Land Use and Conservation Values of Farmland Forests:

Outcomes of Livestock Grazing on the Aspen Forest Understorey

in the Greater Riding Mountain Region, Manitoba

By
Karin E. Newman

A thesis
Submitted to the Faculty of Graduate Studies of the
University of Manitoba
in partial fulfillment of the requirements for the degree of
Master of Science

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"Land Use and Conservation Values of Farmland Forests: Outcomes of Livestock Grazing on the Aspen Forest Understorey in the Greater Riding Mountain Region, Manitoba"

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MASTER OF SCIENCE

Abstract

The past 125 years of agricultural settlement in North America has resulted in extremely fragmented habitats. In farming landscapes, small patches of remaining native vegetation on private land are generally intermixed with agriculture or are actively grazed by livestock. This study takes place in the primarily agricultural rural municipalities surrounding Riding Mountain National Park (RMNP), Manitoba, Canada. Even as the critical necessity to engage in conservation beyond borders is recognized, the importance of native vegetation habitats on private land, including forest, is too often overlooked. Although livestock are widely perceived as adversely affecting natural habitat, relatively little is known about the impacts of livestock grazing on these remnant forest habitats.

To examine the effects of cattle grazing on forests, the understorey diversity was compared across sites with different livestock grazing histories and intensities. Patch- and landscape-level environmental factors were measured at sites both in and around RMNP. The diversity of the matrix (non-forest) habitat of privately owned sites was invariably adversely affected by the intensity of agricultural land use, while forests showed more resilience. In forests, grazing intensity played a strong role in determining understorey composition. While livestock grazing tended to be associated with exotic species, only heavy grazing was significantly associated with increased cover of certain grazing-tolerant exotic species. Other native perennials were associated with non- grazed or moderately grazed sites. Furthermore, moderate grazing had no effect on the native understorey diversity, as compared to non-grazed and past grazed landscapes. These results suggest that both protected forests and moderately grazed forests act as important

refuges for native species in agricultural landscapes. A diversity of land uses, including moderate forest grazing, can be compatible with the protection of regional forests.

Although National Parks are increasingly surrounded by intense human land uses, often very little is known about the conservation goals of neighbouring local communities. Management ideals, attitudes and values that local landowners held about privately owned forests were collected through a series of structured interviews and a mail-out questionnaire in communities within the Riding Mountain Biosphere Reserve, surrounding RMNP. Because knowledge in the farming culture is often passed down from previous generations, each individual farmer holds decades of personal observations about this environment. Thus, survey participants were an important source of local knowledge and observations on the conservation and use of native vegetation in their environment. Landowners in the study area are managers of a substantial amount of native vegetation, much of which was used for cattle production. Conservation motivations for maintaining relatively undisturbed land were often associated with function and environmental services, including erosion, water retention and habitat protection. Forest cover also represented a significant proportion of native vegetation on private land. Participating landowners voiced the importance of maintaining non-production land on their farms. Despite financial reliance on the land base, stewardship and conservation reasons were the main motivations cited by participants for maintaining forested land. Current and future conservation plans to revitalise and preserve forested fragments in the greater Riding Mountain region will necessarily rely heavily on the knowledge experience and resources of local landowners.

Acknowledgements

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Table of Contents

List of Figures

List of Tables

1. Introduction and Literature review

1.1. General Introduction

Almost two centuries of farming settlement in North America has resulted in the conversion of extensive tracts of original grassland and forest to agricultural and livestock grazing lands (Boutin and Jobin 1998). The clearing and fragmentation of forests for cultivation has accompanied economic development through much of the world (Tyrchniewicz et al. 1999), effects of which include overall reduction of forest habitat and increased isolation of remaining forests (Kruess and Tscharntke 1994). Fragmentation has been linked to the loss of species and habitats (Boutin and Jobin 1998; Hobbs 1993), as well as changes to ecological processes (Hobbs 1993). Decades of fire suppression that have accompanied settlement (Hobson et al. 2002), along with the potential firebreak effect of widespread agricultural lands (Weir and Johnson 1998) have lengthened the fire cycle, changing patterns of forest renewal and succession, e.g. in the boreal forest (Weir and Johnson 1998; Bergeron and Dubuc 1989), and elsewhere in the world (Jantzi et al. 1999).

In western Canada, the aspen parkland/ boreal transition region settlement occurred in the late 1800s (Hobson et al. 2002; Bird 1961), and continued through to 1930. Prior to agricultural settlement, surveys undertaken were generally designed and carried out to qualify the timber and agricultural resource potential of the lands (Tyrell 1888). However, it is difficult to estimate the precise amount of loss for any habitat type prior to agricultural settlement, as there are few, if any, quantitative environmental surveys dating back to that time. Recently, there has been increasing interest in assessing what remains of the original vegetation cover in agricultural landscapes (Hobson et al.

2002) in order to monitor, to manage and to better preserve remnants of native vegetation (Fitzsimmons 2003; Keddy and Drummond 1996). Land cover in the rural municipality of Clanwilliam in the 1870s, before intense agricultural expansion took place, has been recently estimated by Sobkowich (2000), using qualitative surveyor notes and maps from this period, (Figure 1.1). On a larger scale, oblique aerial photography from 1948, which is available for the entire Biosphere Reserve region, has been used to create maps depicting land cover after the most intense agricultural expansion, (Figure 1.2.A). When compared to recent remotely sensed data, (PFRA 1994), it is apparent that forest clearing has continued steadily to the present (Figure 1.2.B). Much of the remaining forests in agricultural landscapes are privately owned as small farm woodlands (Jacobson 2002; Ranney et al. 1981). There is slow but increasing recognition that these small forests are an integral part of the landscape and contribute to the health of the greater ecosystem (Freemark et al. 2002; Erickson et al. 2001; Bayne and Hobson 1998; Boutin and Jobin 1998; Middleton and Merriam 1983).

(A) (B) (C)

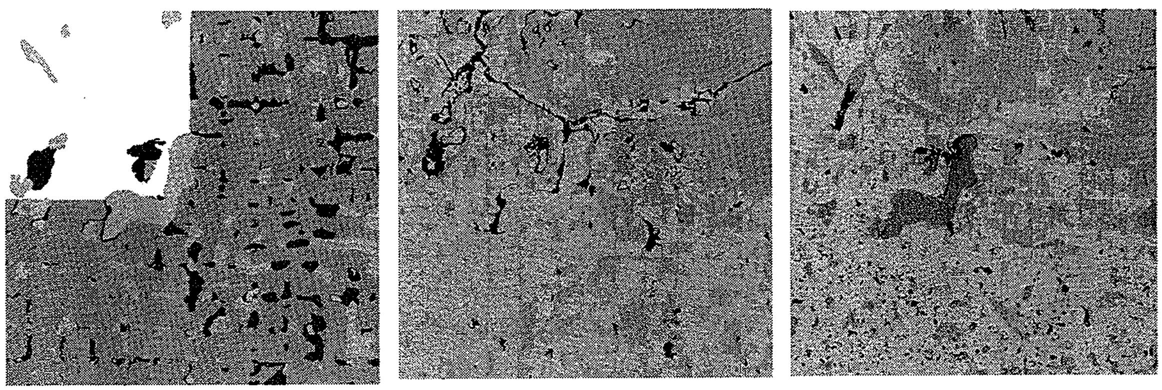
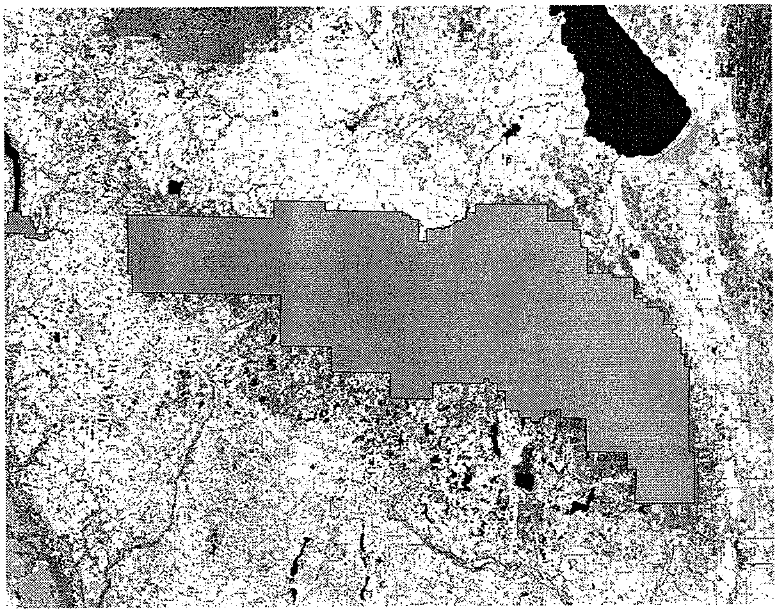


Figure 1.1. The land cover in the rural municipality of Clanwilliam, Manitoba, located southeast of and adjacent to Riding Mountain National Park, as calculated from (A) surveyors notes of 1874; (B) 1948 oblique aerial photography; and (C) 1993 remotely sensed data (Sobkowich 2000). Forested areas are portrayed as green, grassland/ agricultural as yellow, wetland as brown and water as blue.

(A)



(B)

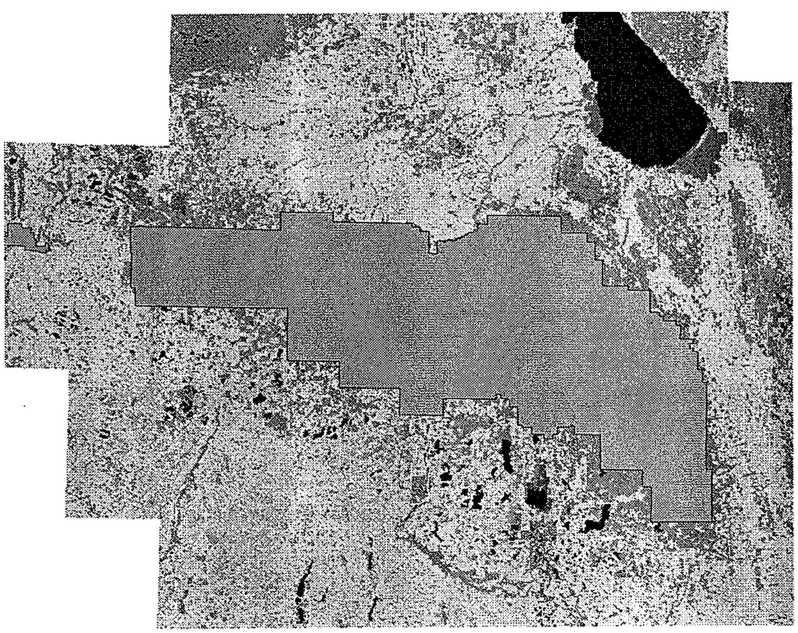


Figure 1.2. Land cover maps depicting land cover in the Riding Mountain Biosphere Reserve using (A) oblique aerial photographs 1948 (RMBR) and (B) remotely sensed data, 1993 (PRFA).

This study area is located in a human-dominated landscape of diverse agricultural and biophysical communities. Manitoba's first National Park, Riding Mountain (RMNP), represents a core area of relatively undisturbed 'wilderness' among current day farmlands, attracting tens of thousands of visitors each summer (Trant 1992). Outside the local forest reserves (RMNP, Duck Mountain Provincial Forest and Duck Mountain Provincial Park), the remaining forests and native vegetation are patchy and generally found near waterways or on non-arable farmland (Walker 2002). The present canopy consists of trembling aspen, balsam poplar and white birch. White spruce occurs occasionally in the canopy, although generally has been limited by past selective logging practices. Small family-owned agricultural and livestock operations continue to be the main land use influences on privately owned forested land. By and large, current landowners of the Riding Mountain region are part of the original community that settled this area for agricultural production, although non-farming landowners are increasingly attracted to the area because of the amenities that RMNP provides. Many long-time residents are a single generation away from the farming pioneers that first broke land in this region, while others remember first hand details about the land prior to settlement and clearing. These longtime local residents have insight into the environmental, economic and social values of their environment (Brook and McLachlan 2005).

1.2. Thesis Objectives

The rationale for this project stems from the growing interest and need to conserve remaining forest in the Riding Mountain region. Many of these forests are remnants of original native vegetation that occur on private land, and are currently influenced by livestock and agricultural production, the dominant economic activities of the region. Many privately owned forests also have ecological and social values.

While there have been several detailed biophysical studies, including numerous theses, within the national park (e.g. Walker 2002; Caners 2001; Caners 1999; Slogan 1995; Bailey 1968; Blood 1966 and others), very few ecological studies have been conducted in the primarily agricultural and privately owned matrix outside park boundaries. Up until now, there have been no data collected on the impacts of livestock grazing on local privately-owned woodlands surrounding Riding Mountain National Park. Furthermore, despite the presence and experience of many long-time landowners in this region, no other project has addressed the local knowledge of remaining forests, and livestock grazing on private lands.

The main purpose of this thesis is to explore attitudes and values farming landowners have towards privately owned forests, and to focus on effects that cattle grazing, a dominant land use in this region, has on these forests. Specific thesis objectives are to:

1. Determine effects of past and present levels of grazing on understorey diversity and species composition.

2. Determine the importance of grazing relative to other site and landscape-level variables.

3. Determine whether livestock grazing affects the relationship between forest and surrounding non-forest habitats.

4. Characterize how and to what extent private forests are used by local landowners.

5. Identify attitudes and values of landowners towards forest management and conservation.

6. Explore opportunities for and barriers to future conservation on privately owned forested land.

In order to carry out these objectives, two approaches were followed. Ecological methods (chapter 2) were used to measure biophysical attributes of local forests to quantify the effects of past and present levels of livestock grazing on fragmented, privately-owned forest patches. A social perspective (chapter 3) sought a deeper understanding of local motivations for owning and maintaining forested land, achieved through a series of interviews and visits with local landowners, and lastly, a mail-out questionnaire.

1.3. Study area

This study takes place in southern Manitoba, Canada in the predominantly agricultural rural municipalities surrounding Riding Mountain National Park (RMNP) (Figure 1), in the broad transition zone between the prairies to the south and the more northern boreal forest. The region occurs within the Boreal Plains Ecozone (Ecological Stratification Working Group [ESWG] 1995), which stretches from the Peace River area of British Columbia to the southeastern corner of Manitoba (Smith et al. 1998). RMNP represents one of ten mostly disjunct Ecodistricts within the Mid-boreal Uplands Ecoregion (Smith et al. 1998), which include the elevated areas of Duck Mountain in Manitoba, the Porcupine Hills in Saskatchewan, and remnants of the Alberta Plateau in Alberta (ESWG 1995).

Mean annual precipitation is approximately 500 mm, of which 25% falls as snow. The July mean temperature at Wasagaming is 16.5 °C and the January mean –19.7 °C. In contrast, north of the park at Grandview the July mean temperature is 18.2 °C and the January mean is –15.7 °C (Smith et al. 1998). The slightly cooler temperatures at Wasagaming are a function of the increased elevation of the Manitoba escarpment, which rises approximately 475 meters above the surrounding farmland (Parks Canada 1997). This area, and indeed the province as a whole, has been shaped by past glaciation. Most recently, the post-glacial conditions of the Wisconsin Ice Age have led to the current day topography, flora and fauna (Löve 1959). Currently, the topography is gently rolling with moderately to severely rocky terrain. Agricultural productivity on these soils ranges from poor to moderate, though cultivation may be limited on some moderately fertile soils due to stony terrain or steep slopes. The soils in the park have not been extensively surveyed, though they include well-drained gray luvisols, developed on calcareous loamy to clayey textured glacial till (Smith et al. 1998). To the south, soils are grey or dark grey wooded soils with textures ranging from clay loam to fine sandy loam (Ehrlich et al. 1958). To the north, soils generally belong to the gray wooded soil association, which have developed under forest vegetation or have been under the influence of forest cover long enough to develop the characteristics of a profile developed by degradation under forests (Ehrlich et al. 1959).

Dominant trees of the region's upland forests are trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.), white birch (*Betula papyrifera* Marsh.), white spruce (*Picea glauca* (Moench) Voss.) and balsam fir (*Abies balsamea* (L.) P. Mill.). Black spruce (*Picea mariana* (P.Mill.) B.S.P.) and tamarack (*Larix laricina* Du Roi) K. Koch) bogs and fens make up forested lowland areas. In the upland forests, the mid-storey shrub canopy consists of beaked hazelnut (*Corylus cornuta* Marsh.), prickly rose (*Rosa acicularis* Lindl.), and wild raspberry (*Rubus idaeus* L.). Characteristic understorey forbs include wild strawberry (*Fragaria virginiana* Duchesne), northern bedstraw (*Galium boreale* L.), and Lindley's aster (*Aster ciliolatus* Lindl.); dominant native graminoids are wheatgrasses (*Agropyron* Gaertn. spp.) and bluejoint (*Calamagrostis canadensis* (Michx.) Beauv.), and non-native bluegrass (*Poa pratensis* L.) and smooth brome (*Bromus inermis* Leyss.).

An early surveyor (Tyrell 1888) documented primarily open grassland areas, interspersed with forest, both north and south of the park, prior to agricultural settlement. The full extent of native grasslands elsewhere in the boreal transition region before settlement is not known (Hobson et al. 2002). Historically, fire was the dominant disturbance regime in the mixed-wood boreal forest, with a pre-settlement fire interval of 25 to 40 years (Weir and Johnson 1998). This area was first opened by the Métis and Cree for hunting (Ringstrom 1981). Later land use and settlement by the Ojibway, the Métis, and other farming pioneers marked the beginning of a period of land clearing and local agriculture, from 1880 to 1920 (Hobson et al. 2002; Siggins 1994; Bird 1961). During this time, forestry provided a substantial resource for the province, and fire posed a significant threat to that industry. The Dominion Forest Reserve was established in 1895 (Trottier 1986), and held a mandate similar to that of the later Parks Act of 1911: to preserve regional forests and to ensure a perpetual supply of timber for the people of the prairies, considering first the needs of the homesteader (Ringstrom 1981). In 1908, white spruce accounted for over 90% of the logging industry in Manitoba (MacMillian and Gutches 1909). Of the four forest reserves in Manitoba at the time (i.e. Lake Manitoba, and the Porcupine, Duck and Riding Mountains), Riding Mountain accounted for 90% of the timber permits granted. Permits for hay were also granted for areas within Riding Mountain, although this was not a major source of income (Dickson 1909) relative to other reserves.

In a report by the chief forester in 1910, the use of livestock grazing was recommended in the Forest Reserve, to reduce fire hazard by reducing the amount of grass litter carried over to the next season (Trottier 1986). In 1914, shortly after these recommendations, approximately 473 cattle were allowed to graze on prairies within the Forest Reserve. Livestock numbers increased until 1920 (peak of ca. 4600 cattle), but decreased thereafter, due in part to the depression (Trottier 1986). Further decline of livestock grazing in the park came about when Riding Mountain received National Park status in 1933 (Trottier 1986). Throughout this time, a controlled timber harvest was permitted and the incidence of fire and hunting was controlled within the Park boundaries. In 1966, a study by D.A. Blood examined the effects of approximately 50 years of livestock grazing in prairie areas inside the park. Blood found that certain heavily grazed areas supported predominantly non-native species: "little more than bluegrasses, dandelion and shrubby cinquefoil". Yet adjacent areas with little or no livestock grazing history were dominated by the rough fescue (*Festuca hallii* (Vasey) Piper) grass association. Based on recommendations from Blood's report, livestock grazing was ceased in all grazing compartments of the park by 1969 (Trottier 1986), in part to preserve and protect the rough fescue grasslands that occurred within the park. Rough fescue is a native grass that is currently extremely limited in its Canadian distribution, recognized only from three localities in Canada (Trant 1992), all of which are national parks (Trottier 1986): Riding Mountain NP in Manitoba; Waterton NP in Alberta; and Grasslands NP in Saskatchewan.

Approximately 45,200 people live in the Mid-Boreal Uplands Ecoregion (ESWG 1995). Production of grain crops of wheat and barley and oil seeds canola and flax and beef cattle dominate agricultural land. Off-farm work has become the principal source of income for many rural people, which is often characteristic of small-scale farming today.

1.4. Literature Review

1.4.1. Forest patches in an agricultural mosaic

Resource development and human use has largely mediated forest fragmentation in agricultural mosaics (Boutin and Hebert 2002; Kreuss and Tscharntke 1994), which have received considerable attention (Barrett and Peles 1994). Forest fragmentation is generally considered to have adverse effects, associated with the loss of natural habitat and a decrease in connectivity among remnants (Theberge and Theberge 2002). Overall, forest fragmentation leads to a decrease in the amount of interior forest habitat and a proportional increase in edge conditions (Matlack 1994; Brothers and Spingarn 1992; Hobbs and Huenneke 1992). Conditions in an edge environment are physically different from adjacent open field and forest interior habitats (Ranney et al. 1981). Physical (abiotic) edge effects include changes to temperature, light and moisture at the forest perimeter. Increased insolation affects plants and other species that occur at the forest edge (Brothers and Spingarn 1992). Increased exposure to wind leads to physical damage and windfall trees, opening the edge to further change in conditions in a self-perpetuating system (Matlack 1994). Biological effects of edge creation include colonization by new, shade-intolerant species that are able to take advantage of edge conditions, and/or a change in growth form of edge vegetation (Ranney et al. 1981).

Fragmentation and the size of remaining forest patches will also affect ecological processes (Fitzsimmons 2003; Hobbs 1993), and biodiversity within a forest patch (Hobbs 1993; Saunders et al. 1991). New conditions brought on through these biotic and abiotic changes will affect not only the edge, but a certain distance into the interior habitat of the patch. Small or irregularly shaped forest patches have greater edge effects and may be lacking entirely in interior habitat (Moffatt et al. 2004), with profound effects on species that colonize or persist in a forest patch. Edge effects generally signal increased numbers or richness of 'opportunistic' species that are able to take advantage of edge conditions (Hester and Hobbs 1992), which can lead to a decline in numbers and/or diversity of interior species (Bayne and Hobson 1998; Ranney et al. 1981).

Forest patches in agricultural landscapes are generally surrounded by a matrix of intensive human land uses characterized by extensive cover and high connectivity. Although not entirely hostile, this surrounding matrix can exert a major control over other landscape elements (Forman 1995), (e.g. restrict the local distribution of some species, and facilitate the dispersion of others). Despite their fragmented nature, forests in agricultural mosaics provide ecologically important habitats, and as such are extremely important to conservation biology research (Hilty and Merenlender 2003; Freemark et al. 2002; Curtin 2002). Although the analogy of "forests as islands in a sea of agriculture" is still common, many studies show that both flora and fauna can make extensive use of these patch and matrix habitats (Boutin and Jobin 1998), and as such these apparently isolated remnants play crucial roles in regional biodiversity (Freemark et al. 2002).

1.4.2. Conservation importance of forest patches

Habitat loss is one of the most pressing problems of conservation biologists today. This is especially true in the boreal transition region of the Canadian prairies (Tyrchniewicz et al. 1999), which has been referred to as the last frontier of agricultural development (Weir and Johnson 1998). While much of the boreal forest of North America is generally made up of relatively mono-specific stands of coniferous forest, the southern boreal plains are composed of diverse and mixed forests, which support a greater diversity of wildlife species (Hobson et al. 2002). Forest conservation research has generally focused on large tracts of forest, although there is increasing evidence that smaller patches of forest are also important for conservation (Erickson et al. 2001; Jantzi et al. 1999; Keddy and Drummond 1996; Barrett and Peles 1994).

Woodlots may have greater plant native species diversity than other farmland habitats (e.g. old field, shelter belts or roadsides) (Freemark et al. 2002). The total cover and configuration of forest patches also provide important habitat for invertebrates (Kreuss and Tscharntke 1994), small mammals (Middleton and Merriam 1983) and birds (Bayne and Hobson 1998; Villard et al. 1999), by maintaining micro-habitat networks and facilitating species movement across a less hospitable matrix (Jantzi et al. 1999).

The importance of forest habitats for cattle grazing is not unique to this region. Similar discussions of cattle use and effects on forest biodiversity and structure occur elsewhere, e.g. in the western United States (Belsky and Blumenthal 1997; Dennis 1997); in Australia (Pettit et al. 1995; Landsberg et al 1999). Yet many of these studies deal with publicly managed forests, or arid environments, and there are relatively few examples of privately owned temperate forests to use for reference.

The principal outcome of grazing is the removal of herbaceous plants and litter and alteration of vegetation structure. Livestock grazing in forested pasture is generally considered to be detrimental, as grazing animals can, through changes to vegetation structure, soil and water (Belsky and Blumenthal 1997), dramatically reduce the suitability of forest for native plant species (Prober and Thiele 1995), wildlife and birds (Maron and Lill 2005). Perhaps the most recognized impact of grazing in general is an increase in non-indigenous species, and the related decline of native species, which has been well studied on local and global scales (Lodge and Shrader-Frechette 2002). While most grazing impacts are perceived as undesirable, the intensity and history of livestock use also affect the outcomes of this disturbance.

Despite the importance of forest on private lands, few studies have focused on these resources. Research into impacts of land use has focused primarily on public land (Hilty and Merenlender 2002). Yet, private lands tend to be more productive, better watered and have higher soil quality than public lands (Scott 2001), thus comparisons are not always possible. While increased research is needed to gain an understanding of land types and biodiversity found on private land, the future of many forest patches cannot be predicted without an understanding of motivations, management needs and goals of landowners (Erickson et al. 2001). The ecological role and cultural importance of forest on private land in the agricultural mosaic remains poorly understood. Nevertheless, it is highly preferable to conserve a component of native vegetation in farming landscapes, for the social, ecological and economic benefits they provide.

Recent research in the boreal transition area of Saskatchewan (Hobson et al. 2002) found that approximately 70% of the region had been converted to agriculture or other human development, since original settlement of the region. Remaining forested areas in this region were not evenly distributed, but occurred on 42% of Indian Reserve lands and on 55% of lands managed by federal or provincial government, whereas less than 20% of private land was forested (Hobson et al. 2002). Suitability for cultivation seems to determine largely whether forest cover will be maintained, as forest cover is found predominantly on lands not suited to agriculture (Hobson et al. 2002). While there are no figures available for the boreal transition region of Manitoba, it may be that northern forests in the agricultural zone of Manitoba are similarly restricted (Tyrchniewicz et al. 1999).

Scientific studies, while crucial to providing an understanding of biophysical communities, rarely take into account the cultural and social qualities that characterize rural communities, which are also important in driving environmental change (Slocombe and Dearden 2002; Turner et al. 1996). The vulnerability of forests on private land is further emphasized by a lack of research and a general indifference towards deforestation on private land in the southern boreal, caused in part by the perceived lack of economic and ecologic value of privately owned forests, a relative abundance of forest on public lands, the prominence of agriculture in the provincial economy, as well as past economic incentives that have promoted the rapid conversion of forests to agriculture (Hobson et al. 2002; Tyrchniewicz et al. 1999).

1.4.3. Societal importance of forest patches

Forest patches in the agricultural mosaic are economically important. Forests provide a source of timber, firewood, as well as grazing benefits (Krzic et al. 2003; Argow 1996), and are also used for hunting, wildlife viewing or tourism.

The economic benefits that forests confer are often associated with the conservation values and environmental services they provide. Forests interspersed with cropland slow the melt of snow in the spring (Forman 1995), and thus the rate of seasonal ground water flow, which allows more water to percolate through the soil. The reduced water flow over land also reduces erosion and improves and preserves soil resources and soil productivity (Jantzi et al. 1999). Forested pastures are commonly maintained for livestock shelter and forage (Dennis 1997), particularly on lands not suited for agriculture (Tyrchniewicz et al. 1999). Private land is subject to private management decisions that are often based on the economic potential for increased income from land conversion (Tyrchniewicz et al. 1999). Yet more recently, society has come to value non-commercial aspects of forests and native vegetation.

There is a growing body of literature concerning attitudes and values towards forested land among private landowners (Erickson et al. 2001), but the study of farmers' attitudes is still considered nascent (Macdonald and Johnson 2000). Much of this research to date has focused on management values as they relate to future outcomes of forest cover (Bliss and Martin 1989). Other research has contrasted attitudes between public and private lands (Tarrant and Cordell 2002). Forested land is an aesthetically important landscape element (Haider and Hunt 2002; Erickson et al. 2001), and often tied to personal and/or cultural identity (Bliss and Martin 1989). Our sense of identity and well-being has been related to undeveloped 'wild' spaces (Trudeau 1993), particularly forested land. The ability to live in nature and to be alone in nature is part of our nation's wealth; to maintain non-productive or wild spaces on public and private lands is a privilege, yet is also part of the North American cultural identity (Saul 1997).

By association, communities surrounding parks and protected areas present valuable opportunity for implication in public management goals of these spaces. Yet, often members of surrounding communities have no input (aside from their geography) into the development of these environmental policy and management goals.

Local residents often have valuable experiences and observations concerning local environments (Nerbonne and Lentz 2003). Over generations of farming practice, many landowners develop an experiential knowledge base, adapted to their specific farming environment, which informs their decision-making and land management choices (Millar and Curtis 1999; Chambers 1993). Local farmer knowledge is as diverse as the physical, social and economic environments in which farmers work and live. The depth and quality of this knowledge largely depends on individual experience, interest and willingness to learn (Millar and Curtis 1999). When used appropriately, local knowledge can form the basis of change at local or regional levels (Millar and Curtis 1999).

There is no shortage of examples of studies where local knowledge is applied to questions of the environment and the natural sciences, particularly in Aboriginal and Indigenous communities (Cruikshank 1998), although fewer studies have been conducted on rural knowledge. Still, relatively little effort has focused on gathering or applying this knowledge and experience in appropriate and meaningful ways (Nelson

2003). Local knowledge operates at local scales (Cruikshank 1998), and the notion that these knowledge systems can solve the modern and global problems, (e.g. loss of biodiversity; climate change) is impractical. There is a growing tendency among researchers to believe that local knowledge, once collected, can be reduced to data, from which representative information can be extracted (Cruikshank 1998). This implies that knowledge is stable and unchanging. The questions used to collect this knowledge, the relationship between asker and teller, and the context of the dialogue will also determine the content of knowledge provided. Yet, it is possible for local narratives and experiences to inform scientific methods and provide science with information that cannot be obtained elsewhere (Curtin 2002; Millar and Curtis 1999; Endter-Wada et al. 1998; Chambers 1993; Kloppenberg 1991). Understanding diverse landowner motivations behind maintaining, protecting and managing forested land, non-productive land and native vegetation, can help local communities take action to preserve remaining resources (Bliss and Martin 1989; Turner et al. 1996; Erickson et al. 2001), and even make up for the lack of scientific data on these important ecosystems.

1.4.4. Opportunities for Cooperation

Early on in their histories, most national parks started out as wild spaces within a larger area of wilderness (McNamee 2002). There is a current and pervasive view that national parks are ecological islands within seas of logging, mining, agriculture, residential lands and other intensive human uses (Eagles 2002 and others). This perception has undoubtedly contributed to friction and distance between park managers and local residents today, and fuels the notion that parks and other patch habitats are isolated from their surrounding environments. However, Parks are but a part of local, regional and national plans to address ecological and biodiversity conservation (Slocombe and Dearden 2002). Interactions between parks and their surrounding areas have been increasingly recognized (Theberge and Theberge 2002; Slocombe and Dearden 2002), and certainly, effective conservation management requires working across administrative or political boundaries (Grumbine 1994). The regional integration of national parks (Parks Canada 2000) recognizes that many of the threats to parks are trans-boundary in nature (Shafer 1999). Broad-based regional conservation plans must necessarily be integrated with existing conservation efforts (Slocombe and Dearden 2002; Octeau 1999) around local industry and practices (e.g. agriculture, grazing and forestry).

There have been a number of management initiatives that focus on agriculture-dominated landscapes, which attempt to bridge the gaps between the need for conservation, and the needs of the people that live and farm in these areas. The Biosphere Reserve Programme, conceived in 1968, is internationally recognized within UNESCO's Man and the Biosphere Program. Biosphere reserves have three complementary functions: to ensure conservation of landscapes, ecosystems, species and genetic variation; to promote culturally, socially and ecologically sustainable local economic development; and to provide support for research, monitoring, education and information exchange related to local national and global issues of conservation and development (Slocombe and Dearden 2002). When fully functioning, biosphere reserves conserve natural and cultural diversity, exemplify or demonstrate models for land management and approaches to sustainable development and support research monitoring education and training.

The concept of the biosphere reserve is highly complementary to other forms of management that seek to include 'beyond-borders' thinking, which continue to evolve today. Ecosystem management was originally proposed for the management of American public lands and protected areas (Grumbine 1994; Agee and Johnson 1988). Ecosystem-based management draws on social and natural science, theory and practice, and recognizes that habitat conservation must be viewed in a system-based context (Agee and Johnson 1988). Ecological information about natural systems is required for their effective management. Regional management plans recognize that most national parks are too small to support wildlife populations, which have become reliant on surrounding private land, e.g. forests, alfalfa fields, and streams, (Canada MAB 2000; Gurd and Nudds 1999), consequently the extension of stewardship to neighbouring and connecting lands is particularly important for small parks (Dempsey et al. 2002).

Ecosystem based management also recognizes that human values play a dominant role in the determination of most management goals (Octeau 1999; Lackey 1998; Grumbine 1994). The consultation and participation of local people are essential to factor human values into regional conservation plans (Slocombe and Dearden 2002) and to research (Curtin 2002). There are a number of ways in which local participation can take place. Stewardship is often used to strengthen provincial endangered species legislation, through governmental or non-governmental organizations financial incentive programmes (Dempsey et al. 2002). Cooperative management programmes (e.g. Steven et al. 1999) focus on co-operation between adjacent landowners to support and protect local vulnerable plant or wildlife populations, while also addressing sustainable farm uses.

Given the relative importance of these forested habitats in terms of their social, economic and conservation benefits, it seems surprising that there has been relatively little research concerning connections between private values and stewardship of these habitats, and the effects of land uses within them. Clearly if local involvement is to be effective and successful, the interests and current farming practices of local landowners must also be considered (Hilty and Merenlender 2003).

2. Effects of Livestock Grazing on the Understorey of Aspen Forests Surrounding Riding Mountain National Park, Manitoba

2.1. Introduction

One of the biggest challenges in conservation biology is to better understand the ecological implications of human land use (Cousins et al. 2003; Curtin 2002; Endter-Wada et al. 1998). Agriculture-dominated landscapes are especially affected, such that threats to 23% of endangered and 15% of threatened species in Canada are associated with agricultural land use (Freemark et al. 2002). Yet private farmland also has great ecological potential (Macdonald and Johnson 2000), as a great deal of native vegetation and endangered species habitat is in private hands (Dempsey et al. 2002).

Often, disturbances to the natural functioning of forests in agricultural landscapes are credited to changes in fire regime and selective logging (Weir and Johnson 1998). Forest grazing by livestock, while seldom discussed in this context, may be as important (Belsky and Blumenthal 1997). The effects of cattle grazing have been examined over a range of habitats (Milchunas and Lauenroth 1993). In grasslands, grazing has been associated with changes to the vegetation community as a whole in terms of its diversity, composition (Stohlgren et al. 1999), as well as its structure and function (Saunders et al. 1991; Fleischner 1994). Plant responses to disturbance are often assessed using guilds, whereby species are associated functionally rather than taxonomically (Gitay and Noble 1997), though specific plant traits remain user-defined (Lavorel et al. 1998; Cousins et al. 2003).

After loss of habitat, introduction and spread of exotic species is another critical issue in conservation biology (Cadenasso and Pickett 2001). Perhaps the most recognized impact of grazing is increased exotic species cover (Hobbs 2001; McIntyre and Lavorel 1994a; Milchunas et al. 1988), and associated declines in native perennial grasses and forbs (Stohlgren et al. 1999; McIntyre and Lavorel 1994b; Hobbs and Huenneke 1992). Most of these studies have been conducted in arid conditions and grasslands, although grazing also affects temperate forests on farmlands. Forest grazing has been associated with the loss of native perennials (Pettit et al. 1995), including grasses (Lavorel et al. 1999; McIntyre et al. 1999), and native woody forbs and shrubs (Hadar et al. 1999; Hobbs 2001). Grazers change the structure of forest canopies by trampling or grazing woody seedlings and saplings, thus reducing woody regeneration (Fitzgerald et al. 1986; Fensham et al. 1999). Physical disturbance and removal of live biomass by grazers can further alter forest structure through soil erosion (Belsky and Blumenthal 1997), decreased water availability (Dennis 1997), and changes to nutrient cycles (Fleischner 1994).

Many studies that examine forest grazing do so in isolation of adjacent land, which, in agricultural regions, is most commonly under cultivation or pasture. Consequently, few data are available on the relationship between characteristics of the agricultural matrix and the adjacent forest patch under grazing. Exotic species are often associated with the forest margin in fragmentation studies (Moffatt et al. 2004; Fraver 1994; Ranney et al. 1981), and species richness can be augmented by invasive species from surrounding land (Hobbs 2001; Norton 1999; Brothers and Spingarn 1992). The structure of the forest edge will also generally exert an effect on the migration of species into forest patches (Thompson 2003; Cadenasso and Pickett 2001); consequently biological information on adjacent habitats is important particularly where they may function as seed sources for forest patches (Cadenasso and Pickett 2001; Murcia 1995; Matlack 1994).

Although most grazing impacts described are perceived as undesirable, the intensity, history, duration and even scale of grazing can affect outcomes of this disturbance (Jones 2000). Some authors indicate certain grazed grassland habitats foster the persistence of some native species (McIntyre et al. 2003), such that moderate levels of livestock grazing may maintain diversity and functioning within ecosystems (Hayes and Holl 2003; McNaughton 1993), although few data are available from forest habitats (Krizc et al. 2003).

2.2. Chapter Objectives

The overall objective of this chapter was to examine the effects of cattle grazing on the understorey of fragmented forests within an agricultural landscape mosaic. The specific questions asked are as follows:

1) What are the effects of past and present levels of grazing on understorey diversity, species composition and plant functional groups?

2) What is the importance of grazing relative to other site and landscape-level variables?

3) How does livestock grazing affect the relationship between forest and surrounding matrix habitats?

2.3. Study area

This study takes place in southern Manitoba, Canada, within Riding Mountain National Park (RMNP) and three surrounding rural municipalities of Clanwilliam, Grandview and Shellmouth-Boulton (Figure 2.1). Riding Mountain was formally designated as a National Park in 1930 and covers 2,976 km^2 (Parks Canada 1997). Topography is gently rolling, with moderately to severely rocky terrain. Agricultural productivity ranges from poor to moderate and is limited by soil stoniness or steep slopes (Ehrlich et al. 1959). Mean annual precipitation is ca 500 mm, of which 25% falls as snow. The July mean temperature at Grandview (north west of RMNP) is 18.2°C, and the January mean is -15.7°C (Smith et al. 1998).

The study area is located in the Mid-Boreal Uplands Ecoregion of the Boreal Plains Ecozone (Smith et al. 1998), and is part of the broad transition between the northern boreal forest and the aspen parkland to the south (Rowe 1972). The forest overstorey is dominated by trembling aspen (*Populus tremuloides* Michx.[1]), balsam polar (*Populus basamifera* L.), and white spruce (*Picea glauca* (Moench) Voss) and mid-storey shrub canopy by beaked hazelnut (*Corylus cornuta* Marsh.), prickly rose (*Rosa acicularis* Lindl.), and wild raspberry (*Rubus idaeus* L.). Characteristic understorey forbs, typical of northern temperate forests include wild strawberry (*Fragaria virginiana* Duchesne), northern bedstraw (*Galium boreale* L.), and Lindley's aster (*Aster ciliolatus* Lindl.); dominant native graminoids are wheatgrasses (*Agropyron* spp. Gaertn.) and bluejoint (*Calamagrostis Canadensis* (Michx.) Torr.), and non-native bluegrass (*Poa pratensis* L.) and smooth brome (*Bromus inermis* Leyss.).

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[1] Botanical nomenclature follows Cody 1988

Since agricultural settlement, remaining forests have become increasingly fragmented and many are privately owned as small (<500 ha) mixed farms (see chapter 3). Native vegetation is intermixed with forage, canola (*Brassica campestris* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) crops, and with livestock production. Livestock grazing was actively encouraged in RMNP from 1914 until 1969, when it was eliminated from the park (Trottier 1986).

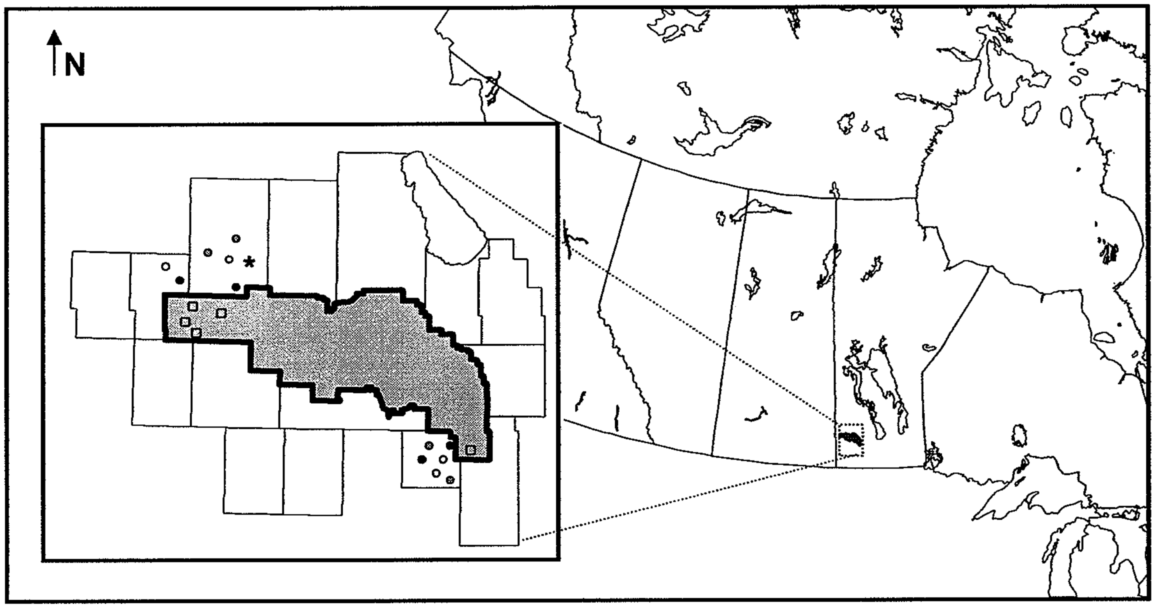

Figure 2.1. Riding Mountain National Park and surrounding Biosphere Reserve (inset) located in southern Manitoba, Canada. Sites are marked by an open circle (non-grazed), gray circle (moderate grazing), closed circle (heavy grazing) or square (past-grazed park). The town of Grandview is indicated (*).

2.4. Methods

Through local meetings and contacts, a number of landowners volunteered to participate in this study. Sites were selected from participants' private land holdings according to several criteria for both the forest patches and the surrounding (e.g. the matrix) habitats. Forest patches were required to be larger than eight hectares within pasture or non- grazed land. These matrix habitats also were required to be large enough to accommodate the sample design, in addition, there was no fence-line or other barrier between grassland and forested portions of pasture (e.g. no restriction to movement of cattle); and forest canopy composition was similar across all sites. Sites were chosen within the national park, in areas that had been grazed by cattle prior to 1969, with the same parameters for site location used on private land, see Figure 2.1 for site locations.

After sampling, and during preliminary analysis, sites were classified into four livestock grazing categories, considered representative of the land use and environment in this region. Categories include past-grazed (within the park, n=5), non-grazed (n=4), moderately grazed (n=4), and heavily grazed (n=4) by livestock, for a total of 17 sites over the study area. A ranked index of grazing intensity was developed to rank the relative disturbance associated with cattle grazing on private land. This index was based on the stocking rate (pasture size and number of cattle present), supplied by each landowner, as well as the percent bare of ground at each site. In addition, participating landowners provided a ranking, from one to ten, of current (within the past five years) livestock grazing intensity for their own sites. Scores applied to each of these vegetation-independent variables were summed to create a relative ranking of livestock grazing intensity for each site. Within the park, the grazing intensity was previously assessed within the prairie areas used by livestock (Blood 1966) using species composition, as well as other soil, plant and animal indicators of range condition. As grazing intensity was calculated differently in the current study, park sites were not distinguished based on their grazing histories.

At each site, three replicate transects were oriented across and perpendicular to the forest patch margin. Transects, randomly situated, were at least 20 m (Matlack 1994) apart and 50 m from the nearest habitat edge. On each transect, six (10 m x 10 m) plots were situated, at 0 m, 20 m and 50 m from the margin (Matlack 1994; Brothers and Spingarn 1992) of the forest, into both the forest and the surrounding matrix (n=306).

Vegetation was classified by physiognomy, and tree, shrub and vegetative ground cover were sampled accordingly. Tree were defined as woody stems with a diameter at breast height (DBH) of ≥5 cm. Shrubs included all woody species <5 cm DBH and >0.5 m in height, while the ground cover included all woody and herbaceous vascular plants ≤0.5 m. Percent cover and species composition for trees were recorded in 408 overstorey plots, each measuring 100 m^2, between early June and late August of 2001 and 2002. The DBH of all trees and percent canopy cover were measured in the 10 m x 10 m overstorey plot. Percent cover and composition of shrubs were recorded in a 5 m x 5 m sub-quadrat, in the bottom left corner of the tree plot. Percent cover and composition of all woody and herbaceous species were recorded using four 1 m x 1 m quadrats, along one edge of the 10 m x 10 m plot.

Soil samples (5 cm x 5 cm x 10 cm) were collected over a period of two days during the first week of September 2002 to assess moisture and nutrient status, with no previous precipitation for >24 hours. Two soil cores were collected from the center of each overstorey plot, and bulked in the field, along two of the three replicate transects (n= 204). Soil moisture cores were immediately weighed, then subsequently dried at 60 °C for 48 h, and re-weighed to determine gravimetric soil moisture. Soil nutrient samples were further bulked to produce one forest and one matrix sample per site. Soil samples were processed by Norwest Labs, Winnipeg. The pH and electrical conductivity were measured on a 1:2 soil: water slurry by volume, and soil organic matter content was determined by loss on ignition (McKeague 1978). Samples from the nutrient soil cores (5 g) were dried, ground (2 mm) and shaken with 50 mL of extracting solution (0.015M ammonium fluoride, 1.0M ammonium acetate and 0.5M acetic acid) for 0.5 h and filtered (type of filter?). Phosphate-P was measured in the filtrate by spectrometry after the complex formation with ammonium molybdate and ascorbic acid, and the extracted K in the filtrate was measured using flame photometry (Ashworth and Mrazek 1995). Nitrate nitrogen was measured on 5 g samples, dried and ground, then calculated using a digestion (sulfuric acid) and distillation (boric acid) method (McKeague 1978).

Landscape level variables were calculated using GIS (geographical information system), (ESRI 1999) and a 16-class vegetation cover map (Manitoba Land Initiative 2003), simplified to five classes (agriculture; grassland; forest; wetlands and water; and built-up areas). Four landscape metrics were calculated within a radius of 1,600 m from the center of each site. The metrics were: the number of forest patches; the mean patch size; the shape index; and the degree of coherence. The mean forest patch size (MPSi) is calculated:

$$MPSi = (\Sigma\, a_i / N_P) * A_L^{-1} \qquad \textbf{(1)}$$

where a_i is the area of the forested patch i, N_P is the number of forest patches and A_L is the total land area (Fitzsimmons 2002). The modified shape index (S_I) is calculated:

$$S_I = \Sigma P/(2\sqrt{\Sigma A_L \pi}) \qquad (2)$$

where the value of P, the patch perimeter, increases as the patch shape departs from circular (McLachlan and Bazely 2001). The degree of coherence (C) measures the probability that any two randomly chosen spots in a site belong to the same patch, is calculated as:

$$C = \Sigma_i \, a_i/A_L)^2 \qquad (3)$$

for i =1 to N_P (Jaeger 2000).

2.5. Data analysis

2.5.1. Species diversity and composition

Hill's (1973) diversity measures (N_0, N_2 and evenness) were used to examine native and exotic species diversity among levels of grazing. The absolute number of species, N_0, is strongly influenced by the presence of rare species. The effective richness, N_2, emphasizes species dominance using the reciprocal of Simpson's index, and is calculated as:

$$N_2 = 1/\Sigma p_i \qquad (4)$$

where p is the proportion. Evenness, to a maximum value of one, is calculated as:

$$Evenness = N_2/S \qquad (5)$$

where S is the total number of species. One-way analysis of variance (ANOVA) was calculated for mean values of native and exotic species assemblages, individual species for each level of grazing, as well as the proportion of native species within the overall assemblage.

All species were further separated into five plant guilds based on physiognomic attributes or light requirements. These guilds included exotics, graminoids, shade tolerant and intolerant forbs and woody species. The percent cover data for individual species variables were summed for all species within each guild, resulting in a reduction of species variables to five. These five new variables represented the percent cover values for each of the five above mentioned plant guilds.

One-way analysis of variance (ANOVA) was used to identify differences among sites with relation to species diversity, proportion of native species and plant guilds. Tukey's test (α=0.05) was used to assess differences among means when the overall models were significant (SAS 1998). Count data used in univariate analyses were log-transformed, while proportions were arcsine transformed to meet assumptions of normality (Zar 1999); original non-transformed data are presented.

Multivariate analyses were further used to examine how species composition varied among the 17 sites, based on species occurring in ≥3 plots. Relationships between plant groups and individual sites were described for forest plots using correspondence analysis (CA). Due to the sensitivity of CA to outliers, principal component analysis (PCA) was used to summarize data from matrix plots. Both methods use orthogonal axes of variation in descending order of importance (ter Braak and Smilauer 1998). Whereas CA axes maximize the correspondence between sites and species variables, PCA axes maximize the linear variation in species space (Kenkel et al. 2002). Data were log transformed to meet the assumptions of normality for multivariate analyses (Zar 1999).

2.5.2. Patch and landscape environment

Spearman coefficients were used to assess correlation among patch and landscape level variables. Canonical correspondence analyses (CCA) were used to determine the relationship between species composition at sites and the constraining patch and landscape environmental variables. A direct method of analysis, CCA explains data through orthogonal axes of variation (ter Braak and Smilauer 1998), and provides a measure of redundancy, used to determine whether there is meaningful correlation between the species and the environmental variables.

2.5.3. Similarity between forest patch and matrix

Two-way ANOVA was used to determine similarities between the forest and matrix habitats, along the transect gradient from the forest margin to interior. Sörenson's similarity index was used to measure the similarity of plant species composition in forest plots (0 m; 20 m; and 50 m from forest margin) and the most distant matrix plot (50 m from the forest margin). This index, ranging from 0 to 1, is calculated as:

$$\text{Sörenson} = 2a / 2a + b + c \qquad (6)$$

where a refers to species present in both plots, b to species occurring only in one plot, and c to species occurring only in the other plot (Mueller-Dombois and Ellenberg 1974). The occurrence of both native and exotic species within forest plots was also compared by distance from forest margin.

2.6. Results

2.6.1. Species diversity

Heavy livestock grazing adversely affected native species diversity in both the forest understorey and the surrounding matrix. Heavily grazed forests had significantly lower absolute native species richness (p=0.0069) and effective richness (p=0.0162), whereas there were no significant differences among past-grazed park, non-grazed and moderately grazed forests (Table 2.1). The park matrix had significantly greater absolute (p=0.0029) and effective (p=0.0012) native species richness than all other grazing categories. However, after park sites the moderately grazed matrix had the greatest number of native species (48 species), followed by the matrix of non-grazed and heavily grazed sites, (39 and 26 species, respectively). While the understorey composition of forest sites was affected under heavy grazing, the species richness of the matrix habitats in sites outside the park was generally low, whether or not the sites were grazed.

Livestock grazing was associated with increases in exotic diversity. Heavily and moderately grazed sites had significantly higher exotic species richness than park sites, in both the forest (p=0.0005) and matrix (p=0.0001). Although exotic species richness was greatest in heavily grazed forests and matrices, the effective exotic species richness (N_2) was similar among all sites, suggesting that infrequently occurring exotic species were promoted by grazing. Evenness of native and exotic species tended to be lower in heavily grazed forests.

In both the forest and surrounding matrix, the proportion of exotic plant cover increased with grazing intensity. Whereas the mean total herbaceous cover in forests was similar across all sites, the proportion of native to exotic species was significantly lower (p=0.0024) in sites with heavy grazing. In the matrix, moderately and heavily grazed sites tended to have lower herbaceous cover than park sites, and like forests, heavily grazed sites had significantly lower ($p= 0.0002$) proportion of native to exotic species than park sites. The total herbaceous cover was lowest in the matrix of agricultural sites, as sampling was conducted after hay cutting.

Table 2.1. The mean ± s.e. for effective species richness (N_2), absolute species richness (N_0) and evenness from (a) understorey plots and (b) matrix plots, for both native and exotic species. Same letters indicate means that are not significantly different. The *p*-values, calculated for $F_{(3, 16)}$, are bolded where significant in analysis of variance (ANOVA).

(a)

	Past/ park	None	Moderate	Heavy	*p*-value
Native					
N_2	18.17±1.12[a]	19.71±0.98[a]	18.44±1.62[a]	12.14±1.48[b]	**0.0069**
N_0	59.60±2.46[a]	65.25±5.48[a]	62.00±3.39[a]	45.25±4.03[b]	**0.0162**
Evenness	0.31±0.02	0.31±0.01	0.30±0.02	0.27±0.04	0.8210
Exotic					
N_2	1.26±0.1	1.86±0.25	2.95±0.67	2.87±0.51	0.0303
N_0	2.80±0.66[c]	6.50±0.29[b]	8.25±1.89[ab]	11.50±1.04[a]	**0.0005**
Evenness	0.57±0.14	0.29±0.05	0.37±0.05	0.26±0.06	0.1129
All species					
N_2	17.75±1.76[a]	20.66±1.15[a]	19.70±2.36[a]	8.66±2.80[b]	**0.0061**
N_0	62.40±2.46	71.75±5.54	70.25±4.66	56.75±4.01	0.0853
Evenness	0.29±0.03	0.29±0.02	0.29±0.02	0.16±0.05	0.0522

(b)

	Past/ park	None	Moderate	Heavy	*p*-value
Native					
N_2	21.65±3.06[a]	10.91±1.4[b]	9.85±1.34[b]	6.33±1.73[b]	**0.0012**
N_0	71.00±7.02[a]	39.00±7.62[b]	48.50±5.84[b]	26.25±6.87[b]	**0.0029**
Evenness	0.30±0.03	0.29±0.02	0.21±0.04	0.28±0.07	0.5145
Exotic					
N_2	1.43±0.17	2.69±0.56	2.36±0.3	2.78±0.4	0.0634
N_0	3.80±0.58[c]	8.00±1.68[b]	12.75±0.75[a]	13.00±1.35[a]	**0.0001**
Evenness	0.40±0.06	0.37±0.09	0.18±0.02	0.21±0.02	0.0405
All species					
N_2	16.64±3.03[a]	9.37±1.16[b]	5.63±0.75[b]	3.37±0.38[b]	**0.0013**
N_0	74.80±6.60[a]	47.00±7.36[b]	61.25±5.65[ab]	39.25±6.97[b]	**0.0098**
Evenness	0.21±0.03[a]	0.21±0.03[a]	0.09±0.01[b]	0.09±0.01[b]	**0.0011**

2.6.2. Species composition

Species composition in the forest understorey was substantially affected by grazing. The primary CA axis separated heavily grazed sites from all others particularly past grazed park sites, accounting for 18.8% of the variation in data (Figure 2.2.). Many species associated with the heavily grazed sites were exotic, including wild carrot (*Carum carvi*[2]), absinthe (*Artemisia absinthium*), or ruderal species, e.g. rough cinquefoil (*Potentilla norvegica*). Park sites were associated with native species, including Seneca snakeroot (*Polygala senega*), hoary puccoon (*Lithospermum canescens*), Richardson's needlegrass (*Stipa richardsonii*), and plains rough fescue (*Festuca hallii*). The second CA axis accounted for 12.0% of the variation in the data. This second axis separated non-grazed and moderately grazed sites from park and heavily grazed sites. Species positively associated with the second axis (non-grazed and moderately grazed sites) included red baneberry (*Actaea rubra*), low-bush cranberry (*Viburnum edule*), wild carrot, and clover (*Trifolium repens*).

In the matrix surrounding forest patches, species composition was also affected by grazing. Unlike forests, the first PCA axis distinguished past-grazed park sites from other sites, accounting for 35.6% of the data variation (Figure 2.3.). Certain species were associated with the park and heavily grazed sites alike, including common yarrow (*Achillea millefolia*) and hair grass (*Agrostis scabra*). As with forests, the second axis separated non-grazed and moderately grazed sites from the park and heavily grazed sites, accounting for 11.4% of the variation. Species positively associated with non-grazed and moderately grazed sites included many-flowered aster (*Aster ericoides*) and red-osier dogwood (*Cornus stolonifera*).

[2] Nomenclature follows Cody 1988.

When examined individually, twenty-two understorey species were significantly affected by grazing (Table 2.2.). Native, perennial forbs including giant hyssop (*Agastache foeniculum*) ($p<0.0001$) and smooth aster (*Aster laevis*) ($p=0.0002$) were associated with park sites, and native woody bog birch (*Betula pumila*) ($p<0.0001$) and trailing dewberry (*Rubus pubescens*) ($p=0.0007$) were associated with non-grazed sites. Native bluejoint (*Calamagrostis canadensis*) ($p=0.0009$) was associated with both park and non-grazed forests. The native Canada mayflower (*Maianthemum canadense*) ($p<0.0001$) was associated with moderate grazing and to a lesser degree, non-grazed forests. In contrast, species associated with heavily grazed forests were exotic, and included dandelion (*Taraxacum officinale*), clover species (*Trifolium* spp.) and Kentucky bluegrass (*Poa pratensis*) (all $p<0.0001$).

In matrices, 38 species were significantly affected by grazing (see appendix, Table A.1). Most species (80%) were native perennials associated with park sites, including purple oat grass (*Schizachne purpuracens*) ($F_{3,\ 149}=25.26$, $p<0.0001$), smooth aster (*Aster laevis*) ($F_{3,\ 149}=58.29$, $p<0.0001$), sedge species (*Carex* spp.) ($F_{3,\ 149}=28.99$, $p<0.\ 0001$), goldenrod (*Solidago rigida*) ($F_{3,\ 149}=17.68$, $p<0.0001$), Canada goldenrod (*Solidago canadense*) ($F_{3,\ 149}=17.05$, $p<0.0001$) and hoary puccoon (*Lithospermum canescens*) ($F_{3,\ 149}=24.51$, $p<0.0001$). Seeded forage species such as alfalfa (*Medicago sativa*) ($F_{3,\ 149}=7.84$, $p<0.0001$) and timothy grass (*Phleum pratensis*) ($F_{3,\ 149}=5.43$; $p=0.0002$) were predictably associated with agricultural sites. Notably, a native violet (possibly *V. adunca*) was significantly ($F_{3,\ 149}=13.90$; $p=0.0002$) associated with moderately grazed matrices. Exotic species were still associated with heavily grazed matrices, including dandelion ($F_{3, 149}$=76.77, $p<0.0001$), Kentucky bluegrass ($F_{3, 149}$=21.12, $p<0.0001$) and common plantain (*Plantago major*) ($F_{3, 149}$=20.86, $p<0.0001$).

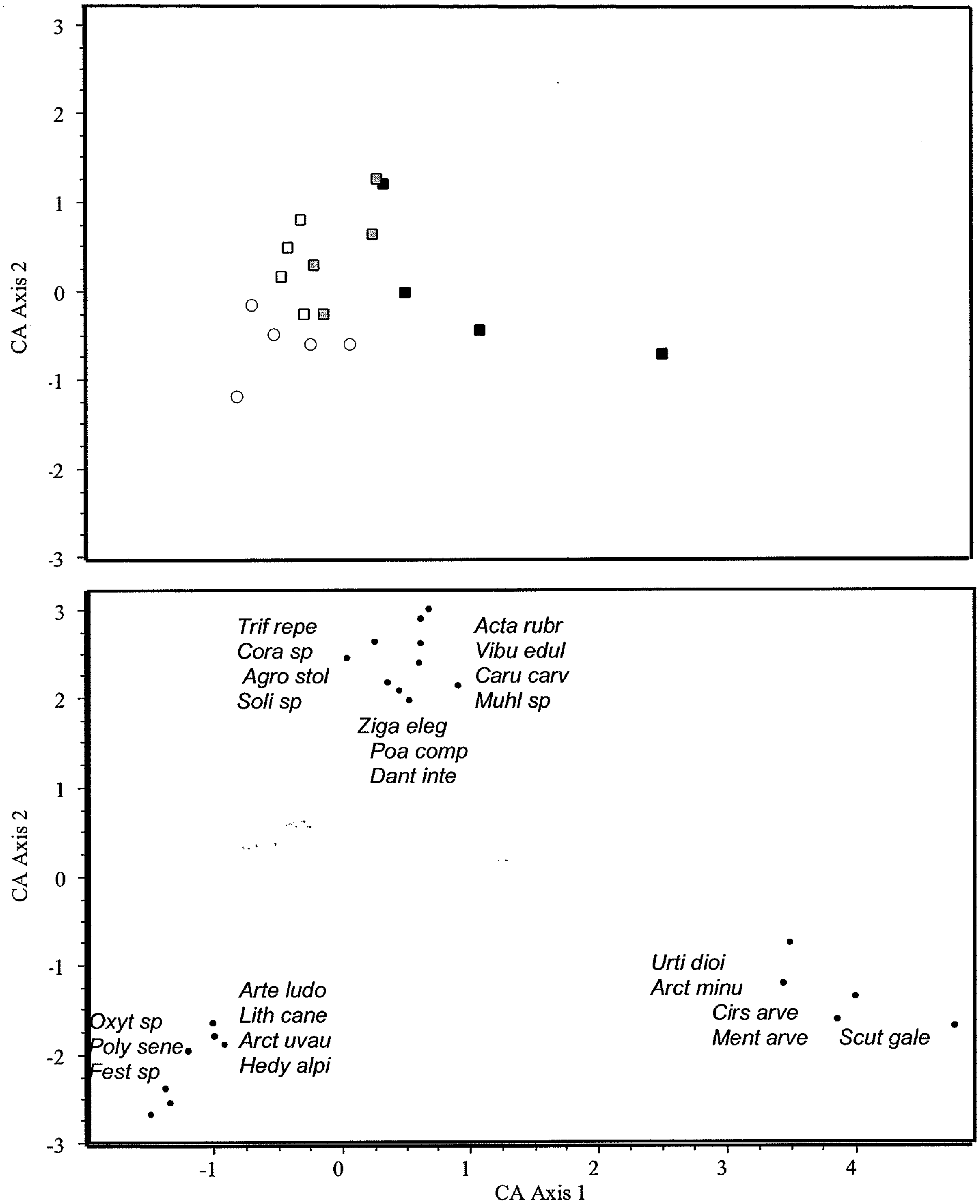

Figure 2.2. Correspondence analysis (CA) ordination biplot of understorey sites (above, n=17) and selected species (below, 141 species). Axes one and two summarize 18.8% and 12% of the variation in the species data respectively. Site symbols are past park grazing (○); no livestock grazing history (□); moderate (▩); and heavy (■) livestock grazing. Species are indicated by the first four letters of both genus and specific epithet.

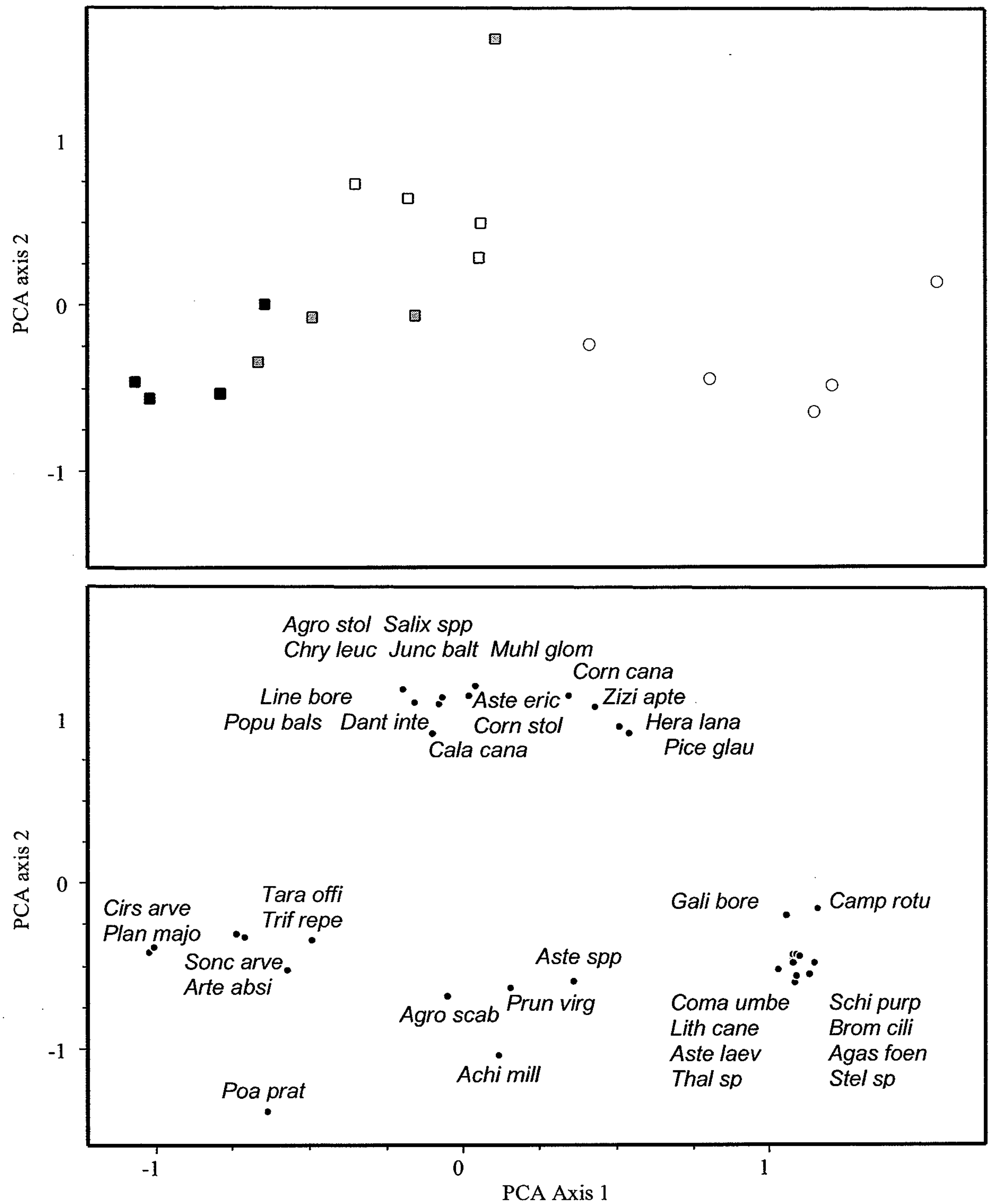

Figure 2.3. Principal components analysis (PCA) ordination biplot for the matrix of a) sites, and b) species (n=201). The first two axes summarize 35.6% and 11.4% of the variation in the species data, respectively. For clarity, not all species are shown; the first four letters of both genus and specific epithet are used. Site symbols are past park grazing (○); no livestock grazing history (□); moderate (▧); and heavy (■) livestock grazing.

Table 2.2. The mean cover ± standard error for 22 species with significant cover values, among all understorey species occurring in ≥ three plots (n=149).

Native species	Park	None	Moderate	Heavy	$F_{(3, 149)}$	P value
Agastache foeniculum	**0.5±0.15** ^{a}	0.10±0.04 ^{b}	0.08±0.05 ^{b}	0 ^{b}	7.81	<0.0001
Aster laevis	**0.98±0.27** ^{a}	0.25±0.12 ^{b}	0.17±0.06 ^{b}	0.05±0.05 ^{b}	7.04	0.0002
Lathyrus sp	**3.43±0.65** ^{a}	1.84±0.34 ^{ab}	0.94±0.15 ^{bc}	0.69±0.12 ^{c}	8.46	<0.0001
Calamagrostis canadensis	**1.61±0.50** ^{a}	**0.89±0.31** ^{ab}	0.09±0.05 ^{b}	0.35±0.35 ^{b}	5.82	0.0009
Epilobium angustifolium	**0.53±0.18** ^{a}	**0.58±0.21** ^{a}	0 ^{b}	0 ^{b}	6.94	0.0002
Smilacina stellata	**0.72±0.12** ^{a}	**0.50±0.13** ^{a}	0.11±0.03 ^{b}	0.03±0.02 ^{b}	13.33	<0.0001
Solidago canadensis	**2.76±0.72** ^{a}	**1.59±0.45** ^{a}	0.02±0.02 ^{b}	0.01±0.01 ^{b}	13.58	<0.0001
Thalictrum sp	**4.74±0.69** ^{a}	**2.63±0.54** ^{a}	1.07±0.18 ^{b}	0.44±0.11 ^{b}	16.94	<0.0001
Betula pumila	0 ^{b}	**0.39±0.14** ^{a}	0.01±0.01 ^{b}	0.01±0.01 ^{b}	11.34	<0.0001
Rubus pubescens	1.14±0.40 ^{b}	**2.58±0.56** ^{a}	0.53±0.17 ^{b}	0.70±0.34 ^{b}	6.03	0.0007
Linnaea borealis	0 ^{b}	**0.36±0.15** ^{a}	**0.39±0.14** ^{a}	0 ^{b}	6.53	0.0004
Oryzopsis asperifolia	1.59±0.31 ^{b}	**2.34±0.35** ^{a}	**1.75±0.29** ^{a}	0.37±0.10 ^{b}	11.28	<0.0001
Galium boreale	**1.03±0.11** ^{a}	**1.21±0.21** ^{a}	**0.77±0.09** ^{a}	0.49±0.09 ^{b}	6.82	0.0002
Maianthemum canadense	0.74±0.21 ^{bc}	1.11±0.26 ^{ab}	**1.71±0.41** ^{a}	0.60±0.19 ^{c}	5.71	0.0010
Arenaria laterifolia	0.01±0.01 ^{b}	0.03±0.01 ^{b}	**0.22±0.07** ^{a}	**0.21±0.06** ^{a}	7.24	<0.0001
Pyrola asarifolia	0.01±0.01 ^{b}	0 ^{b}	**0.92±0.35** ^{a}	**0.45±0.18** ^{a}	6.63	0.0024
Exotic species						
Plantago major	0 ^{b}	0.01±0.01 ^{b}	0.24±0.11 ^{b}	**0.79±0.19** ^{a}	16.1	<0.0001
Poa pratensis	5.74±1.36 ^{b}	5.10±1.14 ^{b}	4.32±1.09 ^{b}	**22.17±3.94** ^{a}	9.46	<0.0001
Sonchus arvensis	0.06±0.06 ^{b}	0.07±0.04 ^{b}	0.03±0.02 ^{b}	**0.61±0.19** ^{a}	9.31	<0.0001
Stellaria media	0 ^{b}	0 ^{b}	0.01±0.01 ^{b}	**0.55±0.30** ^{a}	7.44	<0.0001
Taraxacum officinale	0.49±0.12 ^{bc}	0.28±0.06 ^{c}	0.70±0.09 ^{b}	**3.69±0.73** ^{a}	51.69	<0.0001
Trifolium spp	0 ^{c}	0.08±0.08 ^{c}	0.83±0.27 ^{b}	**4.40±1.14** ^{a}	25.04	<0.0001

Notes:

1. Same letters indicate means that are not significantly (p>0.05) different according to Tukeys multiple means comparison test, where overall models were significant (p<0.005).
2. Analyses on log transformed data; non-transformed mean ± SE presented.

2.6.3. Plant guilds and native plant cover

Plant guilds were also affected by livestock grazing. Heavily grazed forests had significantly ($p=0.001$) greater exotic cover. Both heavily and moderately grazed sites had significantly less graminoid ($p=0.006$) and shade intolerant ($p=0.009$) cover than past grazed park sites (Table 2.3A). Cover value for shade tolerant (closed) forest forbs differed among forest sites ($p=0.046$), and were lowest in heavily grazed and greatest in non-grazed sites. Heavily grazed forests also had significantly ($p=0.035$) lower woody cover than past grazed park and non-grazed sites. In the matrix, percent cover of graminoids, woody plants, shade tolerant and shade intolerant forbs were significantly ($p<0.002$) greater in past grazed park sites (Table 2.3B). As with forests, exotic plant cover in the matrix was greatest ($p=0.003$) in heavily grazed sites.

Table 2.3. The mean percent cover ± standard error for plant guilds, and overall proportion of native species in the (A) forest and (B) surrounding matrix, for all grazing categories. Significant p-values are bolded.

(A)

	Past/ park	None	Moderate	Heavy	$F_{(3, 16)}$	P value
Exotic (28)	5.26 ±3.98^{b}	7.32 ±2.06^{b}	7.40 ±2.58^{b}	30.51 ±11.70^{a}	10.85	**0.001**
Graminoid (31)	11.86 ±1.19^{a}	6.72 ±2.22^{ab}	4.89 ±2.04^{b}	5.44 ±2.25^{b}	6.62	**0.006**
Open forb (32)	7.17 ±1.24^{a}	7.53 ±2.31^{ab}	2.75 ±0.44^{b}	2.28 ±0.78^{b}	5.98	**0.009**
Closed forb (50)	19.38 ±2.29^{ab}	20.70 ±2.72^{a}	14.96 ±4.99^{ab}	10.34 ±1.61^{b}	4.70	**0.046**
Woody (28)	16.96 ±2.16^{a}	20.02 ±0.63^{a}	16.08 ±3.47^{ab}	8.28 ±1.80^{b}	3.91	**0.035**
Native proportion	0.91±0.05^{b}	0.89±0.03^{b}	0.81±0.05^{b}	0.49±0.12^{a}	8.03	**0.0028**
Total cover	68.28±3.45	61.15±10.45	46.80±10.73	67.17±9.39	1.33	0.3081

(B)

	Past/ park	None	Moderate	Heavy	$F_{(3, 16)}$	P value
Exotic (32)	18.41 ± 5.92^{c}	20.56 ±11.40^{bc}	40.17 ± 8.94^{ab}	77.90 ± 9.68^{a}	7.74	**0.003**
Graminoid (40)	19.82 ± 4.40^{a}	3.85 ± 1.02^{b}	6.11 ± 4.11^{b}	3.63 ±2.57^{b}	9.37	**0.002**
Open forb (52)	22.26 ± 3.64^{a}	3.97 ± 1.07^{b}	4.44 ± 1.47^{b}	1.58 ± 0.36^{b}	17.89	**<0.0001**
Closed forb (39)	17.97± 2.52^{a}	3.51 ± 0.58^{b}	4.85 ± 0.89^{b}	1.49 ± 0.46^{b}	20.64	**<0.0001**
Woody (25)	12.36 ± 1.67^{a}	5.30 ± 0.82^{b}	6.77 ± 1.64^{b}	1.44 ± 0.65^{b}	9.86	**0.001**
Native proportion	0.79±0.07^{a}	0.54±0.10^{b}	0.38±0.08^{b}	0.10±0.04^{c}	14.26	**0.0002**
Total cover	92.43±3.33^{a}	37.63±12.75^{b}	63.35±6.30^{a}	86.40±9.55^{a}	9.18	**0.0016**

Notes:

1. Parentheses following plant guilds represent number of species included.
2. Same letters indicate means that are not significantly different ($p>0.05$).
3. Count data log-transformed, proportions arcsine-transformed for analysis; non-transformed mean ± SE are shown.

2.6.4. Patch and landscape environment

While understorey species composition was clearly affected by grazing, it was also affected by other patch and landscape level variables. The first CCA axis separated heavy grazing from other sites, which explained 29.1% of the variation in the data (Figure 2.4), with a high redundancy value of 59.3%. The grazing index was associated positively with the first axis and significantly ($F_{3, 16}$=37.43; p<0.0001) with heavily grazed sites. The shape index, number of patches (r= 0.87; p>0.001) and woody canopy cover were negatively associated with this axis, and associated with non-grazed and past-grazed park sites. Past-grazed park sites were also characterized by a significantly higher ($F_{3, 16}$=8.33; p=0.0024) degree of coherence and slightly higher mean patch size index than non-grazed and moderately grazed sites. Past-grazed park sites also had significantly higher soil moisture ($F_{3, 16}$=7.90; p=0.0028) and lower soil pH ($F_{3, 16}$=5.56; p=0.0112) than both heavy and moderately grazed sites, see Appendix A, table A.2. Soil moisture and pH were significantly (r=-0.62; p<0.01) correlated.

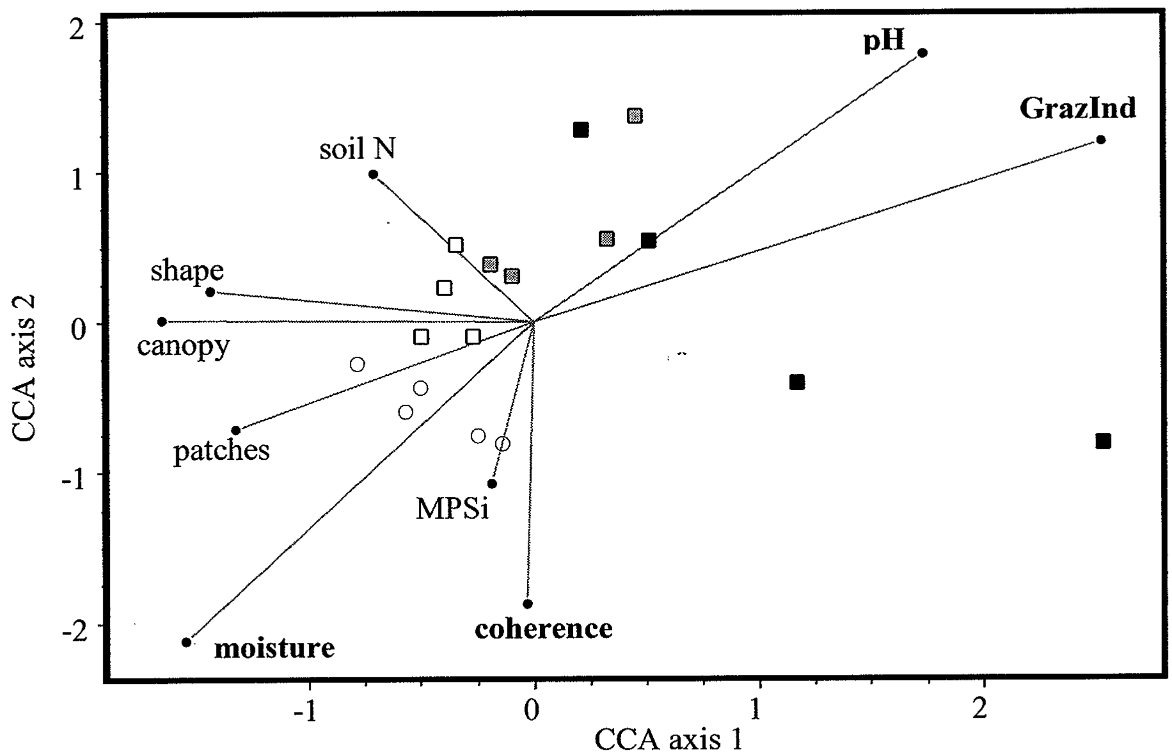

Figure 2.4. Canonical correspondence analysis (CCA) of all forest species variables constrained by five patch and four landscape level variables. The first two axes account for 29.1% and 17.8% of the variation in the data, redundancy 59.3%. Site symbols are past park grazing (○); no livestock grazing history (□); moderate (▩); and heavy (■) livestock grazing. Abbreviations are MPSi = mean patch size index; GrazInd = grazing index. Significant variables are bolded (ANOVA).

2.6.5. The Forest -Grass Ecotone

Overall, grazing affected the similarity of species composition between the forest understorey and the adjacent matrix. Using the Sörenson similarity index, high similarity values indicate greater species overlap between the plots compared. Figure 2.5A shows the overall similarity of species composition in the understorey (at each distance from the forest margin) when compared to the surrounding matrix (at 50 m from the forest margin), for all grazing levels combined. Predictably, the species composition of the forest margin (0 m, adjacent to the matrix) had the highest ($F_{24, 152}$=35.1; p<0.0001) similarity values when compared to the composition of the surrounding matrix. The similarity in species composition between the surrounding matrix and the forest edge (20 m from the matrix), and the surrounding matrix and forest interior (50 m from the matrix) was not significantly different.

Next, an overall comparison was made based on grazing levels, (Figure 2.5B). In both moderately and heavily grazed sites, there were relatively few species in common between the forest understorey and their respective surrounding matrices. In contrast, park sites had higher similarity values and more species in common between the understorey and the surrounding matrix. Species composition between the forest understorey and surrounding matrix was most distinct in non-grazed sites. In these sites, the understorey shared lowest species similarity ($F_{24, 152}$=80.5; p<0.0001) with the matrix, which was generally used for hay production, (Figure 2.5B). Finally, among the currently grazed sites (e.g. moderately and heavily grazed), species similarity between the forest and the adjacent matrix tended ($F_{24, 152}$=2.0; p<0.0719) to increase with grazing intensity.

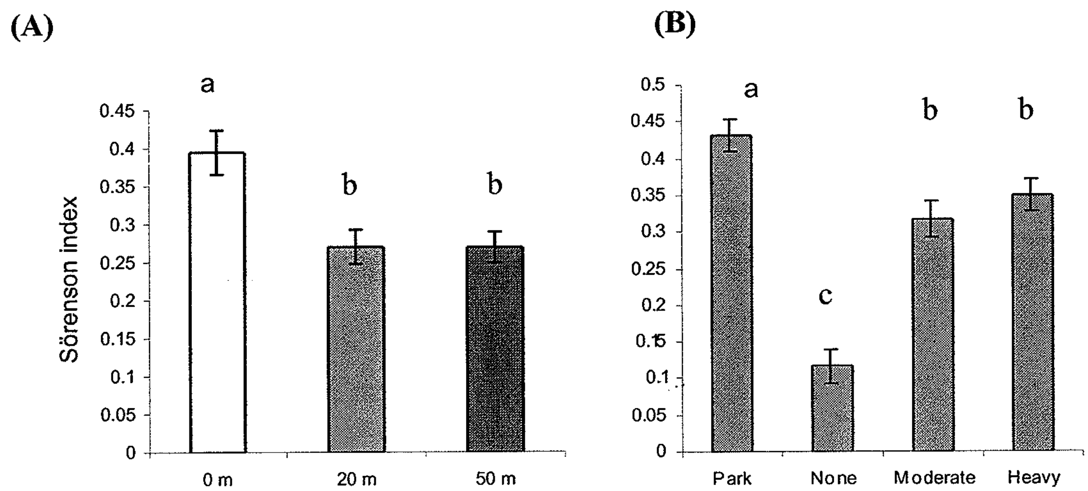

Figure 2.5. Mean Sörenson similarity index values comparing the overall similarity in species composition between each forest plot (0 m; 20 m; 50 m) and the matrix plot (50 m), according to the (A) distance from forest margin and (B) grazing category. Same letters indicate means that are not significantly different (p>0.05).

Further examination including native species only, showed that the occurrence of native understorey species increased significantly ($F_{24, 152}$=5.57; $p<0.0048$) between margin, edge and interior plots (Figure 2.6). However, the grazing category interacted significantly ($F_{24, 152}$= 4.31; $p=0.0005$) with plot distance from the forest margin. Thus, native species richness was generally greatest in forest interior plots for all grazing categories, with the exception of park sites. In past grazed park sites, the forest interior had decreased native species richness, as compared to plots at the forest margin.

When exotic species were examined separately, species richness was again significantly greater in heavily grazed sites ($F_{24, 152}$=31.79; $p<0.0001$), and in forest margins ($F_{24, 152}$=12.85; $p<0.0001$). No interaction was detected ($F_{24, 152}$=1.01; $p=0.4190$) between grazing and plot distance.

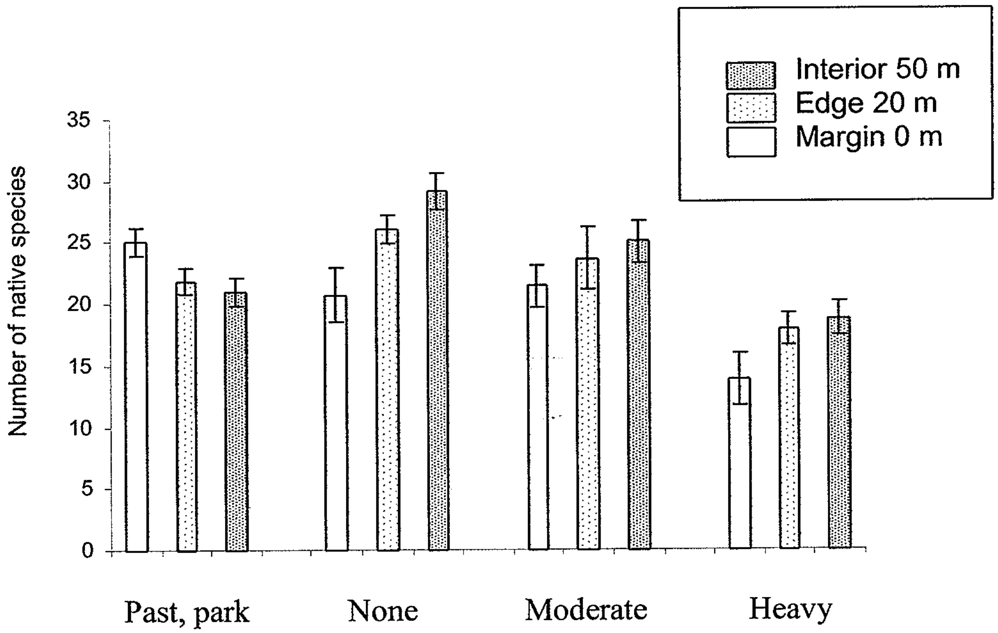

Figure 2.6. The number of native understorey species shown by their distribution in forest margin, edge, and interior plots, for each site category. Standard error bars are shown.

2.7. Discussion

Forests in rural North America have been widely cleared for intensive crop and livestock production since agricultural settlement. Intensive land uses (such as cattle grazing) are generally perceived to threaten the diversity and persistence of remaining forests, many of which are remnants of original pre-settlement vegetation (Keddy and Drummond 1996). These remnants are often small, surrounded by agricultural use and actively grazed by domestic livestock. Grazing in particular is widely viewed as adversely affecting natural habitat (Jones 2000; Stohlgren et al. 1999; Milchunas et al. 1988), and in this study, grazing was indeed associated with exotic species. However, these results suggest that forest remnants are also important refuges for native species in the agricultural mosaic, and that moderate levels of livestock grazing do not adversely affect native understorey species.

Although grazed forests and adjacent matrices were generally associated with exotic species, grazing intensity affected species composition. While there were no exotic species strongly associated with moderately grazed sites, many were significantly associated with heavy grazing, in particular *Taraxacum officinale*, *Trifolium repens*, and *Plantago major*. These species have characteristics (e.g. early flowering, high fecundity) that enable them to persist in highly disturbed arid environments (Landsberg et al. 1999; Pettit et al. 1995), and to be pervasive in temperate grasslands (Baskin and Baskin 1998).

It was anticipated that livestock might facilitate seed exchange, resulting in greater similarity between the forest interior and the pasture matrix of heavily grazed patches. Cattle that feed in surrounding areas and shelter in forests may act as vectors for exotic seeds (Belsky and Blumenthal 1997) either by direct dispersal or indirectly, by physically opening forest edges or increasing soil disturbance (Saunders et al. 1991).

Thus, under heavy grazing, species similarity between forest patches and open areas tends to increase (Landsberg et al. 1999). However, there was no association between grazing intensity and species similarity between adjacent habitats, although heavily grazed sites tended to share more species with their surrounding matrices than did the moderately grazed sites.

Exotic dispersal is likely enhanced by the small size of forest patches in agriculture dominated landscapes (Moffatt et al. 2004) and the open nature of grazed forests, which facilitate seed dispersal by wind and increase light availability in the understorey (Weir and Johnson 1998). Invasion by shade intolerant exotics is likely further facilitated by increases in bare ground associated with grazing (Pettit et al. 1995). Many exotic species remain excluded from the forest interior by lower light levels and lack of soil disturbance (Ranney et al. 1981) or by the physical structure of edge vegetation (Cadenasso and Pickett 2001), especially in old-growth patches (Brothers and Spingarn 1992). In these sites, exotics were not equally dispersed but were largely concentrated in the margins of the patch, regardless of grazing category. Moreover, no exotic species were unique to the understorey, suggesting that the surrounding matrix may be the primary source of exotic plants. Nevertheless, exotic species effective richness and all evenness measures were not affected by grazing. Furthermore, in the absence of heavy livestock grazing, most exotic species occurred infrequently or were relatively minor components of the understorey species assemblage.

Native understorey species were uniformly affected by the intensity of livestock grazing. The forest understorey of heavily grazed sites consistently had lowest native species richness, effective richness and cover, whereas no significant differences existed among all other grazing categories (i.e. past-grazed park, non-grazed, and moderately grazed sites). Replacement of native species by exotics is frequently associated with disturbance (Lodge and Shrader-Frechette 2002), as for example under intense livestock grazing (McIntyre and Lavorel 1994b; Milchunas et al. 1988). Some forest fragmentation studies (Brothers and Spingarn 1992; Norton 1999) note an increase in species richness at edges due to an increase in exotic species. While this may be the case in these moderately grazed sites, the heavily grazed sites had an overall reduction in species diversity. The lower diversity of heavily grazed sites was due to a loss of native species. Moreover, although these sites had an increase in cover of a subset of grazing-tolerant exotics (e.g. *Carum carvi*, *Cirsium arvense*, *Plantago major* and *Poa pratensis*), there was no corresponding increase in effective richness for exotic species.

Native species diversity generally increased towards the forest interior in all grazing categories, except for past grazed park sites, where the opposite pattern was observed. Many species found in the park understorey plots are considered to be more characteristic of the matrix including *Agastache foeniculum*, *Aster laevis*, *Monarda fistulosa* and *Potentila arguta*. The greater concentration of native species in the margins of park forests is reflected by the greater diversity of the adjacent matrix, and further reflected by the increased similarity of species found within the forest and the grassland plots, in these park sites. In contrast, the matrices of sites located outside the park were generally dominated by exotics and planted species, reflecting their more intensive land uses. These findings highlight the importance of surrounding or adjacent habitats (i.e. seed source habitats) when assessing livestock effects on species composition.

While grazing was important, landscape level factors also influenced understorey diversity and species composition. Here, past-grazed park sites were primarily distinguished from private sites. Not surprisingly, park forests generally covered larger areas than forests on private land. Consequently, the connectivity and mean patch size had greater values in the park, where forest was largely contiguous, and accounted for a greater proportion of the land cover than at privately- owned sites. Forests in general, are naturally patchy landscapes (Weins 1997; Lord and Norton 1990), which reflect the intermittent availability of resources, water or nutrients across a landscape (Theberge and Theberge 2002). However, clearing on private land often takes the geometrical form of survey lines (Sharpe et al. 1987) and remaining forests often represent distinct blocks that have abrupt, linear edges. Privately owned forests are generally smaller in size (Erickson et al. 2001) than public forests, which also can compromise diversity or resilience to disturbance. Furthermore, private sites, frequently adjacent to or surrounded by agricultural habitats, are often more prone to invasion (Freemark et al. 2002; Hobbs 2001), and may show greater and longer lasting responses to grazing disturbance. However, it was the heavily grazed sites that appeared overall to be the most compromised in terms of native species diversity. Heavily grazed sites were consistently characterized by low native diversity, despite their locations, often proximal or adjacent to contiguous expanses of the relatively undisturbed forests found within the national park. In the absence of heavy grazing, private forests were found to be as diverse as past grazed park forests.

A central outcome of this study is that remnant forests, even those grazed by livestock, can have diverse understorey plant communities and therefore may play an important role in regional conservation. This project represents the first systematic study of its kind in this region. However, the importance of cattle use of native forest pasture habitats, as discussed here, is not unique to this region. Similar discussions of cattle use and effects on the biodiversity and structure of forest vegetation occur elsewhere, e.g. in the western United States (Belsky and Blumenthal 1997; Dennis 1997); in Australia (Landsberg et al. 1999; Pettit et al. 1995). Yet many of these studies deal with arid environments, or publicly managed forests.

The federal agency responsible for conservation in this region, Parks Canada, has committed to a program of 'regional integration', to address that many threats to its large parks are trans-boundary in nature (Parks Canada 1997). However, the importance of these relatively small privately owned forests continues to be neglected in this region, and in North America as a whole (Hilty and Merenlender 2003; Freemark et al. 2002). Nevertheless, regional conservation plans must necessarily rely on these privately owned and often ecologically diverse forest patches. Given the relative importance of these forest habitats, in terms of their social, economic and conservation benefits, it seems surprising that there has been relatively little research concerning connections between private values and stewardship of these habitats, and the effects of land uses within them. Meaningful collaborative research including landowners and local communities is crucial (Curtin 2002; Scott et al. 2001) if regional conservation is to proceed effectively among parks, protected areas and private land, particularly given the large experiential knowledge base of long-term landowners.

3. Land Use and Conservation Values of Native Vegetation on Private Farmland surrounding Riding Mountain National Park, Manitoba

3.1. Introduction

Almost two centuries after agricultural settlement in North America, clearing of original vegetation is still ongoing, and areas of intact native habitat are ever-dwindling (Freemark et al. 2002; Erickson et al. 2001; Trant 1992). While this is true of most agricultural landscapes, it is perhaps most clearly and actively illustrated in the transition between the southern aspen parkland and the northern boreal forest (Tyrchniewicz et al. 1999), an area recently referred to as the last frontier of agricultural settlement (Weir and Johnson 1998). However, the combination of marginal soils and small scale farming often result in patches of native vegetation, including forests, interspersed with farmed land. These remnants have become a focus for those interested in reducing the continued loss of native vegetation in agricultural landscapes. These remaining small patches play an important role in regional conservation and the maintenance of biodiversity across the landscape, yet they are still poorly understood (Freemark et al. 2002; Bayne and Hobson 1998; Middleton and Merriam 1983). Scientific descriptions alone cannot adequately shape management decisions (Curtin 2002; Slocombe and Dearden 2002; Lackey 1998; Grumbine 1994), and social values and local practices must also inform management and policy-making regarding protected areas (Slocombe and Dearden 2002; Octeau 1999).

Forests on public and private lands are economically important (National Resources of Canada 2004), and frequently used for timber, livestock pasture, tourism or hunting (Krzic et al. 2003; Argow 1996; Hardesty et al. 1993). Forests also have tremendous social and cultural importance (Haider and Hunt 2002; Jantzi et al. 1999). In the United

States, it has been conservatively estimated that approximately 58% of all commercially viable forested land is privately owned (Hardesty et al. 1993), the large majority of which is made up of small parcels of <20 ha (Birch 1997 in Jacobson 2002). Understanding what has motivated landowners to maintain, protect and manage forested land can help local communities take action to preserve and conserve these systems (Erickson et al. 2001; Turner et al. 1996; Bliss and Martin 1989). At the community level, local knowledge and experiences of rural residents have the potential to inform and direct regional conservation plans and management decisions (Jacobson 2002; Endter-Wada et al. 1998), especially in the absence of adequate scientific data (Curtin 2002; Erickson et al. 2001; Millar and Curtis 1999). Documenting interests, needs and perspectives of local residents and stakeholders is the first step in this process (Brook and McLachlan 2005).

The contrast between public land and privately owned, often intensively used land can be striking. Canada's national parks face a number of threats to their ecosystem integrity, many of which are associated with surrounding communities and adjacent land use (Octeau 1999). This island mentality around parks was once well illustrated by Parks Canada (1987) with the description of Riding Mountain National Park as:

> "*...an island of natural environment surrounded by a sea of man-altered environment. The transition zone from farmlands is illustrated dramatically by the wheat fields and pastures abutting the natural environment.*"

Much of the attention towards private lands surrounding national parks has centred on conservation benefits for park wildlife populations or conservation of natural habitats within the park. The land use surrounding national parks is generally seen as a threat to the park, but also ignored in terms of its conservation value. Yet, local people and communities also have strong stewardship values, and often see themselves as a part of nature (McNeely 1990), therefore are alienated by this preservationist view (Octeau 1999).

There has been much recent recognition that parks and protected areas cannot be designed or managed in isolation from their surrounding landscapes (Slocombe and Dearden 2002; Octeau 1999), as they are very much part of the "social and political mainland" (Brandon et al. 1998). In protected areas, the importance of regional conservation plans, which involve local communities and practices has been recently recognized (Parks Canada Agency 2000), particularly in dealing with trans-boundary issues. Many environmental or non-governmental groups (e.g. the Nature Conservancy of Canada; Ducks Unlimited Canada) provide information and some financial incentive for farmers and landowners to practice conservation techniques within their own farming operations. This is resulting in the establishment of larger networks of habitats, which may link to other reserved areas (Simberloff 1997; Forman 1995). Nevertheless, there have been relatively few attempts to understand how privately owned natural environments, including forests, are used and managed (Hardesty et al. 1993). Consequently the role that these habitats might play in conservation initiatives is not fully understood (Keddy and Drummond 1996).

The conversion of forest to crop and pasture in western Canada is a relatively recent phenomenon, taking place over the past 100 years (Fitzsimmons 2002). Landowners are often long term residents, or in many cases, are the second or third generation of farmers and direct descendants of those pioneers that originally settled this area for agricultural production. Long-time residents often have deep insight into the environmental, economic and social values that people place on local forest patches, and in the changes taking place in these landscapes (Koontz 2001). It is the local needs and values, which will ultimately shape management decisions about forested land (Tyrchniewicz et al. 1999), and in part will determine the future of remaining forests in the region.

3.2. Chapter objectives

The objective of this chapter is to determine the importance of native vegetation habitats, particularly privately owned forests, to landowners within the agricultural mosaic. Specific objectives of this chapter were to:

1) Characterize how and to what extent private forests are used by landowners;

2) Identify attitudes and values of landowners toward forest management and conservation;

3) Explore opportunities for and barriers to future conservation on forested land.

3.3. Study area

This study takes place in southern Manitoba, Canada, and involves cattle producers that reside in rural municipalities adjacent to Riding Mountain National Park (RMNP) (Figure 3.1.), including primarily the municipalities of the Riding Mountain Biosphere Reserve. Participants of this study are part of a larger community that has been farming since the original agricultural settlement of the area. The region around RMNP was first settled for farming in the 1880s. During this time, families that farmed near the current RMNP boundaries frequently used what is now park land for watering livestock, grazing, haying and timber harvest. These activities were continued even after the area was declared a Dominion Forest Reserve in 1895 (Ringstrom 1981). By 1914, over 400 cattle were grazed within the Reserve (Trottier 1986). This livestock grazing was actively encouraged by the chief forester, primarily to protect the timber resource from fire (MacMillan and Gutches 1909). In 1933, Riding Mountain was formally designated as a National Park (Parks Canada 1997), which naturally led to the restriction of these familiar uses by local landowners. In 1969 livestock grazing was eliminated entirely from the park (Trottier 1986).

Today, the region is a human dominated landscape of diverse agricultural and biophysical communities. Riding Mountain National Park itself covers 2,976 km^2. The park is located in the Boreal Plains Ecozone (Smith et al. 1998), and represents a confluence of mixed hardwoods, coniferous forests, and fescue and mixed grass prairies (Bird 1961). In this region, trees of the upland forests are dominated by hardwoods trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.), and white birch (*Betula papyrifera* Marsh.). Black spruce (*Picea mariana* (P. Mill.) B.S.P.) bogs make up forested lowland areas. Soil productivity ranges from poor to moderate and is limited in places by soil stoniness and steep slopes (Ehrlich et al. 1959). Farms tend to be small (Jacobson 2002) and comprise both livestock and crop production, while commercial and small scale forestry is also important. Hay, canola (*Brassica campestris* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) crops, as well as pasture land, are intermixed with patches of native vegetation.

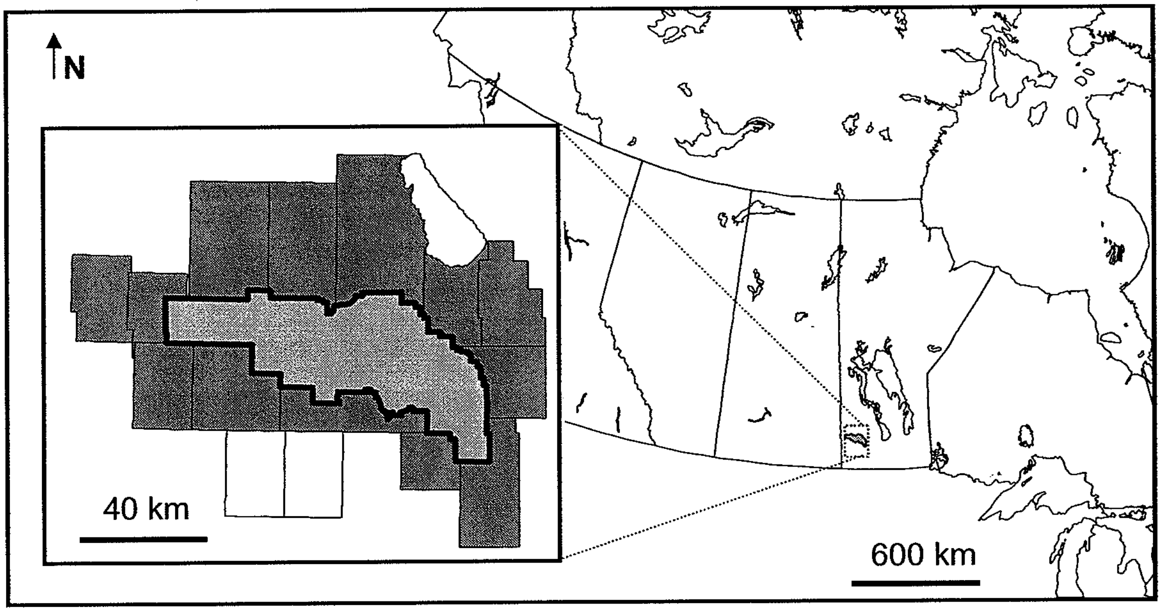

Figure 3.1. Riding Mountain National Park (RMNP), Manitoba (shown in light grey) and outlines of the rural municipalities in the Riding Mountain Biosphere Reserve. Landowner participants from personal interviews and mail-out surveys reside in the municipalities indicated in dark grey.

3.4. Methods

3.4.1. Ethical Considerations

This project and its methods met the strict guidelines of the Joint-Faculty Review Ethics Board at the University of Manitoba. Participating landowners were fully informed of the details and goals of this project from its beginnings, and all stages of involvement were voluntary. Participants also had the opportunity to withdraw from this research at any time. Information gathered for the purposes of this project was treated in confidence and was not shared or distributed to other organisations. All names and specific farm locations of participants have been kept anonymous.

3.4.2. Interviews and Questionnaires

In early 2001, a core group of ten local landowners were identified and agreed to participate in an ecological study on the impacts of livestock grazing on aspen forests surrounding RMNP (see Chapter 2). Each landowner also agreed to be a participant in a study that focused on their values and motivations as farmers. Initial meetings and interviews with the core group of landowner participants were used to develop a number of question themes, including history and changes in the environment over time, land and livestock management practices, attitudes towards non-productive land (i.e. forested land), and values they placed on their land. From these early, exploratory interviews, questionnaires were constructed and used in structured interviews to determine local landowners' attitudes about forest values and uses, emphasizing privately owned forested land. Demographic questions, asked at the end of the interview, included age, source and range of income, and level of education.

Structured Interviews

Structured interviews were conducted in two phases. In the first phase, ten volunteer livestock producers were interviewed using a structured questionnaire, between October 2001 and February 2002. All structured interviews generally lasted from one to three hours, depending on the participant.

In the second phase, an additional 21 landowner participants were randomly chosen from the study area, in January 2003. Both the initial contact and the invitation to participate were made by telephone. The original questionnaire was refined and used in this second phase. The final questionnaire instrument was eight legal pages in length, and consisted of 34 multi-parted questions, for a total of 200 question variables (Appendix B). The questionnaire included some open-ended questions, but was primarily based on Likert questions, which used a seven-point scale that ranged from strongly disagree to strongly agree, with an eighth option for 'don't know/ not applicable'.

Mail-out questionnaires

In the third and final phase of this chapter research, the questionnaire was more widely distributed. In March 2003, it was sent to 3550 farming households (as defined by Canada Post), by unaddressed advertisement mail. All recipients were located in rural municipalities that comprise the Riding Mountain Biosphere Reserve (RMBR), (Figure 3.1). This method was chosen to focus as much as possible on people who currently own land, and therefore are making management decisions about forested or once forested land. Consequently, any non-farming households (e.g. residents of hamlets and small towns) were eliminated. Survey administration followed the tailored design method

(Dillman 2000), incorporating three participant contacts, spaced over four weeks. Questionnaires were sent with an introduction letter, followed up with a reminder card and a subsequent and final thank-you/reminder mailing (Dillman 2000). A blank page was provided to encourage participants to add any comments or elaborate on opinions, after completing the questionnaire.

Two months after survey returns ceased, a follow-up telephone interview was conducted with randomly selected landowners from the geographically surveyed area, using a sub-set of questions asked in the survey. The telephone survey was used to determine whether a non-response bias was associated with the questionnaire (Dillman 2000). A non-response bias would indicate that the people who did not respond or participate in this survey differed consistently form those people that did participate.

3.5. Data compilation and analysis

The variety of early techniques employed, (e.g. semi-structured interviews, surveys completed through in-person interviews and mail out questionnaires), generated results that were not directly comparable. Landowner comments were made at each stage of the survey (in person or in writing on questionnaires), and provided insight into subsequent phases. These comments represented an important source of qualitative data. Statements and comments by participants from the interview and mail-back phases of the research were systematically assessed and underlying themes were identified. All comments are presented anonymously and verbatim, with an indication whether the quote originated from the original semi-structured interview (Semi), structured interviews (Interview), or subsequent mail-out survey (Mail). If needed, clarification of participants' comments was added as: [non-italics]. Data exploration and question responses from the mail-out survey were summarized using SPSS 10.1. (SPSS 2000). Demographic data reflect the results from the mail-out survey, as it included the largest sample of participants, and is thus considered to be the most representative of the population as a whole.

3.6. Results

3.6.1. Response Rates

In the first two phases, the great majority (>80%) of those initially contacted readily agreed to participate in the project. The responses that were personally collected during 31 structured interviews from both volunteer and randomly chosen landowners were generally of very high quality, with very high response rates per question (96.3%). In these structured interviews, the questions that were not completed were generally not applicable to the participant.

In the third phase, 404 mail-out surveys were returned, representing a response rate of only 11.4%. Despite the effort to target only farming households (i.e. landowners), several uncompleted surveys were returned, with an indication that the recipient either lived in a town or did not currently own any land. For the purposes of analysis, respondents were considered to be landowners and included in the results if they were local residents owning more than four hectares of land. In the non-response survey conducted by telephone (n= 68), it was determined that 58.1% of those called that were eligible to receive a survey did not receive one, and 2.9% received a survey yet were not eligible.

Telephone interviews with non-respondents of the mail-back survey showed that demographic information and ownership of forested land of the survey non-respondents was not distinguishable from responses provided by landowners that completed the questionnaire. Furthermore, demographic information collected during the personal structured interviews was very similar to demographic responses collected in the mail-out survey. Finally, returned surveys were of extremely high quality; the average response rate per question was 93.8%.

3.6.2. Demographics

Overall, most respondents (82.8%) were male, averaging 53 years of age. Many were formally educated, either having completed high school (39.5%) or post-secondary degrees (41.2%). Respondents were long-time (24.1 years) primary managers of relatively small (average size 427.2 ha) farms. On average, respondents' families had been farming for 77.1 years, indicating that most people surveyed were second or third generation farmers. These figures are very similar to census data reported by Statistics Canada, which calculates the average age of farm operators in this region to be 50 years (Statistics Canada 2002), and 78% of farmers in the region are male. Census data indicates that the average size farm in this region is 419 ha (Statistics Canada 2002).

> *My parents farmed before I took over and when my son was old enough I sold him my own farm and bought the neighbours for myself. I've been farming 55 years.* [Mail 10]

Over 80% of landowners on farms (i.e. >4 ha) cited agriculture as their main land use. Respondents reported mixed sources of income, most commonly crop and cattle production, as well as off-farm work. Overall, slightly more people earned the majority of their income from crop production (58.9%), as compared to cattle (51.1%). Off-farm income was also important to many respondents (66.0%), either by supplementing a farm income, or accounting for the majority of household income. Off farm work was extremely varied, ranging from the trades (e.g. construction, electrical, mechanical), to professional (e.g. teacher, lawyer, doctor, consultant) to entrepreneurial (e.g. outfitting, tourism, artist, native seed production).

3.6.3. Agricultural land use and native vegetation cover

As expected, the vegetation cover in this farming community consisted primarily of crop (45.8%), hay 17.7% or pasture 23.4% land, (mean areas shown in table 3.1). Farms were generally small (427.2 ha on average), with more land devoted to crop cover than to pasture. Most crops covered areas of less than a section of land (195 ha), although there was a large range of land area ownership among respondents (4 to 5353 ha).

Many people (84.9%) also reported that an average of 13.1% of their land was set-aside from production. Among cattle producers, 75.8% of all pasture was reported as native, i.e. original vegetation with no history of seeding or cultivation to the pasture. Pasture area was composed either of forests (39.9%), native grassland (35.8%), or seeded pasture (24.3%), i.e. planted to non-native forages species.

Table 3.1. The main land uses among mail-out survey respondents (n). The mean (hectares; standard error) land holdings are shown for each main land use e.g. crop, hay, pasture and idle land.

Variable and definition	mean hectares	*(s.e.)*	farm land base (%)	landowner (%)[1]	n
Crops, grain/ oil seed	195.46	*(15.71)*	45.76	81.98	282
Livestock, hay	75.78	*(6.22)*	17.74	82.56	284
Livestock, pasture	99.87	*(9.41)*	23.38	79.94	275
Idle land, set aside	56.07	*(6.13)*	13.13	84.88	292
Land holdings [1]	**427.19**	*(24.8)*	**100**	**100**	**344**

1. All participants included in this summary lived on farms larger than four hectares.

Almost all of the landowners surveyed (95.6%; 329 people) reported having native vegetation on their farms. While this may in part reflect the marginal nature of the agricultural land in this region, native vegetation (i.e. native pasture, native hay and non-cultivated idle land) was nevertheless an important component of many respondents' farms, averaging 35.3% of all land holdings among participants (Table 3.2).

Table 3.2. Types of native vegetation and mean (standard error) hectares owned among mail-out survey respondents (n).

Variable and definition	**mean hectares**	*(s.e.)*	**conservation land base (%)**	**landowner (%)**[1]	**n**
Native hay[2]	19.02	*(4.42)*	12.62	48.84	168
Native pasture[2]	35.80	*(5.82)*	23.75	54.65	188
Mixed bush pasture[2]	39.85	*(4.29)*	26.44	64.83	223
Bush	43.31	*(5.58)*	28.73	75.00	258
Wetland	12.76	*(1.15)*	8.47	64.53	222
Native Vegetation, combined	**150.74**	*(16.23)*	**35.29**[3]	**95.64**	**329**

Notes:

1. All participants included in this summary lived on farms larger than four hectares.

2. This native vegetation area is used in the production of livestock.

3. Conservation land base: the proportion of all native vegetation maintained on farmland among participants.

Several descriptions, taken from personal individual interviews with 31 landowners, indicated that native vegetation on private land was represented by a variety of habitat types.

- *Land that isn't broken* [Interview 2]
- *Meadows, sloughs and waterways* [Interview 6]
- *Native pasture* [Interview 14]
- *The swamp areas left to wildlife* [Interview 22]
- *The bluffs on my fields and the forests by the creek* [Interview 26]
- *Pasture that's unbroken or heavily wooded* [Interview 30]

Clearly, these habitats are integrated into actively used farmland, and not necessarily restricted simply to idle or abandoned areas. Notably, almost two thirds (62.8%) of the land base currently under original vegetation was reportedly used for livestock production, either as pasture, forested pasture or harvested for hay. Furthermore, the dominant native vegetation cover was forest (55.2%), followed by grassland pasture (23.8%); native hay (12.6%) and wetlands (8.5%).

> [Trees] *are part of an important part of the natural ecosystem. I like to keep things as natural as possible.* [Interview 24]

Forested land cover was very important in the study area, reported on 75.4% of all farms. According to respondents, forest cover represented 19.5% of the land base, including all types of private land cover. Regardless of the main source of income, many participants felt that forested land was an integral part of the agricultural landscape.

3.6.4. Landowner Management of Farmland Forests

The great majority (86.7%) of respondents indicated that they would maintain their current management priorities. When asked about the future of native vegetation on their land and intended management goals, most indicated they would reforest some areas (68.0%), plant shelterbelts (59.0%), or allow portions of land to revert to natural cover (31.4%). There was also an indication among participants that further expansion of existing livestock operations or conversion of new land to livestock production is ongoing. Almost half (49.6%) the respondents agreed that they would fence some land in the near future, while few indicated they would drain (27.3%) or clear (18.1%) land in the future (Table 3.3). These data suggest that the maintenance and conservation of forest cover is of great importance on private lands.

Table 3.3. The median and mean (standard error) responses regarding forest management goals on private land, among mail-out survey respondents (n).

Variable	median[1]	mean[1]	*(s.e.)*	agree (%)[2]	n
Maintain current management style	6	5.99	*(0.07)*	86.7	376
Plant trees	5	5.15	*(0.09)*	68.0	376
Plant shelterbelts	5	4.99	*(0.10)*	59.0	371
Fence land	5	4.67	*(0.12)*	49.6	373
Allow land to revert to 'natural' cover	4	3.97	*(0.12)*	31.4	377
Drain land	4	3.45	*(0.12)*	27.3	377
Clear land	2	2.79	*(0.11)*	18.1	377

Notes:

1: 1= strongly disagree; 2= disagree; 3= slightly disagree; 4= neutral; 5= slightly agree; 6= agree 7= strongly agree. For full questions refer to Appendix B.

2: Agree (%) is based on the proportion of landowners those that chose any of the following: slightly agree, agree or strongly agree.

Conservation interest in forests on farmland was at times focused on environmental functions and utilitarian concerns. For example, forested areas, bluffs on fields, and shelterbelts were associated with erosion control and moisture retention around crops.

> *We don't summer fallow the land anymore, we work towards minimum tillage, we leave more trash* [i.e. stubble] *on the ground for erosion, and to slow the water. Bush also holds back the snow. The slower melt is important to us.* [Interview 2]

Forested areas in particular were identified as an important element of livestock operations. Privately owned forests that were grazed by livestock accounted for almost half (39.9%) the native vegetation used for livestock production. Cattle producers and farmers alike noted that "*You have to have trees to have cattle*" [Interview 12]. Forest habitats are necessary to livestock production, as "*Cows also need some shade and protection from the weather*" [Mail 41], while also providing a limited amount of forage. Moreover, many landowners (82.8%) felt that moderate grazing by livestock was also good for forested areas.

> *You have to appreciate the way nature works. ...* [Trees] *provide erosion control on hill sides. ...Pasturing is good for the trees, it helps thin them out.* [Interview 5]

One cattle producer felt that proper stocking of livestock could be an important management tool in forests, in the absence of wildfire. This landowner felt that forest grazing could be beneficial to cattle weight gains while also increasing the productivity of forests for wildlife.

> *Grazing techniques can be used on a lot of bush land to improve the carrying capacity of he land both in terms of livestock and wildlife.* [Mail 31]

Although forested land was clearly an important component of livestock production in this area, there was a general feeling that forests on private land should not be lost to agricultural use. Most people (70.5%) reported no recent decrease in the forest cover on their own land, although many participants felt that there were currently fewer forests overall on surrounding lands, than in the recent past (Table 3.4.). While forested land makes up a substantial part of native vegetation cover today, this was not always so:

> *Forest and bush in our area are ever encroaching with little harvest, no fire, no natural succession. Historically there is more forest in this region than before white settlement.*
> [Mail 15]

This view, that parts of this region were once open grassland, prior to the agricultural settlement of this region is also supported in historical data and writings on early explorations (e.g. Tyrell 1888), and is evidenced in the post-glacial development of this environment (Löve 1959), but also see Figure 1.1.

Table 3.4. The median and mean (standard error) responses to selected question variables concerning opinions on local forests, among mail-out respondents (n).

Variable	**median**[1]	**mean**[1]	*(s.e.)*	**agree (%)**[2]	**n**
Wildlife benefit from pasture management	6	5.76	*(0.07)*	86.83	357
Light livestock grazing benefits forest	6	5.61	*(0.07)*	82.79	366
Cattle need access to bush pasture	6	5.54	*(0.09)*	79.89	373
There is less bush on surrounding land	6	5.32	*(0.11)*	71.47	354
I have less bush on my land today	3	3.22	*(0.13)*	29.51	366
All bush suitable for cattle grazing	3	3.05	*(0.10)*	21.98	364
Heavy livestock grazing benefits forest	2	2.66	*(0.09)*	15.30	366
Convert forests to agriculture (in my area)	2	2.19	*(0.09)*	5.49	364
Convert forests to agriculture (on my land)	2	2.18	*(0.09)*	7.82	371

Notes:

1: 1= strongly disagree; 2= disagree; 3= slightly disagree; 4= neutral; 5= slightly agree; 6= agree 7= strongly agree. For full questions refer to Appendix B.

2: Agree (%) is based on the proportion of landowners that chose the following responses: slightly agree, agree or strongly agree.

Another common concern brought up among respondents was the rate of deforestation on both public and private lands, and the role that the forestry industry played in forest decline. While many respondents (62.6%) agreed that forests are a source of income, a similar proportion (63.0%) felt that commercial clear cutting was the cause of forest decline in their area.

> *The fact that Louisiana Pacific has been allowed into this area is a national disgrace and should never have been done. The mess left behind is horrific and environmentally destructive. It cannot be cleaned up even to make into pasture. Nothing can walk through the junk left behind, not even wildlife. Go ...and see for yourself.* [Mail 33]

Most people today (59.8%) would not allow timber harvest on their land, or clear any land themselves (81.9%) in the near future. The majority of respondents (95.0%) responded that their land had not been previously cleared for commercial forestry. Rather, 80.5% of respondents reported their land was cleared by the previous generation/ landowner in order to make way for crops (75.0%) or pasture (60.4%). This suggests perhaps the decline in forest cover participants recognize today, is due to recent or ongoing timber harvest activities, separate from the original timber clearing by farming pioneers.

Not all people were concerned about timber harvest in the area, as some respondents (22.7%) maintained forests on their land specifically for timber production. Although some indicated that clearing might better be achieved by small scale and less intensive approaches.

> *Selective logging by horses and careful cutting of deadfall for firewood can leave a woodlot in healthy condition for years to come.* [Mail 33]

Moreover, others identified that there were barriers that prevented them from clearing land, such as limited accessibility to timber (9.1%); marketability of timber (16.2%); or lack of time or money to clear forested land (13.2%).

3.6.5. Landowners Values of Farmland Forests

Many of the questions asked focused on participants' personal values and attitudes towards forest within agricultural land. Regardless of whether people had forest on or near their land, many derived a strong enjoyment from seeing wildlife on their land and in their area. Aside from the benefits of direct land use and forest utility, other motivations to retain forested land, as taken from the comments, were drawn from personal preferences, and were often embedded in concepts of environmental stewardship, which focused on benefits for biodiversity.

> *Out of 160 acres only 10 have been used as driveway and building sites. The remainder is made up of lake, forest, natural sloughs and meadows. It has never been logged and we are trying to ensure that it will never be. It is a refuge and sanctuary for many birds, animals, and whatever wild species are left in this area.* [Mail 59]

Participants voiced strong values of stewardship, including an association of forest with the farming landscape, the protection of wildlife, and the environmental quality of air, soil and water. When making management decisions, almost all respondents indicated that they considered impacts those decisions might have on soil (93.1%) and water (91.0%) quality, and many people also considered possible impacts to wildlife (72.3%). Many respondents (92.5%) were conscious of managing their land in a way that did not compromise near future production. This is exemplified in respondents' concern for the effects their land management decisions might have on the next generation (89.6%) and their neighbours (75.7%), (Table 3.5).

Table 3.5. The median and mean (standard error) responses to the extent each variable is considered, when making management decisions, among mail-out respondents (n).

Variable	**median**[1]	**mean**[1]	*(s.e.)*	**agree (%)**[2]	**n**
Soil quality	6	6.11	*(0.06)*	93.1	373
Water quality	6	5.97	*(0.06)*	91.0	375
Wildlife	5	5.17	*(0.08)*	72.3	371
The next five years of production	7	6.19	*(0.06)*	92.5	361
The next generation	6	6.03	*(0.06)*	89.6	373
The neighbours	5	5.21	*(0.08)*	75.7	375

Notes:

1: 1= strongly disagree; 2= disagree; 3= slightly disagree; 4= neutral; 5= slightly agree; 6= agree 7= strongly agree. For full questions refer to Appendix B.

2: Agree (%) is based on the proportion of landowners that chose the following responses: slightly agree, agree or strongly agree.

3.6.6. Conservation Costs and Farmland Forests

Stewardship and the inherent value placed on non-productive land were often tempered by economic pressures the participants faced as landowners and as farmers in this region. While most mail-out respondents (72.7%) felt that having forested land did not compromise farm operations, it was clear that many (55.6%) felt that some cost was associated with maintaining non-productive land, including forests. Some participants felt there were disincentives for maintaining non-productive land; over half (58.0%) felt that the taxes they paid on their forested land were too high.

> *This day in farming it is impossible to consider anything other than more productive acres to meet expenses, tax increases with the loss of elevators and population. You cannot consider paying taxes on land that produces no income.* [Mail 12]

Many participants were concerned about the lack of compensation for costs associated with conservation, which some identified as a constraining issue.

> *Many farmers try and set aside a little bush land, but in these increasingly tough economic times we must use every acre possible to make ends meet.* [Mail 8]

Some respondents spoke strongly against forest cover on their land, especially when forests and native vegetation on private land might undermine their livelihood. One respondent felt that forest habitat attracts wildlife, which could pose a threat if exposed to their cattle, for example through an increased possibility of animal disease transmission.

> *I would like to think that some of my answers could be more positive in regards to wildlife and conservation. But being a livestock producer and dealing with the TB* [Bovine Tuberculosis] *situation here makes it quite difficult to provide habitat for wildlife or to even want wildlife on my land...As a livestock producer, the best scenario is no forested land... anything to discourage wildlife from coming on to my land.* [Mail 73]

Also underappreciated was that private landowners are managers of a substantial amount of land under native vegetation. Many landowners clearly feel that by maintaining forests, wetlands and streams on their land, they provide a contribution by preserving the quality of the local and regional environment.

> *There are a lot of benefits that a diverse farm like this one provides society: from wildlife, to carbon sequestration, to clean water, if you do it right. I don't mind having society pay some share in having me maintain the place to provide those benefits. ...If that money comes from the federal government, or if it comes from Ducks Unlimited... it doesn't really matter. I think it's a good idea that society in general pays for some of these societal benefits.* [Semi 8]

These contributions are consistently perceived as services and "*green benefit to society*", which extend beyond the needs and benefits of any individual farming operation. Indeed, the importance of this contribution was underappreciated during the research and development of this survey.

> *Nowhere in this questionnaire is asked what it costs us as active farmers,* [through financial] *cost or losses to our operations, to preserve natural habitat so our city dwellers come out once a year to visit it and maybe hunt all the wildlife out of it. .... After*

all we are all responsible for our wildlife and habitat. The way it is today the landowners are charged for it. [Mail 3]

Undeniably, many participants felt that monetary compensation to landowners was lacking, either through the price paid for farm products, or through land taxes paid by farmers. However, some participants also expressed the need for more awareness (from society, from other agencies) and simple recognition of the landowner's role as environmental stewards.

There's very little concern in this country for the people that produce cheap food for this nation. Only governments pushing for more intensive farming such as intensive livestock operations that produce even cheaper food and pollute our environment, our ground water and put family farms out of business. [Mail 40]

Most respondents (78.0%) felt that recognition for conservation efforts taken on private land is important, however, any acknowledgment or compensation received for stewardship activities appears to be rare.

3.6.7. Private landowners and protected areas

A number of questions investigated how the national park affected farmers on nearby private land. Overall, many participants appreciated the nearby park and its amenities, other chose to live in the area because of the park. A significant number of people (34.6%) agreed that the presence of the park impacted the management of private land. The most common impacts on private farm management, which respondents associated with the national park, involved wildlife. Waterfowl and ungulates damage crops and bales. Through damming and tree removal, beaver alter their local environment, which may result in flooding in the park and/ or on neighbouring lands. These changes may have, in turn, contributed to increased risk for the spread of bovine tuberculosis (TB) in the region.

> *When I discuss wildlife damage to my farm I am thinking primarily of beavers that have migrated out of the park. I spent $12,000 on* [name of] *Creek to stop flooding of my land. Trapping should have been allowed to continue in the park... Flooding in the park has significantly reduced habitat for whitetail deer and elk. TB has now become a major issue for ranchers around the park. As elk migrate out in search of food they come in contact with livestock. Some of theses elk are known carriers of TB. Transmitting this disease to commercial livestock becomes a problem.* [Mail 56]

Many of these impacts were perceived as damaging, for example through the loss or destruction of farm products; the loss of habitat; or other financial cost of managing problems associated with wildlife. Some thought that where wildlife populations originated in the park, the consequent responsibility of wildlife management should fall in part to the government, yet many felt that it is the farmer pays the price for park related issues.

> *Riding Mountain National Park does not seem to be taking responsibility for the damage it causes. These problems are studied, surveyed and discussed to death instead of being dealt with…Farmers' herds are destroyed if they are found to have tuberculosis. Manage the elk herd accordingly. A farmer cannot let his cattle roam free and neither should the government's elk be allowed to do so.* [Mail 20]

Increased use of resources within the park was favoured by some respondents. Many of these were resources that were once available to citizens and surrounding landowners, such as returning cattle grazing to the park (31.1%), harvesting timber (67.7%) or hay (49.6%). Nevertheless, the majority of participants (73.1%) felt that the park recreates the landscape as it may have been in the past. Relatively few people (12.2%) saw the park simply in terms of the potential productive value of its land, (Table 3.6).

> *If we destroy a natural park such as RMNP by allowing grazing, clear cutting, and fencing then future generations will not benefit from the beauty of one of the few parks that remain unscathed.* [Mail 76]

Table 3.6. The median and mean (standard error) responses regarding perceptions of the national park, among mail-out survey respondents (n).

Variable	**median**[1]	**mean**[1]	*(s.e.)*	**agree (%)**[2]	**n**
The park is a reminder of the past	6.0	5.45	*(0.10)*	73.1	374
Permit logging	6.0	5.05	*(0.11)*	67.7	375
The park improves my quality of life	6.0	5.26	*(0.10)*	64.6	377
Farmers pay a price for the park	6.0	5.23	*(0.11)*	63.2	375
Permit haying	5.0	4.34	*(0.12)*	49.6	378
Permit cattle grazing	4.0	3.85	*(0.12)*	31.1	377
The park is a waste of productive land	1.0	2.23	*(0.93)*	12.2	377

Notes:

1: 1= strongly disagree; 2= disagree; 3= slightly disagree; 4= neutral; 5= slightly agree; 6= agree 7= strongly agree. For full questions refer to Appendix B.

2: Agree (%) is based on the proportion of landowners those that chose any of the following: slightly agree, agree or strongly agree.

Overall, respondents valued their farming experience and felt knowledgeable about the environment (71.8%). There was an overwhelming sentiment (94.7%) that both government and scientific ventures (e.g. policies, research and management) should include landowner knowledge and experience. This would seem like fertile ground for co-operation and collaboration among various stakeholders, however, few local residents (20.0%) felt that park officials would take the concerns of private landowners into account.

> *I have mistrust. They say they want to hear* [from us], *but they don't. The park* [officials]*...should keep the land management at a local level, so that decisions are made locally...more grassroots.* [Interview 9]

Other respondents felt that any co-operation between locals and park officials was on the decline.

> *My attitude toward the park has become much more ambivalent than it would have been if you had done this survey 4 or 5 years ago. This is due to the creation of the TB zone and the park authorities and staff apparent lack of concern for the cattle producers in the area.* [Mail 80]

Yet, with the proper funding in place, some felt that the park might actually have a chance to address regional ecological integrity. One landowner felt that the park would simply:

> *...become another player on the landscape outside the park, trying to influence the way we treat the land. Just like Ducks Unlimited, or Habitat Heritage Corporation, providing money to help farmers do things the way they want them done.* [Semi 8]

Another participant had high hopes for cooperation among landowners and protected areas:

> *I have some concerns about the rate LP* [Louisiana Pacific] *and private land has been harvested. I believe it is just reasonable to harvest older trees but as indicated earlier, the rate is too fast. We need re-growth before continued harvesting. Being involved with* [name of a local] *Conservation District, I foresee benefits of the Conservation District as an educator and a peace maker for changes to our lifestyles.* [Mail 77]

In particular, this suggests that issues that cross the borders of public and private land, including the conflicting uses and demands on forests in this region (e.g. cattle, agriculture and forestry), would benefit from locally run organisations.

3.7. Discussion

Stewardship and habitat conservation on private farmland has enormous potential (Dempsey et al. 2002). Privately owned forested land, including those forests used for economic benefits, has important conservation value across North America (Freemark et al. 2002; Dennis 1997) and elsewhere in Central America and Europe (Jantzi et al. 1999; Hanski and Tiainen 1988). Results in this study indicate that the maintenance of native vegetation is a central priority on many private farms. This may in part reflect the intermittently marginal nature of the agricultural land in this region, relative to that further south. Indeed, one respondent said he practiced "*conservation by default*", as his forest was preserved by the high cost of improving marginal land. Nevertheless, whether by default or design, private landowners in this region are managers of a substantial amount of land under native vegetation. This has also been recognized in the US, where it has been variously estimated that private landowners account for 57-70% of the country's forested land (Jacobson 2002; Tarrant and Cordell 2002; Hardesty et al. 1993), and in Europe, where over half the forested land is privately owned (Stevens et al. 1999). Private landowners are likely to remain custodians of these habitats (Macdonald and Johnson 2000), and it is difficult to envision successful regional conservation plans that do not include their involvement and acceptance.

Forested land represented over half the native vegetation land cover in this region. Much of the privately owned native vegetation on private land, and more specifically forest, was used for the production of livestock. Management decisions are often more likely to be based on financial motivations, where there is a reliance on the land for economic livelihood (Koontz 2001). Despite their prevalent economic reliance on the land, many of those surveyed clearly felt a strong connection with nature and their environment. By maintaining forests, wetlands and streams on their property, landowners provided a significant contribution to the health of the local and regional environment. These acts of conservation are perceived by some as public services, the benefits of which extend beyond any one individual farming operation. Strong stewardship and non-monetary values regarding forested land among private landowners have been noted elsewhere in North America. Studies have highlighted that aesthetic reasons, scenic enjoyment (Hardesty et al. 1993; Erickson et al. 2001), preservation of wildlife species and habitat, and watershed protection (Erickson et al. 2001; Stevens et al. 1999) are important motivations for retaining forests among both farming and non-farming landowners. These values and motivations were also clearly expressed in the results of the current study.

The long farming history of the participants suggests that many of their families were pioneer farmers that broke and settled the land in this region. The long personal farming histories further suggest that the farmers surveyed have a great deal of experience and knowledge about farming and about their own land and the environment. Farmer knowledge and observations are vital to our understanding of agricultural environments (Corselius et al. 2003; Erickson et al. 2001), and long-time landowners have deepest insights as, through observation and experimentation, they continually adapt their management practices (Chambers 1993) in response to their local environments. The importance of these rural knowledge systems for regional conservation is only now becoming recognized (Brook and McLachlan 2005).

One important characteristic of this region is the presence of Riding Mountain National Park, and the surrounding Riding Mountain Biosphere Reserve, an organization that serves to reflect the concerns of local stakeholders in regional conservation priorities. Like most southern parks, the landscape surrounding Riding Mountain has been intensely altered by human activity (Parks Canada 1987), and thus many effectively dismiss the conservation value of land outside the park.

This attitude has, in part, contributed to an antagonistic relationship between the park and surrounding landowners. The relatively recent restriction (1969) of familiar resource uses (i.e. haying, grazing, timber harvest) in the park may have left some residual tensions. With an average age of 53 years, many among the region's current cohort of farmers would have been on the eve of taking responsibility of their own farms when livestock grazing was removed from the park. Some landowners felt that the park restricted their use of lands they had traditionally accessed for resources or recreation. Yet, the "island mentality" once held is increasingly being challenged.

Ecosystem management is becoming more widely accepted in the natural and social sciences (Eagles 2002; Octeau 1999; Lackey 1998), as well as through policy. The value of ecosystem-based management and the regional integration of conservation plans are highlighted in a recent report from the panel on ecological integrity (Parks Canada Agency 2000). In large part, this is because many of the perceived threats to parks are trans-boundary in nature (Shafer 1999; Octeau 1999), including climate change, water quality, wildlife habitats and disease. The agency recognizes that maintaining ecological integrity in existing parks is dependent upon neighbouring or connecting lands (Dempsey et al. 2002). Input from all stakeholders, including private landowners is necessarily a crucial part of this process (McNamee 2002; Parks Canada Agency 2000). These steps, long recognized but only recently more widely enacted, are the first steps towards increasing public involvement.

The Biosphere Reserve programme, conceived in 1968 by UNESCO through the Man and the Biosphere programme, is another approach that fosters co-operation between protected areas and neighbouring private landowners. The common purpose among biosphere reserves is to balance biodiversity conservation with social and economic development, while preserving cultural values (Slocombe and Dearden 2002; Canada MAB 2000). The Riding Mountain Biosphere Reserve, established in 1986, has since been involved in a number of local and national projects that have linked surrounding private lands to protected areas and national parks, including the recent Landscape Change Project, an analysis of over 200 years of land cover changes (Canada MAB 2000) in six Biosphere Reserves across Canada, with a national park or protected area at their core. Biosphere Reserves have become important and effective advocates for landowners interacting with National Parks and protected areas.

The planning and management of protected areas are ultimately a question of values (Octeau 1999; Lackey 1998), and the future success of these areas depends on the support and cooperation of local communities. An understanding of the ecosystem, and values placed on all parts of the ecosystem, makes up a large part of the effectiveness of any resource management plan (Eagles 2002). This study has shown that livestock producers and rural communities as a whole clearly have a strong conservation ethic, and recognize values of their land, including inherent and non-monetary values.

Remnant forests in agricultural landscapes, even those that are grazed by livestock, have important ecological value and contain many desirable native plant species (e.g. Chapter 2; Freemark et al. 2002; Hanski and Tiainen 1988). Rather than being perceived as a threat to conservation, the contribution that these and other landowners continue to make in agriculture-dominated landscapes should be acknowledged and encouraged (Hilty and Merenlender 2003; Curtin 2002). Promoting and maintaining working landscapes, which link sustainability and farmer stewardship, is an important part of a conservation strategy that is ultimately dependent on the knowledge base, resources and co-operation of private landowners.

4. Conclusions

4.1. Summary and Future Directions

The approach to research (perhaps 'double-edged') used in this thesis was considered in the interest of examining the phenomenon of forest grazing, among landowners living in a unique region: the 'backyard' of a National Park. By conducting ecological research with those landowners who were particularly interested (i.e. willingly volunteered!) this study has provided specific information, using scientific methodologies on the effects of a common land use within privately owned forests. By returning to a wider group of landowners (with a questionnaire), the biological questions asked were grounded in the social context of current land uses and forest values of the larger community at the time.

One of the significant findings of this research was the amount of native vegetation in this region that remains on private land. Results showed that many people had set aside (or left aside) areas on their farms that were not devoted specifically to agricultural production. The conservation of these natural areas was clearly important to the participants in this study. Values ranged from functional (e.g. erosion, water retention, livestock shelter) to aesthetic (e.g. beauty, heritage). Also notable was the composition and uses of land under native vegetation, much of which is represented by forest cover. In particular, a substantial portion of native vegetation, including forests, was used for the production of livestock (either through grazing or hay production). These findings emphasize the significance of livestock use in native vegetation habitats, including forests, in this region. Several barriers to conservation of forested habitats were found among the research participants including mistrust of various agencies or government, financial constraints or the loss of personal freedom. Yet, despite these and other pressures, the results of this study show that stewardship values underlie much of the management priorities of rural and farming landowners living in this area.

Forest conservation efforts that recommend the removal of livestock from certain habitats ignore the regional economic importance of livestock production, which engages many of the farms in this area. , and indeed that production and conservation priorities might potentially coexist. Furthermore, such recommendations are highly unlikely to be adopted by livestock producers, especially long time landowners. Livestock removal from forests denies the conservation contribution of these grazed habitats (Curtin 2002; Jones 2000). In some instances, production and conservation priorities may potentially coexist, for example, where there is a possibility that at least some species might be dependent upon grazing (McIntyre et al. 2003). Moreover, the maintenance of forested areas for livestock pasture is, in some areas, a conservation-positive alternative to forest clearing for other more intensive land uses (Hardesty et al. 1993), including development or the conversion of unimproved land to cultivation.

Although the questions asked in the mail-out survey were formed and developed in discussion with local people, they likely were restrictive to many participants. Several themes were tackled, which increased the survey's length, likely explaining the low response rate. Further iteration should be worked into similar projects, to ensure that the findings accurately captured themes that are important. Regarding demographics, a diversity of people chose to participate in this project. Nevertheless, based on the responses and comments received, most respondents were in support of conserving forests on their land. Follow-up meetings or interviews with those who had cleared their forests might better elucidate the nature of ongoing clearing in this region.

The cost that landowners pay (directly and indirectly) to maintain these areas has been generally unappreciated by society. Many participants cited taxation of non-productive areas (e.g. their native vegetation) as a barrier to implementing conservation and maintaining "wildlife habitat" on private farmland. A recent review (Tyrchniewicz et al. 1999) of policy options that might reduce deforestation due to agricultural clearing in Canada found that while limited private incentives remain to clear land, virtually no incentives are available to maintain forests or reforest land. Moreover, Louisiana Pacific Canada, a multinational timber company takes as much as 35% of its timber in this area from existing pasture land (Manitoba Agriculture and Food 2002). An in-depth analysis of policies affecting privately owned forests could be undertaken to reduce conflicts between private landowners, private industry and protected areas.

This study was not meant specifically to document locations of non-cultivated or original vegetation. While participants provided many examples of relatively undisturbed habitats, none of this information was collected systematically, much less mapped. Mapping relatively undisturbed areas within this agricultural landscape could be extremely useful tool for local conservation groups or landowners interested in cooperative agreements (Stevens et al. 1999), i.e. where neighbouring landowners enter into an agreement to preserve particular landforms, plants or wildlife on their lands, without compromising their current farming operations.

Working closely with cattle producers I measured the diversity and cover of vegetation, including native grasses and forbs, on pastures and in forests. Outcomes of this work indicate that conservation of native species is compatible with agricultural production, including cattle grazing. While grassland and forested sites were visited in the park to provide an example of prolonged rest from grazing, the privately owned sites grounded this research within the range of current and local management practices. Within this range of current practices, moderate levels of livestock grazing allowed for a high diversity of native species in forested pastures. Yet, negative impacts, such as the proliferation or persistence of certain exotic species, were observed under more intensive grazing.

There are few examples of the effects of forest grazing on northern temperate forests with which to compare the results from this study. However, recent research has explored the possibility of using cattle grazing as a management tool after forest clearing, for example, to make use of available forage (Krzic et al. 2003) or to control aspen re-growth (Fitzgerald et al. 1986). While outcomes of forest grazing have been explored in arid environments in Australia and the US (e.g. Pettit et al. 1995; Prober and Thiele 1995), it is not necessarily possible to extend results to other environments or climates. More work is needed in temperate forests comparable to those of this study region, particularly given the predominance of cattle use on these forested habitats.

Due to its relative abundance, forested land was the focus of this study. Many of the conservation initiatives in this area also focus on the conservation of remaining forest. However, the prairie habitat is perhaps the most vulnerable land type, particularly in agriculture-dominated landscapes. As of yet, there has been no effort to document tracts of native prairie that remain uncultivated in this region, or indeed throughout Canada (Hobson et al. 2002). While many prairie areas have already been converted to agriculture (ESWG 1995; Trant 1992; Trottier 1986), any information on remaining native grasslands would certainly be extremely valuable from a conservation standpoint. As with all effective regional conservation plans and initiatives, the preservation of native prairie will necessarily have to rise from landowner needs, as well as consider current local land uses without marginalizing the environment.

4.2. Reflections

There is a strong recognition in the political sphere as well as in conservation literature from the natural and social sciences that the values people hold ultimately determine conservation goals (Hull et al. 2001; Tyrchniewicz et al. 1999; Lackey 1998), and affect management decisions (Kootnz 2001; McFarlane and Boxall 2000; Octeau 1999). Conservation plans in any landscape must take into account the current interests, needs and practices of the local residents (Slocombe and Dearden 2002). Towards this end, I have attempted emphasize the importance of asking questions about the connections between the effects of cattle grazing, the conservation values of forest habitats, and the motivations behind the management of these habitats. I have found in this thesis an opportunity to provide social contexts for biological questions. This is an increasingly critical engagement as resources become scarce, depleted and in greater demand, and as multiple (and often conflicting) land uses surround protected areas.

The results of this study indicate that the values, experiences and knowledge systems of rural landowners, including farmers, could make a large contribution to regional conservation planning and decision-making. A further outcome of involving landowners in this research has been to acknowledge the importance of non-productive habitats on privately owned farm land, and the way in which these habitats are managed and valued. Hopefully, the landowners involved, through their participation, (as well as other readers of this research), may recognize the potential contribution that many rural landowners make as custodians of native vegetation habitats.

5. Literature Cited

Agee, J.K. and D.R. Johnson. 1988. Ecosystem Management for Parks and Wilderness. University of Washington, Seattle. 237pp.

Argow, K.A. 1996. This land is their land. Journal of Forestry 94: 30-33.

Ashworth, J. and K. Mrazek. 1995. "Modified Kelowna" test for available phosphorus and potassium in soil. Commun. Soil Science Plant Anal. 26: 731-739

Bailey R.H. 1968. Notes on the Vegetation of Riding Mountain National Park, Manitoba. Forest Survey No.2 Departement of Forestry and Rural Development. Forest Management Institute, Ottawa. 80pp.

Barrett G.W. and J.D. Peles. 1994. Optimizing habitat fragmentation: an agro-landscape perspective. Landscape and Urban Planning 28: 99-105.

Baskin, C.C. and J.M. Baskin. 1998. Seeds: Ecology, biogeography and evolution of dormancy and germination. Academic Press, San Diego.

Bayne, E.M. and K.A. Hobson 1998. The Effects of habitat fragmentation by forestry and agriculture on the abundance of small mammals in the southern boreal mixed-wood forest. Canadian Journal of Zoology 76: 62-69.

Belsky, A.J. and D.M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west. Conservation Biology 11: 315-327.

Bergeron, Y. and M. Dubuc. 1989. Succession in the southern part of the Canadian boreal forest. Vegetatio 79: 51-63.

Birch, T.W. 1997. Private forest landowners of the southern United States, 1994. USDA Forest Service Resource Bulletin NE-138. 195 pp.

Bird, R.D. 1961. Ecology of the aspen parkland of western Canada in relation to land use. Contribution No 27, Research Station Canada Department of Agriculture, Ottawa, Canada. 155pp.

Bliss, J.C. and A.J. Martin. 1989. Identifying NIPF management motivations with qualitative methods. Forest Science 35: 601-622.

Blood, D.A. 1966. Range relationships of elk and cattle in Riding Mountain National Park, Manitoba. Canadian Wildlife Service Wildlife Management Bulletin, Series 1, No. 19. 62 pp.

Boutin, C. and B. Jobin. 1998. Intensity of agricultural practices and effects on adjacent habitats. Ecological Applications 8: 544-557.

Boutin, S. and D. Hebert. 2002. Landscape ecology and forest management: Developing an effective partnership. Ecological Applications 12: 390-397.

Brandon, K., K.H. Redford and S.E. Sanderson. 1998. Parks in Peril: People, Politics and Protected Areas. The Nature Conservancy Island Press Washington, D.C. 519pp.

Brook, R.K. and S.M. McLachlan, 2005. Factors Influencing Farmers' Concerns Regarding Bovine Tuberculosis in Wildlife and Livestock Around Riding Mountain National Park. Journal of Environmental Management. *In press.*

Brothers, T.S. and A. Spingarn. 1992. Forest fragmentation and alien plant invasion of central Indiana old-growth forests. Conservation Biology 6: 91-100.

Cadenasso, M.L. and S.T.A. Pickett. 2001. Effect of edge structure on the flux of species into forest interiors. Conservation Biology 15: 91-97.

Canada MAB 2000. Landscape changes at Canada's Biosphere Reserves. Environment Canada. Toronto, Ontario, Canada.

Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 1994. Canadian species at risk (April). Environment Canada, Ottawa.

Caners, R. 2001. Landscape level vegetation dynamics in Riding Mountain National Park, Manitoba, Canada. M.Sc. thesis, Department of Botany, University of Manitoba, Winnipeg, MB.

Caners, R. 1999. Grasshopper Valley Grassland Restoration Project, Riding Mountain National Park, Manitoba. Department of Canadian Heritage, Parks. 95pp.

Chambers R. 1993. Methods for analysis by farmers: The professional challenge. Journal of Farming Systems Research Extension 4: 87-101.

Corselius, K.L., S.R. Simmons and C.B. Flora. 2003. Farmer perspectives on cropping systems diversification in northwestern Minnesota. Agriculture and Human Values 20: 371-383.

Cousins, S.A.O., S. Lavorel and I. Davies. 2003. Modeling the effects of landscape pattern and grazing regimes on the persistence of plant species with high conservation value in grasslands in south- eastern Sweden. Landscape Ecology 18: 315-332.

Cruikshank, J. 1998. The Social Life of Stories: Narrative and Knowledge in the Yukon Territory. UBC Press, Vancouver. 211pp.

Curtin, C.G. 2002. Livestock Grazing, Rest, and Restoration in Arid Landscapes. Conservation Biology 16: 840-842.

Dempsey, J., P. Dearden and J.G. Nelson. 2002. Stewardship: Expanding ecosystem protection. Pp 379-400. *In*: Parks and Protected Areas in Canada: Planning and Management second edition. Eds. P. Dearden and R. Rollins. Oxford University Press, Toronto.

Dennis, A. 1997. Effects of livestock grazing on forest habitats. *In:* Conservation in highly fragmented landscapes, pp313-341. Ed. M.W. Shwartz, International Thomson Publishing, New York.

Dickson, J.R. 1909. The Riding Mountain Forest Reserve. Bulletin No 6. Department of the Interior, Ottawa. 44pp.

Dillman, D.A. 2000. Mail and Internet Surveys, the tailored design method. John Wiley & Sons, Inc. New York. 464 pp.

Eagles, P.F.J. 2002. Environmental Management pp 265-294. *In*: Parks and Protected Areas in Canada: Planning and Management second edition. Eds. P. Dearden and R. Rollins. Oxford University Press, Toronto.

Ehrlich, W.A., L.E. Pratt, E.A. Poyser and F.P. LeClaire. 1958. Report of Reconnaissance Soil Survey of West-Lake Map Sheet Area. Soils Report No. 8. Manitoba Department of Agriculture and Conservation.

Ehrlich, W.A., L.E. Pratt and F.P. LeClaire. 1959. Report of Reconnaissance Soil Survey of Grandview Map Sheet Area. Soils Report No. 9. Manitoba Department of Agriculture and Conservation.

Endter-Wada, J., D. Blahna, R. Krannich and M. Brunson. 1998. A framework for understanding social science contributions to ecosystem management. Ecological Applications 8: 891-904.

Erickson, D.L., R.L Ryan and R. De Young. 2001. Woodlots in the rural landscape: landowner motivations and management attitudes in a Michigan (USA) case study. Landscape and Urban Planning 860: 1-12.

ESRI. 1999. Arcview GIS 3.2. for Windows, 1999. Redlands, CA: ESRI Inc.

Ecological Stratification Working Group. 1995. A National ecological framework for Canada. Agriculture and Agri-Food Canada. Research Branch, Centre for Land and Biological Resources Research and Environment Canada. Ottawa/Hull.

Fensham, R.J., J.E. Holman and M.J. Cox. 1999. Plant species along a grazing disturbance gradient in Australian grassland. Journal of Vegetation Science 10: 77-86.

Fitzgerald, R.D., R.J. Hudson and A.W. Bailey. 1986. Grazing preferences of cattle in regenerating aspen forest. Journal of Range Management 39:13-18.

Fitzsimmons, M. 2002. Estimated rates of deforestation in two boreal landscapes in central Saskatchewan, Canada. Canadian Journal of Forest Research 32: 843-851.

Fitzsimmons, M. 2003. Effects of deforestation and reforestation on landscape spatial structure in boreal Saskatchewan, Canada. Forest Ecology and Management 174: 577-592.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3): 629-644.

Forman, R.T.T. 1995. Land Mosaics: The Ecology of landscapes and regions. Cambridge, UK. 632.

Fraver, S. 1994. Vegetation responses along edge-to-interior gradients in the mixed hardwood forests of the Roanoke River Basin, North Carolina. Conservation Biology 8: 822-832.

Freemark, K.E., C. Boutin and K.J. Keddy. 2002. Importance of farmland habitats for conservation of plant species. Conservation Biology 16:399-412.

Gitay, H. and I.R. Nobel. 1997. Plant Functional Types: their relevance to ecosystem properties and global change. Eds T.M. Smith, H.H. Shugart and F.I. Woodward. Cambridge ; New York : Cambridge University Press. 369pp.

Gitay, H., I.R. Nobel and J.H. Connell. 1999. Deriving functional types for rain-forest trees. Journal of Vegetation Science 10: 641-650

Grumbine, R.E. 1994. What is Ecosystem Management? Conservation Biology 8:27-38.

Gurd, D.B. and T.D. Nudds. 1999. Insular biogeography of mammals in Canadian parks: A re-analysis. Journal of Biogeography 26:973-982.

Hadar, L, I. Noy-Meir and A. Perevolotsky. 1999. The effect of shrub clearing and grazing on the composition of a Mediterranean plant community: functional groups versus species. Journal of Vegetation Science 10: 673-682.

Haider, W. and L. Hunt. 2002. Visual Aesthetic Quality of Northern Ontario's Forested Shorelines. Environmental Management 29:324-334.

Hanski, I. and J. Tianen. 1988. Populations and communities in changing agro-ecosystems in Finland. Ecological Bulletins 39: 159-168.

Hardesty, L.H., J.H. Lawrence, S.J. Gill and R.C. Chapman. 1993. Private forest landowner's perceptions of forest grazing in Washington State. Journal of Range Management 46: 49-55.

Hayes, G.F. and K.D. Holl. 2003. Cattle grazing impacts on annual forbs and vegetation composition of mesic grasslands in California. Conservation Biology 17: 1694-1702.

Hester, A.J. and Hobbs, R.J. 1992. Influence of fire and soil nutrients on native and non-native annuals at remnant vegetation edges in the Western Australian wheatbelt. Journal of Vegetation Science, 3: 101-108.

Hill, M.O. 1973. Diversity and Evenness: A unifying notation and its consequences. Ecology 54: 427-432.

Hilty, J. and A.M. Merenlender. 2003. Studying Biodiversity on Private Lands. Conservation Biology 17: 132-137

Hobbs, R.J. 2001. Synergisms among habitat fragmentation, livestock grazing and biotic invasions in southwest Australia. Conservation Biology 15: 1522-1528.

Hobbs, R.J. 1993. Effects of landscape fragmentation on ecosystem processes in the Western Australian wheatbelt. Biological Conservation, 64: 193-201.

Hobbs, R.J. and L. Huenneke. 1992. Disturbance, diversity, and invasion: implications for conservation. Conservation Biology 6: 324-337

Hobson, K.A., E.M. Bayne and S.L. Van Wilgenberg. 2002. Large-scale Conversion of Forest to Agriculture in the Boreal Plains of Saskatchewan. Conservation Biology 16: 1530-1541.

Hull, R.B., D.P. Roberston and A. Kendra. 2001. Public understandings of nature: A case study of local knowledge about "natural" forest conditions. Society and Natural Resources 14: 325- 340.

Jacobson, M.G. 2002. Factors affecting private forest landowner interest in ecosystem management: linking spatial and survey data. Environmental Management 30: 577-583.

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

Jantzi, T, J. Schelhas and J.P. Lassoie. 1999. Environmental values and forest patch conservation in a rural Costa Rican community. Agriculture and Human Values 16: 29-39.

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

Jones, A. 2000. Effects of cattle grazing on North American arid ecosystems: a qualitative review. Western North American Naturalist 60: 155-164.

Keddy, P.A. and C.G. Drummond. 1996. Ecological properties for the evaluation, management, and restoration of temperate deciduous ecosystems. Ecological Applications 6(3): 748-762.

Kenkel, N.C., D.A. Derksen, A.G. Thomas and P.R. Watson. 2002. Multivariate analysis in weed science research. Weed Science 50: 281:292.

Kloppenberg, J. 1991. Social theory and the de/reconstruction o f agricultural science: Local knowledge for an alternative agriculture. Rural Sociology 56: 519-548.

Koontz, T.M. 2001. Money talks—but to whom? Financial versus nonmonetary 0motivations in land use decisions. Society and Natural Resources 14:51-65.

Kruess, A. and T. Tscharntke. 1994. Habitat fragmentation, species loss and biological control. Science, 264: 1581-1584.

Krzic, M., R.F. Newman and K. Broersma. 2003. Plant species diversity and soil quality in harvested and grazed boreal aspen stands of northeastern British Columbia. Forest Ecology and Management 182: 315-325.

Lackey, R.T. 1998. The seven pillars of ecosystem management. Landscape and Urban Planning 40: 21-30.

Landsberg, J., S. Lavorel and J. Stol. 1999. Grazing response groups among understorey plants in arid rangelands. Journal of Vegetation Science 10: 683-696.

Lavorel, S., S. McIntyre and K. Grigulis. 1999. Plant response to disturbance in a Mediterranean grassland: How many functional groups? Journal of Vegetation Science 10: 661-672.

Lavorel, S., B. Touzard, J.-D. Lebreton and B. Clement. 1998. Identifying functional groups for response to disturbance in an abandoned pasture. Acta Oecologica 19: 227-240.

Lodge, D. and K. Shrader-Frechette. 2002. Non-indigenous species: ecological explanation, environmental ethics, and public policy. Conservation Biology 17: 31-37.

Lord, J.M. and D.A. Norton. 1990. Scale and the Spatial Concept of Fragmentation. Conservation Biology 4: 197- 202.

Löve, D. 1959. The Postglacial Development of the Flora of Manitoba: A Discussion. Canadian Journal of Botany 37: 547-585.

Macdonald, D.W. and P.J. Johnson. 2000. Farmers and the custody of the countryside: trends in loss and conservation of non-productive habitats 1981-1998. Biological Conservation 94: 221-234.

MacMillan, H.R. and G.A. Gutches. 1909. Forest products of Canada, 1908. Bulletin No. 8, Canada Forestry Branch Ottawa Government Print Bureau. 18pp.

Manitoba Agriculture and Food News Release. 2002. Cattle and Trees Can Co-Exist http://www.gov.mb.ca/agriculture/research Accessed May 2003.

Manitoba Land Initiative. Manitoba Conservation. 2003. Data layers available on the internet at <http//:web2.gov.mb.ca/mli> Accessed January 2004.

Maron, M. and A. Lill. 2005. The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants. Biological Conservation 124: 439-450.

Matlack, G.R. 1994. Vegetation dynamics of the forest edge— trends in space and successional time. Journal of Ecology 82: 113-123.

McFarlane, B.L. and P.C. Boxall. 2000. Factors Influencing Forest Values and Attitudes of Two Stakeholder Groups: The Case of the Foothills Model Forest, Alberta, Canada Society and Natural Resources, 13 : 649-661.

McIntyre, S. and S. Lavorel. 1994a. How environmental and disturbance factors influence species composition in temperate Australian grasslands. Journal of Vegetation Science 5: 373-384.

McIntyre, S. and S. Lavorel. 1994b. Predicting richness of native, rare and exotic plants in response to habitat and disturbance variables across a variegated landscape. Conservation Biology 8: 521-531.

McIntyre, S., S. Lavorel, J. Landsberg and T.D.A. Forbes. 1999. Disturbance response in vegetation— towards a global perspective on functional traits. Journal of Vegetation Science 10: 621-630.

McIntyre, S., K.M. Heard and T.G. Martin. 2003. The relative importance of cattle grazing in subtropical grasslands: does it reduce or enhance plant biodiversity? Journal of Applied Ecology 40: 445-457.

McKeague, J.A. 1978. Manual on soil sampling and methods of analysis. Canadian Society of Soil Science, 2nd ed. 212pp.

McLachlan, S.M. and D.R. Bazely. 2001. Recovery patterns of understorey herbs and their use as indicators of deciduous forest regeneration. Conservation Biology 15: 98-110.

McNamee, K. 2002. From wild places to endangered spaces pp21-50 *In*: Parks and Protected Areas in Canada: Planning and Management second edition. Eds. P. Dearden and R. Rollins. Oxford University Press, Toronto.

McNaughton, S.J. 1993. Grasses and grazers, science and management. Ecological Applications 3: 17-20.

McNeeley, J.A. 1990. The Future of National Parks. Environment 32: 16-20.

Middleton, J. and G. Merriam. 1983. Distribution of Woodland Species in Farmland Woods. Journal of Applied Ecology 20: 625-644.

Milchunas, D.G., and W.K. Lauenroth. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs 63: 337-366.

Milchunas, D.G., O.E. Sala, and W.K. Lauenroth. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. The American Naturalist 132(1): 88-106

Millar, J., and A. Curtis. 1999. Challenging the boundaries of local and scientific knowledge in Australia: Opportunities for social learning in managing temperate uplands pastures. Agriculture and Human Values 16: 389-399

Moffatt S.F., S.M. McLachlan and N.C. Kenkel. 2004. Impacts of land use on riparian forests along an urban-rural gradient in southern Manitoba. Plant Ecology 174: 119-135.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons Inc. New York.

Murcia, C. 1995. Edge effects in fragmented forests: Implications for conservation. TREE 10: 58-62.

Natural Resources Canada. 2004. State of Canada's Forests. Canadian Forest Service, Ottawa.

Nelson, J.G. 2003. Linking public and private stewardship: The Sand Dunes National Monument Region, Colorado and its implications for Canada. Pp 133- 146. *In:* Protected areas and the regional planning imperative in North America eds. J.G. Nelson, J.C. Day, L.M. Sportza, J. Loucky and C. Vasquez.

Nerbonne, J.F. and R. Lentz. 2003. Rooted in Grass: Challenging patterns of knowledge exchange as a means of fostering social change in a southeast a Minnesota farm community. Agriculture and Human Values 20: 65-78.

Norton, D. 1999. Forest reserves. *In:* Maintaining biodiversity in forest ecosystems ed. M.L. Hunter Cambridge University Press. pp 525-555.

Octeau, C. 1999. Local Community Participation in the Establishment of National Parks: Planning for Cooperation. M.A. Thesis University of Calgary.

Parks Canada. 1987. Riding Mountain National Park Management Plan, Environment Canada, Ottawa.

Parks Canada. 1996. Riding Mountain National Park Management Plan. Riding Mountain National Park Round Table.

Parks Canada. 1997. Riding Mountain National Park Ecosystem Conservation Plan. Canadian Environmental Assessment Act Registry Number RMNP000017.

Parks Canada Agency. 2000. Unimpaired for Future Generations? A report from the Panel on Ecological Integrity of Canada's National Parks.

Pettit, N.E., R.H. Froend and P.G. Ladd. 1995. Grazing in remnant woodland vegetation: changes in species composition and life form groups. Journal of Vegetation Science 6: 121-130.

PFRA. The Prairie Farm Rehabilitation Administration. Classified Landsat Imagery, 1994.

Prober, S.M. and K.R. Thiele. 1995. Conservation of the grassy White Box Woodlands: relative contributions of size and disturbance to floristic composition and diversity of remnants. Australian Journal of Botany 43: 349-366.

Punter, C.E. 1998. Manitoba Conservation Data Centre Vascular Plant Species Listing (confirmed reports). Unpublished report, 55pp.

Ranney, J.W., M.C. Bruner and J.B. Levenson. 1981. The Importance of Edge in the Structure and Dynamics of Forest Islands, pp67-95. *In*: Forest Island Dynamics in

Man-Dominated Landscapes, ed. R.L. Burgess and D.M. Sharpe. Springer-Verlag, New York.

Ringstrom, E. 1981. Riding Mountain Yesterday and Today. Prairie Publishing, Winnipeg, Manitoba. 111pp.

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forest Service, Ottawa, Publication No. 1300.

Saul, J. Ralston. 1997. Reflections of a Siamese twin: Canada at the end of the twentieth century. Viking. Toronto, Canada. 546pp.

Saunders, D.A., R.J. Hobbs and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5: 18-32.

Scott, J.M., F.W. Davis, R.G. McGhie, R.G. Wright, C. Groves and J. Estes. 2001. Nature reserves: do they capture the full range of America's biological diversity? Ecological Applications 11: 999-1007.

Sharpe, D.M., G.R. Guntenspergen, C.P. Dunn, L.A. Leitner and F. Stearns. 1987. Vegetation Dynamics in a southern Wisconsin Agricultural Landscape. *In*: M. G. Turner, ed. Landscape heterogeneity and disturbance. Springer-Verlag, New York. 239 pp.

Shafer, C.L. 1999. US National Park Buffer Zones: Historical, Scientific, Social, and Legal Aspects. Environmental Management 23: 49-73.

Siggins, M. 1994. Riel: A Life of Revolution. Harper, Toronto. 507pp.

Slocombe, D.S. and P. Dearden. 2002. Protected Areas and Ecosystem-Based Management pp294-320 *In*: Parks and Protected Areas in Canada: Planning and Management second edition. Eds. P. Dearden and R. Rollins. Oxford University Press, Toronto.

Slogan, J.R. 1997. Long-term vegetation dynamics of plains rough fescue (*Festuca hallii*) grassland in Riding Mountain National Park, Manitoba. M.Sc. Thesis, University of Manitoba, Winnipeg, MB.

Smith, R.E., H. Veldhuis, G.F. Mills, R.G. Eilers, W.R. Fraser and G.W. Lelyk. 1998. Terrestrial Ecozones, Ecoregions, and Ecodistricts, An ecological Stratification of Manitoba's Natural Landscapes. Technical Bulletin 98-9E. Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada, Winnipeg, Manitoba.

Sobkowich, D. 2000. Riding Mountain Biosphere Reserve Landscape Change Study. *In:* Landscape changes at Canada's Biosphere Reserves. Canada MAB. Environment Canada. Toronto, Canada.

SPSS for Windows, Rel. 10.1.0. 2000. Chicago: SPSS Inc.

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

Stevens, T.H., D. Dennis, D. Kittredge and M. Rickenbachs. 1999 Attitudes and preference toward co-operative agreements for management of private forestlands in the North-eastern United States. Journal of Environmental Management 55:81-90

Stohlgren, T.J., L.D. Schell, and B. Vanden Heuvel. 1999. How grazing and soil quality affect native and exotic plant diversity in Rocky Mountain grasslands. Ecological Applications 9: 45-64

Tarrant, M.A. and H.K. Cordell. 2002. Amenity Values of public and private forests: Examining the value-attitude relationship. Environmental Management 30: 692-703.

ter Braak, C.J.F and P. Smilauer. 1998 CANOCO, version 4. Center for Biometry, Wageningen, The Netherlands.

Theberge, J.C. and J.B. Theberge 2002. Application of ecological concepts to the management of protected areas pp 70-96. In: Parks and Protected Areas in Canada: Planning and Management second edition. Eds. P. Dearden and R. Rollins. Oxford University Press, Toronto.

Thompson, B. 2003. Effects of Urbanization on seed dispersal in riparian forests. Masters thesis. Department of Botany, University of Manitoba. Winnipeg, Canada.

Trant, D. 1992. Land use change around Riding Mountain National Park. Discussion Paper No. 12. National Accounts and Environment Division, Statistics Canada. 18pp.

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

Trudeau, P.E. 1993. Memoirs. McClelland & Stewart Inc. Toronto, Canada. 379pp.

Turner, M.G., D.N. Wear and R.O. Flamm. 1996. Land ownership and land-cover change in the southern Appalachian highlands and the Olympic Peninsula. Ecological Applications, 6(4): 1150-1172.

Tyrchniewicz, E. R. Gray, J. Holzman and A. Tyrchniewicz. 1999. Assessing Policy Options for Reducing Deforestation Due to Agricultural Land-Clearing, A consulting report prepared for the Joint Forest Sector Table/Sinks Table International Institute for Sustainable Development IISD, Winnipeg, Canada. 41 pp.

Tyrell, J.B. 1888. Notes to accompany a preliminary map of the Duck and Riding Mountains in north-western Manitoba. Annual report, Geological Survey of Canada. Dawson Brothers, Montreal. 16 pp, map (fold.)

Villard, M.-A., M.K. Trzcinski and G. Merriam. 1999. Fragmentation on Forest Birds: Relative Influence of Woodland Cover and Configuration on Landscape Occupancy. Conservation Biology 13: 774-783.

Walker, D. J. 2002. Landscape complexity and vegetation dynamics in Riding Mountain National Park, Canada. PhD thesis, Department of Botany, University of Manitoba, Winnipeg, Manitoba. 224pp.

Weins, J.A. 1997. The Emerging Role of Patchiness in Conservation Biology. *In*: The Ecological Basis of Conservation. Eds. S.T.A. Pickett, R.S. Ostfield, M. Shachak and G.E. Likens. International Thompson Publishing, Toronto. 466pp.

Weir, J.M.H. and E.A. Johnson 1998. Effects of escaped settlement fire and logging on forest composition in the mixedwood boreal forest. Canadian journal of Forestry Research 28: 459-467.

Zar, J.H. 1999. Biostatistical Analysis 4th ed. Prentice Hall New Jersey.

Appendix A. Selected Tables

Table A.1. The mean cover ± standard error for 38 species with significant cover values, among all species occurring in ≥ three plots, in matrix habitats.

Native species	Park	None	Moderate	Heavy	f -value	p-value
Arctostaphylos uva-ursi	**1.42±0.43a**	-^{b}	0.05±0.03b	-^{b}	8.39	<0.0001
Agastache foeniculum	**1.64±0.37a**	0.08±0.06b	-^{b}	-^{b}	14.95	<0.0001
Agoseris glauca	**0.49±0.15a**	0.01±0.01b	-^{b}	-^{b}	8.36	<0.0001
Agropyron trachycaulum var *unilaterale*	**1.97±0.42a**	0.27±0.13b	0.39±0.13b	0.25±0.21b	9.91	<0.0001
Anenmone canadensis	**1.12±0.32a**	0.03±0.03b	-^{b}	-^{b}	9.65	<0.0001
Artemesia ludoviciana	**1.11±0.34a**	0.22±0.12b	0.05±0.03b	-^{b}	6.67	0.0003
Aster laevis	**3.86±0.58a**	0.18±0.09b	0.08±0.04b	0.03±0.02b	58.29	<0.0001
Bromus ciliatus	**0.99±0.20a**	0.17±0.10b	-^{b}	-^{b}	14.74	<0.0001
Campanula rotundifolia	**0.37±0.06a**	0.16±0.05b	0.12±0.04b	0.01±0.01b	11.03	<0.0001
Carex spp	**6.23±1.16a**	0.71±0.29bc	3.42±1.43b	0.09±0.04c	28.99	<0.0001
Comandra umbellata	**0.45±0.11a**	0.09±0.05b	0.03±0.02b	-^{b}	10.55	<0.0001
Elymus innovatus	**0.76±0.18a**	0.03±0.03b	0.02±0.02b	-^{b}	12.52	<0.0001
Festuca hallii	**3.29±0.93a**	-^{b}	-^{b}	-^{b}	9.95	<0.0001
Fragaria virginiana	**3.23±0.60a**	0.90±0.39b	1.73±0.32b	0.52±0.13^{b}	8.5	<0.0001
Galium boreale	**1.31±0.14a**	0.64±0.20b	0.48±0.09bc	0.12±0.05^{c}	14.67	<0.0001
Hierochloe odorata	**0.11±0.03a**	0.01±0.01^{b}	-^{b}	-^{b}	8.31	<0.0001
Lathyrus venosus	**2.67±0.41a**	**0.45±0.14ab**	0.24±0.10b	0.10±0.04^{b}	25.34	<0.0001
Lithospermum canescens	**1.43±0.30a**	0.05±0.04b	0.01±0.01^{b}	0.01±0.01^{b}	24.51	<0.0001
Monarda fistulosa	**1.70±0.53a**	0.31±0.17b	-^{b}	-^{b}	7.11	0.0002
Muhlenbergia racemosa	**0.89±0.24a**	0.03±0.03b	0.10±0.10b	-^{b}	8.5	<0.0001
Polygala senega	**0.12±0.04a**	0.01±0.01^{b}	0.01±0.01^{b}	-^{b}	6.75	0.0003
Schizachne purpuracens	**1.61±0.36a**	-^{b}	0.03±0.02b	-^{b}	25.26	<0.0001
Smilacina stellata	**0.42±0.11a**	0.17±0.07b	0.04±0.02b	-^{b}	6.77	0.0003
Solidago canadense	**3.52±0.78a**	1.66±0.62b	0.02±0.02b	-^{b}	10.14	<0.0001
Solidago rigida	**1.86±0.46a**	0.03±0.03b	-^{b}	-^{b}	17.68	<0.0001
Stachys palustris	**0.36±0.09a**	-^{b}	0.01±0.01^{b}	0.07±0.04b	9.23	<0.0001
Stellaria longifolia	**0.19±0.04a**	0.03±0.02b	0.01±0.01^{b}	0.01±0.01^{b}	15.7	<0.0001
Stipa richarsonii	**0.41±0.13a**	0.04±0.02b	-^{b}	-^{b}	7.03	0.0002
Thalictrum venulosum	**5.14±0.57a**	0.81±0.37b	0.33±0.12b	0.07±0.04b	42.49	<0.0001
Vicia americana	**0.97±0.12a**	0.35±0.13b	0.26±0.06b	0.25±0.06b	12.57	<0.0001
Medicago sativa	-^{b}	**4.44±1.576a**	0.17±0.07b	0.28±0.13^{b}	7.84	<0.0001
Phleum pratensis	0.13±0.07b	**4.96±1.85a**	0.125±0.06b	0.69±0.20b	5.43	0.0002
unknown Poaceae	-^{b}	**0.82±0.27a**	-^{b}	-^{b}	9.66	<0.0001
Viola spp	0.37±0.15b	0.08±0.03b	**0.68±0.11a**	0.08±0.05b	13.9	0.0002
Plantago major	-^{b}	0.03±0.02b	0.40±0.13b	**1.20±0.29a**	20.86	<0.0001
Potentilla norvegica	-^{b}	0.01±0.01^{b}	0.03±0.01b	**0.09±0.03a**	8.04	<0.0001
Taraxicum officinale	0.26±0.07b	2.11±0.71b	1.78±0.37b	**14.06±1.65a**	76.77	<0.0001
Poa pratensis	15.18±2.12bc	10.58±2.39c	20.03±2.87b	**41.65±2.23a**	21.12	<0.0001

Table A.2. Soil analysis results for soil nitrate-N (N), pH, percent moisture, percent organic matter (OM%), electrical conductivity (EC), phosphorus, (P), potassium (K), and sulfate-S (S) by site type for soils of forested and non-forested matrix plots.

Forest Soils

		Park	None	Moderate	Heavy
N	(ppm)	35.0	41.1	39.9	36.2
pH		6.1	6.9	6.9	6.5
moisture	(g)	77.9	69.1	69.9	74.8
OM	(%)	10.5	17.0	16.4	13.8
EC	(dS/m)	0.5	0.8	0.9	0.6
P	(ppm)	18.2	12.3	9.1	18.8
K	(ppm)	293.0	222.8	250.5	281.0
S	(ppm)	8.8	12.3	14.5	9.8

Non-forest Matrix Soils

		Park	None	Moderate	Heavy
N	(ppm)	26.6	33.7	29.2	27.1
pH		6.3	7.0	7.4	6.8
moisture	(g)	74.7	76.2	78.4	82.0
OM%	(%)	11.5	9.6	8.4	5.8
EC	(dS/m)	0.5	0.6	0.9	0.5
P	(ppm)	10.8	9.8	5.5	17.0
K	(ppm)	323.2	234.3	248.2	295.3
S	(ppm)	10.0	7.3	6.7	5.5

Table A.3. Species list

Species list for 238 vascular plants recorded from plots in seventeen sites on private land in the Riding Mountain Biosphere Reserve and within Riding Mountain National Park, collected from June through September, 2001 and 2002. Nomenclature follows Cody (1988) and Scoggan (1959). Common names are taken from Punter (1998, unpublished data).

Ferns and allies

Genus	species	common name
Botrychium	*virginianum*	Rattlesnake fern
Equisetum	*arvense*	Common horsetail
Equisetum	*pretense*	Meadow horsetail
Equisetum	*scirpoides*	Dwarf scouring-rush
Equisetum	sp.	A horse tail

Graminoids

Genus	species	common name
Agropyron	*cristatum*	Crested wheatgrass
Agropyron	*repens*	Quack grass
Agropyron	sp.	A wheatgrass
Agropyron	*trachycaulum*	Slender wheatgrass
Agropyron	*trachycaulum* var. *unilaterale*	Awned wheatgrass
Agrostis	*scabra*	Tickle grass
Agrostis	*stolonifera*	Red top
Bromus	*ciliatus*	Fringed brome
Bromus	*inermis*	Smooth brome
Bromus	sp.	A brome grass
Calamagrostis	*canadensis*	Blue joint
Calamagrostis	*inexpansa*	Northern reed grass
Carex	*assiniboinensis*	Assiniboia sedge
Carex	*atherodes*	Awned sedge
Carex	*aurea*	Golden sedge
Carex	*capillaris*	Hair-like sedge
Carex	*deweyana*	Dewey's sedge
Carex	*eburnea*	Bristle-leaved sedge
Carex	*granularis*	Granular sedge
Carex	*laeviconica*	Smooth-fruited sedge
Carex	*pellita*	Sedge
Carex	*pensylvanica*	Sun-loving sedge
Carex	*praegracilis*	Graceful sedge
Carex	*praticola*	Northern meadow sedge
Carex	*siccata*	Hay sedge
Carex	spp.	Unknown sedge species
Carex	*sprengelii*	Sprengel's sedge
Carex	*tenera*	Sedge
Carex	*torreyi*	Torrey's sedge
Carex	*utriculata*	Bottle sedge
Danthonia	*intermedia*	Poverty oats grass
Deschampsia	*caespitosa*	Tufted hair grass
Elymus	*canadensis*	Canada wild rye

Graminoids	*Cont'd*	
Genus	**species**	**common name**
Elymus	*innovatus*	Hairy wild rye
Festuca	*hallii*	Plains rough fescue
Festuca	*saximontana*	Rocky mountain fescue
Glyceria	*striata*	Fowl manna grass
Habenaria	sp.	An orchis
Helictotrichon	*hookeri*	Hooker's oat grass
Hierochloe	*odorata*	Sweet grass
Hordeum	*jubatum*	Fox-tail barley
Juncus	*balticus*	Baltic rush
Juncus	*compressus*	Flattened rush
Juncus	sp. A	A rush
Juncus	sp. B	A rush
Koeleria	*cristata*	June grass
Luzula	*pilosa*	A wood rush
Muhlenbergia	*asperfolia*	Scratch grass
Muhlenbergia	*glomerata*	Bog muhly
Muhlenbergia	*richarsonis*	Mat muhly
Oryzopsis	*asperfolia*	White-grained mountain rice grass
Phleum	*pratense*	Common timothy
Poa	*compressa*	Canada blue grass
Poa	*nemoralis*	Common blue wood grass
Poa	*pratensis*	Kentucky blue grass
Poa	sp.	A blue grass
Schizachne	*purpuracens*	Purple oat grass
Setaria	*viridis*	Green foxtail
Sporobolus	*cryptandrous*	Sand dropseed
Sporobolus	*heterolepis*	Prairie dropseed
Stipa	*richardsonii*	Richardson's needle grass
Stipa	*spartea*	Needle and thread grass
Stipa	*viridula*	Green needle grass

Forbs		
Achillea	*millefolium*	Common yarrow
Actaea	*rubra*	Red baneberry
Agastache	*foeniculum*	Giant hyssop
Agoseris	*glauca*	Large false dandelion
Agrimonia	strigosus	Agrimony
Allium	sp.	An onion
Androsace	*septentrionalis*	Pygmyflower
Anemone	*canadensis*	Canadian anemone
Anemone	*cylindrica*	Long-fruited anemone
Anemone	*multifida*	Cut-leaved anemone
Anemone	sp.	Unknown anemone
Antennaria	spp.	Everlasting
Arabis	sp.	A rock cress
Arctium	sp.	A burdock
Arenaria	sp.	A sandwort
Artemisia	*absinthium*	Absinthe

Forbs *Cont'd*

Genus	**species**	**common name**
Artemisia	*ludoviciana*	Prairie sage
Asclepias	*ovalifolia*	Dwarf milkweed
Aster	*ciliolatus*	Lindley's aster
Aster	*ericoides*	Many-flowered aster
Aster	*laevis*	Smooth aster
Aster	*lateriflorus*	Wood aster
Aster	*umbellatus*	Flat-topped white aster
Aster	sp.	An aster
Astragalus	sp.	Vetch
Brassica	sp.	a Mustard
Caltha	*palustris*	Marsh marigold
Campanula	*rotundifolia*	Harebells
Capsella	*bursa-pastoris*	Shepherd's purse
Carum	*carvi*	Wild caraway
Castilleja	*miniata*	Indian paintbrush
Cerastium	*arvense*	Field chickweed
Chenopodium	*album*	Lamb's-quarters
Chrysanthemum	*leucanthemum*	Ox-eye daisy
Cirsium	*arvense*	Canada thistle
Cirsium	*flodmanii*	Flodman's thistle
Cirsium	*vulgare*	Bull thistle
Cirsium	sp.	A thistle
Comandra	*umbellata*	Bastard toadflax
Corallorhiza	sp.	striped/ spotted coralroot
Crepis	*tectorum*	Narrow-leaved hawks-beard
Disporum	*trachycarpum*	Fairybells
Epilobium	*angustifolium*	Fireweed
Epilobium	*glandulosum*	Hairy willow-herb
Erigeron	*acris*	Northern daisy fleabane
Erigeron	*canadensis*	Canada fleabane
Erigeron	*glabellus*	Smooth fleabane
Erigeron	*lonchophyllus*	Hirsute fleabane
Erigeron	sp. A	Unknown fleabane
Erigeron	sp. B	Unknown fleabane
Erigeron	sp. C	Unknown fleabane
Fragaria	*virginiana*	Wild strawberry
Galium	*boreale*	Northern bedstraw
Galium	*triflorum*	Sweet-scented bedstraw
Gentiana	*amarella*	Felwort
Geum	*aleppicum*	Yellow avens
Geum	*triflorum*	Three-flowered avens
Halenia	*deflexa*	Spurred gentian
Hedysarum	*alpinum*	American hedysarum
Heracleum	*lanatum*	Cow parsnip
Heuchera	*richardsonii*	Hooker's oat grass
Hieraceum	*umbellatum*	Canada hawkweed
Impatiens	*capensis*	Spotted touch-me-not
Knautia	*arvensis*	Bluebuttons

Forbs	*Cont'd*	
Genus	**species**	**common name**
Lactuca	*biennis*	Tall blue lettuce
Lappula	*echinata*	Blue burr
Lathyrus	spp.	Wild peavine
Lepidium	*densiflorum*	Common pepper grass
Liatris	*ligulistylis*	meadow blazingstar
Lilium	*philadelphicum*	Wood lily
Linnaea	*borealis*	Twin flower
Lithospermum	*canescens*	Narrow-leaved puccoon
Lycopus	*asper*	Western water-horehound
Lysimachia	*ciliata*	Fringed loosestrife
Maianthemum	*canadense*	Canada mayflower
Medicago	*lupulina*	Black medick
Medicago	*sativa*	Alfalfa
Melilotus	*officinalis*	Sweet clover
Mentha	*arvensis*	Field mint
Mertensia	*paniculata*	Tall lungwort
Mitella	*nuda*	Bishop's cap
Monarda	*fistulosa*	Wild bermagot
Orthocarpus	*luteus*	Owl's clover
Osmorhiza	*longistylis*	Sweet cicely
Oxytropis	sp.	a locoweed
Petasites	*palmatus*	Palmate-leaved colt's-foot
Petasites	*sagittatus*	Arrow-leaved colt's-foot
Plantago	*major*	Common plantain
Polygala	*senega*	Seneca snakeroot
Polygonum	*convolvulus*	Black bindweed
Polygonum	sp.	A polygonum
Potentilla	*arguta*	Tall cinquefoil
Potentilla	*gracilis*	Graceful cinquefoil
Potentilla	*norvegica*	Rough cinquefoil
Potentilla	sp. A	A cinquefoil
Potentilla	sp. B	A cinquefoil
Prenanthes	*alba*	White lettuce
Ranunculus	sp.	a buttercup
Rubus	*pubescens*	Dewberry
Rudbeckia	*serotina*	Black-eyed susan
Sanicula	*marilandica*	Snakeroot
Scutellaria	*galericulata*	Skullcap
Silene	sp.	A catchfly
Sisyrinchium	*montanum*	Blue-eyed grass
Smilacina	*stellata*	Star-flowered Solomon's-seal
Solidago	*canadensis*	Canada goldenrod
Solidago	*hispida*	Hairy goldenrod
Solidago	*missouriensis*	Low goldenrod
Solidago	*rigida*	Stiff goldenrod
Solidago	*spathulata*	Mountain goldenrod
Solidago	sp. rough	A goldenrod
Solidago	spp.	A goldenrod

Forbs Genus	*Cont'd* **species**	**common name**
Sonchus	*arvensis*	Sow-thistle
Stachys	*palustris*	Woundwort
Stellaria	*media*	Common chickweed
Stellaria	sp.	A Stichwort
Taraxacum	*officinale*	Common dandelion
Thalictrum	*dasycarpum*	Tall meadow-rue
Thalictrum	*venulosum*	Veiny meadow-rue
Trifolium	*hybridum*	Alsike clover
Trifolium	*pratense*	Red clover
Trifolium	*repens*	White clover
Urtica	*dioica*	Stinging nettle
Vicia	*americana*	Common vetch
Viola	*rugulosa*	Canada violet
Viola	sp.	A violet
Zizia	*aptera*	Heart-leaved alexander
Zizia	*aurea*	Golden alexander
Zygadenus	*elegans*	White camas

Woody species		
Abies	*balsamea*	Balsam fir
Acer	*negundo*	Manitoba maple
Alnus	*incana* ssp. *rugosa*	Speckled alder
Amelanchier	*alnifolia*	Saskatoon
Apocynum	*androsaemifolium*	Spreading dogbane
Aralia	*nudicaulis*	Wild sarrsaparilla
Arctostaphylos	*uva-ursi*	Bearberry
Betula	*pumila*	Swamp birch
Betula	*papyrifera*	White birch
Cornus	*canadensis*	Canadian bunchberry
Cornus	*stolonifera*	Red-osier dogwood
Corylus	*cornuta*	Beaked hazelnut
Crataegus	*chrysocarpa*	Round-leaved hawthorne
Fraxinus	*pennsylvanica*	Green ash
Lonicera	*dioica*	Twinning honeysuckle
Picea	*glauca*	White spruce
Populus	*balsamifera*	Balsam poplar
Populus	*tremuloides*	Trembling aspen
Potentilla	*fruticosa*	Shrubby cinquefoil
Prunus	*pensylvanica*	Pincherry
Prunus	*virginiana*	Choke cherry
Pyrola	*asarifolia*	Pink pyrola
Pyrola	*secunda*	One-sided pyrola
Quercus	*macrocarpa*	Bur oak
Rhamnus	*alnifolia*	Alder-leaved buckthorn
Ribes	*americanum*	Wild black currant
Ribes	*oxyacanthoides*	Northern gooseberry
Ribes	*triste*	Wild red currant
Rosa	*acicularis*	Prickly rose

Woody species	*Cont'd*	
Genus	**species**	**common name**
Rosa	*woodsii*	Wood's rose
Rubus	*idaeus* var. *strigosus*	Wild red raspberry
Salix	*bebbiana*	Beaked willow
Salix	*lucida*	Shining willow
Salix	*petiolaris*	Basket willow
Salix	*pseudomonticola*	Mountain willow
Salix	*sp.*	Willow sp.
Shepherdia	*canadensis*	Canada soapberry
Spiraea	*alba*	Meadowsweet
Symphoricarpos	*occidentalis*	Western snowberry
Viburnum	*edule*	Mooseberry
Viburnum	*opulus*	High-bush cranberry

Appendix B. Mail-out Questionnaire

Section I. Values and Attitudes

1. Forests mean different things to different people. To what extent do you agree or disagree with each of the following perceptions about forests (bush) <u>in your area</u>?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

Forested land in my local area . . .	-3	-2	-1	0	+1	+2	+3	dk/na
is a source of beauty	O	O	O	O	O	O	O	O
helps provide clean air	O	O	O	O	O	O	O	O
is part of the natural agro-ecosystem	O	O	O	O	O	O	O	O
is a fire hazard	O	O	O	O	O	O	O	O
improves peoples' well-being	O	O	O	O	O	O	O	O
takes up productive land	O	O	O	O	O	O	O	O
controls soil erosion	O	O	O	O	O	O	O	O
is in decline	O	O	O	O	O	O	O	O
helps provide clean water	O	O	O	O	O	O	O	O
provides a source of income	O	O	O	O	O	O	O	O

2. Which of the following activities would you consider allowing on your land?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

To what extent would you allow...	-3	-2	-1	0	+1	+2	+3	dk/na
Hunting	O	O	O	O	O	O	O	O
Trapping	O	O	O	O	O	O	O	O
Gravel pits	O	O	O	O	O	O	O	O
Timber harvest	O	O	O	O	O	O	O	O
Cross-country skiing/ hiking	O	O	O	O	O	O	O	O
Off-road vehicle riding	O	O	O	O	O	O	O	O
Wildlife viewing	O	O	O	O	O	O	O	O
Seed collecting	O	O	O	O	O	O	O	O

3. The amount of forest cover across the region has declined since 30 years ago. <u>In the last five years,</u> do you agree or disagree with each of the following as possible causes of forest decline in <u>your local area</u>? *Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.*

Forest decline in my local area is caused by:	-3	-2	-1	0	+1	+2	+3	dk/na
Commercial clear cutting	O	O	O	O	O	O	O	O
Climate change	O	O	O	O	O	O	O	O
Development	O	O	O	O	O	O	O	O
Insects/ Disease	O	O	O	O	O	O	O	O
Firewood collection by individual landowners	O	O	O	O	O	O	O	O
Flooding	O	O	O	O	O	O	O	O
Livestock overgrazing	O	O	O	O	O	O	O	O
Livestock grazing	O	O	O	O	O	O	O	O
Selective logging by individual landowners	O	O	O	O	O	O	O	O
Lack of forest management by individual landowners	O	O	O	O	O	O	O	O
Road construction	O	O	O	O	O	O	O	O
Other____________________	O	O	O	O	O	O	O	O

4. This question involves your attitudes towards bush cover (forests) <u>on or near</u> your own land. To what extent do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
All my land is under production	O	O	O	O	O	O	O	O
I enjoy seeing wildlife on my land	O	O	O	O	O	O	O	O
Forests on/ near my land are healthy	O	O	O	O	O	O	O	O
Forests on/ near my land are poorer quality than 30 years ago	O	O	O	O	O	O	O	O
Forests on/ near my land are best left untouched	O	O	O	O	O	O	O	O
Forests on/ near my land should be converted to crop land	O	O	O	O	O	O	O	O
Forests on/ near my land should be turned to cattle production	O	O	O	O	O	O	O	O
Wildlife damage on my land is a serious problem	O	O	O	O	O	O	O	O
I have less bush on my land than I did 5 years ago	O	O	O	O	O	O	O	O

25943

5. This question involves your attitudes towards bush cover (forests) in your local area. To what extent do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
I enjoy seeing wildlife in my local area	○	○	○	○	○	○	○	○
Forests in my local area are healthy	○	○	○	○	○	○	○	○
Forest clearing is an event of the past	○	○	○	○	○	○	○	○
Forests in my local area are poorer quality vs. 30 years ago	○	○	○	○	○	○	○	○
Forests in my local area are best left untouched	○	○	○	○	○	○	○	○
Forests in my local area should be converted to crop land	○	○	○	○	○	○	○	○
Forests in my local area should be turned to cattle production	○	○	○	○	○	○	○	○
Wildlife damage is a serious problem for farmers in my area	○	○	○	○	○	○	○	○
Locally, there is less bush land than 5 years ago	○	○	○	○	○	○	○	○

Section II. Land Management

6. To what extent do you agree or disagree with each of the following statements concerning your land?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

Over the next five years I intend to:	-3	-2	-1	0	+1	+2	+3	dk/na
Carry on with my current management style	○	○	○	○	○	○	○	○
Plant shelterbelts	○	○	○	○	○	○	○	○
Plant trees	○	○	○	○	○	○	○	○
Clear some land	○	○	○	○	○	○	○	○
Allow some land to 'go back' to natural	○	○	○	○	○	○	○	○
Drain some land	○	○	○	○	○	○	○	○
Fence some land	○	○	○	○	○	○	○	○
Other________________________________	○	○	○	○	○	○	○	○

7. This question involves your perceptions of cattle grazing in your local area. To what extent do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Cattle need access to bush pasture	○	○	○	○	○	○	○	○
Rotational grazing is common in my local area	○	○	○	○	○	○	○	○
All bush is suitable for cattle grazing	○	○	○	○	○	○	○	○
Light grazing is beneficial to the bush	○	○	○	○	○	○	○	○
Heavy cattle grazing is beneficial to the bush	○	○	○	○	○	○	○	○
Wildlife benefit from some types of pasture management	○	○	○	○	○	○	○	○

8. Please indicate how many acres you managed last year in each of the following types of land use. Please include all land whether owned, rented from another landowner or managed with another owner.

	Acres		Acres
Cropped Land		Natural land Pasture	
Hay land (seeded)		Mixed bush pasture	
Native hay		Wetland (slough)	
Seeded pasture		Bush	
		Other________________	

25943

9. Last year, what proportion of your total household income came from each of the following farm and nonfarm operations? Please list as a percent of total income.

Crops	%		Crop Types
Hay sales	%		
Cattle production	%		
Other livestock	%		Livestock Types
Wood sale	%		
Fruit or vegetable produce	%		Produce Types
Off-farm income	%		Employment Types
Other	%		Other Income

10. Are there any forests on your land?

○ No. If NO, SKIP to question **12**

○ Yes. If YES, proceed to next question.

11. If yes to above: Please indicate the extent to which you agree or disagree with the following statements. *Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.*

I leave some bush up on my land...	-3	-2	-1	0	+1	+2	+3	dk/na
for recreational purposes	○	○	○	○	○	○	○	○
for future generations	○	○	○	○	○	○	○	○
because I manage my land for wildlife	○	○	○	○	○	○	○	○
because I manage for timber production	○	○	○	○	○	○	○	○
because I can't access the timber	○	○	○	○	○	○	○	○
because there is no good timber on my land	○	○	○	○	○	○	○	○
because I have no time/ money to clear	○	○	○	○	○	○	○	○
for conservation reasons	○	○	○	○	○	○	○	○
because trees require little care	○	○	○	○	○	○	○	○
Other________________	○	○	○	○	○	○	○	○

12. This question involves your perceptions of farm management and forest cover. To what extent do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Having bush cover on my land hinders my ability to farm	○	○	○	○	○	○	○	○
I would consider a conservation agreement on my land	○	○	○	○	○	○	○	○
I leave some uncultivated 'natural' areas on my farm	○	○	○	○	○	○	○	○
Bush on my land connects to bush on neighbouring land	○	○	○	○	○	○	○	○

13. Which of the following resource groups would you consult for information about forest management? *Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.*

	-3	-2	-1	0	+1	+2	+3	dk/na
Community groups	○	○	○	○	○	○	○	○
Environmental groups	○	○	○	○	○	○	○	○
Governmental agencies	○	○	○	○	○	○	○	○
Industry /companies	○	○	○	○	○	○	○	○
Publications	○	○	○	○	○	○	○	○
Researchers	○	○	○	○	○	○	○	○
Neighbours	○	○	○	○	○	○	○	○
Self & Family	○	○	○	○	○	○	○	○
Other________________	○	○	○	○	○	○	○	○

25943

14. In some instances, having forests on your land may represent a cost to farmers and farm operations. To what extent do you consider each of the following as costs associated with forest cover?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Seed planting is delayed	O	O	O	O	O	O	O	O
Snow melt is delayed	O	O	O	O	O	O	O	O
Trees are susceptible to disease	O	O	O	O	O	O	O	O
Forests are a fire hazard	O	O	O	O	O	O	O	O
Forests look messy	O	O	O	O	O	O	O	O
Weed increase on property	O	O	O	O	O	O	O	O
Forests harbor insect pests	O	O	O	O	O	O	O	O
Forested land reduces crop yields	O	O	O	O	O	O	O	O
Tax on forested land is high	O	O	O	O	O	O	O	O
Problem wildlife from forests	O	O	O	O	O	O	O	O
I don't like non-productive land	O	O	O	O	O	O	O	O
Other____________________	O	O	O	O	O	O	O	O

15. To what extent do you agree or disagree with the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

In the past, the trees on my land were:	-3	-2	-1	0	+1	+2	+3	dk/na
cleared to make way for buildings	O	O	O	O	O	O	O	O
cleared commercially by a forestry company	O	O	O	O	O	O	O	O
cleared to make cropland	O	O	O	O	O	O	O	O
cleared to make pasture	O	O	O	O	O	O	O	O
cleared because trees killed by flooding	O	O	O	O	O	O	O	O
cleared because trees killed by fire	O	O	O	O	O	O	O	O
cleared by the previous generation or landowner	O	O	O	O	O	O	O	O
Other____________________	O	O	O	O	O	O	O	O

Section III. Living near the Park

16. This section involves your perceptions of living and farming in the Riding/ Duck Mountain region. To what extent do you agree/ disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
My quality of life is improved because I live near the park	O	O	O	O	O	O	O	O
In general, I benefit from the proximity of parks to my farm	O	O	O	O	O	O	O	O
Park policies influence my farming practices	O	O	O	O	O	O	O	O
The park officials take into account farmers' concerns	O	O	O	O	O	O	O	O
Farmers pay a price for the existence of the park	O	O	O	O	O	O	O	O
Cattle grazing should be returned to the park	O	O	O	O	O	O	O	O
The park should be fenced to protect local livestock	O	O	O	O	O	O	O	O
Selective logging should be allowed in the park	O	O	O	O	O	O	O	O
Haying should be allowed in the park	O	O	O	O	O	O	O	O
The park is a reminder of what the land used to be	O	O	O	O	O	O	O	O
The park is a waste of good production land	O	O	O	O	O	O	O	O

Section IV. Stewardship

17. For how many generations (in years) has your family been farming?

[ ][ ][ ] Years

18. How long has this land been in your family?

[ ][ ][ ] Years

19. How long has management of this land been your responsibility?

[ ][ ][ ] Years

25943

20. This question relates to future management on your farm. To what extent do you agree or disagree with each following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
I am currently considering the sale of my farm	O	O	O	O	O	O	O	O
My children will take over the farm when I retire	O	O	O	O	O	O	O	O
Other relatives will take over the farm when I retire	O	O	O	O	O	O	O	O

21. When you make management decisions on your land, to what extent do you consider each of the following?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

I take into account:	-3	-2	-1	0	+1	+2	+3	dk/na
Impacts my decisions may have on my neighbours	O	O	O	O	O	O	O	O
Impacts my decisions may have on wildlife	O	O	O	O	O	O	O	O
Impacts my decisions will have on water quality	O	O	O	O	O	O	O	O
Impacts my decisions will have on soil quality	O	O	O	O	O	O	O	O
Impacts my decisions have for the next generation	O	O	O	O	O	O	O	O
Impacts my decisions will have on next year's production	O	O	O	O	O	O	O	O
Impacts on my farm production over the next 5 years	O	O	O	O	O	O	O	O

22. Which of the following groups would you be most willing to consult for information on land stewardship?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Community groups	O	O	O	O	O	O	O	O
Environmental groups	O	O	O	O	O	O	O	O
Government agencies	O	O	O	O	O	O	O	O
Industry /companies	O	O	O	O	O	O	O	O
Publications	O	O	O	O	O	O	O	O
Neighbours	O	O	O	O	O	O	O	O
Self & family	O	O	O	O	O	O	O	O
Other__________	O	O	O	O	O	O	O	O

23. Which of the following would you consider to be acceptable acknowledgment for outstanding conservation management strategies you implement on your land?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Public recognition (e.g. sign on my land)	O	O	O	O	O	O	O	O
A token payment	O	O	O	O	O	O	O	O
Tax break on my land	O	O	O	O	O	O	O	O
Full payment for each acre out of production	O	O	O	O	O	O	O	O
I don't want any recognition	O	O	O	O	O	O	O	O
Recognition for conservation is important	O	O	O	O	O	O	O	O
I do not manage my land for wildlife	O	O	O	O	O	O	O	O
Other__________	O	O	O	O	O	O	O	O

24. This question involves monetary compensation for forested land. To what extent would you consider the following offers for your forested land?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
An offer of dollars for cords of wood by a timber company	O	O	O	O	O	O	O	O
An offer of dollars for acres by a conservation organization	O	O	O	O	O	O	O	O
Purchase of my land by a conservation organization	O	O	O	O	O	O	O	O
Purchase of my land by a timber company	O	O	O	O	O	O	O	O
I am not interested in receiving any offers	O	O	O	O	O	O	O	O
I am actively considering a conservation agreement	O	O	O	O	O	O	O	O
I am actively considering a timber agreement to clear trees	O	O	O	O	O	O	O	O

25. This question involves possible barriers to conservation on your own land. To what extent to do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

The following are barriers to conservation on my land:	-3	-2	-1	0	+1	+2	+3	dk/na
I don't have enough time	O	O	O	O	O	O	O	O
Costs too much money	O	O	O	O	O	O	O	O
I am already doing all I can for conservation on my own land	O	O	O	O	O	O	O	O
I don't have the info I need to make conservation changes	O	O	O	O	O	O	O	O
I'm not interested in increasing conservation on my own land	O	O	O	O	O	O	O	O
I need all my land for production	O	O	O	O	O	O	O	O
I have no natural areas on my farm to conserve	O	O	O	O	O	O	O	O
I'm concerned that increased conservation will devalue my land	O	O	O	O	O	O	O	O
Other____________________	O	O	O	O	O	O	O	O

26. The next question concerns knowledge about the environment. To what extent do you agree or disagree with each of the following statements?
Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.

	-3	-2	-1	0	+1	+2	+3	dk/na
Landowners are knowledgeable about the environment	O	O	O	O	O	O	O	O
The government is knowledgeable about the environment	O	O	O	O	O	O	O	O
Researchers are knowledgeable about the environment	O	O	O	O	O	O	O	O
Government policies should include landowner experience	O	O	O	O	O	O	O	O
Scientific findings should include landowner experience	O	O	O	O	O	O	O	O
Experience is equally important as education	O	O	O	O	O	O	O	O

Section V. Personal Information

We realize that some of this personal information may be sensitive. By filling out this optional section, you are helping us to assure that views collected in this research are representative of farmers in your community and across your region.

27. Do you feel you were able to convey your thoughts about Land Use and Stewardship through this survey? *Responses: strongly disagree= -3; neutral= 0; strongly agree= +3; dk/na = don't know/ not applicable.*

-3	-2	-1	0	+1	+2	+3	dk
O	O	O	O	O	O	O	O

28. In what year were you born? ☐☐☐☐

29. Are you: O Male O Female

30. In which RM do you live?

O Clanwilliam O McCreary O Rosedale O Shellmouth-Boulton
O Grandview O Ochre River O Rossburn O Silver Creek
O Langford O Park South O Russell O Other ________

31. What is your legal land description?

☐☐ (Section) ☐☐ (Twp) ☐☐ (Range)

32. What is your highest level of schooling?

O Some grade school O Finished technical schooling
O Finished high school O Finished university
O Finished college O Graduate level university

33. For statistical purposes, what was your total gross household income before taxes for last year?

O Under $15,000 O $75,001 to $90,000
O $15,001 to $30,000 O $90,001 to $105,000
O $30,001 to $45,000 O More than to $105,001
O $45,001 to $60,000 O Choose not to reply
O $60,001 to $75,000

34. Are you willing to take part in / or receive info on further aspects of this study?

Yes, okay to contact me O If yes, please include mailing address on next page

No, please do not contact me O

25943