Assessment of corridors for movement of Gray wolf (*Canis lupus*) across rural land between two protected parks in south western Manitoba, Canada

By

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ABSTRACT

Riding Mountain National Park (RMNP) occupies 2,974 km^2 of mixed wood boreal forest in south western Manitoba that is almost completely surrounded by agriculture. There is concern that wide-ranging, large carnivore populations in the park are genetically isolated and consequently nonviable over the long term. This study was carried out to identify areas with potential to support wolf dispersal from RMNP to the nearby Duck Mountain Provincial Park and Forest Reserve (DMPP&F) across the human disturbed land outside the park boundaries. Wolf telemetry data from RMNP provided information about preferred habitats within a protected and relatively undisturbed area. Presence of wolves between the parks was gathered from personal interviews with local landowners as well as wolf tracks. It was found that wolves avoid human disturbed areas within RMNP and select undisturbed areas outside the park boundaries. Furthermore, negative attitudes towards wolves held by local residents and its associated mortality threat comprise the major barrier to wolf-movement between the parks. A regionally connected wolf population depends on protection of remaining undeveloped land between the parks and acceptance by resident humans. Long term viability of the regional wolf population further relies on protection of wolves in the whole area and joint management amongst stakeholders at all levels.

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"A thing is right if it tends to preserve the stability, integrity, and beauty of the biotic community. It is wrong if it tends otherwise"

***Aldo Leopold*, 1887 - 1948**

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CHAPTER 1:

INTRODUCTION

1.1 BACKGROUND

Protecting large carnivores.--Fragmentation of natural landscapes inhibits wildlife movement and isolates populations, which threatens survival of small populations due to loss of genetic variability (Pimm et al. 1988, Fritts & Carbyn 1995, Rosenberg 1997, Farina 2000, Duke et al. 2001). Wide ranging animals, such as large carnivores, are particularly susceptible to fragmentation effects (Paquet et al. 1996, Carroll et al. 2001, Noss 2001). Because large carnivores also are highly sensitive to human disturbance, they strongly depend on protected areas for their long-term survival (Noss 1992, Fritts & Carbyn 1995, Carroll et al. 2001). Existing protected parks are however rarely large enough to sustain viable wolf population (Fahrig & Merriam 1994, Height et al. 1998). Assuming that predators limit herbivores and therefore limits overgrazing through top-down, it is critical to maintain viable populations of large carnivores as regulators of healthy ecosystems (Terborgh et al. 2001).

Movement corridors.--Genetic exchange between isolated populations may be promoted by corridors that connect habitats through dispersal. Because populations are unviable in isolation (Maehr 1990, Beir & Noss 1998, Duke et al. 2001, Paquet et al. 2001), it is crucial to identify suitable corridors that enhance individual exchange across fragmented landscapes (Morrison et al. 1998). Animals are known to select travel along pathways that comprise similar land cover as within their natural habitat (Harrison 1992, Rosenberg et al. 1997), although there is little information about species-specific corridor barriers (Morrison et al. 1998).

Connecting wolf populations.--The physical presence of vegetated corridors enhances dispersal amongst sub-wolf populations because they provide protection from human disturbance (Maehr 1990, Beir & Noss 1998, Duke et al. 2001, Paquet et al. 2001). Given extensive fragmentation of natural landscapes outside protected areas, it is however important to identify conditions that sustain dispersal in the lack of structurally connective corridors. Functional connectivity enhances the regional conservation value of core-areas that support protected but isolated wolf-populations (Carroll et al. 2003).

1.2 ISSUE STATEMENT

1.2.1 **Setting the context**

Wolves in RMNP.--Riding Mountain National Park (RMNP) in south western Manitoba is almost completely surrounded by land that has been modified and fragmented by human activities. The park sustains a limited population of wolves. In isolation, the sheer park size of almost 3000 km^2 is barely large enough to function as a viable ecosystem for large carnivores (Carbyn 1980). The size of the park would however be physically large enough to protect a core wolf population, assuming there is interchange with wolves from nearby areas (Ballard et al. 1983, Fritts 1983, Shaffer 1987, Gese & Mech 1991, Ream et al. 1991, Fritts & Carbyn 1995).

Isolation.--The analogy of RMNP as an island of wilderness in a sea of agriculture describes the isolated status of the park (Noss 1995). Natural vegetation is almost perfectly enclosed within the park boundary, which acts as a dividing border from adjacent human disturbed land (Noss 1995) (Figure 1.2.1-1). Transition between forest and agricultural land is exceptionally sudden in the area, given the lack of surrounding buffer zones (Carbyn 1989, Fritts & Carbyn 1995).

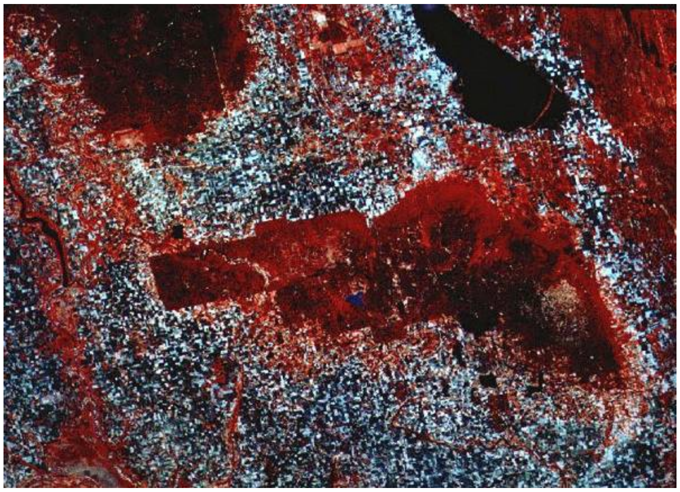


Figure 1.2.1-1: Vegetation within and surrounding RMNP, based on infrared Landsat 5 MSS sensor image of bands 1,2 and 4 (The Canada Centre for Remote Sensing Parks Canada, May 1986).

Corridors.--There are no longer continuous strips of natural vegetation that structurally connect the RMNP with the nearby Duck Mountain Provincial Park and Forest Reserve (DMPP&F) (Walker 2002) (Figure 1.2.1-2). It is however believed that wildlife travel between the parks along the Valley River (Rose Ridge corridor, Grandview) and the Pleasant Valley Creek (Squance Lake-Bluewing swamp-corridors, Boulton/Hillsberg). These presumed functional corridors mostly comprise waterways and land exempted from commercial development due to soil-type, rocks and slope (Newman 2001).

Wildlife movement.--It is uncertain how the isolated status of RMNP effect wildlife-populations in the park (Carbyn 1980). Movement of ungulates has been frequently reported between the parks (Carbyn 1980). However, regional genetic exchange of wolves between RMNP and the DMPP&F is regarded unlikely or rare at normal population densities (Carbyn 1980).

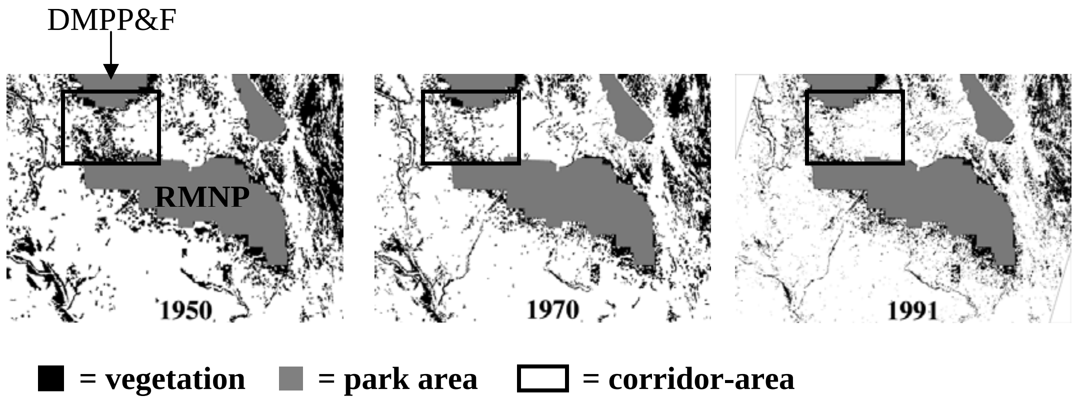


Figure 1.2.1-2: Loss of vegetation between RMNP and DMPP&F over past decades, based on satellite data (Walker 2002).

1.2.2 **Study justification**

The RMNP border presents a major mortality threat for wolves that attempt to leave the park, due to conflicting human interests on surrounding land (Noss 2001). Because the island effect of RMNP assumingly confines movement to within the boundaries, there is concern that the wolf population of the park is genetically isolated (Carbyn et al. 1975, Wilson 2000). Large carnivores serve a critical role in top-down control of ecosystems (Peterson 1984, Mladenoff et al. 1995) and have the potential to serve as natural regulators of regional Bovine tuberculosis by their ecological role as predators (Stronen et al 2007). It is therefore crucial to endorse conditions that sustain wolves in functional ecosystems (Peterson 1984, Mladenoff et al. 1995).

Immigration is a requirement for any small or isolated wolf populations to overcome loss of genetic variability (Theberge 1983, Fritts & Carbyn 1995, Haight et al. 1998). Long-term survival of wolves in RMNP is therefore dependent on exchange with individuals of nearby wolf populations (Carbyn 1980). Although the DMPP&F reserve is only approximately 30 km from RMNP, the two parks are separated by vast human developed land. Because structurally connective corridors no longer exist between the parks, there is a need to identify conditions that sustain functional connectivity among the regional wolf population. This includes identification of specific barriers to wolf movement between the parks

1.3 PURPOSE & OBJECTIVES

Purpose.--The overall aim of the study was to promote long-term viability of the regional wolf population in western Manitoba by assessing dispersal of wolves to and from RMNP and DMPP&F .

Objectives.--Major study objectives were to:

- Identify habitats selected by wolves within the protected RMNP
- Identify land cover composition between RMNP and DMPP&F
- Identify land cover types between the parks with greatest potential to sustain wolf movement
- Identify barriers to wolf movement in the area
- Assess the prospect that wolves travel between RMNP and DMPP&F
- Map land identified as high quality dispersal areas and provide recommendations for corridor management between the parks

1.4 SCOPE OF STUDY

1.4.1 Riding Mountain National Park

Location.--RMNP (50º11’-51º26’ N, 99 º06’-101º38’ W) in southwestern Manitoba is 2,974 km^2 in size (Walker 2002). At it’s broadest point, the park measures 115 km in the east-west direction and 60 km from north to the south (Walker 2002).

Topography.--The RMNP surface mainly comprises rolling upland of the Saskatchewan Plain, although The Manitoba Escarpment is most prominent as it rises 396 m above the Plain and the Manitoba Lowland (Bailey 1968, Lang 1974). The highest point in the park elevates nearly 762 m above sea level. Short streams, including the Vermillion and Wilson rivers, run through the escarpment. Clear Lake is the largest lake in the park at 24.6 km^2 with a max-depth of 33.5 m (Lang 1974).

Geology.--The bedrock in RMNP is from the late Mesozoic (Cretaceous) age (Lang 1974). Both RMNP and the DMPP&F consist primarily of end moraine deposits and secondary of ground moraine and glacial-fluvial deposits, with low boulder till lime-content (Ehrlish et al. 1959).

Soil.--Surface deposits in RMNP mainly comprise glacial tills. Most of the soils in the park belong to the grey wooded soils group that contains clay horizons of fine textured material with varied lime content (Bailey 1968).

Climate.--RMNP lies within a dry, continental climatic zone that is characterized by cold winters and moderate snow depth (Carbyn 1983). The average annual precipitation in the area is 46 cm of which eighty percent falls as rain from April to October and the rest as snow. The mean annual temperature is 2.2°C (Bailey 1968). The park experiences a greater annual temperature range than areas at similar altitude (Parks Canada 1977), with mean temperature of minus 19.7°C in January and 16.5°C in June. There are further variations in temperatures within the park due to elevation differences (Parks Canada 1977). The hilly uplands of RMNP receive slightly more rainfall and cooler temperatures than surrounding areas (Ehrlish et al. 1959).

Vegetation.--The area may be described as a forest-agriculture transition zone. RMNP is dominated by mixed wood boreal forest, dominated by mixed wood boreal forest (Bailey 1968) that comprises representative species of mixed coniferous and deciduous forest with interspersed grassland (Carbyn 1983).

Protection of RMNP.--RMNP and surrounding land was cleared and utilized for lumber, agriculture and wildlife harvest, following local settlement in the late 19th and early 20th centuries (Bailey 1968, Carbyn 1980). The area was withdrawn from settlement in 1895 and designated a forest reserve in 1906 following evident need for resource protection. The area was formally opened as a National Park in 1930 (Carbyn 1980), although cattle grazing was allowed within the park until 1970 (Parks Canada 1977).

1.4.2 Duck Mountain Provincial Park and Forest Reserve

The DMPP&F is situated on the Manitoba escarpment, thirty miles (48.3 km) north of RMNP. The area encompasses 3,764 km^2 (51°15’-52° 00’ N, 100°35’-102°35’E (Ehrlish et al.1959) and is dominated by mixed wood boreal forest (Bailey 1968). The forest reserve was established in 1906 in response to concern for settler development in the area. However, a large part of the reserve still remained as licensed timber land. The central one third of the reserve was in 1962 designated as a Provincial Park that at the same time remained as a Forest Reserve with relaxed management regulations. As a multiple use park, resource extraction activities have been allowed to continue within the park boundaries (Goldrup 1992).

1.4.3 **Intermountain area**

Location.--The focus of the study was in western Manitoba, Canada in the area located between the northern RMNP border and the southern border of the DMPP&F (Figure 1.4.3-1).

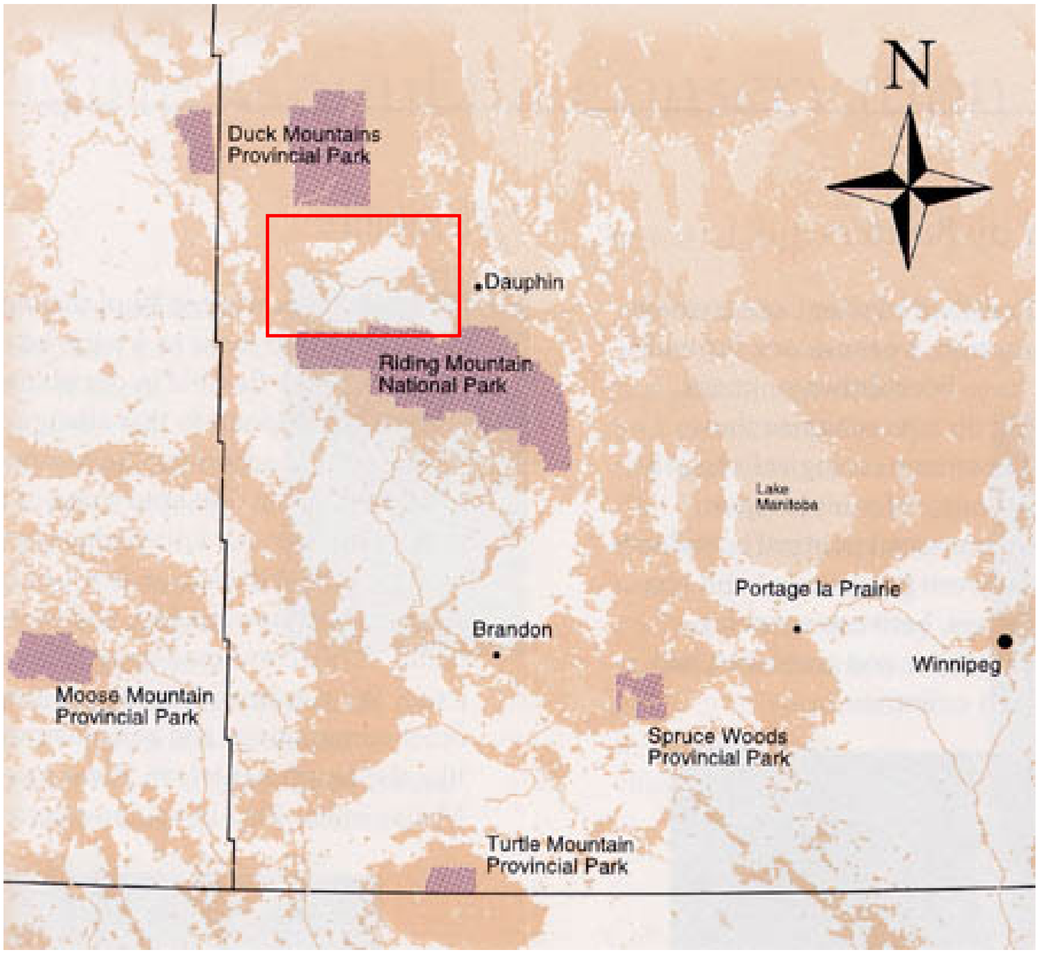
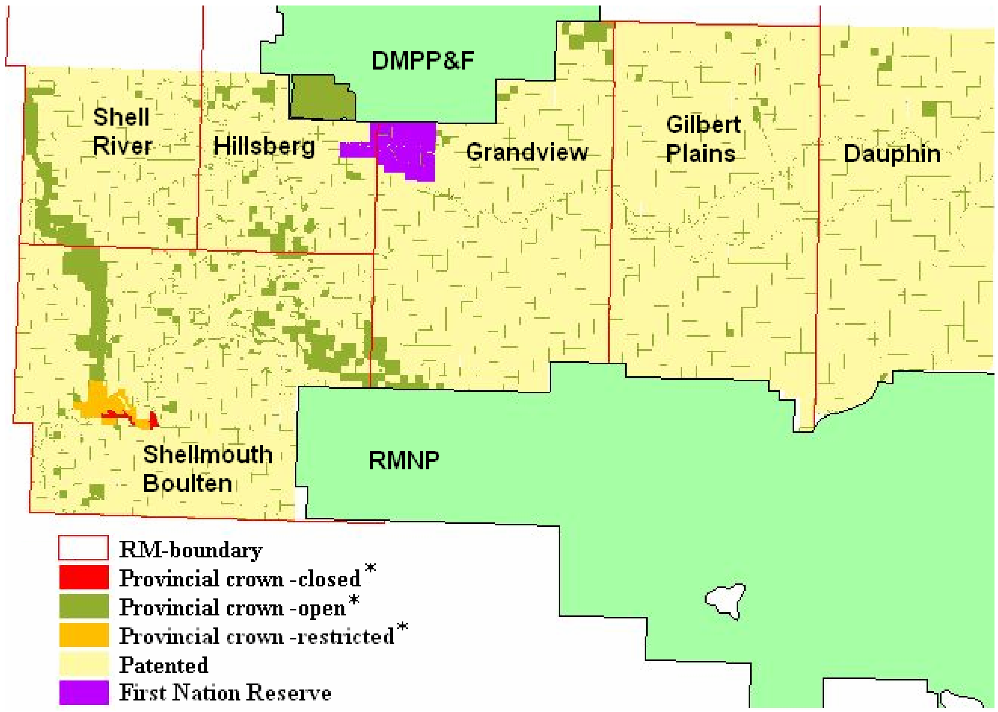


Figure 1.4.3-1: Highlighted study area between RMNP and DMPP&F on regional map of parks in south western Manitoba (CPAWS, year unknown).

The study area covers 4,334 km^2 that comprises the rural municipalities of Shell-River, Hillsberg, Shellmouth-Boultin, Grandview, Gilbert Plains and Dauphin (Figure 1.4.3-2). A First Nation Reserve (Tootinaowaziibeeng Treaty Reserve) is located south of the DMPP&F border. There are also community pastures south east and south west of the DMPP&F.



Open refers to areas where timber harvesting is allowed, *closed* means no harvesting, and *restricted* refer to areas where harvesting may be allowed under certain conditions and guidelines (R.E. Frank, Manitoba Land Initiative, personal communication 2006).

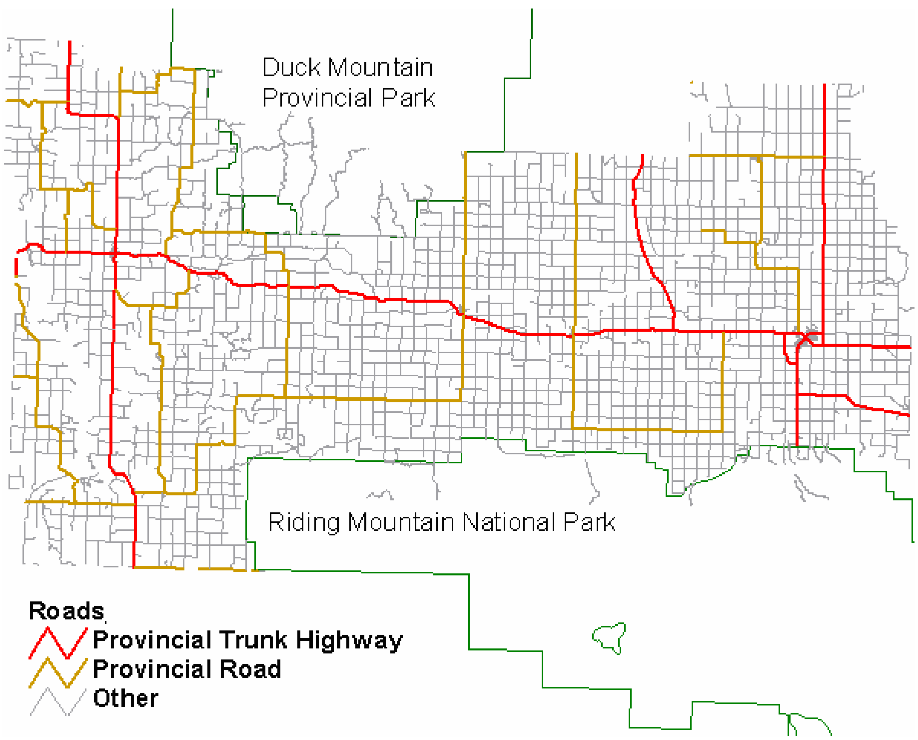
Figure 1.4.3-2: FRI-based ownership of land (MLI 1991-92) in Rural Municipalities (RM) between RMNP and DMPP&F, Manitoba (PFRA 2001) (1:50,000).

Most of the area is open for timber harvest, including a majority of the land being patented to private land owners (Table 1.4.3-1). Landowners are free to clear forested land for crops or pasture as they wish on their patented private land slots (R.E. Frank, Manitoba Land Initiative, personal communication 2006).

Table 1.4.3-1: Proportional (%) ownership of land (m^2) in area between RMNP and the DMPP&F, Manitoba (MLI 1991-92).

Land-type	Area (km^2)	Percent
Patented	3836	88.50%
Provincial crown-open	428.25	9.90%
First Nation Reserve	47.04	1.10%
Provincial crown-restricted	19.51	0.50%
Provincial crown-closed	3.48	0.10%
Total	4334.28	100%

The majority of the land is segregated into square mile blocks by an extensive network of gravel roads (meaning of road-classes) (Figure 1.4.3-3).



* *Provincial Roads* are gravel or paved two lane roads, designated and maintained by the province. *Provincial Trunk Highways* are all major highway roads, paved and maintained by the province. *Other Roads* include a general grouping of town-roads and Rural Municipal roads of varying degrees of condition and maintenance; from single lane dirt trail roads, to well maintained two lane gravel roads (J.B. Hewitt, Prairie Farm Rehabilitation Administration Manitoba, personal communication 2006).

Figure 1.4.3-3: Spatial distribution of roads between RMNP and the DMPP&F, Manitoba (PFRA 2001) (1:50,000).

Topography.--The RMNP and the DMPP&F are separated by the Grandview Valley that occupies the Wilson and Valley Rivers. Another broad valley, formed by the Assiniboine River, runs between the RMNP and the Sasakatchewan Plain to the west. Both these valleys may be seen as extensions of the Manitoba Plain (Lang 1974). The remainder of the landscape between Riding and Duck Mountains consists of the flat to gently sloping Valley River Plain and the Lowland Plain (Ehrlish et al. 1959).

Geology.--The surface deposits on the plains consists of high limestone ground moraine, lacustrine deposits and alluvial sediments (Ehrlish et al. 1959).

Soil.--Soils of this region are characterized by orthic grey wooded soils that have developed under forest vegetation. Most of the soil is relatively fertile and therefore used for cultivation and improved pastures. Soils that are saline, stony, swampy or sandy in the area are utilized as pastures and woodlots (Ehrlish et al. 1959).

Climate.--The area is characterized by highly variable annual temperatures, resulting from great distance to the ocean. The area is sub-humid with 25 % of the precipitation falling as snow from November to March (Ehrlish et al. 1959).

Vegetative composition.--The area between RMNP and DMPP&F encompass the Boreal Forest Region (Ehrlish *et al.* 1959). Remnants of deciduous forest between the parks is composed of Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*Populus balsamifera*) and White Birch (*Betula papyrifera*), whereas coniferous forest patches are mainly composed of Pine (*Pinus* spp.) and Spruce (*Picea* spp.). The area also comprises scattered grasslands, marshes and lakes. Residual natural vegetation between the parks is dominated by mixed-grass prairie and Trembling Aspen (Bird 1961).

Human modification.--The intermountain area was first cleared for lumber and agricultural development following regional settlement in the late 19^{th} century (Carbyn 1980). Land between RMNP and the DMPP&F has been continuously modified through new land use practices and human activities (Carbyn et al. 1975, Carbyn 1980, Walker 2002). As a consequence, agricultural cropland is the dominating land type outside the park boundaries while there are only fragmented pockets of remnant forest (Carbyn 1980).

1.5 ORGANIZATION

This thesis is presented in 5 chapters. Chapter 2 is a review of literature related to land fragmentation and wolves. Chapter 2 examines habitat selection by wolves within RMNP while the focus of Chapter 3 is wolf selection for land outside the park boundaries. Finally in Chapter 5, management recommendations are provided based on findings from the previous two chapters.

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CHAPTER 2:

LITTERATURE REVIEW

2.1 INTRODUCTION

2.1.1 **Connecting ecosystems**

Core-areas.--As a result of human expansion, undeveloped land today mainly remains in areas that have been specifically designated as nature reserves. Ideally, protected parks should constitute core-areas for conservation of regional ecosystems. However, restricted space of single reserves limits the capacity of parks to provide complete systems of natural processes in isolation. Chances to protect regional ecological integrity can be enhanced by established linkages between reserves (Noss et al. 1992).

Metapopulations.--By definition, a population entails a group of individuals that belong to the same species and are confined to a limited area. In reality, habitats of separate populations may overlap and there is often individual interchange between these (Campbell & Reece 2004). Localized but interacting populations are collectively referred to as a meta-population (Levins 1970). Because larger populations stand a higher chance of long-term survival, conservation and landscape management should focus on connecting isolated sub populations (Hess 1994, Burkey 1995). As few as a couple of interchanging individuals per generation may be sufficient to sustain a meta-population, particularly in large ranging animals (Allendorf 1983, Lacy 1987).

2.1.2 **Fragmentation**

Human modified landscapes.--Intensive human growth and industrial development over the past century have contributed to heavily modified landscapes today

(Farina 2000). Human development often fragments natural land (Wilcox and Murphy 1985). Human-caused fragmentation is characterized by sparse, isolated patches of native vegetation across a predominantly human disturbed matrix (Noss 1992, Farina 2000).

Fragmentation effects.--Habitat fragmentation reduces the potential for migratory and large ranging species to disperse freely (Burkey 1995, Farina 2000, Meegan & Maehr 2002, Russel et al. 2003). Isolation poses a threat in particular to survival of small populations due to loss of genetic variability (Pimm et al. 1988, Fritts & Carbyn 1995, Rosenberg et al. 1997, Farina 2000, Duke et al. 2001).

Sensitivity to fragmentation.--Fragmented landscapes may support populations if individuals are capable of moving between patches that provide their life history requirements (Beir & Noss 1998). Fragmentation affects vary spatially depending on species specific scale perception (Dooley & Bowers 1998, Farina 2000) as well as the perceived level of risk (Haddad 1999).

Measuring fragmentation.--Physical connection of one or more contiguous habitat types is measured as connectedness of the landscape (Farina 2000) or as structural connectivity (D.J. Walker, University of Manitoba, personal communication 2006). The measure of functional connectivity on the other hand accounts for behavioral aspects involved in animal-selection of a movement path (Haddad 1999, Farina 2000). Compared to connectedness, functional connectivity refers to a species specific dispersal behavior rather than mere structural attributes of the landscape (Farina 2000; D.J. Walker, University of Manitoba, personal communication 2006). Functional connectivity is the preferred tool for estimating viability of subpopulations across fragmented landscapes (Farina 2000).

Importance of connectivity.--Considering the limited space and trend towards greater isolation of core refugee, there is an increased need to link sub-populations (Height et al. 1998). Functional connectivity reduces the size required by individual reserves to sustain populations, because it allows access for to a greater total area (Noss 1995). Spatially separated reserves that are interconnected provide for greater long term species viability compared with single reserves of equal total size (Goodman 1987, Noss 1995).

2.1.3 Corridors

Purpose.--Dispersal of wildlife across fragmented landscapes can be promoted by conservation of connective corridors that link otherwise separated landscape units (Meegan & Maehr 2002). Corridors that facilitating genetic exchange across human dominated landscapes increases survival of otherwise isolated populations (Maehr 1990, Beir & Noss 1998, Duke et al. 2001, Paquet et al. 2001) and may be viewed as extensions of reserves (Noss 1992).

Structural and functional corridors.--Corridors may be defined as "narrow strips of land which differ from the matrix [the environment in which habitat and linear patches are embedded] on either side" (Forman & Godron 1986). Other definitions include "linear, two-dimensional landscape elements that link previously connected patches (Duke et al. 2001)". Hedgerows, riparian features and vegetation patches are examples of structural corridors that may provide dispersal of wildlife (Merriam 1984, Noss 1992, Paquet et al. 2001). The physical presence of a continuous corridor does not necessary per se achieve the goal to prevent isolation of populations by promoting exchange of individuals through fragmented landscapes (Merriam 1984, Rosenberg et al. 1997, Paquet et al. 2001). Corridors that lack structural connectivity may functionally connect populations through behavioral dispersal tactics. Animals may for example move more rapidly through less favorable environments (Garret and Franklin 1988, Wig-get and Boag 1989). Corridors may be more comprehensively described from its both its structural and functional aspects as “physical or functional narrow patches that increase connectivity and allow the movements of [species] in a hostile matrix” (Paquet et al. 2001). In addition to being spatially variable, the dispersal function of corridors is a temporal concept that may vary with season and time of the day (P.C. Paquet, University of Calgary, personal communication 2006).

Corridor selection.--Dispersing animals are known to follow paths that comprise specific habitat types or shapes, such as linear features (Garret and Franklin 1988, Wigget and Boag 1989, Rosenberg et al. 1997). Paths that support higher survival rates compared with the surrounding matrix are more likely to be selected for travel (Rosenberg et al. 1997). Animals are also known to use pathways that comprise components from their natural habitat (Harrison 1992, Rosenberg et al. 1997).

Corridor design.--Habitat composition influences the effectiveness of dispersal corridors (Henein & Merriam 1990, Harrison 1992). Movement data for corridor design is scarce (Harrison 1992), but it is recommended that corridors should follow the natural landscape to greatest possible extant (Henein & Merriam 1990). Although corridors are not intended to supply all life-requirements for a species (Harrison 1992), corridors comprising habitat suitable for a permanently residing population would provide dispersal of that same species (Bennett 1990, Harrison 1992).

Corridor parameters.--Travel barriers may disrupt the functionality of connective corridors (Rosenberg et al. 1997, Duke et al. 2001). Hunting, trapping and livestock grazing are example of human activities and land uses that may conflict with species requirements and compose movement barriers (Harrison 1992). Other than human influence; width, length, noise, light and edge effect are other important parameters for functional wildlife corridors (Duke et al. 2001). Sufficient corridor width is important to minimize edge effects and offer protection from the surrounding land (Henein & Merriam 1990, Harrison 1992). The required corridor width for a particular species can be estimated based on its home range diameters (Harrison 1992).

2.1.4 **Managing matrix-land**

Regional management.--A comprehensive conservation strategy that combines management of core areas with human utilized matrix land results in landscape protection greater than the sum of the reserves (Fritts & Carbyn 1995, Noss et al. 1999). Effective conservation plans for protected areas should therefore incorporate management of surrounding buffer land (Noss 1992, Noss 1995).

Buffer-zones.--Establishment of buffer zones is a tool to extend management of protected areas to surrounding semi-developed land and to insulate reserves from intensive surrounding land use (Harrison 1992, Noss 1995, Paquet et al. 2001). Buffers comprise multiple use public land adjacent to reserves where human activities are managed to comply with conservation (Noss 1995). The goal of buffer management is to create areas adjacent to reserves where people and wildlife can coexist, by buffering populations against conflicts with human in marginal habitats (Mladenoff et al. 1995, 1997; Noss 1995, Mladenoff & Sickley 1998; Carroll et al. 1999, 2001).

Buffers management.--Both buffer zones and corridors of adequate width that are managed for minimal development may provide connectivity to nearby reserves may thus serve a role as linkages between reserves (Noss 1995, Paquet et al. 2001). Both further serve an important role in landscape management to expand the effective size of core areas to semi-developed lands where human disturbance is reduced (Noss 1995, Paquet et al. 2001). Effective buffer- zones and corridors depend on identification of optimal habitat with suitable levels of human activity (Paquet et al. 2001).

Human activity levels.--Human activities should comply with conservation standards and ideally be restricted to low usage in buffer zones and corridors (Noss 1992, Noss 1995). Buffer-zones and corridors intended for animal movement should exhibit low levels of habitat fragmentation and restricted development and clear-cutting (Noss 1992). Because conserving is less effective when human uses are totally restricted, the minimum level of protection necessary to buffer populations against human conflicts must be identified (Mladenoff et al. 1995, 1997; Noss 1995; Mladenoff & Sickley 1998; Carroll et al. 1999, 2001). Establishment of buffer zones and corridors may require that private land is attained and converted into public land (Noss 1992).

2.1.5 **Conservation models**

Ecological models.--Management decisions are often based on ecological monitoring and hypothesis testing (Noss 1990). Models can be used to predict effects of habitat distribution and fragmentation on populations (Russel et al. 2003). Empirical models that base statistical predictions on actual field studies are preferred (Beier 1993, Fahrig & Merriam 1994, Mladenoff et al. 1995, 1999, Carroll et al. 2003). Mapping of future and present conditions could further aid in strategies for long term conservation planning (Noss 1995).

Corridor models.--Effective management of wildlife corridors relies on mapping of potential linkages and regional networks (Noss 1995). A geographical information system (GIS) is a helpful tool for mapping and assessing environmental impacts. Telemetry data add valuable biological information that can be related to environmental impacts in a corridor-movement analysis (Beier 1993). Processing telemetry data in GIS is particularly useful when assessing corridor selection by highly mobile animals (Farina 2000).

Model limitations.--Despite advances in science and technology, habitat models are limited by human knowledge about species- and habitat relationships (Nelson 1993, Carroll et al. 2003). Science may be complemented by indigenous traditional knowledge about the local environment (Nelson 1993). Conservation plans are in principle experiments and implemented management practices must therefore be flexible for modifications in accordance with new findings (Noss 1990).

2.2 LARGE CARNIVORES

Habitat requirements.--Large carnivores are generally cover wide ranges across land that supports their prey (Noss 2001). Other than prey, factors such as topography, landscape structure, and human tolerance influences the abundance and distribution of wolves (Carroll et al. 2001). Large carnivores are particularly sensitive to isolation and structural changes on the landscape due to their extensive area requirement and low numbers (Fritts & Carbyn 1995, Carroll et al. 2001, Noss 2001).

Ecological importance.--Large carnivores maintain healthy ecosystems by herbivore control, which prevents outbreak of disease and overgrazing of vegetation (Primack 1993, Mech 1995, Goulet 1997). Based on their ability to stabilize systems, large carnivores are often considered as keystone species (Beier 1993, Mech 1995, Noss 1995, Goulet 1997). Large carnivores further make for ideal umbrella species, given their demanding area requirements and sensitivity to human impacts (Noss 1990, Beier 1993). Because relatively undisturbed landscapes are required for sustained viable populations of large carnivores, these animals are also considered indicator species for healthy ecosystems (Noss et al. 1996, Paquet et al. 1996).

Viability.--Protected parks serve an important role to ensure survival of large carnivores due to human intolerance towards these animals (Shafer 1990, Goulet 1999). Wide ranging animals are further are likely to be exposed to threats along reserve borders (Woodroffe & Ginsberg 1998). Because of their wide ranging distribution and vulnerable to regional processes, few reserves are individually capable of supporting large carnivores (Hummel 1990, Noss 1992, Carroll et al. 2001). It is estimated that millions of hectares of undeveloped land is required to ensure their long- term persistence (Hummel 1990, Noss 1992, Carroll et al. 2001). Viable populations of wide ranging large carnivores must therefore be managed within a network of reserves (Noss 1992) including multi-regional planning for connectivity (Noss 1995). Dispersal corridors are known to facilitate connectivity amongst isolated large carnivore subpopulations of (Fritts & Carbyn 1995, Carroll et al. 2001).

2.3 WOLVES

2.3.1 **Wolf Ecology**

Pack structure.--Wolves usually live in social units of packs that range between 2-9 animals (Mech 1977, Fritts & Mech 1981). The pack activities are controlled by a hierarchical order dominated by the “alpha” male and female (Mech 1977). Only the alpha-pair breeds and the majority of remaining pack members constitute their offspring (Mech 1977, Fritts et al. 1992). The pack normally range and hunt in a defended territory that vary in size depending on number of pack members and regional abundance of prey (Mech 1970).

Demography.--Wolves are demographically stable (Carroll et al. 2001). Litters of 5-6 are born in early spring (April to May) and the pups usually remain within the pack until 1-2 years of age. Young adult wolves disperse from their pack in search for a mate and establishment of their own territory (Fritts et al. 1992). Dispersing wolves may have to travel extensive distances by themselves across secondary habitats to avoid territorial conflicts; hence the term “lone wolf” (Carbyn 1980, Fritts & Mech 1981).

Prey selection.--Given a flexible nature, individual wolves exhibit vastly varied behaviours (Carroll et al. 2001, Houts 2000). Choice of prey is an example of a behavior that is socially transferred from older pack members to juveniles (Paquet et al. 1996, Houts 2000). Although large ungulates constitute their main prey in North America, wolves are opportunistic predators that regionally feed on various species (Mech 1970, Gese & Mech 1991). Wolves do however adapt to feed on specific prey found in abundance within their local habitat (Paquet & Carbyn 2003).

Ecological importance.--Wolves serve an important role in forest ecosystem food-chains by naturally regulating prey numbers (Mech 1970, Peterson et al. 1984, Mladenoff et al. 1995). Through top-down control, wolves help maintenance of healthy prey populations and stimulate birth- rates by removing weaker animals before they can pass on harmful genes. Because wolves naturally select for fawn and older adults in an abundant prey population, human hunting success of mature ungulate hunting is usually not affected by wolf presence (Mech 1970, Gese & Mech 1991).

Population dynamics.--Wolf population dynamics are primarily influenced by prey availability and vulnerability to human activities (Mech 1970, Packard & Mech 1980). Long term fluctuating prey numbers and sustained high levels of human induced mortality could affect territoriality and viability of wolves (Carbyn 1980, Height et al. 1998, Carroll et al. 2001). Random removal of pack members may disrupt the hierarchy and social behavior of remainder pack members, which poses a threat to survival of the regional wolf population (Carbyn 1980, Packard & Mech 1980).

2.3.2 **Human - wolf interactions**

Historical views of wolves.--Acceptance of wolves is historically related to the bond between man and nature (Kellert et al. 1996). Native North-Americans were inspired by the wolf’s power and strong family bonding (Carbyn 1980, Kellert et al. 1996). Europeans that colonized North America however viewed the wolf as a threat to human development and safety. During settlement, wolves were extirpated from the United States through official poisoning, shooting and trapping-programs. Negative attitudes towards the wolf remained in the United States long after the animal had been nearly exterminated. A smaller human population in Canada was unable to eliminate the wolf completely, despite similar attitudes as in the US. The wolf became a symbol of human interference with nature during the twentieth century, following a major paradigm shift due to increased awareness about conservation (Kellert et al. 1996).

Human attitudes today.--People today generally support wolves in the wild, especially when their presence does not interfere with human activities (Kellert et al. 1996). Many people recognize the ecological value of predators and view the wolf as a symbol of wilderness and persistence (Fuller 1989). Younger, educated, urban residents are most likely to hold positive attitudes towards the species. Senior livestock producers residing close to existing wolf populations are most likely to express negative attitudes towards the animal (Kellert et al. 1996) due to financial and political concerns (Carbyn et al. 1975, Fuller 1989, Fritts & Carbyn 1995).

Livestock predation.--Wolf depredation on livestock is a major challenge to human tolerance in areas where wilderness adjoins human developed land (Fritts et al. 1992). The view of wolves as a threat to livestock is however often exaggerated (Bangs et al. 1995). In reality, livestock is rarely disturbed by adjacent wolf populations and only few claimed depredation losses are actually proved to be wolf related (Fritts and Mech 1981, Bangs et al. 1995, Goulet 1997). Known cases of livestock depredation are often linked to availability and susceptibility of natural prey (Mech 1995). Wolves with human inflicted injuries may kill easy farm animals when restrained from natural hunting (Fritts et al. 1992). Careless animal husbandry practices, including calving or deposit of dead stock on pastureland or near farmyards is further known to attract wolves to cattle (Fritts et al. 1992, Mech 1995).

Human induced mortality.--Unfortunately, human perception often weighs heavier than facts (Kellert et al. 1996). Human control methods, including hunting and trapping, have been the prime limiting factor for wolves in North America since European settlement (Paquet et al. 2001). Approximately 80% of total wolf mortality is human related (Fritts & Mech 1981, Fuller 1989, Mech 1989, Bangs et al. 1995, Pletcher et al. 1997), out of which direct prosecution constitutes the major cause of death. The high proportion of human induced mortality has been linked to the wolf's extensive area requirement and high level of human interference (Paquet et al. 1996, Carroll et al. 2001). Human caused extirpation is greatest along reserve borders that represent population sinks due to conflicts with people on adjacent developed land (Noss 2001). Road accidents further contribute to mortality rates; both on protected and unprotected land (Paquet et al. 1996). High road densities near wolf habitat also indirectly contribute to wolf mortality by provide greater access for hunters (Fritts & Carbyn 1995).

Causes of human disturbance.--Unselective removal of wolves caused by human exploitation disrupt the social pack hierarchy and alter pack behavior (Carbyn 1980, Fritts et al. 1992, Pletcher et al. 1997, Goulet 1999). Changed behavior may resultant in an increase in lone wolves, modified migration patterns (Carbyn 1980, Pletcher et al. 1997) and disrupted transfer of knowledge to young, including information about natural prey selection. Remaining pack members may become dependent on livestock, with consequential increased wolf- human interactions (Fritts et al. 1992). Control methods are therefore often counterproductive, whereas maintained stable populations of wolves and natural prey are more likely to prevent livestock predation (Fritts et al. 1992, Goulet 1999).

2.3.4 **Managing wolf populations**

Controlled harvest.--Because prey numbers and human exploitation have the greatest impact on wolf survival (Mech 1970), legal regulation of wolf and ungulate harvest is the most direct tool to manage wolf populations (Fritts & Mech 1981). Legal protection against poaching is a prerequisite for successful dispersal of wolves across semi-developed land (Height et al. 1998). The legislation should firmly aim to minimize losses of wolves outside protected reserves and also be flexible to allow for modifications according to experience (Noss 1990, Fritts & Carbyn 1995,). Even when wolf-harvest is prohibited except for depredation control, wolves may still be killed illegally without reporting (Mech 1977, Fritts & Mech 1981). Illegal wolf harvest may disrupt management strategies based on accurately monitored harvest and population densities (Friits & Mech 1981, Fuller 1989, Fritts & Carbyn 1995). Assuming constant natural mortality, controlled legalized wolf harvest may allow for more certain mortality rates that provide more reliable predictions about population densities (Fritts & Mech 1981).

Importance of human attitudes.--Wolves can tolerate high levels of development, as long as they are tolerated by humans (Mladenoff et al. 1999). Viability of wolves ultimately depends on human attitudes, since these shape laws and policies that determine the tolerable level of large carnivore protection (Fritts & Carbyn 1995, Paquet et al. 1996). To be successfully implemented, environmental standards must be accepted by the public and consider cultural and historical aspects of the management area (Paquet et al. 1996, Breitenmoser 1998). Conservation that balances preservation of with human use is most effective (Noss 1995).

Promoting positive human attitudes.--Human caused wolf mortality is usually high along reserve- borders because people that live closest to their habitat often hold the most negative attitudes towards the animal (Schonewald-Cox et al. 1992, Noss 2001). Wolf conservation in protected areas depends on favorable human attitudes adjacent to the reserves (Fritts & Carbyn 1995). Coexistence of wolves and human could be attained by promoting better understanding of wolf behavior and how it relates to human presence (Thurber et al. 1994). People adjacent to wildlife habitats may further be encouraged to more positive wolf attitudes by practices that minimize livestock predation. Proper disposal of dead stock carcasses, calving away from pastures and avoided access of livestock in wooded areas are examples of farm practices that could be implemented to reduce wolf-livestock problems. Control programs should be in place to encourage appropriate practices by compensating livestock producers for predation that occurs despite exercised precautions (Fritts et al. 1992).

2.3.5 Viability in reserves

Limiting factors.--Wolf viability depends on factors including habitat destruction, population size and isolation (Fuller 1989). Human activities in particular are known to influence distribution, movement and survival of wolves (Paquet et al. 1996). Protected areas with minimal densities of roads and human are therefore required for long-term persistence of viable wolf populations (Houts 2000, Carroll et al. 2001).

Area requirements.--There is no minimum threshold reserve-size that guarantees long term viability of gray wolf populations (Fritts & Carbyn 1995). The reserve must however provide adequate space for a stable food source and security from human destruction (Fritts & Carbyn 1995). The social structure of wolf populations contributes to extensive area requirements (Carroll et al. 2001).

Population size.--The minimum viable population size (MVP) of wolves is not fully understood (Fritts & Carbyn 1995). Small and isolated wolf populations are however likely to experience viability problems due to lack of new genetic material (Fritts & Carbyn 1995, Haight et al. 1998). It is estimated that an effective size of 200, or a total population of 600, is necessary for an isolated wolf population to overcome loss of genetic variability (Soule 1980). Such large populations are difficult to sustain within single reserves, considering estimates that a 13,000 km^2 area is required to support only 50 wolves (1 wolf per 260 km^2) (Theberge 1983). Studies based on lower density estimates (1 wolf per 129 km^2) indicate that an isolated population of 200 wolves requires a minimum contiguous area of 25,906 km^2 to be viable (Paquet et al. 2001). Few nature reserves in North America offer such extensive areas, although densities of wolves residing in those parks usually are higher. For example, Banff National Park holds approximate 10-20 wolves per 100 km^2 (Paquet et al. 1996).

Linking reserves.--Based on the insufficient space of existing reserves and increasing isolation, regional viability of wolf populations require that local packs are able to interact as regional sub populations (Fahrig & Merriam 1994, Paquet et al. 1996, Height et al. 1998, Houts 2000). The size required for a single reserve to hold a viable wolf population is significantly reduced when there is interchange with individuals from nearby reserves (Ballard et al. 1983, Fritts 1983, Shaffer 1987, Gese & Mech 1991, Ream et al. 1991). A 3000 km^2 reserve could adequately hold a viable wolf population, assuming that a larger total area is accessible through dispersal (Fritts & Carbyn 1995, Noss 1995). Management that incorporates core, buffer, and dispersal habitats can therefore increase the effective size of reserves by allowing wolves to expand into semi-developed land (Fritts & Carbyn 1995).

2.3.6 **Wolves and connectivity**

Linking populations.--Since wolf populations are unviable under total isolation, introduction of new genetic material through immigration is a requirement for their long-term persistence (Fritts & Carbyn 1995, Haight et al. 1998). Survival of regional population thus depends on the ability of local populations to disperse (Fahrig & Merriam 1994). The ultimate goal conservation goal for wolf viability is to create a meta-wolf population with continuous exchange among sub-units (Fritts & Carbyn 1995). Because human dominated landscapes often separate sub-populations, these must be linked by regional travel networks that accommodate dispersal (Paquet et al. 1996).

Importance of corridors.--The fact that wolves are naturally great dispersers makes the presence of discrete dispersal corridors of less importance to wolves than to most other species (Fritts & Carbyn 1995). However, human impacts pose a high mortality risk for large carnivores and limit their long distance dispersal across modified landscapes (Beier 1993, Fritts & Carbyn 1995, Paquet et al. 1996, Carroll et al. 2003). Safe travel routes for wolves require protection from human impacts and developments that disrupts wolf-dispersal, such as roads (Noss 1992, Carroll et al. 2003). Regional exchange of wolves across human dominated landscapes can be managed by interlinked quality patches that enhance connectivity between reserves (Beier 1993, Fritts & Carbyn 1995, Paquet et al. 1996).

Corridor requirements.--Wolves that travel across fragmented landscapes with sharp boundaries between natural and disturbed land are known to select forested areas and avoid extensive open spaces (Fritts et al. 1992). Creeks further provide natural corridors for movement of large carnivores (Beier 1993). Based on home-range size, effective corridors for wolves should be a minimum width of 12 km (Nowak & Paradiso 1983). It is further suggested that corridors for movement of predators should sustain efficient prey and cover for protection from human interference (Harrison 1992). Although conservation of larger, vegetative land patches are a priority; also smaller forest patches may serve as stepping stones for movement of wildlife (Meegan & Maehr 2002). Development that isolates or destroys habitat should be avoided to enhance dispersal (Beier 1993).

Joint management.--Administrative restrictions and different mandates amongst agencies often limit active conservation of wide-ranging carnivores (Salwasser et al. 1987, Beier 1993, Noss 1995). Because most reserves are of inadequate size to ensure long term survival of isolated populations, wolf dispersal depends on joint management of reserves and bordering land (Fritts & Carbyn 1995, Noss et al. 1999). Effective conservation of buffers and corridors further require cooperation between regional authorities (Fritts & Carbyn 1995).

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CHAPTER 3:

WOLF HABITAT IN RIDING MOUNTAIN

Abstract.--The study was carried out to identify habitats selected for or avoided by wolves in RMNP and use these findings to determine the most suitable cover for dispersal outside the park-boundaries. Habitat selection was determined based on telemetry locations related to five distinct land classes in the park; including forest, water, shrub, wetland, and disturbed land. Buffers were created around the point locations to account for potential error in the telemetry data. The selection results were quantitatively assessed by Neu´s analysis. The results showed that wolves within the park select equally for all natural habitat types but avoid areas of disturbance (Fuller et al 1992, Mech 1995, Mladenoff et al 1995, Glenz et al 2001). It was concluded that movement of wolves outside the protected park is likely driven by avoidance of human disturbance rather than by selection for any particular habitat.

3.1 INTRODUCTION

3.1.1 Habitat generalists

Attraction or avoidance exhibited by wolves to specific habitats is a result of complex interactions amongst variables, including physiography, security, food-access, population density and choice-availability (Paquet et al. 1996). Compared with other large carnivores, wolves express great ecological resilience and occupy broad, geographical distributional ranges (Carroll et al. 2001). It has been suggested that wolves potentially could live anywhere there is sufficient prey and human acceptance (Fuller et al. 1992, Mech 1995, Mladenoff et al. 1995). Given their low affinity for specific habitat, including prey, wolves are described as ecosystem generalists (Fuller et al. 1992, Mech 1995, Mladenoff et al. 1995). Wolves are however habitat specialists on a restricted level, because they adapt to habitats locally (Paquet & Carbyn 2003).

3.1.2 **Habitat selection**

Limiting factors.--Vegetation and prey-availability are of prime importance in wolf habitat selection. Presence of wolf packs correlate with forested cover and high ungulate densities (Houts 2000). Although wolves do not depend on vegetation attributes per se, availability, or lack of forest cover, reflects presence or absence of prey and human (Carroll et al. 2001). Frequent occurrence of wolves in forest-dominated areas is relates to lower levels of human exploitation compared with open and developed areas (Licht & Fritts 1994).

Prey.--Prey availability is the second limiting factor to wolf presence after human tolerance (Fuller 1989). In the absence of human disturbance, there is often a direct relation between ungulate biomass and wolf densities (Fuller 1989). Wolf use of vegetative cover usually correlates with densities and distribution of their major prey (Paquet et al. 1996, Carroll et al. 2001). Ungulates may however utilize land where wolves are otherwise deterred as an anti-predator strategy (Paquet & Brook, 2004).

Snow.--By affecting prey availability, snow conditions directly influence habitat selection by wolves (Peterson 1977). Snow depth hinders movement of both wolves and their prey although the wolf's relatively light foot loading gives them advantage over heavier ungulates (Paquet et al. 1996).

Vegetation.--Wolf selection for vegetative cover is primarily influenced by prey-distribution (Fuller 1989, Paquet 1996, Carroll et al. 2001). Wolves use deciduous and open habitat less and conifer and mixed stands more in heavy snow, concurrently with ungulates being forced by snow conditions to use the same cover for browsing (Peterson 1977, Paquet et al. 1996). Wolves may further be attracted to logged forest that attracts browsing ungulate with regenerated forage (Mladenoff and Sickley 1998).

Habitat structures.--Because wolves adapt to local conditions, there is great regional variety in habitats specialized for denning, forage, and prey (Paquet et al. 1996). Studies show that shrub and water are preferred over forest (Kuzuk 2002). Wolves have been found to occupy areas with high proportions of wetlands and lakes (Mladenoff et al. 1995) because open areas and water ridges bodies are preferred for denning (Carbyn et al. 1975). In other regions, wolves rarely use treeless marshes (Fritts & Mech 1981

Topography.--Topography, aspect, and elevation influence distribution and densities of wolves (Fritts & Mech 1981, Paquet et al. 1996, Carroll et al. 2001). In mountainous areas, most activity occurs below 1850 meters (Paquet et al. 1996). Wolf avoidance of steep slopes relates to higher vulnerability and lower availability of prey in rugged terrain (Carbyn 1980, Paquet et al. 1996).

3.1.3 **Human influence on habitat selection**

Human disturbance.--Human activities and attitudes influence distribution and survival of wolves (Theil 1985, Fuller et al. 1992, Mladenoff et al. 1995, Paquet et al. 1996). Absence of wolves in human dominated areas is a result of human caused-mortality and active behavioral avoidance (Fuller et al. 1992, Paquet et al. 1996).
Even low levels of human activity may displace wolves from their preferred habitats (Paquet et al. 2001).

Human densities.--Wolves generally select areas with low human densities because the potential for wolf survival and growth is higher in remote areas (Fuller et al. 1992, Mladenoff et al. 1995). Threshold human densities are estimated to less than 0.4 per km^2 in core wolf habitats, including denning and rendezvous sites, and 1.54 humans per km^2 outside core-areas (Mladenoff et al. 1995). Threshold concentration of human in time and space is estimated to fewer than 1000 people or events per month in optimal wolf habitat (Paquet et al. 2001). Because landownership often relates to human disturbance, wolves generally use publicly owned lands more frequently than private land (Mladenoff et al. 1995, Houts 2000).

Road effects.--It is well-documented that roads affect wolves negatively at local, landscape, and regional levels (e.g. Fuller 1989, Thurber et al. 1994, Mladenoff et al. 1995). Roads contribute to wolf mortality directly by vehicle collisions and indirectly by increasing access to human activities such as trapping and hunting (Jensen et al. 1986). Road densities can be used as a subsidiary measure of human densities (Paquet et al. 1996). Presence of roads further relates to landscape fragmentation, habitat loss (Jensen et al. 1986, Paquet et al. 1996) and increased encounters between wolves and livestock (Carroll et al. 2003).

Road thresholds.--Threshold road densities has been identified to 0.6 km/km^2 or less in wolf territories (Thiel 1985, Jensen 1986, Fuller 1989). Even lower road densities have been suggested in other places (less than 0.45 km/km^2 in overall pack area and 0.23 km/km^2 in core areas) (Mladenoff et al. 1995, 1999). Threshold road densities vary with levels of public access as it relates to hunters and vehicles (Mladenoff & Sickley 1998). Because highways are a major cause of wolf mortality, wolf habitats should further sustain threshold speed limits less than 70 km/hour and traffic volumes of less than 200 vehicles per day (Paquet et al. 1996, Paquet et al. 2001). It is also recommended that buffer zones of at least 500 m are established between roads and existing wolf populations (Paquet et al. 1996).

Tolerance to disturbance.--Human disturbance impacts many aspects of wolf ecology, including distribution, movements, survival, and fecundity (Paquet et al. 1996). Wolves can however withstand high levels of human pressure, fragmentation and other landscape modifications in some cases (Mech 1995, Blanco et al. 2005). Wolves may for example be more tolerant to human activities where the development is near prime wolf habitat (Paquet et al. 1996) or where they have adapted to local disturbance over time (Mech 1995, Blanco 2005). Favorable human attitudes and protection from human caused mortality are however requirements for wolves to coexist with development (Fuller et al. 1992, Mladenoff et al. 1999, Mladenoff et al. 2006).

Individuality.--Although the impact of disturbance depends on the environmental and social context, individual wolves express varied reactions to human activities due to inherent behavior (Paquet et al. 1996). For example, individual pack-members have expressed loss of fear of human activities by occupying areas close to major highways (Thurber et al. 1994) and by scavenging on campgrounds (Carbyn 1975). Experience plays an important role in response reaction of wolves, due to their long-lived nature and learning through social transmittance (Paquet et al. 1996).

3.2 WOLVES IN RIDING MOUNTAIN NATIONAL PARK

3.2.1 Wolf population dynamics

Regional populations.--There are an estimated 4000 wolves left in Manitoba, although there is uncertainty in exact numbers due to lack of reliable data (Manitoba Conservation 2006). Wolves in rural Manitoba persist as segregated “island”-populations within parks such as the RMNP, DMPP&F and the Spruce Woods Provincial Park (Manitoba Conservation 2006).

Historic population dynamics.--Records indicate that wolves were present in southern Manitoba before settlement but went absent from RMNP during the 1920´s and the 1930´s (Carbyn 1980). The local extinction of wolves correlate with persistent land clearing and extirpation caused by European settlers (Carbyn 1980). The wolf population was re-established in RMNP in the late 1930´s, presumably by southward migration of wolves from northern areas such as the DMPP&F (Carbyn et al. 1975).

Recent population fluctuations.--Since recolonization, the RMNP wolf population has fluctuated between 40 to 120 animals (Carbyn 1989). Annual park surveys indicate a significant decline in numbers during the 90’s (Goulet 1997), when the park population was estimated to only 40-60 wolves (Kellert et al.1996). The drastic decline in wolf numbers was most likely a result of combined effects of disease, habitat fragmentation, and high human-caused mortality (Goulet 1997).

3.2.2 Ecology and viability of wolves

Prey.--RMNP is a highly productive system that supports three ungulate species in moderate to high densities year round (Fritts & Carbyn 1995) which may be related to the relatively smooth terrain in the park. Elk is the most important year round prey for wolves in the park, comprising 52% of the winter diet and 37% of the summer diet . Moose and deer comprise smaller portions of the wolf diet, as well as beaver found in abundance within the park (Carbyn 1980).

Population viability.--The abundance and even distribution of natural prey in RMNP appears to secure its wolf population over the short term (Mech 1970, Carbyn 1980, Fritts & Carbyn 1995, Goulet 1999). Long- term survival of wolves within the park depends on additional factors to a stable prey base, including ability to disperse and extent of surrounding human activities (Carbyn 1980). Based on estimates of viable wolf densities in North America, the 3000 km^2 area of RMNP could support 70 wolves at the most (Fritts & Carbyn 1995). In isolation, RMNP is therefore barely large enough to function as a viable ecosystem for large carnivores (Carbyn 1980). RMNP would however be physically large enough to protect a core wolf population, provided there is interchange with wolves from nearby areas (Fritts & Carbyn 1995). The wolf population in RMNP is however believed to be isolated (Carbyn et al. 1975, Wilson et al. 2000).

3.2.3 **Wolf range and movement**

Pack activity.--Based on aerial telemetry data (1976-79), wolf activity in RMNP is concentrated around the den site during spring (April-May) and the rendezvous sites during summer (June-September) (Carbyn 1980). Pups mature and begin their winter travel in the fall (October-November). Average territory size for wolf packs in RMNP is 234 km^2, ranging between 104 km^2 to 631 km^2. Overlap of neighboring pack activity zones is low, whereas territories shift and expand over years. Territory shift indicates instability in a system (Fritts 1979), which in RMNP likely is a result of disrupted pack hierarchies caused by human exploitation on surrounding parkland (Carbyn 1980).

Travel.--Although not recorded by mid-day aerial telemetry locations, observations hold that wolves often travel the cleared trail along the park boundary. It is suggested that wolves avoid areas adjacent to human activities during the day, while travel closer to the park border increases at night. Deeper snow in the park may be one reason for wolves to leave the park and frequent areas of settlement at night when risks of human detection is lower (Carbyn 1980).

Lone wolves.--Lone wolves in RMNP are rare but travel more extensively than pack members and their home ranges are relatively large (Fritts 1979, Carbyn 1980). Lone wolves are more likely than pack animals to occupy periphery park habitat, such as areas close to the developed park town (Wasagaming), and adjacent agricultural land (Carbyn 1980). The spatial occurrence of lone wolves in the RMNP-area is a combined result of active avoidance of established pack territories and limited park space (Carbyn 1980, Fritts 1981). High levels of human induced mortality outside the park boundary may explain the relative scarcity of lone wolves in RMNP (Carbyn 1980).

3.2.4 **Wolf Management in RMNP**

Wolf population in RMNP.--RMNP is viewed as the essential effective wolf conservation zone for the park population, given that surrounding agricultural land provides poor protection (Fritts & Carbyn 1995). Wolves in RMNP are managed based on yearly mid-winter park-surveys that monitor wolves and their prey (Carbyn 1980). Park wardens patrol to ensure that there are no violations to prohibited hunting, use of motor vehicles or resource extraction within RMNP. Development in the National Park is further restricted. Although fully protected within the federal park, long term survival of wolves in RMNP depends on their ability to travel undisturbed across neighboring private and provincial land (Goulet 1997).

3.2.5 **Purpose and objectives**

Purpose.--The purpose of the study was to determine land cover most suitable for wolf dispersal between RMNP and DMPP&F, based on land cover preferences in the natural park habitat

Objectives.--Specific objectives were to:

- Quantitatively assess and identify habitat types selected and avoided by wolves in RMNP.
- Extrapolate selection results from the established RMNP territories to potential dispersal habitats outside the protected park boundaries.

3.3 STUDY AREA

See 1.4.1.

3.4 METHODS

3.4.1 **Wolf location data**

Collection methods.--Very high frequency (VHF) radio telemetry provides a technique to gather location data that may be used to predict animal movement and habitat usage. However, telemetry point locations are associated with error that could result in data-misclassification. It is difficult to estimate the telemetry error, because it is a function of several unique factors that interact and accumulate with the grid-error. The likelihood of incorrectly interpreting information at fixed telemetry locations can be reduced with buffers created around the telemetry-points (Rettie & McLoughlin 1999).

Data-set.--Eight wolves from separate packs in RMNP were collared with VHF radio transmitters that were located from the air during 1976 to 1979 (P.C Paquet, University of Calgary, personal communication 2003). In total, 408 wolf locations were recorded in the western corner of the park. These locations were entered in Excel adjoined with associated attributes for UTM coordinates; pack name, date, and unique id. The ESRI software Arc View 3.1 was used to assess the point data in a Geographical Information System (GIS). The wolf telemetry data was exported from Excel as a dbf-file and added to Arc View 3.1 as an event theme. The resulting point shape file had to be converted from NAD 27 to NAD 83 by the Projection Extension in Arc View 3.1, to be compatible with other data sources used.

3.4.2 **Buffered telemetry points**

To reduce the estimated location error associated with the telemetry data, a buffer with a radius of 30 m was created in Arc View 3.1 around each point by the Spatial Analyst-extension. It was assumed that 30 m would be sufficient to cover the estimated precision error in the telemetry data. Each buffer point was uniquely identified and spatially intersected with the habitat layer through use of the Geoprocessing wizard- extension. The intersected buffers were than spatially joined to the original wolf-location points, to retain all attributes from the telemetry data in addition to the habitat information. The amount of land contained in the buffers for each habitat-class was calculated from the total buffer area. Double counting of areas included in overlapping buffers was assumed to indicate affinity to the contained habitat rather than redundant bias. To confirm that double counted habitats had no effect of on the overall results, overlapping buffers were dissolved by the Geoprocessing Wizard- extension and analyzed separately.

3.4.3 Land-cover data

A habitat layer was created from the Forest Resources Inventory (FRI) aerial survey for Forest Management Unit (FMU) 15, provided by Manitoba Land Initiative (MLI). Tiles containing national park-land ("owner class 3") were merged by the Geoprocessing Extension in ArcView 3.1 to create a land-cover-layer strictly for park-land. The numerous land-classes represented by the FRI were categories into five distinct habitat classes, including forest, shrub, wetland, water, and disturbed land. A broad habitat classification was chosen to reduce the possibility of Type 1 error due to pair- way selection. With an initial broad land classification, it would further be possible to identify need for more detailed classes in the future (D.J. Walker, University of Manitoba, personal communication 2004).

3.4.4 Statistical methods

Neu's method.--Neu's analysis is a quantitative method to evaluate species-habitat selection from location data. The method does not recognize individuals but assumes that the whole area is availability for and used by all animals at a population level. It is therefore required that the species home range is large enough for allowing individuals to select from the whole study area. Observations are represented as frequency point-data. Because the analysis assumes that each observation is independent, it is further required that the data points are not spatially or temporally autocorrelated but collected apart in time (Neu et al. 1974). Neu´s analysis eliminates the effect of disproportional representation of land classes, where evenly distributed classes appear being selected more often than rare and uneven classes. The analysis does however not account for the spatial distribution of land classes on the landscape (D.J. Walker, University of Manitoba, personal communication 2004).

Significance testing.--A log-likelihood chi-square test can be used to determine if observed and expected counts differ significantly (Manly et al. 1992). More habitat classes result in more possible pair-wise combinations and therefore multiplication in type 1-error. Problems associated with multiple confidence intervals can be reduced by adjusting the normal 95% significance level. A more appropriate significance level can be found by a Bonferroni correction, where the probability (α) is dividing with the number of non-independent tests undertaken (k) (Bonferroni 1936).

3.4.5 **Data analysis**

Neu's analysis variables.--Neu's analysis was used to assess quantitatively selection of specific habitat types. The criteria for using the method were met by the wolf's extensive range and independently collected data points. A number of variables were derived from the data to suit Neu's testing method (MMU 2004). Proportional habitat availability (prop *a*) was based on the proportion of the area for each class available in the habitat- layer relative to the total park-area. Proportional habitat usage (prop *u*) was calculated from the observed area of each habitat type in the buffers (obs *u* (area)) related to the total buffer area. The observed buffer area (obs *u* (area)) for each habitat class was converted to frequency values to meet the criteria of point data. Observed frequency values (obs *u* (freq)) were obtained by dividing the total buffer area observed for each habitat class (obs *u* (area)) with the individual buffer-area (2827 m^3). Each buffer thus came to represent potential habitat for the associated wolf-telemetry points. Expected frequency values (exp (freq)) were obtained by multiplying the proportional habitat available (prop *a*) for each habitat class with the total observed buffer frequency (total obs *u* (freq)).

Chi square.--As part of Neu's analysis, a modified chi-square was performed to determine if expected and observed counts differed with enough significance to reject the null hypothesis of no selection. The chi square value was calculated based on a log-likelihood two-tailed chi-square-test, using the following formula (MMU 2004):

$$[\ \chi_L^2 = 2\Sigma \text{ observed}.\log_e \{{}^{\text{observed}}/_{\text{expected}}\}\ ]$$

$$= [\ \chi_L^2 = 2\Sigma \text{ (obs } u \text{ (freq)) } \{{}^{\text{(obs } u \text{ (freq))}}/_{\text{(exp (freq))}}\}\ ]$$

Confidence limits (CL) for each habitat class were further calculated to determine which particular habitat types that were selected for, based on the formula (MMU 2004):

$$[\text{ observed +/- } z_{\alpha/2} \sqrt{(\text{observed (1-observed) / total count})}\ ]$$

$$= [\text{ (prop } u\text{) +/- } z_{\alpha/2} \sqrt{(\text{prop } u \text{ (1- (prop } u\text{)) / (total (obs } u \text{ (freq))})}\ ].$$

If the proportional area available (prop *a*) for any habitat type falls within its CL- range, there is no significant difference between observed and expected frequencies. On the other hand, a proportional ratio outside the CL range for a land class indicates selection for that specific habitat type.

Bonferroni correction.--The normal 95% significance level was corrected to account for the non-independent CL:s for the different habitat classes (MMU 2004). Five test-statistics were to be calculated at a chance probability of 5% (α= 0.05).

Selection index.--A selection index (SI) was obtained for each habitat class by dividing the proportional area used (prop *u*) by corresponding proportion of habitat available (prop *a*). SI significantly below one indicates avoidance, whereas a SI significantly above indicates selection (MMU 2004). A standardized SI (SSI) was further obtained by dividing each SI by its total sum. The SSI represents the probability of selection for a particular cover type if all habitats were available in equal quantities (MMU 2004).

3.4.6 **Polygon size**

There was concern that the selection results would be affected by distinct variation in polygon characteristics; including shape, patchiness, and size; amongst different habitat types. The likelihood of a wolf point being included in a polygon based on its dimensions was explored by relating the frequency of telemetry-points to polygon size. The polygon area was found by the *.ReturnArea* command in Arc View 3.1. Each habitat polygon was than uniquely identified and joined with the wolf-points contained within. The relationship was graphed as the frequency of revisited polygons against average polygon-size. Furthermore, the effect exerted by polygon patchiness on inclusion of cover-classes in buffers was visually examined in GIS.

3.4.7 **Prey-influence**

Given the correlation between wolf distribution and presence of prey (Fuller 1989), a prey- layer was created from ungulate locations within and adjacent to RMNP. Data representing ungulate occurrences within RMNP was based on telemetry surveys conducted in 2005 of animals inside the park. Locations of ungulates outside the park mainly comprised recordings between 1998-2002 of dead animals that were killed by hunters, predators or disease (T.A Sallows, Riding Mountain National Park, personal communication, 2005).

3.5 RESULTS

3.5.1 **Land-cover and wolf locations**

The buffered telemetry location points from within RMNP were overlaid on the land cover layer in ArcView 3.1 to visually assess the distribution of wolves in relation to the park habitat (Figure 3.5.1-1)..

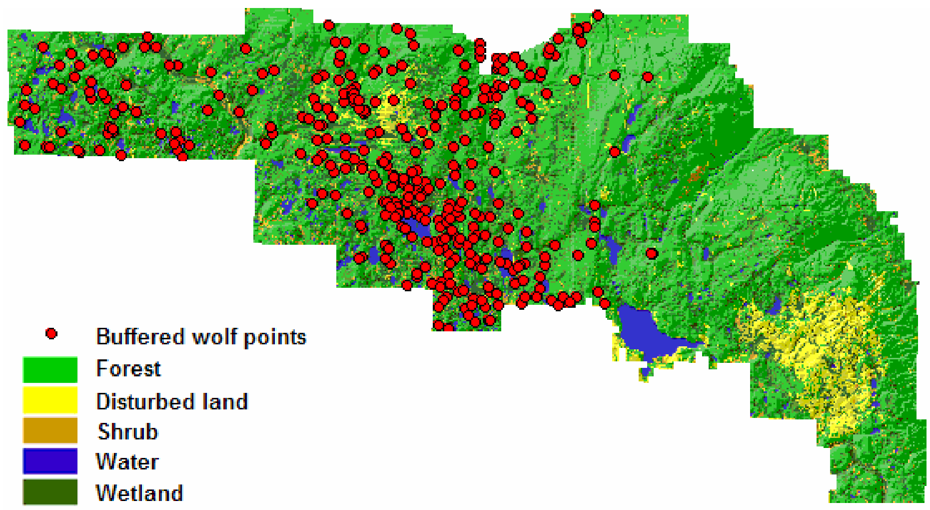

Figure 3.5.1-1: Buffered wolf telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1975-79) in RMNP, Manitoba, based on FRI-data (MLI 1980-82) (1:15840)

Visual examination of proportional land-cover available in RMNP compared with land-cover within buffered wolf locations reveals that disturbed land is being used less than expected (Figure 3.5.1-2).

a. **b.**

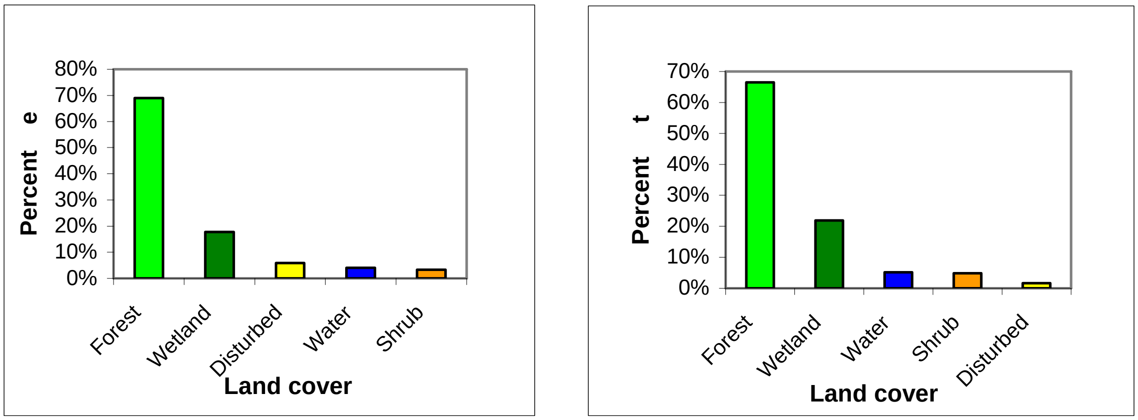

Figure 3.5.1-2: Proportional distribution of land cover classes in RMNP (a) based on FRI- data (MLI 1980-82) compared with cover classes contained within buffered wolf telemetry locations (b) (Canadian Wildlife Serve, P.C Paquet, personal communication 1975-79).

3.5.2 **Neu's Analysis**

Results from Neu's analysis quantitatively support that disturbed land is being used less than expected based on availability (Table 3.5.2-1). Because the calculated test value (27.71) falls outside the non-significance range of critical values for a two tailed chi square test at $\alpha = 0.05$, df 4 (0.48442- 11.14329), the hypothesis of no selection is rejected. Thus, at least one of the habitat-classes is being used disproportional to its availability.

Table 3.5.2-1: Neu's test for FRI-based land classes (MLI 1980-82) selected by overlapping, buffered wolf telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1975-79) in RMNP, Manitoba.

class	obs *u* (area)	prop *u*	obs *u* (freq)	prop *a*	exp (freq)	SI	SSI
Wetland	262630	0.22	92.89	0.177877	75.44	1.23	0.24
Shrub	57699	0.05	20.41	0.032541	13.7	1.48	0.28
Water	61766	0.05	21.85	0.040833	17.32	1.26	0.24
Forest	797273	0.66	281.98	0.689708	292.5	0.96	0.18
Disturbed	19724	0.02	6.98	0.058791	24.93	0.28	0.05
Total:	1199092	1	424.09	0.99975		5.22	1

class	chi^2	CL+	CL-	prop *a*	sign
Wetland	23.77054	0.17	0.27	0.18	NS
Shrub	6.62475	0.02	0.08	0.03	NS
Water	8.158075	0.02	0.08	0.04	NS
Forest	-17.0365	0.61	0.72	0.69	NS
Disturbed	-7.76038	0	0.03	0.06	S
	27.71288				

The CL were calculated based on a z- value of 2.576 for a 2-tailed test at α=0.01, after Bonferroni correction of the probability level for five test-classes (0.05/5). The CL (Table 3.5.2-1) show that disturbed land is the only land-class that significantly affects habitat selection by wolves in RMNP. The SI values further confirm that disturbed land is avoided. The SSI values indicate that wolves select rather evenly among natural habitat classes in the park. The higher indices for shrub, water, and wetland however indicate that wolves are more likely to select for these classes than forest, although the selection is non-significant.

3.6 DISCUSSION

3.6.1 **Significance of selection results**

Natural habitat selection.--Non-significant preference for any particular natural cover type in the park conforms to previous findings that wolves are ecosystem generalists (Fuller et al. 1992, Mech 1995, Mladenoff et al. 1995, Paquet et al. 1996).

Wolves do however adapt to specific habitats on a local scale (Paquet & Carbyn 2003). The finding of no apparent habitat selection may further be related to the even distribution of ungulate in the park (Figure A.4-1), because prey densities strongly influence wolf usage of vegetation cover (Paquet 1996, Carroll et al. 2001). Furthermore, the relatively low level of threatening human activities makes usage of forested cover for security of less relevance within to wolves in RMNP.

Disturbance avoidance.--The finding that wolves in RMNP avoid disturbed land conforms to the prevailing notion that wolves select areas distant from human modification and development (Fuller et al. 1992, Mladenoff et al. 1995, Paquet et al. 1996). Because avoidance of disturbed land was the only significant result, it can be concluded that wolves in RMNP are locally adapted to undisturbed land. It can further be assumed that wolf usage of habitat within RMNP is driven by avoidance behavior to a greater extant than by selection for particular cover types.

Selection outside RMNP.--Most of the intermountain landscape consists of more severe and widespread human caused disturbance compared with RMNP (see 1.4.3). Because wolves avoid the relatively sparsely available and mildly disturbed land within the protected park (Table A.2-1), it is expected that human modified land outside the boundaries deter wolves to an even greater extent. In a regional context, it can therefore be concluded that the natural land matrix in RMNP constitute preferred habitat for wolves, while they avoid the surrounding disturbed land matrix. Based on the finding, it is further assumed wolf movement outside the park-boundary primarily would be influenced by avoidance behavior.

3.6.2 **Limitations**

Buffers.--As most data, the FRI- habitat layer contains classification and precision errors that are additive to any precision error in the telemetry data. However, the anticipated benefit of using buffers to reduce location error in the telemetry data may have been counteracted by the spatial structure of the land-cover data. Selection results are affected by polygon size (Figure A.5-1) and patchiness (Figure A.5-2). Due to the patchy nature of water-, wetland-, and shrub-polygons, these land classes stand a proportionally higher chance of being included in the buffers compared to the forest-matrix (Figure A.5-2). The higher selection probability found for shrub, water and wetland might thus be an effect of the patchy nature of these polygons rather than true habitat preference. It could therefore be argued that the buffer analysis reduces the accuracy of the results, because it does not reflect selection based on actual point locations. Never less, it was assumed that use of buffers in the analysis provided more accurate results than without, given uncertainty in the precision of the telemetry locations and error in the habitat layer.

Lack of data.--The scarce location data (total 408 telemetry points) further limits the accuracy of the findings. Any specific point location simply represents a snapshot in time that fails to account for habitat usage between the recordings. Particularly considering the wolf’s extensive range of movement, the ability to determine habitat selection based on sparse location data is limited. A more accurate assessment of wolf movement relies on more frequent location data attained by either VHF- or GPS-telemetry. It is also possible that the scarcity of human disturbed land within the park limits the accuracy of the results, although Neu´s analysis supposedly eliminates the effect of disproportionally distributed classes.

Extrapolated results.--Caution must be taken when applying results from one specific environment to another. Unique contexts of disturbance may restrict effective application of findings from the protected park to the largely modified landscape outside the park-boundaries. Furthermore, given the low frequency occurrence of disturbed land in the park (Table A.2-1), the finding of significant avoidance of this land class should be treated with discretion.

3.7 CONCLUSION

The results support that wolves do not select any particular natural habitat type in RMNP, although they avoid disturbed park areas. It can thus be concluded that wolves in RMNP are locally adapted to the relatively undisturbed land in the park and naturally avoid disturbed areas (Chapter 3). The findings were of interest for identification of land cover that may be used by wolves outside the isolated park, with potential to form linkages to nearby DMPP&F. Based on extrapolation of the results, it can be assumed that land outside the park boundaries also is determined by avoidance of disturbance rather than by selection for particular cover-types. Given the great abundance and intensity of disturbed land between RMNP and the DMPP&F, wolves in RMNP likely avoid traveling across land that surrounds the protected park. It is however important to keep in mind that a combination of interlinked factors influence specific habitat usage.

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CHAPTER 4:

DISPERSAL OF WOLVES BETWEEN RMNP AND DMPP&F

Abstract.--The area between RMNP and DMPP&F has been modified by primarily agricultural practices to such extent that disturbed land now constitutes the core matrix. There is concern that this hostile landscape prevents wildlife from moving between the parks, with consequent effects of isolated populations. Isolation is particularly a threat for large carnivores such as wolves, due to their wide-ranging nature and sensitive to human disturbance. The aim of the study was to identify specific land-types suitable for wolf-movement and interlinked areas with the potential to function as dispersal corridors between the parks. Interviews with local residents and GPS recorded wolf tracks provided evidence of wolf presence in the area. Wolf presence between the parks was further related to presence of prey by a tasseled greenness layer. Interviews revealed negative attitudes to wolf movement that assumingly comprise a barrier for wolf dispersal due to the associated threat of human caused mortality. Track data showed that wolves are reluctant to travel further distances from the park boundary. Tracks outside the park were predominantly close to vegetated cover and areas with reduced human activity. The greenness analysis further indicated it being unlikely that wolves primarily leave the park to search for prey on the surrounding hostile land. In conclusion, human caused mortality constitutes the greatest barrier to wolf travel between the parks, by making the animals sensitive to the human disturbed land that dominate the landscape. Wolf dispersal therefore depends at the very least on conservation of the sparse vegetated patches that remain between RMNP and the DMPP&F.

4.1 INTRODUCTION

4.1.1 Dispersal

Form and function.--Wolves display widespread dispersal patterns in comparison with other large carnivores (Carroll et al. 2001). Wolf dispersal follows a stratified diffusion pattern that includes short-distance dispersal for expansion of territories combined with long-distance dispersal in search for new territories (Carroll et al. 2003). Dispersal behavior further varies among individual wolves. A flexible dispersal strategy allows for rapid adjustment to environmental and social factors, which enhances survival rates (Gese & Mech 1991). Enhanced dispersal capability in combination with high annual productivity rates make wolves demographically more resilient than other large carnivores (Weaver 1996, Carroll et al. 2001).

Inbreeding avoidance.--Wolf dispersal plays an important role in inbreeding avoidance (Gese & Mech 1991). Although wolf packs naturally sustain high rates of inbreeding, even a few immigrants aid to buffer populations against environmental fluctuations (Gese & Mech 1991, Haight et al. 1998). Immigration is particularly important for smaller and isolated populations (Haight et al. 1998). Dispersal may further result in formation of new packs when two individuals of opposite sex join and establish territory on unoccupied land (Fritts & Mech 1981).

Resource competition.--Wolf dispersal results from avoidance of resource competition (Gese & Mech 1991). Subordinate animals are often forced to leave their packs due to territorial strife and tension that arises due to limited space or low prey numbers (Fritts & Mech 1981, Gese & Mech 1991). Older wolves further direct aggression towards younger animals during the breeding season, to prevent competition for mates (Gese & Mech 1991). Documented increase in dispersal frequencies from February through April coincide with the breeding season from early February until early March (Fritts & Mech 1981, Peterson et al. 1984, Gese & Mech 1991).

Demographics.--Young adults predominate in wolf dispersal. Wolves become sexually mature around 10 months of age and often initiate dispersal at an age of 11-12 months (Gese & Mech 1991). Wolves past breeding age disperse to form new packs and rarely stay within their natal pack, unless they become the alpha animal. Maturing adult wolves thus adhere to the optimum breeding strategy (Fritts & Mech 1981).

Dispersal extent.--Wolves are capable of extensive travel. Yearlings and pups disperse both short and long distances and may travel more than 200 km, which approximately equals 10 pack territories. Dispersing adults on the other hand tend to disperse shorter distances of less than 50 km to nearby territories. Males predominate in long distance movement (Gese & Mech 1991).

Inter-territorial travel.--Pack territories usually cover larger areas in the winter than in the summer. Pack members travel extensively within their territories before the breeding season, from October through November (Gese & Mech 1991). During this time, subordinate pack-members often explore the territory perimeter to obtain information about dispersal options (Fritts & Mech 1981, Gese & Mech 1991).

4.1.2 **Movement variables**

Optimum routes.--Physical features and patch quality of fragments are important for wolf connectivity (Paquet et al. 2006). Wolves select their travel routes based on factors including prey distribution, habitat quality and human activity (Paquet et al. 2001). Optimum routes for wolf travel are characterized by a combination of security and energetic efficiency (Duke et al. 2001).

Movement barriers.--Wolves are displaced from their preferred habitats and travel routes primarily by physical structures and human facilities (Paquet et al. 1996, Duke et al. 2001). Examples of human caused disturbances and terrain that constitute major impediments to wolf movement include large water bodies, resource exploitation, highways, pollution and human settlement (Paquet et al. 1996). The permeability of these barriers varies with structure, location and degree of human disturbance (Duke et al. 2001, Paquet et al. 2001). Wolf avoidance of human dominated areas is primarily a result of human caused mortality (Fuller et al. 1992).

Roads.--Wolves actively avoid high road densities as a result of direct road mortality (see 3.1.3) (Thurber et al. 1994, Carroll et al. 2001) and keep a minimum distance of 400 m from heavily trafficked roads (Paquet et al. 1996). Particularly highways constitute a serious movement barrier and mortality threat to large carnivores (Beier 1993, Paquet et al. 1996). However, wolves may use roads that receive limited human activity as routes for easy travel (Thurber et al. 1994, Paquet et al. 1996).

Snow.--Wolf-mobility is impaired by certain combinations of snow depths and densities (Paquet et al. 1996). The wolf’s relatively short legs and low chest height impair movement in soft, non-compacted snow where they sink more than 40-50 cm (Peterson 1977, Paquet et al. 1996). Snow depths vary with habitat cover, where coniferous habitats hold less snow than deciduous and open habitats. Wolves also prefer travel low elevated valleys with frozen water, shorelines and ridges in the winter due to lower snow depths that provide for ease of movement (Paquet et al. 1996).

Trails.--Compacted pathways allow for efficient movement in deep snow (Mech

1970, Paquet et al. 1996). Wolves often travel natural wildlife trails through habitats with moderate snow depth, such as riparian and closed coniferous forests. In open habitats where off-trail snow depths exceed 40 cm, wolves are more inclined to use manmade paths including winter roads, power line corridors and snowmobile- and ski-trails. Although human created paths enhance and expand wolf movement, they artificially open access to agricultural and urban areas with the risk of arising human conflicts (Paquet et al. 1996).

Natural areas.--Dispersing large carnivores are more tolerant to movement barriers such as highways, rivers and open areas compared to resident animals. Nevertheless; dispersing carnivores avoid urban areas and utilize forest cover wherever possible (Meegan & Maehr 2002). Wolves select forested areas due to lower levels of human interference and avoid crossing open and disturbed areas such as agricultural, pasture and urban land (Fritts et al. 1992, Licht & Fritts 1994). Regardless of the proximity to disturbance, any forested patches serve to buffer edge effects (Meegan & Maehr 2002). Riparian areas, shrub and wetland are examples of other habitats that offer protection from human exposure (Licht & Fritts 1994).

Edges.--Wolves that travel across patchy landscapes with sharp boundaries between natural and disturbed land select forested areas while avoiding extensively open spaces (Fritts et al 1992). Reserve borders often represent population sinks because of wolf mortality arising from conflicts with neighboring people (Woodroffe & Ginsberg 1998, Noss 2001).

Prey.--The time spent within an isolated patch is related to food availability. Feeding opportunities may facilitate connectivity, although the effect of barriers that impede wolf movement is greater (Paquet et al 2006).

Water.--Rivers and creeks provide natural movement corridors for many species (Beier 1993). Wolves are known to parallel river shorelines and may adapt to swim across at shorter shore distances in the summer (Paquet et al. 1996, Paquet et al 2006). However, permeability of frozen water may constitute an impediment to travel in the winter (Paquet et al. 1996).

Resilience.--The influence exerted by any disturbance on wolf dispersal is case specific and dependent on complex interactions over time and space (Paquet et al. 1996, Mladenoff et al 1999). Individual wolves and populations react and adapt differently to local human induced activities (Paquet et al. 1996, Blanco et al. 2005). For example, four-lane high ways and extensive human disturbed landscapes do not comprise wolf movement barriers in some (Mech 1995, Blanco et al. 2005). Wolf populations that have expanded into semi-developed areas may be locally habituated to human activity and less reluctant to cross highways than wolves in wilderness areas (Blanco et al. 2005). Wolves may further adjust to travel across poor-quality, human disturbed habitats by rapid movement (Garret and Franklin 1988, Wigget and Boag 1989, Rosenberg et al. 1997), or by travel at night (Carbyn 1980). It can however be generally applied that successful dispersal of wolves across human modified landscapes depends on protection against human caused mortality (Height et al. 1998).

4.2 WOLVES BETWEEN RMNP AND DMPP&F

4.2.1 **Movement outside RMNP**

At times of over crowding and scarce resources, individual wolves may be expelled from their established packs in RMNP and forced to search for new territories across surrounding land (Fritts 1981). Given the small size of RMNP, it is likely that wolf territories extend outside the park border also under normal conditions. Wolves may be attracted to move outside the park boundary by prey that uses habitats on surrounding parkland (Goulet 1997). Elk-cows are for example known to raise their calves on open agricultural land outside RMNP as a strategy to avoid predators (Paquet & Brook 2004).

Movement deterrents.--Ungulate telemetry studies have demonstrated that elk move between RMNP and the DMPP&F (R.K Brook, University of Manitoba, unpublished data 2003). However, genetic differences in DNA of wolves in RMNP and DMPP&F indicate that exchange of wolves between the parks is rare (Goulet 1999). Wolves in RMNP are likely reluctant to move outside the park due to local hostility and high vulnerable to human exploitation on surrounding land (Carbyn 1980). Recent telemetry studies from RMNP indicate that death is the likely fate of wolves that remain outside the park for extended periods, based on omitted transmitter signals (A.V Stronen, University of Calgary, unpublished data 2004).

Human attitudes.--Eastern European settlers brought negative attitudes of wolves to the RMNP area (Carbyn 1980, Goulet 1999). These attitudes were often based on myths and perceptions that became further reinforced by occasional cases of livestock-predation. Today, the public generally supports presence of the predator in southwestern Manitoba, although residents adjacent to RMNP express divergent attitudes towards wolves in the area (Carbyn 1980). A study on local wolf tolerance suggests that education, age and gender are main factors that determine attitudes and knowledge about wolf-ecology. Local residents and livestock producers obtained the lowest knowledge score in the survey, whereas their attitudes were between positive and negative. Local outfitters obtained the highest knowledge score while they also expressed the least positive attitudes towards the animal (Ponech 1997). This finding is peculiar, as trappers and hunters generally support wolf restoration because of their great knowledge about the animal's ecological importance (Kellert et al. 1996). A more recent local study found that believes and perceptions had the strongest affect on attitudes towards wolves, while education and age were of less influence (Stronen et al 2007). The most positive attitudes towards wolves in the RMNP area are often found among environmental groups and urban park visitors (Carbyn 1980).

Eradication.--Given infrequent wolf problems in the area, local outcry against the wolf population in RMNP has been rare (Carbyn 1980). Livestock predation and personal safety are however major concerns for local residents and some individuals still call for complete eradication of wolves in the park (Carbyn 1980, Ponech 1997). Although there was never a structured wolf control program around RMNP (Carbyn et al. 1975), local trapping and shooting of wolves has occurred since early human settlement in the area (Goulet 1999). Most reported wolf kills have been from along the park's southwest corner, the mid-northern "notch" area and adjacent to the Ochre River and Henderson Creek (Carbyn 1980). The major factor to wolf mortality around the park is local negative attitudes that contribute to blames for unresolved cases of predation and vanished livestock (Goulet 1999). An estimated 70% of the RMNP wolf population is vulnerable outside the park boundaries due to human exploitation (Carbyn 1989), which limits wolf distribution between the parks (Mech 1970).

Protection around RMNP.--In response to recent declines in the RMNP wolf population, Manitoba Conservation imposed a regulation in 2001 that exempted wolves from permitted hunting in General Hunting Areas (GHA) 23 and 23A that surrounds RMNP (Manitoba Conservation 2006). Despite the regulation, human inflicted and illegal wolf mortality likely persists unreported in the area. A study showed that out of nine wolves poisoned or shot by local residents east of the DMPP&F, only six of the kills were reported (Goulet 1999). To secure a future, stable wolf population in RMNP, there is need to monitor human-interactions outside the park boundaries (Fuller 1989).

Regional wolf protection.--Compared to RMNP, relatively little conservation efforts are in place within and along the boundary of DMPP&F. More lenient conservation regulations in the Provincially Park include restricted use of motorized all-terrain vehicles, permitted hunting and trapping regulations as well as regulated industrial activity that includes clear cutting. There are no official estimates of the wolf population size in DMPP&F, although registered trap-lines provide some information (L.Bruces, Dauphin Manitoba Conservation Officer, personal communication 2003). Hunting of wolves is further permitted from the southern boundary of DPMPP&F to highway 5 in GHA 18, 18B and 18C (Goulet 1999, Manitoba Conservation 2006).

Livestock predation.--Reported livestock predation incidents in the RMNP-area from 1993-98 mentioned wolves in 21% of a total 350 cases. One should note that only one of the claimed wolf reports was confirmed (Goulet 1999) and that many local people are known to mistake coyotes with wolves (Stronen et al. 2007). Predation reports were highest in the Grandview district and east of DMPP&F (Ranges 21 and 22, Townships 26 to 32) (Goulet 1999). A recent local study found that most wolf observation and damage were within 30 km from either park boundary (Stronen et al 2007). The fact that livestock predation diminish with an increased distance from the parks suggests that wolf-movement between the RMNP and DMPP&F is uncommon (Goulet 1999). Local residents have however expressed concern about increased wolf activity outside the DMPP&F, which may be linked to socially disrupted pack hierarchies due to human caused mortality (Carbyn 1980).

Compensation.--Manitoba Crop Insurance Corporation (MCIC) introduced a local predator damage compensation program in 1997 to compensate livestock owners in the area for eligible predation claims. The program encourages livestock producers to discourage predators from attractants such as easily obtained food sources. Suggested animal husbandry practices include proper disposal of carcasses, supervised calving and regular check of livestock (Goulet 1999).

4.2.2 **Wolf management between the parks**

Surrounding park land.--In contrast to buffered nature reserves in other places, human disturbed land surrounds RMNP (Carbyn 1989). Protection of corridors that create linkages to the DMPP&F has the potential to reduce the risk of genetic isolation of wolves in RMNP (Carroll et al. 2003). Because it is difficult to reverse existing effects of development, conservation in the area should focus on protecting remaining natural patches from modification (Beier 1993, Carroll et al. 2003). Development and activities that isolate or destroy the natural landscape should be avoided (Beier 1993). Establishment of managed biosphere- or buffer-zones adjacent to the protected reserves could reduce the risk of isolated wildlife populations (UNESCO 1974). Because areas surrounding RMNP mostly comprise private land, it may however not be feasible to buffer around the whole park (Shafer 1990).

Human tolerance.--Future perceptions and attitudes held by local residents determine whether wolves are to persist in the RMNP area (Carbyn 1980) because human attitudes shape laws and policies related to wolf conservation (Fritts & Carbyn 1995). Information-sessions and workshops on livestock predation may facilitate acceptance of local wolf conservation by educating landowners about the importance of large carnivores (Goulet 1999), for example as a natural regulator of Bovine Tuberculosis that is spread by local elk (Stronen et al 2007). Compensation programs further serve an important role to increase tolerance for wolves and other large carnivores (Fritts et al. 1992).

Legal mandates.--RMNP serves an important role under federal protection to ensure that viable wolf populations persist as part of the ecosystem. On the other hand, provincial wildlife branch policies and regulations that govern the DMPP&F aim at resource use and predator control (Goulet 1999). Management of a regional wolf population and dispersal through established buffers and corridors requires a joint federal- provincial effort (Carbyn 1980).

4.2.3 **Purpose & Objectives**

Purpose.--The purpose was to identify focus areas for management of corridors between RMNP and DMPP&F, based on cover types that sustain wolf dispersal between the parks.

Objectives.--Specific objectives were to:

- Provide existing information about wolf presence between the parks
- Assess availability of different cover types in the area
- Identify specific land cover types selected by wolves outside the park boundaries
- Identify barriers to wolf movement between RMNP and the DMPP&F
- Assess the influence of prey on wolf presence outside the park boundary
- Provide a map of land best suited for dispersal of wolves between RMNP and DMPP&F where conservation efforts should be focused

4.3 STUDY AREA

See 1.4.3.

4.4 METHODS

4.4.1 Land categories

Land cover.--FRI-data for FMU 10, provided by MLI, formed basis for the analysis of land cover selection between the parks. I created a land cover-layer in ArcView 3.1 by merging FRI-tiles through the Geoprocessing Extension. I used the FRI to represent land cover in the area, given its detailed land classification that could be narrowed into customized land categories. The original FRI-data was reclassified into 18 new land classes believed to provide sufficient details for identification of wolf selection. The FRI-data further proved to fit relatively well with local orthophotos that resemble the regional landscape with high precision (R.S. Frey, Parks Canada, Ecosystem Data

Specialist, personal communication 2003). The biggest shift in the FRI tiles of the area compared with the orthophotos was estimated to 55 m.

Roads.--Given previous findings that roads exert significant influence on wolf movement, I used a detailed data layer provided by the Prairie Farm Rehabilitation Administration (PFRA) to represent the road layer. The road data was categorized in 3 classes. “Provincial Trunk Highways” were all paved, major highway roads maintained by the province. “Provincial Roads” were 2-lane gravel- or paved roads designated and maintained by the Provincial Department of Transportation. “Other roads” include everything from roads in towns, cities and villages, to Rural Municipal roads that can vary in condition and maintenance from single lane dirt trail roads to well maintained 2-lane gravel roads (J.B. Hewitt, Prairie Farm Rehabilitation Administration Manitoba, personal communication 2006). The different road categories were assumingly related to relative traffic volumes, where “Provincial Trunk Highways” received the highest and “Other” the lowest traffic pressure.

4.4.2 **Exploratory land-data analysis**

Availability and distribution.--The spatial distribution of land cover between RMNP and DMPP&F was visualized in GIS by ArcView 3.1. I highlighted each land class separately in the data attribute table, to better visualize the spatial distribution of individual land types. I calculated in Excel the proportional abundance of each land class based on total available land cover. I also created maps to visualize each of the road categories.

Distance to RMNP.--I calculated the distance from each of the 18 land- and 3 road-classes to the RMNP and the DMPP&F boundaries by a nearest neighbor analysis.

The nearest neighbor algorithm assigns objects mapped in multidimensional space to classes, based on closest training examples. Points are commonly assigned to the most frequent class among k nearest training samples, based on Euclidean distances. The analysis was performed in Arc View 3.1 by the "Compiled Theme Tool"- extension under the "find nearest feature"- option. I used the resulting tabulated distances to create frequency histograms in Data-Desk, where the frequency axis represented occurrence of land data polygons. Distance bins were set to 500 m to account for the precision error in the data layers. I corrected the histograms in Adobe Illustrator and saved the final version as bit-map.

Ground-level experience.--Together with a research assistant, I traversed the land between RMNP and the DMPP&F by foot to gain ground level information about presence of potential movement barriers for wolves in the area. The hike was commenced on 18 June 2003 and preceded over the next 1.5 day with overnight camping between the parks. The route followed along the hike was undetermined at start. Because the aim of the hike was to experience the area from the perspective of a traversing wolf, we avoided human contact and followed forested patches wherever possible.

4.4.3 **Wolf presence data**

Local interviews.--Interviews with local residents were conducted to gather preliminary information about wolf movement and potential corridors in the area. Other objectives served by the interviews were to create local awareness about the research project and to establish connection with land-owners for future wolf activity references. The interviews were thus conducted as informal, personal discussions during Jul-Oct 2002. I selected residents to interview based on their proximity to the RMNP boundary as well as based on recommendations from other landowners. During interviews at appointed times at their residences, landowners were briefed about the study and questioned about wolf- and other wildlife activity in the area (see Appendix B.3). The researcher recorded answers and comments made during interviews on paper and later compiled the results as an interview summery. 60 residents in total were interviewed between the parks, not including discussions with local park-wardens and conservation officers.

Interest groups.--Provincial, federal and non-government organizations with stake in local conservation issues were further contacted and visited over the period of conducted field-work. Agencies visited included Local Manitoba Conservation branch-offices (Dauphin, Grandview Roblin), Rural Municipalities (Hillsberg, Gillbert Plains, Grandview, Dauphin, Shellmouth-Boulten and Shell-River), Prairie Farm Rehabilitation Administration (PFRA), Tootinaowaziibeeng Treaty Reserve (Valley River First Nation Reserve), Manitoba Crop Insurance Corporation (MCIC) and The Nature Conservancy Canada (NCC). Communication with representatives from these groups provided additional information about wolves in the area and further served in local advertisement. MCIC further supplied local data on wolf-predation claims by quarter section that were mapped and visualized in ArcView 3.1.

*Wolf-trackin*g.--Wolf-tracks in the snow were recorded between the two parks during winter 2002-03 to gain direct evidence of wolf presence in the area. Accompanied by a volunteer research assistant, I located tracks that initiated from either of the park boundaries while snowmobiling along the northern RMNP border and the southern DMPP&F border. I searched for tracks further from the parks by driving a 4-wheel drive vehicle along systematic transects on the roads between the parks, as well as from trails by snowmobile or skies. The contacts established with local residents and representatives from local interest groups further proved useful to acquire tips regarding wolf-track locations. Tracks identified as wolf prints in accordance with assistance advice or a track-guide were followed by foot, snowshoes or snowmobile exterior to the park-boundary and recorded from its origin to its furthest end-point. A 12 channels Garmin Etrex GPS was used to record the track position, as well as changes in habitat, snow depth, gate, estimated number of animals, and signs of other wildlife.

4.4.4 **Habitat selection**

*Track data managemen*t.--The GPS recorded track-point data were sorted in Excel. I saved joint track location points as individual tracks (dbf- files) that were exported to ArcView 3.1 and viewed as separate themes. Adjacent points included in the same track were recorded at roughly the same time and likely represented the same animal in the same habitat. To minimize the effect of temporal and spatial autocorrelation, I only included points 100 m apart along a track in the analysis because most polygons were separated by this distance. To achieve this, points of a continuous track were converted to a poly-line by the “X-tools”-extension in ArcView 3.1. I than used the “Points & Polyline tools 1.2”-extension, where the “Poly conversion to spaced points”- option allowed me to select points at a specified distance along the poly-line. Out of the total 2521 GPS recorded track points, only 775 track points remained after I had discarded points less than 100m apart. The remaining track-points from separate tracks were merged to a single table that was used for analysis.

Distances to land features.--The selected track points were overlaid on the layers representing land cover and the park boundary in ArcView 3.1 (I conducted a nearest neighbor analysis to find the distance from the track point to the closest polygon of each land class, by same methods as described above (see 4.4.2 Exploratory land-data analysis). I graphed the resultant distances in Data-Desk as histograms with 500 m distance bins and the frequency axis representing observed wolf track points. Final corrections to the histograms were made in Adobe Illustrator. I further conducted a nearest neighbor analysis to find the distance from all track-points to the RMNP and the DMPP&F boundaries. The same methods were also used to create histograms representing distance from all track points to each of the road-classes .

Assessment of selection.--To detect selection for or against particular cover types, I visually compared the graphed distances from tracks to individual land classes with the distance from the same class to the RMNP boundary. I compared the distance from land cover to tracks versus park border with the assumption that RMNP comprise the preferred habitat and origin of tracked wolves. I further visually assessed the track distances with the proportional abundance and spatial distribution of land classes. By visually comparing the graphed distance frequencies with spatial GIS data, I assured to account for the spatial distribution of land classes in the selection assessment. A combined evaluation of findings from quantitative tests in conjunction with spatially based GIS data provided a comprehensive result assessment (D.J. Walker, University of Manitoba, personal communication 2004).

4.4.5 **Ungulates related to greenness**

Tasseled cap.--A tasseled cap transformation converts six of the reflectance bands in a Landsat based thematic map into three major axes of variation that are fixed for all data. These axes are standardized directly from unclassified satellite imagery and represented as tasseled cap indices. Indices including greenness, brightness, and wetness may be correlated with other ecological factors and metrics, such as vegetation and habitat. Greenness has previously been related to primary productivity and abundance of prey species (Carroll et al. 2001).

Data sources.--I evaluated the influence of prey occurrence related to vegetation on wolf selection for land between the parks by producing a Tasseled cap map of greenness. Ungulate locations derived from recorded kills by hunters and predators (1998-2002) as well as live animals monitored by telemetry (2005) served as input prey-data. I further used wolf-locations from GPS recorded track points and radio telemetry points as sources for input wolf- data. The landscape layer was produced by a tasseled cap analysis on band 1,2,3,4,5, and 7 on a Landsat 7 image from Jul. 2001 for the area from northeastern RMNP to the southern edge of the DMPP&F (62N), which was downloaded from the MLI digital imagery website.

Methods.--A linear, tasseled cap transformation was performed on the six reflectance bands (1,2,3,4,5 and 7) in the Landsat 7 image of the area, primarily to isolate greenness that included dense, vegetative cover. Each of the spectral bands was multiplied with an individually weighted eigenvector by a standardized ETM formula. The red and near infrared band 3 and 4 were weighted the strongest, because these bands were associated with photosynthesis of green vegetation. Combining the resultant linear transformations from all six bands produced a tasseled cap image of greenness values, representing levels of primary productivity. The tasseled cap values were grouped in 10 different clusters identified by an iterative, self-organized unsupervised classifier, based on the maximum likelihood procedure. Two of the clusters of the tasseled cap image were visually identified to represent tree-cover that assumingly represented prime ungulate habitat. Together with clusters identified as water and marsh, the greenness clusters were isolated to a separate image on which the prey-data was overlaid and associated with habitat types. Wolf- data was further added to the layer and associated with presence of ungulates and forested clusters.

4.5 RESULTS

4.5.1 **Land cover**

Cropland was the most abundant land class between RMNP and the DMPP&F (Figure 4.5.1-1, Table 4.5.1-1). Other cover classes representing human land modifications included human disturbed, town site and roads, which all were evenly distributed across the landscape (Figure 4.5.1-1). Human modified land represented 67% of the total land (Table 4.5.1-1) and thus comprised the core matrix of the area (Figure B.1-3). Remaining natural land cover classes between the parks were imbedded as fragmented pockets within the human modified matrix.

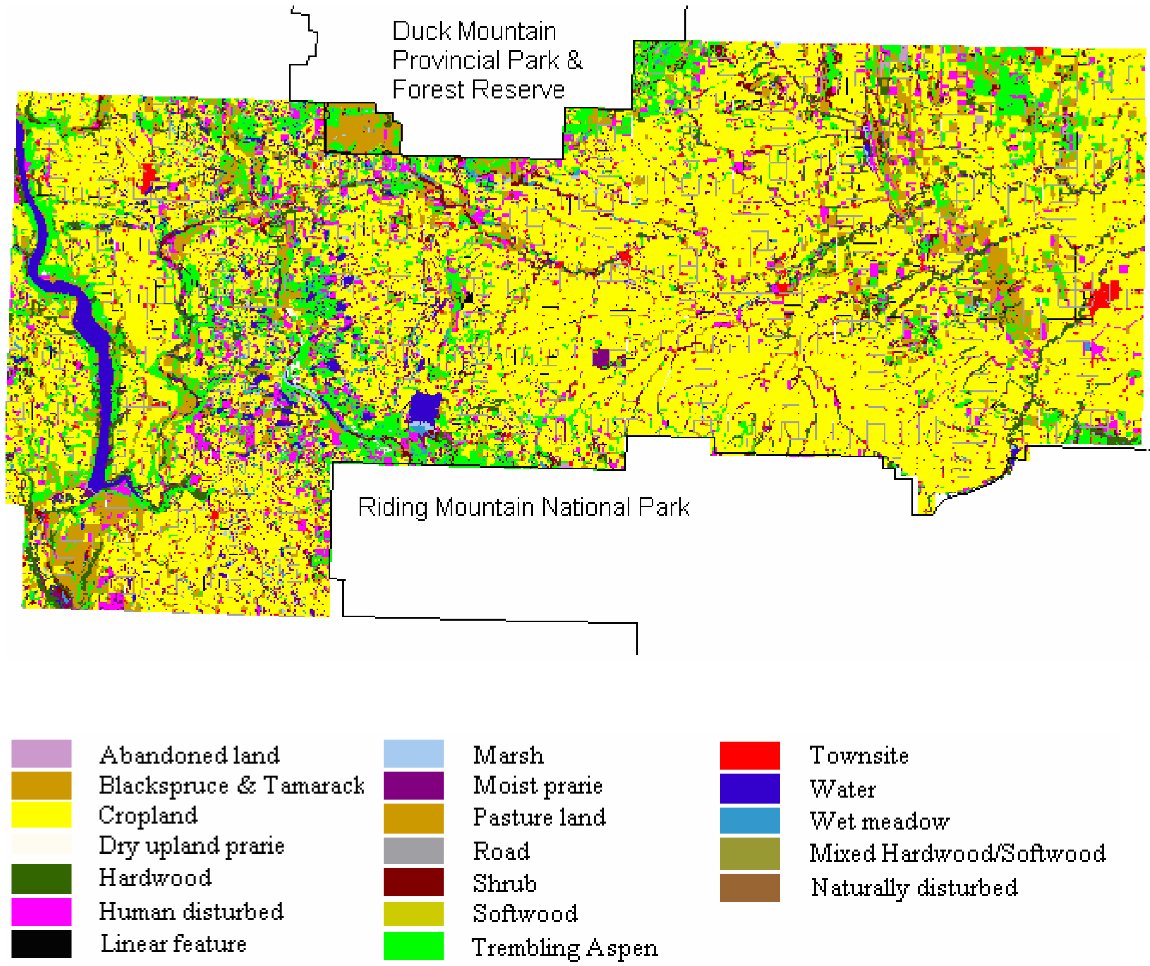


Figure 4.5.1-1: Classified land cover based on FRI-data (MLI 1980-81) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

Table 4.5.1-1: Proportional distribution (%) of land FRI-based cover-classes (km^2) (MLI 1980-81) between RMNP and DMPP&F, Manitoba.

Land cover*	Total area (km^2)	Percent
Cropland	2468.77	56.96%
Trembling Aspen >=70%	481.14	11.10%
Pasture land	343.04	7.91%
Human disturbed	187.91	4.34%
Hardwood	169.88	3.92%
Roads	138.86	3.20%
Moist prairie	127.60	2.94%
Town site	101.37	2.34%
Water	96.22	2.22%
Shrub	92.03	2.12%
Wet meadow	43.38	1.00%
Linear feature	25.27	0.58%
Marsh	24.21	0.56%
Black Spruce & Tamarack	10.24	0.24%
Abandoned land	9.94	0.23%
Softwood	4.89	0.11%
Dry upland prairie	4.27	0.10%
Mixed hard/softwood	4.10	0.09%
Natural disturbed	1.16	0.03%
Total	2468.77	100%

**See Table B.1-1 for original FRI- classes contained within the revised land classes*

4.5.2 **Interview Results**

Table 4.5.2-1: Summary of informal interviews conducted Jul-Oct 2002 with local landowners about wolf activity in the area between RMNP and DMPP&F, Manitoba.

Variables	Categories	Results related to wolves
Sighting	*Frequency*:	Rare
	Quantity:	1-3; larger packs seen in the past
Movement	*Behavior*:	Zigzag between park and bordering land
	Selected land-cover:	Forest for protection, open fields and roads for ease of movement, same as prey (i.e. rejuvenated bush)
	Linear features:	Creeks, roads, snowmobile trail i.e. along park-border
Prey affect	*Occurrence*:	Wolf tracks common along deer and elk tracks
	Behavior:	Follow prey that are forced to search forage outside park in winter due to heavy snow/ wolves remain in park because their advantage over prey in deep snow
	Edge affect:	Remain along forest borders while prey species are less reluctant to use open habitats
Dispersal	*Behavior*:	Triggered by scarcity of food within their habitat. Wolves remain close to park border because prey feed on adjacent cropland
	Corridors:	Along unpopulated valley- and swamp areas; i.e. “Rose Ridge” and “Pleasant Valley” corridors
Livestock-predation	*Negative:*	Frequent on cattle-calves adjacent to the Ethelbert community pasture
	Positive:	Wolves coexist adjacent to cattle and attacks are abnormal
Local attitudes	*Negative*:	Economic concerns, competition with hunters. Want fence around park. Aversion to national park staff, provincial conservation officers and local research
	Positive:	Trappers and hunters are most conservation minded because they recognize the role of wolves in maintaining a healthy big game population.
	Valley River First Nation:	Reserve members traditionally sympathize with wolves and utilize natural resources responsively
Wolf kills:	*Reason*:	Landowners fear wolves that approach calves, cattle or fenced property
	Result:	Landowners kill wolves that enter private property

See Appendix B.4 for a more detailed summary of interviews

4.5.3 **Wolf Presence**

Most recorded tracks followed established trails along the park boundary or zigzagged between the park and land adjacent to the park perimeter (Figure 4.5.3-1).

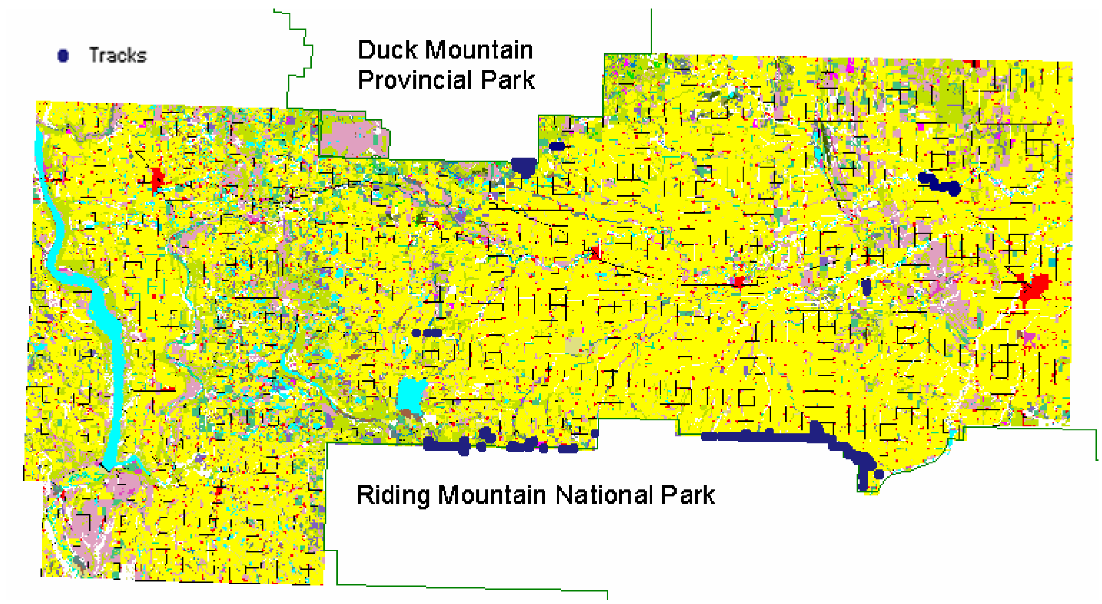
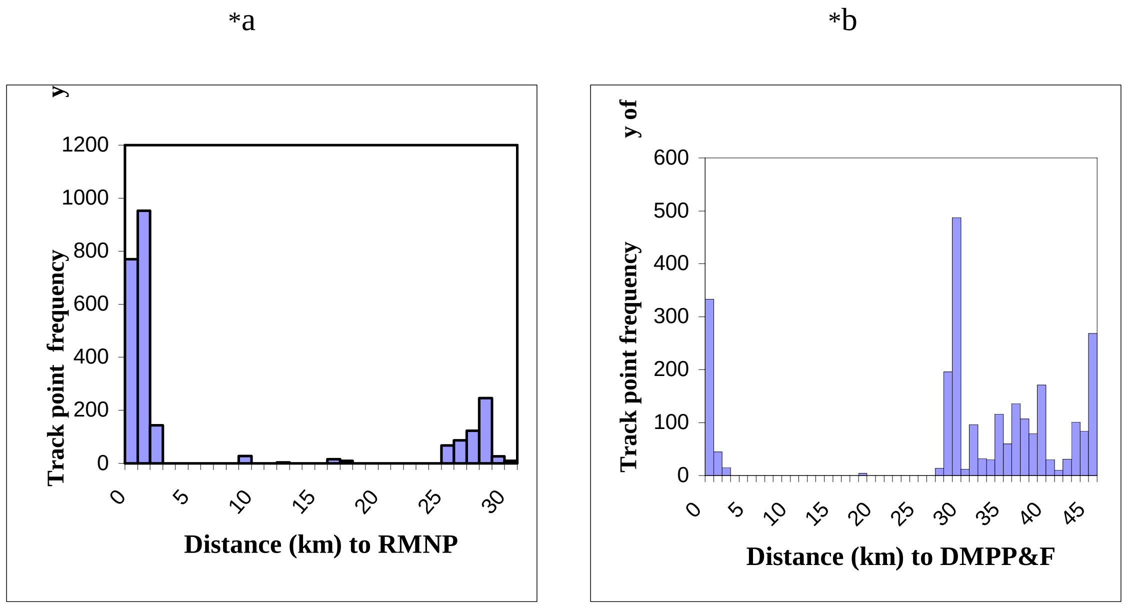


Figure 4.5.3-1: GPS-recorded track locations (winter 2002-03) related to FRI-based land cover (MLI 1980-81) between RMNP and DMPP&F, Manitoba (1:15,840).

4.5.4 **Tracks related to land features**

Boundary distances.--Most of the recorded wolf tracks were found adjacent to RMNP, while there were less tracks adjacent to the DMPP&F and very few tracks between the two parks (Figure 4.5.4-1).



** The beginning of the distance scale represent adjacency to the specified park, while track-points that falls at the end of the distance scale are closer to opposite park (40-50 km distance from RMNP to DMPP&F).*

Figure 4.5.4-1: Frequency of GPS recorded wolf track points (winter 2002-03) within a specified distance (km) from the borders of RMNP (a) and the DMPP&F (PFRA 2001) (b), Manitoba.

Land cover selection.--Distances from land cover to tracks compared to distances from land cover to RMNP indicate that vegetated land is selected for outside the park, including hardwood, mixed hardwood/softwood**,** shrub, softwood and Trembling Aspen (Table 4.5.4-1). Also water**,** wet meadow, marsh-land, and Black Spruce-Tamarack appear to be selected by wolves between the parks (Table 4.5.4-1). Results further show that wolves actively avoid roads with high traffic volumes, such as provincial roads and the provincial trunk highway (Figure B.6-2, Figure B.6-3).

Table 4.5.4-1: Summed results of FRI- based land classes (MLI 1980-81) selected by wolves between RMNP and DMPP&F, Manitoba, based on visual assessment of the nearest distance from GPS-recorded tracks (winter 2002-03).to cover class compared with the distance to the RMNP boundary (PFRA 2001), considering the spatial and proportional distribution of the land class.

Land cover class[a]	Occurrence[b]	Distribution[b]	Cluster shape[b]	Spread from RMNP[b]	Results[c]
Abandoned	rare	uneven	patchy	widespread	N/A
BS, T, T & M	rare	skewed	patchy	distant	S
Cropland	abundant	even	patchy	widespread	N/A
Dry upland prairie	rare	uneven	patchy	adjacent	N/A
Hard wood	frequent	uneven	fine, joined	adjacent & between	S
Human disturbed	common	even	regular	widespread	N/A
Linear	rare	uneven	fine, regular	distant	S
Marsh	rare	uneven	fine	distant	S
Mixed HW	rare	skewed	patchy	distant	S
Moist prairie	moderate	even	fine, irregular	widespread	N/A
Natural disturbed	rare	skewed	fine	further	N/A
Pasture	abundant	even	patchy, clumped	widespread	S
Shrub	moderate	even	fine, joined	widespread	S
Soft wood	rare	skewed	patchy	distant	S
Trembling Aspen	abundant	uneven	joined patches	adjacent & distant	S
Town site	moderate	even	regular	widespread	N/A
Water	moderate	uneven	fine & regular	distant	S
Wet meadow	rare	uneven	fine	adjacent & between	N/A

[a] *See Figure B.5-1 - B.5-18 for assessment of each cover-class.*
[b] *Classification relative based on visual assessment*
[c] *S = selected, N/A = results not available due to lack of data.*

Land cover selected by wolves outside the park boundaries remain only as fragmented, non-continuous patches in the area (Figure 4.5.4-2).

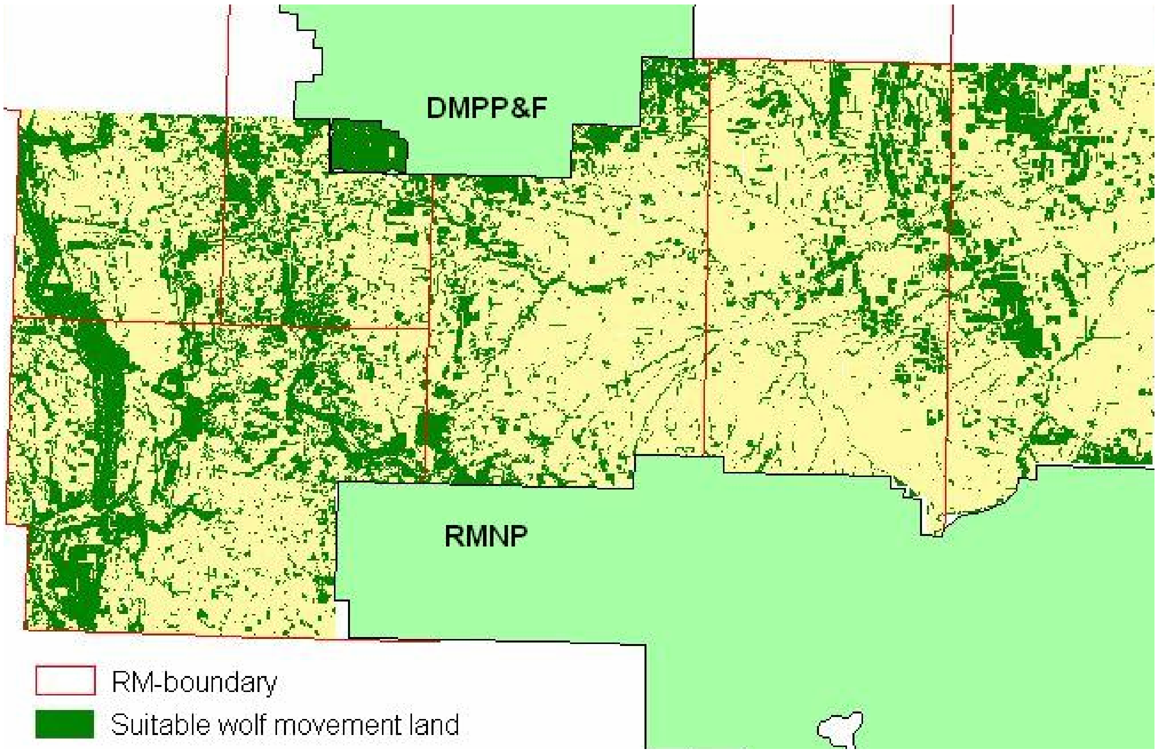


Figure 4.5.4-2: Spatially highlighted combined results for FRI-based land cover (MLI 1980-81) selected by wolves between RMNP and DMPP&F, Manitoba based on nearest distance from tracks and park boundaries (PFRA 2001) as well as spatial and proportional distribution of land cover (1:50,000).

4.6 DISCUSSION

4.6.1 **Avoidance of travel areas**

Human disturbance barrier.--Scarcity of tracks at a distance away from RMNP (Figure 4.5.4-1) suggests that wolves are reluctant to leave the protected habitat within the park for surrounding land. Interviews with residents in the area indicated that local negative attitudes towards wolves are associated with mortality risks for the animal (Table 4.5.2-1). Human presence is therefore likely to constitute a barrier that deters wolves from moving outside the park (Carbyn 1980). Results further show that wolves actively avoid roads with high traffic volumes, such as provincial roads and the provincial trunk highway (Figure B.6-2, Figure B.6-3). Although widespread distribution of human modified land prevented findings of avoidance, these land classes likely constitute barriers to wolf movement in the area because of associated human pressure. Given the abundance of human exploited land (Table 4.5.1-1, Figure B.1-3), it can be concluded that the area between the parks provides a hostile environment for wolf movement. Heavy hunting pressure on ungulate around the park boundary (Figure A.4-1) is another likely deterrent for wolves to leave the park during hunting season in the winter.

4.6.2 Selection for travel areas

Undisturbed areas.--The fact that most tracks were found adjacent to RMNP (Figure 4.5.4-1) support the assumption that the park comprises the preferred habitat and origin of most tracked individuals. Wolves in RMNP are locally adapted to a relatively undisturbed environment in the park and naturally avoid disturbed areas (see results from chapter 3). Results from assessment of land cover selection indicate that wolves outside the protected park boundaries select land remote from human interference, including wetland, waterways and vegetated areas (Table 4.5.4-1). Avoidance of human disturbance is assumingly related to avoidance of detection and associated mortality threat (Licht & Fritts 1994). The resultant selection for pasture land is not necessarily related to predation of cattle, since many pastures not used in winter when tracks were observed. Wolves are more likely to select pastureland outside the parks because these often occur near forested, undisturbed land.

Linear corridors.--Concentration of tracks along the cleared park boundaries (Figure 4.5.4-1) indicates that wolves outside the park prefer travel along linear, compact routes adjacent to forest cover. Assessment of land cover selection further indicate that wolves select linear features as travel routes outside the park boundaries including frozen waterways (Table 4.5.4-1). Previous studies support that wolves utilize compact routes to increase the efficiency of travel during periods of greater snow depths (Mech 1970, Paquet et al. 1996). Although there are no supporting results (Figure B.6.1), wolves may use low use roads in the area for ease of travel in the winter.

Prey influence.--Observed track data and local interviews (Table 4.5.2-1) support that wolves utilize the same travel paths as their prey outside the park boundaries. Visual assessment of prey and wolf data related to greenness (Figure B.8-1) confirms that there is no apparent relationship between wolves and ungulates outside the park boundaries. Given a stable prey base within the protected park (Carbyn 1980), it is questionable whether wolves leave RMNP specifically to hunt on surrounding, unprotected land. Lone wolves expelled from their territories may however be forced to search for prey on unoccupied land outside the park boundaries. Snow conditions in the park may further attract ungulates and wolves to surrounding land.

4.6.3 **Presence of corridors**

Effects of disturbed land.--Although capable of extensive travel (Gese & Mech 1991), wolves are deterred from movement by human induced activities and disturbances (Paquet et al. 1991, Paquet et al. 1996, Chapter 2). Undisturbed land selected by wolves outside the park boundaries is present only as fragmented patches (Figure 4.5.4-2). There does not seem to be any continuous structurally connective corridors that offer protection from edge effects for wolves that attempt to move between RMNP and DMPP&. The difficulty of remaining within protective forest cover while moving between the parks was further experienced first hand on the ground (Figure B.7-1). Wolves are however highly resilient and individual animals may adopt to withstand altered landscapes (Mech 1995, Paquet et al. 1996). It was proved possible for two people to hike between the RMNP to the DMPP&F undetected by human (Figure B.7-1). Provided their resilience, wolves could possible traverse the area by using remaining undisturbed land patches as stepping stones and moving rapidly across land with high human interference. Although there are no existing structurally connected corridors between the parks, there may thus still be functional connective corridors available for wolf-movement. Both corridors and barriers are likely not be stationary fixed but vary temporary with the risks of human detection. Wolves may for example stand a greater chance to avoid human activity by traveling at night or using agricultural croplands for protection in the summer. Although excluded from hunting on land surrounding the park, wolves may further be deterred from moving outside the park in the winter due to heavy hunting outside the boundaries on other big game.

Adaptability to disturbance.--Although few tracks were found away from the park-boundaries (Figure 4.5.3-1), there were several wolf predation compensation claims between the parks (Figure B.9-1). Claim locations seem to be a concentrated in the western section of the study area, in the Rural Municipalities of Shellmouth-Boulten, Hillsberg and Shell-River. These predation locations coincide with the highest concentration of land identified as most suitable for wolf movement (Figure B.9-2). Most of the claims do however not fall directly within the identified selection areas. Although it is possible that the claims were faulty assessed as cases of wolf predation, this may indicate that wolves that predate on livestock do not require remote, undisturbed areas. A potential explanation is that a few wolves have become habituated to human activity and livestock predation. Based on the results from this study, it can however be concluded that the majority of the wolves in the RMNP are locally adapted to undisturbed land. Wolf movement between RMNP and DMPP&F therefore depends on areas that are free from human impacts and threatening activities.

Movement evidence.--Although a few wolf tracks and predation claims were present at a distance away from either of the park boundaries, there is no concrete evidence that wolves actually are moving between the RMNP and DMPP&F. Telemetry-from collared wolves could potentially provide evidence of individual exchange between the parks. To date, no evidence of movement to the DMPP&F can be established from transmitter signals of recently collared wolves in RMNP. Data from GPS collars has the potential to provide more extensive information about actual paths and cover types used by traveling wolves. Ongoing DNA analysis of wolf tissues may further provide clues about if the wolves in RMNP and the DMPP&F are separate, isolated populations or part of a genetically interchangeable regional population.

4.6.4 **Study limitations**

Data collection methods.--The track data that formed base for the selection results was limited by the collection methods. Given the vast size of the area and limited resources available for the study, search-efforts were mainly concentrated along the park boundaries. The very nature of the landscape further limited unbiased data collection, because tracks are more difficult to detect in open, wind-blown areas compared to areas enclosed by forest cover. Advice on tracks from local residents and conservation officers and park wardens may further have introduced human bias, given that people are more likely to find tracks in human-utilized areas. Furthermore, findings of more tracks adjacent to RMNP may arguably be a result of skewed sampling efforts. Although search efforts were similar north of RMNP as south of DMPP&F, more track tips came from the RMNP area. This is because the boundary of the national park is intensely monitored by national park wardens and patrolling provincial conservation officers. In comparison, there is less patrolling effort is place within and around DMPP&F. Although care was taken to assure proper identification of tracks, there is further a possibility that some tracks may have been caused by large dogs. The livestock loss claims may also be of limited value in terms of wolf locations, given the likelihood of unconfirmed cases of wolf predation.

Data precision.--There was a noticeable shift in various distances and directions within and among tiles of the FRI data layer used for the land classification, compared with the orthophotos. The park boundary layer used for distance analysis was also shifted up to 600 m in comparison to the FRI layer. GPS recorded habitat changes on ground along the track did not always coincide with the change in FRI classes. This is due to precision error in the GPS- data in addition to FRI data error. Large frequency bins created for the distance histograms would partly have accounted for the precision error in the distance analysis. Because the FRI-data was gathered in 1980-82, parts of the land classification was likely outdated, provided the rapid rate of land-modification in the area (Figure 1.2.1-2).

Selection analysis.--Although allowing for detailed findings, the use of numerous land cover categories may have weakened the selection assessment. In some cases, the abundance and distribution of different land categories prevented detection of selection or avoidance. Moreover, basing selection findings on distances from land cover to RMNP may have biased the results, given that tracks adjacent to DMPP&F likely originated from that park. Furthermore, road classes are not homogonous, because traffic volumes likely vary at different locations along the same road. Finally, concluding selection of land-classes based on visual examination of spatial data compared with calculated distance frequencies may have provided highly subjective results.

4.7 CONCLUSION

The matrix land between RMNP and DMPP&F consist of extensively human modified land, whereas undisturbed land only remains as sparsely, fragmented patches. Disturbed land constitutes a barrier to wolf movement in the area, because hostility from local residents threatens the animal's survival. It can be concluded that RMNP constitutes the preferred habitat for local wolves because it offers protection from human caused mortality.

Wolves on land outside the protected park boundaries select cover with minimal human disturbance, including wetland and vegetated areas. Wolves further use linear, cleared trails adjacent to forest cover for undetected ease of travel. Although wolves may utilize same trails as their prey outside the park boundaries, they do not likely leave RMNP primarily to hunt on surrounding land.

Suitable wolf movement areas are sparse and fragmented between the parks. Although there are no existent spatially connective corridors that connect RMNP and

DMPP&F, functional corridors may be present if wolves are able to avoid human interactions. Because wolves in RMNP are locally adapted to the undisturbed park environment, they are however likely reluctant to move across the human modified landscape between the parks.

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CHAPTER 5:

MANAGEMENT OF WOLF MOVEMENT BETWEEN RMNP AND DMPP&F

5.1 RECOMMENDATIONS

5.1.1 **Land protection**

Need for corridors.--Findings from this study indicate that wolves in RMNP are adapted to land free from human disturbance and are reluctant to leave the park. Threat of lethal encounters with human activities is a prominent barrier to wolf movement outside the park boundaries. Although RMNP constitute their preferred habitat, wolves may be forced to leave the protected land in the park for surrounding land at times of resource competition and over-crowding. Individual exchange with nearby wolf populations is further necessary to avoid genetic isolation and effects of inbreeding. Despite the wolf's resilience, presence of structural, continuous vegetative corridors between RMNP and DMPP&F would protect dispersing animals against human interference.

Natural land protection.--Results from this study indicate that only fragmented patches of undisturbed land that is suitable for wolf-movement remains between RMNP and DMPP&F. Given the quantity of human disturbed land (Figure B.1-3) and the rapid rate of landscape modification between the parks (Figure 1.2.1-2), protection of remaining natural land is urgently required. Restoration of human modified land to its natural state will likely to conflict with present human activities. Land management should rather focus on protecting remaining natural land from additional modifications by preventing future clearing of forested land. Considering there are fewer resident landowners in the area today compared to 20-30 years ago (D. Bergeson, Riding

Mountain National Park, personal communication 2006), the Province could also convert abandoned private land into public, protected land. While conservation of large forest blocks are preferred, small and fragmented vegetative patches function as stepping stones for movement of wildlife across disturbed land (Beier 1993, Carroll et al. 2003).

Buffer zones.--Land management that encourages regional dispersal of wolves could be achieved by extended protection of parks to buffer zones that incorporate surrounding agricultural land. Establishment and management of buffers should be a joint federal and provincial effort. Because RMNP is surrounded by private land, public acceptance is required for protection of buffer land where wildlife and human can coexist. Human resistance to conservation would likely be less pronounced if low levels of human activities are allowed in the buffer areas. Management strategies for buffer zones must therefore consider the level of land protection tolerated by local residents. Research should also identify the minimum level of protection necessary to provide effective buffer conservation.

Promoting conservation.--While local conservation should aim to protect remaining natural between the parks, it is important that land strategies address attempts to minimize conflicts with the local economy. NGOs with interest in land protection between the parks, such as the Biosphere Reserve and the Nature Conservancy Canada, play an important role to guide and involve landowners in efforts to preserve their natural land. Financial incentives could encourage landowners to leave identified suitable wolf movement areas untouched. Through appointed home visits by conservation group representatives, landowners should be informed about the need for land protection and offered incentives. Local NGOs that focus on stimulating land owners to conservation minded decisions should be strengthened both financially and institutionally.

5.1.2 Human acceptance of wolves

Increasing tolerance.--Effective conservation of a regional wolf population depends on support from local residents. Promoting dispersal of wolves between the parks requires reduced negative human attitudes that constitute a movement barrier due to associated risks of mortality. Research should identify why local residents are hostile to wolves on their land. Because negative attitudes often are rooted in perceived economical losses, it is important that effective, local predation compensation programs are in place. Provincial programs, as the one run by MCIC, may increase tolerance to wolves and encourage local practice of measures that reduce risks of livestock predation. Compensation programs should be made more effective by including workshops that teach livestock owners about different predators and safe animal husbandry practices. Landowners may be encouraged to visit these workshops by incentives, such as lower crop insurance.

Education.--Negative attitudes held by local residents about wolves are commonly based on misperceptions about the species. Increased acceptance and, consequently, more effective wolf conservation, can be promoted by educating landowners about the ecology and importance of large carnivores. Education should be delivered as joint effort by federal, provincial, and non-government conservation groups. Because landowners may identify easier with other residents, local people that hold positive attitudes towards wolves and conservation should be encouraged to share their views with the public. Presentations, workshops, media advertisements and featured magazines are tools that may be used to communicate the desired information local landowners. Education should be delivered with an overall aim to increase local understanding and interest in conservation. Specific topics may include the function of predators in ecosystems, ecology of large carnivores and importance of wolf dispersal. Resident children should at an early age be taught the value of natural land and conservation of large carnivore, for example through school assignments and field-trips.

Local responsibility.--There is a prevailing notion among local residents that the Provincial Parks, Federal Park, and private land owners are separate entities. To promote positive local views about conservation, governing agencies must strive to eliminate the currant feeling held by landowners of alienation from regional land decisions. Local residents would be more entitled to care about how development and human activities are effecting the regional environment if they felt they were part of an interdependent system. A first step to promote local respect and responsibility for conservation matters is to invite landowners to round table discussions and local conservation meetings held by scientist and government agencies. Governing authorities should further ensure that local residents feel that their opinion is valued and considered.

5.1.3 **Legal mandates**

Protecting dispersing wolves.--To promote safe dispersal of wolves from RMNP to DMPP&F, there is a need to protect wolves against legal harvest in the whole area between the parks. Strict regulations against wolf harvest around RMNP should be maintained and the provincial government should legislate for similar wolf protection south of the DMPP&F boundary. Human-wolf interactions should be monitored by national park staff and conservation officers outside both park boundaries and penalties for violations must be strictly enforced. Sustaining a regional viable wolf population depends on protection of the animal along their dispersal path as well as at their destination. There is a need for pilot provincial monitoring of wolves in DMPP&F as well as research on how wolves in that park are affected by the lenient regulations against poaching and timber-harvest.

Joint management.--Under the recognition that wolf populations are not viable as confined units in isolated parks, federal government mandates should further extend protection of wolves in RMNP to surrounding land. There is also need for preliminary research on wolves in DMPP&F to ensure that the regional population enjoys sufficient protection. Closer collaboration among federal and provincial agencies is necessary to attain effective regional management of wolves. Successful regional dispersal of wolves throughout the region also depends on joint cooperation and shared responsibility among authorities throughout the region. Governing agencies should make an effort to lessen the gap between groups by involving stakeholders at all levels in the decision-making process. NGOs and other local interest groups should be part of a joint management effort, including consultation with representative First Nation's members and consideration to their traditional knowledge.

"Corridor Watch"- program.--An existing or new independent NGO should aim to consolidate conservation interests from all local stake holders, including federal and provincial agencies, First Nation communities, livestock producers and hunters. Apart from identifying shared and conflicting conservation interests in the area, such an organization should also serve to create public awareness about wolves and corridors in the area. This could be achieved by monthly meetings, presentations and round-table

discussions among different stake-holders. The organization should aim to involve landowners in a “corridor-watch”- program that promotes local reports about dispersing wildlife activities in the area.

5.1.4 **Future recommendations**

Data collection.--Telemetry data from VHF collared wolves and DNA analysis could potentially provide evidence of individual exchange between the parks. GPS data from collared wolves would be even more valuable, because it could provide detailed information about exact habits and routes used between the parks, including barriers.

5.2 CONCLUSION

The greatest barrier to movement of wolves between RMNP and DMPP&F is the risk of mortality caused by some local residents that perceive wolves as a threat to their livelihood. There is an urgent need for protection of remaining natural, undisturbed land between the RMNP and DMPP&F to promote undetected dispersal of wolves between the parks. Although residual patches that comprise suitable wolf movement land are unconnected, these may serve as stepping-stones across otherwise human disturbed land. There is further a need for enforced legal protection of wolves from hunting in the whole area between the parks. Wolves should further be monitored in both the RMNP and DMPP&F to increase knowledge about regional wolf population dynamics. Data from GPS collared wolves may further bring celerity in exact travel routes used by wolves between the parks, including effects of barriers.

Legal regulation does not assure successful protection of dispersing wolves between the parks without local acceptance. Governing agencies and conservation groups should promote local appreciation for conservation strategies through education programs and increased local participation in regional land management. If the goal is for landowners to accept conservation plans, governing agencies must first show that they respect and include public opinion in their decisions. Research should identify why local residents are hostile to wolves on their land and the level of protection required and accepted to promote wolf dispersal. Financial incentives to protect natural land on private property and to practice safe animal husbandry measures that deter predators are further recommended.

Regional management of a viable wolf population requires joint cooperation between government agencies. Establishment of buffer zones between the parks should further be a joint federal and provincial effort that also includes land owners participation. An independent NGO that focuses on corridor management may serve to consolidate the interest from different stake-holders in the area.

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APPENDIX A:

Wolves within RMNP

A.1 Wolf locations

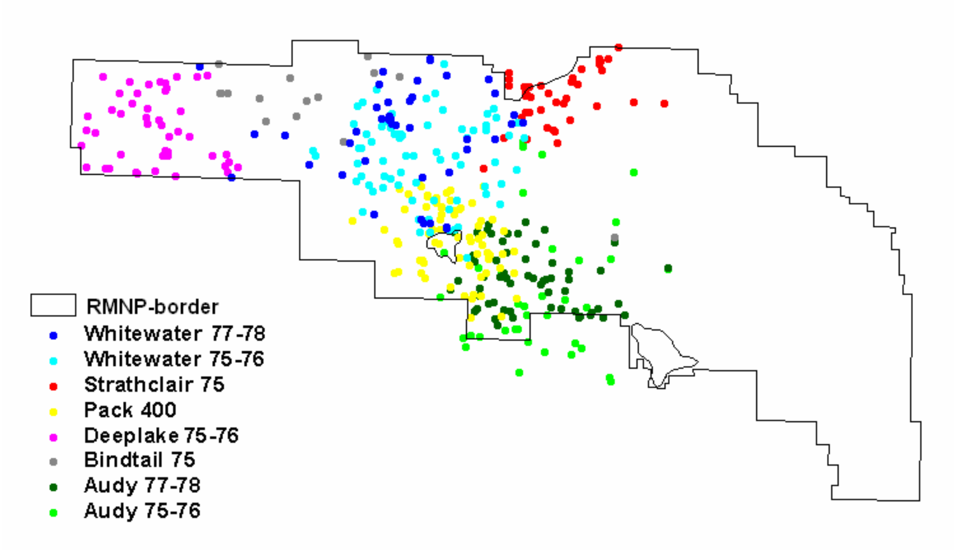


Figure A.1-1: Telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1975-79) of radio collared wolves in RMNP (PFRA 2001), Manitoba, color coded by pack and collection year (1:50,000).

A.2 Land cover

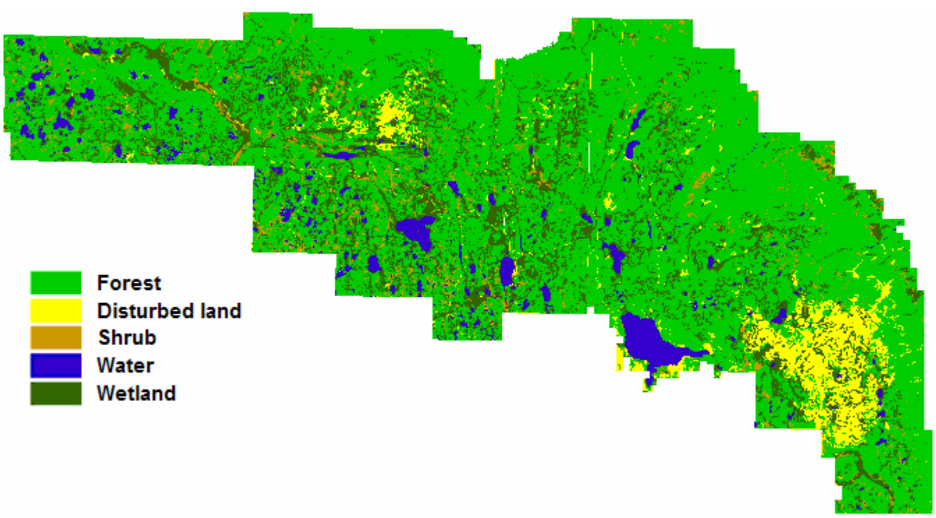


Figure A.2-1: Spatial distribution of land cover in RMNP, Manitoba, based on FRI data (MLI 1980-82) (1:15840).

Table A.2-1: Original FRI classes (MLI 1980-82) contained within newly created revised land categories between RMNP and DMPP&F, Manitoba, including proportional representation of each class based on total park area (*park prop*) and total buffered area (*buff prop*) for wolf telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1975-79).

Forest	buff prop	park prop
Balsam Poplar >=70%	0.000	0.000
Balsam Fir >=70%	0.000	0.000
Bur Oak >=70%	0.000	0.001
mixed Hardwood >=70%	0.167	0.197
mixed Hard>Softwood, 60-40%	0.021	0.048
mixed Hard-Softwood, 50-50%	0.003	0.011
mixed Softwood >=70%	0.018	0.049
mixed Soft>Hardwood 60-40%	0.040	0.049
Trembling Aspen >=70%	0.398	0.314
White Birch =>70%	0.002	0.000
White Spruce >=70%	0.016	0.019
Total:	**0.665**	**0.690**

Water	buff prop	park prop
Water	0.052	0.040
Total:	**0.052**	**0.041**

Shrub	buff prop	park prop
Shrub	0.000	0.001
Shrub/Prairie	0.000	0.000
Willow	0.043	0.031
Dwarf Birch	0.005	0.001
Total:	**0.048**	**0.033**

Wetland	buff prop	park prop
Black Spruce >=70%	0.023	0.031
Wet meadow	0.023	0.014
Beaver flood	0.107	0.085
Tamarack treed	0.000	0.003
Black Spruce treed	0.013	0.010
Marsh	0.010	0.004
Moist prairie	0.029	0.015
Tamarack >=70%	0.003	0.002
Tamarack <70% mix wood	0.002	0.004
Alder	0.000	0.001
Mud/ Salt flat	0.000	0.001
Muskeg	0.009	0.007
Total:	**0.219**	**0.178**

Disturbed	buff prop	park prop
Precipitation slope	0.000	0.001
Recreation site	0.000	0.001
Residential site	0.000	0.001
Roads/Dikes/Dams	0.006	0.004
Transmission line	0.000	0.001
unknown	0.010	0.049
Total:	**0.016**	**0.059**

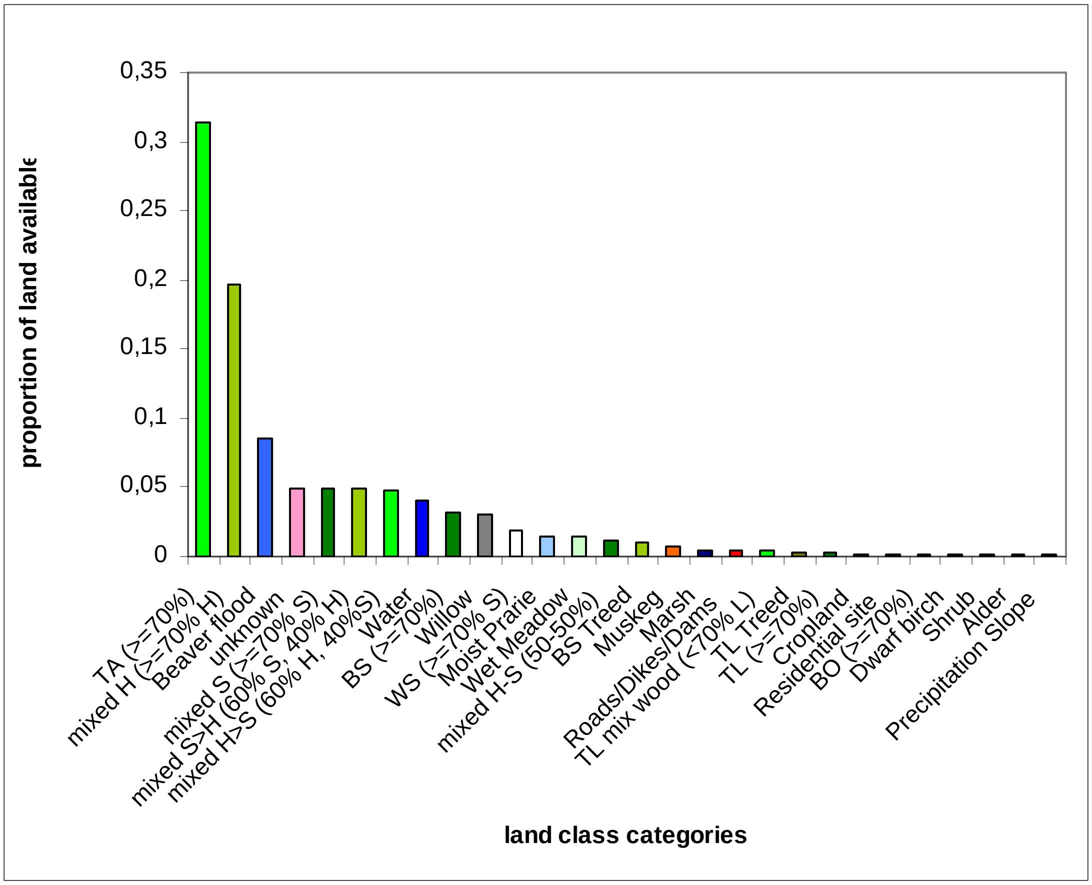


Figure A.2-2: Proportional representation of the largest land classes in RMNP, Manitoba, based on the original FRI classes (MLI 1980-82).

Table A.2-2: Proportional representation of revised land cover classes based on FRI data (MLI 1980-81) in RMNP, Manitoba, compared with proportion of cover types contained within buffered telemetry wolf locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1976-79).

PARK		BUFFERS	
Forest	69%	**Forest**	66%
Wetland	18%	**Wetland**	22%
Disturbed	6%	**Disturbed**	2%
Water	4%	**Water**	5%
Shrub	3%	**Shrub**	5%

A.3 **Data Analysis**

The calculated buffer frequency (obs. u freq) (i.e. 424) was estimated to a greater total than the actual number of buffers used in the analysis (i.e. 408). This divergence may have been a result of double counting of areas included in overlapping buffers. After dissolving buffers to exclude the overlap, the resultant total buffer frequency was smaller than the true number of buffers used (Table A.3-1). Furthermore, the buffer area found by *.ReturnArea* in ArcView 3.1 (2813 m^3) differed from the true area of a circle with a radius of 30 m (2827 m^3). The distortion in buffer area was believed to have arisen from the fact that pixel based vector data do not produce true circles. Furthermore, the total area included in buffers dissolved by the Geoprocessing Wizard-extension (1041629) differed from the total area found when buffers were dissolving immediately upon creation by the Spatial Analyst-extension (1041239, by *.ReturnArea*). Varied results attained by different methods flag for caution in interpretation and in reliance of accurate findings. Despite the data discrepancies, comparison of results from overlapping and non- overlapping buffers indicate that the relative significance among habitat classes is unaffected by double counting of areas.

Table A.3-1: Results from Neu's test for selection of FRI based land cover (MLI 1980-82) by non- overlapping buffered wolf telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1976-79) in RMNP, Manitoba.

class	obs *u* (area)	prop *u*	obs *u* (freq)	prop *a*	exp (freq)	SI	SSI
Wetland	244180	0.23	86.36	0.177877	65.51	1.32	0.24
Shrub	49477	0.05	17.5	0.032541	11.98	1.46	0.27
Water	61766	0.06	21.85	0.040833	15.04	1.45	0.27
Forest	668202	0.64	236.33	0.689708	253.99	0.93	0.17
Disturbed	17614	0.02	6.23	0.058791	21.65	0.29	0.05
Total:	1041239	1	368.26	0.99975		5.45	1

class	chi^2	CL+	CL-	Prop *a*	sign
Wetland	19.32885	0.18	0.29	0.18	NS
Shrub	7.98233	0.02	0.08	0.03	NS
Water	5.074546	0.03	0.09	0.04	NS
Forest	-10.3303	0.58	0.7	0.69	NS
Disturbed	-8.88541	0	0.03	0.06	S
Total:	26.34007	1			

Bonferroni corrected significance level: $\alpha = 0.01$, *z* = 2.576

A.4 **Prey distribution**

Visual assessment of ungulate telemetry location data in relation to RMNP shows that prey is widely distributed within the park (Figure A.4-1). Locations of dead ungulates killed by hunters surround the park boundary.

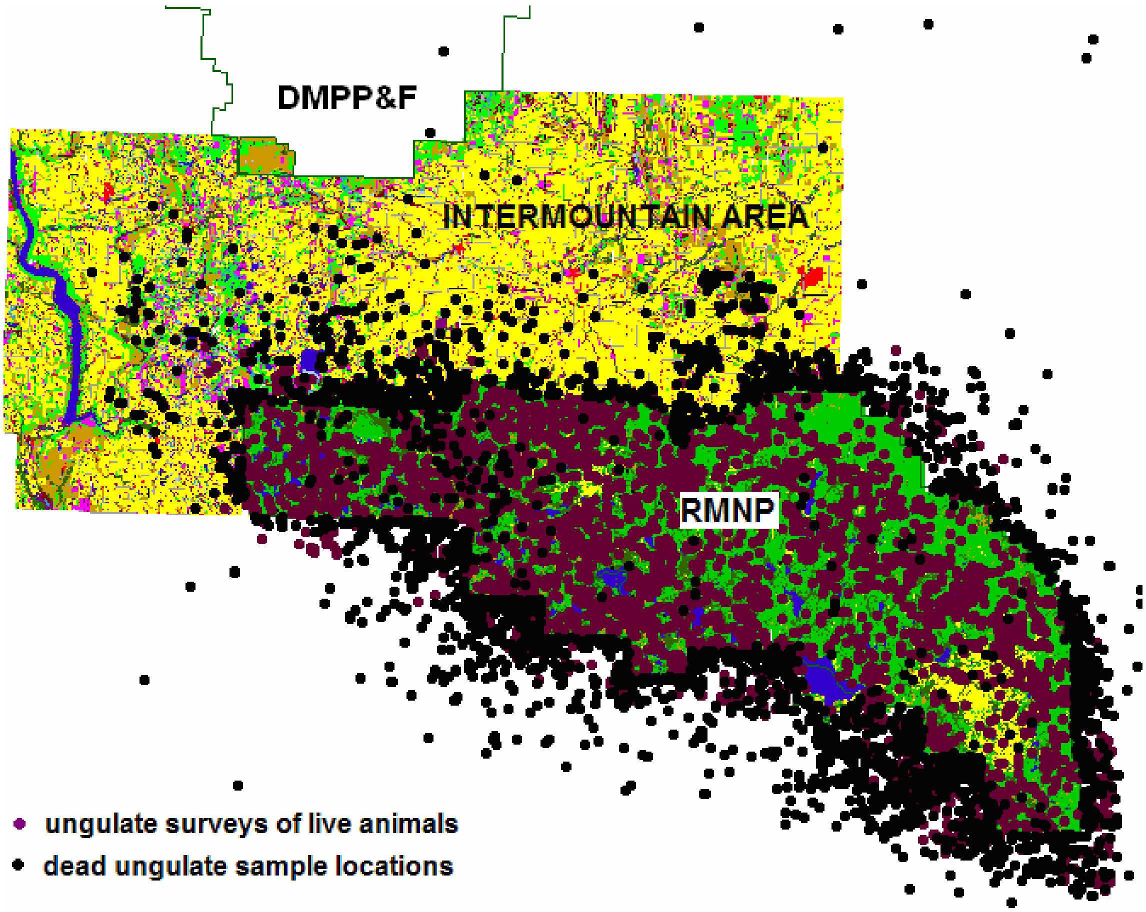


Figure A.4-1: Ungulate locations from telemetry data (Parks Canada 2005) and recorded kills (Parks Canada 1998-2002) within RMNP and area south of DMPP&F, Manitoba, based on FRI land data (1980-82) (1:15840).

A.5 **Assessment of polygon affects**

The positive correlation between polygon size and revisits by wolf points (Figure A.5-1) indicates that polygon structure influences selection results.

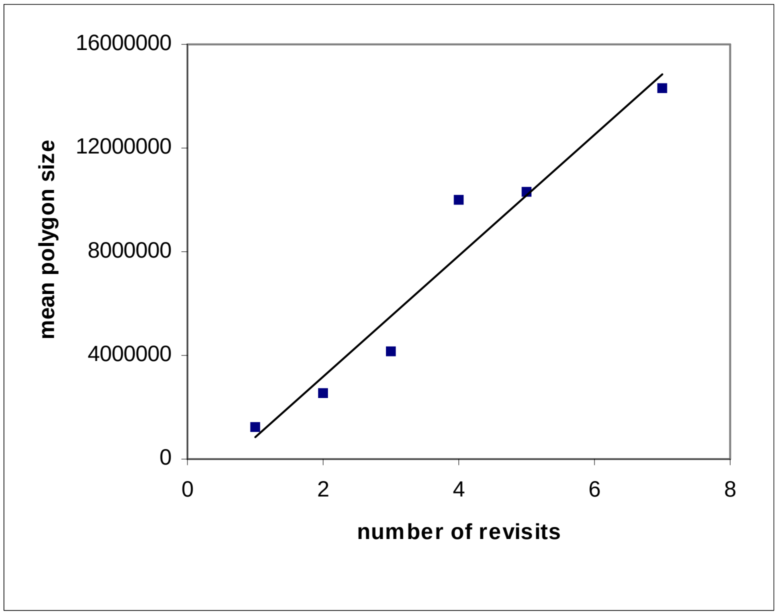


Figure A.5-1: Positive correlation between size of FRI based habitat polygons (m^2) (MLI 1980-82) and number of revisits to same polygon by telemetry based wolf locations points (Canadian Wildlife Serve, P.C Paquet, personal communication 1976-79) in RMNP, Manitoba.

Figure A.5-2 demonstrates how patchy land polygons stand a proportionally higher chance of being included in buffers, since they always border the forest matrix. This means that although the actual location of a wolf point may be in the forest, the buffer may include other another habitat classes of nearby polygon patches.

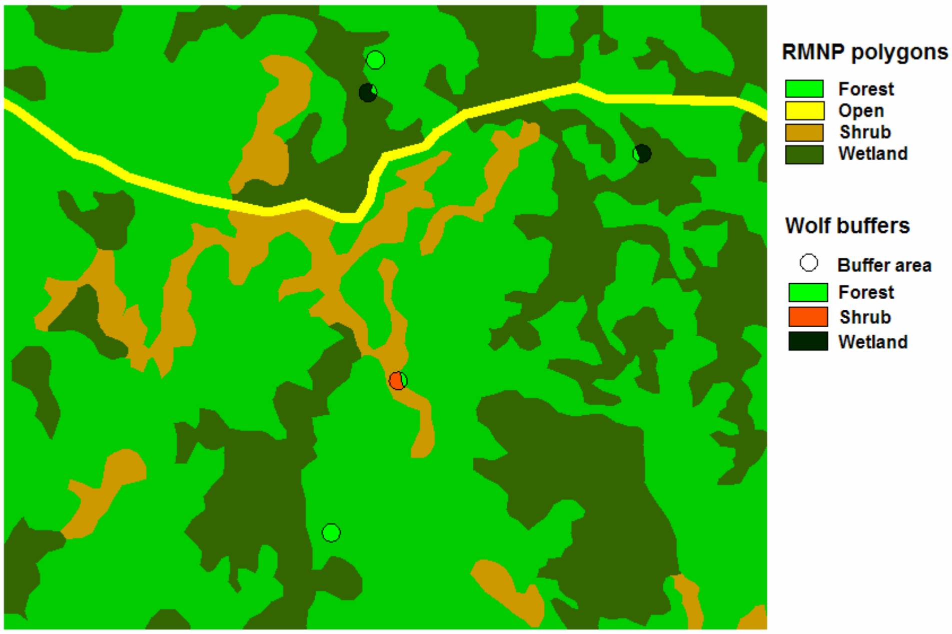


Figure A.5-2: Section from RMNP, Manitoba, demonstrating the influence of patchy polygons on inclusion of FRI based land cover classes (MLI 1980-82) in buffered wolf telemetry locations (Canadian Wildlife Serve, P.C Paquet, personal communication 1976-79) (1:15840).

.

APPENDIX B:

Wolves between RMNP and DMPP&F

B.1 Land cover

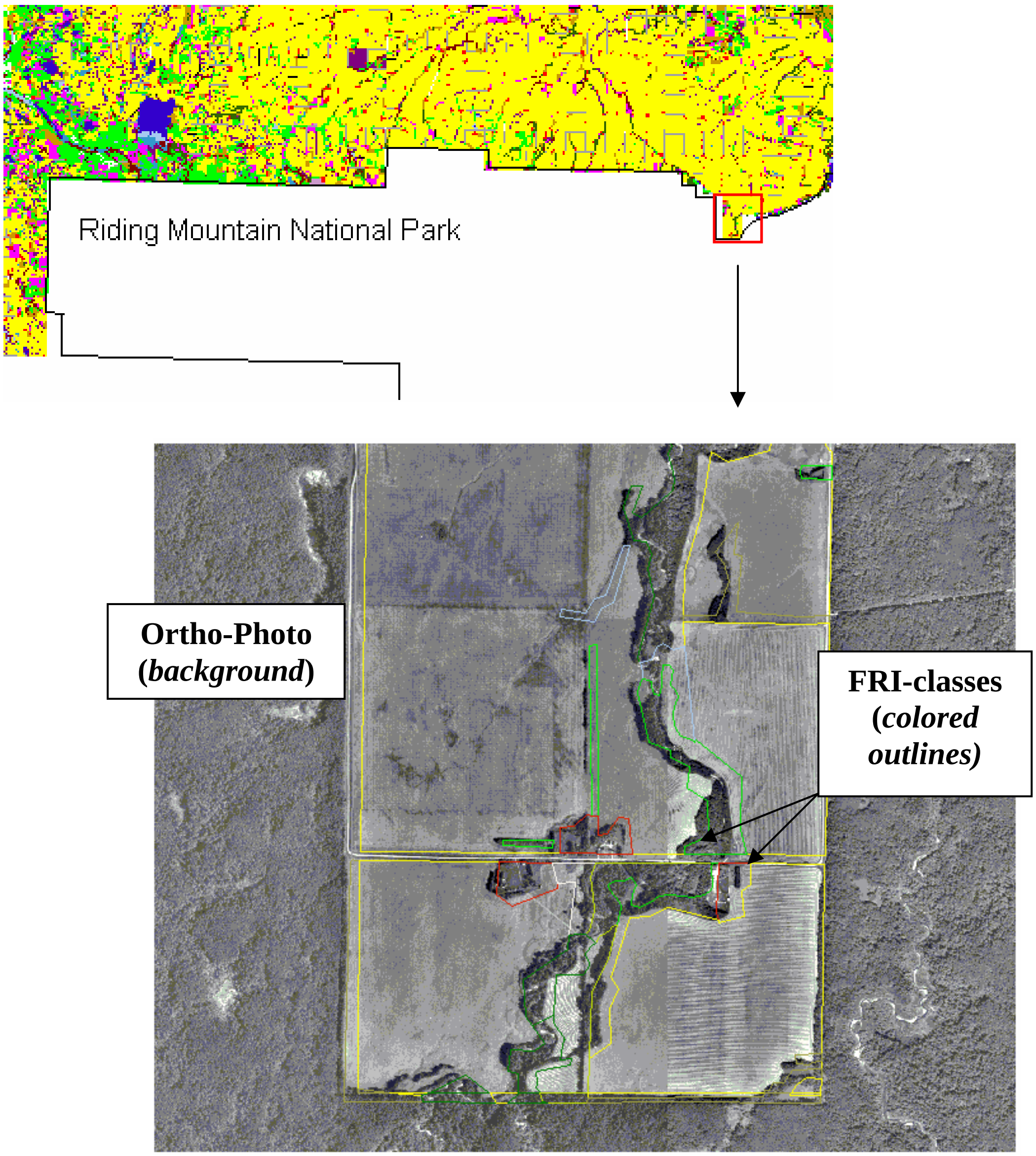


Figure B.1-1: Section from the notch area along the northern RMNP boundary, Manitoba, demonstrating deviation of classified FRI data (MLI 198081) compared with orthophoto (MLI 1996) (1:1:60000).

Table B.1-1: Original FRI classes (MLI 1980-81) comprised within newly created land classes[a] used for assessment of wolf selection for land between RMNP and DMPP&F, Manitoba.

New Class	FRI class
Abandoned land[b]	Abandoned land
Black Spruce & Tamarack	Black Spruce >=70%
	BS muskeg
	Muskeg
	Tamarack mix wood >=70%
Cropland	Cropland
Dry upland prairie	Dry upland ridge prairie
	Shrub/Prairie
Hardwood (H)	Balsam Poplar >=70%
	Bur Oak =70%
	Manitoba Maple >=70%
	Mixed H >=70%
Human disturbed	Airstrips
	Gravel pits/ Mine
	Recreation sites
	Barren tundra
	Land clearing
	Blank
	Drainage ditches
	Dugouts/ Water holes
	Unknown
Linear features	Shelter belts
	Fence lines (community- pasture)
	Transmission lines

New Class	FRI class
Marsh	Marsh
Mixed Hard/softwood (H/S)	Mixed H>S (60% H)
	Mixed H-S (50-50%)
	Mixed S>H (60% S)
Moist prairie	Moist prairie
Natural disturbed	Bare rock- igneous
	Mud / Salt flats
	Precipitous / Fragile
	Sand beaches
	Small island
Pasture land	Pasture land
Shrub	Shrub
	Dwarf Birch
	Willow
Softwood (S)	Mixed S >=70%
	White Spruce >=70%
Trembling Aspen	Trembling Aspen >=70%
Townsite	Townsite/ Residential
Water	Water
	Assiniboine river
	Rivers
Wet meadow	Wet meadow
	Beaver floods

[a] polygons classified as roads by the FRI based land cover were excluded from the analysis
[b]abandoned land in most cases refer to abandoned cultivated land that was cleared for crop or hay land but has been left to go back to grass or shrub (R.E. Frank, Manitoba Land Initiative, personal communication).

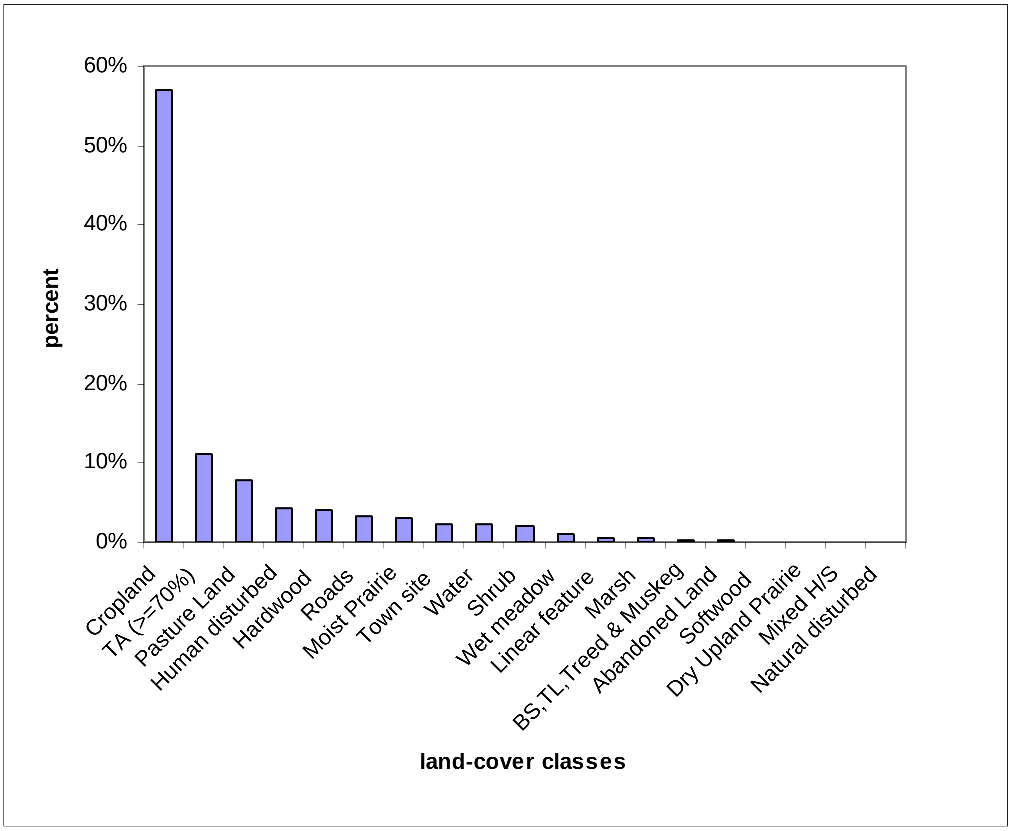


Figure B.1-2: Proportional distribution of land cover between RMNP and DMPP&F, Manitoba, based on FRI data (MLI 1980-81).

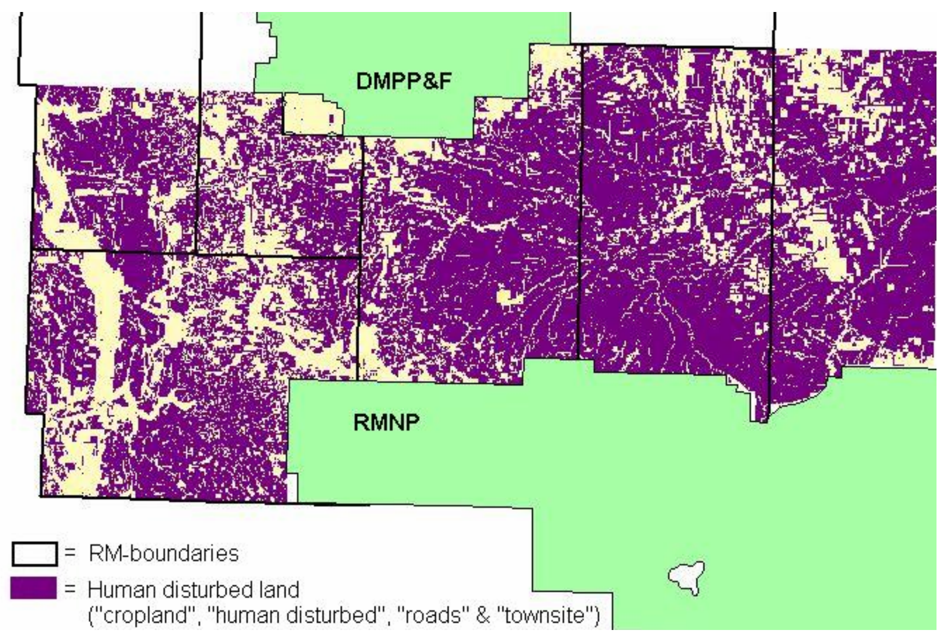


Figure B.1-3: Human disturbed land between RMNP and DMPP&F (PFRA 2001), Manitoba, based on FRI data (MLI 1980-82) (1:15840).

B.2 **Track locations**

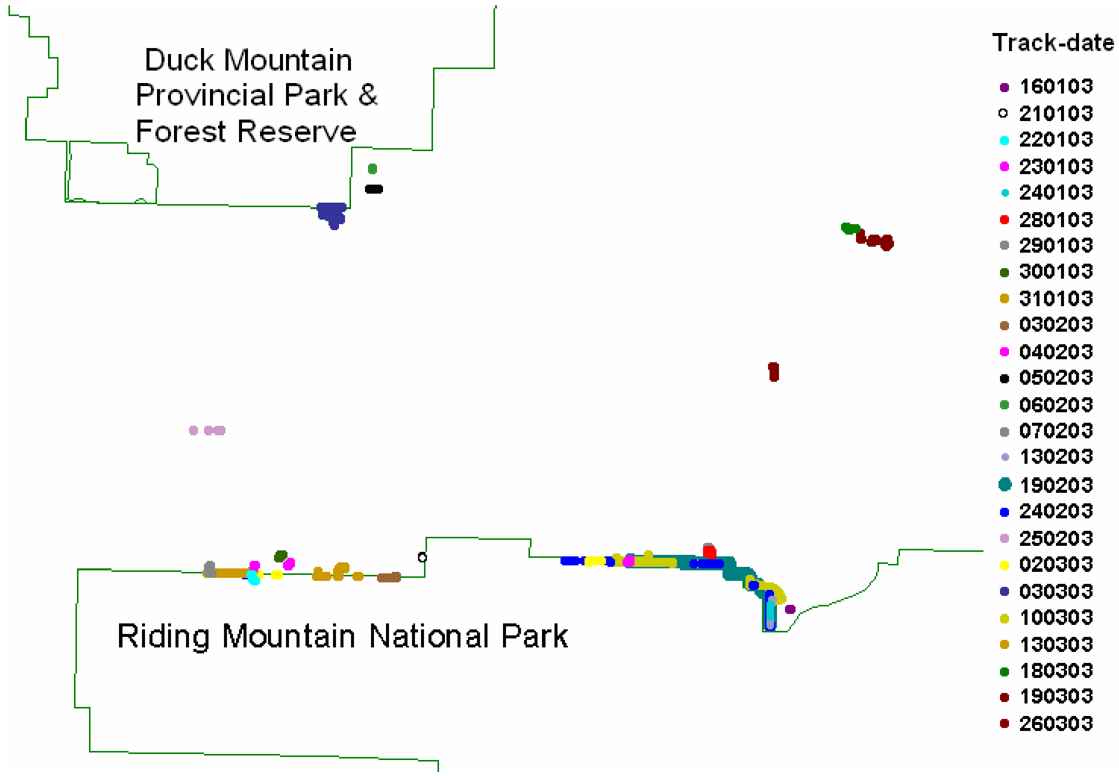


Figure B.2-1: GPS recorded wolf tracks (winter 2002-03) between RMNP and DMPP&F (PFRA 2001), Manitoba, color coded by collection date (1:50,000).

B.3 **Interview questionnaire guideline**

1) Landownership:

- Acres of land owned
- Years of possession
- Type of crops grown and use of tilling methods
- Presence of cattle

2). Wildlife Presence:

a). How often do you encounter the following wildlife species on your land?

- Dear
- Moose
- Elk
- Bear
- Coyotes
- Other

b). At what time of the year are the different wildlife species mostly seen?

c). Have the wildlife sightings remained constant over the years?

d). Have there ever been problems with wildlife on the land (related to crop or cattle?

3). Wolves

a). How often have wolves been encountered on the land?

b). How often have wolf tracks been encountered on the land?

c). How many wolves were encountered at a time?

d). Where were sightings made (e.g. open areas, forest, roads)?

e). What time of the year are wolves mostly sighted?

f). Sighting of wolves in the area outside private property?

e). Where and when have wolves/wolf tracks been encountered in the past?

c). Have the wolf sightings remained constant over the years?

d). Have there ever been problems with wolves on the land?

4). Additional knowledge/experience about wildlife movement

B.4 **Interview Results**

Wolf sightings.--Interviews with landowners adjacent to the park indicate that wolves rarely are encountered outside the protected area. At occasional sightings, wolves appear in groups of no more than 2-3 individuals at a time. According to senior residents, larger groups of wolves were occasionally seen outside the park in the past.

Movement behavior.--Several residents reported having sighted wolf tracks leaving the park boundary, only to return in a loop after a couple of kilometers. Many landowners were further under the impression that wolves outside the park commonly select forested areas for protection. A few encounters of wolf tracks on open fields were also reported. Some local people believe that wolves will cross fields at times of low detection risk, such as at night or in the summer when crops cover pastures. It is further commonly believed among residents that wolves follow linear features outside the park, including creeks, fire lines, roads and trails. Sightings of wolf tracks on snowmobile trails along the park boundary were frequently reported.

Prey influence.--Several residents claimed having observed wolf prints outside RMNP adjacent to deer and elk tracks. There was a general notion among local people that wolves exterior to the park boundary select the same habitat as their prey, such as shrub that attract deer. Some landowners believed that wolves on unprotected land are more inclined to use forest edges than their prey, including deer and elk that may be found feeding on wide open cropland. Some residents suggested that wolves leave the park in the winter when moose, elk, and other prey species are forced to search forage outside the park due to high snow levels. Other interviewed people were under the impression that wolves stay and hunt inside the park during heavy snow fall, because they have advantage over prey in deep snow.

Corridors.--Many locals were skeptical of the idea of wolves moving between RMNP and the DMPP&F. There was a prevailing notion among residents that extensive wolf movement is triggered by scarcity of food within their habitat. Some people believed that abundant feeding opportunities for prey on exterior cropland avert distant movement of ungulates. Consequently, predators refrain from moving but stay where their prey are. Other landowners were assured that wolves occasionally travel between the parks along unpopulated valley- and swamp- areas, including the "Rose Ridge" and "Pleasant Valley" corridors.

Livestock predation.--A number of landowners expressed concern about frequent wolf predation on cattle calves between the parks, particularly adjacent to the Ethelbert community pasture. It should however be noted that few of these reports actually had been confirmed as wolf attacks. Other livestock owners held a strong perception that wolves will only harm livestock under abnormal circumstances. Observations of wolves adjacent to cattle in the area supported this belief.

Local attitudes.--Interviews with local residents indicated opposing attitudes towards wolves. Many residents expressed a dislike towards wolves that in most cases was linked to economic concerns. In extreme cases, people were under the impression that the only solution to problems associated with wolves would be to build a fence around the park. Some people that expressed intolerance towards wolves in the area were convinced that the species competes with hunters and had been secretly reintroduced to the park by the government. It appeared that many landowners had aversion to not only wolves, but also national park staff, provincial conservation officers and local research in general. Most interviewed trappers and hunters however seemed to be conservation minded and under the opinion that wolves serve an important role in maintaining a healthy big game population. Interviewed members of the Valley River First Nation Treaty Reserve adjacent to DMPP&F further expressed great sympathy with the species, in accordance to traditional custom and knowledge. Despite lack of hunting and trapping regulations within the reserve boundaries, First Nation members told that residents of the reserve utilize the community's resources responsibly. It was further stated that resident treaty members trap and hunt only during prime pelt hunting seasons and that the two activities are performed interchangeably.

Wolf eradication.--A few confessions about wolf kills were made during interviews. In most cases, it was claimed that wolves had been killed because of landowners' fear when the animal approached calves, cattle or fenced property. One anonymous landowner adjacent to RMNP bluntly stated: "A wolf that enters my property never leaves".

B.5 **Land selection**

Abandoned land is rarely occurring (Figure B.1-2) and unevenly distributed in patchy clusters across the area (Figure B.5-1a, B.5-1b). The track points are at inconsistent distances from this land class (Figure: B.5-1c). Given that abandoned land is rare and widely spread across the landscape, the tracks do not provide enough evidence to conclude that wolves select for this land category.

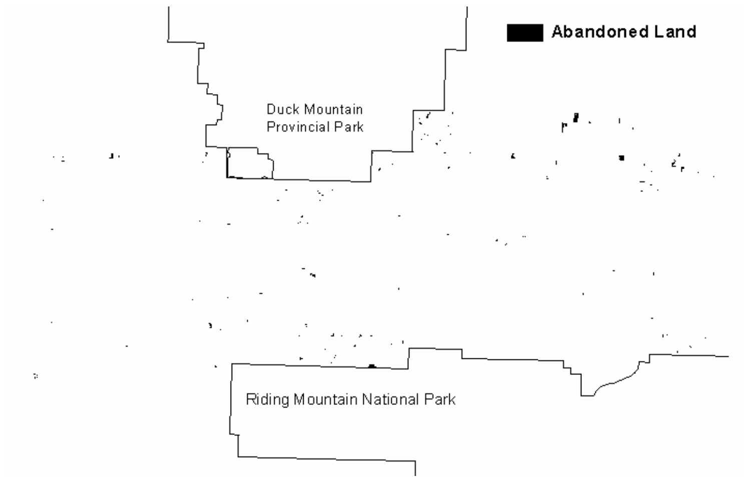


Figure B.5-1*a*: Spatial distribution of FRI based abandoned land polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:15840).

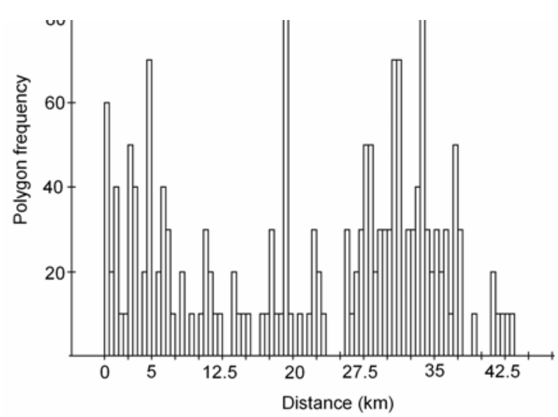


Figure B.5-1*b*: Distance (km) from RMNP border (PFRA 2001) to closest abandoned land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

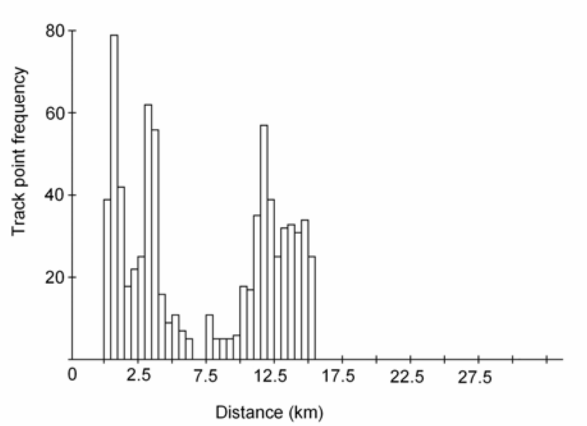


Figure B.5-1*c*: Distance (km) from wolf track points (2002-03) to closest abandoned land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

BS is scarce (Figure B.1-2) and unevenly distributed across the landscape as patchy and irregularly sized clusters (Figure B.5-2*a*). Although this land class is sparsely occurring adjacent to RMNP compared to closer to DMPP&F (Figure B.5-2*b*), the track points are relatively close to BS (Figure B.5-2*c*). The results therefore indicate that wolves outside the park boundaries select for BS.

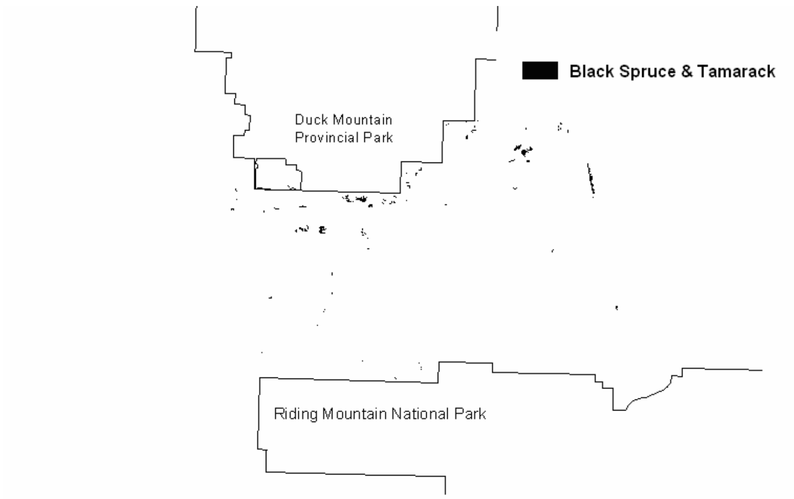
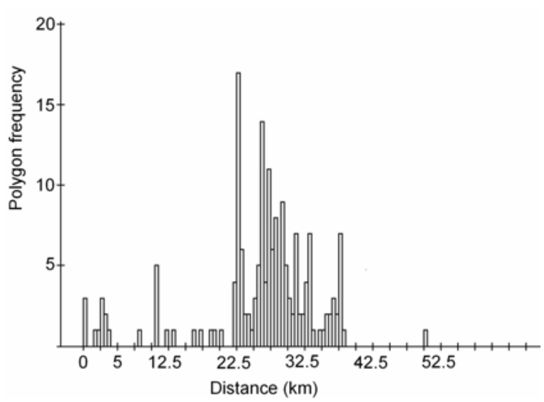


Figure B.5-2*a*: Spatial distribution of FRI based Black Spruce & Tamarack (BS) polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000)



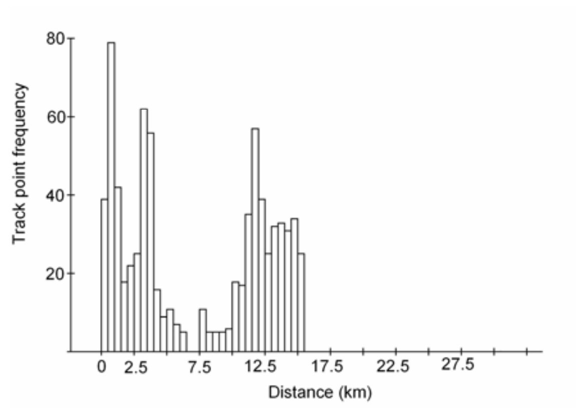


Figure B.5-2*b*: Distance (km) from RMNP border (PFRA 2001) to closest BS polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Figure B.5-2*c*: Distance (km) from wolf track points to closest BS polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Cropland is the most commonly occurring and widespread land class in the area (Figure B.1-2), although patchy distributed (Figure B.5-3 *a* & *b*). All track points are close to cropland (Figure B.5-3*c*) as a result of the fact that this land class constitutes the dominant matrix rather than an indication of habitat selection.

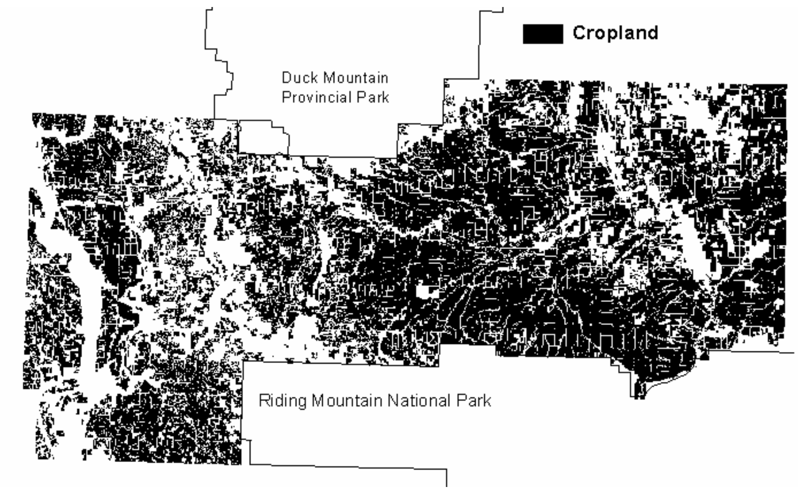


Figure B.5-3*a*: Spatial distribution of FRI based cropland polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

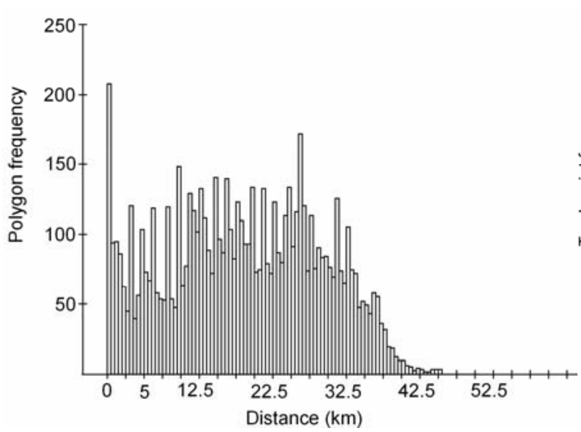


Figure B.5-3*b*: Distance (km) from RMNP border (PFRA 2001) to closest cropland polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

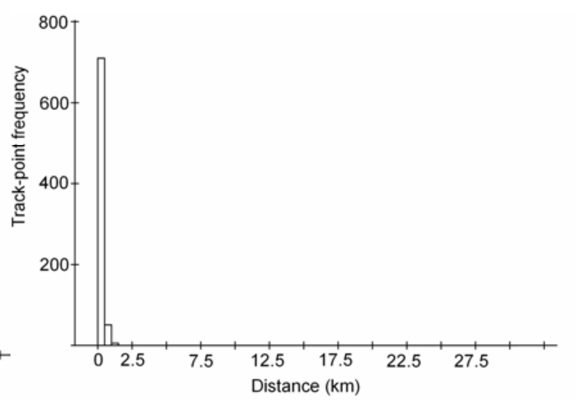


Figure B.5-3*c*: Distance (km) from wolf track points to closest cropland polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Dry upland prairie is sparsely occurring between the parks (Figure B.1-2) as patchy, unevenly distributed clusters (Figure B.5-4*a*). There is a peak occurrence of this land class adjacent to RMNP (B.5-4*b*) that does not correspond to the more remote peak in track distances (Figure B.5-4*c*). However, given the uneven and rare distribution of the cover class, the track distances alone do not provide sufficient evidence to conclude that wolves actively avoid dry upland prairie in the area.

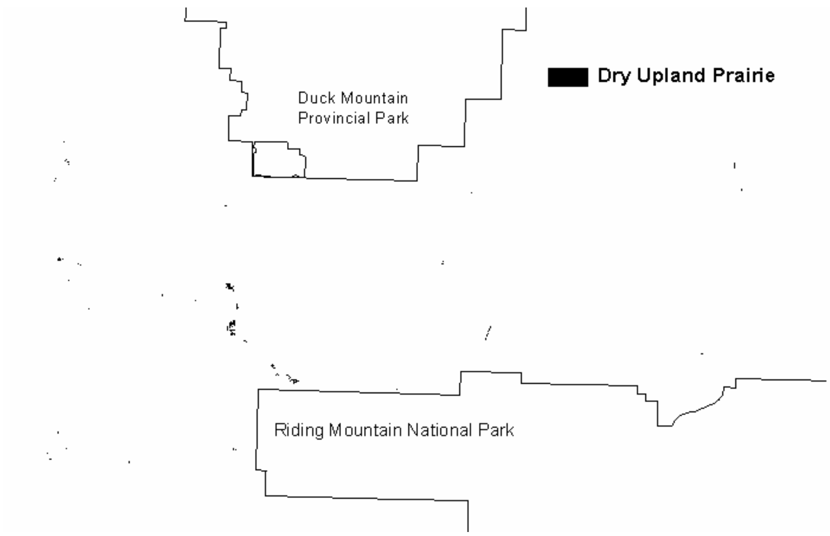


Figure B.5-4*a*: Spatial distribution of FRI based dry upland prairie polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

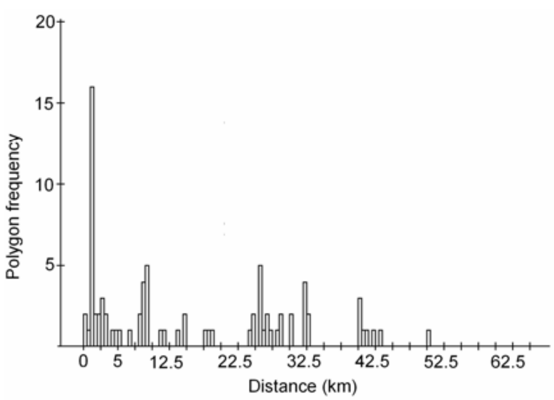


Figure B.5-4*b*: Distance (km) from RMNP border (PFRA 2001) to closest dry upland prairie polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

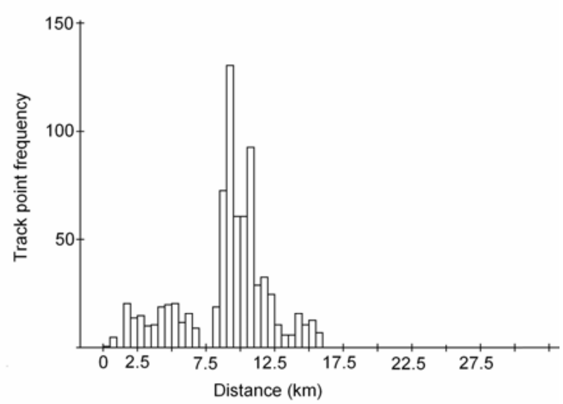


Figure B.5-4*c*: Distance (km) from wolf track points to closest dry upland prairie polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Hardwood is relatively frequently occurring (Figure B.1-2) and unevenly distributed between the parks as finely joined clusters (Figure B.5-5*a*). Although there is a peak in hardwood adjacent to the park boundary, this land class also peaks and is frequent between the parks (Figure B.5-5*b*). All tracks are however found in close adjacency to hardwood (Figure B.5-5*c*), which strongly indicates selection for this cover class.

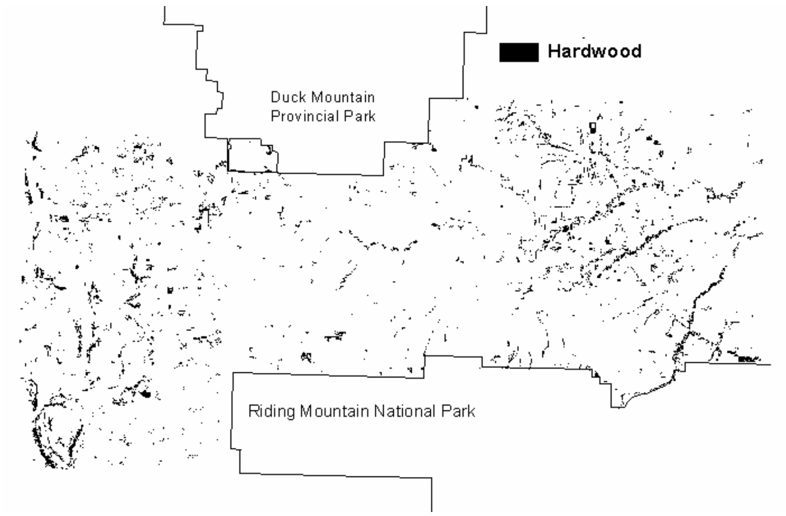


Figure B.5-5*a*: Spatial distribution of FRI based hardwood polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

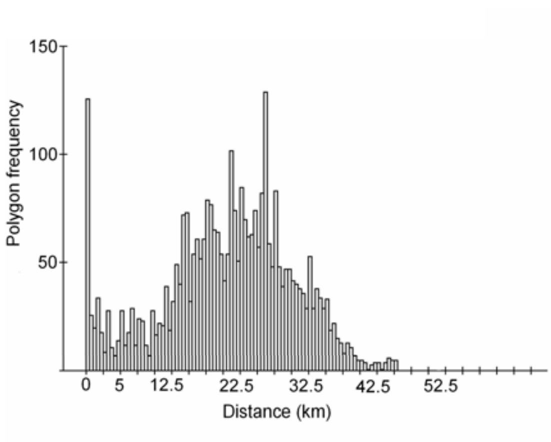


Figure B.5-5*b*: Distance (km) from RMNP border (PFRA 2001) to closest hardwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

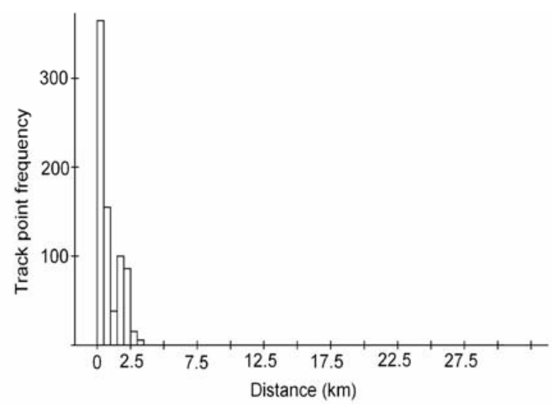


Figure B.5-5*c*: Distance (km) from wolf track points to closest hardwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Human disturbed land polygons are relatively commonly occurring (Figure B.1-2) and evenly distributed across the area as regularly shaped but unevenly sized clusters (Figure B.5-6*a*). The widespread, even distribution of this land class (Figure B.5-6*b*) causes all track points to be close to human disturbed land, without indicating selection (Figure B.5-6*c*).

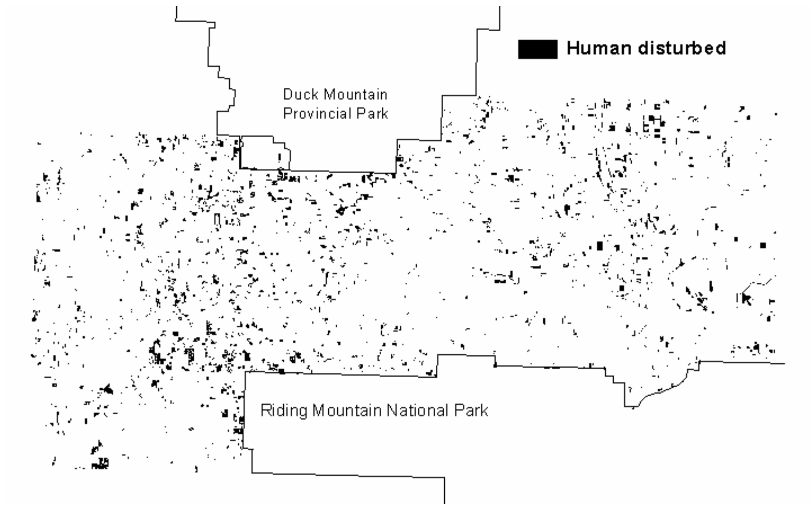


Figure B.5-6*a*): Spatial distribution of FRI based human disturbed land polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

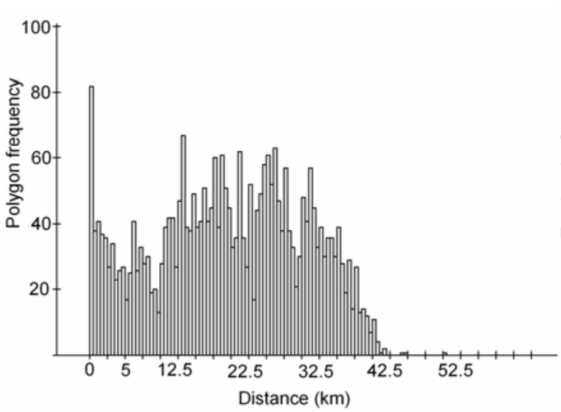


Figure B.5-6*b*: Distance (km) from RMNP border (PFRA 2001) to closest human disturbed land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

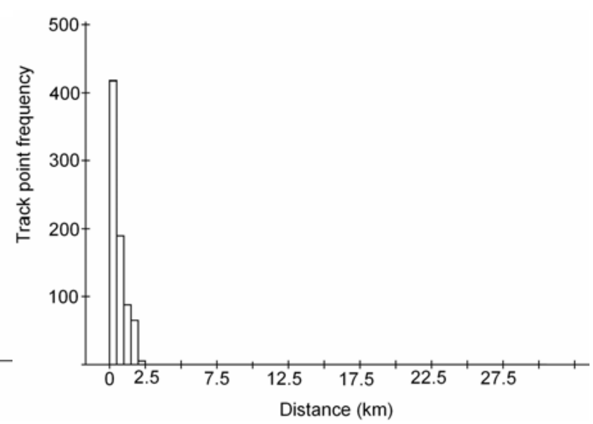


Figure B.5-6*c*: Distance (km) from wolf track points to closest human disturbed land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Linear features are rare on the landscape (Figure B.1-2) and irregularly distributed as fine lines (Figure B.5-7*a*). Linear features are most commonly occurring away from the RMNP boundary (Figure B.5-7*b*), whereas all recorded tracks are found a short distance from this land class (Figure B.5-7*c*). Given the uneven distribution of this land category across the landscape and the proximity to wolf tracks, in can be concluded that traveling wolves between the parks select for linear features.

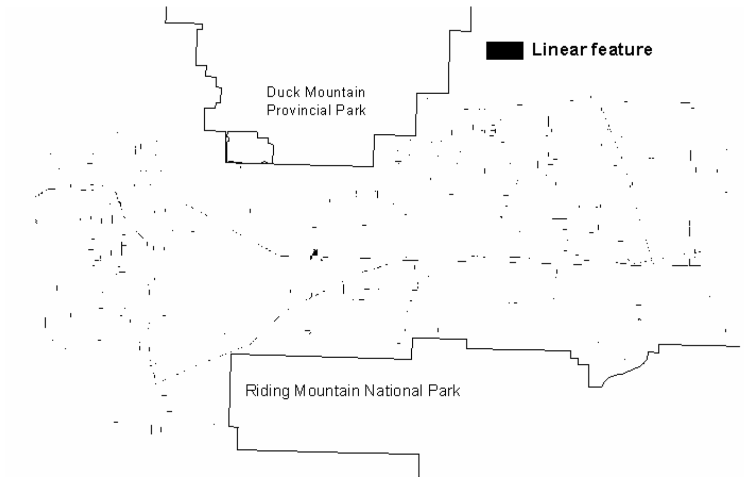
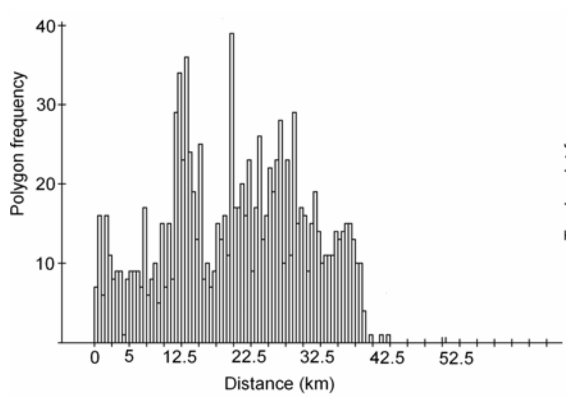


Figure B.5-7*a*: Spatial distribution of FRI based linear feature polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).



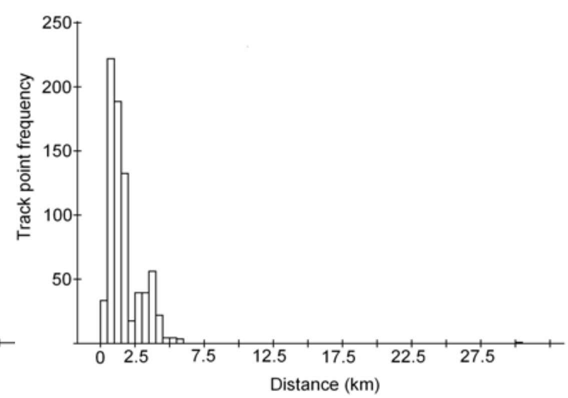


Figure B.5-7*b*: Distance (km) from RMNP border (PFRA 2001) to closest linear feature polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Figure B.5-7*c*: Distance (km) from wolf track points to closest linear feature polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Marsh is rare (Figure B.1-2) and unevenly distributed across the area in fine clusters (Figure B.5-8*a*). Most polygons of this land class are located away from RMNP (Figure B.5-8*b*). Compared to the spatial distribution of marsh polygons, the recorded tracks are in relatively close proximity to this habitat class (Figure B.5-8*c*). It can therefore be concluded that wolves select for marshland between the parks.

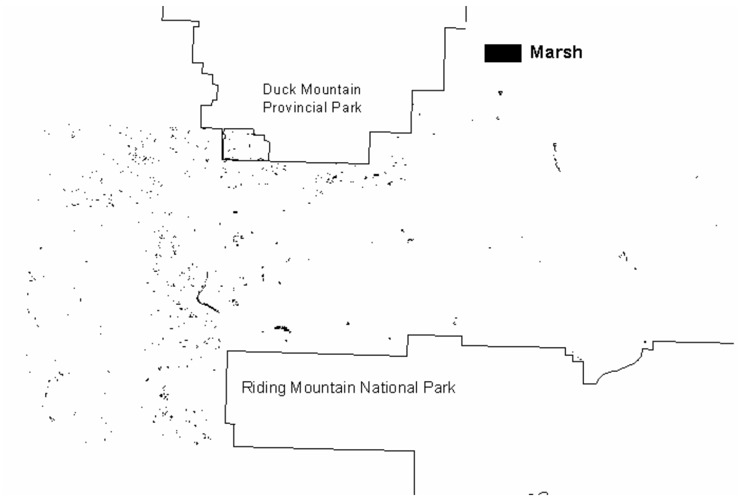


Figure B.5-8*a*: Spatial distribution of FRI based marsh polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

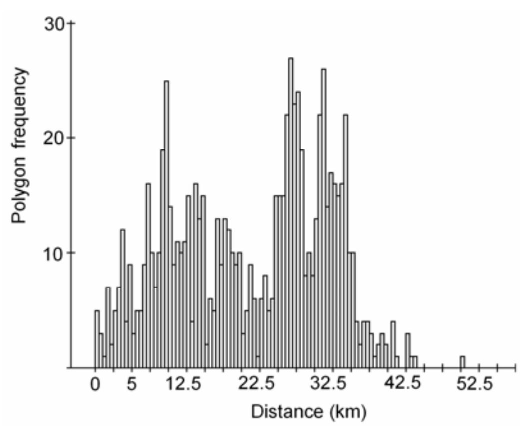


Figure B.5-8*b*: Distance (km) from RMNP border (PFRA 2001) to closest marsh polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

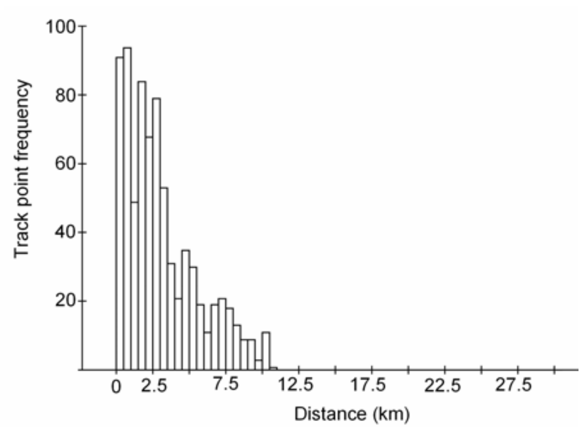


Figure B.5-8*c*: Distance (km) from wolf track points to closest marsh polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Mixed hardwood/softwood is rarely occurring between the parks (Figure B.1-2) and is disproportionally distributed as patchy clusters that occur mainly south of the DMPP&F (Figure B.5-9*a*). The peak occurrence of mixed hardwood-softwood is approximately 22,000 meters away from RMNP (Figure B.5-9*b*), which also coincides with a peak in distances from tracks to this land class (Figure B.5-9*c*). There is also a predominant peak in track points adjacent to this land class, which indicates that wolves select for mixed hardwood/softwood- stands between the parks.

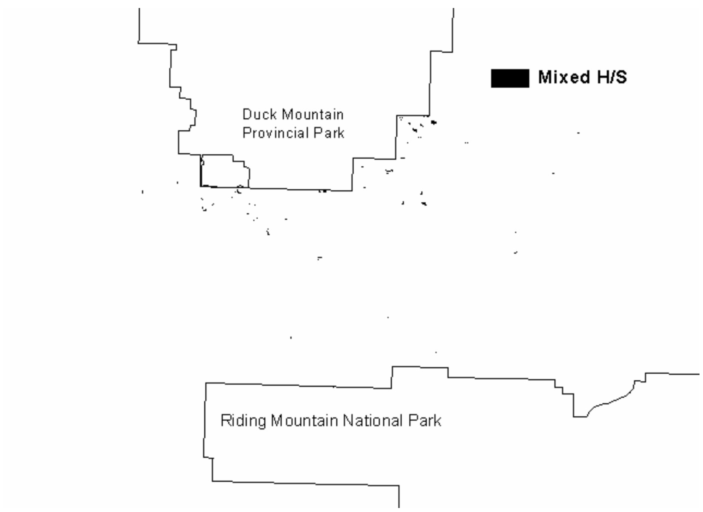
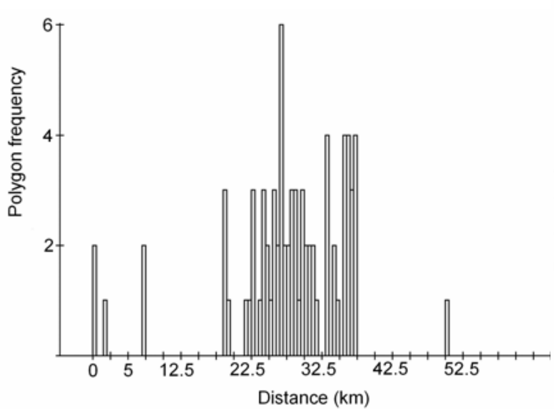


Figure B.5-9*a*: Spatial distribution of FRI based mixed hardwood/softwood polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).



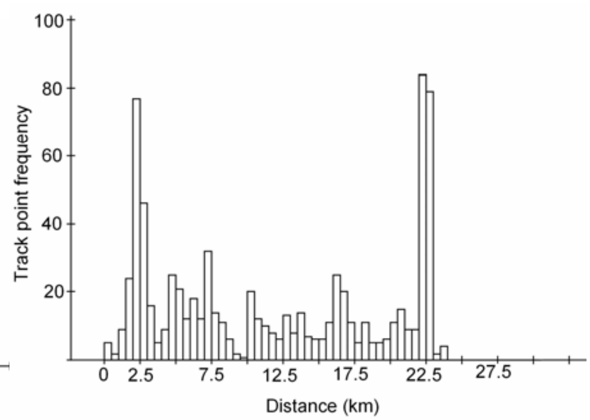


Figure B.5-9*b*: Distance (km) from RMNP border (PFRA 2001) to closest mixed hardwood/softwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Figure B.5-9*c*: Distance (km) from wolf track points to closest mixed hardwood/softwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Moist prairie is moderately occurring (Figure B.1-2) and relatively evenly distributed across the whole area as fine, irregularly sized clusters (Figure B.5-10*a*, Figure B.5-10*b*). As a result of the wide spread distribution of this land class, there is not enough evidence to conclude that the close adjacency of tracks to moist prairie (Figure B.5-10*c*) indicates selection.

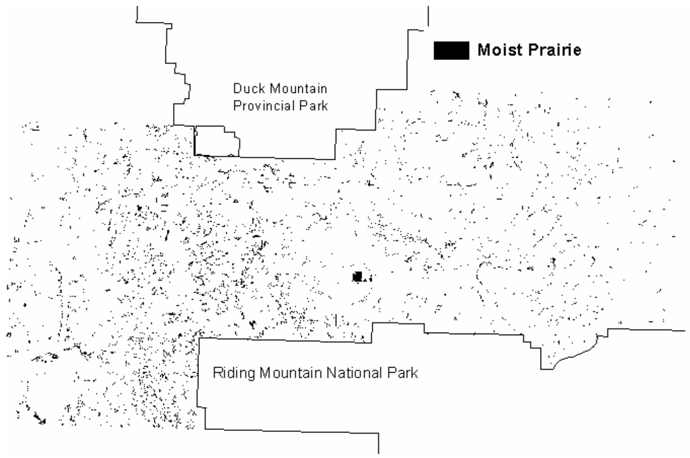
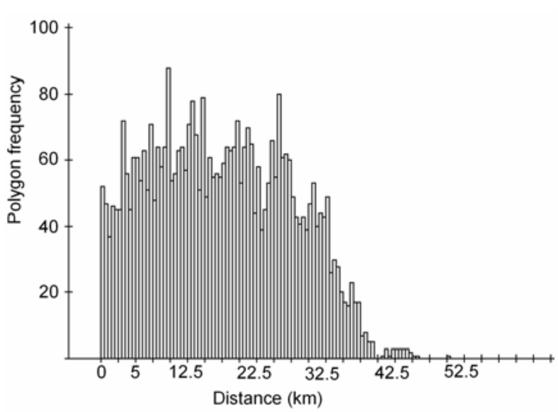


Figure B.5-10*a*: Spatial distribution of FRI based moist prairie polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).



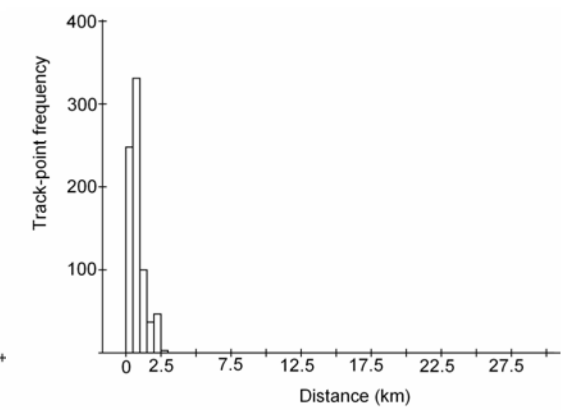


Figure B.5-10*b*: Distance (km) from RMNP border (PFRA 2001) to closest moist prairie polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Figure B.5-10*c*: Distance (km) from wolf track points to closest moist prairie polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Land classified as naturally disturbed is rarely occurring between the parks (Figure B.1-2) and disproportionally distributed to the west of RMNP in fine clusters (Figure B.5-11*a*,). The scattered distance frequencies from track points (Figure B.5-11*b*) reflect the uneven distribution of this land class. While there is a peak in track points distances adjacent to naturally disturbed land (Figure B.5-11*c*), the land class is to rarely occurring to infer selection based on the findings.

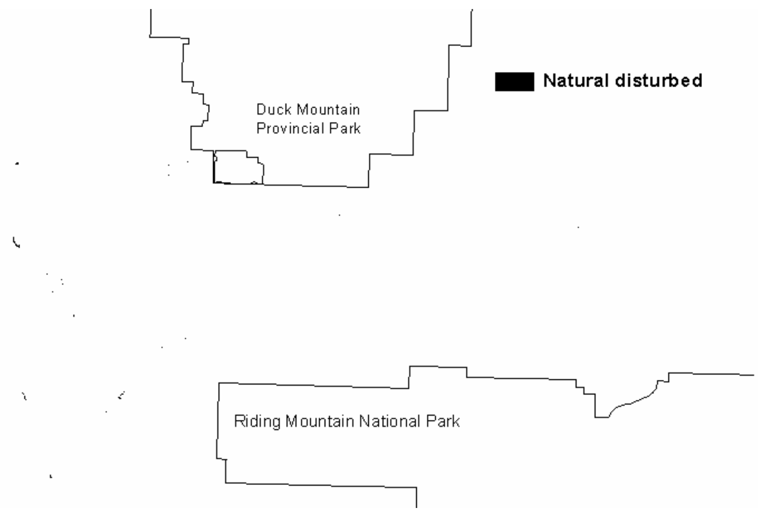
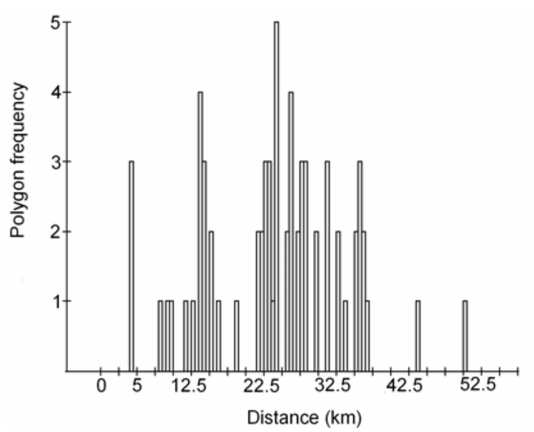


Figure B.5-11*a*: Spatial distribution of FRI based natural disturbed land polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).



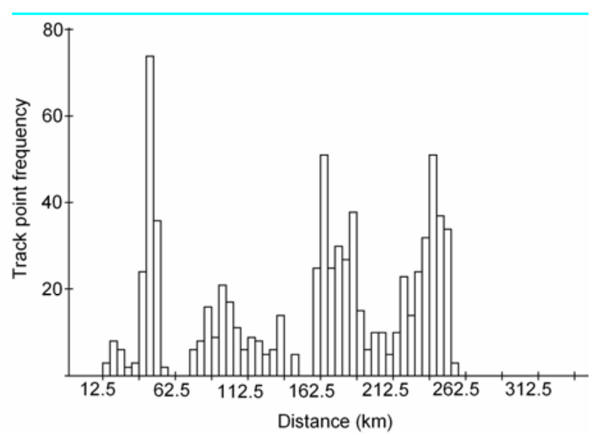


Figure B.5-11*b*: Distance (km) from RMNP border (PFRA 2001) to closest naturally disturbed land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Figure B.5-11*c*. Distance (km) from wolf track points to closest naturally disturbed land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

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Pastureland is an abundant land class (Figure B.1-2) that is widely distributed as congregated patchy clusters across the landscape (Figure B.5-12*a*). The occurrence of this land category peaks between the two parks (Figure B.5-12*b*). All recorded track points are however relatively close to pastureland (Figure B.5-12*c*). Based on the results, it can be concluded that wolves select for pastureland outside the park boundaries.

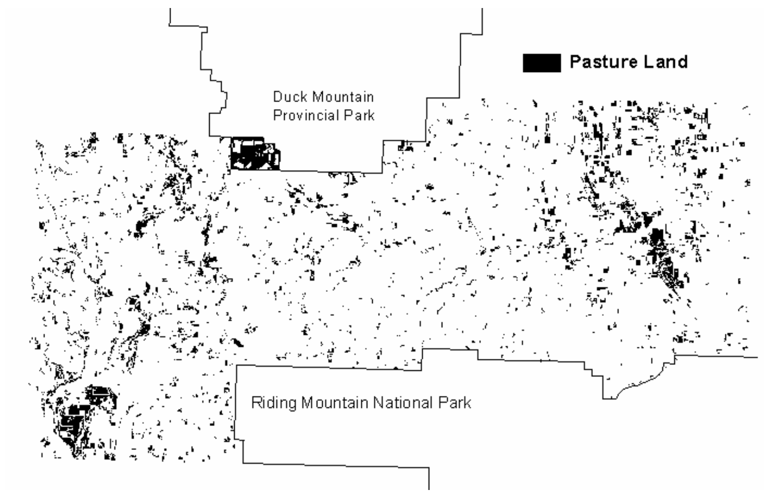

Figure B.5-12*a*: Spatial distribution of FRI based pasture land polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

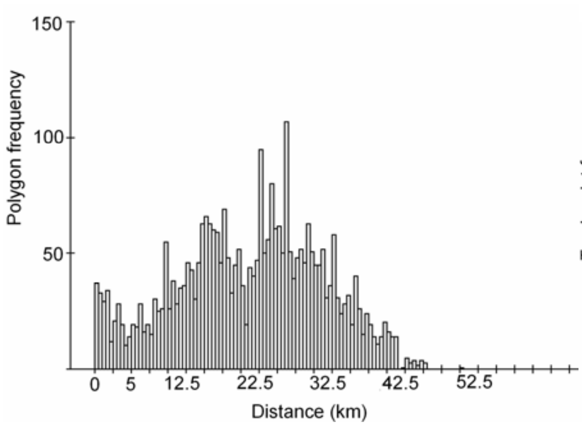

Figure B.5-12*b*: Distance (km) from RMNP border (PFRA 2001) to closest pasture land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

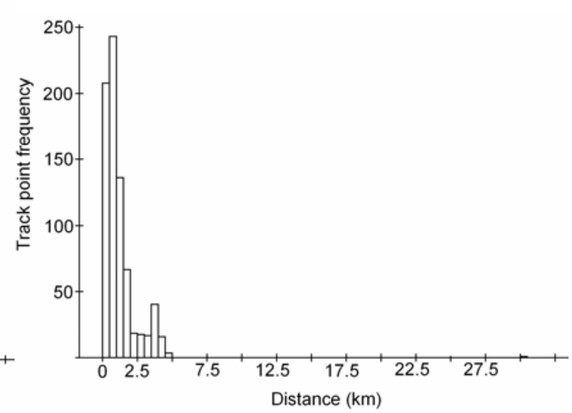

Figure B.5-12*c*: Distance (km) from wolf track points to closest pasture land polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Shrub land is moderately occurring (Figure B.1-2) and evenly distributed over the landscape as finely joined, linear polygons (Figure B.5-13*a*). There are peaks in shrub occurrence adjacent to RMNP as well as between the parks (Figure B.5-13*b*). The fact that all track points are in close proximity to this land class indicates that wolves select shrub land between the parks (Figure B.5-13*c*).

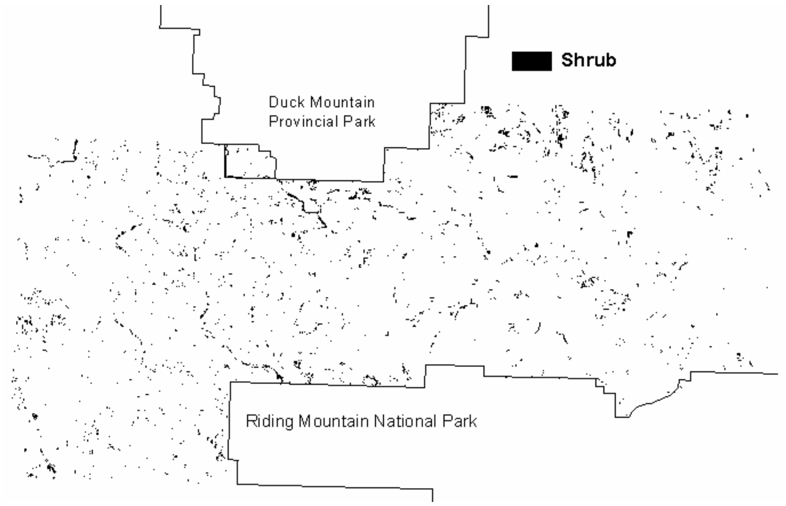

Figure B.5-13*a*: Spatial distribution of FRI based shrub polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

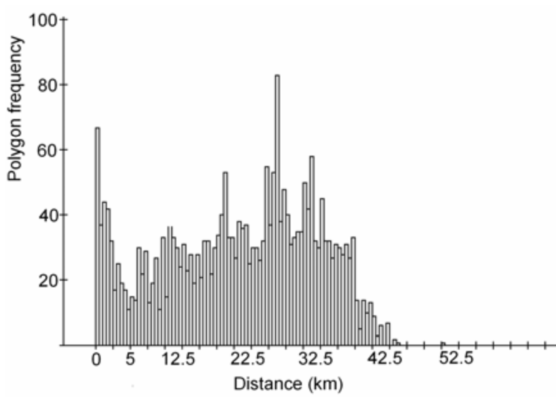

Figure B.5-13*b*: Distance (km) from RMNP border (PFRA 2001) to closest shrub polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

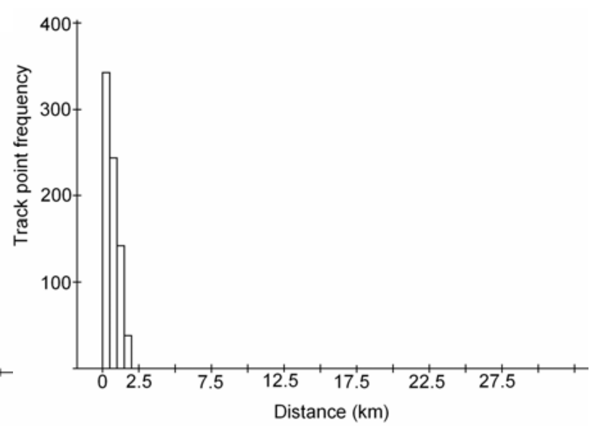

Figure B.5-13*c*: Distance (km) from wolf track points to closest shrub polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Softwood is sparsely distributed (Figure B.1-2) as patchy clusters that mainly occur closer to the DMPP&F (Figure B.5-14*a*). Concurrent with the peak in softwood approximately 25 km from RMNP (Figure B.5-14*b*) is a corresponding peak at similar distance from track points to softwood (Figure B.5-14*c*). There is however also another peak in track point distances adjacent to softwood that likely results from tracks recorded close to the Duck Mountains. Based on the assumption that the wolves originate from the RMNP, it can be concluded that softwood is selected for by wolves outside the park boundaries.

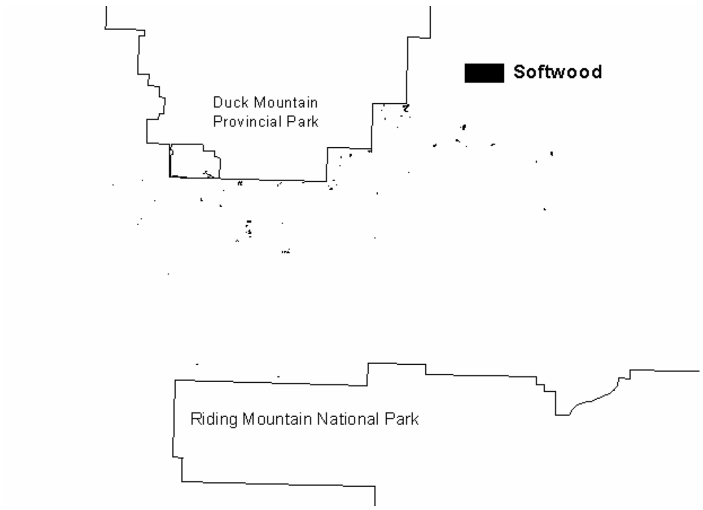

Figure B.5-14*a*: Spatial distribution of FRI based softwood polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

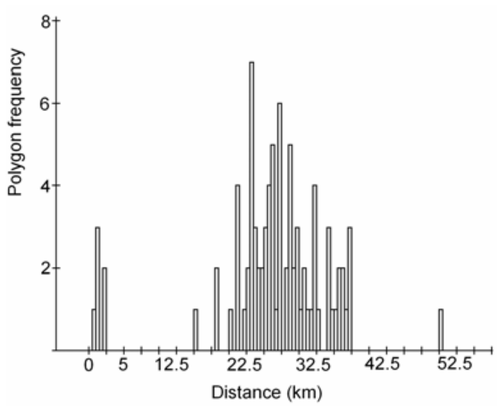

Figure B.5-14*b*: Distance (km) from RMNP border (PFRA 2001) to closest softwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

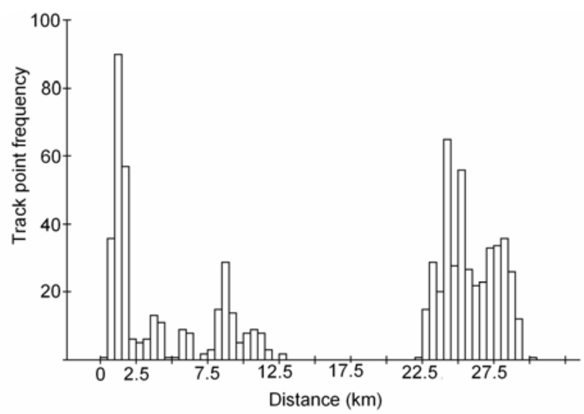

Figure B.5-14*c*: Distance (km) from wolf track points to closest softwood polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Town site polygons are moderately occurring (Figure B.1-2) and relatively evenly distributed; although more frequently occurring and larger in size further from the park boundaries (Figure B.5-15*a*).Given the wide spread distribution of town site polygons (Figure B.5-15*b*), the finding of tracks adjacent to this land category does not provide enough evidence to conclude selection (Figure B.5-15*c*).

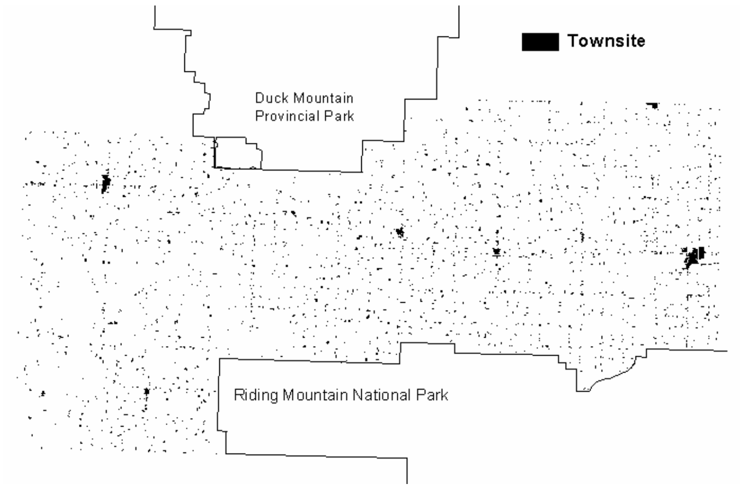

Figure B.5-15*a*: Spatial distribution of FRI based town site polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

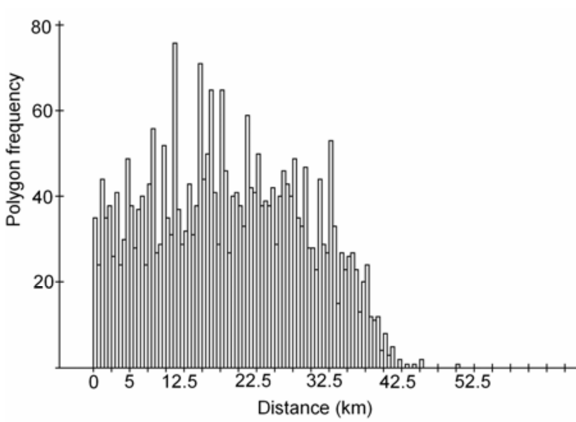

Figure B.5-15*b*: Distance (km) from RMNP border (PFRA 2001) to closest town site polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

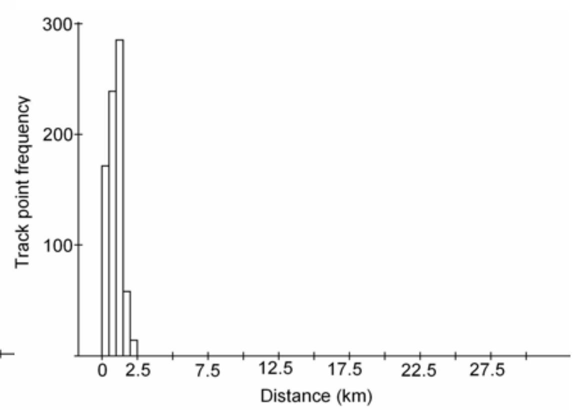

Figure B.5-15*c*: Distance (km) from wolf track points to closest town site polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Trembling Aspen is present on the landscape in relatively large quantities (Figure B.1-2) and is unevenly distributed as congregated patches (Figure B.5-16*a*). The abundance of this land class peaks adjacent to the park perimeter, but larger quantities also occur between the parks (Figure B.5-16*b*). All track points are adjacent to Trembling Aspen (Figure B.5-16*c*), which compared to the spatial distribution of the land class indicates selection by wolves between the parks.

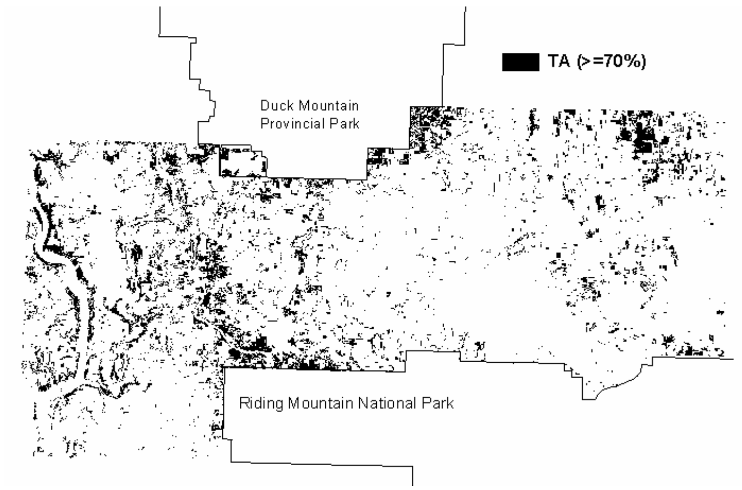

Figure B.5-16*a*: Spatial distribution of FRI based Trembling Aspen polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

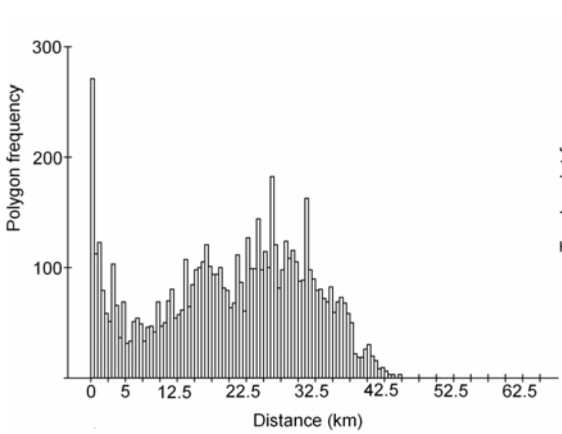

Figure B.5-16*b*: Distance (km) from RMNP border (PFRA 2001) to closest Trembling Aspen polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

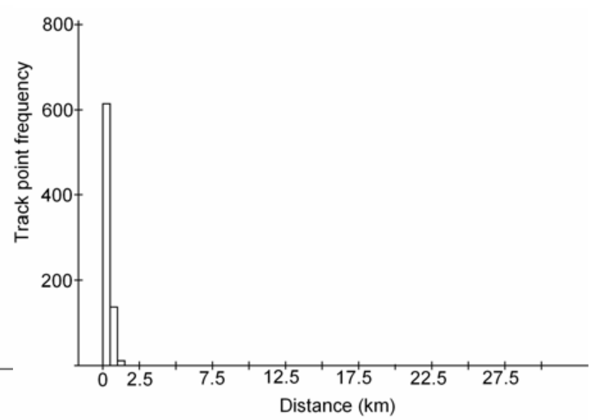

Figure B.5-16*c*: Distance (km) from wolf track points to closest Trembling Aspen polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

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Water polygons are moderately occurring (Figure B.1-2) and unevenly distributed across the landscape as joint, fine as well as larger clusters (Figure B.5-15*a*). Most of the water in the area is located at a distance away from RMNP (Figure B.5-15*b*). The fact that most track points are relatively close to this land class (Figure B.5-15*c*) indicates that wolves select for water between the parks.

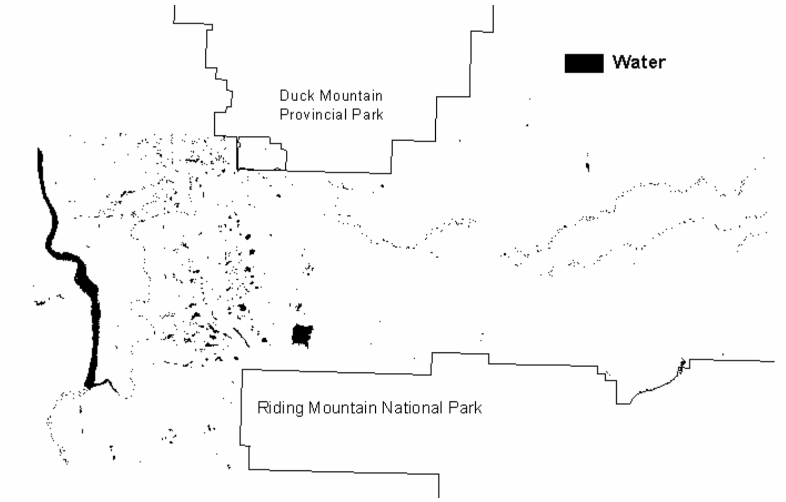


Figure B.5-15*a*: Spatial distribution of FRI based water polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

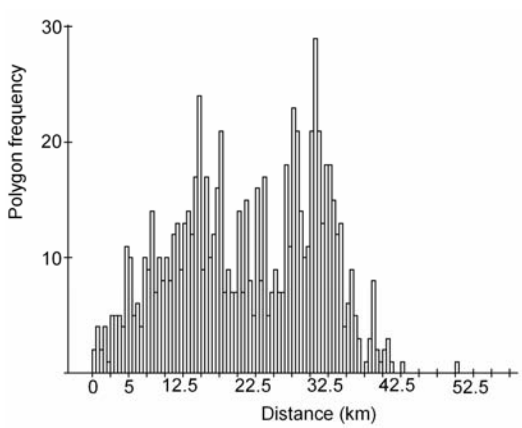


Figure B.5-15*b*: Distance (km) from RMNP border (PFRA 2001) to closest water polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

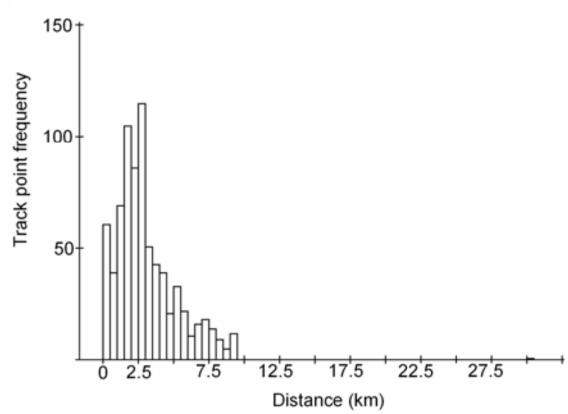


Figure B.5-15*c*: Distance (km) from wolf track points to closest water polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

Wet meadow is rare (Figure B.1-2) and unevenly distributed over the landscape as fine patches (Figure B.5-18*a*). Although this land class peaks close to RMNP, there are prominent occurrences of the cover type at away from the park boundary (Figure B.5-18*b*). Most tracks are relatively close to wetland (Figure B.5-18*c*), which compared to the land distribution indicates selection for this habitat type.

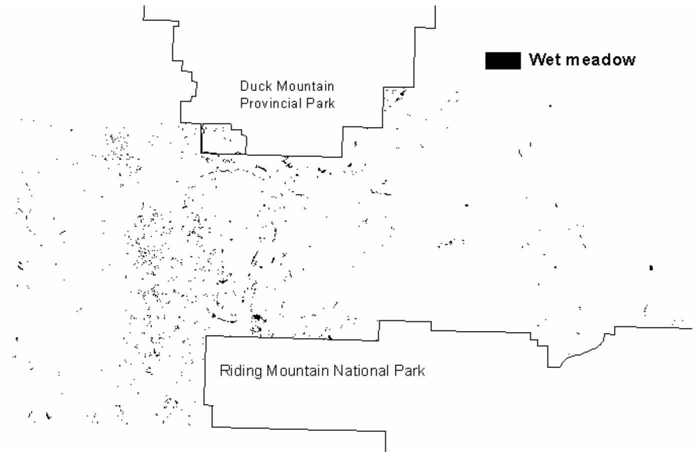


Figure B.5-18*a*: Spatial distribution of FRI based wet meadow polygons (MLI 1980-82) between RMNP and DMPP&F (PFRA 2001), Manitoba (1:50,000).

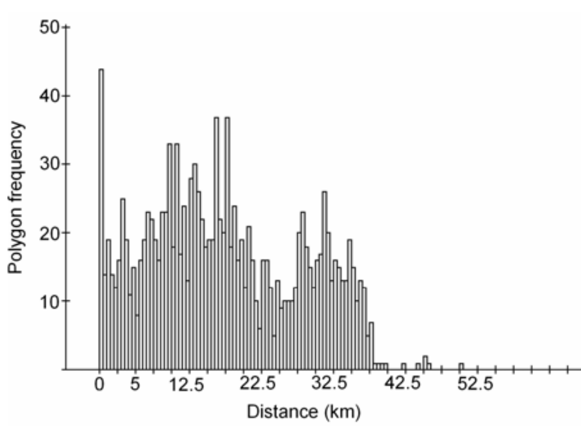


Figure B.5-18*b*: Distance (km) from RMNP border (PFRA 2001) to closest wet meadow polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

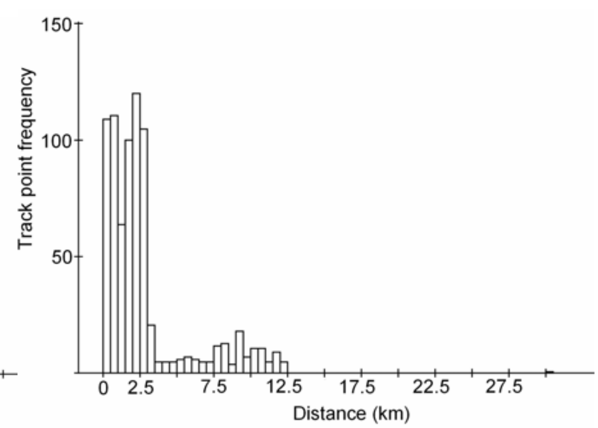


Figure B.5-18*c*: Distance (km) from wolf track points to closest wet meadow polygon, based on FRI data (MLI 1980-82) between RMNP and DMPP&F, Manitoba.

B.6 Road distances

Roads classified other are common across the landscape (Figure B.6-1*a*), although the peak occurrence is a distance away from the park (Figure B.6-1*b*). The widespread distribution of this road class results in short distances to all track points (Figure B.6-1*c*), without indicating selection.

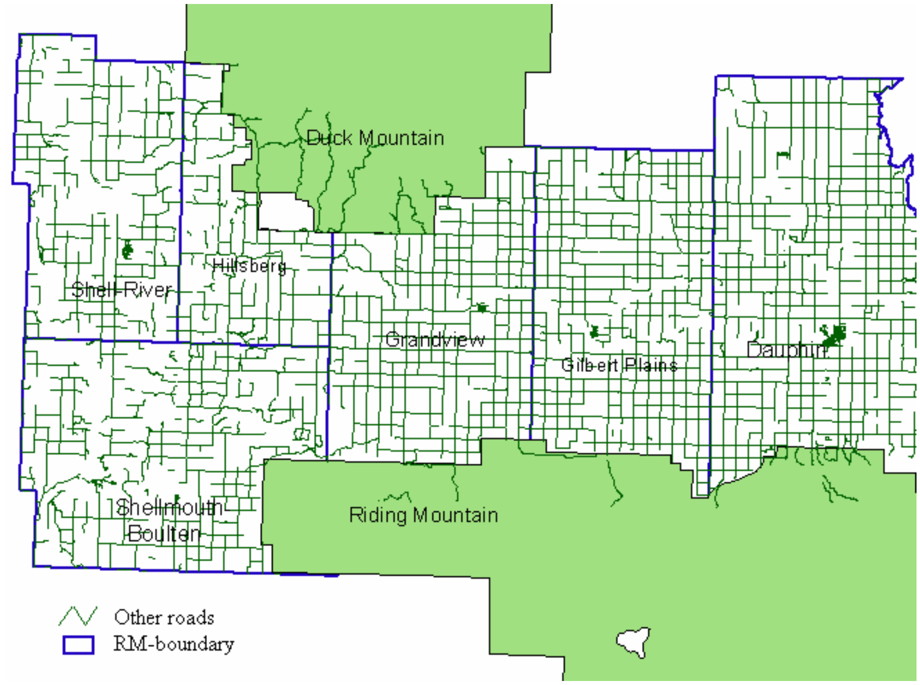


Figure A4.5-1*a*: Spatial distribution of roads classified other between RMNP and DMPP&F, Manitoba (PFRA 2001).

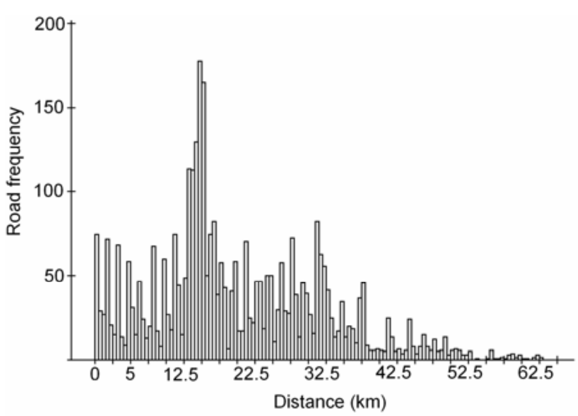


Figure B.6-1*b*: Distance (km) from RMNP to nearest other roads (PFRA 2001) between RMNP & DMPP&F, Manitoba.

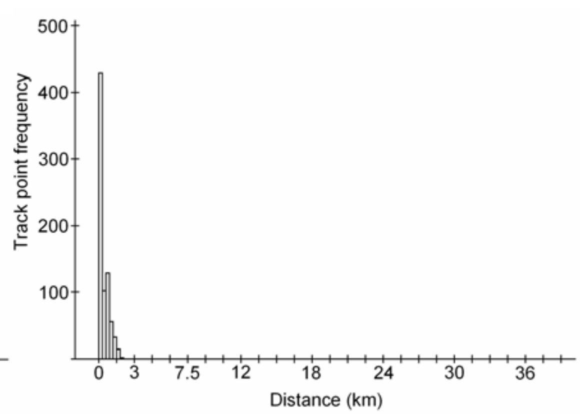


Figure B.6-1*c*: Distance (km) from wolf track points (winter 2002-03) to nearest other road (PFRA 2001) between RMNP & DMPP&F, Manitoba.

Provincial roads are relatively rare but widely spread across the area (Figure B.6-2*a*), with peak occurrences at distances away from RMNP (Figure B.6-2*b*). Compared to this peak, recorded track points are relatively close to provincial roads (Figure B.6-2*c*). This is an effect of the extended linear shape of the road type rather than selection, which is confirmed by the lack of tracks in direct adjacency this road class. The immediate gap in distance to tracks further indicates that wolves avoid provincial roads.

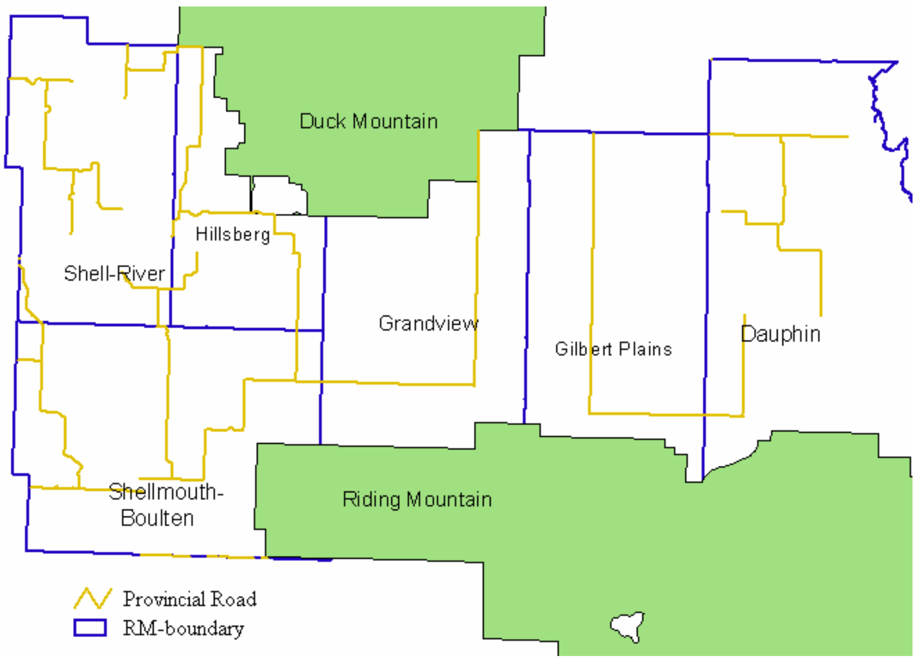


Figure B.6-2*a*: Spatial distribution of roads classified provincial roads between RMNP and DMPP&F, Manitoba (PFRA 2001) (1:50,000).

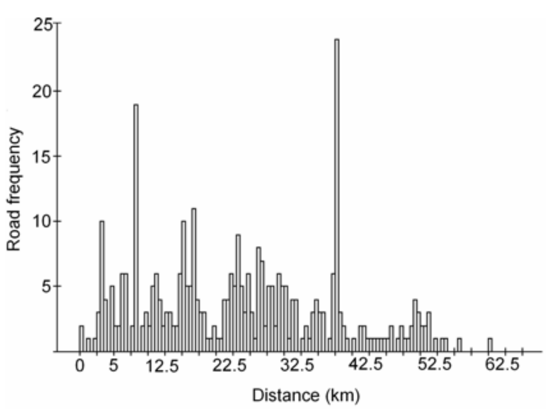


Figure B.6-2*b*: Distance (km) from RMNP to nearest provincial road (PFRA 2001) between RMNP and DMPP&F, Manitoba.

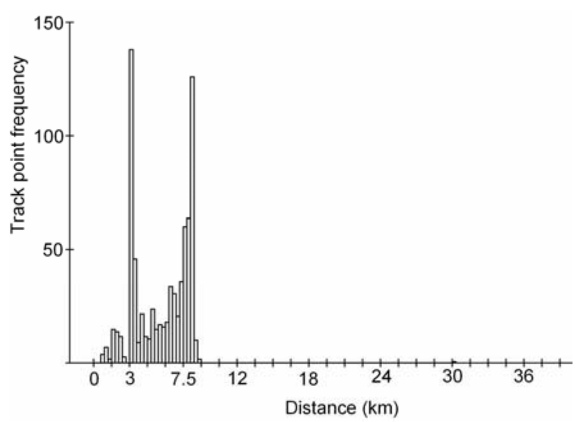


Figure B.6-2*c*: Distance (km) from wolf track points (winter 2002-03) to nearest provincial road (PFRA 2001) between RMNP and DMPP&F, Manitoba.

Provincial trunk highways are rare and unevenly distributed in the area (Figure B.6-3*a*), with peak occurrence a distance away from both park boundaries (Figure B.6-3*b*). The peak in track point distances are further from this road class than the distance from roads to the park (Figure B.6-3*c*). Based on these findings, it can be concluded that wolves in the area avoid highways.

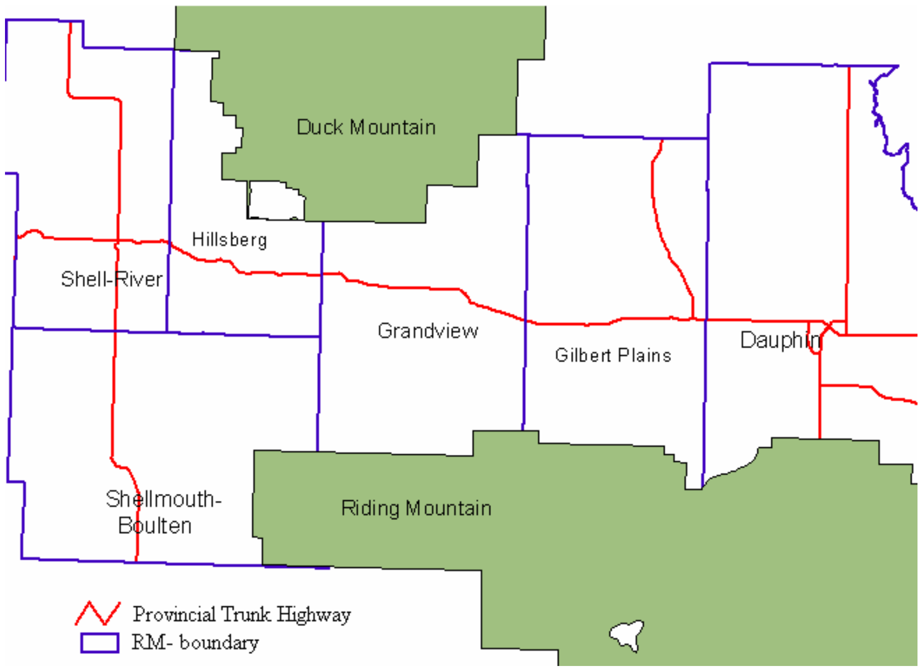
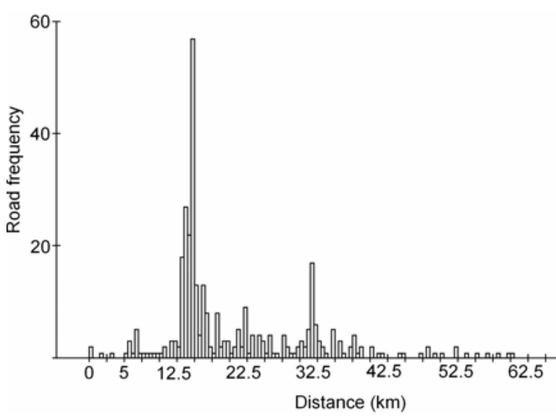


Figure B.6-3*a*: Spatial distribution of roads classified provincial trunk highway between RMNP and DMPP&F, Manitoba (PFRA 2001) (1:50,000).



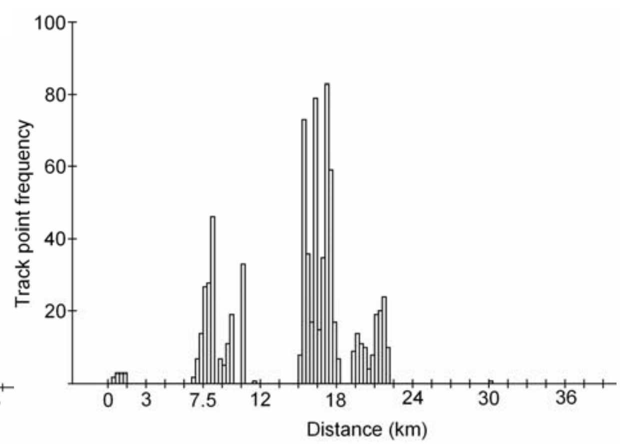


Figure B.6-3*b*: Distance (km) from the RMNP-boundary to nearest provincial trunk highway (PFRA 2001) between RMNP & DMPP&F, Manitoba.

Figure B.6-3*c*: Distance (km) from GPS wolf track points (2002-03) to nearest provincial trunk highway (PFRA 2001) between RMNP & DMPP&F, Manitoba.

B.7 **Hike between RMNP & DMPP&F**

The hike from RMNP to DMPP&F provided ground level experience in the difficulty of remaining within protective land cover between the parks (Figure B.7-1). Two people could however travel undetected between the parks for 1.5 days by following forest edges and linear features whenever possible. Open fields and roads often were adjacent to woodland, although crossing these human disturbed areas often provided safe shortcuts given the general lack of human activity. The high way between the parks, assumed to be a barrier, received low traffic volumes at the time it was reached. It was further possible to wait undetected in ditches until roads were clear for crossing.

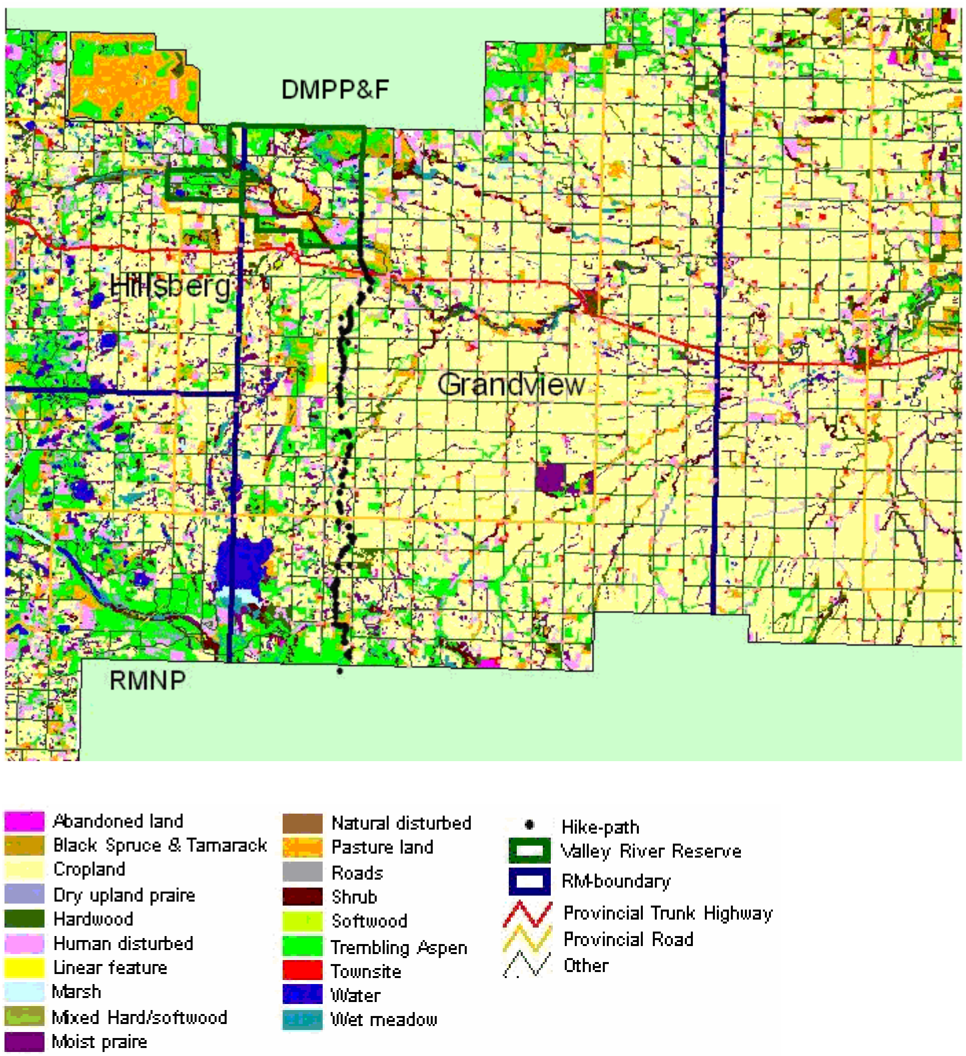


Figure B.7-1: GPS recorded path hike “from a wolf’s perspective” 18-19 June 2003 between RMNP and the DMPP&F, Manitoba (PFRA 2001), overlaid on FRI based land cover (MLI 1980-81) including road network (PFRA 2001) (1:15840).

B.8 **Wolves related to ungulate and greenness**

Based on visual assessment of prey and wolf locations related to greenness (B.8-1), ungulates are less likely to avoid open areas between the parks compared to wolves that seem to use forest edges. There is no apparent relationship between wolves and ungulates outside the park boundaries.

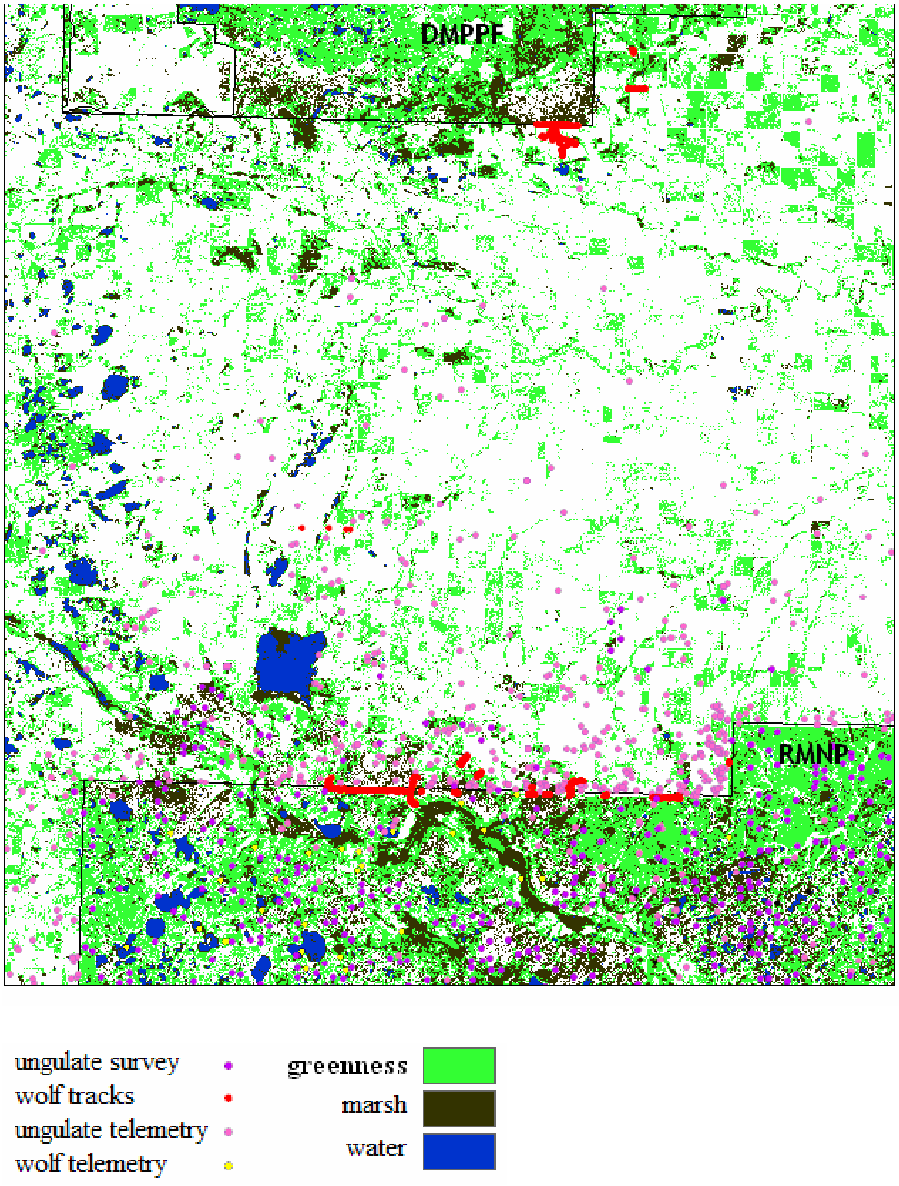


Figure B.8-1: Locations of GPS recorded wolf tracks (winter 2002-03) and ungulates based on kill locations (Parks Canada1998-2002) and telemetry data (Parks Canada 2005) between RMNP and DMPP&F, Manitoba, related to greenness, based on linear tasseled cap transformation on band 1,2,3,4,5,and 7 of a local Landsat 7 image (MLI, Jul 2001).

B.9 **Compensation claims**

A number of compensation claims occurred between the parks (Figure B.9-1). Several of these claims do not fall within the identified selection areas between the parks (Figure B.9-2).

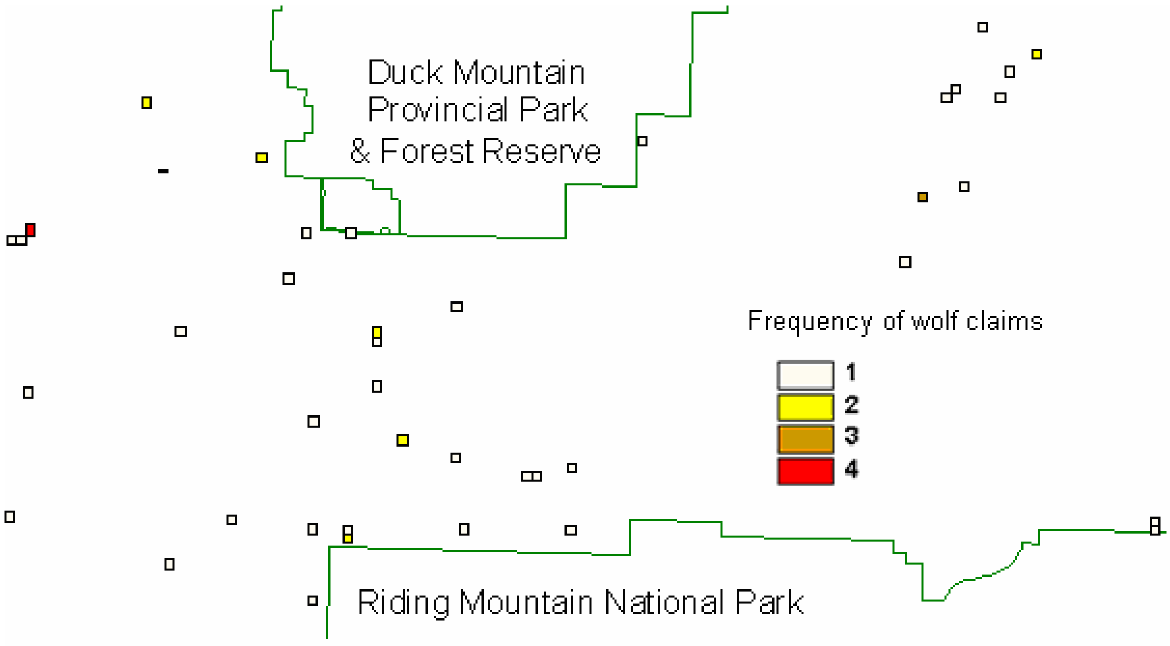
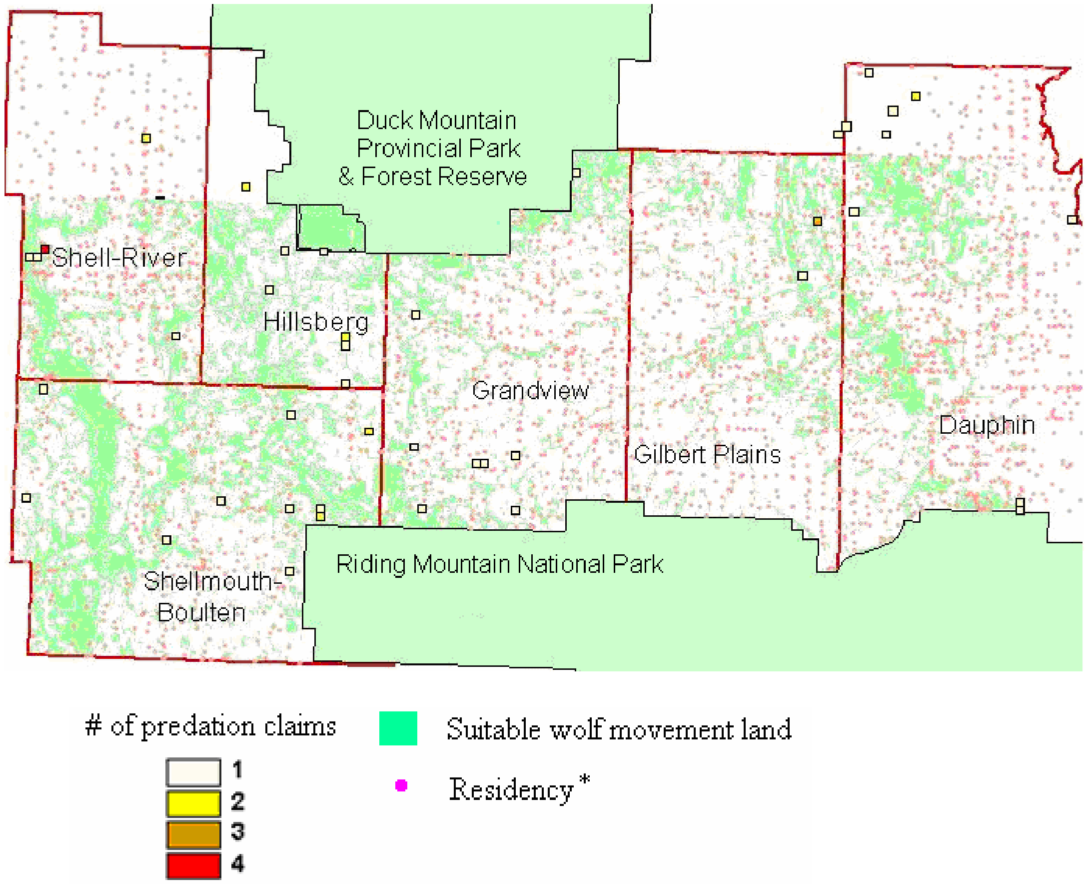


Figure B.9-1: Locations for wolf predation compensation claims (MCIC 1999-2002) between RMNP and DMPP&F, Manitoba (PFRA 2001) (1:50,000).



**Data missing for Hillsberg*

Figure B.9-2: Suitable land cover for wolves between RMNP and DMPP&F, Manitoba (PFRA 2001) related to wolf predation compensation claims (MCIC 1999-2002) and residencies (Rural Municipality Councilors 2001) (1:50,000).

B.10 Recommended methods and analysis

GPS telemetry.--Location data can be collected by GPS telemetry, which is less restricted to environmental conditions compared with VHF telemetry (Mech & Barber 2002). GPS telemetry further provides increased number as well as more accurate and finer scale location data than VHF (Mech & Barber 2002).

Non-invasive methods.--Telemetry sampling techniques are often costly; both in terms of money and impacts in terms of stress on monitored wildlife (Mech & Barber 2002). Recently developed genetic sampling methods provide cost effective and non-invasive alternatives that require less intensive fieldwork. Sampling methods that do not interfere with the animal's natural behavior are particularly useful for monitoring elusive animals, such as large carnivores (Kendall 1999).

Assessing connectivity.--Models can be used to evaluate effects of habitat loss on wolf distribution (Paquet et al. 2001). It is further important to assess the influence exerted by human activities that modify and constrain wolf behavior (Paquet et al. 2001). Human disturbance may be accounted for in habitat models as distances and densities of road (Paquet et al. 1996). Ideal conditions are usually identified as absence of human activity and disturbance (Paquet et al. 2001). Demographic modeling can further be used to determine tolerable levels of degradation (Doak 1995, Carroll et al. 2001). Location data can be integrated with data on population growth and landscape change to help determine areas where conservation efforts should be focused (Carroll et al. 2001). Given the complexity of wolf dispersal behavior, variations in dispersal results must be considered in evaluation of model outputs (Carroll et al. 2003). Models used to evaluate fragmentation effects on populations must further assess the spatial landscape structure (Fahrig & Merrian 1994). Ecological relations between wolves, prey and other predators are other factors of importance in suitability models (Fuller 1989).

Population models.--Population models may be used as a tool to predict the effects of habitat loss and fragmentation on wolf survival rates (Russel et al. 2003). The relative importance of various habitat types may be identified based on results from predicative models (Paquet et al. 1996). These findings could also be used to map the most suitable habitat composition for coexistence of wolves and humans (Noss et al. 1996). Spatial habitat information can be further combined with demographic data in population models to predict area requirements and to evaluate connectivity (Carroll et al. 2003). Behavioral aspects of wolves can be further incorporated for more accurate predictions of the effects of landscape modifications on species movement (Russel et al. 2003).