no use of forage or grain crops and selected deciduous and mixed wood forest as well as marsh and water bodies. Elk that exclusively used agricultural areas strongly selected forage crops but showed no selection for any other habitat variables. They avoided coniferous and mixed wood forest, which were rare on farmlands, and similarly avoided water bodies. Parturient cows that used both farmland and protected areas selected deciduous forest and forage crops and avoided coniferous and mixed wood forest, marsh, and grassland. The most dramatic differences in habitat selection by elk using the different strategies is the selection of forage crop, which is strongly selected by cow elk using agricultural lands only (SR>6). Forage crops are also selected by elk using both farmland and protected areas, though much less so (SR=2). In contrast, forage crops were completely unavailable and thus unused by elk that remained solely within protected areas.

Natality Sites

Elk natality sites were identified for 28 GPS-collared cows and all showed characteristic drops in movement rates on the day the calf was born, movement rates then returning to previous levels the following day (Figure 8.2). For the GPS collared animals, more than half (57%) of the natality sites were on agricultural land, 43% were within protected areas, and none straddled a protected area boundary, reflecting that they were captured near the park boundary. Of the 102 farmers that were interviewed, 39 provided locations of 67 different natality sites, all of these occurring on agricultural lands. Only 6% of those interviewed had visited either RMNP or

DMPF over the last decade and none was able to identify elk natality sites within these protected areas. The use of islands within lakes outside of protected areas for calving was observed by one participant.

Of the five habitat types examined at natality sites in agricultural areas, only deciduous forest was selected (SR>1.0) whereas grain cropland and water were both avoided (SR<1.0) and there were no significant differences ($p<0.05$) between the selection ratios derived using local knowledge and GPS collars (Figure 8.3). Parturient cows strongly selected natality sites within 5 km of a protected area and selected less strongly sites 6-10km away, while strongly avoiding sites >10km from protected areas for both GPS and interview data (Figure 8.3). Due to these similarities, interview and GPS collar datasets were combined to derive a final integrated RSF, which identified proximity to protected area, deciduous forest cover, agricultural cropland, forage crop cover, and grassland as important variables, in order of importance (Table 8.2). These modelled results that represented the relative probability of use as natality sites by parturient cow elk were then extrapolated into an RSF map for the agriculture-dominated lands outside of the protected areas (Figure 8.4).

The predictive capacity of the model derived using the combined datasets was assessed for both used and unused sites. An independent accuracy test set was used that included 24 100% MCP home ranges during the calving period of the VHF-collared cow elk that used agricultural lands and 24 natality sites identified in farmer interviews. For these used sites, 93% of the pixels within the home range scored >0.80 and none were <0.20, indicating that all of these elk selected high quality calving habitat during the calving period. For the 100 sites known to have no elk calving activity during the study period, 89% of the pixels within these sites had RSF scores <0.20 and 4% scored >0.80, such that unused sites had relatively poor quality calving habitat.

These assessments indicate that the model had good predictive capacity for both used and unused sites.

Agricultural Crop Use

Cow elk were observed using cereal, oilseed and forage crops throughout the year (Figure 8.5). As expected, crop use was generally highest during the most productive part of the growing season, particularly June and July. However, use of all crop types through fall and early winter was also important, especially when native vegetation was senescing. Elk were frequently observed feeding on crop residues after harvesting was completed. Indeed, farmers frequently left crop residue behind specifically for elk to feed on:

> *Some land owners with large hayfields let the elk feed there and don't allow anyone to hunt. This may be well meaning but it causes serious problems. Elk gather in huge herds, which is not healthy. If calves are born there, they will come back, eventually causing more and more elk to come out of [Riding Mountain] Park and cause problems for other farmers.* (Grain farmer R707)

Of the available crop types within the study area, parturient elk used forage crops most frequently, with up to 14% of the locations of radio-collared cows occurring on forage fields in June (Figure 8.5). In contrast, wheat use was highest during fall and early winter when animals fed on grain spilled on the ground during harvest or on swaths intentionally left behind to feed elk and other wildlife. Interestingly, collared elk seemed to make greater use of canola fields during the spring and early summer, immediately after the canola was seeded in April and May. VHF-collared elk made especially high use of these newly seeded areas. Use of specific crop types identified by GPS and VHF collars was largely consistent between the two sampling methods (Figure 8.5).

Crop Damage

In total, 17% (17 of 102) of the farmers identified that the calving of elk on their farms and their subsequent return caused significant damage to standing crops and stored hay bales throughout the year:

> *The elk got very habituated. There was a herd that calved on our place on the other side of the road. They stayed out with their calves for most of the summer and then they came back to eat here in the winter and felt quite at home. They were really making a mess of the hay.* (Cattle producer R542)

Three farmers observed that the location of natality sites also influenced the movements of bull elk and one noted that:

> *We have resident elk cows that have their calves and summer on our farm until fall rut comes. The bulls come out of the park and round them up and take them back. If snow is deep they all come back out in winter to graze the alfalfa.* (Cattle producer R211)

Human Disturbance from Farming

Farmers observed that most elk strongly avoided interactions with humans and were easily disturbed during the calving period:

> *Two cow elk were calving when we came walking over the hill. If we would have known they were there we would have never went there but you know it just happened that way. I turned around and walked away but the placenta was just hanging out and the calf had just fallen out. I know the cow was really bothered.* (Cattle farmer R233)

One farmer observed the calf of a radio-collared elk that regularly used his farm being struck and killed by a vehicle on a farm road, and three others reported accidentally killing elk calves while working in their fields:

> *Several times I've been just backing up with the stone picker to dump the bucket and then this little calf will come running out, you're lucky if you don't squish them with a bucket of stones.* (Cattle Producer R222)

Although some farmers observed that calving elk were habituated to their activities and remained with their calves despite moderate levels of disturbance, others noted that cows could abandon their calves if disturbed aggressively:

> *We were having big groups of elk come into the hay field at night and they were causing lots of damage in the spring, so I went racing out there with my truck, honking the horn and flashing the lights to scare them off. The cows ran away but two young calves were left behind and their mothers never came back.* (Cattle farmer 245)

Long-term Change

Interviews with farmers showed a considerable long-term increase in the selection of natality sites on agricultural lands in recent decades and a corresponding change in regional land use practices within RMNP and on the adjacent farmlands. In total, 11% (11 of 102) of farmers observed that use of agricultural lands adjacent to the protected areas by parturient elk had been higher in the 1940s, while the other participants either did not see elk calving or were unaware of changes. The observed change was often related to changes in forest cover:

> *I remember the old guys always telling stories of big herds of elk coming out in the 1940's and 1950's when there was more bush.* (Cattle producer R008).

Elk movement outside of protected areas later declined in the 1960s and 70s, reflecting a concomitant decline in forest cover and an increase in grain production throughout the region:

> *I don't remember seeing any elk when I was a kid and my parents said that before I was born the only place you could see an elk was in the Riding Mountain Park. It was a rare thing to have an elk out.* (Cattle producer R007)

In contrast, more than one third (36%) of farmers observed that calving on agricultural lands has increased dramatically over the last two decades. This was attributed to a number of factors including a decline in habitat quality within protected areas caused by beaver flooding; elimination of resource use (i.e. livestock grazing and hay harvesting); and fire control inside

RMNP and DMPF; and declining wolf and bear numbers in the agricultural matrix and corresponding increases of these predators inside the protected areas (Figure 8.6):

> *All of the elk habitat in Riding Mountain Park is flooded out by the beavers so they've got to come out of the Park to eat. There is nothing left in there so I believe that main reason they are coming out of the Park is because of the beaver. They have quite a few timber wolves back in there that are not helping them stay in, especially for calving, they have to come out to get away from the wolves.* (Grain farmer R542).

These changes also reflected a regional change from grain to forage production over this period (Figure 8.6):

> *My parents were grain farming so we did not see any elk. It wasn't until after I took over and ran the farm for twenty years and switched over to cattle and hay that we started seeing elk calving on our place. (Cattle producer R008)*

Cattle-Elk Interactions

Use of cattle pastures by parturient elk has important implications for potential disease transmission, as boinve TB is endemic in the elk population within RMNP. Seven (58%) of the twelve GPS-collared elk that were initially captured in or near RMNP used the agricultural areas during the calving period and six (50%) actually calved on farmland. Four of the GPS (33%) and 17 (15%) of the VHF-collared elk were located on cattle pastures during the calving period and two (17%) of the GPS-collared cow natality sites occurred within a cattle pasture. Use of cattle pastures during the calving period was sometimes intensive, with an average of 14% of these GPS collar locations on cattle pasture (SE = 0.09, Range 0% – 37%). On average, each cattle pasture used by elk was visited by 1.6 different collared animals (SE = 0.13; Range = 1-6). Farmers frequently observed cow elk within cattle pastures during the calving period and 84% of elk natality sites were detected on cattle pastures.

Considerable overlap was observed in space use by cattle and parturient cow elk and cattle summer pastures typically had high RSF values for elk calving habitat (Figure 8.7). While cattle and elk are often both dispersed widely throughout a pasture block and elk and cattle sometimes avoid each other, farmers frequently observed them feeding together. An important point of contact was frequently observed at mineral supplement blocks placed within pastures for cattle:

> *On summer pasture, elk, cattle and deer are all on the same range. The area lacks salt, so a lot is consumed by wildlife at mineral blocks. They will leave a quarter inch of foam saliva on a mineral block and this would be a great place to spread tuberculosis.* (Cattle producer R814, 2005)

The high level of observed cattle-elk interaction during calving suggests that a risk for bovine TB transmission does exist. Bovine TB was found in 6.2% of the adult collared cow elk (3 GPS and 6 VHF) over the course of this study. One GPS collared TB-positive animal was located on cattle pasture 20% of the time and calved 470m from cattle pasture. The following winter, that same cattle farm tested positive for bovine tuberculosis and the entire livestock herd was destroyed. Another GPS-collared TB positive elk calved 1.4km from a cattle pasture and that farm also tested positive for bovine TB, which necessitated destruction of the cattle herd.

Discussion

Relative Importance of Agricultural and Protected Areas

Results of this study indicate that parturient elk in and around protected areas have three options available to them during the calving period: exclusive use of protected areas, exclusive use of farmland, or a combined use of both farmland and protected areas. Each of these strategies has important implications for access to high quality forage, predation and, indeed, transmission of bovine TB. Most (73%) parturient elk in the region used protected areas exclusively during their calving periods, and many (21%) made partial use of protected areas during this time. This indicates the importance of relatively large (>1,000km^2) and high quality protected areas for elk reproduction and survival.

Human use of the remote or 'backcountry' areas within Riding Mountain National Park and Duck Mountain Provincial Forest is low throughout the year and is largely limited to the sparse network of trails (Campbell and MacKay 2004). Intensive clear-cut forestry is widespread throughout much of DMPF and removes approximately 350,000 m^3 per year (Soprovich 2007), however harvesting and hauling activities are limited during the calving period, so the impacts on calving are likely more on habitat change than behavioural disturbance.

Hunting has been excluded from RMNP at any time of the year for all types of hunting since its inception in 1930. In contrast, within the Duck Mountains, recreational hunters harvest elk during the fall and winter seasons and Aboriginal people can do so at any time of year. Most hunting within the Duck Mountains is closely associated with the network of trails and roads throughout, but little Aboriginal elk hunting occurs during the calving period. The limited human activity within these protected areas and the large areas of intact forest cover suggest that humans exert a relatively minor influence on elk during the calving period. In contrast, predator numbers are high and wolves and black bears kill large numbers of elk neonates within the protected areas during the calving and post calving periods, whereas predators are much less active on farmland (Carbyn 1983, Paquet 1991).

A substantial number (26%) of parturient cows in my study made extensive use of agricultural areas around the protected areas and relied on farm crops as an important part of their diet, although only a small proportion (6%) used farmland exclusively. The agricultural landscape is highly fragmented and dominated by cropland interspersed with a complex road network. However, the number of rural residents is relatively low and declining in this region as the number of farms continues to decline (Statistics Canada 2007). Anthropogenic disturbance can compromise elk neonate survival, and parturient cows generally seek out areas with little or no human use during calving (Cassirer *et al.* 1992, Morrison *et al.* 1995, Shively *et al.* 2005).

Calving occurs in May and June when farmers are actively working throughout the landscape in their fields and with their livestock. Although neonates are occasionally disturbed and even killed by farming activities, these risks are relatively minor. Potential predators, particularly wolves and bears, are generally disliked and often killed by farmers in agricultural landscapes and thus tend to avoid roads and other areas used by humans (Paquet 1991, Mladenoff *et al.* 1995, Stronen *et al.* 2007). Natality sites then occur in areas within or adjacent to cattle pastures where predators are less common and where there is sufficient cover to avoid humans.

Habitats Associated with Elk Natality Sites on Farmland

Agricultural land surrounding protected areas also represent important habitat for parturient cow elk, providing particularly high quality forage during the pre-calving and post-calving periods. Lactation and recovery from gestation during the post-calving season both add considerably to the energetic requirements of females (Oftedal 1985). Agricultural crops have relatively high dietary protein and digestible energy, which elk use to supplement the intake of native forage (Haigh and Hudson 1993). Although farmland was important for one quarter of the parturient elk within the population, only two natality sites were located more than ten kilometres from RMNP and DMPF, one located using local knowledge and one using GPS collar data. This close association with protected areas reflects the requirement for greater security during the intensive hunting seasons in fall and winter and the higher levels of forest cover near these protected areas. Indeed, all elk populations now occurring in agricultural landscapes in Manitoba are closely associated with protected areas.

The importance of hiding cover in agricultural areas in my study is consistent with other research in North America that underscores the importance of cover in any landscape, although the type of cover varies in different regions, from forest (Waldrip and Shaw 1979) or shrub (Reichelt 1973) to herbaceous vegetation (Roberts 1974), rocks and topographic features (Wallace and Krausman 1991), or riparian habitat (Harper 1971). In my study area, there is relatively little topographic variation and the vast majority of non-forested lands had been converted into forage and grain crops. Although extant patches of deciduous forest represented important hiding cover, proximity to protected areas was still the most important determinant of natality sites. Patches of native grassland were also sometimes used when they had sufficient herbaceous cover.

Cow elk strongly avoided areas <200m from roads; however any movements within the agricultural matrix requires frequent road crossings. One farmer observed the calf of a radio-collared elk that regularly used his farm being struck and killed by a vehicle on a farm road, and two other farmers reported accidentally killing elk calves while working in their fields. Wallace and Krausman (1991) found that elk calved relatively close to roads and moved farther away once the calves were mobile. This likely represents a predator avoidance strategy, as carnivores have been shown to strongly avoid roads due to hunting pressure, noise, and the associated human presence (Mladenoff *et al.* 1995, Trombulak and Frissell 2000).

Although natality sites were typically situated away from water, elk also make use of some islands for calving within RMNP (Paquet and Brook 2004) and one island in the agricultural matrix was also used for calving in this study. While this appears to be an effective strategy to maximize calf survival and foraging efficiency of the cow elk, it was adopted by less than 1% of the elk that calved on farmland. Although there are many lakes dispersed throughout the agricultural region, representing 3% of the land cover, few of these have islands, so there are a small number of areas where this strategy could be implemented.

Potential Bovine Tuberculosis Transmission

Identification of natality sites in agricultural areas has important implications for understanding the potential for transmission of bovine tuberculosis among elk and between elk and cattle. In white-tailed deer, bovine TB-infected animals have been found to be much more closely related than non-infected animals (Blanchong *et al.* 2007), this likely the result of contact rates. It is unlikely that elk calves are born infected with *M. bovis* (Francis 1947). Contact rates between cow elk and their calves are high and associated with frequent grooming and the social bond that lasts upwards of nine months, these factors likely facilitating disease transmission (Kelly and Whateley 1975, Zanini *et al.* 1998, Phillips *et al.* 2003). Nursing may also act as an important disease transmission route from the mother to the calf through infected milk (Zanini *et al.*, 1998).

While an endemic disease like bovine tuberculosis may not negatively affect the elk population, it does have important socioeconomic implications if it is being transmitted to livestock since any cattle herds testing positive for bovine TB are destroyed (Koller-Jones *et al.* 2006). These direct impacts are relatively rare, but the indirect impacts, including stress associated with the potential for infection and reduced sales of cattle and hay to other regions fearful of infection resulting in great hardship for producers (Dorn and Mertig 2005, Brook and McLachlan 2006). As such, understanding and mitigating the risks associated with cattle-elk interaction are paramount.

Elk make extensive use of summer pastures, which has important implications for disease transmission (R. Brook, *unpublished data*). Transmission of bovine TB between cattle and elk can occur on these pastures through consumption of mucus, urine or faeces deposited on vegetation and soil by infected animals (Benham and Broom 1991, Phillips *et al.* 2003). Most studies show that elk make the greatest use of pasture in the absence of cattle (Stillings 1999, Coe *et al.* 2001, Stewart *et al.* 2002). Although these indirect contacts may represent important disease transmission sites, my study identified considerable concurrent and sustained use of pastures by cattle and parturient elk.

In order to reduce the apparent risks associated with bovine TB transmission, I recommend that farmers alter their grazing practices to separate cattle from areas important to parturient cow elk. This can be accomplished by timing the movements of cattle between pastures to minimize commingling opportunities, but a more effective approach would be to fence cattle permanently out of areas identified to have a high value as calving habitat. The RSF map of elk natality habitat and detailed map of existing cattle summer pastures produced from this project together can provide a tool for prioritizing areas in greatest need of mitigation. Efforts should also be made to fence water sources for cattle and artificial mineral blocks in a manner that excludes elk, as these may also be important risk sites for disease transmission (Phillips *et al.* 2003). Development of approaches to protect livestock producers from predator losses that do not involve killing bears and wolves should also help to keep elk within protected areas and reduce disease risk (Stronen *et al.* 2007).

Comparing Farmer Knowledge and Radio-collaring

This is one of few wildlife studies that makes use of both conventional ecological data and local knowledge to better understand and resolve environmental problems. Comparisons among these different data sets emphasized the benefits of this combined approach (Table 8.3). Each dataset could be used to triangulate and affirm the other. Many similarities existed among the datasets, and, indeed, farmer observations largely agreed with the collar data in describing elk natality habitat. Accepting that there are limitations to each data set, they can also be viewed as complementary in nature and, when combined, all contribute to a greater understanding of elk calving in agricultural landscapes.

Farmer knowledge provides the only means of examining historical changes in calving on agricultural lands, as there were no existing conventional ecological data before this study with which to examine any past changes (Table 8.3). Indeed, my results indicate that farmers contributed a rich knowledge of both past change and current conditions. Farmer knowledge, as well as the GPS and VHF collars, were effective at locating natality sites and describing movement patterns. However, farmers rarely made use of protected areas, so their knowledge was limited to agricultural lands, the areas for which ecological data are most scarce. Although farmers were generally confident about their knowledge of elk movements on their own and adjacent farms, they acknowledged that they had little insight into elk distribution elsewhere. This potential limitation was addressed by integrating the mapped elk movements obtained from all farmers that were interviewed. Since farmers normally were unable to distinguish among individual animals, mapping the home ranges of individual cow elk was best accomplished using GPS or VHF collar data, particularly in areas where the animals made use of protected areas, where farmer knowledge was limited.

Conclusion

While most elk are dependent upon protected areas, many also make extensive use of agricultural land during the calving period. Their use of farmland has increased over the last twenty years and reflects adaptations that capitalize on the reduction of predators and their extensive use of crops as subsidies. As the proportion of the elk population that calves outside of protected areas continues to increase, I anticipate a corresponding increase in conflicts with agriculture as crop damage and opportunities for disease transmission intensify. These conflicts will be most evident during calving and post-calving periods when cattle are on summer pasture and when crops are being actively planted and grown, but will also carry forward through all seasons and into subsequent years. It is important to identify ways of mitigating this already growing conflict in ways that benefit both producers and parturient elk.

The combined use of farmer knowledge and collar data resulted in a better understanding of elk calving in agriculture-dominated landscapes and providing insights into long-term dynamics in the use of farmland, which could not be obtained otherwise. I have also shown the value of using local farmer knowledge to help characterize the implications for agricultural production, elk conservation and the transmission of bovine TB. Another important outcome of documenting and using farmer knowledge is the good will that it generates by involving the farmers in generating their own solutions to the threats posed by bovine TB, this especially important in times of conflict among stakeholders.

Literature Cited

Altmann, M. 1952. Social behaviour of elk, *Cervus canadensis nelsoni*, in the Jackson Hole area of Wyoming. Behavior 4:116-143.

Ballard, W. B., H. A. Whitlaw, S. J. Young, R. A. Jenkins, and G. J. Forbes. 1999. Predation and survival of white-tailed deer fawns in northcentral New Brunswick. Journal of Wildlife Management 63:574–579.

Benham, P. F. and D. M. Broom. 1991. Responses of dairy cows to badger urine and faeces on pasture with reference to bovine tuberculosis transmission. British Veterinary Journal 147:517-532.

Bennett, A. F., K. Henein, and G. Merriam. 1994. Corridor use and the elements of corridor quality: chipmunks and fencerows in a farmland mosaic. Biological Conservation 68:155–165.

Blanchong, J. A., K. T. Scribner, A. N. Kravchenko, and S. R. Winterstein. 2007. TB-infected deer are more closely related than non-infected deer. Biology Letters 3:103-105.

Bowyer R. T., J. G. Kie, and V. Van Ballenberghe. 1998. Habitat selection by neonatal black-tailed deer: climate, forage, or risk of predation? Journal of Mammalogy 79:415–425.

Brook, R. K., and S. M. McLachlan. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. University of Manitoba, Winnipeg, Manitoba, Canada. (http://www.thegreenpages.ca/tb)

Brook, R. K., and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain National Park, Manitoba, Canada. Journal of Environmental Management 80:156-166.

Bulte, E. H., and R. D. Horan. 2003. Habitat conservation, wildlife extraction and agricultural expansion. Journal of Environmental Economics and Management 45:109-127.

Burel, F. 1996. Hedgerows and their role in agricultural landscapes. Critical Reviews in Plant Sciences 15:169–190.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

Butler, D. A., W. B. Ballard, S. P. Haskell, and M. C. Wallace. 2006. Limitations of thermal infrared imaging for locating neonatal deer in semiarid shrub communities. Wildlife Society Bulletin 34:1458-1462.

Campbell, J. M. and K. J. MacKay. 2004. The role of people, place and process in implementing a successful backcountry monitoring program: the case in Riding Mountain National Park. Environments 32:31-45.

Canadian Council on Animal Care. 2003. Guidelines on the care and use of wildlife. Canadian Council on Animal Care, Ottawa, Ontario, Canada.

Carbyn, L. N. 1983. Wolf predation on elk in Riding Mountain National Park, Manitoba. Journal of Wildlife Management 47:963-976.

Carl, G. R. and C. T. Robbins. 1988. The energetic cost of predator avoidance in ungulates: hiding versus following. Canadian Journal of Zoology 66:239-246.

Cassirer, E. F, D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375-381.

Cattet, M. R., N. A. Caulkett, C. Wilson, T. Vandenbrink, and R. K. Brook. 2004. Intranasal administration of xylazine to reduce stress in elk captured by net gun. Journal of Wildlife Diseases 40:562-565.

Coe, P. K., B. K. Johnson, J. W. Kern, S. L. Findholt, J. G. Kie, and M. J. Wisdom. 2001. Responses of elk and mule deer to cattle in summer. Journal of Range Management, 54:A51-A76.

Collins, W. B., and P. J. Urness. 1983. Feeding behavior and habitat selection of mule deer and elk on northern Utah summer range. Journal of Wildlife Management 47:646–663.

Dorn, M. L. and A. G. Mertig. 2005. Bovine tuberculosis in Michigan: stakeholder attitudes and implications for eradication efforts. Wildlife Society Bulletin 33:539–552.

Dragon, D. C. and B. T. Elkin. 2001. An overview of early anthrax outbreaks in Northern Canada: field reports of the health of animals branch, Agriculture Canada, 1962-71. Arctic 54:32-40.

ESRI. 2004. ArcGIS Version 9.0. ESRI, Redlands, California, USA.

Fancy, S. G., L. F. Pank, K. R. Whitten, and W. L. Regelin. 1989. Seasonal movements of caribou in arctic Alaska as determined by satellite. Canadian Journal of Zoology 67:644–650.

Ferguson, S. H., A. T. Bergerud, and R. Ferguson. 1988. Predation risk and habitat selection in the persistence of a remnant caribou population. Oecologia 76:236–245.

Francis, J. 1947. Bovine tuberculosis, including a contrast with human tuberculosis. Staples Press, London, England, UK.

Frid, A. and L. M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1):11. (http://www.consecol.org/vol6/iss1/art11)

Gehring, T. M. and R. K. Swihart. 2004. Home range and movements of long-tailed weasels in a landscape fragmented by agriculture. Journal of Mammalogy 85:79-86.

Geist, V. 2002. Adaptive behavioral strategies. Pages 389-434 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: Ecology and management. Smithsonian Institution Press, Washington, USA.

Gese, E. M., and S. Grothe. 1995. Analysis of coyote predation on deer and elk during winter in Yellowstone National Park, Wyoming. American Midland Naturalist 133:36-43.

Gustine, D. D., K. L. Parker, R. J. Lay, M. P. Gillingham, and D. C. Heard. 2006. Calf survival of woodland caribou in a multi-predator ecosystem. Wildlife Monographs 165:1-32.

Haigh, J. C., and R. J. Hudson. 1993. Farming wapiti and red deer. Mosby Year-Book, St. Louis, Missouri, USA.

Harper, J. A. 1971. Ecology of Roosevelt elk. PR W-59-R. Oregon State Game Commission, Portland, Oregon, USA.

Hayes, R. D., and J. R. Gunson. 1995. Status and management of wolves in Canada. Pages 21-34 *in* L. N. Carbyn, S. H. Fritts, and D. R. Seip, editors. Ecology and Conservation of Wolves in a Changing World. Canadian Circumpolar Institute, Occasional Publication No. 35, University of Alberta, Edmonton, Alberta, Canada.

Hebblewhite, M., and Merrill, E. H. 2007. Multiscale wolf predation risk: does migration reduce risk? Oecologia 152:377-387.

Houston, D. B. 1978. Elk as winter-spring food for carnivores in northern Yellowstone National Park. Journal of Applied Ecology 15:653-661.

Hygnstrom, S. E., M. A. Cover, B. A. Stillings, R. D. Crank, J. W. Fischer, J. W. Merchant, and S. P. Korte. 2005. Elk in Nebraska: opportunity or another private-public land conundrum. Proceedings of the Wildlife Damage Management Conference 11:213-218.

Johnson, D. E. 1951. Biology of the elk calf, *Cervus canadensis nelsoni.* Journal of Wildlife Management 15:396-410.

Johnstone-Yellin, T. L., L. A. Shipley, and W. L. Myers. 2006. Effectiveness of vaginal implant transmitters for locating neonatal deer fawns. Wildlife Society Bulletin 34:338–344.

Joly, D. O., and F. Messier. 2004. Factors affecting apparent prevalence of tuberculosis and brucellosis in wood bison. Journal of Animal Ecology 73:623-631.

Kelly, R. W., and J. A. Whateley. 1975. Observations on the calving of red deer (*Cervus elaphus*) run in confined areas. Applied Animal Ethology 1:293-300.

Kendrick A., P. O. B. Lyver., and Lutsel K'E Dene First Nation. 2005. Denesoline (Chipewayan) knowledge of barren-ground caribou (*Rangifer tarandus groenlandicus*) movements. Arctic 58:175-191.

Kernohan, B. J., R. A. Gitzen, and J. J. Millspaugh. 2001. Analysis of animal space use and movements. Pages 126-147 *in* J. J. Millspaugh and J. M. Marzluff, editors. Radio tracking and animal populations. Academic Press, San Diego, CA.

Koller-Jones, M. A., C. Turcotte, C. Lutze-Wallace, and O. Surujballi. 2006. Effect of bovine tuberculosis in wildlife on a national eradication program – Canada. Pages 226-237 in C.O. Thoe, J., Stelle, and M. J. Gilsdorf, editors. *Mycobacterium bovis* infection in animals and humans.Blackwell Science, Oxford, England, UK.

Lent, P. C. 1974. Mother-infant relationships in ungulates. Pages 14-55 *in* V. Geist and F. Walther, editors. The behaviour of ungulates and its relation to management. IUCN Publication 1973, No. 24, Vol. 1. IUCN, Morges, Switzerland.

Lillesand, T. M., and R. W. Kiefer. 1994. Remote sensing and interpretation. John Wiley and Sons, New York, New York, USA.

Manly B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Kluwer Academic Publishers, Boston, Massachusetts, USA.

MacArthur, R. H. and E. R. Pianka. 1966. On optimal use of a patchy environment. American Naturalist 100:603–609.

Margules, C. R. and R. L. Pressey. 2000. Systematic conservation planning. Nature 405:243-253.

Meagher, M. and M. E. Meyer. 1994. On the origin of brucellosis in bison of Yellowstone National Park: A review. Conservation Biology 8:645-653.

Mech, L. D. 1977. Wolf-pack buffer zones as prey reservoirs. Science 198:320–321.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the Northern Great Lakes Region. Conservation Biology 9:279-294.

Morrison, J. R., W. J. deVergie, A. W. Alldredge, A. E. Byrne, and W. W. Andree. 1995. The effects of ski area expansion on elk. Wildlife Society Bulletin 23:481-489.

Murie, O. J. 1951. The elk of North America. Stackpole, Harrisburg, Pennsylvania, USA.

Nixon, C. M., L. P. Hansen, P. A. Brewer, and J. E. Chelsvig. 1991. Ecology of white-tailed deer in an intensively farmed region of Illinois. Wildlife Monographs No. 118.

Nixon, C. M., P. C. Mankin, D. R. Etter, L. P. Hansen, P. A. Brewer, J. E. Chelsvig, T.L. Esker, and J. B. Sullivan. 2007. White-tailed deer dispersal in an agricultural environment. The American Midland Naturalist 157:212-220.

Oftedal, O. T. 1985. Pregnancy and lactation. Pages 215–239 *in* R.J. Hudson and R.G. White, editors. Bioenergetics of wild herbivores. CRC Press, Boca Raton, Florida, USA.

Paquet, P. C. 1991. Black bear ecology in the Riding Mountains, Manitoba. John/Paul and Associates, Wasagaming, Manitoba, Canada.

Paquet, P. C. and R. K. Brook. 2004. Island use as an anti-predator tactic by parturient elk and nursery herds in Riding Mountain National Park, Manitoba. Wildlife Society Bulletin 32:1321-1324.

Peek, J. M. 2003. Wapiti, *Cervus elaphus*. Pages 877-887 *in* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.

Peek, J. M., M. D. Scott, L. J. Nelson, D. J. Pierce, and L. L. Irwin. 1982. Role of cover in habitat management for big game in northwestern United States. Transactions of the 47th North American Wildlife and Natural Resources Conference.

Phillips, C. J. C., C. R. W. Foster, P. A. Morris, and R. Teverson. 2003. The transmission of *Mycobacterium bovis* infection to cattle. Research in Veterinary Science 74:1-15.

Phillips, G. E., and A. W. Alldredge. 2000. Reproductive success of elk following disturbance by humans during calving season. Journal of Wildlife Management 64:512-530.

Rachlow J. L., and R. T. Bowyer 1998. Habitat selection by Dall's sheep (*Ovis dalli*): maternal trade-offs. Journal of Zoology 245:457–465.

Reichelt, L. R. 1973. Characteristics of elk calving sites along the west fork of the Madison River, Montana. Thesis. Montana State University, Bozeman, Montana, USA.

Rettie, W. J., and F. Messier. 2001. Range use and movement rates of woodland caribou in Saskatchewan. Canadian Journal of Zoology 79:1933–1940.

Riiters, K., J. Wickham, R. O'Neill, B. Jones, and E. Smith. 2000. Global-scale patterns of forest fragmentation. Ecology and Society 4(2):3 (http://www.consecol.org/vol4/iss2/art3/)

Roberts, H. G. 1974. Effects of logging on elk calving habitat, Moyer Creek, Salmon National Forest, Idaho. U.S. Forest Service, Salmon National Forest, Idaho, USA.

Rodgers, A. R., and A. P. Carr. 1998. HRE: The Home Range Extension for ArcView. Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada.

Rousseau, P., and D. Bergeson. 2005. Bovine tuberculosis in the Riding Mountain National Park region. Proceedings from the 2004 Bovine Tuberculosis Eradication Conference, Lansing Michigan, USA.

Sadlier, R. M. F. S. 1987. Reproduction of female cervids. Pages 123-144 in C. M. Wemmber, editor. Biology and management of the Cervidae. Smithsonian Institute Press, Washington, D.C., USA.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18–32.

Schlegel, M. 1976. Factors affecting calf survival in north-central Idaho – a progress report. Proceedings of the Western Association State Game Fish Commission 56:342-355.

Seward, N. W., D. S. Maehr, J. W. Gassett, J. J. Cox, and J. L. Larkin. 2005. Field searches versus vaginal implant transmitters for locating calves. Wildlife Society Bulletin 33:751-755.

Shively, K. J., A. W. Alldredge, and G. E. Phillips. 2005. Elk reproductive response to removal of calving season disturbance by humans. Journal of Wildlife Management 69:1073–1080.

Skovlin, J. M. 1982. Habitat requirements and evaluation. Pages 369-415 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America; ecology and management. Wildlife Management Institute, Stackpole, Harrisburg, Pennsylvania, USA.

Smith, B. L., R. L. Robbins, and S. H. Anderson. 1996. Patterns of neonatal mortality of elk in northwest Wyoming. Canadian Journal of Zoology 74:1229-1237.

Soprovich, D. 2007. Overallocation of forests to Louisiana-Pacific. Eco-Journal 17:1-4.

Statistics Canada. 2007. 2006 census of agriculture: farm data and farm operator data. Unpublished Statistics Canada Report, Ottawa, Ontario, Canada.

Stewart, K. M., R. T. Bowyer, J. G. Kie, N. J. Cimon, and B. K. Johnson. 2002. Temporospatial distributions of elk, mule deer and cattle: resource partitioning and competitive displacement. Journal of Mammalogy 83:229-244.

Stillings, B. A. 1999. Ecology of elk in northwestern Nebraska: Demographics, effects of human disturbance, and characteristics of calving habitat. Thesis. University of Nebraska, Lincoln, Nebraska, USA.

Stronen, A., R. K. Brook, P. C. Paquet, and S. M. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Surujballi, O. 2005. Use of antemortem blood tests. Proceedings from the 2004 Bovine Tuberculosis Eradication Conference, Lansing, Michigan, USA.

Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Vore, J. M., and E. M. Schmidt. 2001. Movements of female elk during calving season in northwest Montana. Wildlife Society Bulletin 29:720-725.

Waldrip, G. P., and J. H. Shaw. 1979. Movements and habitat use by cow and calf elk at the Wichita Mountains National Wildlife Refuge. Pages 177-185 *in* M.S. Boyce and L. D.

Hayden-Wing, editors. North American elk: ecology, behavior, and management. University of Wyoming, Laramie, Wyoming, USA.

Walker, D. 2001. Landscape connectivity and vegetation dynamics in Riding Mountain National Park, Canada. Dissertation. University of Manitoba, Winnipeg, Manitoba, Canada.

Wallace, M. C., and P. R. Krausman. 1991. Neonatal elk habitat in Central Arizona. International Symposium on the Biology of Deer 2:69-75.

Walther, F. R. 1969. Flight behaviour and avoidance of predators in Thomson's gazelle (*Gazella thomsoni:*Guenther 1884). Behaviour 34:184-221.

Wegner, J., and G. Merriam. 1979. Movements by birds and small mammals between a wood and adjoining farmland habitats. Journal of Applied Ecology 16:349–357.

Zanini, M. S., E. Moreira, M. T. Lopes, P. Mota, and C. E. Salas. 1998. Detection of *Mycobacterium bovis* in milk by polymerase chain reaction. Journal of Veterinary Medicine Series B 45:473–479.

Table 8.1. Environmental variables used to examine factors influencing natality sites of parturient cow elk and derive resource selection function models.

Abbreviation	Variable
DISTANCE	minimum distance to protected area (RMNP or DMPF) boundary (km)
ROADS	distance to road (km)
CROPLAND	% cover cereal and oilseed crops
DECIDUOUS	% cover deciduous forest
WATER	% cover water
GRASSLAND	% cover grassland
FORAGE	% cover forage crop

Table 8.2. Model averaged coefficients and 95% confidence intervals for independent variables associated with parturient elk selection of natality sites around Riding Mountain National Park using locations from GPS collared parturient cow elk combined with observations by farmers of parturient elk.

Variable[b]	Cumulative AICc weight [c]	β coefficient	95% confident interval
DISTANCE	1.00	-6.86	-6.90, -6.81
DECIDUOUS	0.96	9.91	7.82, 11.99
CROPLAND	0.93	8.60	6.59, 10.60
FORAGE	0.93	9.69	7.57, 11.81
GRASSLAND	0.92	9.17	7.12, 11.23
WATER	0.31	-0.44	-1.14, 0.25
ROADS	0.27	-0.06	-0.26, 0.14

[a] AICc = Akaike's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).
[b] Variables are described in table 1.
[c] Cumulative AICc weight of a variable = the percent of weight attributable to models containing that particular variable and is calculated by summing the AICc model weights of every model containing that variable.

Table 8.3. Role and contribution of each method of monitoring elk calving in and around Riding Mountain National Park.

	Farmer Interviews	GPS Collars	VHF Collars
Long-term Changes			
Location of Birthing sites			
Movement Patterns			
Home Range			

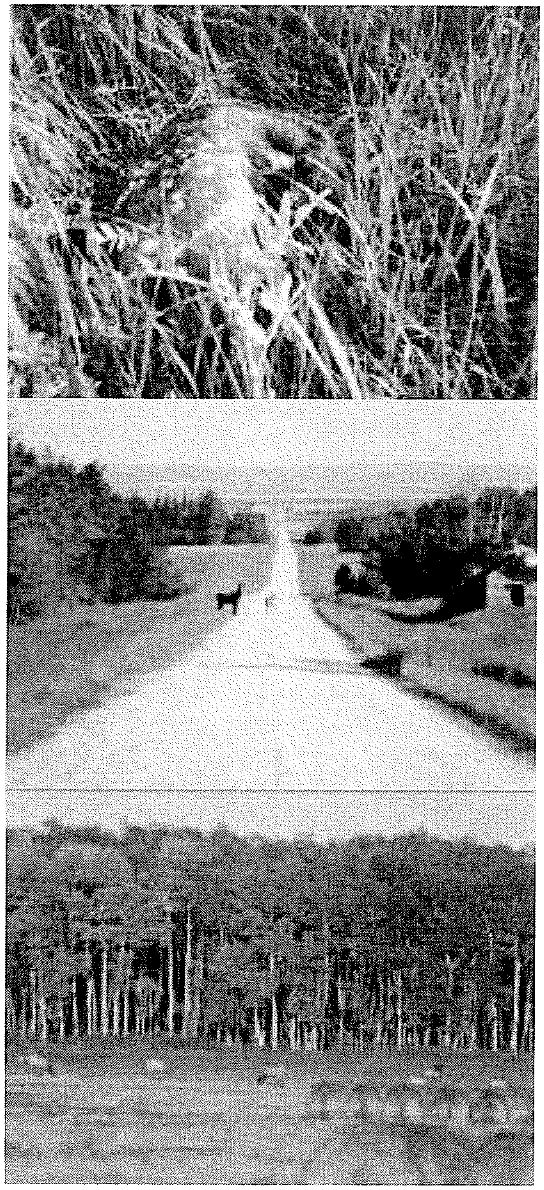


Plate 1. Newborn calf elk are immobile and highly vulnerable to predation, so security is a central consideration for parturient females selecting natality sites. After 10-20 days, the cow and calf leave the birth site and move extensively through the agricultural matrix, forming large cow-calf groups through the summer and one quarter of the population feeds intensively on agricultural crops.

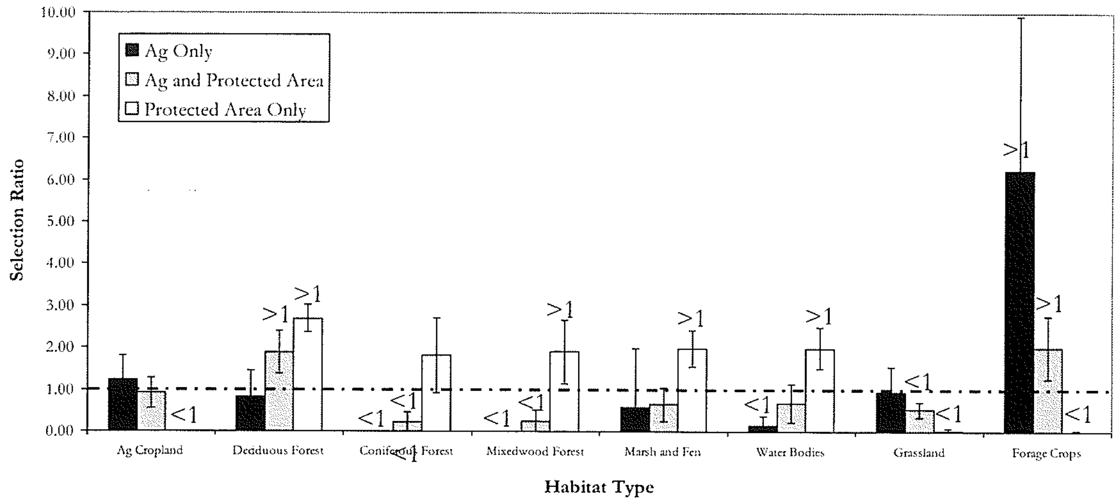


Figure 8.1. Selection ratios and 95% Bonferroni-corrected confidence intervals for habitat variables associated with VHF-collared parturient cow elk 100% MCP home ranges that occur only on agricultural lands (n = 7), on both agricultural lands and protected areas (n = 24), or only in protected areas (n = 85) during the calving period (25 May to 14 June) (2002-2005).

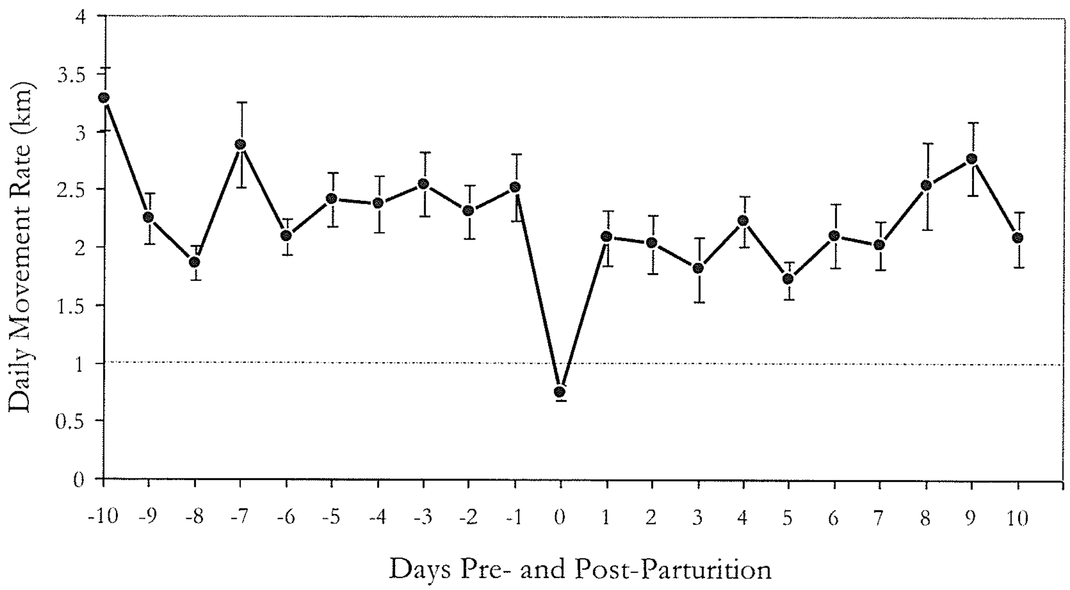


Figure 8.2. Daily movements of the GPS-collared cow elk (n=28) for the period spanning ten days before and after parturition (mean ± SE) (2002-2005).

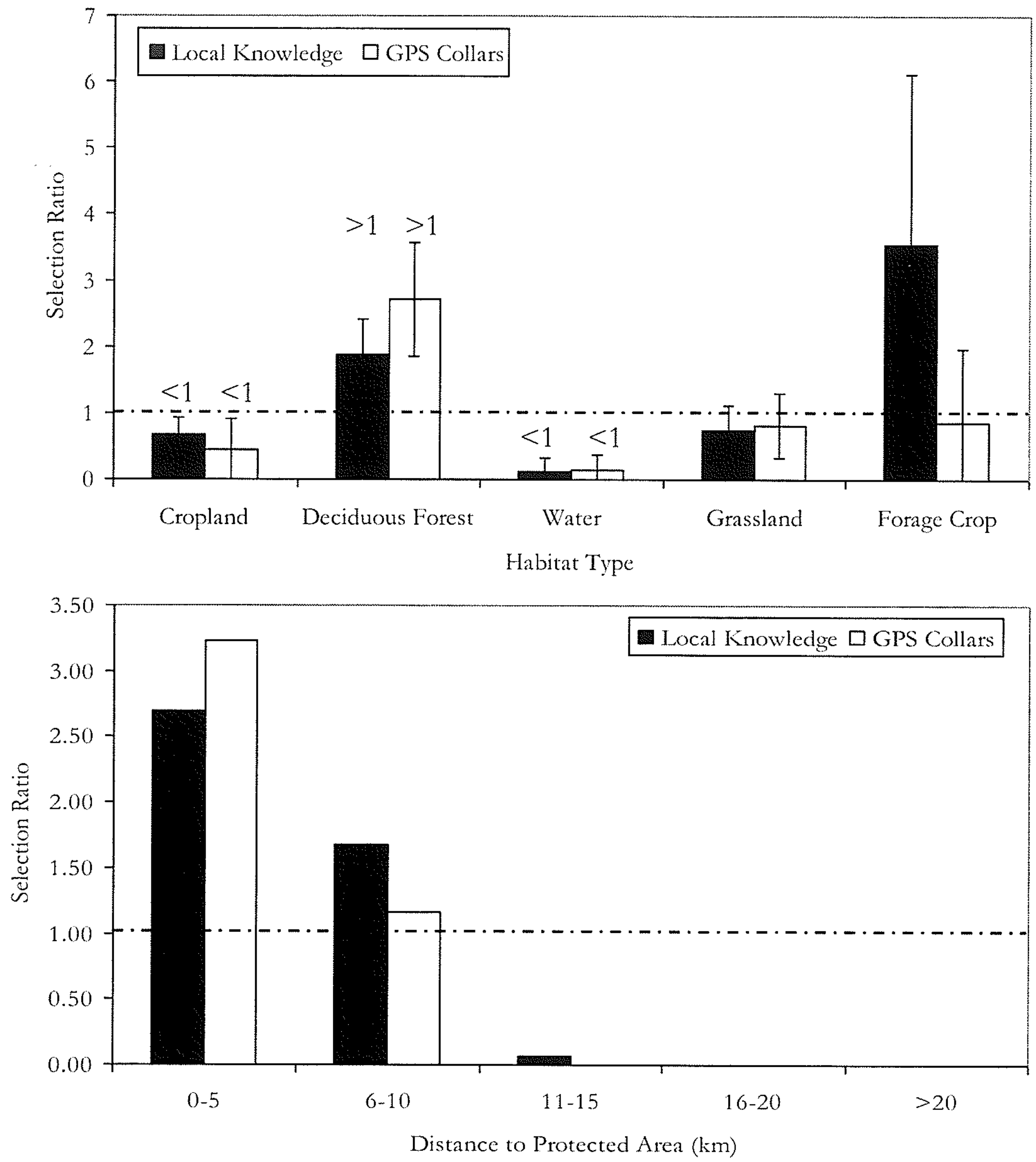


Figure 8.3. Selection ratios and 95% Bonferroni-corrected confidence intervals for environmental variables associated with elk parturition sites within the agricultural matrix identified using patches identified from farmer interviews (n = 67 sites) and GPS collared cow elk (n = 16) (a). Variables marked with >1 and <1 are significantly different from 1. Selection ratios for proximity of elk parturition sites to the nearest protected area for all data pooled. The dashed line represents the preference threshold, above which selection is occurring and below which habitats are used less than they are available.

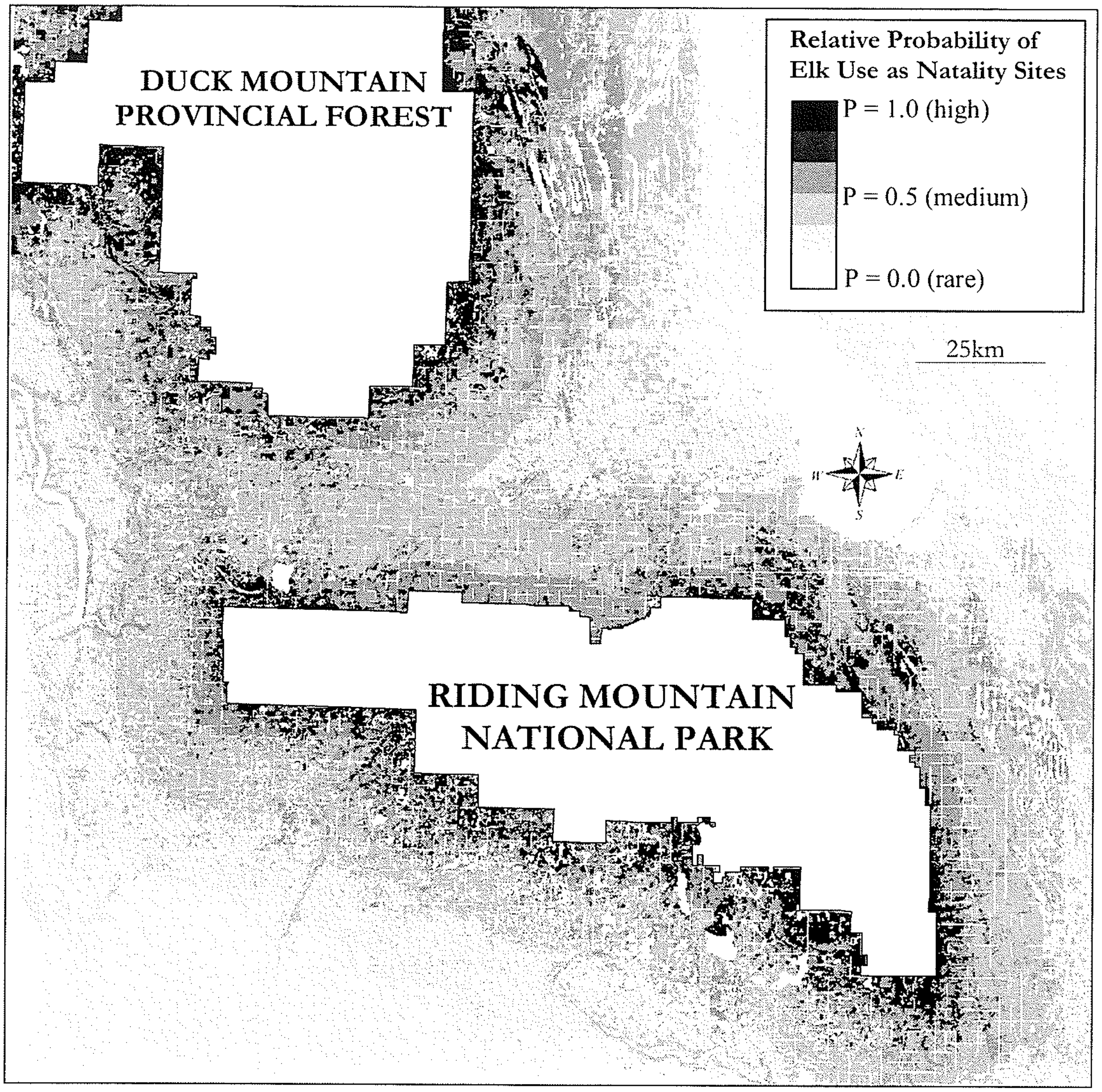


Figure 8.4. Predicted probability of occurrence of elk natality sites on agricultural lands in southwestern Manitoba extrapolated from the model-averaged resource selection function using known natality sites from GPS collared parturient cow elk and observations by farmers of parturient elk combined (2002-2005).

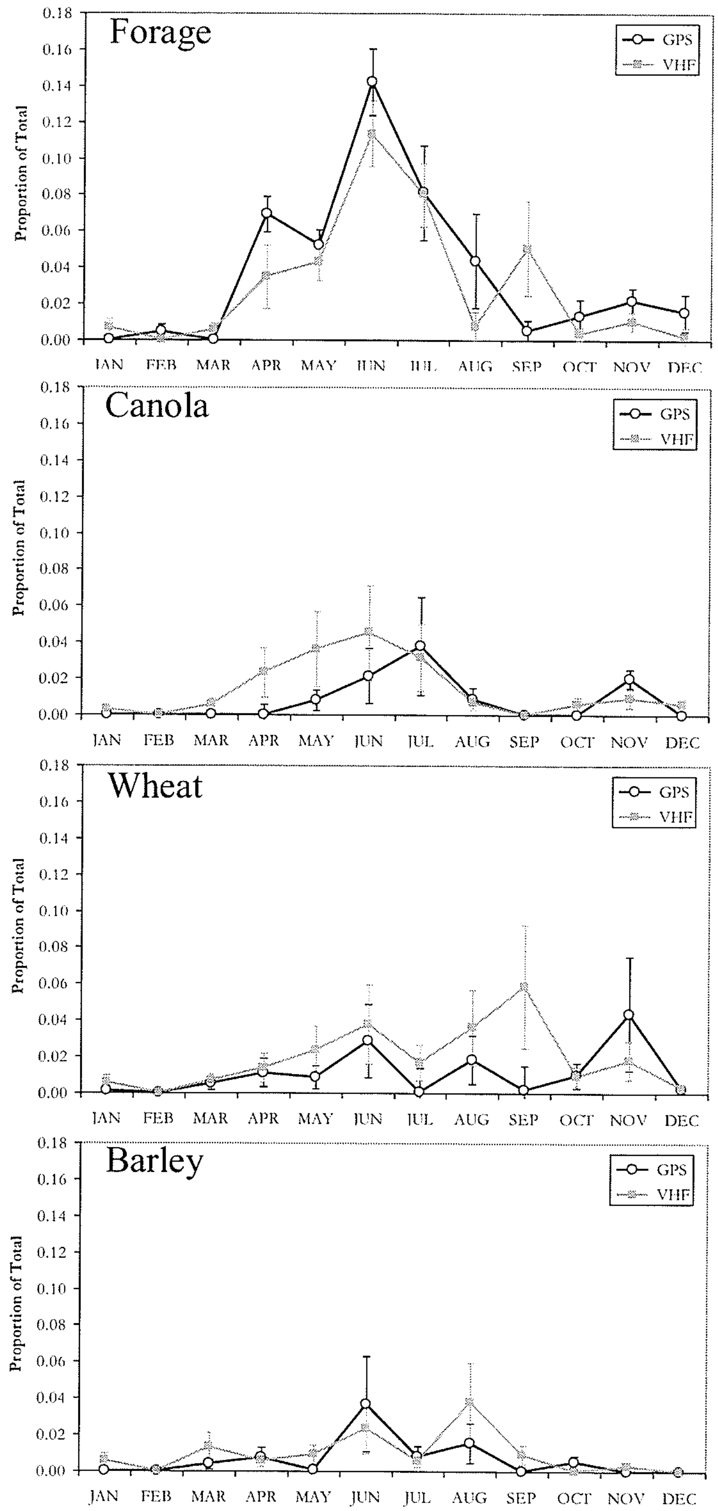


Figure 8.5. Adult cow elk use of agricultural crops from GPS (n=55,962) and VHF (n=9,533) collared elk locations (2002-2005).

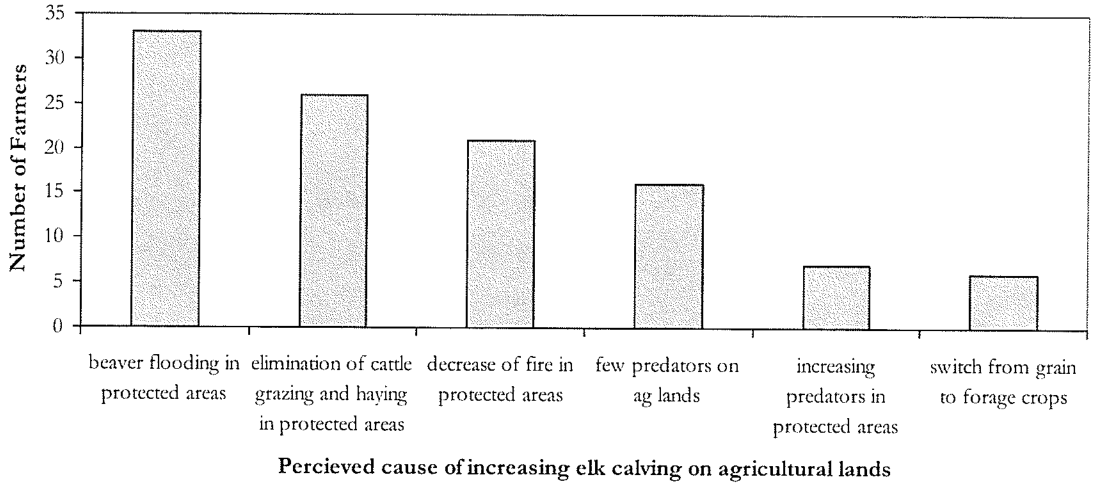


Figure 8.6. Perceptions of farmers interviewed regarding the observed increase in elk calving on agricultural lands over the last two decades (n=37 respondents; most identified >1 factor). These provide important hypotheses for future research.

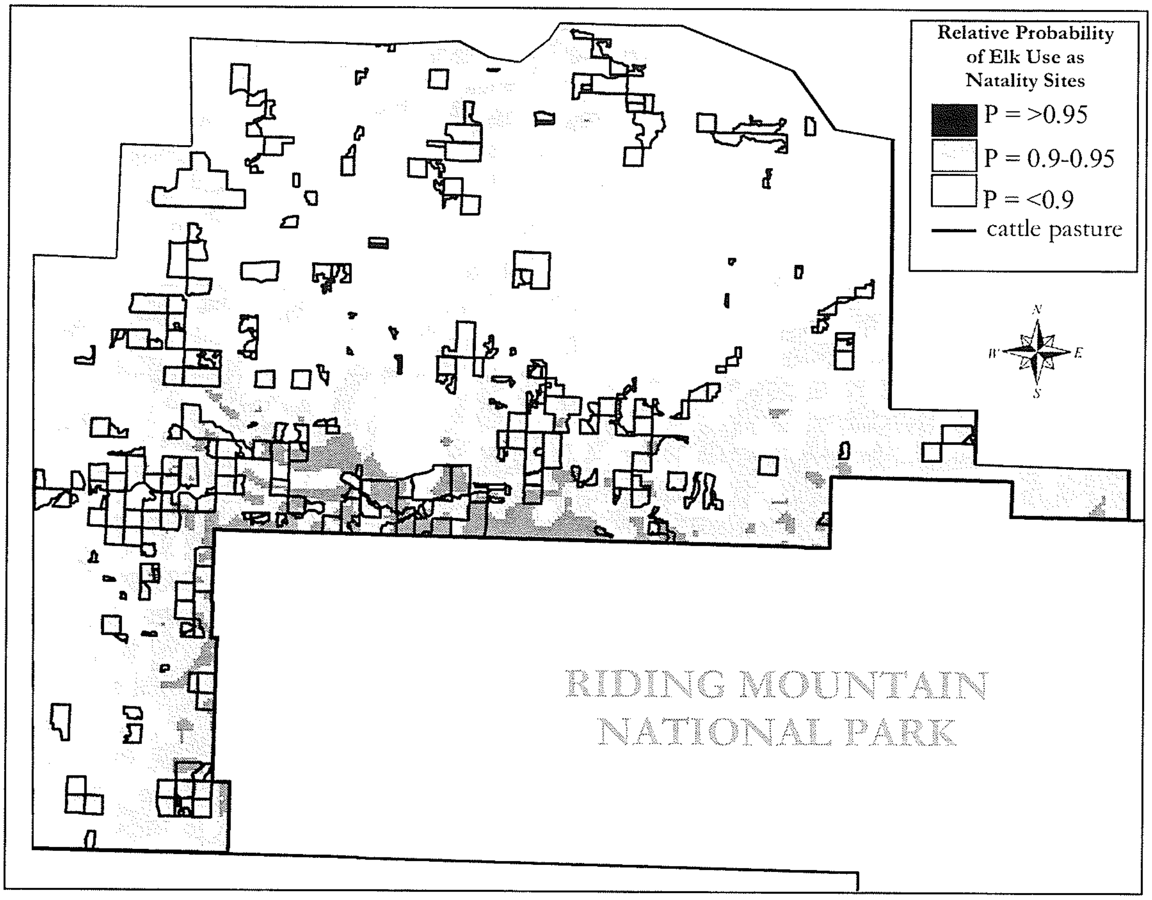


Figure 8.7. High quality elk natality habitat around Riding Mountain National Park associated with cattle summer pastures (n=294).

CHAPTER 9

BARRIER FENCING AT THE WILDLIFE-LIVESTOCK INTERFACE: INCORPORATING FARMER KNOWLEDGE, ATTITUDES AND ACTIONS TO FACILITATE ADAPTIVE MANAGEMENT OF BOVINE TUBERCULOSIS

"The fences should be mandatory in the bovine tuberculosis eradication zone and if the fence is not accepted then there should be no compensation to those producers for wildlife damage to cattle feed. If you don't want to protect your feed source, you are asking for trouble." --Cattle Producer near Riding Mountain National Park

Introduction

Disease transmission between wild ungulates and livestock has important implications for the social and economic security of farms, but also for the conservation of wildlife and their habitats (Aguierre *et al.* 1995, Brook and McLachlan 2006, Stronen *et al.* 2007). Indeed, numerous diseases have been detected in overlapping species of ungulates and livestock globally, including anthrax, brucellosis, foot-and-mouth disease, rinderpest, and bovine tuberculosis (Bengis *et al.* 2002, Nishi *et al.* 2005, Kock 2005). However, direct evidence of actual transmission across the wildlife-livestock interface is relatively poor and it in most cases it is assumed by the presence of infected wild and domestic animals that transfer has occurred between them (Phillips *et al.* 2003). In the case of bovine tuberculosis (TB), it is well established that transmission within and among species is feasible either directly through coughing, sneezing, and licking (Sauter and Morris 1995), or indirectly via shared hay, grain, silage, or pasture contaminated with bovine TB-infected urine, faeces, or saliva (Hutchings and Harris 1997). However, the specific nature of transmission within any particular region is much less understood, particularly since most regions have more than one potential wildlife and livestock species that can be infected or infective.

Bovine tuberculosis is a bacterial disease (*Mycobacterium bovis*) that primarily infects livestock, but can also be transmitted to and become endemic in wildlife when contact with domestic livestock occurs (Barlow 1993, Schmitt *et al.* 1997). Infected wildlife can then potentially function as a disease reservoir, infecting other wildlife and farm animals, particularly cattle. In Canada and the United States, the bovine TB national management policies involve the complete slaughter of any cattle herd with even a single individual testing positive (Frye 1995, Koller-Jones *et al.* 2006). Whole herd eradication is necessary due to the limitations of the existing live animal tests, which frequently do not detect infected individuals in a herd, combined with the absence of an economical or efficacious treatment for infected animals. Despite these limitations, the test and slaughter programs have been largely successful over the last fifty years at dramatically reducing or eliminating bovine TB in livestock in most areas where no wildlife reservoir exists.

The direct impacts of cattle herd removal on farm families can be devastating despite existing financial compensation programs that only partially cover the costs and ignore the social aspects (Griffore and Phenice 2001, Dorn and Mertig 2005). At the same time, indirect impacts on farms at risk of becoming infected can undermine potential cattle and hay sales and are associated with stress and the financial burden of mitigation (Brook and McLachlan 2006). At the scale of the individual farm, efforts to prevent transmission of bovine TB to livestock have focused on reducing or eliminating direct contact between wildlife and cattle (Seward *et al.* 2007) and protection of stored farm crops (Craven and Hyngstrom 1994).

Initial efforts to prevent the spread of TB from wildlife to livestock when infections are first detected have normally emphasized intensive culling of the wild populations. These reduction efforts have often been highly controversial and there is little evidence that they has ever been effective (Nishi *et al.* 2005) and some research suggests that they may even exacerbate the problem (Donnelly *et al.* 2006). While hunting seasons often help to reduce wildlife damage and disease risk, they do not usually eliminate contact or disease transmission risk (Conover 2001). Non-lethal deterrents, including the use of blood meal, frightening devices, and chemical repellents are sometimes effective during the first few weeks of implementation but rarely provide long-term protection (Wagner and Nolte 2001, VerCauteren *et al.* 2006a, Seward *et al.* 2007). Measures that merely reduce contact may partially limit disease transmission, but are unlikely to eliminate it over the long term. Permanent fencing to protect stored hay has been suggested as perhaps one of the most effective barriers to bovine TB transmission between ungulates and livestock (Kaneene *et al.* 2002, VerCauteren *et al.* 2006b).

Barrier fencing has been used under diverse conditions to prevent ungulate damage to stored and standing agricultural crops and these have included woven wire barriers or several strands of electrified wire which create a pain or shock stimulus when contacted and these have been evaluated extensively (e.g. Fitzwater 1972, Hygnstrom and Craven 1988, Curtis *et al.* 1994). I was able find relatively few documented cases where fencing was used explicitly in an attempt prevent disease transmission (except see Sutmoller 2002, Machackova *et al.* 2001). Of all of the fencing evaluations that I reviewed, all except one (Drake *et al.* 1999) focused on expert-based data collection using cameras, wildlife tracks, and radio-collared animals, but did not document the experiences and attitudes of the fence owners or any other people living and working near the fences (e.g. Seamans and Vercauteren 2006, Seward *et al.* 2007, Vercauteren *et al.* 2007).

Research is increasingly revealing the value of incorporating the experiences of local people in understanding ecological processes and evaluating natural resource management interventions (Selin *et al.* 2000). This local ecological knowledge (LEK) complements and augments conventional ecological studies and may be used effectively by itself without scientific data (Brook and McLachlan 2005, Berkes and Turner 2006).

LEK can contribute long-term observations that span decades and even generations (Berkes and Folke 1998, Chapter 4). While the 'objective' aspect of these observations are important, such as the timing and nature of wildlife observations; the 'subjective' aspects that include the attitudes of each individual regarding these observations are also important and ultimately influence the long-term success of resource management programs. Efforts are needed to document and link the objective and subjective aspects of risk at the farm scale throughout the period of its operation to adapt to effectively changes in ways that are both functionally appropriate and socially acceptable.

Adaptive resource management represents a systematic approach to advancing the management process and responding to change by learning from the results of the implemented interventions and policies that drive them (Holling 1978, Walters and Holling 1990). This adaptive approach is intended to assist resource managers in responding to the surprises that inevitably occur during a management program (Clark 1981). When uncertainty is especially high, an adaptive response is critical since the uncertainty limits the ability of science to predict the future (Robertson and Hull 2001). Disease problems are particularly fraught with high levels of uncertainty when multiple species of wildlife are involved and the disease and its mechanisms of transmission are poorly understood.

After a century of dealing with bovine tuberculosis and decades of intensive management to eradicate the disease, the Canadian province of Manitoba was declared bovine tuberculosis free in 1986 (Copeland 2002). Since then, 11 cattle herds have been confirmed bovine TB positive and most of these farms have been near Riding Mountain National Park (RMNP) (Lees *et al.* 2004, Chapter 5). Since most bovine TB samples from these cattle and nearby cases of infected deer and elk are of the same unique strain, it has been widely assumed by resource managers and the public, that the disease is transmitted from infected deer and elk to cattle (Brook and McLachlan 2006). There have been numerous hypotheses generated regarding the potential routes of bovine TB transmission and what the highest risk areas are, but none have been evaluated using empirical data (except see Chapters 7 and 8). Despite these uncertainties, management actions have focused on reducing elk and deer interactions with hay bales during the winter months as the most likely source of bovine TB transmission to cattle.

In 1999, RMNP staff began working with farmers adjacent to the park boundary to develop a program to protect stored hay from elk in order to reduce the risk of bovine tuberculosis transmission to livestock. The program initially cost $20,000 during 1999 and 2000. In 2001, the provincial agencies, Manitoba Conservation and Manitoba Food, Agriculture and Rural Initiatives participated in an expanded fencing program to provide free paige wire fences to cattle producers considered most at risk to elk and deer contact. Each fence is typically around 75m x 75m in size, built using pressure treated 4.3m tall posts and 2.4m tall heavy gauge paige wire (sometimes referred to as game wire). During the period 1999 to 2006, the three agencies together spent $1 million on the program.

The objective of this study was to evaluate the evolution and effectiveness of the barrier fencing program around Riding Mountain National Park in reducing cattle contact with deer and elk, from its inception in 1999 to its present status in 2007, through analysis of farmer knowledge, attitudes and actions. I further evaluate the adaptive nature of the barrier-fencing program to identify areas where it can be improved and modified from its current plan, but also where the overall management process can be more adaptive and science-based.

Study Area

My study took place in southwest Manitoba, Canada and includes the entire Riding Mountain TB Eradication Area (RMEA) (5000 km^2) which was created in 2003 by the Canadian Food Inspection Agency around RMNP as an area of intensive TB testing and movement controls on cattle in order to eradicate the disease in livestock (Figure 9.1). The area surrounds RMNP (3000 km^2), a federally protected block of wilderness dominated by aspen, mixed, and coniferous forest interspersed with small grasslands and wetlands. Lands within the RMEA are 94% privately owned and 6% is provincial land. Half (48%) of all lands are in cereal, oilseed, or forage crop. Forest cover has been mostly fragmented into small patches on lands that are unsuitable for agriculture, but continues to cover 20% of the area. Deer and elk occur throughout most of the RMEA, however their numbers have not been well documented. Elk are more concentrated within RMNP, but also make extensive use of the RMEA. Deer are ubiquitous throughout the RMEA and are observed at least occasionally on 99% of all farms (Brook and McLachlan 2003). There are approximately 1300 farms within the RMEA, of which 600 raise cattle, with total holdings of approximately 50,000 head. The landscape is largely flat with RMNP rising almost 500m above the agriculture-dominated RMEA.

Several outbreaks of TB occurred in cattle herds near RMNP in the 1950s and 1960s and TB was endemic to cattle in Manitoba until at least 1970 (Zhao 2006). Over the last 15 years, TB has been found in 31 wild elk, 7 white-tailed deer and in 12 cattle herds, within the RMEA and all of these have been within 10 km of the national park boundary. In addition, one radio-collared elk that was initially captured within RMNP was also confirmed TB positive after it dispersed to the Duck Mountains. Positive test results for TB in both wildlife and livestock in close proximity have intensified concerns that TB is spreading from wildlife to domestic cattle and that RMNP acts as a disease reservoir. There has been bovine TB testing of a small number of other potential host species within the RMEA, such as beaver (*Castor canadensis*), black bears (*Ursus americanus*), coyotes (*Canis latrans*) and ground squirrels (*Sciuridae*), but no systematic monitoring of these species has been implemented and no infected animals have been found.

Methods

Regional Scale Attitudes Assessment

As a first step to understanding farmers' attitudes toward the potential use of barrier fencing on their farms to protect hay bales, a mail-back survey was sent to all 4220 rural households listed by Canada Post within 50 km of RMNP and identified as operating a farm (Brook and McLachlan 2003, Brook and McLachlan 2006). Each farm was mailed a questionnaire in late winter 2002 and a follow-up reminder was sent out in the spring. While cattle farms have been the primary focus of concern for bovine tuberculosis management, it was recognized that many farms in the region produce grain and forage crops that are attractants to wildlife and these are also often sold to cattle farms and thus are a disease concern as well. As a result, all farm types were included in the survey. Adjusted response rate to the mail-out survey was 25%, calculated as the number of farmers responding to the survey divided by the number of known farm operations

(Brook and McLachlan 2006). A random sample of 75 survey recipients that had not responded to the survey were telephoned and asked five questions from the original survey in order to compare respondents with non-respondents but no significant differences were detected (Brook and McLachlan 2006).

Farmer Interviews

All 56 cattle producers that had a hay yard barrier fence for more than one year were contacted by telephone to determine if they were willing to participate in an interview to document their experiences with the hay yard fencing program, determine their perceptions of the effectiveness of the fences at reducing hay damage and wildlife-cattle contact, and provide insights into how the program might be adapted in the future. Some producers were interviewed over the telephone, but most were done in person, on their farm, based on the wishes of the respondent. Interviews lasted from 0.5 to 3.1 hours and included three components: quantitative characterization of wildlife observations on the farm before and after the fence, quantitative perceptions regarding fence construction and operation, and both qualitative and qualitative observations regarding the fence effectiveness.

In order to document and assess the reasons behind farmers refusing barrier fences, ten of the eighteen farmers that refused a fence were interviewed. The other eight farmers could not be reached or refused to be interviewed. No attempt was made to change the attitudes of the participants regarding the barrier fence, rather the interview focused on better understanding the rationale for refusing a fence. Six of the participants were willing to discuss their concerns regarding the barrier fence openly but four respondents did not want their specific statements recorded or used.

Resource Manager Surveys and Field Staff Interviews

A one-page survey was also distributed to members of the Task Group for Bovine Tuberculosis (TB Task Group) at two of their meetings in January and March 2003. Members of this group include the federal and provincial resource managers responsible for funding and guiding the barrier fencing program and all other aspects of the bovine TB management program, as well as representatives from the Manitoba Cattle Producers Association and the Manitoba Wildlife Federation. The surveys were handed out at the beginning of each meeting and it was requested that they be returned at the end of the meeting or mailed back. However, only one survey was returned so no useable data could be obtained from this part of the study. Personal interviews were then conducted with five of the field staff and resource managers directly involved in funding and implementing the barrier-fencing program in 2006 and 2007 to document their experiences throughout the process.

Results

Overall, the barrier fences have been highly effective in reducing elk and deer damage to hay bales and farmers are, for the most part, satisfied with the quality and function of their fences. In total, there have been 154 hay yard barrier fences constructed at an average cost of $6200 per fence. One hundred of the fences have been constructed in the last two years, so the information on their effectiveness was limited and I focus the results here on farms that have had a fence for >2 years.

Field Staff Interviews

According to government staff that was interviewed, between 1880 and 1998, there were very few options available to farmers to mitigate elk and deer damage to hay bales. Kill permits were provided by provincial staff to farms having damage, but these have been often hard to obtain and then only after considerable damage had already occurred. Hunting has been encouraged as a management tool and special seasons have been enacted to help control problem elk in some years. Provincial conservation staff also provided blood meal and bangers to deter elk and deer, but agency staff generally agreed that these approaches were not fully effective and normally provide only short-term solutions, particularly in extreme winters.

Although there was no formal assessment done of the initial fencing efforts conducted in 1999 and 2000 to provide electric fencing or metal panel gates to protect hay bales, it was generally felt that these were only partially effective, or very ineffective:

> *Initally all deer that had been feeding at the site stayed away or fed at the bales outside of the fence in the yard site. Within two weeks, five or six white-tailed deer had figured out how to crawl under the fence as the bottom wire was now a ground, but no animals jumped over the fence.* (Parks Canada field staff, 2001)

One producer that participated in this early program agreed:

> *I had an electric fence built by Parks Canada. It was made up of 6 strands of electrical wire that was powered by solar power. The fence didn't work very well, it made the wildlife go through the fence faster.* (Cattle Farmer, 2003).

All government agency field staff that was interviewed agreed that the paige wire-fencing program was a much more effective approach than the previously used methods and all were supportive of continuing with the program. All agency participants also agreed that there were important social benefits to providing fences that helped alleviate the mistrust and absence of communication that is characteristic of the relationship between local farmers and the government agencies involved in bovine TB management:

> *We have found that the value of the fences has been more than just a mechanism to reduce indirect transmission of TB from wildlife to cattle. The barrier-fencing program has focused farmer attention on the importance of eliminating elk and deer contact with cattle and has been a tool for us to promote further education on managing risk. This program also began at a time when our relationship with farmers was very poor and we needed a good news story. By paying for the fences and having them installed, the government agencies involved have demonstrated a commitment to local producers and I think they have responded very positively.* (Coordinator for the Riding Mountain National Park Wildlife Health Program, 2007)

Regional Scale Attitudes Assessment

In the regional mail survey assessment, farmers in the Riding Mountain region expressed highly variable perceptions of paige wire fencing of hay yards that ranged from very strong support to very strong opposition, but more than half of all respondents (52%) indicated positive support (Figure 9.2). At the same time, farmers identified important issues related to fencing. One respondent stated that "*barbwire fences don't stop wildlife. Only an eight foot high paige wire fence will stop deer, elk, and Moose. Barb wire and electric fence don't.*" (Mail Survey Respondent R0411, 2002). Another respondent noted that "*paige wire fencing is a waste because it cannot be used or moved to another site where needed*" (Mail Survey Respondent R0033, 2002). Many hay producers noted the economic value of the damage to hay done by elk and deer: *"Farmers should all have elk fences if they have hay damages of $20,000 like myself"* (Mail Survey Respondent R0780, 2002).

At the time of the mail survey in 2002, the hay yard barrier-fencing program was only available to cattle producers, but concerns were raised by farmers that all hay bales may create important risks even if they are not on a cattle farm. Within the RMEA, 12% of all farms produce >50acres of hay per year, but do not own any cattle. Of the farms producing hay but having no cattle, 19% reported seeing elk regularly on their farm and 86% reported seeing deer regularly. Many of these farmers indicated that they sold all of their hay bales to cattle producers, sometimes even after they had been fed on by deer or elk.

Fence Owner Interviews

The cattle producers that received a fence responded positively to the interviews and most were very pleased that an assessment was being done to determine how well the hay yard barrier fences were working. Only one fence owner refused to participate in the study and 5 could not be reached despite >7 attempts to contact them during the study. In total, 50 fence owners were interviewed. Concerns were expressed by some respondents who felt that government agencies were not responsive to farmer concerns or input, so 14% felt that the interviews were of little value since their input would be ignored regardless of what was said. Other participants were pleased to have an opportunity to discuss the fences and many asked for information about the bovine TB situation and existing management activities. Most participants felt that their knowledge of the current bovine TB management program was relatively low, while their knowledge of wildlife on their own farms was typically very high. All farmers that were interviewed felt confident in identifying elk and deer visually and by their tracks and feces. Most producers visited their cattle herds and hay yards at least once per day throughout the year, so they felt that they were aware of most elk and deer use of their farm.

Barrier Fence Refusals

Of the 10 farmers that refused a fence and were willing to share their perspectives, the reasons for refusal included previous negative experiences with government agencies regarding charges laid in previous years for various offences, and other wildlife management conflicts (especially related to beavers and to a lesser degree wolves, bears, elk, and deer) were important in their decision. Six respondents that refused a fence felt that they did not need a fence since they had little or no wildlife use of their farm anyway and no damage to hay bales. Five respondents felt that the bovine TB issue was entirely the responsibility of government and it was not up to the individual farmer to deal with. Three participants felt the fences would be too much trouble for them to set up and maintain or would be difficult to work around. Fire risk that occurs when the entire feed supply is in one small area was a concern for three farmers. Two respondents expressed concerns regarding bales in the fenced area rotting during wet years. One farmer noted that the process of building the fence by the contractor was unacceptable:

> *I was disappointed with the service. I took a couple of days off work to help the contractors put up the fence but the contractors didn't show up to put up the fence on those days. The contractors didn't give a shit and they stalled me a few times. The contractors had already dropped off the fence posts but I got really frustrated and asked them to just pick up the posts and they eventually did. I've now sold my cattle but still supply feed to other cattle producers. I wasn't big into cattle production and felt that the inconveniences of TB made them not worth keeping.* (Cattle farmer that refused a barrier fence, 2005).

Hay Damage and Disease Risk

Damage to agricultural crops and barbwire fences was considerable for most of the fence owners, with 96% of respondents having some form of crop damage by elk or deer in the five years prior to getting the fence and 82% of respondents had damage to hay bales in the field or in the yard. At the same time, 84% reported damage to barb wired fences by elk or deer, indicating wildlife crossing over or under them (Table 9.1). The farmers that had not experienced damage by elk or deer in the past expressed doubt as to why they qualified for a hay yard barrier fence and 3% of respondents felt that they really did not need or even want a fence. In the five years prior to receiving to the fence, a total of $44,300 in damage was done to hay bales in the field and in the yard for the 48 respondents (two respondents could not recall the value of damage done on their farms) (Table 9.2). There was an overall strong feeling among most fence owners that the barrier fences effectively protected hay bales, with 77% of all respondents agreeing that the fences eliminated damage (Figure 9.3):

> *We used to have herds up to 60 elk coming onto our land now there is zero. Wildlife don't even come to the fence. We used to have lots of damage to bales. The first year the fence was up the elk came and looked at the fence and never came back. Last year, [2004] a couple of bull elk came and walked along the edge of the fence and then went on their merry way.* (Cattle farmer, 2005).

However, 23% of respondents were still having some damage to stored hay bales. This was most often caused by the farmer not getting the bales inside the fence quickly enough (17% of respondents), the fence was not large enough to contain all of the bales produced (4%), or bales were purposely left on the periphery of the farm to keep elk and deer from mixing directly with the cattle (2%) – a strategy referred to locally as intercept feeding.

Although the fences generally have worked well at preventing damage, 18% of fence owners reported wildlife incursions inside the fence. None of those interviewed had observed elk inside the fence, but 18% of all interviewees had observed deer incursions at least once since it was constructed. Of the farms that had deer inside the fence, 78% came in through an open gate, 11% got through a hole in the fence, and 11% deer were able to slip between the bars of the gates. This problem was resolved by covering the bars of the fence with paige wire.

All fence owners indicated that they sometimes left their gates open while working around the farm and 18% left gates open continuously for periods >1 week in the year. Although this has allowed deer inside the fences in some cases, the farmers felt that it was relatively rare for this to occur and they indicated they would close the gates if deer or elk began entering the fence.

While the fences greatly affected access of deer and elk to hay bales, fencing did not normally substantially affect ungulate observations on the farm. There was very little observed decline in deer on most farms after the fence was installed and only a moderate decline in elk observations (Figure 9.4). During each month of the year, there was no overall difference in deer observations on the farms after fence construction and only a 7-12% decrease in elk observations (Figure 9.5).

Regarding the statement *"my fence has reduced the risk of my cattle getting TB"*, 68% agreed, 21% disagreed and 11% remained neutral (Figure 9.6). Of particular concern are the 8% of respondents that strongly disagreed, and the 3% that moderately disagreed. Livestock contact with wildlife continues to occur and the potential risk of TB transmission, although not well understood, remains. Indeed, 4% of farmers were concerned that the fences may have actually placed them at greater risk of bovine TB transmission to their cattle by keeping elk and deer out of stored hay and forcing them to feed alongside their cattle:

> *More deer are eating with the cattle now. There hasn't been as many elk coming into the yard in the last 2 to 4 years, so, they are not a problem but they used to be. I used to leave some bales out for the elk during the winters when they were in*

feeding with the cattle. I would see 40 to 50 elk feeding on the bales that were left out. (Cattle farmer, 2005).

While hay bales were generally well protected from elk and deer, there were mixed responses to the statement *"my fence has eliminated contact between wildlife and my cattle"*, with 44% agreeing, 49% disagreeing, and 7% remaining neutral (Figure 9.6). Respondents felt that contact was occurring between wildlife and livestock at hay bales in cattle feeding areas, at mineral supplements in winter feeding areas and summer pastures, and co-feeding on summer pastures.

Fencing Cattle Wintering Areas

One producer that was interviewed had fenced the entire farmyard using the barrier fencing design, including hay, cattle, and grain bins:

> *When Manitoba Conservation came out and offered the fence, I didn't feel that the normal fence was going to be adequate. We agreed on cost sharing, so that I could fence the whole yard. The idea was that it was going to be a pilot project. The decision to make the larger fence was the right one. I make silage bales and need a lot of room. The proposed fence was not adequate. They grasped the idea because of the cost sharing commitment. I built the fence myself and was compensated for the work. I know that building the fence right the first time was beneficial.* (Cattle farmer, 2005).

Based on the preliminary findings of this research, it became evident that fencing of some cattle winter-feeding areas would be prudent and four of these were fenced in the fall of 2006. Although it is too early to assess their overall effectiveness, the fence owners have all strongly indicated that this is a positive step in reducing the risk of bovine tuberculosis transmission on their farms.

Fence Construction and Maintenance

All respondents indicated that they believed the fences were well constructed and would function for more than ten years. However, it was generally recognized that the fences would require on-going maintenance to keep them functioning. Some of the fences that were 2-3 years old were already showing some signs of wear, including leaning fence posts, crooked gates, and sagging wire. In some cases, bales had fallen over and stretched the wire, which sags over time and create places where wildlife can jump over the fence. One respondent felt that regular use of the gates places considerable stress on the supporting poles and this person chose to cement the poles into the ground to stabilize them. Although this is not currently done by the contractors installing the fences, he suggested that all fence owners should do this to avoid problems in the future. It is currently the policy of the barrier-fencing program that fence owners are responsible for any maintenance or repairs required.

Fence Allocation

The majority of respondents (67%) believed that the process of deciding who receives a fence is fair to everyone. Some indicated concerns that some other farmers that they knew who have significant elk and deer damage to hay had not yet received a fence. Others knew of neighbours who produce hay but do not own cattle and therefore did not qualify for a fence under the program, but these concerns were allayed when the program was modified to include these producers. Some concerns were also raised by producers that felt that although they accepted their fence, they did not really need it because prior to the fence, they rarely or never saw elk or deer on their farms. It was felt by these producers that perhaps the fences should have been given to other farms that did have serious wildlife problems:

> *I felt that I was 'strong armed' into taking the fence with the fact that if we didn't take the fence that we would not be covered by insurance for damaged hay bales from wildlife.* (Cattle Farmer, 2006).

However, farmers were largely pleased with the fence and support for the barrier-fencing program has increased substantially from the early days of 2001 when there was considerable scepticism and most farmers did not fully understand the nature and intent of the program. In recent years, the number of farms refusing a fence has declined and many that had initially refused have now requested a fence.

Overall Satisfaction with Barrier Fencing

Regarding the statement *"My fence meets the needs of my cattle operation"*, there was a strong overall positive response, with most (95%) agreeing. This suggests that farmers are quite pleased with the overall function of the fence on their farm and there were few concerns expressed regarding the design or function of the fences. Respondents commonly used the phrase 'cautiously optimistic' when talking about their fence. They often stated that they felt the fences have worked well so far, but required a severe winter to test it at maximum level of elk and deer activity. It is universally believed by farmers and government agency staff that winters with early snowfall, deep snow accumulation, and extreme cold temperatures push elk out of RMNP and cause deer and elk to seek out hay bales much more than normal. Many respondents felt that the success of the fences could only be fully evaluated after several 'bad winters' have occurred. As a result, the evaluations made by fence owners should be considered preliminary and an evaluation should be conducted at least every five years. As one respondent noted: *"The fences are a* *good idea but only time will tell if they really work and benefit the farmer."*(Cattle Farmer, 2006).

Discussion

Hay damage by elk and deer has been an annual problem around RMNP since farming began in the 1880's. During the first one hundred and ten years of farming there were limited options for farmers to mitigate the impacts from wildlife, which frequently exceeds $200,000/year. Concerns regarding the potential transmission of bovine tuberculosis from elk and deer to cattle further intensify the need for management interventions to block ungulate direct and indirect interactions with cattle. While the hay yard barrier-fencing program in general has been successful in reducing ungulate-cattle interaction, it has only resulted in a partial reduction in contacts. As such, there reains a need to improve on the existing program and augment it with other approaches that address the shortcomings of the fences and that acknowledges that the bovine tuberculosis issue is a regional problem that will require integrated solutions.

Key aspects of adaptive management include implementing management actions as scientific experiments with detailed monitoring of the results in order to learn and modify as required (Walters and Holling 1990). Prior to this study, no formal assessment had been done of the barrier fencing program to evaluate its progress and changes were made on an informal, ad-hoc basis by representatives from the government agencies with some informal input from fence owners. The stated goal of the program was to "reduce contact between domestic cattle and wild cervids by constructing barriers that exclude cervids from either stored hay yards or cattle feeding sites" (Task Group for Bovine Tuberculosis

2002). However, The Riding Mountain barrier fencing program was not implemented as an experiment and did not have stated hypotheses or predictions of potential alternative outcomes. There was no formal monitoring process in place to assess regularly fence effectiveness, nor was there any evidence of preparation for unexpected effects of the fencing program. While there have been several important changes to the program in response to new information, these were made in the absence of empirical data and the overall broad objectives of the program remained unaltered throughout.

Evaluation of the fences was also confounded by the many other concurrent management actions, including changes to baiting and feeding regulations and enforcement effort, decrease of the RMNP elk population, extension of the hunting season, and changes in the number of hunting licenses issued that were all implemented while the fences were being constructed. All of these variables, combined with annual variation in weather conditions, hunter effort, and ever changing farm management practices, influence wildlife activity and so make it difficult to fully elucidate the effectiveness of the fences.

While changes have been made to the fencing program, including provision of fences to cattle winter feeding areas and to hay producers that do not own cattle, there is little evidence of adaptive management occurring. These changes have been made on an ad-hoc basis with little input from from farmers and no scientific studies. However, there have been important successes in the first nine years of the program that were identified in this first formal assessment, most notably the good will generated between farmers and government agencies and the protection of hay bales in areas at high risk of bovine TB transmission. But perhaps the most important limitation of the current fencing program is that despite its primary purpose to prevent disease transmission, there is no way to determine what, if any, contribution the program has made or will make to the prevalence of bovine in wildlife or livestock. The low prevalence of bovine TB in cattle, the limited testing in wildlife, and the confounding influences of other management interventions makes it impossible to determine if the barrier fences are influencing the prevalence of bovine TB in wildlife or livestock. On-going monitoring will be required to better understand the role and effectiveness of the fences, but given the timing and diversity of management actions, combined with natural variability of bovine TB, the impacts of the fences on disease prevalence in wildlife and livestock will be difficult to determine. However, setting up the barrier fencing program as a large scale management experiment with associated intensive disease testing for wildlife and livestock could have provided more meaningful insights into fence effectiveness.

The cost of building the fences does not provide a net economic benefit to most farmers for hay damage reduction alone, as the cost of the fence will be equivalent to the financial cost of the damage after 34 years of operation. If indeed a fence does prevent bovine TB transmission to the farmer's cattle herd, then it will be highly cost effective, since this prevents the entire herd from being destroyed and compensation paid out to the farmer, often in tens of thousands of dollars or more.

The costs associated with the barrier fencing program currently exceeds \$1 million in total over the last nine years and the associated costs of disease testing and research which currently exceeds \$1 million annually for the four government agencies involved. When all costs of the bovine tuberculosis outbreak in and around RMNP are considered, the total exceeds \$10 million. As such, one of the important lessons to be learned from the

TB situation in Riding Mountain is that prevention of disease is much more cost effective and considerably less stressful on local people and government resources than trying to eliminate a disease once it is firmly established. Early intervention and investments in prevention are favorable and indeed cost effective.

This study has also demonstrated the value of incorporating local knowledge into the monitoring process of adaptive management. The results of this type of monitoring approach provides rich information on the long-term experiences of farmers with wildlife prior to the fence being built and detailed observations after construction. At the same time, the interviews and mail survey provided quantitative and qualitative information on the attitudes of farmers with fences that can only be documented using these kinds of approaches. The collaborative nature of the fencing program, where each farmer is consulted regarding the design of the fence helps ensure that it best fits the needs of each individual (Ferreyra and Beard 2007). At the same time, a cooperative approach generates discussion that can increase knowledge of farmers and government staff. Perhaps most importantly, it may also help initiate a longer lasting trust and communication that will be of benefit far into the future.

Management Implications

Although some limited, short-term successes have been achieved with metal fencing panels, electric fencing, blood meal, screamers and other wildlife deterrents, these are, at best, short-term solutions and at worst, completely ineffective or may even exacerbate the problem. Hunting has been and continues to be an important part of an effective management strategy to mitigate elk and deer use of stored hay, but implemented alone, it is generally not sufficient and only provides a partial solution (Conover 2001). Wherever possible, paige wire fencing should be considered as the optimal ungulate deterrent, in that it is proven highly effective, long-term, and cost effective solution to ungulate-agriculture conflicts. However, barrier fences are not suitable for moving to different locations on a farm as the farming operation evolves, so farming practices may require modification to adapt to these immobile storage sites.

Literature Cited

Aguirre, A., E. E. Starkey, and D. E. Hansen. 1995. Wildlife diseases in national park ecosystems. Wildlife Society Bulletin 23:415-419.

Barlow, N. D. 1993. A model for the spread of bovine TB in New Zealand possum populations. Journal of Applied Ecology 30:156-164.

Bengis R. G., R. A. Kock, and J. Fischer. 2002. Infectious animal diseases: the wildlife/livestock interface. Scientific and Technical Review 21:53–65.

Berkes F, J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251–1262.

Berkes, F., and N. J. Turner. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. Human Ecology 34:479-494.

Brook, R.K., and McLachlan, S.M. 2003. Wildlife-agriculture interactions in the Greater Riding Mountain Ecosystem: Report to Mail Survey Respondents. A Report to Manitoba Agriculture, Food, and Rural Initiatives. University of Manitoba, Winnipeg, Manitoba, Canada. http://www.thegreenpages.ca/tb, accessed 05/09/06.

Brook, R. K., and S. M. McLachlan. 2005. On using expert-based science to "test" local knowledge. Ecology and Society 10, r3. http://www.ecologyandsociety.org/vol10/iss2/resp3/

Brook, R.K., and S. M. McLachlan. 2006. Factors influencing farmers' concerns associated with bovine tuberculosis in wildlife and livestock around Riding Mountain

National Park, Manitoba, Canada. Journal of Environmental Management 161:156-166.

Clark, W. C. 1981. Witches, floods, and wonder drugs: Historical perspectives on risk management. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Craven, S. R., and S. E. Hyngstrom. 1994. Deer. Pages D25-D40 in S. E. Hyngstrom, R. M. Timm, and G. E. Larson (editors). Prevention and Control of Wildlife Damage. University of Nebraska Cooperative Extension Service, Lincoln, USA.

Conover, M. R. 2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29:521-532.

Copeland, S. 2002. Timeline of bovine tuberculosis (TB) in Canadian and Manitoban cattle and bison. Manitoba Agriculture and Food, Brandon, MB [online]. URL:http://www.gov.mb.ca/agriculture/livestock/anhealth/jaa04s02.html.

Craven, S. R., and S. E. Hygnstrom. 1994. Deer. Pages D25–D40 in S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Prevention and Control of Wildlife Damage. University of Nebraska CooperativeExtension, Lincoln, Nebraska, USA.

Curtis, P. D., M. J. Farigone, and M. E. Richmond. 1994. Preventing deer damage with barrier, electrical, and behavioral fencing systems. Proceedings of the Vertebrate Pest Control Conference 16:223–227.

Donnelly. C.A., R. Woodroffe, D. R. Cox, F. J. Bourne, C. L. Cheeseman, R. S. Clifton-Hadley, G. Weil, G. Gettinby, P. Gilks, H. Jenkins, W. T. Johnston, A. M. Le Fevre, J. P. McInerney, and W. I. Morrison. 2006. Positive and negative effects of widespread badger culling on tuberculosis in cattle. Nature 439:843-846.

Dorn, M. L. and A. G. Mertig. 2005. Bovine tuberculosis in Michigan: stakeholder attitudes and implications for eradication efforts. Wildlife Society Bulletin 33:539–552.

Drake, D., J. Grande, and R. Lawless. 1999. New Jersey's 1998 supplemental deer fence program: An evaluation. New Jersey, USA.

Fitzwater, W.D. 1972. Barrier fencing in wildlife management. Proceedings of the Fifth Vertebrate Pest Conference 5:49-55.

Ferreyra, C. and P. Beard. 2007. Participatory evaluation of collaborative and integrated water management: insights from the field. Journal of Environmental Planning and Management 50: 271-296.

Frye, G. H., 1995. Bovine tuberculosis eradication: the program in the United States, in: C.O. Thoen and J.H. Steele (Eds). Mycobacterium bovis infection in animals and humans, Iowa State University Press, Ames, IA. pp. 119-124.

Garnett, B. T., R. J. Delahay, and T. J. Roper. 2002. Use of cattle farm resources by badgers (*Meles meles*) and risk of bovine tuberculosis (*Mycobacterium bovis*) transmission to cattle. Proceedings of the Royal Society (Series B) 269:1487-1491.

Griffore, R. J. and L. A. Phenice. 2001. Bovine Tuberculosis: The perspective of farm families. Michigan State University. East Lansing, Michigan, USA.

Holling, C. S., editor. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York, New York, USA.

Hutchings, M. R., and S. Harris. 1997. Effects of farm management practices on cattle grazing behavior and the potential for transmission of bovine tuberculosis from badgers to cattle. Veterinary Journal 153:149–162.

Hygnstrom, S. E. and S. R. Craven. 1988. Electric fences and commercial repellants for reducing deer damage in cornfields. Wildlife Society Bulletin 16:291-296.

Kaneene, J. B., C. S. Bruning-Fann, L. M. Granger, R. Miller, and B. A. Porter-Spalding. 2002. Environmental and farm management factors associated with tuberculosis on cattle farms in northeastern Michigan. Journal of the American Veterinary Medical Association 221:837-842.

Kock, R.A. 2005. What is this Infamous “Wildlife/Livestock Disease Interface?” A Review of Current Knowledge for the African Continent in: Osofsky, S.A., Cleaveland, S., Karesh, W.B., Kock, M.D., Nyhus, P.J., Starr, L. and Yang, A. (Eds). Pages 1-14. Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health. IUCN, Gland, Switzerland and Cambridge, UK.

Koller-Jones, M.A., C. Turcotte, C. Lutze-Wallace, and O. Surujballi. 2006. Effect of bovine tuberculosis in wildlife on a national eradication program – Canada. Mycobacterium bovis infection in animals and humans, 2nd edn (eds C.O. Thoe, J., Stelle, & M.J. Gilsdorf, pp. 226-237. Blackwell Science, Oxford, UK.

Lees, V. W. 2004. Learning from outbreaks of bovine tuberculosis near Riding Mountain National Park: applications to a foreign animal disease outbreak. Canadian Veterinary Journal 45:28-34.

Machackova M., J. Lamka, J. Docekal, V. Liska, J. Smolik, O. Fischer, and I. Pavlik. 2001. Paratuberculosis of wild ruminants in free nature and in captivity (in Czech). Veterinarstvi 51:395–408.

Nishi, J.S., T. Shury, and B. T. Elkin. 2006. Wildlife reservoirs for bovine tuberculosis (*Mycobacterium bovis*) in Canada: Strategies for management and research. Veterinary Microbiology 112:325-338.

Phillips, C. J. C., C. R. W. Foster, P. A. Morris, and R. Teverson. 2003. The transmission of Mycobacterium bovis infection to cattle. Research in Veterinary Science 74:1-15.

Robertson, D. P., and R. B. Hull. 2001. Beyond biology: toward a more public ecology for conservation. Conservation Biology 15:970–979.

Sauter, C.M., and R. S. Morris. 1995. Behavioural studies on the potential for direct transmission of tuberculosis from feral ferrets (Mustela furo) and possums (Trichosurus vulpecula) to farmed livestock. New Zealand Veterinary Journal 43, 294–300.

Schmitt, S. M., S. D. Fitzgerald, T. M. Cooley, C. S. Bruning-Fann, L. Sullivan, D. Berry, T. Carlson, R. B. Minnis, J. B. Payeur, and J. Sikarskie. 1997. Bovine tuberculosis in free-ranging white-tailed deer from Michigan. Journal of Wildlife Diseases 33:749-758.

Seamans, T. W., and K. C. Vercauteren. 2006. Evaluation of ElectroBraid fencing as a white-tailed deer barrier. Wildlife Society Bulletin 34:8-15.

Selin, S. W., M. A. Schuett, and D. Carr. 2000. Modeling stakeholder perceptions of collaborative initiative effectiveness. Society and Natural Resources 13:735-745.

Seward, N. W., G. E. Phillips, J. F. Duquette, and K. C. Vercauteren. 2007. A frightening device for deterring deer use of cattle feeders. Journal of Wildlife Management 71:271-276.

Stronen, A., R. K. Brook, P. C. Paquet, and S. M. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Sutmoller, P. 2002. The fencing issue relative to the control of foot-and-mouth disease. Annals of the New York Academy of Science 969:191-200.

Task Group for Bovine Tuberculosis, 2002. 2002/2003 Manitoba Bovine Tuberculosis Management Program Implementation Plan. Manitoba Government, Winnipeg, MB, Unpublished Report, 65 pp.

VerCauteren, K. C., J. A. Shivik, and M. J. Lavelle. 2006a. Efficacy of an animal-activated frightening device on urban elk and mule deer. Wildlife Society Bulletin 33:1282–1287.

Vercauteren, K. C., M. J. Lavelle, And S. Hygnstrom. 2006b. Fences and deer-damage management: a review of designs and efficacy. Wildlife Society Bulletin 34:191-200.

Vercauteren, K. C., M. J. Lavelle, N. W. Seward, J. W. Fischer, and G. E. Phillips. 2007. Fence-line contact between wild and farmed cervids in Colorado: Potential for disease transmission. Journal of Wildlife Management 71:1594-1602.

Wagner, K. K., and D. L. Nolte. 2001. Comparison of active ingredients and delivery systems in deer repellents. Wildlife Society Bulletin 29:322–330.

Walters, C.J., and Holling, C.S. 1990. Large-scale management experiments and learning by doing. Ecology 71:2060-2068.

Zhao, F. 2006. Historical overview of bovine tuberculosis in the Riding Mountain National Park ecosystem. Thesis, University of Manitoba, Winnipeg, Manitoba, Canada.

Table 9.1. Damage to barbwire fences and agricultural crops observed by barrier fence owners around Riding Mountain National Park before and after the barrier fences were installed (1999-2006).

Type of Damage	% of Respondents Reporting Damage Prior to Fence[a]	% of Respondents Reporting Damage After Fence Installed[b]	Difference
ELK			
hay bales field	44%	6%	-38%
hay bales yard	36%	2%	-34%
standing hay	40%	28%	-12%
standing grain	48%	32%	-16%
cattle pasture	12%	10%	-2%
barb wire fences	78%	60%	-18%
DEER			
hay bales field	44%	10%	-34%
hay bales yard	58%	4%	-54%
standing hay	30%	18%	-12%
standing grain	26%	20%	-6%
cattle pasture	8%	4%	-4%
barb wire fences	38%	38%	0%

[a] *for the five years prior to receiving a fence.*

[b] *for the 2-4 years after receiving a fence.*

Table 9.2. Total value of damage done by elk, deer, and moose on farms with barrier fences around Riding Mountain National Park during the five years prior to the barrier fence and in the time since the fence was built for 48 respondents (1999-2006). Two of the fifty respondents could not recall the value of damage done on their farms.

Type of Damage	$ Value of Cervid Damage in 5 Years Prior to Receiving Fence	$ Value of Cervid Damage in 2-4 years After Receiving Fence
Hay bales field	$11,500	$0
Hay bales yard	$32,800	$0
Standing hay	$0	$0
Standing grain	$25,000	$1,700
Pasture	$0	$0
Barb wire Fences	$500	$500

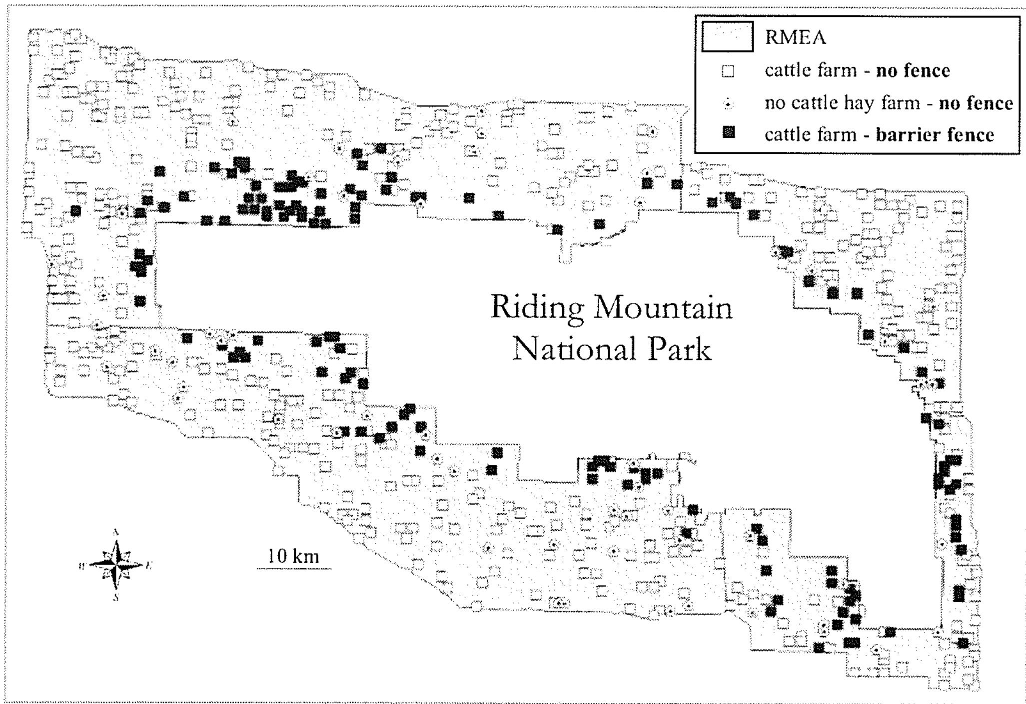


Figure 9.1. Locations of all cattle farms (n=547) and farms with hay yard barrier fences (n=154) within the Riding Mountain TB Eradication Area (RMEA) in 2007.

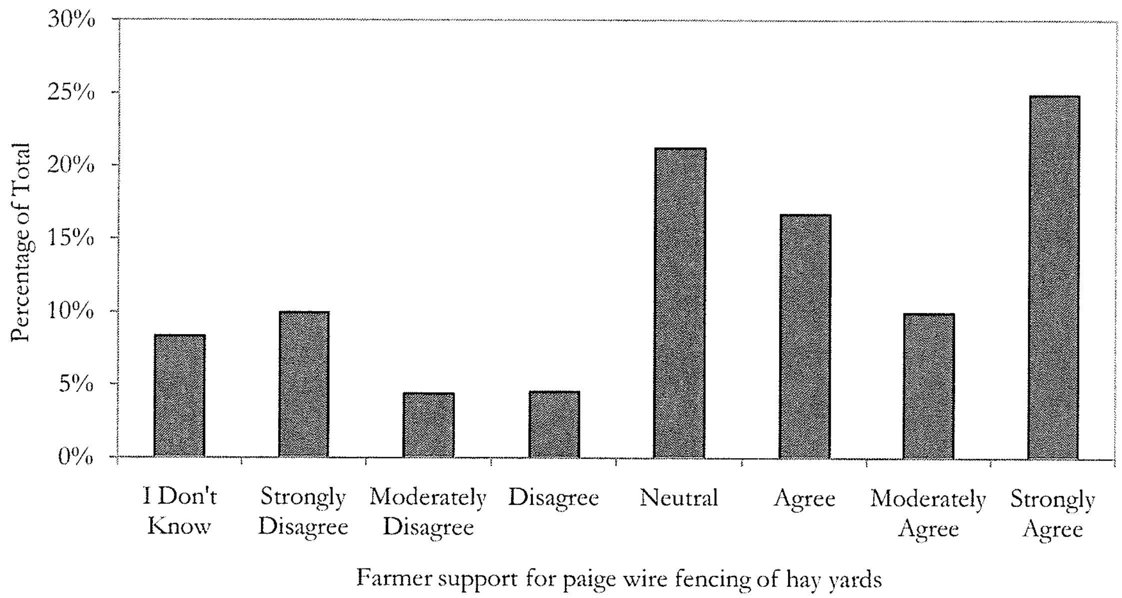


Figure 9.2. Willingness of farmers (n=683) around Riding Mountain National Park to use or support paige wire fencing of hay yards to reduce wildlife damage and interactions with cattle, based on responses to the 2002 mail survey.

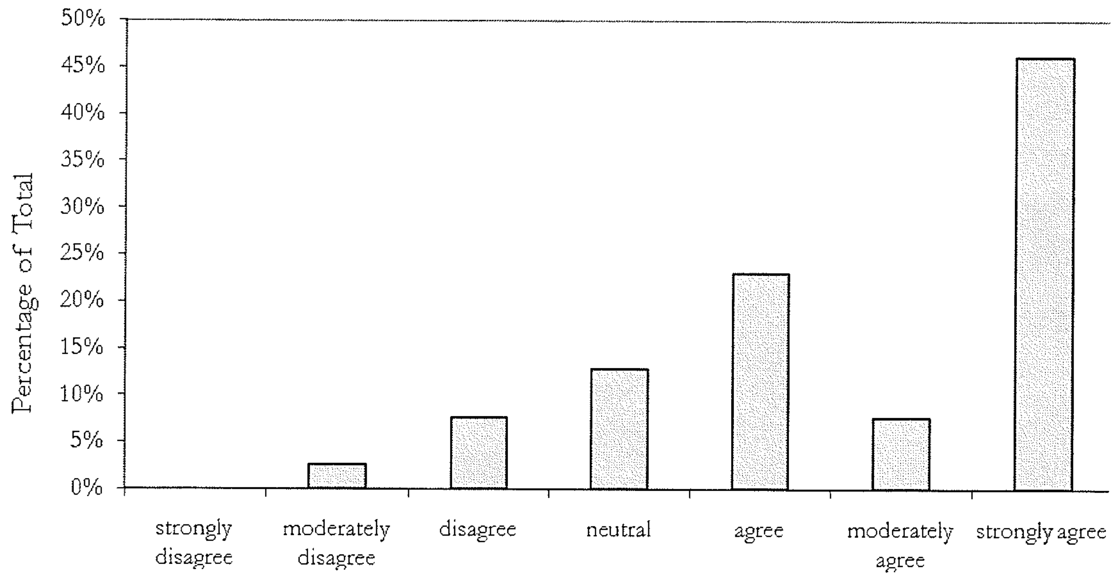


Figure 9.3. Barrier fence owner (n=50) attitudes toward fence effectiveness at eliminating damage by wildlife to baled hay on their farms in 2005.

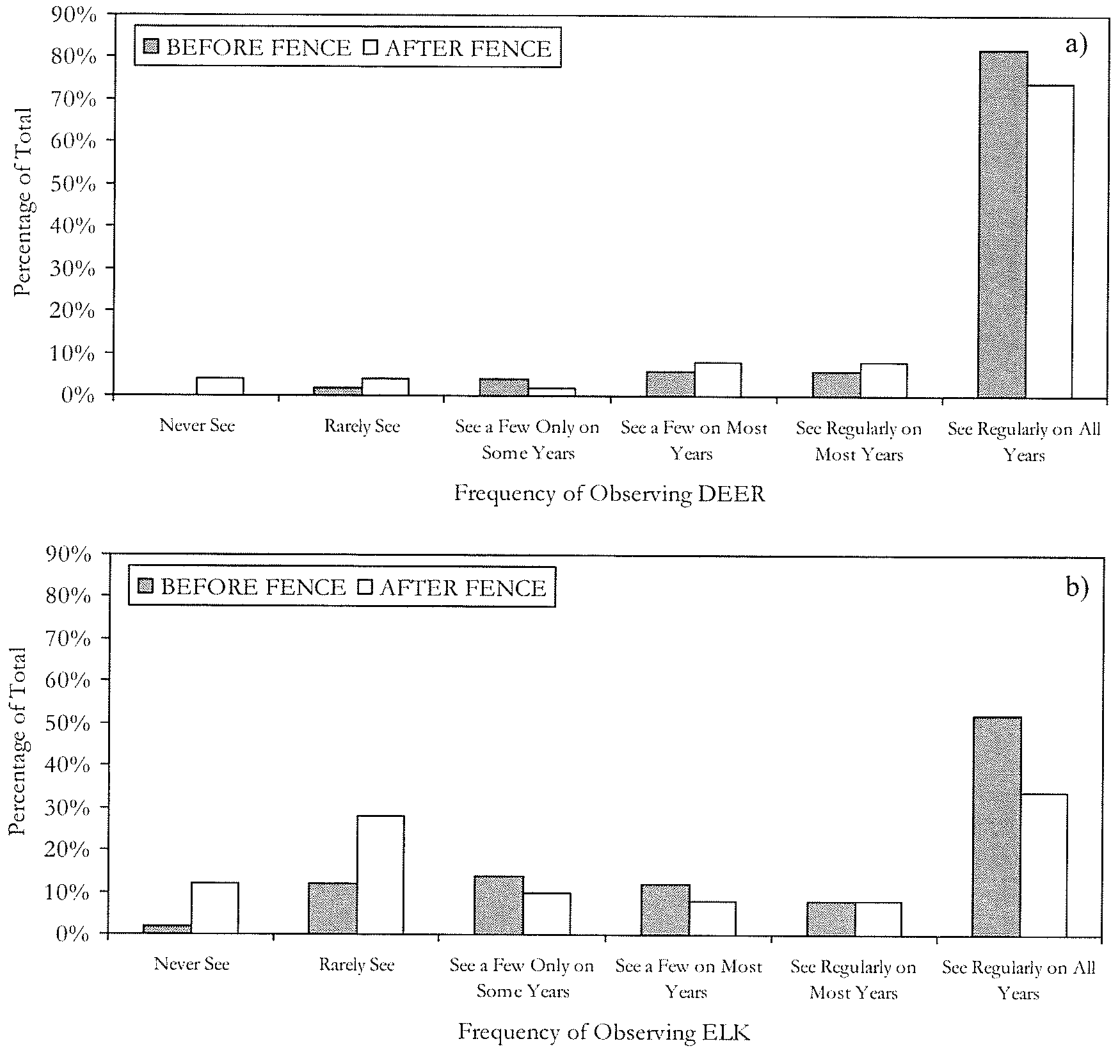


Figure 9.4. Barrier fence owner (n=50) observations of deer (a) and elk (b) on their farms in the five years prior to receiving the fence and in the 2-4 years following fence construction.

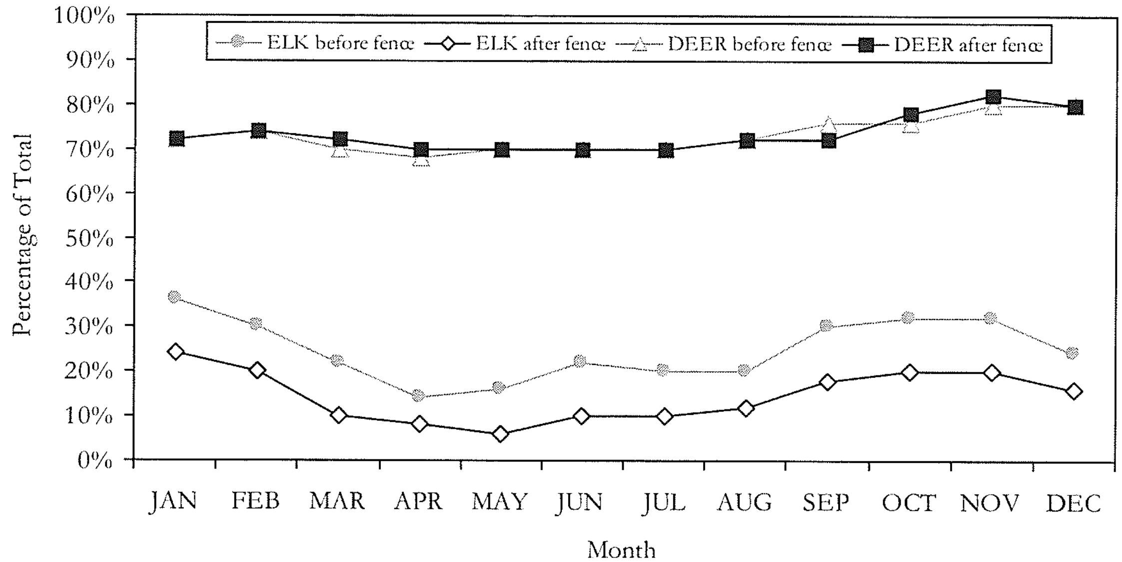


Figure 9.5. Monthly observation of elk and deer on cattle farms around Ridiing Mountain National Park before and after hay yard barrier fence construction.

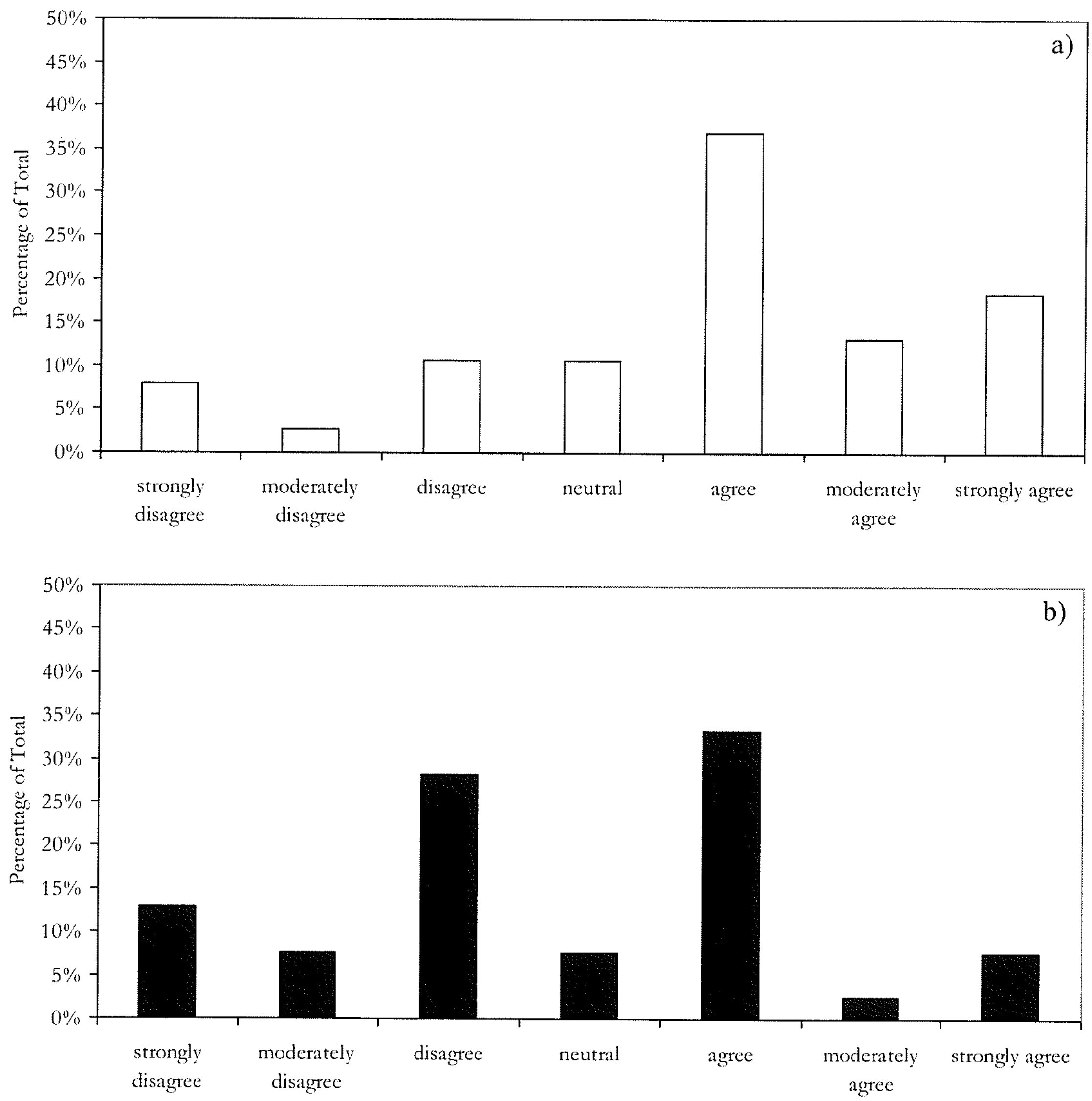
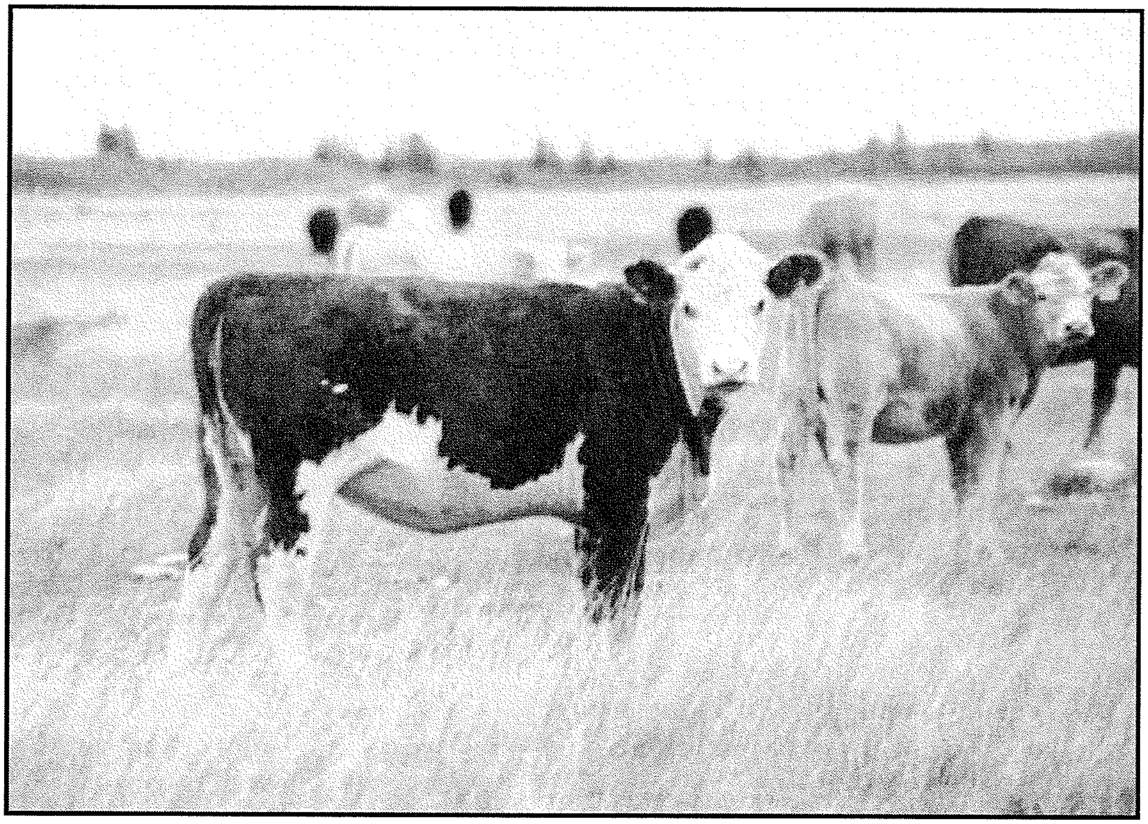


Figure 9.6. Farmer perspectives on the effectiveness of hay yard barrier fences at reducing the risk of their cattle becoming infected with bovine tuberculosis (a) and at eliminating contact between wildlife and their cattle (b) around Ridiing Mountain National Park.

CHAPTER 10

DISSERTATION SUMMARY:
A SYNTHESIS OF KNOWLEDGE



"All generalizations are false, including this one." --Mark Twain

Introduction

In this dissertation, I describe the ecological and social aspects of conflict between elk and agriculture in and around Riding Mountain National Park (RMNP) and the relationships between them. The following chapter summarizes the key findings of the study as a whole and provides associated recommendations for farmers and government agencies that I believe are essential next steps in resolves these issues. Herein, I address the three primary overall objectives of the thesis and relate the findings back to these objectives.

The primary contribution of this thesis is to provide new ways of linking local knowledge with expert-based science to understand and mitigate risk. I have also shown that these human-wildlife conflicts often quickly translate into high intensity human-human conflicts. Existing conflicts are commonly interrelated and they are strongly influenced by historical relationships.

Specifically, my thesis research:

- Identified tools for using ecological and social science data together in a rigorous manner to characterize risks and derive socially acceptable solutions in a flexible and adaptable manner.
- Described approaches for developing trust, respect, and communication to ensure that linking ecological and social data are done respectfully and with the full knowledge of all participants.
- Compared local knowledge and expert-based science in order to use them to validate each other and identify the benefits and limitations of each.

Objective #1: *Characterize the biophysical aspects of the risks associated with elk-agriculture interactions.*

I. Elk Movements Out of RMNP

Elk in the study area make substantial and often long-term use of surrounding agriculture dominated lands. Elk move out of RMNP in all months of the year, often spending weeks and months out of the park. Use of areas outside of the park is greatest in the spring and summer months (April –August). Radio-collared elk found outside of RMNP were most commonly located near the park boundary, with 96% of all collared elk locations within 6 km of RMNP. However, extensive movements out of RMNP (>20km from the boundary) were documented for one adult cow and three juvenile bull VHF radio-collared elk. At the same time, some farmers living >20km from RMNP actually have little or no elk use of their land. These results from farmer interviews, a mail survey, large samples of GPS collared cow elk and VHF collared bulls and cows are supported by independent data from hunter harvest data, winter aerial surveys and crop insurance damage claims. These results also indicated that elk-cattle interaction risk is highest in areas closest to RMNP. Efforts to effectively manage elk-agriculture interactions should largely be focused on farms within 10km of RMNP and more specifically on farms with high levels of wildlife use identified through mail surveys, interviews, aerial surveys, and radio-collaring of elk.

While the agriculture-dominated lands surrounding RMNP provide very important elk habitat, the elk population makes much greater use of RMNP than the adjacent lands. When elk are outside of RMNP, much of their time is spent in isolated patches of deciduous forest and grassland. It is widely perceived by stakeholders that the habitats within RMNP have changed dramatically due to fire control practices, high levels of beaver flooding, and the elimination of forestry, hay cutting, and cattle grazing. However, RMNP continues to be used extensively and intensively by elk (86% of all VHF elk locations and 78% of all GPS elk locations were within RMNP during the three years of monitoring).

Local farmers have observed small herds of <30 elk that live exclusively on the agriculture-dominated lands outside of protected areas. However all collared elk in the study used RMNP and/or the Duck Mountains at some point. It appears that the existence of these relict groups of elk that are observed far outside of protected areas represent a small proportion of the overall elk numbers in the region and these are frequently wiped out or dispersed by intensive harvest by local hunters.

As long as elk-agriculture interactions continue to be such a critical issue, I recommend long-term monitoring of radio-collared elk and documenting local knowledge regarding elk movements. Data from this study indicates the long-term variability in elk movements and dispersal that requires at least several years of data to elucidate. For example, the movements of cow elk RE118 were relatively consistent during the first three years of monitoring (2002-2005), but this animal made a long distance movement 33km south of RMNP after three years of being located several times per week. Without long-term monitoring, it is difficult or impossible to determine if these distant movements are dispersal events or part of the natural wide movements of elk. On-going monitoring for hunter-killed returns of marked and/or collared animals should also be done in order to provide further information on the ultimate fate of collared elk and their movements.

II. Regional Movements of Elk in Southwestern Manitoba

In southwestern Manitoba, the primary concentrations of elk are within the three large 'protected' areas, Duck Mountain Provincial Forest (DMPF), Riding Mountain National Park (RMNP), and Spruce Woods Provincial Park (SWPP)/Shilo Military Reserve (SMR). The term protected area is used loosely here, since all of these have extensive human developments, including buildings, roads, and in one case, a town site (RMNP), intensive forestry (DMPF), and extensive military activity (SMR). At the same time, elk use agriculture-dominated lands as an important part of their range for feeding during summer and winter, and for spring calving (Chapters 7 and 8). While long distance movements through the human dominated matrix are relatively rare, they have been documented through participatory mapping with farmers and movements of VHF-collared elk. Movements of elk between the three major protected areas has been documented and local knowledge suggests that most or all elk currently in DMPF originated from RMNP.

(Figure 10.1).

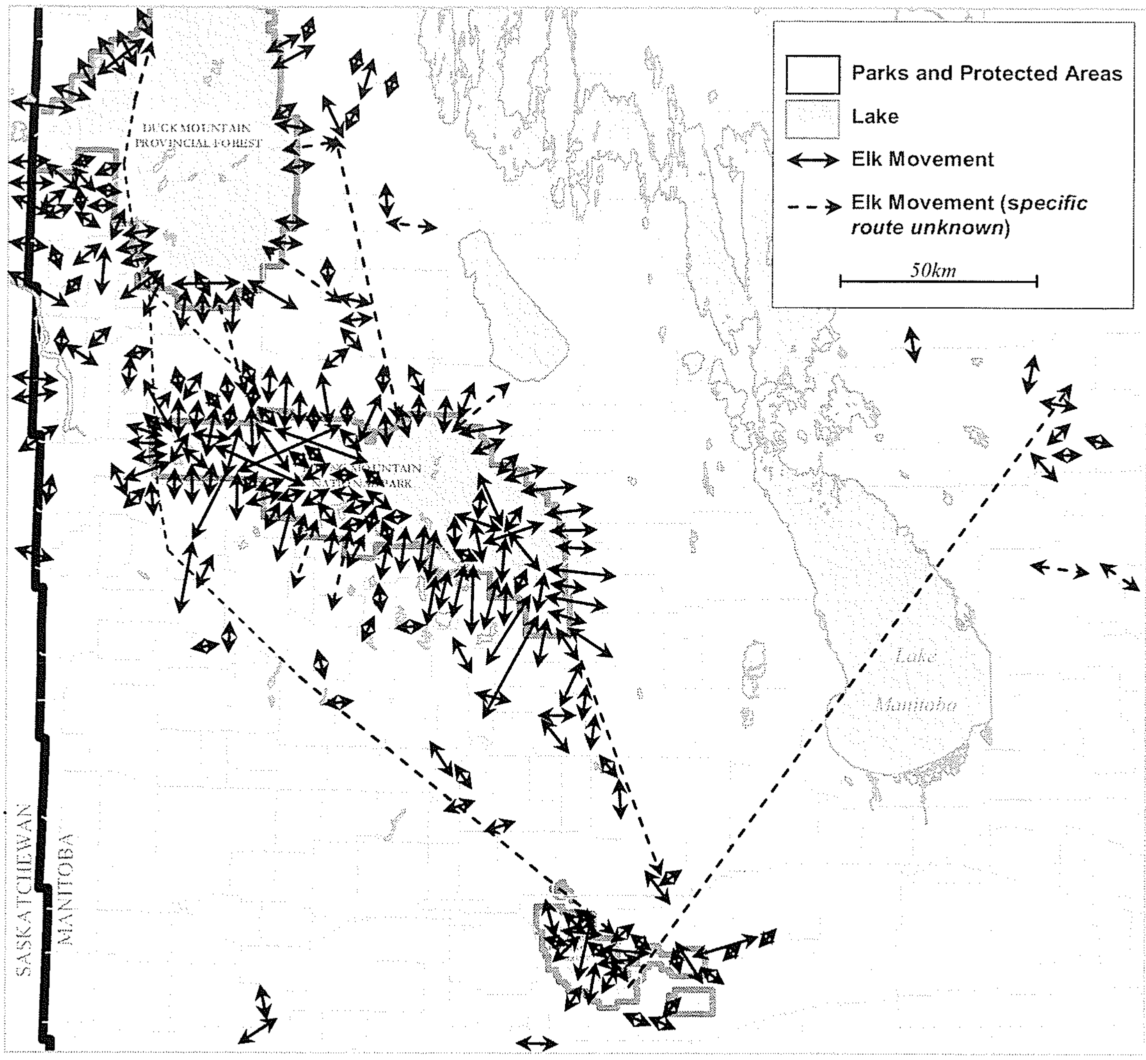


Figure 10.1. Synthesis of knowledge regarding elk movements in southwestern Manitoba, including local and traditional knowledge collected in this study (2002-2006), telemetry data from radio-collared animals (2002-2005) and hunter harvest of tagged animals (1997-2006). Data are also included from previous studies in the region (Strong 1981, Rebizant 1989, Peckett 1999).

III. Factors Associated with Ungulate Use of Farms

Elk use of farms is influenced by a combination of environmental factors and farm management practices. Thus, while elimination of hay bales is an obvious means of reducing elk use of farms and reducing disease transmission risk, my results indicate that hay management alone will not eliminate elk use of farms or interactions with cattle. For deer, the most important variables were distance to protected area and forest cover within a 3km radius, while leaving hay bales out for wildlife and percentage pasture was of minimal influence. For moose, the three important variables were distance to protected area, road density, and percentage forest cover of the farm, with percentage pasture cover being also of some importance. For elk, deer, and moose, distance to protected area was the most important regional variable.

IV. Baiting and Feeding of Elk

Virtually all of the observations that I made of collared and non-collared elk outside of RMNP during the winter of 2001-2002 were at hay bales and grain piles (these include hunting bait sites, wildlife feeding areas, and bales left in the field). In subsequent years, these baiting and feeding activities were lower. During the winter of 2003-2004, there appeared to be a resurgence in hay and grain use by elk in November and December, particularly at illegal hunter bait sites, but the number of observations of elk at these hay and grain sites decreased following action by Manitoba Conservation to have the baits removed. Two radio-collared elk that moved to the Duck Mountains as well as numerous non-collared elk groups were regularly seen at hunter bait sites during the winter in all years of the study along the north and south boundary of Duck Mountain Provincial Forest.

Although baiting and feeding of elk by landowners and hunters around RMNP and the Duck Mountains appears to have been reduced in recent years in response to concerns regarding bovine TB and rigorous communication and enforcement of regulations by Manitoba Conservation, there are no data available on how much baiting and feeding was occurring or how much is currently occurring within the RMEA or where it is taking place. Despite these uncertainties, occasional observations from this study, park staff, and provincial staff indicate that some baiting and feeding continues to occur, which are known to attract and congregate elk and deer. It is my opinion that the current efforts to manage elk-agriculture interactions are significantly hampered by the presence of these baiting and feeding sites within the region. While old and rain damaged hay bales and straw bales typically do not concentrate elk and deer under normal winter conditions, higher quality hay bales, particularly those containing alfalfa have been observed concentrating ungulates in many sites near RMNP and the Duck Mountains. Lower quality bales may also be sites of concern if winter conditions become extreme, as occurred in 2001 when cervids fed on any agricultural products they could access, regardless of quality. Small piles of grain on top of the snow have also been observed being used by elk and deer every year of this study from 2002 to 2005.

Data on the number and spatial distribution of bait sites collected on a regular basis using a consistent methodology would be of great value to provide insight into the effects of baiting on on wildlife and would also provide information on changes in the number and distribution of baits in response to enforcement activities. Ongoing intensive communication, monitoring, and enforcement regarding baiting and feeding is required. Communication with farmers and hunters regarding current regulations, occurrences of charges being laid, and the implications of baiting and feeding should be conducted regularly as most farmers and other stakeholders are not well informed about these activities.

V. Intercept Feeding

Some farmers around RMNP and the Duck Mountains continue to conduct intercept feeding, using hay bales placed at the periphery of the farm as a means of separating elk and deer from livestock and thus keeping them out of the majority of the hay bales. This activity provides an attraction for wildlife, concentrates animals in unnaturally large numbers, brings elk and deer into unnatural contact, provides good conditions for disease transmission, and so should be discontinued in all cases. However, efforts to eliminate intercept feeding will require other farm management changes since many farmers perceive this is as the best option to prevent direct elk or deer contact with their cattle or with hay bales that will be fed to cattle. Communication of management options with farmers and provision of support is crucial for success.

VI. Moving Hay Bales into the Farmyard

Although most farmers are taking serious steps toward protecting their farms from elk and deer, some individual farmers choose to take little or no action. As a result, not all hay bales are being brought into farmyards and placed inside the barrier fences. In several situations, hay bales are left sitting in fields unprotected until October or November and in some cases until January or later before being brought into the hay yard. Efforts should be made to communicate the importance of moving hay bales inside fenced yards as quickly as possible, but certainly before October 15 at the very latest, as is currently required on Crown lands, unless extremely wet conditions exist which prevent getting to the bales until the ground is frozen. Even through August and September elk and deer are regularly seen feeding on hay bales lying in the field. Indeed the majority of claims to Manitoba Crop Insurance for elk damage are made in August and September. Since summer and fall are very busy times on the farm, one option would be to provide a government contracted tractor operator to help move hay bales out of the field in areas considered a particularly high risk. Other incentives should also be identified to entice farmers to get bales inside the fence as soon as possible since the price of bales directly influences hay management. When the value of hay is high, bales are often brought into the yard sooner than when hay prices are poor. It is my opinion that only partial reductions in the number of hay bales on the landscape (as is currently the case) will not be sufficient to eliminate elk-agriculture interactions.

VII. Hunting

Hunting is an important management tool that can help reduce the risk of contact between wildlife and agriculture by reducing wildlife population size, eliminating problem individuals, disturbing animals from using farmyards, and maintaining a fear of human activity. Hunting was permitted on 67% of farm operations around RMNP for elk, deer and/or moose in 2001. Increasing the intensity and duration of hunting on farms, may help to reduce contact between wildlife and agriculture. There are local First Nations communities that could help resolve wildlife problems by harvesting animals throughout the year if landowner permission is provided. However, most respondents strongly opposed allowing Aboriginal hunting on their land. Any initiative to include First Nations hunters to reduce wildlife contact risk will require considerable communication with both landowners and the Aboriginal hunters. Further research and communication is needed to examine ways of optimizing hunting pressure to reduce wildlife-agriculture contact risk. Management of possible negative impacts by hunters, such as fence damage and safety issues will be required to ensure that landowners continue to allow hunter access. While hunting may help eliminate elk-livestock interactions to limit spread of bovine TB, intensive hunting may result in long distance dispersals of infected animals. Potential negative impacts of hunting on disease transmission should also be examined such as the impact of hunting on elk dispersal.

Objective #2: *Characterize the social aspects of the risks associated with elk-agriculture interactions*

VIII. Park-Farmer Relationships

When I conducted interviews with farmers, one of the questions asked was about their relationship with RMNP. I anticipated that there would be some mix of positive and negative responses, but I was quite surprised to find that the most common answer was that there was no relationship at all. Most farmers that live near RMNP currently make little or no use of the park and rarely or never interact with park staff. So when a conflict arises such as crop damage or bovine tuberculosis, which is perceived by local people to be caused by the presence of RMNP, it is not surprising that tension is high. I believe that the single most effective way to help resolve park-farmer conflicts would be to identify ways of facilitating local people to use the park and to have frequent meaningful interactions between park staff and local people. Rebuilding of trust will take considerable time and effort by all concerned.

IX. Community Communication and Extension

Communication and cooperation between farmers and the agencies involved in wildlife-agriculture interactions is an essential component of successful management. Most farmers that I interviewed did not feel adequately informed regarding elk-agriculture interactions, the status of bovine TB in the region and efforts to eliminate it, nor did they feel adequately informed regarding potential changes to farm management practices that they could implement to reduce further the risk of bovine TB transmission on their farm.

This need for information was also clearly demonstrated in the mail survey results. Many respondents were very concerned about ongoing direct and indirect cattle-cervid interactions on their farms and expressed a strong interest in learning about other options for keeping elk and deer out of their cattle pastures and wintering areas. Frequent updates to hay yard barrier fence owners and all other farmers are critical so that they are well informed. Most producers that were interviewed also felt they had little or no input into management of wildlife problems and felt excluded from the process, but desired a greater voice in future decisions.

Much greater efforts are needed to include farmers in the wildlife management process and keep them informed of government actions. I recommend the development of a communications plan for the region related to elk-agriculture interactions and the identification of criteria and indicators that can be used to monitor its success since there is currently no way of knowing how well communication efforts are working. I also recommend establishing an on-farm program that provides an opportunity for agriculture extension experts, biologists, and farmers to work together to develop individualized farm management plans to eliminate or reduce wildlife contact with hay bales and cattle.

X. Information Sharing

Farmers considered the potential for bovine TB transmission to be the most important aspect of elk-agriculture interactions and they felt that they were not receiving enough information about all aspects of the bovine TB situation. Farmers also felt that they learned a moderate amount about the bovine TB situation from newspapers, radio and television and very little from government agencies. However, it is worth noting that many of the stories running in the media were initiated by or include individuals from government agencies. Considerably more work is needed to communicate effectively a range of information regarding all aspects of bovine TB on a regular basis. This study has identified a number of communication needs that government agencies should address. Of particular importance is communicating the risks associated with wildlife-cattle interactions and ways of reducing them. In addition, information should be presented regarding government regulations, regulation changes, research outcomes, mechanisms of disease transfer, and hunter and farmer health risks. This information should be made available through different media and should be presented often, since the complex nature of the issue makes it difficult for any individual to receive and retain all of the information obtained at a single meeting or from a single newspaper article. Although farmers expressed an interest in receiving more information, their willingness to make an effort to receive this information was highly variable with some willing to attend meetings and workshops and others being uninterested in being informed.

XI. Farmer Involvement

An important aspect of the communication issue that requires further thought and discussion is the commonly held belief of many stakeholders that government agencies would do whatever they wanted, regardless of what individual stakeholders say or do. Because of this feeling of being excluded, many farmers indicated that they would not attend meetings or voice their opinions because they felt no one was really listening. This frustration also significantly influences farmers willingness to take action on their own farms –many have expressed that if government is so strongly pushing their own agenda without seeking meaningful input from farmers then the responsibility should be solely with government to manage the problems. Government agencies have then expressed some frustration regarding the sometimes low level of apparent interest in information programs that were offered. For example, recent information meetings held in communities around RMNP about wildlife research and bovine TB had very low numbers of farmers attend. This issue of trust and communication transcends all aspects of elk-agriculture interactions and influences all aspects of bovine TB management. Indeed, this trust issue is based on decades of interactions with government agencies over many other factors than just elk. For example, many farmers were opposed to current government actions to manage bovine TB due to past experiences with beaver or bear damage that are not directly related, but are all viewed by farmers as being caused by wildlife moving out of RMNP.

XII. Other Stakeholders

This study has revealed important observations, attitudes, and concerns of agricultural operators regarding wildlife-agriculture interactions within the Greater Riding Mountain Ecosystem, particularly elk and deer. This study has focused largely on farmers because they are the group most directly impacted by elk and as the largest private landowners, farmers also are able to influence the habitat and survival of elk outside of protected areas. The interviews and mail surveys focused only on farm operators, but throughout the communication process of this study, which shared information broadly, other groups also expressed a keen interest in participating in the study and having their perspectives documented as well. While farmers were the focus of this study, it is important to recognize that there are other key stakeholders as well, including First Nations, non-farming landowners, hunters living elsewhere in Manitoba, and indeed all Canadians.

Local First Nation communities have unique and important perspectives regarding wildlife and are directly affected by issues such the presence of bovine tuberculosis. Interviews and focus groups should be conducted by experienced researchers with First Nations communities to document their knowledge, attitudes and concerns. Surveys should also be conducted with hunters in order to identify ways of increasing hunter success, decreasing hunter impacts and gaining input into management options. Hunting represents an important management tool for dealing with problems in wildlife-agriculture interactions. Landowners that do not operate a farm are also an important stakeholder in this issue and their knowledge and concerns should be further documented.

XIII. Town Hall Meetings

Town hall meetings can be useful for sharing information and obtaining input from stakeholders on a wide range of issues relating to wildlife-agriculture interactions. However, the results of the mail survey suggest that views expressed at these meetings are not necessarily reflective of the overall opinion of agricultural producers in the region. Extreme actions to reduce or eliminate wild elk or to fence RMNP to keep the elk in were advocated regularly at all bovine TB update meetings. However, the results of the mail survey and interviews indicate that a large proportion of producers strongly oppose such actions. If town hall meetings are to be held again in the future to discuss elk-agriculture interactions or bovine TB, it is recommended that a professional facilitator be hired to plan and facilitate the meetings. Increasing opportunities for two-way communication rather than focusing on making presentations is strongly encouraged. Again, I believe that the *process* of interacting with stakeholders is fundamentally important and needs to be significantly improved if meaningful input and discussion is the goal.

XIV. Perceptions of Government

Farmers generally considered government agencies, along with other agencies such as the Manitoba Cattle Producers Association, to be primarily responsible for managing bovine TB in the region. Indeed, most felt that all other groups and organizations were more responsible than they were themselves. However, a large number of respondents indicated dissatisfaction with past and present management actions at town hall meetings, in mail survey responses, and in personal interviews. For example, in the mail survey, 39% of respondents agreed that the presence of bovine TB is largely a result of mis-management by government agencies. Furthermore, most farmers around RMNP felt that they had little or no meaningful contact with government representatives from any agency. Clearly, there is a need to foster further trust-based relationships between farmers and government and non-government organizations involved in managing elk-agriculture interactions. I recommend that all government agencies take actions to share information with local people regarding their activities and provide greater opportunity for local stakeholders to participate in decision-making and develop trust-based relationships. The most effective government staff in the region are those that are known and respected by local people. I also recommend a formal independent review of the role and effectiveness of the Riding Mountain TB Stakeholders Advisory Committee (TBSAC) and Riding Mountain Regional Liaison Committee (RMRLC) to build on their successes and develop a strategy for the future. An important area of concern is the current relationship between the government task group and the TBSAC. The overall role and effectiveness of the TBSAC is currently being undermined by poorly developed linkages with the the Task Group.

An important point of consideration is that all of the main issues related to information sharing, wildlife conflicts, and the relationships between local people and government that were identified by Schroeder (1981) continue to be concerns of local people and the situation has changed very little since Schroeder's study 25 years ago. Why has there been so little change over that period of time? There is no easy answer, but it behooves all parties to consider carefully this question. It certainly is linked to the different cultures of farmers and government agencies that have unique and sometimes opposing short-term objectives. For the most part, the status quo continues to involve very little direct and meaningful communication among farmers and government staff outside of the few individuals sitting on the TBSAC, so it is not surprising that these conflicts continue.

XV. Attitudes Regarding Wildlife-Agriculture Interactions

Agricultural producers, including those not raising cattle, reported a high level of concern regarding disease issues related to elk and deer interactions with agriculture, particularly bovine tuberculosis in cattle, elk and deer. Damage by elk and deer to fences, grain, hay, and pasture is widespread and often severe. Interactions between elk, deer, and livestock are perceived my most farmers to increase the risk of bovine TB transmission. Overall, farmer attitudes toward elk, deer and moose were largely positive. However, concerns over transmission of bovine TB between wildlife and cattle have serious implications for the relationship between farmers and wildlife. Indeed many farmers indicated they were becoming less tolerant of wildlife due to concerns regarding the spread of bovine TB or other diseases. While the results of this survey indicate that attitudes toward deer and elk are largely positive, this may change if these species are implicated in further cases of TB in cattle. Indeed, 24% of all farmers supported fencing of the RMNP boundary and 9% of all farmers supported completely eradicating the elk population. Clearly, these individuals are highly concerned about the impacts of wildlife and these concerns must be taken seriously. Continued frustration with wildlife will likely result in more frequent calls for such actions. Many individuals currently manage their land in ways that benefit wildlife, but many have also indicated that these activities will be reduced or stopped, if wildlife impacts become too great.

XVI. Crop Damage and Insurance

Crop damage by elk continues to be an important issue for farmers and government agencies. Impacts can be severe and not all damage is eligible for compensation. The current Manitoba Crop Insurance program that provides compensation to farmers for wildlife damage is an effective short-term strategy to help farmers deal with impacts from wildlife. However, it largely removes the incentive for farmers to examine ways of eliminating the damage and the associated risks of disease transmission that exist whenever wildlife and livestock come into direct or indirect contact. As a result, over the long term, the existing Manitoba Crop Insurance program can be a disservice to farmers with chronic wildlife problems and may play a role in indirectly facilitating disease transmission. It is strongly recommended that MCIC begin exercising the option that they have to provide fences to be used toward preventing wildlife damage in lieu or in partial replacement of cash payments for damages.

XVII. Farm Management Practices

Despite high levels of concern regarding elk-agriculture interactions and the potential transmission of bovine TB, relatively few changes in farm management practices reduce personal risk of contact with elk were documented in personal interviews and the mail survey. The most commong change that respondents reported was bringing hay bales in from the field. Changes in farm management practices were observed throughout the study, with farmers taking more actions to reduce their personal risk, including accepting and effectively using a hay yard barrier fence. While regional actions, such as reducing the elk population and banning baiting and feeding of elk and deer ,will likely reduce the risks associated with elk-agriculture interaction, changes to individual farming practices will also be critical in reducing personal risk. Though study participants did not report making many farm management changes, they did indicate a strong willingness to support or implement some additional changes. Farm operators did express support for additional hunting opportunities for landowners with wildlife damage and increasing the length of the hunting season. But it was also recognized that licenced hunters that are not landowners also play an important role in maintaining hunting pressure. Changes to farm management practices such as intercept feeding and use of hay yard barrier fencing were supported (however see recommendation IV regarding intercept feeding). Successful management of elk-agriculture interactions will require both regional management of the elk population and changes to individual farm management. I recommend that programs be established to help farmers make significant changes to their farming practices to reduce risks associated with wildlife contact. Government agencies can provide advice and support on "best practices" regarding hay management, winter cattle feeding, summer grazing in ways that are cost effective and reduce wildlife contact risk.

XVIII. Compensation to Farmers

Farmers indicated very strong support for compensation regarding direct and indirect losses associated with bovine TB in addition to existing programs. Government agencies should initiate a formal discussion regarding a jointly funded compensation program to offset the costs associated with bovine TB and if such a program is not possible provide a clear explanation why not. While compensation can provide short-term benefits, it can ultimately reduce farmers' willingness to change their farm operations in order to reduce their personal risk and may have a long-term net negative influence on managing elk-agriculture interactions. As such, discussions regarding compensation should emphasize provision of compensation for cattle mustering, which all cattle farmers must do as part of regional cattle testing within the RMEA. However, compensation for farms that refuse barrier fences, bait for deer and elk, leave hay bales in the field after October 15, or are otherwise unwilling to address the risks associated with bovine TB transmission should not be considered eligible for on-going compensation.

XIX. Issues with other Wildlife Perceived to Influence Elk Movements

While elk and deer interactions with agriculture continues to be a key issue in the region, other wildlife concerns that were frequently raised by farmers included species such as beaver, wolves, geese and bears which are also perceived to have negative impacts on many farms and directly influence farmers' relationship with government agencies. These issues are not unrelated, as many producers feel that movements of elk out of RMNP are primarily driven by beaver-mediated habitat change, and predator activity inside the park. Many farmers felt that cow elk were increasingly leaving RMNP to calve in order to avoid predators. The potential role of predators, including wolves and bears, in influencing elk movements out of RMNP should be examined as they are poorly understood.

XX. Perceptions of Wildlife Habitat

Concerns over beaver impacts both inside RMNP and on surrounding private lands remains very high. There is also a commonly held perception that the elk habitat inside RMNP has changed dramatically in recent decades, with large areas flooded by beavers. Many areas of the Park are considered overgrown with forest and shrub cover due to the rarity of fire and the discontinuation of haying, forestry, and cattle grazing. These perceived changes in habitat are often considered primary factors associated with wildlife problems on surrounding agricultural lands. It is often felt that poor quality habitat inside RMNP forces wildlife out of the park. Studies are needed to better understand the nature and extent of elk habitat changes within RMNP and determine some of the factors causing the changes to occur. Studies of the perceptions of local people regarding elk habitat change both inside RMNP and on surrounding agricultural lands would also be beneficial. There is also a need to share information from these studies with the farming community.

XXI. Wildlife Population Size and Observations on Farms

It is unlikely that there is an overall population level or frequency of observation on farms for elk, deer, moose, or wolves that would be satisfactory to all agricultural producers. Some individuals have positive attitudes toward wildlife and enjoy seeing them on their land regularly and many benefit from hunting opportunities. These individuals frequently indicate a preference for similar or higher population levels and frequency of observation on farms in the future. Other respondents have negative attitudes toward wildlife, feel a high level of risk associated with wildlife interactions and would prefer lower population sizes and rarely or never to see them on farms. Research is needed to determine the Wildlife Stakeholder Acceptance Capacity (WSAC) for the region, which reflects the abundance of wildlife that local stakeholders are willing and able to live with, recognizing that both the frequency of wildlife use of farms and producer tolerance are highly variable over time.

***Objective #3:** Characterize and explain the differences that underlie objective descriptions and subjective perceptions of the risks associated with elk-agriculture interactions.*

XXII. Expert-Based Research and Local Knowledge

This study has shown the value and importance of incorporating local knowledge to understand better wildlife distribution, movements, and interactions with livestock, as well as understanding the knowledge, perceptions, and concerns of farmers. While there are sometimes apparent differences between local knowledge and scientific data, these differences often reflect unique perspectives, ways of obtaining information, and fundamentally different worldviews and do not necessarily reflect errors or problems. I recommend that all future ecological studies explicitly include local knowledge, concerns, and perspectives at all stages and work to establish and maintain trust-based relationships with local people as essential components of every research project. On-going communication with stakeholders is critical for two-way information sharing, to effectively share study results, and to receive meaningful feedback. It has been my experience that the *process* of doing research is much more important and has greater impact on local communities than the specific study findings. I strongly recommend that researchers communicate frequently with local people before, during and after each study. Government agencies can help facilitate this by requiring it their research permits and funding agreements and by helping researchers make connections with the local community and by including some funding for community meetings, interviews, and follow-up meetings to share study results.

XXIII. Comparing Farmers and Management Agencies

Unfortunately, it is not possible to address the sub-objective of this thesis that was aimed at examining differences and similarities between the attitudes and management approaches of farmers and management agencies. While I was able to obtain an abundance of information from farmers, participation by government agency staff was not sufficient to make any comparisons. Although the government staff initially unanimously supported this aspect of the study at a TB task group meeting in 2003 and further indicated support five months later, only 1 completed survey was obtained during this period. Interviews with several non-participants indicated that perhaps the initial questionnaire was too long at 16 questions, so a much shorter survey was later offered with only 5 questions, but again only one completed survey was provided.

Conclusion

The Riding Mountain regional elk population uses both Riding Mountain National Park and surrounding agriculture-dominated lands for its survival. While these elk use RMNP much more than the surrounding landscape, the agricultural lands are very important in that they provide large volumes of high quality agricultural crops during the summer months for growth and reproduction. Elk have traditionally made considerable use of hay bales during the winter months, particularly in years with high snow accumulation. Indeed, elk spend long periods of time out of RMNP, make frequent use of agriculture crops and frequently interact with numerous cattle herds surrounding RMNP directly and indirectly. Movement patterns of the elk in and out of RMNP are highly complex and are influenced by numerous factors, including habitat types, snow cover, human activity, farming practices, and hunting activities.

It is my opinion that elk-agriculture interactions can be effectively mitigated and the largely positive attitudes currently held by farmers toward elk can potentially be maintained. Research and communication play a vital role in helping to reduce both direct and indirect contact between elk, deer, and livestock. Hay yard barrier fences are a critical part of the solution, but additional efforts are also needed to eliminate potential opportunities for disease transmission. On-farm trials are needed to develop fencing options that effectively keep elk and deer out of cattle winter-feeding areas and summer pastures. Efforts are also needed to eliminate baiting and feeding of wildlife in the region, with the ultimate goal being to have no hay bales accessible to wildlife in any areas within the Riding Mountain TB Eradication Area. Success will only occur through meaningful cooperation, communication, and contribution among farmers and government agencies.

Literature Cited

Peckett, M.K. 1999. Anishinabe homeland history: traditional land and resource use of Riding Mountain, Manitoba. M.N.R.M. Practicum, University of Manitoba, Winnipeg, Manitoba.

Rebizant, K. 1989. Seasonal range use, aerial survey observability and survivorship of male elk (*Cervus elaphus manitobensis*) in southwestern Manitoba. M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba.

APPENDIX 1

CONSENT FORMS AND RESEARCH INSTRUMENTS

UNIVERSITY
OF MANITOBA

Riding Mountain Regional Wildlife and Agriculture Study

Research Conducted by
Ryan Brook, Ph.D. Student
and
Dr. Stephane McLachlan
Environmental Science Program
at the University of Manitoba

Please complete this questionnaire at your earliest convenience, seal it, and drop it in the mail (return postage has been provided). ***We would appreciate it if you would return this survey to us by May 10, 2002. Your responses will remain confidential and will never be associated with your name.***

Question 0: Are you currently operating or have you operated a farm within 150 km (90 miles) of Riding Mountain National Park?

❑.................Yes
❑.................No

IF YOU ANSWERED NO TO THIS QUESTION, please stop filling out the questionnaire and return it in the self-addressed, stamped envelope.

IF YOU ANSWERED YES, please continue on to question 1.

The following questions ask about your attitudes toward wildlife in the region. (Answers include, Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Q1. ELK are an important component of a healthy environment.	☐	☐	☐	☐	☐	☐	☐	☐
Q2. There are too many ELK in the region.	☐	☐	☐	☐	☐	☐	☐	☐
Q3. I enjoy seeing ELK on my land.	☐	☐	☐	☐	☐	☐	☐	☐
Q4. I enjoy seeing ELK in the region, but not on my land.	☐	☐	☐	☐	☐	☐	☐	☐
Q5. If the elk numbers were reduced, there would be less elk damage.	☐	☐	☐	☐	☐	☐	☐	☐
Q6. An ELK that causes damage to my crops should be killed.	☐	☐	☐	☐	☐	☐	☐	☐
Q7. Elk have lived in this region for hundreds of years.	☐	☐	☐	☐	☐	☐	☐	☐
Q8. ELK are pests.	☐	☐	☐	☐	☐	☐	☐	☐
Q9. ELK are an important resource for the hunting industry.	☐	☐	☐	☐	☐	☐	☐	☐
Q10. I enjoy seeing DEER on my land.	☐	☐	☐	☐	☐	☐	☐	☐
Q11. I enjoy seeing DEER in the region, but not on my land.	☐	☐	☐	☐	☐	☐	☐	☐
Q12. I enjoy seeing MOOSE on my land.	☐	☐	☐	☐	☐	☐	☐	☐
Q13. I enjoy seeing WOLVES on my land.	☐	☐	☐	☐	☐	☐	☐	☐

Q14. Have you lived at this at this location for five or more years? **YES** ☐ **NO** ☐
If YES, please go on to question 15. If NO, please go to question 19.

Q15. In the last FIVE years (1997-2001), how frequently did you see the following species **on your land**?

	Never See	**Rarely** See	See a **Few** Only on **Some** Years	See a **Few** on **Most** Years	See **Regularly** on **Most** Years	See **Regularly** on **All** Years	I Don't Know
ELK	☐	☐	☐	☐	☐	☐	☐
DEER	☐	☐	☐	☐	☐	☐	☐
MOOSE	☐	☐	☐	☐	☐	☐	☐
WOLVES	☐	☐	☐	☐	☐	☐	☐

Q16. In the last FIVE years (1997-2001), have you experienced damage to any of the following by wild ELK, DEER, and/or MOOSE?

	ELK	DEER	MOOSE	TOTAL $ VALUE of Damage	Number of Years Claims Made	Compensation Claimed? YES	NO
Hay Bales in the Field	☐	☐	☐			☐	☐
Hay Bales in the Yard	☐	☐	☐			☐	☐
Standing Hay	☐	☐	☐			☐	☐
Standing Grain	☐	☐	☐			☐	☐
Pasture	☐	☐	☐			☐	☐
Fences	☐	☐	☐			☐	☐
OTHER__________	☐	☐	☐			☐	☐

Q17. Over the last FIVE years (1997-2001), how serious do you feel the financial damage was by the following wildlife species on your land?

	ELK	DEER	MOOSE	WOLVES
Never Serious	☐	☐	☐	☐
Seldom Serious	☐	☐	☐	☐
Serious in **Some** Years	☐	☐	☐	☐
Serious in **Most** Years	☐	☐	☐	☐
Serious in **All** Years	☐	☐	☐	☐
I Don't Know	☐	☐	☐	☐

Q18. Over the last FIVE years (1997-2001), what management actions did you do on your land in order to benefit wildlife? (CHECK ALL THAT APPLY)

leave forest cover near fields for wildlife	☐
provide a water source for wildlife	☐
leave some crop residues for wildlife	☐
provide hay bales for wildlife	☐
provide mineral blocks for wildlife	☐
I DO NOT manage my land to benefit wildlife	☐
OTHER_______________	☐

Q19. Listed below are factors that may influence the numbers of **wild ELK** that come onto your land. Please indicate what you consider to be the importance of each (1=of no importance, 5=of moderate importance, 10=of very high importance).

	1	2	3	4	5	6	7	8	9	10	I Don't Know
Snow Accumulation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hunting Pressure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crop Type Grown	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hay Management Practices	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forest Cover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Burning on my Land	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mineral Blocks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER__________	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q20. Where do you think that the **wild ELK** on your land come **from**? (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Private land on or near my land	☐	☐	☐	☐	☐	☐	☐	☐
Duck Mountain Provincial Park	☐	☐	☐	☐	☐	☐	☐	☐
Duck Mountain Provincial Forest Reserve	☐	☐	☐	☐	☐	☐	☐	☐
Riding Mountain National Park	☐	☐	☐	☐	☐	☐	☐	☐
ELK do not come onto my land	☐	☐	☐	☐	☐	☐	☐	☐
OTHER_______________	☐	☐	☐	☐	☐	☐	☐	☐

Q21. Do you feel that the current population size of the following species in the region are:

	ELK	DEER	MOOSE	WOLVES
Too High	☐	☐	☐	☐
About Right	☐	☐	☐	☐
Too Low	☐	☐	☐	☐
I Don't Know	☐	☐	☐	☐

Q22. Please indicate your willingness to use or support the following management activities in order to reduce wildlife damage and interactions with cattle. (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
additional hunting for landowners with wildlife damage	☐	☐	☐	☐	☐	☐	☐	☐
allow Aboriginal (Indian) hunting on your land	☐	☐	☐	☐	☐	☐	☐	☐
barb-wire fencing of hay yards	☐	☐	☐	☐	☐	☐	☐	☐
chemical repellants	☐	☐	☐	☐	☐	☐	☐	☐
reducing the entire elk population	☐	☐	☐	☐	☐	☐	☐	☐
electric fencing of hay yards	☐	☐	☐	☐	☐	☐	☐	☐
guard dogs	☐	☐	☐	☐	☐	☐	☐	☐
habitat modifications (eg. prescribed burns)	☐	☐	☐	☐	☐	☐	☐	☐
increase length of hunting season	☐	☐	☐	☐	☐	☐	☐	☐
increase number of hunting licenses	☐	☐	☐	☐	☐	☐	☐	☐
page wire fencing of hay yards	☐	☐	☐	☐	☐	☐	☐	☐
intercept feeding (providing some feed to wildlife to keep them away from cattle and the main hay storage area)	☐	☐	☐	☐	☐	☐	☐	☐
OTHER_______________	☐	☐	☐	☐	☐	☐	☐	☐

Q23. What amount ($) of **compensated** damage by wildlife do you feel is acceptable on your land **in a year?**__________

Q24. Please estimate the average NUMBER OF HUNTING DAYS **in 2001** for ELK, DEER, and MOOSE on your land by each of the following groups.

(IF YOU DO NOT ALLOW ANY HUNTING ON YOUR LAND PLEASE CHECK THIS BOX ❑ and go to question 25)

	ELK	DEER	MOOSE
Yourself or your immediate family	____ days	____ days	____ days
Other family or close friends	____ days	____ days	____ days
Paying visitors	____ days	____ days	____ days
Non-Paying visitors	____ days	____ days	____ days
Aboriginal people (Natives)	____ days	____ days	____ days

Q25. Please indicate the number of acres of each type that you had on your land in 2001.

Forest Cover (Bush)	________ acres
Wetland (Slough)	________ acres
Wheat	________ acres
Oats	________ acres
Barley	________ acres
Canola	________ acres
Improved Hay	________ acres
Alfalfa	________ acres
Native Hay	________ acres
Improved Pasture	________ acres
Native Pasture	________ acres
Mixed Bush Pasture	________ acres
OTHER__________	________ acres
OTHER__________	________ acres
OTHER__________	________ acres

Q26. On January 1, 2002, approximately what percentage of your hay bales were: (SHOULD TOTAL TO 100%)

Stacked in your hay yard	_____%
Stacked in the field	_____%
Lying where they came out of the baler	_____%
OTHER__________	_____%

Q27. How many head of livestock do you currently have on your land (**on the day you fill out this questionnaire**)?

	0	1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	>160
Beef Cattle	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Dairy Cattle	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Calves (under 1 year)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Horses	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Pigs	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Sheep	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER__________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER__________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER__________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q28. Approximately how many salt and mineral blocks did you use on your land in 2001? ________

IF YOU OWN CATTLE, PLEASE CONTINUE WITH QUESTION 29. IF YOU DO NOT OWN CATTLE PLEASE SKIP TO QUESTION 37.

Q29. Do you feel that any of the following animals have come into **physical contact or indirect contact** with your cattle **in 2001**? *Physical contact is nose-to-nose contact or sniffing, touching or licking each other, including through the fence. Indirect contact is eating from the same food source (e.g. mineral blocks, hay, and grain) at some time, without actually touching.*

	Physical Contact	Indirect Contact	No Contact	I Don't Know
Wild ELK	❑	❑	❑	❑
Ranched ELK	❑	❑	❑	❑
Wild DEER	❑	❑	❑	❑
Wild MOOSE	❑	❑	❑	❑

Q30. Approximately how far is it from the nearest residence to the **storage site** for the winter feed for your cattle?

<50 Yards	50-100 Yards	101-200 Yards	201-400 Yards	401-600 Yards	601-800 Yards	801-1000 Yards	>1000 Yards	I Don't Know
❑	❑	❑	❑	❑	❑	❑	❑	❑

Q31. Approximately how far is it from the nearest residence to the **site where your cattle are fed** during the winter?

<50 Yards	50-100 Yards	101-200 Yards	201-400 Yards	401-600 Yards	601-800 Yards	801-1000 Yards	>1000 Yards	I Don't Know
❑	❑	❑	❑	❑	❑	❑	❑	❑

Q32. How often do you normally feed your cattle during the winter?

More than Once Per Day	Once Per Day	Every Two Days	Three Times Per Week	Less Than Three Times Per Week	I Don't Know
❑	❑	❑	❑	❑	❑

Q33. How do you provide roughage to your cattle? (CHECK ALL THAT APPLY)

round bale feeders	❑
square bale feeders	❑
unroll bales on the ground	❑
shred bales onto the ground	❑
OTHER____________________	❑

Q34. Do you feed grain concentrate to your cattle? **YES** ❑ **NO** ❑

Q35. If you do feed grain concentrate to your cattle, how is it provided? (CHECK ALL THAT APPLY)

complete mixed ration	❑
top dressed on roughage	❑
in mangers as required	❑
OTHER____________________	❑

Q36. During the last five years, have concerns over disease transmission between wildlife and your cattle caused you to change your farm management practices regarding the following. (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
access of cattle to water source	❑	❑	❑	❑	❑	❑	❑	❑
crop types that are grown	❑	❑	❑	❑	❑	❑	❑	❑
feeding wildlife in winter	❑	❑	❑	❑	❑	❑	❑	❑
fencing of hay yards	❑	❑	❑	❑	❑	❑	❑	❑
grazing management	❑	❑	❑	❑	❑	❑	❑	❑
intercept feeding of wildlife	❑	❑	❑	❑	❑	❑	❑	❑
use of mineral blocks	❑	❑	❑	❑	❑	❑	❑	❑
winter cattle feeding	❑	❑	❑	❑	❑	❑	❑	❑
bringing hay bales in out of the field	❑	❑	❑	❑	❑	❑	❑	❑
OTHER____________________	❑	❑	❑	❑	❑	❑	❑	❑

Q37. Listed below are several issues that have been discussed in the region. Please indicate the relative level of concern that you have for each issue (1=of no concern, 5=of moderate concern, 10=of extremely high concern).

	1	2	3	4	5	6	7	8	9	10	I Don't Know
Bovine Tuberculosis in **CATTLE**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Bovine Tuberculosis in **wild ELK**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Bovine Tuberculosis in **captive ELK**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Bovine Tuberculosis in **wild DEER**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Bovine Tuberculosis in **wild MOOSE**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Cuts in Agricultural Subsidies	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
ELK Baiting by Hunters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
ELK Ranching	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Chronic Wasting Disease **risk** in ELK	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Feeding **ELK**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Grain elevator closures	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Length of the **ELK** Hunting Seasons	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Number of **ELK** Hunters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Foot and Mouth Disease **risk** in **CATTLE**	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Rural Crime	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q38. The following are some hypothetical ways of potentially managing the risk of TB in the region. **We emphasize that these are hypothetical and are not necessarily being considered as any government policy.** They are included to gain an understanding of the perspectives of local residents on different issues. (Answers include, Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Fence around Riding Mountain National Park	❑	❑	❑	❑	❑	❑	❑	❑
Reduce cattle populations in close proximity to Riding Mountain National Park	❑	❑	❑	❑	❑	❑	❑	❑
Fully compensate agriculture producers for economic losses	❑	❑	❑	❑	❑	❑	❑	❑
Meaningful participation of Aboriginal (Native) groups	❑	❑	❑	❑	❑	❑	❑	❑
Develop a landowner guide to farm management for reducing TB	❑	❑	❑	❑	❑	❑	❑	❑
Reduce the number of elk in areas where TB has been identified	❑	❑	❑	❑	❑	❑	❑	❑
Substantially reduce the entire Riding Mountain elk population	❑	❑	❑	❑	❑	❑	❑	❑
Completely eradicate the entire Riding Mountain elk population	❑	❑	❑	❑	❑	❑	❑	❑
Improve the quality of elk habitat inside Riding Mountain Park	❑	❑	❑	❑	❑	❑	❑	❑
Cull TB positive wild elk	❑	❑	❑	❑	❑	❑	❑	❑
More TB testing of wild elk	❑	❑	❑	❑	❑	❑	❑	❑
Remove the bison population from Riding Mountain National Park	❑	❑	❑	❑	❑	❑	❑	❑
Reduce the amount of wildlife baiting and feeding	❑	❑	❑	❑	❑	❑	❑	❑
Meaningful participation of rural people in management of TB	❑	❑	❑	❑	❑	❑	❑	❑
OTHER________________	❑	❑	❑	❑	❑	❑	❑	❑

Q39. Recently there has been a suggestion that a TB management zone may be established. The following are some hypothetical ways of establishing this zone. **We emphasize that these are hypothetical and are not necessarily being considered as any government policy. However, if a zone must be implemented, please indicate your attitude towards each option.** (Answers include, Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Establish Canada as a single TB management zone	❑	❑	❑	❑	❑	❑	❑	❑
Establish Alberta, Saskatchewan and Manitoba as a single TB management zone	❑	❑	❑	❑	❑	❑	❑	❑
Establish Manitoba as a single TB management zone	❑	❑	❑	❑	❑	❑	❑	❑
Establish the Rural Municipalities that border Riding Mountain National as a single TB management zone	❑	❑	❑	❑	❑	❑	❑	❑
Establish a 15 kilometer area around Riding Mountain National Park as a single TB management zone	❑	❑	❑	❑	❑	❑	❑	❑
OTHER________________	❑	❑	❑	❑	❑	❑	❑	❑

Q40. The following groups could potentially be responsible for the management of Bovine Tuberculosis in the region. Please indicate your response to the involvement of each group. Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Yourself and your family	☐	☐	☐	☐	☐	☐	☐	☐
Residents of your local community	☐	☐	☐	☐	☐	☐	☐	☐
Residents living outside of the Riding Mountain region	☐	☐	☐	☐	☐	☐	☐	☐
Local elected officials in your community	☐	☐	☐	☐	☐	☐	☐	☐
Canadian Food Inspection Agency	☐	☐	☐	☐	☐	☐	☐	☐
Parks Canada	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Conservation	☐	☐	☐	☐	☐	☐	☐	☐
Non-governmental conservation organizations	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Agriculture and Food	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Cattle Producers Association	☐	☐	☐	☐	☐	☐	☐	☐

Q41. How much would you say you have learned in the past year about TB from the following sources (1=nothing, 5= a moderate amount, 10=learned a great deal).

	1	2	3	4	5	6	7	8	9	10	I Don't Know
Family Members	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Friends and Neighbors	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Newspapers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Radio and Television	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Public Meetings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Cattle Producers Association Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Conservation Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manitoba Agriculture and Food Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Parks Canada Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Canadian Food Inspection Agency Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Riding Mountain Biosphere Reserve Staff	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Local Veterinarians	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER____________________	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q42. Would you say that you have received **adequate** information on the following aspects of Bovine Tuberculosis (TB)? (Answers include I Don't Know, Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Management practices to minimize TB risk	☐	☐	☐	☐	☐	☐	☐	☐
Areas where TB testing has occurred	☐	☐	☐	☐	☐	☐	☐	☐
Number of TB occurrences in the region	☐	☐	☐	☐	☐	☐	☐	☐
Actions by government to deal with TB	☐	☐	☐	☐	☐	☐	☐	☐
Results of TB testing in cattle	☐	☐	☐	☐	☐	☐	☐	☐
Results of TB testing in wildlife	☐	☐	☐	☐	☐	☐	☐	☐
Reliability of TB test	☐	☐	☐	☐	☐	☐	☐	☐
Other____________________	☐	☐	☐	☐	☐	☐	☐	☐

Q43. Would you be interested in attending a workshop on any of the following issues? (please rate the following from 1=not interested, 5=somewhat interested, to 10=very interested)

	1	2	3	4	5	6	7	8	9	10
Elk damage prevention	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bovine Tuberculosis prevention	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bovine TB management programs in other regions	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Elk research	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Risk of TB to hunters and people eating country food	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER_______________	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please indicate your agreement or disagreement with the following statements. (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Q44. The presence of Bovine Tuberculosis (TB) in elk is largely a result of mis-management by government agencies.	❑	❑	❑	❑	❑	❑	❑	❑
Q45. Important decisions regarding Bovine Tuberculosis (TB) management should be primarily made by government	❑	❑	❑	❑	❑	❑	❑	❑
Q46. The presence of Bovine Tuberculosis (TB) in cattle is largely the result of mis-management by cattle producers.	❑	❑	❑	❑	❑	❑	❑	❑
Q47. Information regarding the TB management process is currently open to all people.	❑	❑	❑	❑	❑	❑	❑	❑
Q48. Information regarding TB should be presented to the general public on a regular basis.	❑	❑	❑	❑	❑	❑	❑	❑
Q49. Chronic Wasting Disease is as important of a concern as TB is.	❑	❑	❑	❑	❑	❑	❑	❑

Please indicate your agreement or disagreement with the following statements. (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

	-3	-2	-1	0	+1	+2	+3	I Don't Know
Q50. Government agencies should be directly accountable to local stakeholders.	❑	❑	❑	❑	❑	❑	❑	❑
Q51. Local rural knowledge (e.g. farmers) should be held in equal value as scientific research in making management decisions.	❑	❑	❑	❑	❑	❑	❑	❑
Q52. Aboriginal traditional knowledge should be held in equal value as scientific research in making management decisions.	❑	❑	❑	❑	❑	❑	❑	❑
Q53. The general public should be directly involved in decision-making.	❑	❑	❑	❑	❑	❑	❑	❑
Q54. The general public should have an influence on what information is gathered and how it should be gathered.	❑	❑	❑	❑	❑	❑	❑	❑

Q55. Do you feel that this questionnaire is a useful way for you to provide information? (Answers include (Answers include I Don't Know, Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know).

-3	-2	-1	0	+1	+2	+3	I Don't Know
❑	❑	❑	❑	❑	❑	❑	❑

Please share any other concerns or opinions that you have regarding wildlife and agriculture in general in the space below. PLEASE PRINT

____

____

____

____

____

____

____

____

continue on other side of this page if needed

We realize that the following questions are of a sensitive nature, but they will be very important in helping to explain wildlife movements and use of agricultural areas. Furthermore, they may help explain people's perceptions regarding wildlife. All of this information will be kept completely confidential and will only be used to identify general trends. Again, please feel free to leave any of the questions blank that you feel uncomfortable sharing with us.

Q56. How old are you? _____ years

Q57. What is your gender? ❑Male ❑Female

Q58. What is your highest completed level of education?

No formal education	❑
Grade school	❑
High school	❑
Technical training	❑
College/University	❑

Q59. How would you define your work situation?

Full-time farmer	❑
Mostly farming, some non-farm work	❑
About equal amount of farming and non-farm work	❑
Mostly non-farm work, some farming	❑
All non-farm work	❑
Retired farmer	❑
OTHER___________________________	❑

Q60. What percentage of your income is derived from the following (SHOULD TOTAL TO 100%):

Farming	_____%
Hunting/Outfitting	_____%
Tourism	_____%
Other Non-Farming Income	_____%

Q61. Number of individuals who reside in your household (including yourself)? __________

Q62. How long have you lived in this Municipality? __________ years

Q63. Approximately, what is the earliest year that your direct family (i.e. parents, grandparents, great-grandparents, etc.) began farming in this region? (e.g. 1912) **1**___ ___ ___.

Q64. Where were you raised? SELECT MORE THAN ONE IF APPLICABLE

Rural Farm	❑
Rural Non-Farm	❑
Village (less than 1000 people)	❑
Town or City (more than 1000 people)	❑

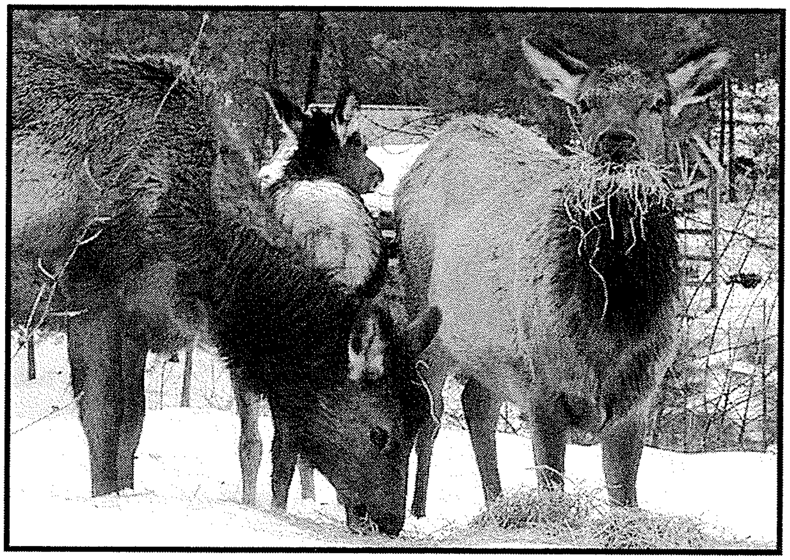
Q65. How many acres do you currently own and rent? (do not include land rented out to others). _________ acres

Q65. What is the location (Legal Description) of your home quarter section (e.g. NE20-10-6E)? _____________

THANK YOU FOR TAKING THE TIME TO PARTICIPATE IN THIS SURVEY.
Your cooperation is important for helping to guide wildlife management in the future. Please remember to return this survey in the stamped, self-addressed envelope to: Ryan Brook, Environmental Science Program, 231 Machray Hall, University of Manitoba, Winnipeg, Manitoba R3T 2N2

UNIVERSITY OF MANITOBA

Riding Mountain Regional Wildlife and Agriculture Study



Farmer Knowledge of Elk-Agriculture Interactions Survey

Research Conducted by
Ryan Brook, Ph.D. Student
and
Dr. Stephane McLachlan
Environmental Science Program
at the University of Manitoba

Riding Mountain Regional Wildlife and Agriculture Study
Release Form

The Riding Mountain Elk Local Knowledge Study is being conducted by Ryan Brook of the University of Manitoba in conjunction with local people within the Riding Mountain Region. The research is sponsored by Parks Canada, Manitoba Conservation, Manitoba Food and Agriculture, Riding Mountain Biosphere Reserve and the University of Manitoba.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. **You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence.** Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

This research has been approved by the University of Manitoba Joint-Faculty Research Ethics Board. If you have any concerns or complaints about this project you may contact Dr. Stephane McLachlan, Associate Professor, University of Manitoba, (204) 474-9316 or the Human Ethics Secretariat at (204) 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

I, ______________________________, agree to participate in the Riding Mountain Regional Wildlife and Agriculture Study, and agree that the information may be used by the researchers to better understand elk ecology, values, and concerns in the region and in presentations and publications related to this research.

Participant's Signature______________________________ Date______________

Researcher and/or Delegate's Signature____________________ Date______________

I agree that my individual map that I made of elk coming onto my land may be used to demonstrate the value of local knowledge in presentations and publications related to this research project.

Participant's Signature______________________________ Date______________

Interview Instrument

Arrive at the home of the interviewer with all necessary equipment, ask the interviewee where they would like to do the interview, set up tape recorder/video-camera, lay out questions to be asked, set up map so the informant can refer to it.

The purpose of this interview is to:
- ***document your knowledge of wildlife***
- ***understand the importance of agricultural areas outside of RMNP to elk and other wildlife***
- ***determine areas of priority for management and communicate them to government***
- ***identify workable management strategies to minize TB risk and crop damage***
- ***recognize the value of local rural knowledge in understanding ecosystems***

BEFORE BEGINNING INTERVIEW DISCUSS AND SIGN CONSENT FORM

I. Background Information

"I am going to ask you some questions about you and your farm. All of this information will be kept completely confidential and will only be used to identify general trends."

Q1. Date of Interview ______

Q2. What is the location of your cattle farm? (e.g. NE-10-20-6E) ____________

Q3. What is your full name? __________________

Q4. Sex____________

Q5. How old are you?_________

Q6. How many years have you been living at this location?_______

Q7. How many years have you been farming?_________

Q8. What is your highest completed level of education?
❑ No formal Education ❑ Grade School ❑ High School ❑ Technical training ❑ College/University

Q9. How many acres do you currently own and rent? (do **not** include land rented out to others). _________ acres

Q10. Where were you raised?
❑ Rural Farm ❑ Rural Non-Farm ❑ Village (less than 1000) ❑ Town or City (more than 1000)

Q11. How many head of cattle do you currently have on your land (**TODAY**)?

	0	1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	>160
Beef Cattle	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Dairy Cattle	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Calves (under 1 year)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q12. How many acres of hay do you currently operate (include all land you own and rent that you produce hay on):

Alfalfa ______________	acres
Improved Hay ______________	acres
Native Hay	acres

3

II. MAPPING COMPONENT

The purpose of this part is to document your knowledge of recent elk use of your land over the last 5 years. On the map can you mark the locations of the following (SHOW EXAMPLE):

1. elk observations (**RED E**, include years observed and numbers, e.g. $E_{12,\ 2001,2002}$)
2. elk movement routes (**RED line**, with arrows for directions, include year(s) observed)
3. elk calving sites (**RED C**, include years observed and numbers)
4. hunter killed elk (**BLACK X**, include years)
5. tree stands/hunting towers/shacks (**BLACK A**, include years)
6. hay bales (**BLACK B**, include years and approximate numbers e.g. $B_{32,2001}$)
7. elk feeding sites (**BLACK F**, include years)
8. natural mineral licks (**YELLOW M**, include years used)
9. mineral or salt blocks for livestock (**YELLOW S**, include years used)
10. cattle winter areas (**outline with BLUE line**, include years)
11. cattle summer areas (outline with **GREEN line**, include years)
12. ANY ADDITIONAL INFORMATION USE (use **PURPLE**)

III. SEMI-DIRECTED

The purpose of this part is to ask your opinions and hear your stories about elk coming onto your land and your concerns about TB.

What are the major changes that you have observed on **YOUR LAND** while living in this location over the years *(eg. wildlife observed, wildlife damage, forest cover, farm size, crop type, number and type of livestock)*?

Q13. What are the major changes that you have observed **in the Riding Mountain Region** over the years *(eg. wildlife observed wildlife damage, forest cover, farm size, crop type, number and type of livestock)*?

Q14. How has the presence of Bovine Tuberculosis (TB) in cattle, elk, and deer in the Riding Mountain Region influenced your activities?

Q15. What is it about your land that attracts elk?

Q16. What needs to be done by government to reduce the risk of TB transmission to your cattle?

Q17. What can you do to reduce the risk of TB transmission to your cattle?

Q18. Can you tell me any stories from your childhood about seeing elk?

Q19. Can you tell me any stories that you were told by your parents or grand-parents about elk?

Q20. How would you describe your relationship with Riding Mountain National Park –both the people and the park itself?

V. PHOTOGRAPHS

Can you show me any photographs you have of farming, wildlife, or anything else of interest?
Talk with them about the stories they have associated with each image.

IV. FENCING EVALUATION

The purpose of this part is to ask about your experience with your hay yard barrier fence.

Q18. Have you noticed any differences in how wildlife uses your land since the fence was built?
Q40. Does the fence interfere with your work in the yard?
Q41. If you could build the fence again what would you do differently?
Q42. What other things do you do on your farm to reduce contact between wildlife and your cattle?
Q23. Has the fence changed interactions between wildlife and your cattle?
Q24. Has the fence changed interactions between wildlife and your hay bales?
Q25. Do you feel wildlife are interacting with **neighboring** farms differently since you received the fence?
Q26. What changes would you recommend to the **process** of receiving a fence?

5

Q27. In the last 5 years **Prior to getting a fence**, have you experienced damage to any of the following?

	ELK	DEER	MOOSE	TOTAL $ VALUE of Damage	Number of Years Claims Made	Compensation Claimed? YES	NO
Hay Bales in the Field	☐	☐	☐			☐	☐
Hay Bales in the Yard	☐	☐	☐			☐	☐
Standing Hay	☐	☐	☐			☐	☐
Standing Grain	☐	☐	☐			☐	☐
Pasture	☐	☐	☐			☐	☐
Fences	☐	☐	☐			☐	☐
OTHER	☐	☐	☐			☐	☐

Q19. Prior To Receiving The Fence, how frequently did you see the following species **on your land**?

	NEVER See	Rarely See	See a **Few** Only on **Some** Years	See a **Few** on **Most** Years	See **Regularly** on **Most** Years	See **Regularly** on **All** Years	I Don't Know
ELK	☐	☐	☐	☐	☐	☐	☐
DEER	☐	☐	☐	☐	☐	☐	☐
MOOSE	☐	☐	☐	☐	☐	☐	☐
WOLVES	☐	☐	☐	☐	☐	☐	☐

Q19. During what months did you observe wildlife on your land in the last 5 years **Prior To Receiving a Fence**?

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec.
ELK	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DEER	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MOOSE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
WOLVE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q20. Since the Fence was BUILT, how frequently did you see the following species **on your land**?

	NEVER See	Rarely See	See a **Few** Only on **Some** Years	See a **Few** on **Most** Years	See **Regularly** on **Most** Years	See **Regularly** on **All** Years	I Don't Know
ELK	☐	☐	☐	☐	☐	☐	☐
DEER	☐	☐	☐	☐	☐	☐	☐
MOOSE	☐	☐	☐	☐	☐	☐	☐
WOLVES	☐	☐	☐	☐	☐	☐	☐

Q21. Since the Fence was BUILT, during what months did you observe wildlife on your land?

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec.
ELK	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DEER	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MOOSE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
WOLVE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q22. Since the Fence was BUILT, have you experienced damage to any of the following?

	ELK	DEER	MOOSE	TOTAL $ VALUE of Damage	Number of Years Claims Made	Compensation Claimed? YES	NO
Hay Bales in the Field	❑	❑	❑			❑	❑
Hay Bales in the Yard	❑	❑	❑			❑	❑
Standing Hay	❑	❑	❑			❑	❑
Standing Grain	❑	❑	❑			❑	❑
Pasture	❑	❑	❑			❑	❑
Fences	❑	❑	❑			❑	❑
OTHER	❑	❑	❑			❑	❑

Please respond to the following statements (Answers include Strongly Disagree (-3), Moderately Disagree (-2), Disagree (-1), Neutral (0), Agree (+1), Moderately Agree (+2), Strongly Agree (+3), I Don't Know, Does Not Apply

	-3	-2	-1	0	+1	+2	+3	I Don't Know	Doesn't Apply
Q30. Since my fence was built I have noticed an improvement in my farm operation.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q31. Since my fence was built I see fewer deer on my land.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q32. Since my fence was built I see fewer elk on my land.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q33. My fence has eliminated damage by wildlife to baled hay on my farm.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q34. The process of deciding who receives a fence is fair to everyone.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q35. My fence has eliminated contact between wildlife and my cattle.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q36. My fence meets the needs of my cattle operation.	❑	❑	❑	❑	❑	❑	❑	❑	❑
Q37. My fence has reduced the risk of my cattle getting TB.	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q27. What agency or agencies **signed you up** for this fencing program? **(Check All That Apply)**

Manitoba Cattle Producers Association	☐
Manitoba Conservation	☐
Canadian Food Inspection Agency	☐
University of Manitoba	☐
Parks Canada	☐
Manitoba Agriculture and Food	☐
Manitoba Wildlife Federation	☐
OTHER________________________	

Q28. What agency or agencies do you think **PAY FOR** this fencing program? **(Check All That Apply)**

Manitoba Cattle Producers Association	☐
Manitoba Conservation	☐
Canadian Food Inspection Agency	☐
University of Manitoba	☐
Parks Canada	☐
Manitoba Agriculture and Food	☐
Manitoba Wildlife Federation	☐
OTHER________________________	

Q29. What agency or agencies **would you prefer sign you up** for this fencing program? **(Check All That Apply)**

Manitoba Cattle Producers Association	☐
Manitoba Conservation	☐
Canadian Food Inspection Agency	☐
University of Manitoba	☐
Parks Canada	☐
Manitoba Agriculture and Food	☐
Manitoba Wildlife Federation	☐
OTHER________________________	

Q38. Have **ELK** ever gotten inside the fenced area? ❑ YES ❑ NO

If YES, how did the elk get in?

Over the Top	❑
Through a Hole	❑
Under the Bottom	❑
Through an Open Gate	❑
OTHER______________	

If YES, during what months did wildlife get in? **(Circle All That Apply)** **J F M A M J J A S O N D**

Q38. Have **DEER** ever gotten inside the fenced area? ❑ YES ❑ NO

If YES, how did the elk get in?

Over the Top	❑
Through a Hole	❑
Under the Bottom	❑
Through an Open Gate	❑
OTHER______________	

If YES, during what months did wildlife get in? **(Circle All That Apply)** **J F M A M J J A S O N D**

9

UNIVERSITY OF MANITOBA

COMMENT SHEET

This comment sheet is provided to people involved in the management of wildlife-agriculture interactions in the Riding Mountain region to ask about your concerns and attitudes toward elk-agriculture interactions, including Bovine Tuberculosis. The information will be used as part of research that is being conducted by Ryan Brook and Dr. Stephane McLachlan of the University of Manitoba. The Joint-Faculty Research Ethics Board of the University has approved this form. Any concerns or complaints should be directed to the Human Ethics Secretariat at the University of Manitoba (204) 474-7122. The study is funded by Manitoba Agriculture and Food, Parks Canada, Manitoba Conservation, Riding Mountain Biosphere Reserve, and the Rocky Mountain Elk Foundation. The results of this project will provide important information about elk interactions with agriculture to local people and management agencies and will help to generate meaningful solutions. This comment sheet will be made available at management meetings on a regular basis in order to see how your concerns and attitudes are changing as the issues continue to change.

If you have any comments or questions about any aspect of TB, elk, or this research, write them here. If you would like to receive an answer or a response directly, include your name, address and phone number (*attach additional sheets if required*).

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

If you have any further questions or comments please contact:

Ryan Brook *umbrook1@cc.umanitoba.ca*

Participation is optional and you can choose to leave any question blank.

Q1. How would you rate the performance of the following groups in influencing and managing TB and the risks of interaction between cattle and wildlife? Answers include, Excellent (A+), Very Good (A), Good (B+), Somewhat Good (B), Neutral (C), Somewhat Poor (D+), Poor (D), Very Poor (F+), Unacceptable (F).

	A+	A	B+	B	C	D+	D	F+	F	I Don't Know
Farmers	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Hunters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Outfitters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Food and Agriculture	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Conservation	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Cattle Producers Association	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Food Inspection Agency	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Parks Canada	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Local Elected Officials	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER ________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q2. On approximately how many **days** did you communicate with these different groups **in the last 6 months** about TB and the risks of interaction between cattle and wildlife?

	1	2	3	4	5	6	7	8	9	10	>10	I Don't Know
Agricultural Producers	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Parks Canada	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Local Hunting Groups	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Conservation	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Individual Community Members	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Local RMs	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Agriculture and Food	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Eco-Network	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Humane Society	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Co-op. Wildlife Health Centre	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Riding Mountain Biosphere Reserve	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Food Inspecton Agency	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Prairie Farm Rehabilitation Association	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
University of Manitoba	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Cattle Producers Association	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Parks and Wilderness Society	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
International Environmental NGO's (eg. World Wildlife Fund)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Aboriginal Groups	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q3. In the last 6 months, what do you think are the most important ways that (1) farmers, (2) hunters, and (3) government agencies influenced or managed the interactions between cattle and wildlife?

(1) farmers ____

(2) hunters ____

(3) government agencies ____

continue on the other side of this page if needed

Q4. What do you think needs to be done to manage TB and wildlife-agriculture interactions?

____

continue on the other side of this page if needed

Q5. What agency or group do you represent? ____

UNIVERSITY OF MANITOBA

COMMENT SHEET

This comment sheet is provided to people involved in the management of wildlife-agriculture interactions in the Riding Mountain region to ask about your concerns and attitudes toward elk-agriculture interactions, including Bovine Tuberculosis. The information will be used as part of research that is being conducted by Ryan Brook and Dr. Stephane McLachlan of the University of Manitoba. The Joint-Faculty Research Ethics Board of the University has approved this form. Any concerns or complaints should be directed to the Human Ethics Secretariat at the University of Manitoba (204) 474-7122. The study is funded by Manitoba Agriculture and Food, Parks Canada, Manitoba Conservation, Riding Mountain Biosphere Reserve, and the Rocky Mountain Elk Foundation. The results of this project will provide important information about elk interactions with agriculture to local people and management agencies and will help to generate meaningful solutions. This comment sheet will be made available at management meetings on a regular basis in order to see how your concerns and attitudes are changing as the issues continue to change.

If you have any comments or questions about any aspect of TB, elk, or this research, write them here. If you would like to receive an answer or a response directly, include your name, address and phone number (*attach additional sheets if required*).

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

If you have any further questions or comments please contact:

Ryan Brook *umbrook1@cc.umanitoba.ca*

Participation is optional and you can choose to leave any question blank.

Q1. How would you rate the performance of the following groups in influencing and managing TB and the risks of interaction between cattle and wildlife? Answers include, Excellent (A+), Very Good (A), Good (B+), Somewhat Good (B), Neutral (C), Somewhat Poor (D+), Poor (D), Very Poor (F+), Unacceptable (F)

	A+	A	B+	B	C	D+	D	F+	F	I Don't Know
Farmers	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Hunters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Outfitters	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Food and Agriculture	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Conservation	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Cattle Producers Association	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Food Inspection Agency	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Parks Canada	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Local Elected Officials	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER____________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q2. How much have you learned in the last 6 months about TB and the risks of interaction between cattle and wildlife from the following sources (1=nothing, 5= moderate amount, 10=learned a great deal).

	1	2	3	4	5	6	7	8	9	10	I Don't Know
Family Members	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Friends and Neighbors	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Newspapers	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Radio and Television	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Public Meetings	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Cattle Producers Association Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Conservation Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Manitoba Agriculture and Food Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Parks Canada Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Canadian Food Inspection Agency Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Riding Mountain Biosphere Reserve Staff	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Local Veterinarians	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
OTHER____________	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q3. In the last 6 months, what do you think are the most important ways that (1) farmers, (2) hunters, and (3) government agencies influenced or managed the interactions between cattle and wildlife?

(1) farmers ____

____

(2) hunters ____

____

(3) government agencies ____

____

continue on the other side of this page if needed

Q4. What do you think needs to be done to manage TB and wildlife-agriculture interactions?

____

____

____

continue on the other side of this page if needed

Q5. Please check all that apply to your personal situation **(Check more than one if applicable).**

❑ livestock producer	❑ government employee____________	❑ hunter
❑ cattle producer	❑ tourism operator	❑ outfitter
❑ grain producer	❑ member of MB Wildlife Federation	❑ I live in a town or city
❑ I am not a farmer	❑ member of CPAWS	❑ I live in the country
❑ councillor or reeve	❑ member of MB Cattle Producers Assoc.	❑ OTHER____________

Q6. What Rural Municipality, town or city do you live in? ____________________

Q7. What is the location (Legal Description) of your home quarter section (e.g. NE20-10-6E)? ________

Thank you for your participation!