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Farmer attitudes toward wolves: Implications for the role of predators in managing disease

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ABSTRACT

The potential for disease transmission between wild and domestic animals may interfere with wildlife and habitat conservation on lands surrounding protected areas. Recently, possible transmission of bovine tuberculosis (*Mycobacterium bovis*) from wild ungulates to domestic livestock has affected the Riding Mountain National Park region in Manitoba, Canada. Wolf (*Canis lupus*) predation on ungulate populations may help lessen the risk of disease transmission to livestock. We conducted an exploratory analysis of causal factors associated with farmer attitudes toward observing wolves on their farms. A survey to 4220 farms within 50 km of the Park resulted in an adjusted response rate of 25%. We constructed several logistic regression models with factors hypothesized to influence whether farmers agreed with the statement "I enjoy seeing wolves on my land", and three candidate models received reasonable support. Factors most affecting attitudes were, in order of importance, perceived wolf population size, frequency of seeing wolves, perceived seriousness of wolf damage, distance to Park boundary and number of beef cattle (*Bos taurus*) owned. The factors least influential on attitudes were education and age. Concern over bovine tuberculosis in wild elk also had minimal influence. Of respondents who perceived the wolf population as "too high", 60% were extremely concerned about bovine tuberculosis in wild elk. Although the role of wolf predation as a potential natural regulator of disease in wild ungulates might not be widely recognized in many areas, we believe this provides a unique opportunity to re-examine the significance of maintaining viable wolf populations.

1. Introduction

The role of wildlife disease in ecosystem conservation is gaining increasing recognition (May, 1988; Aguirre et al., 1995; Hess, 1994), as is the realization that large scale management of protected areas will require cooperation with local landowners (Schonewald-Cox, 1988; Irby et al., 1997; Naughton-Treves et al., 2003a; Maehr, 2004). Whereas many core wildlife areas are public lands, the lands surrounding and connecting these areas are often privately owned (Ruediger, 2004). The attitudes, concerns and values of landowners who manage this land are increasingly recognized as relevant, especially regarding transboundary issues related to wildlife (Laubhan and Gammonley, 2001; Beedell and Rehman, 1999; Mattson, 2004). Although use of private land by wild species can be beneficial to wildlife and landowners, it

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often results in overlapping ranges between wild and domestic animals, which can facilitate disease transmission among them (Foreyt and Jessup, 1982; Simonetti, 1995). North American examples of this situation are elk (*Cervus elaphus*) and bison (*Bison bison*) infected with brucellosis (*Brucella abortus*) using areas surrounding Grand Teton and Yellowstone National Parks in the U.S. (Thorne and Herriges, 1992), and bison infected with brucellosis and bovine tuberculosis (*Mycobacterium bovis*, bovine TB) in Wood Buffalo National Park in Canada (Tessaro et al., 1990; Joly and Messier, 2004). Bovine tuberculosis was also discovered in Michigan white-tailed deer (*Odocoileus virginianus*) in 1994 (Schmitt et al., 1997) and the disease has been found in 32 cattle (*Bos taurus*) herds in the state (VanderKlok, 2004).

Bovine tuberculosis presents major challenges for the protection of human and animal health, economic sustainability of agriculture, and the conservation of wildlife (Tessaro et al., 1990; Schmitt et al., 1997; Dorn and Mertig, 2005). Wildlife–agriculture interactions associated with bovine TB transmission have therefore become a contentious issue in the region surrounding Riding Mountain National Park (RMNP) in southwestern Manitoba, Canada (Lees, 2004). Over the last 15 years bovine TB has been found in 31 wild elk and seven white-tailed deer in and around RMNP, as well as in 12 cattle herds near the Park. The disease was also identified in two RMNP wolves (*Canis lupus*) in 1979 (Carbyn, 1982). Movement of infected wildlife from Parks to surrounding areas has intensified concerns that diseases such as bovine TB and brucellosis are spreading from wildlife to domestic cattle and has raised questions of whether Parks such as Yellowstone and RMNP are acting as reservoirs of disease (Simonetti, 1995; Lees, 2004).

Although lands surrounding Parks are vital for conservation of wide-ranging mammals, the risk of disease transmission and other costs such as crop damage may discourage landowners from permitting wildlife use of their lands (Simonetti, 1995). Farmer acceptance of wildlife use may vary depending on the species, and farmers may be willing to tolerate some wildlife impacts in exchange for the presence of ungulates such as elk and deer (Irby et al., 1997). However, increasing public attention to disease in ungulate populations in and around Parks also pose important questions for the ecological role of predators such as wolves and the role of predation in disease management. Although several recent studies suggest wolves may have complex ecosystem effects (Dekker et al., 1996; Ripple and Larsen, 2000; Ripple et al., 2001), hostility toward all predators is strong in many rural areas and human-caused mortality rates of wolves leaving Parks to use surrounding areas are often high (Carbyn, 1980; Forbes and Theberge, 1996; Callaghan, 2002). A review of 38 North American and European quantitative studies on attitudes toward wolves across social groups from 1972 to 2000 shows that rural residents and farmers and ranchers had the lowest percent positive attitudes (Williams et al., 2002). Whereas 55% of respondents in a random sample of all residents had positive attitudes toward wolves, only 45% of rural residents and 35% of ranchers and farmers had positive attitudes.

Although the financial costs of living with wolves are relatively easy to calculate, there may also be benefits that are more difficult to express in monetary terms (Estes, 2004). Livestock losses to wolves and the risk of livestock losses are, at times, direct costs to farmers on lands surrounding Parks. However, the risk of disease transmission also directly affects some farmers near protected areas (Simonetti, 1995). These farmers may benefit from wolves as predators on wild ungulate populations. Higher density of a host species can sometimes lead to increased disease prevalence because of increased transmission rates (Scott, 1988), and wolves may therefore play a positive role in managing diseases such as bovine TB by decreasing the size of prey populations. In addition, wolves have been found to reduce average group sizes of social ungulates such as elk, which effectively reduces elk density (Creel and Winnie, 2005).

Because farmer attitudes toward wildlife have important implications for persistence of many species (Irby et al., 1997), understanding how farmers perceive wildlife is important, especially in regions where protected areas are becoming increasingly isolated. Whereas public attitudes toward wolves may be overall positive, people living and interacting with wolves can have very different opinions (Ericsson and Heberlein, 2003), and wolf survival in rural agricultural areas is disproportionately dependent on the actions of people who depend on the productivity of the landscape for their livelihood (Musiani et al., 2004). Riding Mountain National Park is surrounded by agricultural lands and considered an isolated reserve (Noss, 1995; Parks Canada, 2002). The insular configuration of RMNP combined with recent concerns over bovine TB transmission between elk and cattle on private lands surrounding the Park provide a valuable opportunity to:

(1) Assess farmer attitudes toward observing wolves on their land and the factors that influence these attitudes.
(2) Determine whether farmers more concerned over disease in wild ungulates have more positive attitudes toward wolves.
(3) Discuss whether the ecological role of wolves may benefit farmers in their efforts to minimize impacts from infections disease on livestock operations.

This analysis is part of a comprehensive study examining wildlife–agriculture interactions around Riding Mountain National Park (Brook and McLachlan, 2006).

2. Methods

2.1. Study area

Our study area is located in southern Manitoba, Canada, and includes the agriculture-dominated area within 50 km of Riding Mountain National Park. It represents a broad transition zone between the prairies and the more northerly Boreal Plains. The Park comprises 2974 km^2, extending 115 km from east to west and 60 km from north to south, and is dominated by the Manitoba Escarpment, which rises 475 m above the surrounding, largely flat, landscape. The Park represents a core area of relatively undisturbed wilderness surrounded by agriculture, which is dominated by canola (*Brassica napus*), wheat (*Triticum* sp.), and hay production. Approximately 50000 beef cattle are raised in the region (Statistics Canada, unpublished data). The Riding Mountain TB Eradication Area, which was established by the Canadian Food Inspection Agency around

RMNP, requires increased bovine TB surveillance and a permit to move cattle out of the area. Wildlife is abundant in the study area, with a regional elk population of approximately 5000 elk, 2500 moose, and more than 5000 deer (RMNP, 2005 unpublished data). Over the past 3 years, the RMNP wolf population has numbered approximately 70–75 individuals in late winter (RMNP, 2005 unpublished data). Other large predators include lynx (*Lynx canadensis*), black bears (*Ursus americanus*), and coyotes (*Canis latrans*). Climate is continental and typical of the Canadian prairies, with warm summers and cold winters. Mean temperatures for July and January are about 20 °C and −19.5 °C, respectively. Growing season is short (mean = 65 days, range 43–106) and snow cover persists for approximately five months (Keck, 1975). Approximately 546 mm of precipitation falls annually, 160 mm as snow.

Wolves have been present in southwestern Manitoba for at least 5000 years (Goulet, 2000) and occupied the Riding Mountain region until a combination of hunting, trapping, land clearing and poisoning likely caused a local extirpation around 1900 (Carbyn, 1980). By the 1930s, reports from Park wardens and residents confirmed that wolves had returned. After years of no provincial designation under the Manitoba Provincial Wildlife Act and predator designation under the Predator Control Act, wolves were classified as a big game species in a 1980 revision of the Wildlife Act (Stardom, 1983). Since 2001, the wolf-hunting season has been closed in areas that surround RMNP, although landowners within this area may shoot wolves in defense of property (D. Chranowski, personal communication). The area closest to RMNP supporting a wolf population is Duck Mountain Provincial Park and Forest (hereafter referred to as the Duck Mountains), approximately 35 km north of RMNP.

2.2. Data collection

This study focused on rural residents living on farms within 50 km of RMNP. The Joint-Faculty Human Subject Research Ethics Board at the University of Manitoba approved our study design. Using Canada Post mailing lists we identified 4220 rural households within our study area, and mailed all listed farm operations a questionnaire on 18 April 2002, and included a self-addressed, stamped envelope. On 18 May 2002 we sent a reminder. All surveys returned before 31 August 2002 were included in subsequent analyses. To test for response bias, we telephoned a sample of 65 survey recipients who did not respond to the survey. We then asked a subset of questions from the original questionnaire to compare responses of respondents and non-respondents.

We designed the mail-out questionnaire to determine farmer attitudes toward bovine TB in wildlife and livestock and identify the influence of socio-demographic variables on attitudes toward wildlife. While attending seven town hall meetings throughout the study area between January and April 2002, we documented comments from over 500 local agricultural producers, which we used to design the survey. We also gained insights from discussions with staff from federal and provincial agencies, as well as other special-interest groups. We pre-tested the questionnaire on 15 highly knowledgeable farmers, as well as researchers and government staff. The final version was nine pages, contained 257 data variables, and took about 30–40 min to complete. Respondents rated statements on a seven-point likert scale ranging from "strongly disagree" to "strongly agree". Respondents were asked to report the location of their farms, provide written comments on all aspects of the survey, and list any other concerns that they had. Comments were recorded verbatim, and systematically assessed and identified with underlying themes. They were then incorporated with the quantitative results as complementary information. Overall mail survey results for the variables age, education, and farm size were compared with data from the 2001 Agriculture Census of Canada to assess the representative nature of the questionnaire data from this study (Statistics Canada 2002).

2.3. Data analyses

We measured minimum distance of each farm to the RMNP boundary using Arcview GIS 3.2 (ESRI). We identified a set of 13 independent variables believed to influence whether farmers agreed with the statement "I enjoy seeing wolves on my land" based on literature review of attitudes to wolves and conversations with local residents (Table 1). Because only

Table 1 – Variables used to analyze farmer attitudes to wolves

Abbreviation	Variable description
Population	Perception of current wolf population (too low, about right, too high)
Damage	Seriousness wolf damage (1997–2001) (never, seldom, some years, all years)
Wolfsee	Wolf observations on farm (never, rarely, … regularly on all years)
Distance	Minimum distance from farm to RMNP or Duck Mountain Provincial Forest (km)
Beefcattle	Size of cattle herd >1 year old (0, 1–20, 21–40, 41–60, 61–80… >160)
Beefcalves	Size of cattle herd <1 year old (0, 1–20, 21–40, 41–60, 61–80… >160)
huntdays[a]	Total number of hunting days for elk and deer on farm
TBconcernelk	Level of concern regarding TB in elk (of no concern…neutral…of great concern)
Horses	Number of horses on farm (0, 1–20, 21–40, 41–60, 61–80… >160)
Farmsize	Size of farm (hectares)
Income	% of total income derived from farming
Education	Education of respondent (grade school high school college/university)
Age	Age of respondent (years)

a Hunting for wolves around RMNP is illegal, but wolves can be shot in defense of property.

9% of respondents were female and because many surveys were likely filled out by both women and men, we chose not to include sex as a variable in the analyses. We used Spearman rank correlation to assess correlation among variables and identified any group of variables with $r > 0.7$.

We designated the lowest and highest 33% of responses, thus the most positive and most negative choices on the likert scale, as a binary response variable in logistic regression to model the probability that farmers enjoy seeing wolves on their land. Because this analysis does not permit missing data for any variable, 191 responses were usable. We ran all possible combinations of logistic regression models with the 13 independent variables hypothesized to influence farmer attitudes toward wolves. Akaike's Information Criterion with small sample adjustment (AICc) and Akaike weights (w) were calculated to assess model fit (Chamberlin, 1965; Akaike, 1973; Burnham and Anderson, 2002). 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 farmer attitude toward seeing wolves on their land, allowing the variables to be ranked from most important to least important (Flanders-Wanner et al., 2004). Based on the cumulative AICc scores, we created 16 candidate models using combinations of the most important variables that we hypothesized to influence farmer attitude toward wolves.

3. Results

3.1. Socio-demographic composition

Average respondent age was 52 years (range 18–85). This is consistent with the 2001 Agriculture Census of Canada for this region (Region 3, Division 15), which determined average age of operators to be 50 (Statistics Canada 2002). Most respondents (92%) had lived at the current location for five or more years and most (81%) were raised on a farm. The average farm size was 467 ha (range 16–5.666 ha), which compares favorably with the overall average farm size of 419 ha for this region (Statistics Canada, 2002). Seventy-one percent (71%) of respondents reported the location of their farm. Sixty-five percent (65%) of respondents owned livestock, and more than half (55%) of survey respondents had at least some cattle, with 45% owning more than 20 cattle. Education level varied; <1% had no formal education whereas 20% had completed grade school, 35% had high school education and 40% had college, university, or technical training. The 2001 agriculture census for all of Manitoba indicated 31.5% of male and 43% of female farm operators have college, university, or technical training and 53.1% of male and 49.8% of females had high school, which is generally consistent with our results.

We received 786 completed useable surveys by mail as well as 62 refusals and 584 surveys that indicated the recipient did not operate a farm. In addition, we received 94 telephone calls. Using the response data, telephone calls received, and telephone calls made to follow-up with non-responders, the overall adjusted response rate was 25%. Although this figure is low, it corresponds with recent findings of declining response rates in natural resource based-surveys (Connelly et al., 2003), which suggests that response rates of less than 30% are no longer uncommon. Because rural addresses are unavailable for purchase in Manitoba we used non-addressed mail, which may have given the survey low priority with some recipients. We did not identify any significant differences between respondents and non-respondents.

3.2. Attitudes toward wolves

Although 51% of farmers felt they had never experienced serious damage from wolves, 44% of all farmers did not enjoy seeing wolves on their land (Tables 2 and 3). More than half of livestock owners (52%) disagreed with the statement 'I enjoy seeing wolves on my land', whereas only 26% agreed with the statement. For the 26% of farmers that reported not owning any livestock, the results were opposite, with 26% disagreeing with the statement and 54% enjoying seeing

Table 2 – Percentage distribution of responses regarding livestock ownership versus the statement "I enjoy seeing wolves on my land" (N = 786)

"I enjoy seeing wolves"	Own livestock			
	No	Yes	No response	Total
Disagree	7	34	3	44
Neutral	4	10	2	16
Agree	14	17	3	34
I don't know	1	2	0	3
No response	0	2	1	3
Total	26	65	9	

Table 3 – Percentage distribution of perceived financial damage by wolves versus perceived wolf population size (N = 786)

Perceived wolf population size	Perceived financial damage by wolves						
	Never serious	Seldom serious	Most years	All years	I don't know	No response	Total
Too high	8	3	2	1	1	5	26
About right	15	3	0	0	1	4	24
Too low	7	0	0	0	0	3	10
I don't know	17	1	0	0	3	6	28
No response	4	1	0	0	0	6	11
Total	51	8	2	1	5	24	

wolves on their land. Twenty-six percent of respondents felt that the regional wolf population size was 'too high' (Table 3). Twenty-four percent felt the wolf population was 'about right', whereas 10% found the population 'too low'. Respondents expressed a diversity of views on management of wildlife populations in and around RMNP. Some respondents had positive attitudes to wolves, and indicated that they had a right to be present:

"*Elk, deer, moose, wolves were here first and are part of this country and we should manage around them" [Respondent #455].*

Others expressed less positive attitudes to wolves:

"*The wolves should be dealt with in the park. They are too many and are chasing the elk out of the park" [Respondent #457].*

Some also had less positive attitudes to other species of wildlife:

"We have too many deer, wolves, beavers in this area" [Respondent # 336].

Although most respondents around RMNP did not feel they had experienced serious damage from wolves, livestock predation is a concern for many farmers. Some comments reflected the concern that farmers will not be granted compensation if there is no physical evidence of livestock predation, and that livestock losses may thus be underreported:

"*Wolves and bears and coyotes cause very heavy damage to my cattle and I am unable to collect compensation due to lack of proof you can not find dead calves taken by bears" [Respondent #404].*

Of respondents that lived within 10 km of RMNP, 7% reported seeing wolves 'regularly, most years', or 'regularly, all years'. For those that lived 11–20 km and 21–30 km away from the park border, the numbers were 4% and 3%. Altogether 49% of respondents described their concern over bovine TB in wild elk as 'extremely high'. Twenty-six percent of respondents felt the regional wolf population was 'too high'. Within this group, 60% were extremely concerned about bovine TB in wild elk, whereas 13% had low or moderate concern about the disease. Some responses from the survey also addressed the role of wolves in regulating the RMNP elk population:

"*Talk to rural people about the Park. The only people that know the Park are the people who live near it. People in Ottawa [Canada's capital] should not be listened to. If you kill the elk off the wolves will starve, etc. Let nature take its course in the park" [Respondent #484].*

Importantly, the potential role of wolves in disease management was also noted:

Table 4 – Cumulative AICc[a] weight of variables

Variable[b]	Cumulative AICc weight[c]
Population	1.00
Damage	0.98
Wolfsee	0.97
Distance	0.78
Beefcattle	0.76
Beefcalves	0.43
Huntdays	0.41
TB concernelk	0.31
Horses	0.29
Farmsize	0.28
Income	0.27
Education	0.26
Age	0.25

a AICc = Akaikes's Information Criterion with small-sample bias adjustment (Burnham and Anderson, 2002).
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 5 – Selected set of candidate models for farmer attitudes to wolves

Model structure	-2Log (L)	k	ΔAIC_c	$AIC_{c\ w}$
Population + damage + wolfsee + beefcattle	161.95	5	0.0	0.648
Population + damage + wolfsee + distance + beefcattle	161.95	6	2.0	0.238
Population + damage + wolfsee + distance + beefcattle + damage * wolfsee + distance * wolfsee	159.48	8	3.5	0.111
Population + damage +wolfsee + distance	173.61	5	11.7	0.002
Population + damage + wolfsee	177.85	4	13.9	0.001
Population + damage + population*damage	181.86	4	17.9	<0.001
Population * wolfsee + population * distance + wolfsee * distance + population * damage + population * beefcattle	185.84	6	25.9	<0.001
Population	195.90	2	27.9	<0.001
wolfsee + damage + beefcattle + damage* beefcattle	207.59	5	45.6	<0.001
Damage + wolfsee + beefcattle^2	209.80	4	45.8	<0.001
Damage	224.22	2	56.3	<0.001
Damage + wolfsee	222.38	3	56.4	<0.001
Beefcattle	242.64	2	74.7	<0.001
Distance	261.35	2	93.4	<0.001
Wolfsee	261.46	2	93.5	<0.001
Population * damage + wolfsee	259.81	4	95.9	<0.001

"Monitor the Park but don't interfere. If you kill wolves the elk will increase and then disease strikes" [Respondent #484].

The factors most important for farmer response to seeing wolves on their land were, in order of importance, perceived wolf population size, frequency of seeing wolves, perceived seriousness of wolf damage, distance to RMNP or the Duck Mountains, and number of beef cattle owned (Table 4). The factors least influential factors were education and age. Concern over bovine TB in wild elk, number of beef calves owned and number of hunter days also had minimal influence. Because all models within 2 units of the minimum delta AICc value should be considered when making inferences (Burnham and Anderson, 2002), three candidate models received reasonable support (Table 5). No models based on any single factor were supported. Positive attitudes toward wolves were associated with less frequent sightings of wolves:

"We have heard of wolf sightings more this winter so they could become a problem" [Respondent # 308].

as well as with less perceived damage from wolves and perceived lower wolf population size:

"I have no problem with wildlife provided their numbers are kept in low numbers" [Respondent # 401].

More positive attitudes were also associated with increasing distance from RMNP or the Duck Mountains, and with owning fewer beef cattle. Positive and negative attitudes were often found on neighboring farms and did not show any clear geographical pattern (Fig. 1).

4. Discussion

4.1. *Wolf predation and wildlife disease*

Many respondents were extremely concerned over bovine TB in wild elk and, at the same time, felt the wolf population was too high. This suggests that the role of wolf predation as a potential natural regulator of elk in the RMNP ecosystem may not be widely recognized or valued by farmers in the area. Wolves likely affect ungulate population dynamics, and wolf predation appears to reduce interactions of density and environmental factors (such as disease and food competition) on population dynamics of species such as elk (Seip, 1995; Hebblewhite et al., 2002). However, long-term monitoring is needed to better understand the relative influence and interactions between various factors such as climate and predation (White and Garrott, 2005). Elk is the most important prey species for wolves in RMNP (Carbyn, 1980; Meleshko, 1986; Paquet, 1989, 1992) and in both summer and winter wolves showed a preference for elk over other prey species (Carbyn, 1980; Meleshko, 1986; T. Sallows, unpublished data). Although the relationship between wolves and bovine TB in wild ungulates is not clear, pathogens such as bovine TB and brucellosis may increase wolf killing success to some degree through debilitation of prey (Joly, 2001). Lower wolf predation rates may thus increase elk density in RMNP and possibly prevalence of bovine TB, as the disease generally

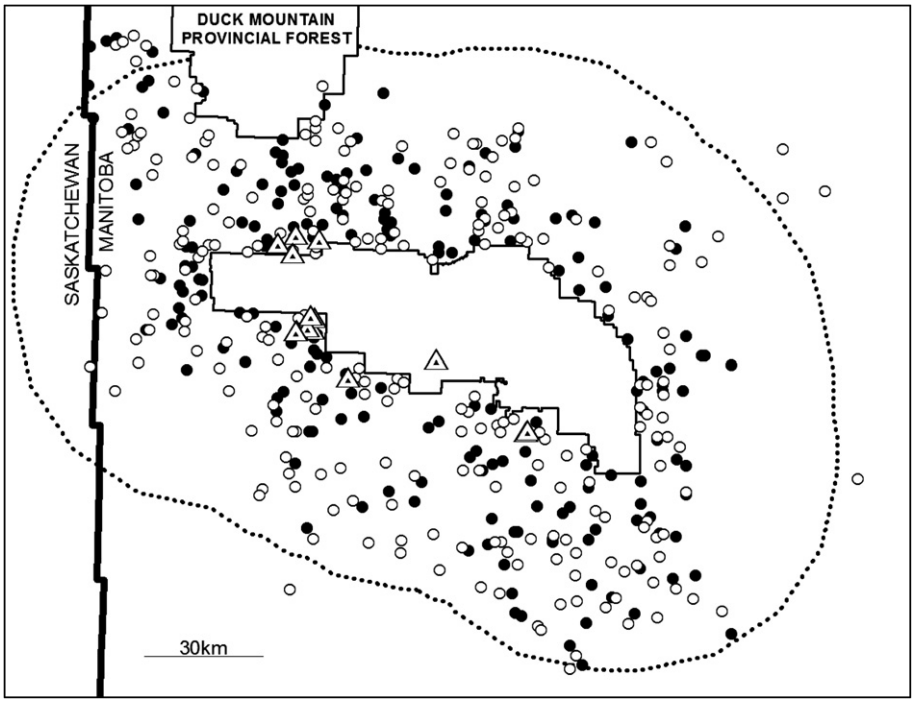

Fig. 1 – Farmer response to the statement "I enjoy seeing wolves on my land" in the Riding Mountain National Park region, Manitoba, Canada – 2004. Black circles indicate farmers who agreed with the statement, white circles farmers who disagreed. Triangles indicate documented cases of bovine tuberculosis in cattle or wild ungulates. A 50 km buffer around Riding Mountain National Park is represented by a dashed line.

transmits from animal to animal by inhalation and ingestion (Clifton-Hadley et al., 2001). Disease and predation may also interact in affecting ungulate abundance (Joly and Messier, 2004), and recent research in Yellowstone also suggests that wolf presence and predation risk may affect ungulate distribution (Ripple and Beschta, 2004). Thus, the effects of wolves may extend beyond direct mortality of ungulates, and affect both crop damage and transmission of diseases such as bovine TB. As hunting is not permitted within the National Park, wolf predation, along with winter severity and hunting outside the Park, will likely continue to be important regulators of elk population size both inside RMNP and, indirectly, on the surrounding farmland.

With recent attention on potential disease transmission between wildlife and domestic animals, it is increasingly important to understand how farmers view movements of wild ungulates and their predators on private land surrounding protected areas. Indeed, the frequency of seeing elk on farms was the primary cause of concern regarding bovine TB (Brook and McLachlan, 2006). Our results suggest that farmer attitudes to seeing wolves on their land around RMNP improve when they perceive wolf populations to be low, rarely see wolves, and when they feel wolves do little damage. Farmers with few or no beef cattle were also more accepting of wolves on their land. While Ponech (1997) found that most respondents, including farmers, favored having wolves in RMNP, Daley et al. (2004) concluded that landowner attitude to wildlife is closely related to reliance on the land for direct economic income. Farmers, especially those that own livestock, may be more positive toward wolves occupying the Park, or wolves in general, than wolves observed on their own land. Should this be the case, this attitude may compromise the long-term viability of the RMNP wolf population. Although attitudes toward wolves may be generally positive as long as animals remain inside the Park boundary, wolves will need to disperse between RMNP and surrounding areas to maintain genetic variation in the Park population. Although dispersal carries the risk of individuals acting as disease vectors between populations (Robertson et al., 2006), increased isolation and inbreeding can also increase an animal's susceptibility to disease and parasites (Acevedo-Whitehouse et al., 2003), which could further reduce viability of the RMNP wolf population.

The relationship between wolf predation and wildlife disease could also be affected by other ecological links. Many farmers in the region feel that the beaver population in and around the Park is too high, and that beaver flooding have forced elk out onto agricultural lands (Schroeder, 1981; Menzies, 1998; Brook and McLachlan, 2006). Wolves are important predators on beavers in RMNP, and beaver remains were found in 33% of summer wolf scat (Meleshko, 1986; T. Sallows, unpublished data). Although elk may leave the Park to find forage, farmland may also provide them with a refuge from predators such as wolves, which are generally discouraged or controlled in agricultural areas (Thompson and Henderson, 1998). In the Canadian Rocky Mountain National Parks, zones with high human activity often exclude or limit wolf presence (Callaghan, 2002) and elk tend to congregate in higher density in these areas (White et al., 1998). Our conversations with local landowners indicate that elk are also coming out to the farmland surrounding RMNP to calve. If attitudes to wolves and other predators were more positive in the landscape surrounding RMNP, this could reduce the refuge status these lands may currently provide and possibly reduce the number of elk using the farmland around the Park.

Whereas human–wolf conflicts associated with livestock predation continue to pose significant problems for global conservation of wolves (Fritts et al., 2003; Woodroffe et al., 2005), perceived wolf damage alone did not provide a good predictor for attitudes to wolves in the RMNP region. The overall risk of livestock predation in the RMNP area is low, and Manitoba farmers have received compensation for livestock killed or injured by wolves and other carnivores since 1997 (Wilcox, 2004). Ponech (1997) also reported that most respondents in all groups disagreed with the statement "Wolves have a significant impact on the livestock industry around RMNP". Although the relationship between actual and perceived levels of damage may be unclear, perceptions are important for farmer attitudes to wildlife (Conover, 1998). We asked farmers to what degree they felt wolves had caused financial damage on their land, so answers likely reflect both confirmed and suspected losses. While financial damage alone was not a good predictor, the threat of predation also creates stress for livestock producers (Fritts et al., 2003), and there are hidden costs involved in livestock predation that are difficult to calculate, including loss of valuable breeding animals and the emotional costs of finding dead and wounded livestock (Wålberg, 1987; Hafer and Hygnstrom, 1991). Increasing distance from RMNP or the Duck Mountains was also associated with a more positive attitude to wolves. Although farmers close to RMNP reported more wolf observations and damage, we received a number of observations >30 km outside RMNP or the Duck Mountains. We believe that some observations may actually have been of coyotes and not wolves. However, it is important to realize that the essential factor is not whether the farmer actually saw and/or experienced financial damage from a wolf, but whether the person *believe* they did.

4.2. *Social and cultural factors*

Williams et al. (2002) report that, overall, those with higher education have more positive attitudes toward wolves while age is negatively correlated with attitudes. In contrast, we found education and age to have no influence on farmer attitudes toward wolves. Beliefs and perceptions are the factors primarily affecting tolerance of wolves (Boitani, 2003; Fritts et al., 2003), and occupation and social identity might be more powerful predictors of tolerance than personal experience (Kellert et al., 1996; Naughton-Treves et al., 2003b; Chavez et al., 2005). Our respondents all operate farms and live in rural areas, and a high percentage of our respondents are multigenerational farmers. If perceptions of family and community are key factors shaping attitudes to wolves, age and education may be relatively unimportant variables in our survey.

Whereas Ponech (1997) reports that most respondents were not afraid to hike in RMNP knowing that wolves are in the Park, Tucker and Pletscher (1989) and Lohr et al. (1996) report that positive attitudes to wolves was associated with less fear for human safety. The following excerpt from a local

newspaper (The Dauphin Herald, 8 October 2002), shows that the fear of wolves is still present in the RMNP region and that it is sometimes still perpetuated by the media:

> *"And now, something not quite so exciting – Timber Wolves. I would caution local nature lovers to be very careful on their long walks. There has been a pack of seven timber wolves spotted in the area and even a bear is suspected of killing a calf. Some domestic animals are missing – and presumed buffet for these beasts."*

This news item also links missing livestock to predation by wolves and bears, and it helps to reinforce many people's perceptions that humans cannot be safe in the presence of wolves, and that wolves and bears are frequent livestock predators in the RMNP region.

Recent research on innovative preventative techniques to minimize and in some cases eliminate livestock predation (Breck, 2004; Musiani et al., 2004; Treves et al., 2004) could reduce costs and limit controversy over predators such as wolves. The species should be conserved and managed as part of a working ecosystem (Mech and Boitani, 2003). However, debates that, on the surface, are about wolves often reflect conflicting human values (Nie, 2004), and urban residents may not sympathize with or understand challenges faced by farmers and other rural residents (Ericsson and Heberlein, 2003; Fritts et al., 2003; Mech and Boitani, 2003; Skogen, 2003). Norton (2000) concludes that "private land is important not only because of its indigenous biodiversity, but also because . . . it is here that most people encounter nature". The sense of personal attachment to the land has long been recognized as instrumental to the support for conservation (e.g. Leopold, 1949), and the importance of this connection is still emphasized (e.g. Van Tighem, 2000). Because wolves have high ability to disperse and exist in a variety of habitats, human tolerance of wolves in the broader landscape may be the most important factor in ensuring their long-term viability (Boyd and Pletscher, 1999; Fritts and Carbyn, 1995).

4.3. *Recommendations*

We believe the potential role of wolves in reducing ungulate populations, and thus possibly mitigate spread of bovine TB to livestock, provide a unique opportunity to re-examine the significance of maintaining viable wolf populations. While the relationship between wolves and ungulate disease is not clear, we recommend further research into the ecological role of wolves and other predators in managing infections disease in prey populations. Increasing exchange of information between rural residents, researchers and various levels of government will be important. The increasing number of forums involving special interest groups established to discuss wildlife and disease concern in the RMNP area is encouraging, as are periodic open-house sessions on this topic.

Many residents have expressed interest in learning more about research in our study area, and several noted that results are not widely publish locally and may be difficult to obtain. Publication and dissemination of research is often focused exclusively on professional and scientific journals with the consequence that local residents may feel left out. We believe increased exchange with local residents about research objectives and findings would offer many benefits. While this does entail extra work for researchers, it could provide a non-confrontational means to address many of the common misconceptions about wolves, especially related to livestock predation and human safety. This approach also provides a means for residents to communicate with and therefore educate researchers about local knowledge and concerns. This is something we have benefited from and have been able to incorporate into our research on elk, wolves and human-wildlife relationships in the Riding Mountain region.

The view of wolves as an integral component of a working ecosystem, as opposed to a species to like or dislike, is important in improving tolerance of the species outside protected areas. Because perceived wolf damage alone was a poor predictor of attitudes in our study, we recommend further research on how farmers calculate potential costs and benefits of having wolves on their land, and on how values and perceptions about wolves interact with personal experience in determining attitudes. This could help identify farmer concerns and facilitate long-term management of ungulate populations and disease around protected areas. While livestock predation by wolves can have significant impact, it is important to consider the role of wolves and other predators in the evolution of ungulates, and thus the help wolves may provide in managing diseases such as bovine TB. Future research might help clarify the role of wolves, and could afford an opportunity to mitigate impacts of bovine TB and other infections diseases on livestock operations while simultaneously promoting conservation of a wide-ranging carnivore.

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