ENVIRONMENTAL INDICATORS FOR SUSTAINABLE BEEF CATTLE/FORAGE PRODUCTION: CASE STUDY FOR THE SOUTH INTERLAKE REGION OF MANITOBA

By

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A Practicum
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Environmental Indicators for Sustainable Beef Cattle/Forage Production: Case Study for the South Interlake Region of Manitoba

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Abstract

Agricultural production across western Canada has been shaped by governmental and non-governmental policies. In some instances, agricultural production has led to certain environmental concerns, including soil erosion. There is a need and demand for agricultural practices in Canada, such as the mixed agriculture practice of beef cattle/forage production, to be conducted in an environmentally sustainable manner to provide a continuous food supply and minimize any impacts on the environment.

The federal government and the province of Manitoba are incorporating sustainable development and subsets of sustainable development, including sustainable agriculture, into its political mandates. To monitor progress towards either sustainable development or agriculture, sustainability indicators are required. A subset of sustainability indicators includes environmental indicators. Environmental indicators are tools that can be used to monitor progress towards environmental sustainability.

Beef cattle/forage production occurs throughout the Interlake region of Manitoba, including Statistics Canada Manitoba Agriculture division No. 14 comprising of the Rural Municipalities of Rockwood, Rosser and Woodlands. Breeds of beef cattle in this division include pure British breeds such as Hereford, cross-breds of British breeds as well as British/exotics such as Limousin. Varieties of forage crops grown include alfalfa.

The goal of this project has been to determine if it is feasible to use environmental indicators for a specific agriculture practice, beef cattle/forage production. This was accomplished by identifying the environmental issues for this agriculture practice, reviewing available environmental indicators from various literature sources and compiling a list of environmental

indicators for the agricultural practice. Data sets were located and researched to determine which could be used for the environmental indicators. Data sets were found for only three environmental indicators in the list. Any other available data sets located were not specific enough to be used for environmental indicators for beef cattle/forage production. The data were collected on a land area basis, not a land development basis. As a result of the extremely low of number of environmental indicators with data sets, it is recommended that environmental indicators cannot be used to determine environmental sustainability of the beef cattle/forage production.

Acknowledgements

I would like to thank members of my Committee, Dr. Clay Gilson, Mr. Allen Tyrchniewicz and Mr. Lorne Colpitts for the time and contribution they made and especially for all their invaluable input contributed to this praticum. I am indebted to you all. I am especially forever indebted to my advisor, Dr. Richard Baydack, for all of his time, advice, suggestions, contributions, guidance and invaluable input given to complete this practicum. Thank you Dr. Baydack for keeping me on the right path. I also thank Professor Slobodan Simonovic for all of his advice and support given to this Natural Resources Institute student and especially for being my advisor during Dr. Baydack's sabbatical. As well, I want to thank the Natural Resources Institute for providing financial support during the course of this degree.

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Chapter One: Introduction

1.1 Preamble

The western Canada land base in the last century has been converted from natural habitats to agricultural production. Agricultural practices in the prairie region have been shaped by policies that inadvertently led to environmental problems, such as soil erosion as well as the continuing decline of the productivity of the land. There is a need for agricultural practices, such as the mixed agriculture practice of beef cattle/forage production, to be conducted in an environmentally sustainable manner to minimize environmental problems and provide a stable food supply. A set of environmental indicators will be needed to assess if an agricultural practice, such as beef cattle/forage production, is being performed in an environmentally sustainable manner in any region, such as the Statistics Canada Manitoba Agriculture division No. 14, consisting of the Rural Municipalities of Rockwood, Rosser and Woodlands in the Interlake region of Manitoba.

1.2 Background

Agricultural development in western Canada has been influenced by current and past policies of government and non-government organizations (Girt 1990; Horner et al. 1980; Tyrchniewicz & Wilson 1994; Baydack et al. 1995; Wilson & Tyrchniewicz 1995; Winfield 1995) (Figure 1). Canadian agricultural policy has evolved over the years in response to the demands of farmers, agri-business interests, consumers and elements in the non-agricultural sectors wanting to use agriculture as a means to their own ends (Crown & Heady 1972). As a result of Canadian agricultural policies, crop specialization and monoculture practices have increased (Horner et al. 1980; Girt 1990; Winfield 1995; Canada, Agriculture and Agri-Food Canada 1997a; Government of Canada 1996). For instance, in 1961, 2.914 million acres of wheat were harvested in Manitoba while in 1990, 5.45 million acres of wheat were harvested (Manitoba Agriculture 1998). Some of the agricultural practices have led to a variety of environmental problems including soil erosion, soil organic matter loss and habitat loss (Bird 1986; Girt 1990; Government of Canada 1996).

Since the Brundtland Report in 1987, sustainable development has been the catch-phrase. Sustainable development is development that meets the needs of the present without comprising the ability of future generations to meet their own needs (WCED 1987). It consists of three key

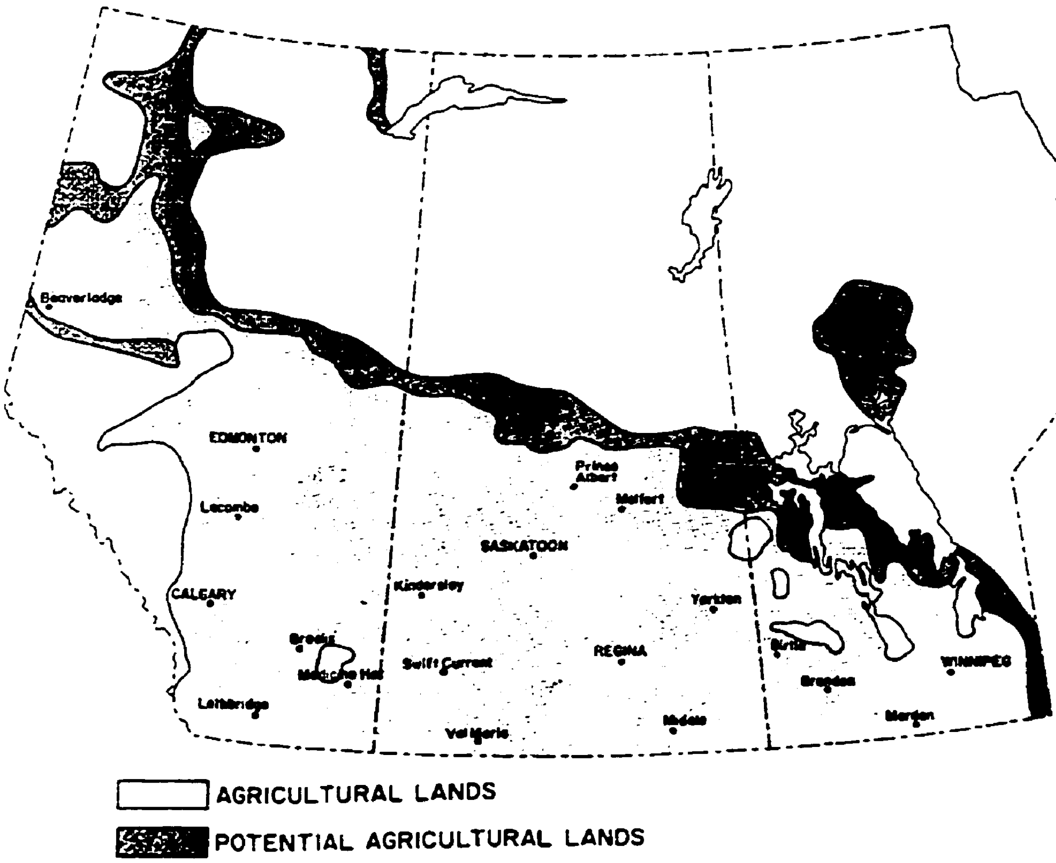

Figure 1. Agricultural development in Western Canada (Faculty of Agricultural and Food Sciences, University of Manitoba 1994).

dimensions: environmental, economic and social (WCED 1987; Bregha 1993; Morita et al. 1993; Ekins 1994; SARD 1994; Herdt & Steiner 1995; Reid and Dower 1997; Canada, Agriculture & Agri-Food Canada 1997a). Various countries, including Canada, have been implementing sustainable development strategies and subsets of sustainable development into their political mandates. One subset of sustainable development is sustainable agriculture.

The Federal-Provincial Agriculture Committee on Environmental Sustainability defines sustainable agriculture as those agri-food systems that are economically viable and meet society's need for safe and nutritious food, conserving or enhancing Canada's natural resources and the quality of the environment for future generations (Canada, Government of Canada 1990; Government of Canada 1991; Science Council of Canada 1992; Wilson & Tyrchniewicz 1995). The federal government of Canada is incorporating subsets of sustainable development, such as sustainable agriculture, into political mandates resulting from agreements of the Earth Summit Conference in 1992 (Carroll-Foster 1993; United Nations Conference on Environment and Development 1993). This incorporation of sustainable agriculture could minimize environmental problems resulting from agricultural practices and make agricultural practices more environmentally friendly. However, sustainability indicators are required to assess if agricultural practices are conducted in an environmentally sustainable manner.

An indicator can be defined as a parameter, or a value derived from parameters, developed for a specific purpose to provide information about a phenomenon (OECD 1994). Sustainability indicators can take the form of quantitative or qualitative variables that are measured or described conditions or observed periodically to demonstrate trends in that variable or both (Opschoor & Reijnders 1991; Duffield 1995; Milon & Shogren 1995; Hardi et al. 1997).

Theoretically, sustainability indicators include components of ecological productivity and assimilative capacity, entitlement to means of production (land), political and social organizations and social services and access to basic needs; thus, implying that sustainability indicators reflect environmental, economic and social dimensions (Opschoor & Reijnders 1991; OECD 1994; Duffield 1995; OECD 1997). Sustainability indicators can be used to monitor changes in the factors underlying people's livelihoods, to signal the need for new resource management practices and to monitor the effects of old and new management policies (Verbruggen & Kuik 1991; Duffield 1995; Hardi et al. 1997).

Sustainability indicators have been developed for certain issues or concerns such as sustainable development (Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993; ARTEE 1994; McRae & Lombardi 1994; McRae et al. 1995a; McRae et al. 1995b; Mitchell 1996; Hardi et al. 1997; IISD et al. 1997; Manitoba Environment 1997; Lautenschlager 1998; Neave & Neave 1998). However, these indicators have not been tested to determine if a particular sector of development in Canada such as the sustainability of an agricultural practice can be measured.

The Interlake region of Manitoba is a matrix of aspen parkland, mixed grasslands and shallow, unproductive wetlands (Neill 1990 **IN** Murkin et al. 1991). The Interlake region contains soils that are stony, have high lime conditions and are phosphorus deficient (Ellis 1938 **IN** Armitage 1990). Due to these conditions, the soils are best suited for growing forage crops (Armitage 1990). The Interlake region is a district of livestock production based on perennial forage crops and farmers have been encouraged to adopt farm systems involving livestock production, particularly beef cattle production based on forage crops (Richtik 1964; Marquardt 1971; Armitage 1990).

Beef cattle production was the first agriculture practice to be performed in large areas of western Canada (Horner et al 1980). Beef cattle are ruminant animals, capable of digesting fibrous material that cannot be used directly by humans and converting the material into high protein food suitable for human consumption (Canada's Beef Cattle Producers 1993). Beef cattle graze on land unsuitable for production of certain crops such as grain or land that is part of an integrated cropping system (Canada's Beef Cattle Producers 1993) such as forage.

Forages are plants grown primarily for livestock feed as whole plants and may be harvested by the grazing animal or may be mechanically harvested as hay, silage or green feed (Howarth & Goplen 1987). Forage crops include a wide array of plant species such as annual and perennial grasses and legumes found in natural grasslands and parkland meadows (Armitage 1990; Howarth & Goplen 1987). Examples of forages include alfalfa, smooth bromegrass and timothy (Marquardt 1971; Gross 1975; Johnson 1978; Smoliak & Wilson 1983 Armitage 1990; Beacom 1991; Canada, Agriculture and Agri-Food Canada 1997b). Forage crops are grown for their benefits in crop rotations, for seed and as feed for animals (Marquardt 1971; Armitage 1990; Manitoba Environment 1993; Canada, Agriculture and Agri-Food Canada 1997b). Forages are able to grow and produce abundantly under low winter temperatures and short growing seasons (Nickel & Pringle 1983) which are prime conditions in the Interlake region (Armitage 1990).

1.3 Issue

Past and present agricultural policies have resulted in some agricultural practices in Canada not being conducted in a sustainable manner. Sustainable development and sustainable agriculture have been incorporated into the political mandates of both federal and provincial governments, including Manitoba. Sustainable development indicators, including environmental indicators, have been developed by various organizations as a method to measure and assess progress towards sustainable development and sustainable agriculture. However, environmental indicators have been used at either a national, city or ecozone level. They also have been used to measure environmental sustainability of Canadian agriculture, but they have not been used to determine if a particular agricultural practice, such as beet cattle/forage operations, is being performed in a sustainable manner in a certain area.

1.4 Purpose

The purpose of this project was to identify, select and evaluate appropriate environmental indicators for the agricultural practice of beef cattle/forge production. Selected indicators were tested to determine whether or not environmental indicators are applicable to a specific agricultural practice. Beef cattle/forage production was the agricultural practice considered in this study. This practice was in the Statistics Canada Manitoba Agricultural division No. 14 comprising the Rural Municipalities (RMs) of Rockwood, Rosser and Woodlands in the Interlake region of Manitoba (Figure 2).

1.5 Objectives

The objectives of this practicum are as follows:

1) to review the concept of sustainable development and possible indicators which have been identified for the environmental dimension of sustainable development,
2) to investigate application of these indicators for beef cattle/forage production in the Statistics Canada Manitoba Agricultural division No. 14 in the Interlake region of Manitoba and,
3) to recommend an approach based on environmental sustainability indicators in assessing beef cattle/forage production.

1.6 Scope

The scope of this project focuses on sustainability indicators developed for the environmental dimension of sustainable development. For sustainability to occur on a social and economic basis, three environmental criteria are required:

1) The consumption of renewable natural resources cannot surpass their rate of regeneration or replenishment:
2) The consumption of non-renewable natural resources cannot surpass the rate of substitution of these resources and;

3) The release of any matter (such as waste material) and energy cannot surpass the ability of the environment to assimilate this release (Faeth 1997; Government of the Federal Republic of Germany 1997).

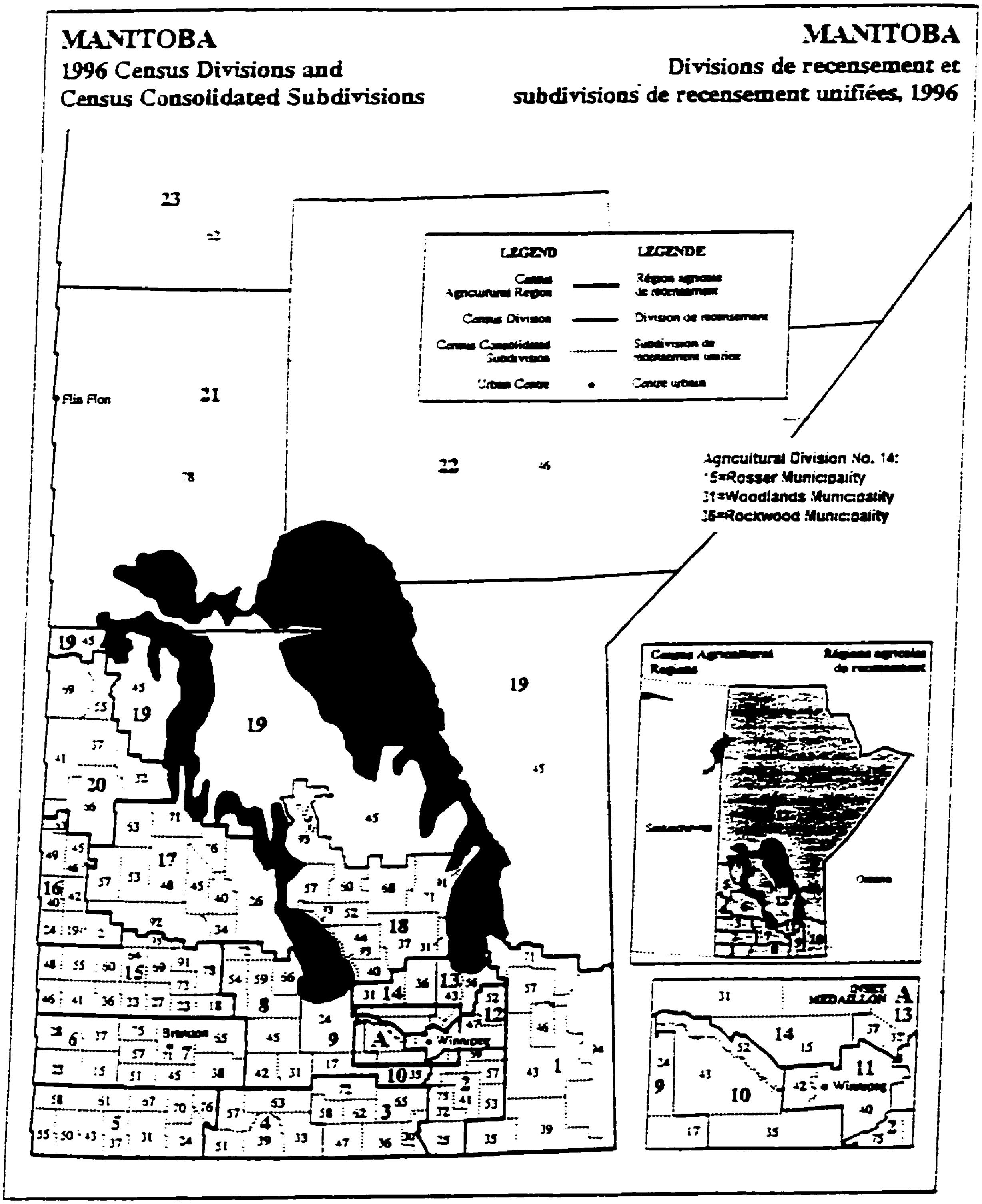

Figure 2. Statistics Canada Manitoba Agricultural Division No. 14 (Statistics Canada 1997).

These environmental criteria would be required for any development to be sustainable in any region, including the agricultural practice of beef cattle/forage production.

1.7 Summary of Research Methods

A comprehensive literature review was conducted concerning background information about sustainable development, sustainable agriculture, sustainability and environmental indicators, and beef cattle/forage operations in Statistics Canada Manitoba Agricultural division No. 14.

Through this literature review, seven environmental issues concerning beef cattle/forage operations were identified from the Report of the Consultation Workshop on Environmental Indicators for Canadian Agriculture published in 1994. These seven environmental issues are:

1) Agricultural land & soil resources;
2) Surface and ground water quality;
3) Water quantity;
4) Wildlife habitat;
5) Air and climate;
6) Genetic diversity;
7) Agricultural inputs (McRae & Lombardi 1994).

The agricultural inputs issue has three sub-issues, but for the purpose of this project, the sub-issues were treated as separate issues: Agricultural Nutrient input, Agricultural Pesticide input and Agricultural Energy input. Therefore, nine environmental issues were identified.

. The agricultural representative for the RMs of Rockwood, Rosser and Woodlands, Mr. Stan Stadnyk, was contacted to receive his input on the relevance of the nine identified environmental issues as well. Farmers who operate beef cattle/forge operations in Statistics Canada Manitoba Agricultural division No. 14 were also contacted to receive their input regarding the relevance of the environmental issues. This was performed to determine whether the identified environmental issues are relevant to beef cattle/forage production in the opinions of both farmers and an agricultural representative.

Through the literature review, environmental indicators were researched and reviewed from various publications from Environment Canada, the province of Alberta, Manitoba Environment, Environmental Indicator Working Group of Agriculture and Agri-Food Canada and the Organisation for Economic Cooperation and Development (OECD). From these various publications, a list of environmental indicators was compiled for beef cattle/forage production.

The availability of data was investigated to determine if there is any suitable data sets that could be used for any of the environmental indicators in the list for the study area, Statistics Canada Manitoba Agricultural division No. 14. The Census of Agriculture reports by Statistics Canada was reviewed to locate any data sets that could be used for the environmental indicators. Professionals in the federal government (Agriculture Canada Land Resource Unit, Canadian Wildlife Service), the provincial government (Manitoba Agriculture, Manitoba Crop Insurance Corporation, Manitoba Department of Conservation which also includes the Manitoba Sustainable Development Co-ordination Unit, Manitoba Water Resources Branch, Manitoba Wildlife Branch, Manitoba Parks and Protected Areas Branch and the Manitoba Conservation Data Centre), the municipal government (Reeve of the RM of Rockwood), and non-government organizations (Manitoba Cattle Producers, Manitoba Forage Council, Ducks Unlimited) were contacted concerning data sets that could be used for the environmental indicators. This investigation determined the availability of data sets for the compiled list of environmental indicators as well as the source of the data sets and also the level the data was collected at. This investigation of data sets availability also determined the feasibility of using environmental indicators for the agricultural practice of beef cattle/forage production.

This methodology provided an examination of the feasibility of using environmental indicators for a specific agricultural practice in a certain region. Recommendations concerning the usage of environmental indicators for beef cattle/forage production were made based on the outcome of the investigation concerning the availability of data sets for the environmental indicators.

Chapter Two: Sustainable Development

2.1 Origin of Sustainable Development

The origin of sustainable development can be deduced from some classical economic theories as the notions of limits to growth and development towards a steady state and can be found in the works of Ricardo, Malthus and Mill (Bergh & Straaten 1994). In the 20th Century, the origin of Sustainable Development lies in the Washington, D.C. conference on "Ecological Aspects of International Development" held in 1968 (Manitoba Round Table on Environment & Economy 1990). The importance of sustainable development was emphasised once again by the World Conservation Strategy in 1980, stressing the maintenance of essential processes and life sustaining systems, the preservation of genetic diversity and the sustainable utilization of species and ecosystems (Manitoba Round Table on Environment & Economy 1990). However, the World Commission on Environment and Development brought international awareness of and support for sustainable development globally (Manitoba Round Table on Environment & Economy 1990).

2.2 World Commission on Environment and Development

In 1983, the United Nations General Assembly established the World Commission on Environment and Development, also referred to as the Brundtland Commission, named after the chair of the Commission, the former Prime Minister of Norway, Dr. Gro Harlem Brundtland (WCED 1987; Canada, Government of Canada 1990). The Commission studied the relationship between economic development and the global environment and made recommendations concerning both economic development and global environment (Canada, Government of Canada 1990). In 1987, the Commission published its findings in a report called "Our Common Future". Within this report the term, Sustainable Development, was coined and it has been the environmental catch phrase since 1987. Sustainable development has been called many things, a goal, a concept, a philosophy, a policy and a paradigm. It is, essentially, in theoretical terms, any development or sector of development that can be perpetuated indefinitely in a positive manner.

2.3 Defining Sustainable Development

The Brundtland Report contains the generalized, well-acknowledged definition of sustainable development, development that meets the needs of the present without comprising the ability of future generations to meet their own needs (WCED 1987). Another definition is the utilization of resources and the environment to optimize economical and other societal benefits today, while not damaging prospects for their use by future generations (Sheehy 1989: Strategic Planning and Co-ordination Branch 1997). In essence, sustainable development implies the improvement of environmental quality and economic living standards without causing detrimental events while pursuing progress toward environmental, economic and social goals (Reid and Dower 1997).

2.31 Explanation for Numerous Definitions

Sustainable development involves a number of different academic disciplines including policy sciences, geography, economics, social sciences and ecology (Berkes et al. 1995). The various sectors of development, such as agriculture, forestry, and service industries have different viewpoints on sustainable development and how to accomplished it (Morita et al. 1993; Wilson & Tyrchniewicz & 1995). For this reason, there are several definitions of sustainable development (Manitoba Round Table on Environment and Economy 1990; Morita et al. 1993; Wilson & Tyrchniewicz 1995). The various definitions contain the perspectives of focusing on the outcomes and maintaining system resilience rather than on the specific linkages (Hardi et al. 1997).

2.4 Concept of Sustainable Development

Sustainable development is a concept linking the goals of human development and environmental quality (Gibbons et al. 1989; Shaw 1990; Manitoba Environment 1997). The concept arose from the global recognition that current development patterns could not be continued indefinitely due to environmental consequences (Gibbons et al. 1989; Shaw 1990). The concept of sustainable development emphasises the ability to endure indefinitely with equitable access to resources both for present and future generations and continued growth in output to support an expanding world population (Science Council of Canada 1992). The concept of sustainable development also involves the management and conservation of the natural resource base, and the orientation of technological and institutional change ensuring the fulfilment of human needs for present and future generations (SARD 1994). Like the various definitions of sustainable development, there are also various interpretations of the concept of sustainable development (Science Council of Canada 1992).

2.41 Normative Aspect of the Concept of Sustainable Development

Sustainable development is a normative concept (*what ought to be*) implying concessions between economic, environmental, social, cultural, ethical and other values (Bregha 1993; National Round Table on the Environment and the Economy 1993). Therefore, sustainable development can be considered an adaptive concept.

This normative aspect of the concept of sustainable development can be viewed both negatively and positively. Sustainable development can be perceived negatively because it is a non-uniform term having a number of different definitions and interpretations of the concept, depending on the discipline or sector of development (Bergh & Straaten 1994). The only definition that has achieved consensus by the various disciplines/sectors is the generalized definition by the

Brundtland Commission. However, this non-uniformity can also be viewed positively because sustainable development is adaptive, can be moulded to suit a particular discipline and/or sector of development.

One criterion of sustainable development is the integration of the environment and economy into decision-making as well as social considerations implying that environmental, economic and social considerations have to be incorporated into decision-making for any future development to occur (WCED 1987; Canada, Government of Canada 1990; Sustainable Development/State of the Environment Reporting Branch 1990; OECD 1991; Dakers 1992; Carroll-Foster 1993; Clement 1993; Jacobs 1993; Morita et al. 1993; OECD 1994; Duffield 1995; United Nations Conference on Environment and Development 1993; Canada 1997; Canada, Agriculture & Agri-Food Canada 1997a; IISD et al. 1997; OECD 1997). The environment is a highly complex, dynamic entity, not static or fixed. The environment is comprised of many ecosystems interacting with one another with abiotic and biotic components interacting with each another (Jacobs 1993; Faculty of Agricultural and Food Sciences, University of Manitoba 1994). An ecosystem is composed of multiple food webs and a food web is composed of many interconnecting food chains. The more interactions within a food web, the healthier the web. The more interactions within a single ecosystem and between ecosystems, the healthier the environment becomes. It also should be noted that every ecosystem is not identical; there are variations between similar ecosystems. Therefore, to incorporate the environment into decision-making, all these complexities within the environment must be taken into account. This implies that the decision-making process concerning sustainable development has to be adaptive due to the dynamic aspect of the environment.

Another key concept or theme of sustainable development is intergenerational and intragenerational equity where such matters as equal and continuous access to environmental resources is available to both the present and future generation (WCED 1987; Dakers 1992; Science Council of Canada 1992; Bregha 1993; Jacobs 1993; SARD 1994). Thus, the concept of sustainable development accounts for the concerns and interests of both the present and future generations (Jacobs 1993).

2.42 Dimensions of Sustainable Development

As previously mentioned, sustainable development cuts across a number of disciplines and sectors of development. However, sustainable development has three key dimensions, environmental, economic and social (WCED 1987; Bregha 1993; Morita et al. 1993; Ekins 1994; SARD 1994; Herdt & Steiner 1995; Government of Canada 1996; Canada, Agriculture & Agri-Food Canada 1997a; Reid and Dower 1997) (Figure 3). These dimensions are interdependent and inter-linked with one another. If one dimension is affected in either a positive or negative fashion, the other dimensions will be affected as well. To achieve or attain sustainable development, all three dimensions must be affected in a positive manner or in harmony.

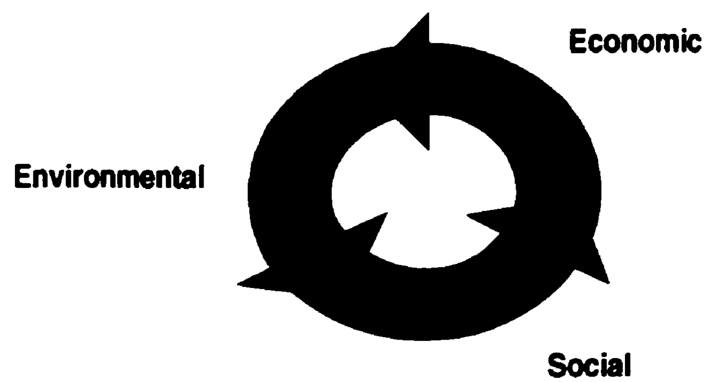

Figure 3. Dimensions of Sustainable Development

2.5 Concept of Sustainability

The terms sustainable development and sustainability are often used interchangeably. The gist of the term sustainability is the same with sustainable development, an indefinite usage and consumption of resources by both present and future generations (Jacobs 1993; Ekins 1994). The concept of sustainability inherits the normative aspect from the concept of sustainable development. Sustainability implies the preservation of the environment to ensure that environmental capacities (the ability of the environment to perform its various functions) are maintained over time guaranteeing that future generations have the opportunity to use the same environmental capacities (Jacobs 1993). In essence, sustainability incorporates a negative feedback loop. A feedback loop is a closed path that connects an action to its effect on the surrounding conditions, which in turn can influence further action (Tietenberg 1994). A negative feedback loop is a self-limiting feedback. Sustainability implies limiting and regulating development instead of maximizing development.

2.6 Achievement of Environmental Sustainability

Sheehy (1989) advocates that in order to achieve sustainability, development must meet the following basic environmental objectives:

1) Protecting natural systems that support life on earth (atmosphere, water, soils, living organisms);
2) Preserving genetic diversity;
3) Using renewable resources at a sustainable rate;
4) Foreclosing as few options as possible for future usage of non-renewable resources.

There is also consensus regarding that to achieve both sustainable social and economic goals, three basic criteria, also referred to as management rules of sustainability, have to be satisfied:

1) The exploitation of renewable natural resources (eg forests) must not, in the long run, exceed their rate of regeneration, otherwise these resources would be lost to future generations;
2) The exploitation of non-renewable natural resources (eg. fossil fuels or agricultural land) must not, in the long run, exceed the substitution of their function (eg. possible fluctuation of fossil fuels by hydrogen from solar electrolysis) and;
3) The release of substance and energy must not, in the long run, exceed the capacity of the natural environment to adjust (eg accumulation of greenhouse gases in the atmosphere or of

acid forming substances in forest soils) (Faeth 1997; Government of the Federal Republic of Germany 1997).

These management rules and basic objectives/goals are all environmentally focused. The environment provides the renewable and non-renewable resources for any development to occur. The environment also assimilates wastes produced by every organism on the planet. Therefore, for any sector of development to occur, it has to be performed in a manner conforming to these management rules and goals outlined.

2.7 Canada's Commitment to Sustainable Development

Canada has undertaken a number of initiatives toward integrating environment and development into the decision-making process (Canada, Government of Canada 1996). Round Tables on the Environment and Economy have been set up by the Federal Government and by the 10 provinces and 2 territories to facilitate co-operation between business, government, environmental organizations and community groups (Carroll-Foster 1993; Government of Canada 1996). The National Round Table on the Environment and the Economy was set up with a mandate to promote sustainable development in Canada (National Round Table on the Environment and the Economy 1991; Government of Canada 1996). The National Round Table advises the federal government on how to integrate sustainable development practices effectively in governmental operations and planning and to act as a catalyst for movement towards sustainable development (National Round Table on the Environment and the Economy 1991; Government of Canada 1996). A policy is a course of action or guiding principle pursed by the government that influences or determines the actions and decisions of government (Knutson et al. 1990). In essence, the federal government of Canada is implementing sustainable development as a federal policy.

Trends in the last quarter century which taken together provide a snapshot of Canada's progress toward sustainable development including:

1) safeguarding natural capital through environmental conservation and protection and the efficient and effective use of resources;
2) maintaining and improving the standard of living and quality of life for Canadians and;
3) strengthening and building the social fabric of Canadian life (Canada 1997).

The general public of Canada increasingly needs to be included in understanding the concept of sustainable development and deciding how to implement this concept (Strategic Planning and Coordination Branch 1997). Communities are becoming more directly involved in decision-making about development, by participating in environmental assessments of resource projects or through shared-management and joint-initiatives with industry and governments (Strategic Planning and Coordination Branch 1997). Clear, concise and user-friendly information is needed to be available for the Canadian public in order for them to gain a better understanding of the environmental, economic and social aspects of resources use and potential development to make value judgments on sustainable development (Strategic Planning and Coordination Branch 1997).

2.8 Manitoba's Commitment to Sustainable Development

2.81 International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) is a non-government policy analysis/advisory group established in 1990 in Winnipeg (IISD et al. 1997). The IISD is attempting to integrate environmental stewardship, economic development and the well-being of the public for the present and future generations through policy recommendations on international trade, economic instruments, climate change and natural resource management (IISD 1999a). The major objective of the Institute's work is to influence decision-makers both in the public and private sectors to implement sustainable development principles in every day practice (IISD et al. 1997; Sustainable Development/State of the Environment Reporting Branch 1990). The role of IISD is to promote the transition toward a sustainable future through policy research, information exchange, analysis and advocacy (IISD 1999a). There are many programs being performed at the IISD including the Great Plains Program and the Measurements and Indicators Program.

The Great Plains program focuses on the Canadian-American ecosystem that serves as a bread-basket for much of the world (IISD 1999b). People occupying the Great Plains face important challenges in maintaining their rural communities, the productivity of their economic enterprises, the quality of their environment and the management of their resources. The recognition of the links between environmental, economic and social issues and the application of principles to guide production and policy, this program addresses the challenge of the protecting the Great Plains for the future (IISD 1999b). From an examination of the sustainability of prairie agriculture policies, the program is expanding into partnerships with other organization to support community and producer adaptation through strategies for economic and ecological sustainability (IISD 1999b).

The Measurements and Indicators program is a combination of grassroots, multi-stakeholder participation in identifying issues and setting goals for sustainable development (IISD 1999c). This is performed within a coherent framework for selecting measurable dimensions and quantifiable indicators (IISD 1999c). The program connects international efforts with community-based decision-making (IISD 1999c). The primary goal of this program is to propose measurement techniques and to provide guidance concerning the selection, reporting and usage project-specific indicator sets (IISD 1999c).

2.82 Manitoba's Sustainable Development Strategy

There is a Sustainable Development Strategy for the province of Manitoba (Clement 1993; Manitoba Environment 1997; Sustainability Manitoba 1998). This strategy provides a world, national and provincial perspective on sustainable development (Sustainability Manitoba 1998).

This strategy outlines goals to be achieved in the following areas: the home; public and private sector education; projects demonstrating sustainable development practices and processes; the operation of provincial and local governments, crown corporations, commissions, hospitals and local schools; environmental management standards for air, soil and water, protection, use and management of natural resources (water, forests, minerals, soils, fish, wildlife and special places); energy use and development; economic development; solid, liquid and hazardous waste reduction and management; environmental business development; establishment of market place mechanisms and government fiscal policy in support of sustainable development; rural and northern Manitoba, the city of Winnipeg and surrounding rural municipalities, towns and villages; and research and development (Clement 1993; Sustainability Manitoba 1998). These goals are to be accomplished through joint participation by the public, private industry, non-government organizations and departments of the provincial government and municipal governments (Sustainability Manitoba 1998).

2.83 State of the Environment Report for Manitoba

In the 1997, the State of the Environment report for the province of Manitoba was published containing the theme of sustainable development. This and other State of the Environment reports provide accurate and accessible information on ecosystem conditions and trends, their significance and society's responses to them (Manitoba Environment 1997).

In the first chapter of this report is a discussion on sustainable development strategies and programs from the provincial government (Manitoba Environment 1997). The next chapter deals with environmental issues such as air quality, water resources and wildlife sustainability in the context of the Prairie ecozone (Manitoba Environment 1997). The Prairie ecozone extends from across the Prairie Provinces and into the midwestern United States including the southwestern corner of Manitoba (Manitoba Environment 1997). The Manitoba's Prairie ecozone once contained vast open grassland areas and tall-grass prairie and almost has been totally converted to agricultural and other industrial activities (Manitoba Environment 1997). The environmental issues were identified for the Prairie ecozone through a consultative process with prairie stakeholders (Manitoba Environment 1997). These environmental issues were used to develop and use environmental and socio-economical indicators to present information about these issues (Manitoba Environment 1997). The last chapter deals with relevant issues through the use of environmental indicators and relates the relevant issues to the other five ecozones in Manitoba (Manitoba Environment 1997). Essentially, this report discusses the concept of sustainable development and how it may be possible to make it functional through environmental and socio-economical indicators in the Prairie ecozone in Manitoba.

2.84 Sustainable Development Act

In 1997, the Sustainable Development Act for the province of Manitoba was passed and was proclaimed and incorporated into the provincial mandate in 1998 (Tammy Gibson 2000). The purpose of the Act is to create a framework through which sustainable development will be implemented in the provincial public sector and promoted in the private sector and in society[1]. Section Nine contains instructions for the Manitoba Round Table to prepare a set of sustainability indicators to be established after the Act comes into force. A report is to be prepared by the Minister based on the set of sustainability indicators and related issues to assess progress of the province of Manitoba towards sustainable development.

[1] [Statue of Manitoba 1997, Chapter S270] 'The Sustainable Development Act' 22pp.

2.9 Summary of Sustainable Development

The term, sustainable development, has referred as many things including a philosophy, concept or goal, but a commonality of different references or terms is that it is normative term, what ought to be or what to ought to occur. The concept of sustainable development has three key dimensions, including environmental.

For any development to be sustainable on an environmental level or basis, the following has occur:

- Renewable resources are available presently and for future generations for usage.
- Non-renewable resources, the rate of usage equals the rate of substitution for other resources to be used.
- The assimilative capacity of the environment, its ability to incorporate and absorb wastes is not damaged or hindered due to our activity.

The federal government and also the Manitoban provincial government are incorporating sustainable development and its subsets into their political mandates. The province of Manitoba has both a Sustainable Development Strategy and a Provincial Act to make sustainable development operational. This will enable policy-makers to determine whether or not the province of Manitoba is heading towards the goal of sustainable development outlined in the Strategy and the Act, including the environmental dimension of sustainable development.

Chapter Three: Sustainable Agriculture

3.1 Agriculture development in Canada

Agriculture is one sector of development involving the systematic management of organisms within an ecosystem (Faculty of Agricultural and Food Sciences, University of Manitoba 1994). Agricultural practices involve the manipulation of soil, water and biological resources to produce enhanced varieties of selected plant and animal species in greater quantities than would generally occur in wild ecosystems (Government of Canada 1991; Janzen et al. 1998). This implies that agricultural practices are dependent on the environment and environmental resources (Janzen et al. 1998). Farmers and other land managers in Canada are the stewards of the nation's agricultural land resources and it is their decisions that most directly affect how the land will be managed (Dumanski et al. 1994).

The trend in primary agriculture has been toward increased production of most commodities on fewer and larger farms that are more specialized (Winfield 1995; Government of Canada 1996; Canada, Agriculture and Agri-Food Canada 1997a). Agricultural policies in many countries have focused on output production (WCED 1987) including Canada (Tyrchniewicz & Wilson 1994; Baydack et al. 1995; Wilson & Tyrchniewicz 1995; Winfield 1995). The effects of agricultural policies in Canada on environmental quality are the result of two sorts of fundamental processes: extensification, the amount of land used in agricultural production, and intensification, the amount of product per unit of land, which generally increases with increased use of non-land inputs (chemicals, labour, machinery) (Reichelderfer 1990). In general, commodity prices, input, farm income and export subsidies maintain a stable, equitable priced food supply from farmlands (Reichelderfer 1990). This has led to the encouragement of developing and maintaining agriculture practices that rely on intensive production systems across agricultural regions where some agricultural regions are both not suited for agriculture and may be susceptible to a range of environmental problems. These include soil erosion from wind and water runoff, a decline in soil organic matter and possibly soil moisture, leaching of nutrients and pesticides in groundwater affecting groundwater quality, and also the loss and fragmentation of wildlife habitat, from any agriculture development (Reichelderfer 1990).

3.11 Agricultural Trends in Manitoba

In Canada, there have been significant trends regarding agriculture. For instance, grain producers no longer have the Western Transportation Grain Act or the Crow's rate available to them. This Act provided a subsidy to the farmer, paying a portion of the Transportation costs to ship grain by rail to Vancouver or Thunder Bay. This Act has not been in effect since 1995. Grain farmers now have to pay for the entire cost of shipping their grain. As a result, there is less grain being produced since 1995 (Manitoba Agriculture 1998).

It was theorized that with this decrease in grain production, there would be a significant increase in beef cattle production, almost 14 percent in the short term, and more acres seeded to forage crops (Kraft & McPhee 1995; McPhee 1996). Mr. Sylvio Tessier (2000) mentioned that beef cattle production in Manitoba has increased by only six percent since 1990. However, in the last four years, hog production in Manitoba has increased by 58 percent. The increase in beef cattle production has not occurred to the degree forecasted.

Another trend in agriculture is diversification. A farmer can diversify his practices by including a different type of practice such as livestock production. A farmer could diversify his income by taking on employment outside the agricultural field to supplement income.

3.2 A Subset of Sustainable Development: Sustainable Agriculture

A subset or sub-discipline of sustainable development is sustainable agriculture (Bergh & Straaten 1994; Tyrchniewicz & Wilson 1995; Wilson & Tyrchniewicz 1995). The concept of sustainable agriculture inherits the same normative aspect of sustainable development as well as the three key dimensions: environmental, economic and social. There are also numerous definitions of sustainable agriculture due to the various interpretations within the disciplines of the sector of agriculture.

3.3 Definitions of Sustainable Agriculture

Similar to sustainable development, there are a number of different definitions of sustainable agriculture. As mentioned previously, one definition of sustainable agriculture is those agri-food systems that are economically viable and meet society's need for safe and nutritious food, while conserving or enhancing Canada's natural resources and the quality of the environment for future generations (Canada, Government of Canada 1990; Government of Canada 1991; Science Council of Canada 1992; Wilson & Tyrchniewicz 1995). Another definition of sustainable agriculture is an agriculture that can evolve indefinitely toward greater human utility, greater efficiency of resource use and a balance with the environment that is favourable both to humans and to most other species (Harwood 1992).

While there are differences among the definitions of sustainable agriculture, these definitions generally emphasize the need for agricultural practices to be economically viable, to meet human needs for food, minimized any environmental impacts from usage of environmental resources for agricultural production and to be concerned with quality of life for generations (McEwen 1990; Dakers 1992; Aaker 1994; Gregorich 1995; Wilson & Tyrchniewicz 1995). Building on the definition of sustainable agriculture from the Federal-Provincial Agriculture

Committee on Environmental Sustainability, principles of sustainable agriculture and food production can be identified as:

1) thorough integration of the farming system with natural processes;
2) reduction of those inputs most likely to harm the environment;
3) greater use of the biological and genetic potential of plant and animal species;
4) improvement in the match between cropping patterns and land resources to ensure the sustainability of present agricultural production levels;
5) efficient production with an emphasis on improved farm management and conservation of soil, water, energy and biological resources; and
6) development of food processing, packaging, distribution and consumption practices consistent with sound environmental management (Science Council of Canada 1992).

These principles of sustainable agriculture can be achieved in a number of different ways implying that sustainable agriculture does not relate to only organic farming and is not linked to any particular agricultural practice (Wilson & Tyrchniewicz 1995; Pretty et al. 1996). Rather, sustainable agriculture is conceptualized in terms of its adaptability and flexibility over time to respond to the demands for food and fiber, its demands on natural resources for production, and its ability to protect soil and resources (Wilson & Tyrchniewicz 1995).

3.4 Concept of Sustainable Agriculture

The concept of sustainable agriculture can be considered as a philosophy, a management strategy or a system of farming performed by present and future generations understanding the long-term impact of agricultural activities on the environment (Francis & Youngberg 1990; MacRae et al. 1990; Gregorich 1995). Sustainable agriculture involves design and management procedures that work with natural processes to conserve all resources, promote resilience of agricultural systems and self-regulation and minimize waste and environmental impact, while maintaining or improving farm profitability (Francis & Youngberg 1990; MacRae et al. 1990; Dakers 1992; Faculty of Agricultural and Food Sciences, University of Manitoba 1994; Gregorich 1995; Government of Canada 1996). Theoretically, the concept of sustainable agriculture involves minimizing environmental degradation, maintaining agricultural productivity, promoting economic viability in both the short and long term and maintaining stable rural communities and quality of life as well as incorporating new technologies, financial viability, legal and institutional structures, tariff barriers and societal values, attitudes and behaviours (Taft 1989; Francis & Youngberg 1990; Thomas 1992; Anderson 1994; Herdt & Steiner 1995; Pretty et al. 1996).

3.5 Necessity for Sustainable Agriculture

By the year 2025, the expected global population will be 8.5 billion (Carroll-Foster 1993; United Nations Conference on Environment and Development 1993; Canada 1997). The endowment of available resources and technologies to satisfy the demands of this growing population for food and other agricultural commodities remains uncertain (United Nations Conference on Environment and Development 1993). Agriculture has to provide a stable food supply for the increasing global population through increasing production on existing agricultural land and avoiding further cultivation on marginal land (Carroll-Foster 1993; United Nations Conference on Environment and Development 1993; Faculty of Agricultural and Food Sciences, University of Manitoba 1994; Government of Canada 1996; Canada 1997; Canada, Agriculture and Agri-Food Canada 1997a).

3.6 Achievement of Sustainable Agriculture

Sustainable agriculture will require agricultural producers to modify their practices to the specific ecological conditions of their farms (Science Council of Canada 1992; Faculty of Agricultural and Food Sciences, University of Manitoba 1994; Pretty et al. 1996). Sustainable agriculture needs to be based on policies and practices that acknowledge environmental concerns, instead of focusing primarily on growth, production and distribution considerations (Anderson 1994).

Sustainable agriculture implies a fundamental understanding of the dynamics of an ecosystem and a maintaining of an ecosystem's equilibrium (Faculty of Agricultural and Food Sciences, University of Manitoba 1994). Sustainable agriculture also will require the integration of environmental concerns into all agricultural policies and these policies have to address environmental problems and not only the adverse consequences of certain systems or practices (Francis & Youngberg 1990; Taft 1989; Science Council of Canada 1992; Thomas 1992; Anderson 1994; Pretty et al. 1996). As well, to achieve sustainability, agriculture has to be economically viable for the present generation of farmers and environmentally sustainable for future generations, implying intergenerational equity (Dakers 1992).

3.7 Participation in Sustainable Agriculture by Canada

Canada has been endeavouring to incorporate sustainable agriculture into the national political mandate. The Green Plan of Canada first outlined initiatives in the early 1990s to aid agricultural producers to adopt environmentally agricultural practices (Carroll-Foster 1993; Canada 1995). Through the Green Plan, the federal government established new programs to strengthen Canada's ability to conserve plant and animal genetic resources (Canada 1995). More recently, there have been federal/provincial agreements on sustainable agriculture to help agricultural producers design and implement activities emphasizing environmental issues like water quality, waste management and soil conservation (Carroll-Foster 1993; Canada 1995). Agri-environmental indicators are being developed to evaluate Canadian's agriculture impact on the environment, provide information on key environmental trends and facilitate the integration of environmental considerations into Canadian agriculture decision-making processes (Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993; McRae & Lombardi 1994; Canada 1995; McRae et al. 1995a; McRae et al. 1995b).

Canadian agriculture and agri-food will continue to be shaped by social and economic forces, including the world's demand for food; commodity prices, federal, provincial and municipal government policies, international trade agreements, technology and agricultural research that will continue to impact on the environment for generations (Winfield 1995; Canada, Agriculture and Agri-Food Canada 1997a). This will imply continued intensification and concentration of production in both crop and livestock commodities and potentially increased impacts on the environment (Government of Canada 1996; Canada, Agriculture and Agri-Food Canada 1997a). Therefore, the agricultural decision-makers from federal and provincial governments, farm groups, food businesses, consumers, universities, volunteer agencies and environmental organizations need to communicate, consult and collaborate. Through this consultation, a consensus can be reached by all participating parties as to how to minimize further environmental impacts (Canada 1995; Government of Canada 1996; Canada, Agriculture and Agri-Food Canada 1997a).

Chapter Four: Sustainability and Environmental Indicators

4.1 Definitions of an Indicator

There are numerous definitions of an indicator. As mentioned previously, an indicator can be defined as a parameter, or a value derived from parameters, developed for a specific purpose to provide information about a phenomenon (OECD 1994). Another definition is that an indicator is a factor that indicates or helps to define the condition of a larger system (Acton & Gregorich 1995). An additional definition of an indicator is a statistic or parameter, when monitored over time, provides information on trends of a phenomenon (Kerr 1994).

An indicator can be a variable (eg the total amount of organically farmed products) or a function of variables (eg a ratio, such as recycled vs. total amount of solid waste) (Hardi et al. 1997). An indicator also can be a qualitative variable (eg safe-unsafe neighbourhood), a ranking variable (eg lowest or highest mortality rate) or a quantitative variable (eg energy use in kilowatt hours/year) (Hardi et al. 1997).

Indicators are repeated measurements of phenomena over a period of time, identifying long-term trends, periodic change and fluctuations in the rate of change of any phenomena (Gosselin et al., 1991 IN Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993; Hardi et al. 1997). Indicators emphasize what is occurring in a system and/or provide a means to assess the status of environmental conditions and the health of the environment (Bregha et al. 1993; Saskatchewan Environment and Resource Management 1992; Hardi et al. 1997; MacGillivray 1997).

4.2 Purpose of Sustainability Indicators

Sustainability indicators serve a multitude of purposes. One purpose of indicators is they can simplify information about complex phenomena, such as sustainable development, in order to make communication easier and quantification usable (Kerr 1994; OECD 1994; Canada 1995; Duffield 1995; Hardi et al. 1997; MacGillivray 1997; OECD 1997). Decision-makers can use the information within indicators to make efficient and effective decisions concerning resource management (Verbruggen & Kuik 1991; Saskatchewan Environment and Resource Management 1992; Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993; Canada 1995; Duffield 1995; Hardi & Pinter 1995; Milon & Shogren 1995; Hardi et al. 1997; Manitoba Environment 1997).

4.3 Necessity for Sustainability Indicators

Sustainable development indicators are needed to better reflect an accurate state of economic and environmental resources (Brundtland 1991; Hardi et al. 1997). Communities, governments, businesses, international agencies and non-governmental organizations have attempted and are continuing to identify and use sustainability indicators as tools or instruments to chart progress toward sustainable development and sustainable agriculture (Science Council of Canada 1992; OECD 1994; Canada 1995; Hardi et al. 1997; IISD et al. 1997; OECD 1997). Theoretically, sustainability indicators can be used as assessment and monitoring tools, tracking progress toward sustainable development through policies and political proceedings (Canada 1995; Dahl 1995; Hardi et al. 1997; IISD et al. 1997) and demonstrating the results of environmental effects from previous policies and political proceedings (Opschoor and Reijnders 1991; Saskatchewan Environment and Resource Management 1992; ARTEE 1994).

4.4 Environmental Indicators

4.41 Definitions of Environmental Indicators

There are a number of definitions of environmental indicators. For instance, environmental indicators are selected key statistics representing or summarizing some aspect of the state of the environment, natural resource assets and related human activities (Environment Canada 1991; Kerr 1994; Manitoba Environment 1995; Anderson 1997). Environmental indicators can also be defined as measures of change in the state of the environment or in human activities which affect the state of the environment, preferably in relation to a standard, value, objective or goal (United States Environmental Protection Agency 1972 **IN** McRae et al. 1995b). Environmental indicators focus on trends in environmental changes, stresses causing them, how the ecosystem and its components are responding to these changes and the societal responses to the environmental changes (Environment Canada 1991; Kerr 1994). Environmental indicators are a mode for a concise measurement of the state and/or health of the environment and the relationship between environmental factors and economic development (Canada, Government of Canada 1990; Manitoba Environment 1995).

4.42 Development of Environmental Indicators

Originally, the OECD used an approach to develop environmental indicators to reflect the *condition* of the environment, the *stresses* imposed on the environment by human activity and the way that we *manage* in response to those stresses (OECD 1991). The OECD later developed the Pressure-State-Response (PSR) framework. This framework or some variation of the framework emphasises a cause and effect of human development on the environment and has been used to develop environmental indicators (OECD 1994). The Pressure-State-Response framework emphasises:

1) pressure on the environment from human and economic activities, leads to changes in the

2) state or environmental conditions that prevail as a result of that pressure, and may provoke
3) responses by society to change the pressures and state of the environment (OECD 1994; OECD 1997).

A modified form of the PSR framework, the Driving Force-State-Response (DSR) framework is used to analyze agri-environmental linkages and develop agri-environmental indicators, environmental indicators for agriculture (Figure 4) (OECD 1997).

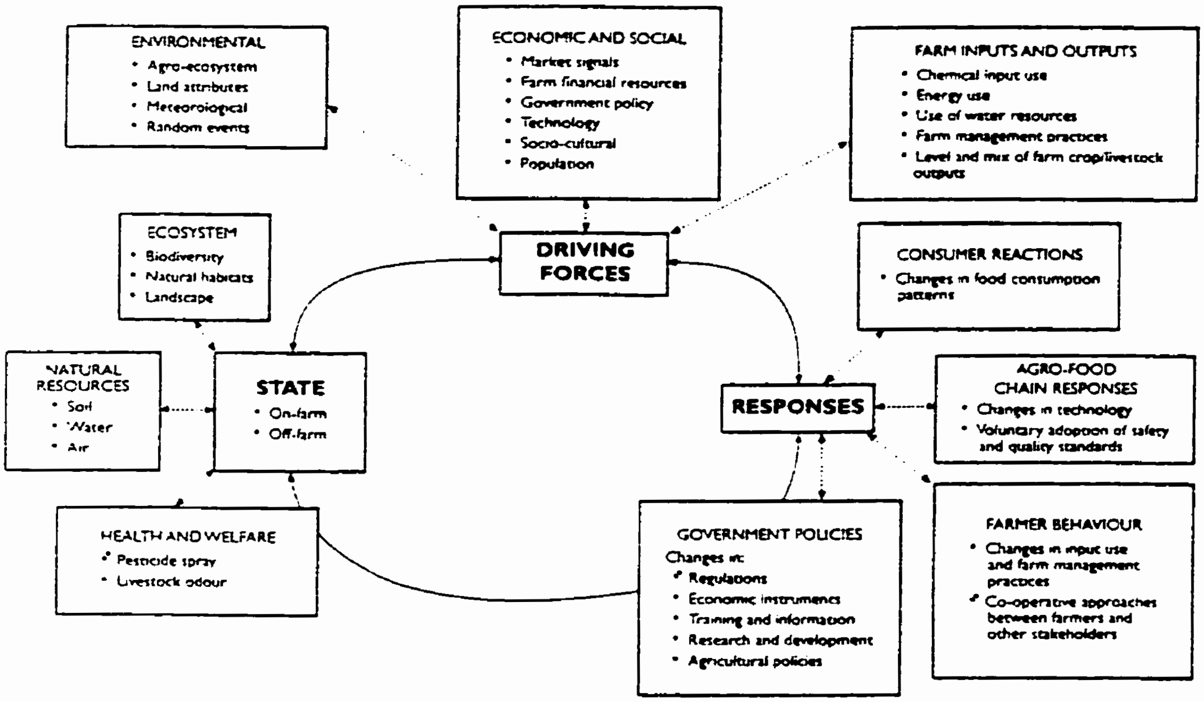

Figure 4. Driving Force-State-Response Framework (OECD 1997).

The DSR framework consists of an array of human-environmental interactions involving different feedbacks and linkages (OECD 1997). This framework accounts for the following: specific characteristics of agriculture and its relation to the environment; the consideration of agriculture in the context of sustainable development and the labour by OECD countries and other organizations in developing environmental indicators (OECD 1997). As well, this framework addresses questions related to an intricate network of agri-environmental linkages and feedbacks, including:

- What is causing environmental conditions in agriculture to change (*driving force*)?
- What effect is this having on the state or condition of the environment in agriculture (*state*)?
- What actions are being taken to respond to changes in the state of the environment in agriculture (*response*)? (OECD 1997).

The *driving forces* component of the DSR framework are those elements causing changes in the state of the environment including:

- Natural environmental process and factors, including the agro-ecological system, the physical attributes of the land, meteorological conditions and random events such as earthquakes;
- Biophysical inputs and outputs at the farm level, covering the use of chemical inputs, energy and water resources, farm management practices; and decisions taken in terms of the level and mix of agricultural commodities produced;
- Economic and societal driving forces, encompassing reactions to economic and policy signals received from markets and governments; variations in the level and composition of farm financial resources, changes in technology, cultural attitudes and public pressure, social structures and population growth (OECD 1997).

The concept of *driving forces* also acknowledges that agricultural activities can produce both beneficial and harmful impacts to the environment and environmental quality (OECD 1997). An example of a beneficial impact is the increasing water storage capacity of certain agricultural systems ameliorating problems like soil erosion and flooding (OECD 1997). An example of a harmful impact is excessive use of fertilizers and pesticides management practices (OECD 1997).

The *state* component of the DSR framework refers to changes in environmental conditions occurring from various driving forces and includes the following range of elements:

- State of the natural resources used in agricultural production – soil, water and air – covering their physical, chemical and biological condition;
- Composition, structure and functioning of the ecosystem affected by agricultural activities, including biodiversity and natural habitats, and man-made environments, such as agricultural landscapes;
- State of human health and environmentally related welfare, such as the risk of human health from pesticide spraying and the public nuisance caused by odours from intensive livestock production (OECD 1997).

The *responses* component of the DSR framework refer to the reaction by groups in society and policy makers to the actual and perceived changes in the state of the environment in agriculture, the sustainability of agriculture and to market signals (OECD 1997). *Responses* include:

1) Farmer behaviour, by changes in input use, farm management practices, such as integrated pest management and co-operative approaches between farmers and other stakeholders;
2) Consumer reactions, through altering food consumption patterns, including preferences for organically produced foods;
3) Responses by the agro-food chain with changes in technology to produce less toxic pesticides and the voluntary adoption of better safety and quality standards by the food industry;
4) Government actions, through changes in policy measures, including regulatory approaches, the use of economic instruments such as subsidies and taxes, training and information programs, research and development and agricultural policies (OECD 1997).

The DSR framework provides a flexible framework that can assisting in:

1) Improving the understanding of the complexity of linkages and feedbacks between the causes and effects of agriculture's impact on the environment, and the responses by farmers, policy makers and society to changes in agri-environmental conditions;
2) Identifying indicators to explain and quantify these linkages and feedbacks (OECD 1997).

4.43 Criteria for Environmental Indicators

Criteria are also used for developing environmental indicators. Agriculture Canada has developed criteria to identify and develop environmental indicators. The criteria include:

1) Policy relevance: the indicators should inform of movement toward or away from established policy objectives or science-based thresholds, or relate to key environmental issues and values in agriculture.
2) Scientific soundness: the indicators should be sound measures technically and their attributed significance should be scientifically defensible and accepted.
3) Understandable: what the indicators represent, and the significance of the values reported, should be readily understood by those who are intended to make use of them.
4) Temporal and/or spatial change: the indicators should be referenced in time and/or space, to allow spatial and/or temporal trends to be identified.
5) Feasible to obtain/develop: the indicators developed should make use of existing data as much as possible. Similarly, the indicators should not be so complex that they discourage regular monitoring, can only be developed over a long time period or are prohibitively expensive to develop (Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993).

There are a large number of indicators that could be developed to help quantify the various components and linkages in the DSR framework (OECD 1997). To assist in the choice of an operational set of indicators within the DSR framework, each indicator is examined against four criteria:

- Policy relevance;
- Analytical soundness;
- Measurability;
- Level of aggregation (0ECD 1997).

The criterion of policy relevance relates to the important agri-environmental issues identified in the DSR framework to policy makers (0ECD 1997). The indicator should quantify the components and issues described in the DSR framework and also recognize that agriculture is a significant component in relation to the identified issue (0ECD 1997). The indicator should also be relevant to an environmental issue in agriculture which can be addressed by policies and policy makers (0ECD 1997).

The criterion of analytical soundness concerns how an indicator can establish and explains links between agriculture activities and environmental conditions; thus, referring to the basis of measuring an indicator (0ECD 1997). The indicators show trends and ranges of values over time which complement nationally defined targets and thresholds (0ECD 1997).

The criterion of measurability relates to availability of data to measure the indicator (0ECD 1997). The indicator should be developed from established national or sub-national data, preferably using a long time series where this is available given the lengthy time period for many environmental effects (0ECD 1997).

The criterion of level of aggregation determine at the level (ie farm, sectoral, regional or national) that the indicator can be applied effectively for policy purposes (0ECD 1997). This criterion highlights the issue of encapsulating the spatial and temporal diversity of the environment and the geographical scale of different environmental issues ranging from the farm through to the global scale (0ECD 1997).

4.44 Purpose of Environmental Indicators

Environmental indicators can be classified as performance indicators. Performance indicators are tools for comparison, incorporating a descriptive indicator and a reference value or a policy goal (Hardi & Pinter 1995; Hardi et al. 1997). They provide decision-makers with information on how they are doing with regard to achieving local, national or international goals, targets and objectives (Dahl 1995; UNEP and SPCSD 1995 **IN** Hardi et al. 1997). Essentially, environmental indicators are important tools for translating and delivering concise, scientifically credible information in a manner that can be readily understood and used by decision-makers and the public to chart progress towards a sustainable future (Environment Canada 1991; Kerr 1994; Manitoba Environment 1995; McRae et al. 1995b; OECD 1994; Anderson 1997).

4.45 Agri-Environmental Indicators

Canada has been developing a subset of environmental indicators called agri-environmental indicators (Canada 1995; McRae et al. 1995a; McRae et al. 1995b). Agri-environmental indicators measure the alteration or the risk of alteration in the state of environmental resources used or affected by agriculture or any farming activities that affect the state of these resources (Acton & Gregorich 1995; Canada, Agriculture and Agri-Food Canada 1997a). Agro-ecosystems are ecological systems that are distinct from 'natural' ecosystems because they are designed primarily for production of food and fiber (McRae et al. 1995b). Agro-ecosystems favour one or more dominant species of plants or animals, but they also provide benefits, such as the availability of wildlife habitat, recycling of nutrients and storage of elements such as through the carbon cycle (McRae et al. 1995b).

Like environmental indicators, agri-environmental indicators are tools for delivering information into the decision-making process (McRae et al. 1995a). For either agri-environmental indicators or environmental indicators to be useful to policy-makers and stakeholders, they have to:

1) Assess to what degree key agri-environmental issues are being addressed and objectives met;
2) Help to identify areas and resources at risk;
3) Help to design and target strategies and actions to ensure all costs are appropriately internalized; and
4) Facilitate communication among stakeholders and between stakeholders and policy makers, on setting appropriate policy responses, especially when it comes to evaluating trade-offs that might have to be made (McRae et al. 1995a; McRae et al. 1995b).

The OECD has developed a set of agri-environmental indicators within the context of agricultural policy reform and the requirement of ensuring consistency between environmental and agricultural policies. The agri-environmental indicators developed by the OECD will:

1) Provide information to policy makers and the wider public on the current state and changes in the conditions of the environment in agriculture;
2) Assist policy makers to better understand the linkages between the causes and effects of the impact of agriculture and agricultural policy on the environment, and help to guide their responses to changes in environmental conditions;
3) Contribute to monitoring and evaluation of the effectiveness of policies in promoting sustainable agriculture (OECD 1997).

Chapter Five: Beef Cattle/Forage Production in the Interlake Region of Manitoba

5.1 Interlake Agriculture Post-European Colonization

Settlement by Europeans in the Interlake region began with the establishment farms and communities in the Teulon-Stonewall area between 1871 to 1875 (Richtik 1964; Gillies & Nickel 1977; Canada, Regional Economic Expansion 1978). These settlements, located on the northern tip of the Red River Plain, prospered (Canada, Regional Economic Expansion 1978). Immigrants from southern Ontario, Quebec, Iceland, Scotland, Ukraine, Germany, Sweden and Poland eventually settled in the Interlake region and eventually learned through experience that the soils were better for forage production (Marquardt 1971; Canada, Regional Economic Expansion 1978; Armitage 1990).

The trend of agriculture in the Interlake region post-1920s was a decrease in the number of farms while the size of individual farms increased (Canada, Regional Economic Expansion 1978; Armitage 1990). The Interlake was designated as an economically distressed region in Canada and two government programs assisted Interlake farmers to increase level of income and standard of living (Giles 1968; Manitoba Interlake Study Team 1968; Canada, Regional Economic Expansion 1978; Armitage 1990). One was the Agricultural and Rural Development Act (ARDA), established in 1961. The objective of the Act was to assist rural people with a very low level of income and standard of living with projects that would intensify the productivity of land (Giles 1968; Todd and Brierley **IN** Armitage 1990). A major ARDA project was the clearing of land, where a total of 8,000 hectares of aspen bush were cleared on 476 Interlake farms between August 1964 and April 1968 for pasture land (MDA 1968 **IN** Armitage 1990). As a result, the Interlake was designated by ARDA as a special rural development area and became eligible for additional financing under a second government program, the Fund for Rural Economic Development (FRED) (Giles 1968; Canada, Regional Economic Expansion 1978; Armitage 1990).

The FRED program was established in 1966 by the federal government and the agreement was signed in 1968 in Arborg (Giles 1968; Canada, Regional Economic Expansion 1978; Armitage 1990). Almost $15 million of the $85 million assigned to the Interlake was for agricultural redevelopment projects such as clearing of bush land to provide more grazing and forage for beef cattle production (FRED 1975 **IN** Armitage 1990).

The motives of these agricultural programs established in the Interlake demonstrated the extent to which farmers of the region were encouraged to adopt a farm system involving livestock production or, more particularly, beef cattle production based on forage crops (Marquardt 1971; Canada, Regional Economic Expansion 1978; Armitage 1990).

5.2 Soils of the Interlake

The soils in the Interlake region have been classified as Rego Black Chernozems and Gleyed Dark Grey Chernozems (Armitage 1990). The high lime content of the soil (Ellis 1938 **IN** Armitage 1990; Gabor 1991; Murkin et al. 1991; Gabor et al. 1994) resulted in a phosphorus deficiency as well as having poor drainage and stoniness limiting agricultural practices primarily to mainly livestock, such as cattle grazing and forage crops such as hay production (Armitage 1990; Gabor 1991; Murkin et al. 1991; Gabor et al. 1994). There are four Land Resource Units in the Interlake region with each unit consisting of groupings of closely related soil associations or series suitable for similar types of crop production and requiring similar management practices (Figure 5) (Armitage 1990). These units are the Arborg/Peguis, Inwood/Meleb, Isafold and Red River/Osborne. The soils in the RMs of Rosser, Woodlands and the southern portion of Rockwood are contained within the Red River/Osborne unit.

The Red River/Osborne unit occupies the southern portion of the Interlake including the RMs of Rosser, Woodlands and much of Rockwood, and the soils in this unit are generally the most productive soils in the region (Weir 1960 **IN** Armitage 1990). Soils in the Red River/Osborne unit were developed on deep, weakly to moderately calcareous lacustrine clay and contain few or almost no stones and has a high fertility (Armitage 1990).

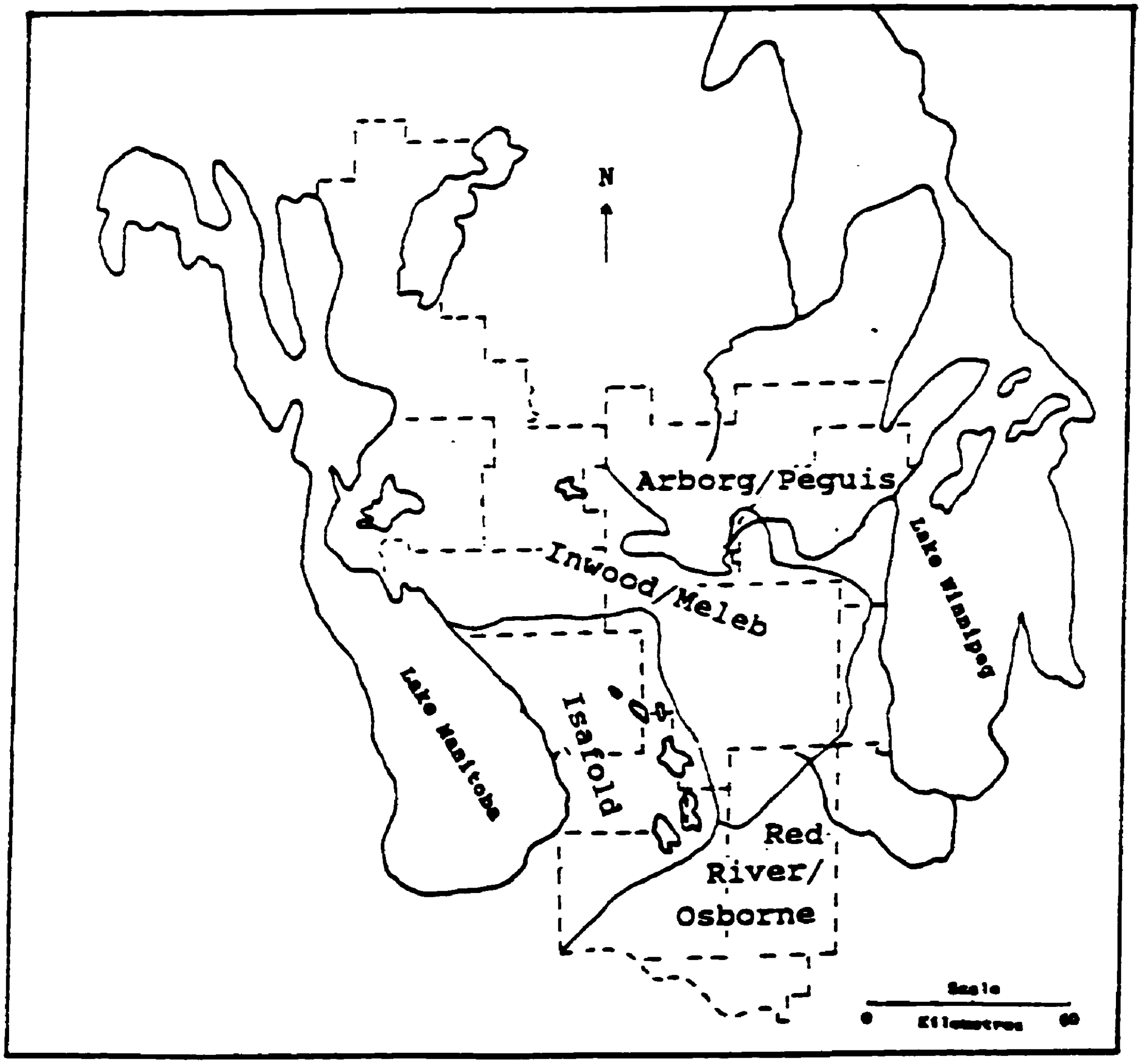

Figure 5. Land Resource Units of the Interlake Region (Armitage 1990).

The fine texture of these soils causes drainage problems, particularly on the Osborne clays, but the installation of drainage ditches throughout the area allows for the production of crops of both forage and grain (Armitage 1990).

The Inwood/Meleb unit occupies almost 50 percent of the Interlake and is the dominant land resource unit in the region (Armitage 1990). Soils within the Inwood series are Gleyed Dark Grey Chernozems while soils within the Meleb series consist of Carbonated Rego Humic Gleysols (Armitage 1990). The northern segment of the RM of Rockwood is contained within this unit.

5.3 Statistics Canada Manitoba Agricultural Division No. 14

5.31 Rural Municipality of Rockwood

The RM of Rockwood covers an area of 121,317 ha in the southern Interlake district of southern Manitoba (Land Resource Unit et al. 1999a). The climate of the RM can be related to weather data from Stonewall in the south area to Gimli in the north area (Land Resource Unit et al. 1999a). The mean annual temperature is 2.0°C while the mean annual precipitation is 534 mm in the south area; the mean annual temperature is 1.1°C while the mean annual precipitation is 528 mm in the north area (Environment Canada 1982, 1993 **IN** Land Resource Unit et al. 1999a). The average number of frost-free days is 119 in the south while it is 122 days along Lake Winnipeg in the north (Land Resource Unit et al. 1999a). The average number of degree-days above 5°C from May to September is 1,623 in the south and 1,543 in the north (Ash 1991 **IN** Land Resource Unit et al. 1999a). An evaluation of growing conditions in this region of Manitoba can be related to estimates of seasonal moisture deficit and effective growing degree-days (EGDD) above 5°C (Land Resource Unit et al. 1999a). The seasonal moisture deficit calculated between May and September is between 250 to 200 mm (Land Resource Unit et al. 1999a). The estimated number of growing degree-days from May to September varies from 1,600 in the south to 1,400 in the north (Agronomic Interpretations Working Group 1995 IN Land Resource Unit et al. 1999a).

The northern part of the municipality is located in the Interlake Plain while the southern portion is situated in the Woodlands Plain with the eastern part in the Red River Valley (Canada-Manitoba Soil Survey 1980 IN Land Resource Unit et al. 1999a). Soil materials in the municipality were deposited during the time of glacial Lake Agassiz (Land Resource Unit et al. 1999a). The Interlake Plain is distinguished by extremely calcareous, loamy, glacial till (Land Resource Unit et al. 1999a). The Woodlands Plain consists of thin, clayey, lacustrine, till materials underlain by loam textured and stony glacial till (Land Resource Unit et al. 1999a). The flat topography throughout the municipality results in the majority of soils being classified as imperfectly to poorly drained (Land Resource Unit et al. 1999a).

The dominant land use in the RM of Rockwood is agriculture (Land Resource Unit et al. 1999a). An assessment of the land use performed in 1994 indicated approximately 50 percent of the RM is seeded with annual crops and approximately five percent is seeded with forage crops (Land Resource Unit et al. 1999a). The vegetative cover in the Interlake Plain remains as a mix of native grassland and treed areas due to the stony nature and poor drainage associated with the glacial, till soils (Land Resource Unit et al. 1999a). This area provides forage and grazing capacity as well as wildlife habitat (Land Resource Unit et al. 1999a). Wetlands cover 5 percent of the area and provide habitat for waterfowl (Land Resource Unit et al. 1999a). Various non-agricultural uses such as infrastructure for urban areas, transportation and recreation occupy nearly five percent of the municipality (Land Resource Unit et al. 1999a). Figure 6 shows land use in the RM of Rockwood.

5.32 Rural Municipality of Rosser

The RM of Rosser covers an area of 44,324 ha in southern Manitoba and is adjacent to the northwest corner of Winnipeg (Land Resource Unit et al. 1999b). The mean annual temperature ranges from 2.8°C at Marquette to 2.4°C at Winnipeg and the mean annual precipitation ranges from 530 mm in the west to 504 mm to the east (Environment Canada 1993 IN Land Resource Unit et al. 1999b). The average number of frost-free days varies from 127 in Marquette to 118 days in Winnipeg (Land Resource Unit et al. 1999b). The average number of degree-days above 5°C from May to September ranges from 1,712 in the west to 1,697 in the east (Ash 1971 IN Land Resource Unit et al. 1999b). An evaluation of growing conditions in this region of Manitoba can be related to estimates of seasonal moisture deficit and effective growing degree-days (EGDD) above 5°C (Land Resource Unit et al. 1999b). The seasonal moisture deficit calculated between May and September is below 250 mm and the estimated number of growing degree-days from May to September is slightly above 1,600 (Agronomic Interpretations Working Group 1995 IN Land Resource Unit et al. 1999b).

The RM of Rosser occupies a part of the northern portion of the Red River Valley and a part of the southern portion of the Woodland Plain to the north (Canada-Manitoba Soil Survey 1980 IN Land Resource Unit et al. 1999a). The area is generally flat with slopes less than two percent; however, a subdued ridge and swale topography is common throughout the Woodlands Plain (Land Resource Unit et al. 1999b). Soil materials in this RM were deposited during the time of glacial Lake Agassiz and consist primarily of both shallow and deep, clayey, lacustrine sediments (Land Resource Unit et al. 1999b). These materials are shallower to the north where a loam textured, stony, glacial till occurs close to the surface (Land Resource Unit et al. 1999b).

Land use in the RM of Rosser is primarily agricultural (Land Resource Unit et al. 1999b). An assessment of the land use in 1995 obtained through an analysis of satellite imagery showing annual crops occupied about 84 percent of the land in the RM with forage production occurring on nearly three percent of the RM (Land Resource Unit et al. 1999b). Small areas of grassland, often associated with farmsteads and along major drainage channel, occupy seven percent of the RM (Land Resource Unit et al. 1999b). Tree cover, mainly shelterbelts associated with farmsteads, occupies about 2 percent of the RM (Land Resource Unit et al. 1999b). Various non-agricultural uses such as infrastructure for urban areas, transportation and recreation occupy nearly five percent of the RM (Land Resource Unit et al. 1999b). Figure 7 shows land use in the RM of Rosser.

5.33 Rural Municipality of Woodlands

The RM of Woodlands covers an area of 124,060 ha located southeast of Lake Manitoba in southern Manitoba (Land Resource Unit et al. 1999c). The climate in the RM can be related to weather data from Stonewall, approximately nine kilometres east of the RM (Land Resource Unit et al. 1999c). The mean annual temperature is 2.0°C and the mean annual precipitation is 534 mm (Environment Canada 1993 **IN** Land Resource Unit et al. 1999c). The average number of frost-free days is 119 and the number of degree-days above 5°C from May to September average 1,623 (Ash 1991 **IN** Land Resource Unit et al. 1999c). An evaluation of growing conditions in this region of Manitoba can be related to estimates of seasonal moisture deficit and effective growing degree days (EGDD) above 5°C (Land Resource Unit et al. 1999c). The seasonal moisture deficit calculated between May and September is between 250 mm and 200 mm (Land Resource Unit et al. 1999c). The estimated number of growing degree days from May to September range from 1600 in the south to about 1,450 in the north (Agronomic Interpretation Working Group 1995 **IN** Land Resource Unit et al. 1999c).

The northern half of the municipality is located in the Interlake Plain while the southern portion is in the Woodlands Plain (Canada-Manitoba Soil Survey 1980 IN Land Resource Unit et al. 1999c). Soil materials in the municipality were deposited during the time of glacial Lake Agassiz (Land Resource Unit et al. 1999c). The Interlake Plain is characterised by extremely calcareous, stony, loamy, glacial till (Land Resource Unit et al. 1999c). The Woodlands Plain consists of thin, clayey, lacustrine and till materials underlain by loam textured, stony, glacial till (Land Resource Unit et al. 1999c). The flat topography throughout the municipality results in the majority of soils being classified as imperfectly to poorly drained (Land Resource Unit et al. 1999c).

Land use in the RM of Woodlands consists primarily of agriculture (Land Resource Unit et al. 1999c). An assessment of the land use in 1995 obtained through an analysis of satellite imagery, showed that 32 percent is seeded with annual crops while 4 percent is seeded with forage crops in the southern portion of the RM (Land Resource Unit et al. 1999c). Grasslands occupy 32 percent while tree cover occupy approximately 16 percent of the RM in the northern portion of the RM and provide forage and grazing capacity as well as wildlife habitat (Land Resource Unit et al. 1999c). Wetlands occupy nine percent and water bodies covering nearly five percent of the municipality provide habitat for waterfowl (Land Resource Unit et al. 1999c). Various non-agricultural uses such as infrastructure for urban areas, transportation and recreation occupy about 2.4 percent of the municipality (Land Resource Unit et al. 1999c). Figure 8 shows land use in the RM of Woodlands.

5.4 Forage Production

5.41 Benefits of Forage Production

Forage crop production does have both agronomic and environmental benefits (Canada, Agriculture and Agri-Food Canada 1997b). Forage crops provide a dense and continuous vegetative cover over soil where is there is little risk of soil erosion forage production areas (Canada's Beef Cattle Producers 1993; Manitoba Environment 1993; Canada, Agriculture and Agri-Food Canada 1997b). Forages also contribute to the accumulation of soil organic matter, enhance the structure and water holding capacity of soils and provide habitat for some wildlife species (Canada's Beef Cattle Producers 1993; Canada, Agriculture and Agri-Food Canada 1997b). Leguminous forage crops such as alfalfa, can fix and store nitrogen in the root system, reducing nitrogen application needs for subsequent crops (Canada, Agriculture and Agri-Food Canada 1997b). As a result of these benefits, incorporating forages into crop rotations is now a recommended agronomic practice in Canada (Canada, Agriculture and Agri-Food Canada 1997b; Manitoba Agriculture 1993).

5.42 Categories of Forage Crops

Forages can be divided into three broad categories: native, tame and seed crops (Armitage 1990). Native forage is naturally occurring, herbaceous vegetation of meadows and forested land, while tame forage is sown by the farmer either into a conventionally prepared seedbed or with the aid of a sod-seeder (Armitage 1990). In the Interlake region, both native and tame forages are generally consumed by livestock species (Armitage 1990). Forage seed is also grown as a cash crop with an international market (Armitage 1990). As a result, forage crops require the same level of management inputs as grains and oilseeds, the only difference being that a crop of forage seed has a perennial rather than annual life cycle (Armitage 1990).

5.5 Beef Cattle

5.51 Importance of Beef Cattle

Beef cattle are an important component of sustainable agricultural systems (Canada's Beef Cattle Producers 1993; Faculty of Agricultural and Food Sciences, University of Manitoba

1994). They require the incorporation of perennial crops into the crop rotation, which adds diversity and stability to the agro-ecosystem and potentially reduces the need for inorganic inputs and decrease soils erosion (Canada's Beef Cattle Producers 1993; Faculty of Agricultural and Food Sciences, University of Manitoba 1994).

The beef cattle industry continues to be an important part of Manitoba's agricultural sector (Manitoba Agriculture 1982). Cattle were dual-purpose animals once where they supplied family farms with both milk and meat (Manitoba Agriculture 1982). This pattern gradually shifted and underwent a major change with the introduction in the late 1960's and early 1970's of European exotic beef breeds that offered the desired size, leanness and milk production (Manitoba Agriculture 1982). This has also occurred in the Interlake region (Stan Stadnyk 1999). The beef cattle industry in Manitoba has intensified into large cow-calf and feedlot operations as well as many beef enterprises that are still secondary to other farm operations (Manitoba Agriculture 1982).

5.52 Beef Cow/Calf Operations

The beef cattle industry at the primary level is typically a two step process (Horner et al 1980). One is the 'cow-calf' operation that produces feeder cattle from a basic beef herd; the second is the growing and fattening of the feeder cattle (Horner et al 1980). In some instances, a farm may carry out both phases, while in other the feeder cattle may be transferred to a farm or feedlot for the second phase (Horner et al 1980). A feedlot is a fenced parcel of land where livestock are confined solely for the purpose of growing or finishing and are sustained by means other than grazing (Agricultural Guidelines Development Committee 1994).

There are presently three types of cattle operations in the Interlake region, cow-calf, feeders and finishers (Paula Douville 2000). Cow-calf operations are those where calves are sold when they reach a certain weight approximately 700 pounds. These calves are sold at stockyards when they are in turn sold as feeders placed in feedlots to increase their body mass. These calves are sold as finishers at a weight between 900-1000 pounds. Finishers are farmers who feed cattle and increase body mass and eventually sell them to processing plants at a weight between 1200 to 1300 pounds.

5.6 Agriculture in the Interlake Region of Manitoba

As previously mentioned, Statistics Canada Agricultural division No. 14 is comprised the Rockwood, Rosser and Woodlands municipalities, the southern portion of the Interlake region (Statistics Canada 1997). Statistics Canada Agricultural division No. 18 is comprised of the Bifrost, Coldwell, Eriksdale, Gimli, St. Laurent, Siglunes, Armstrong, Fisher and Grahamdale municipalities, the northern portion of the Interlake region. The total number of farms in the Interlake region from Statistics Canada Agricultural divisions No. 14 and 18 were 2,835 in 1991, but decreased to 2,744 in 1996 (Statistics Canada 1992 & 1997). Thus, the trend of a decrease in the number of farms in Manitoba has also been occurring in the Interlake region. The total area of farms in the Interlake region from Statistics Canada Agricultural divisions No. 14 and 18 was 2,277,523 acres in 1991, but increased to 2,338,463 in 1996 (Statistics Canada 1992 & 1997). As well, the area of land in crops in the Interlake region from Statistics Canada Agricultural divisions No. 14 and 18 was 834,362 acres in 1991, but increased to 920,980 in 1996 (Statistics Canada 1992 & 1997). Thus, a trend of an increase in farm area and area of land in crops has been coinciding with a decrease in the number of farms during the 1990s.

In Manitoba, the number of beef cows increased by 24% between 1991 to 1996 (Statistics Canada 1997). This also has occurred in the Statistics Canada Agricultural division No. 14 where beef cows numbers were 13,011 in 1991 and increased to 17,523 in 1996 (Statistics Canada 1992 & 1997). There also has been corresponding increase in number of acres used to produce forage crops such as alfalfa and alfalfa mixtures in the Statistics Canada Agricultural divisions No. 14 and 18. The number of acres for alfalfa and alfalfa mixtures production in the Statistics Canada Agricultural division No. 14 and 18 was 255,361 in 1991 and increased to 272,386 in 1996 (Statistics Canada 1992 & 1997).

5.7 Beef Cattle/Forage Production in Statistics Canada Manitoba Agricultural Division No. 14

The beef cattle breeds in the Interlake region in the past included Herefords, Angus, Shorthorn, Charolais and Limousin (Marquardt 1971). Herefords, Angus, Shorthorn and Charolais are typical British breeds while Limousin is an exotic breed, exotic breeds implies any cattle breed that is relatively new to North America such as the Simmental (May 1981). Another exotic breed used in Manitoba is Simmental (Stan Stadnyk 1999). Forage crops in the Interlake region grown in the past included alfalfa, timothy, clover and hay (Marquardt 1971).

There are total of 949 farms in the Statistics Canada Manitoba Agricultural division No. 14 from the 1996 Census of Agriculture (Statistics Canada 1997). From the 1996 Census of Agriculture concerning the Statistics Canada Manitoba Agricultural division No. 14, the total number of beef cows was 17,523 while the total number of cattle (beef cows, calves, steers, bulls, heifers) was 48,977 (Statistics Canada 1997).

These farms with cattle in the Statistics Canada Manitoba Agricultural division No. 14 currently raise primarily Exotic/British cross-breed cattle. Cross breeding is popular with cattle farmers because it helps to increase productivity (Neumann & Lusby 1996). The most common cattle raised are the Charolais/Hereford cross, followed by Simmental/British cross, Limousin/British cross and a small representation of less common exotic breeds. There are pure breed cattle producers of each of the exotic and traditional breeds of British cattle (Stan Stadnyk 1999).

From the 1996 Census of Agriculture, the number of farms producing alfalfa and alfalfa-grass mixtures in the Statistics Canada Manitoba Agricultural division No. 14 was 421 with the total number of acres of alfalfa and alfalfa-grass mixtures being 61,832 (Statistics Canada 1997). The predominant type of forage is an alfalfa-grass mixture that is used as feed for beef cattle (Stan Stadnyk 1999).

From the 1996 Census of Agriculture, the number of farms producing forage seed in the Statistics Canada Manitoba Agricultural division No. 14 was 16 with the number of acres of forage seed being 52,509 (Statistics Canada 1997). From the same census the number of farms with tame or seeded pasture in the Statistics Canada Manitoba Agricultural division No. 14 was 230 with the total number of acres being 19,707 (Statistics Canada 1997). The same census listed the number of farms with natural land for pasture in the Statistics Canada Manitoba Agricultural division No. 14 as 497 with the total number of acres being 154,682 (Statistics Canada 1996). Native grasses are used for grazing of livestock including cattle and in some instances, native grasses are mixed with tame forage, between 10 to 15% alfalfa, for grazing in pasture areas (Stan Stadnyk 1999).

5.8 Environmental Concerns of Beef Cattle/Forage Operations in the Interlake Region

In the Interlake region, there appears to be a trend of an increase in total farm area, beef cow numbers and area of land used for forage crops production, including the Statistics Canada Agricultural division no. 14. With this increase in total farm area, beef cow numbers and area of land for forage crops production, logically, there should be a corresponding increase in agricultural components or inputs including energy output regarding consumption of petroleum products (gasoline), labour both family and employed, conversion of wild lands into forage crops and cattle pasture and feedlots and cattle manure management. An increase in usage of fertilizers, herbicides, pesticides and fungicides may also occur, however, from conversations with farmers, the application of these chemicals is minimal to avoid toxic accumulations of these chemicals in the forage crops. Therefore, an increase in fertilizers, herbicides, pesticides and fungicides may not significant. An increase in agricultural components could have adverse effects on the environment. Thus, even though beef cattle/forage production can be considered as a conservation practice, particularly the forage component, there are environmental considerations regarding this agricultural practice.

Energy is required to produce forage crops including petroleum products. Emissions from consumption of petroleum products contribute to emissions of greenhouse gases such as carbon monoxide. This implies that forage production contributes to the accumulation of greenhouse gases affecting climate and contributing to global warming. Land is required to seed forage crops. This implies that the conversion of natural habitats to the production of non-native forages crops, thereby reducing amount of available wildlife habitat. Fertilizers, herbicides, pesticides and fungicides are minimally applied to help increase to forage production. This application could lead to the leaching of chemicals from fertilizers, herbicides, pesticides and fungicides in groundwater or surface runoff into neighbouring surface water sources, thereby, reducing water quality. Therefore, forage production can affect climate, wildlife habitat and water quality in a negative fashion.

There are environmental concerns regarding beef cattle production. One concern is the potential accumulation of manure from cattle in a water source used for water consumption by cattle or the surface runoff of ammonia from manure to a nearby water body. There is also the potential of leaching of ammonia from manure into groundwater. This could decrease water quality of water sources. Another concern is that cattle can cause damage to riparian areas surrounding water sources by trampling the vegetation within the riparian area, reducing the availability of wildlife habitat. Another concern is the clearing of trees and shrubs in order to use the land for pastures or feedlots. This clearing would decrease the amount of available wildlife habitat. Cattle also emit methane, a greenhouse gas that affects climate and thus, contributing to the accumulation of greenhouse gases and global warming. Petroleum products are consumed or used in beef cattle production such as during the transporting of cattle from their winter pastures to summer pastures as well as transporting cattle to processing and packaging plants. This consumption of petroleum products contributes to greenhouse gas emissions. Thus, beef cattle production in can also affect water quality, wildlife habitat and climate in a negative fashion.

Chapter Six: Application of Environmental Indicators to Statistics Canada Manitoba Agricultural Division No. 14

6.1 Introduction

There is no prescribed or universal methodology for the usage or selection of sustainability indicators or for any particular type of sustainability. One process described by Environment Canada (1991) as follows:

1) identify societal goals to which the indicators relate;
2) devise a framework within which they operate;
3) identify selection criteria by which to judge potential indicators;
4) consult with data holders, experts and potential users; and
5) verify that the indicators communicate the message effectively to the intended audiences.

For the purpose of this project, a modified version of the above process was used as follows:

1) Identify environmental issues concerning the agricultural practice of beef cattle/forage production;
2) Compile a list of existing environmental and/or agri-environmental indicators;
3) Determine whether any sets of data exist and can be used for indictors in the compiled list in the Statistics Canada Manitoba Agricultural division No. 14;
4) Recommend a list of environmental and/or agri-environmental indicators with sets of data for the Statistics Canada Manitoba Agricultural division No. 14.

6.2 Identifying Environmental Issues for Beef Cattle/Forage Production

The Environmental Indicator Working Group of Agriculture and Agri-Food Canada (1993) released a report, Developing Environmental Indicators for Agriculture for Canada, containing eight environmental issues. These eight environmental issues were used for the development of agri-environmental indicators. A subsequent report, Report of the Consultation Workshop on Environmental Indicators for Canadian Agriculture, narrowed the list to seven environmental issues to be used for the development of agri-environmental indicators. These seven environmental issues were:

1) Agricultural land & soil resources;

2) Surface and ground water quality;
3) Water quantity;
4) Wildlife habitat;
5) Air and climate;
6) Genetic diversity;
7) Agricultural inputs (McRae & Lombardi 1994).

The issue, agricultural inputs, has three sub-issues, nutrient, pesticide and energy input. For this practicum, these sub-issues were treated as individual issues. Therefore, a total of nine environmental issues were identified for the beef cattle/forage production.

These issues were presented to Mr. Stan Stadnyk, an agricultural representative for the Rockwood, Rosser and Woodlands municipalities. Mr. Stadnyk concurred that these environmental issues would be suitable for beef cattle/forage production in the RMs of Rockwood, Rosser and Woodlands.

Farmers who practice cattle/forage operations in the Rockwood, Rosser and Woodlands were also contacted to further determine whether or not the above environmental issues were relevant to cattle/forage operations. Twenty farmers were contacted to participate in a survey regarding the relevance of the environmental issues for cattle/forage operations. Fifteen agreed to participate in the survey and the results are tabulated in Table 1. Due to a confidentiality agreement, the names of the farmers who participated will not be published.

Table 1. Farmer's Survey Results

Environmental Issue	Number of Farmers concurring issue relevant	Percent relevance
Land & soil resources	15	100%
Surface & ground water quality	14	93%
Water quantity	15	100%
Wildlife habitat	8	53%
Air & climate	15	100%
Genetic diversity	14	93%
Agricultural nutrient input	15	100%
Agricultural pesticide input	12	80%
Agricultural energy input	15	100%

From the results, the surveys demonstrate a consensus by all participants that five environmental issues are relevant for cattle/forage operations. There was not consensus by all participants that the other four environmental issues are relevant. However, since all environmental issues were confirmed by a minimal of 53 percent of the participants, environmental indicators will be compiled for all environmental issues.

6.3 Compiling List of Environmental and/or Agri-Environmental Indicators

6.31 Literature Search for Environmental and/or Agri-Environmental Indicators

For each of the stated issues, many environmental and/or agri-environmental indicators have been developed in recent years. Environment Canada published a report of a national set of environmental indicators for Canada (Environment Canada 1991). The province of Alberta has developed a set of sustainability indicators, including environmental (ARTEE 1994). Manitoba Environment published a State of the Environment report containing sustainability indicators, including environmental, for the prairie ecozone (Manitoba Environment 1997). The Environmental Indicator Working Group of Agriculture and Agri-Food Canada developed agri-environmental indicators, indicators that specifically monitor the development of agriculture on the Canadian environment (Environmental Indicator Working Group of Agriculture and Agri-Food Canada 1993). The OECD published a report containing agri-environmental indicators as well (OECD 1997).

From these publications, a list of environmental and agri-environmental indicators was compiled. While compiling the list, similarities between indicators from one record to other records were noted. If two indicators were similar in their data requirements, only one common indicator was included. Irrigation indicators were not included due to the fact that there is little irrigation conducted for beef cattle/forage production in the Rockwood, Rosser and Woodlands municipality (Stan Stadnyk 1999).

6.32 Indicator List

The following environmental indicators were developed for the identified environmental issues concerning beef cattle/forage production.

Table 2. Environmental Indicator List

Issue	Indicator	Data Source
Agricultural land & soil resources	▪ Land in use ▪ Soil/cover management ▪ Adoption of soil conservation practices* ▪ Nutrient balance ▪ Soil contamination ▪ Soil degradation risk ▪ Soil quality* ▪ Crop yield	▪ Statistics Canada
Surface & ground water quality	▪ Pesticide contamination ▪ Agricultural by-products ▪ Fertilizer use intensity ▪ Soil contamination ▪ Soil/cover management ▪ Adoption of soil conservation practices* ▪ Composite pesticide risk ▪ Composite pesticide management ▪ Percentage agricultural land with sub-surface ▪ drainage ▪ Habitat quality* ▪ Nutrient balance* ▪ Water quality/bio-health*	
Water quantity	▪ Moisture stress index ▪ Precipitation ▪ Available soil moisture ▪ Ground water levels	
Wildlife habitat	▪ Habitat availability & fragmentation ▪ Habitat quality* ▪ Wildlife species ▪ Habitat restoration	▪ Manitoba Parks & Protected Areas Branch

	▪ Wildlife species at risk*	
Air & climate	▪ Agricultural greenhouse gas balance ▪ Changes in the agricultural climate ▪ Crop use efficiency ▪ Precipitation	
Genetic diversity	▪ Genetic utilization ▪ Agro-ecosystem biodiversity ▪ Crop & livestock genetic preservation ▪ Beneficial species indicator ▪ Non-crop soil cover	▪ Manitoba Agriculture, Manitoba Crop Insurance Corporation
Agricultural Nutrient input	▪ Fertilizer use intensity* ▪ Nutrient balance* ▪ Nutrient management ▪ Plant nutrient contamination ▪ (of water)	
Agricultural Pesticide input	▪ Composite pesticide management ▪ Pesticide use intensity* ▪ Composite pesticide risk ▪ Composite pesticide use	
Agricultural Energy input	▪ Quantity of fuel use (by type) for field operations/cultivated area/quantity of output and value of product by province ▪ Energy input-output balance ▪ Energy consumption by livestock under confinement/unit of output & value of product by province	

A * indicates that the indicator is from two or more sources.

A total of 41 environmental indicators were compiled, but as noted, an indicator can be used for more than one environmental issue. Table 2 also shows data sources for indicators.

6.4 Sets of Data for Environmental and Agri-Environmental Indicators

From the list of environmental and agri-environmental indicators, availability of any empirical data collected in Statistics Canada Manitoba Agricultural division No. 14 was determined. In addition, the period of time the data has been collected, the area where the data has been collected, the trend displayed in any indicator or whether or not there has been any suitable data sets previously collected which could be used for either environmental and agri-environmental indicators was assessed.

6.5 Data Sources

A challenge of this project was locating empirical data for any of the indicators in the compiled list. The publications of Census of Agriculture by Statistics Canada were researched to locate any environmental data sets that could be used. Other governmental and non-governmental agencies were contacted regarding any potential data sets. Contacts included the Agriculture Canada Land Resource Unit, Canadian Wildlife Service, Manitoba Agriculture, Manitoba Crop Insurance Corporation, Manitoba Department of Conservation, the Reeve of the Rockwood municipality, Manitoba Cattle Producers Association, Manitoba Forage Council and Ducks Unlimited. All were contacted in relation to prospective data sets for environmental indicators of beef cattle/forage production. The following sections summarise available data by source.

Of the 41 indicators, data were located for three indicators, land in use, crop and livestock genetic preservation and wildlife species. Statistics Canada, Manitoba Crop Insurance Corporation, Manitoba Parks and Protected Areas Branch and Manitoba Agriculture provided data that can be used for environmental indicators for beef cattle/forage production.

6.501 Statistics Canada

Statistics Canada has been conducting a National Census of Agriculture, every five years, with 1996 being the last census period. The Census of Agriculture publications for the province of Manitoba has collected some relevant data regarding the agricultural practice. Data sets from Statistics Canada can be used for the land in use indicator of the land and soil issue. Table 3 indicates the number of acres and hectares seeded with tame hay, alfalfa, alfalfa mixtures, alfalfa-grass mixtures and forage seeds in the Statistics Canada Manitoba Agricultural division No. 14. This data can be used to address the environmental indicator, land in use. Table 4 shows the number of acres and hectares for improved pasture and unimproved pastures. This data can also address the land in use indicator.

Statistics Canada contains data concerning fertilizer and pesticide (herbicide, insecticide and fungicide) application. This fertilizer application data could be used for the fertilizer use intensity indicator for the surface and ground water quality and the agricultural nutrient input issues. The pesticide application data could be used for the composite pesticide use indicator for the agricultural pesticide input issues. However, fertilizer and pesticide was applied to all agriculture crops in the division, not just for forage production and can not be directly linked to forage crops. Thus, data for fertilizer and pesticide application from Statistics Canada publications cannot be used for the fertilizer and pesticide indicators since the application data cannot be linked to the forage production.

6.502 Agriculture Canada Land Resource Unit

Dr. Robert Eilers (2000) of the Agriculture Canada Land Resource Unit was contacted regarding potential data/information for the environmental issue of land and soil resources. Dr. Eilers mentioned that provincial soil testing was performed approximately 12 years ago. Currently, any soil testing and analysis conducted on beef cattle/forage lands is performed by farmers who send their soil samples to private laboratories for analysis. This information could be used for the soil quality indicator for the land and soil resources issue. However, this information is confidential and inaccessible to the public and cannot be used at the present time for the soil quality indicator.

6.503 Canadian Wildlife Service

Mr. Ron Bazin (2000) of the Canadian Wildlife Service was contacted concerning information relating to the environmental issue of wildlife habitat. The Canadian Wildlife Service, in conjunction with the US Fish and Wildlife Service, conducts May surveys regarding waterfowl in Manitoba. The US Fish and Wildlife Service performs the aerial surveys, counting and recording waterfowl species and numbers along a stratum, a survey route. The Canadian Wildlife Service performs ground surveys at specific locations along the stratum. The Canadian Wildlife Service performs ground surveys around the Gunton area. Mr. Bazin provided a preliminary list of waterfowl species observed during the surveys at the Gunton area. These waterfowl species observed by the Canadian Wildlife Service are highlighted in Table 19.

These waterfowl species could be used for the wildlife species indicator for the wildlife habitat issue. The waterfowl species were not observed on beef cattle/forage lands. This information cannot be linked to beef cattle/forage operations and cannot be used for the wildlife species indicator.

6.504 Manitoba Agriculture

Mr. Stan Stadnyk (1999) was contacted on the subject of probable data sets of environmental indicators. Mr. Stadnyk is a representative of Manitoba Agriculture for the RMs of Rosser, Woodlands and 60 percent of Rockwood and expressed that there is not any environmental data collecting or monitoring of beef cattle/forage production in the Agricultural division No. 14.

Mr. Stadnyk provided a list of beef cattle breeds in the municipalities. Statistics Canada and the Manitoba Crop Insurance have collected information regarding beef cattle breeds and varieties of forage crops in the three RMs of the Statistics Canada Manitoba Agricultural division No. 14. Table 6 shows beef cattle breeds & forage crop types for the division. Table 6 can be used for the crop & livestock genetic preservation indicator for the genetic diversity issue, providing an index of breeds of beef cattle and types of forage crops used by farmers.

Mr. John Ewanek (1999) is a soil specialist and was contacted on the subject of probable data sets of environmental indicators and is a representative of Manitoba Agriculture stationed in the Selkirk office who was also contacted regarding information for potential data sets of environmental indicators, focusing on environmental issues regarding agricultural land and soil resources. Mr. Ewanek also conveyed that there is no monitoring of soils of beef cattle/forage operations.

6.505 Manitoba Crop Insurance Corporation

Mr. Neil Hamilton (2000), General Manager of the Manitoba Crop Insurance and Mr. Doug Wilcox (2000), Manager of Agronomy and Program Development was contacted regarding for potential data sets for environmental indicators. Mr. Wilcox mentioned an Internet program, Management Plus Program (www.mmpp.com), which allows an individual to search for information regarding crops acreage, crop yield and fertilizer application such as forage crops. Table 5 shows the results of acreage and yield of forage crops seeded in the RMs of Rockwood, Rosser and Woodlands from 1996 to 1997 from the program. This acreage information could be used for the land in use indicator for the land and soil resources issue. The yield information could also be used for the crop yield indicator, also for the land and soil resources issue. Table 5 also shows the fertilizer information concerning application of nitrogen, phosphorus and sulphur in pounds/acre in Rockwood, Rosser and Woodlands municipalities from 1996 to 1997. This data could be used for the fertilizer intensity use indicator for the surface and ground water quality and the agricultural nutrient input issues. However, Mr. Wilcox stated that only 15-20 percent of the Interlake region is insured. The Management Plus Program also has a disclaimer that the fertilizer data has not been verified and the information is to be used only as a planning tool in conjunction with soil tests, common sense and economic experience. Therefore, Table 5 contains only a sample of data/information that could be used for the environmental indicators of land in use, crop yield and fertilizer use intensity in the municipalities. The data is not exact enough to be used for either the land in use, crop yield or fertilizer use intensity indictor.

6.506 Manitoba Department of Conservation

The Manitoba Department of Conservation is an agglomeration of the Sustainable Development Co-ordination Unit, Water Resources Branch, Wildlife Branch, Parks and Protected Areas, Conservation Data Centre, and also regional offices throughout the province. Various professionals within the numerous branches of this Department were contacted regarding any including Mr. Dave Bezak (2000), who was contacted regarding potential data/information for the environmental issue of air and climate. Mr. Bezak mentioned that Manitoba does not collect data concerning greenhouse gases emissions or accumulations. Therefore, there is no relevant data concerning greenhouse gases emissions from beef cattle/forage operations or the impact or effect of this agricultural practice on the agricultural climate.

Mr. Andrew Dickson (2000) of Manitoba Agriculture and Mr. Richard Rentz (2000) of the Manitoba Department of Conservation were contacted regarding the potential data for environmental indicators for land and soil resources. Mr. Rentz mentioned also that any soil testing and analysis conducted on beef cattle/forage lands was performed by farmers themselves by sending their soil samples to private laboratories. This testing was performed mainly to determine soil fertility and this testing was performed in a very irregular basis. The information could be used for the soil quality indicators of the land and soil resources issue. However, this information is private and confidential and currently not available to be used for the soil quality indicator.

With the Manure Act, farmers whose livestock operations over 400 animal units are required to submit a manure management plan to the province. A requirement of this management plan, soil testing and analysis has to be performed by livestock operators and the results submitted to the provincial government. This information could be used for the nutrient management indicator for the agricultural nutrient input issue. Currently, this information is also confidential and inaccessible by the public. Therefore, any information that could be used for the soil quality and nutrient management indicator indicators for beef cattle/forage production areas lands are presently inaccessible.

Mr. Dave Green (2000) of the Manitoba Department of Conservation was contacted regarding potential data/information for the environmental issue of surface and ground water quality. Mr. Green mentioned that any testing of surface water quality and water resources on beef cattle/forage lands, such as dugouts, is not performed by the province. Farmers collect water sample and has the quality tested and analysed at private laboratories, and this testing is probably performed very sporadically. This information could be used for the water quality indicator for the surface and ground water quality issue. However, any information regarding water quality is also private, confidential and inaccessible. Thus, any information that could be used for the water quality indicator on beef cattle/forage lands is currently unavailable for use.

Surface water quality sampling is conducted in various stations in the Interlake region. This information could potentially also be used for the water quality indicator. However, Mr. Green also mentioned that it would be difficult to link the impact of beef cattle/forage operations on water quality.

Mr. Robert Witzke (2000) of the Manitoba Department of Conservation was contacted regarding data/information regarding the agricultural energy input issue. Mr. Witzke mentioned that any data energy consumption or usage that has been collected for the province, thus, it is not feasible to link this directly to beef cattle/forage operations. Mr. Witzke also mentioned that the department is focusing on energy policy rather than data collection. Therefore, any environmental data regarding quality of energy cannot be linked directly to the beef cattle/forage operations.

5.5061 Manitoba Sustainable Development Co-ordination Unit

The office of the Manitoba Sustainable Development Co-ordination Unit (1999) was contacted concerning information for possible data sets for environmental indicators. This is a provincial government organisation involved in public participation and consultations relating to projects involving research for sustainable development. This organization does not conduct any environmental data collection that could be used for environmental indicators for beef cattle/forage production.

6.5062 Manitoba Water Resources Branch

Mr. Alfred Warkentin (2000) and Mr. Anderson Premdas (2000) of Manitoba Water Resources Branch were contacted regarding data concerning environmental indicators for the water quantity issue. Mr. Premdas provided precipitation data from monitoring sites in Gimli, Grosse Isle, Stonewall and Winnipeg. Since the Information Bulletins for the RMs of Rockwood, Rosser and Woodlands used precipitation data from these monitoring sites for the RMs, the data could also be used for the precipitation indicator for beef cattle/forage operations in each RM. This precipitation data could be used for the precipitation indicator for the water quantity and air and climate issues.

Figure 10 show precipitation levels from the Gimli monitoring site from January 1, 1960 to December 31, 1971. This could be used for the precipitation indicator of beef cattle/forage operations in the northern section of the RM of Rockwood. Figure 11 shows precipitation levels from the Stonewall monitoring station from January 4, 1960 to September 30, 1991. This could be used for the precipitation indicator of beef cattle/forage operations in the southern section of the RM of Rockwood and also for the entire RM of Woodlands. Figure 12 shows precipitation levels from the Grosse Isle monitoring station from November 6, 1964 to November 31, 1995. This data could be used for the precipitation indicator of beef cattle/forage operations in the northern section of the RM of Rosser. Figure 13 shows precipitation levels from a Winnipeg monitoring station at the international airport from January 1, 1960 to June 30, 1994 and could be used for the precipitation indicator of beef cattle/forage operations in the southern section of the RM of Rosser. However, there has not been any precipitation data measured in relation to beef cattle/forage production lands. The precipitation data that has been previously collected cannot be linked to the agricultural practice. Thus, precipitation data already recorded can be used on a land area basis.

Mr. Bob Betcher (1999) and Mr. Chris Romano (2000) of Manitoba Water Resources Branch were contacted concerning information regarding to prospective data sets of environmental indicators, focusing on the environmental issues of surface and ground water quality and water quantity. Mr. Betcher and Mr. Romano mentioned that there are monitoring stations for ground water levels and quality in the RM s of Rockwood, Rosser and Woodlands. This information regarding ground water levels could be used for the ground water levels indicator for the water quantity issue.

There are 35 observation wells in the Rockwood, Rosser and Woodland municipalities. A daily measurement of ground water levels and a daily measurement of ground water levels are taken from these wells. However, 34 of these observation stations are located on Crown land while the other one is located on private property in Winnipeg. In the Interlake region, the public relies on ground water aquifers for their daily consumption of water. It would be very difficult to link the data collected at these observation wells to rates of consumption by beef cattle/forage operations in the municipalities. It may be more feasible to use this data concerning ground water levels on a land area basis rather than a specific agricultural level since there has not been any collection of data concerning ground water levels and consumption from beef cattle/forage operations.

Mr. Betcher also mentioned that there is some sampling from these stations concerning ground water quality, but it is performed very sporadically. The information regarding monitoring ground water quality could also be used for the water quality indicator for the surface and ground water quality issue. He also mentioned it would not be possible to link the impact of beef cattle/forage operations on ground water. Therefore, any data regarding ground water quality cannot be linked directly to beef cattle/forage operations.

6.5063 Manitoba Wildlife Branch

Ms. Janet Moore (1999) of the Manitoba Wildlife Branch was contacted in relation to data sets for environmental indicators for the wildlife habitat issue. Ms. Moore mentioned that a vegetation inventory was conducted in the RM of Rosser, but there were no surveys conducted in the RMs of Rockwood or Woodlands. Some of the vegetation surveys conducted for the inventory were performed on beef cattle/forage land, such as pastures. This information can address the wildlife species indicator for the wildlife habitat issue. However, this information applies to beef cattle/forage lands only in the RM of Rosser.

6.5064 Manitoba Parks and Protected Areas Branch

Mr. Roger Schroeder (2000) and Ms. Maureen Peniuk (2000) of the Manitoba Department of Parks and Protected Areas were contacted regarding potential data/information regarding wildlife habitat issue. Ms. Peniuk mentioned that there are no parks, protected areas or ecological reserves in the Rockwood, Rosser and Woodlands municipalities. Ms. Peniuk supplied the document containing a vegetation inventory of the RM of Rosser mentioned in section 6.509. The Critical Wildlife Habitat Program performed this vegetation inventory in the summer of 1998 and 1999. Landowner permission was acquired to perform these vegetation surveys on various properties in the Rosser municipality. Table 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 contains species list of native and non-native vegetation species surveys on various sites in the RM of Rosser. Table 17 contains species list of animal sightings during the surveys. These surveys were performed at locations in the Rosser municipality sites and some of locations were parcels of land pasture, grazing, haying or former pastures. Therefore, the data in Tables 7-17 can address the wildlife species indicator.

6.5065 Manitoba Conservation Data Centre

Mr. Francois Blouin (2000), the Information Manager for the Manitoba Conservation Data Centre, was contacted regarding data/information concerning the wildlife habitat issue. Table 18 contains a list of wildlife species at risk in the Interlake region with their provincial status ranking. This information could be used for the wildlife species at risk indicator. However, the impact of beef cattle/forage operations cannot be directly linked or measured on the species in Table 18 in the Rockwood, Rosser and Woodlands municipalities. Thus, this information cannot be connected directly to beef cattle/forage operations and cannot be used as a wildlife species indicator for beef cattle/forge operations.

The Manitoba Conservation Data Centre also has a website containing vegetation and animal species present in the province of Manitoba. This information could potentially be used for wildlife species indicator. However, this information cannot be linked to the presence of wildlife species on beef cattle/forage areas in the RMs of the Statistics Canada Manitoba Agricultural division No. 14. Thus, the information for the wildlife species indicator cannot be linked to beef cattle/forage operations; however, this information is applicable on a land area basis.

6.5066 Manitoba Department of Conservation, Gimli office

Mr. Gene Collins (2000), a Regional Wildlife Specialist stationed in the Gimli office, was contacted regarding any potential data sets for the environmental issue of wildlife habitat. He mentioned that any inventory work performed by the Department concerning vegetation and animal species is conducted on Crown land. Thus, any data pertaining to vegetation and animal species cannot be linked to beef cattle/forage operations. The data collected on Crown land could be used on a land area basis.

6.507 Reeve of the Rockwood Municipality

Mr. Leon Vandekerckhove (1999), the Reeve of the RM of Rockwood was contacted on the topic of potential data sets of environmental indicators. Mr. Vandekerckhove mentioned that the RM of Rockwood does not partake in any environmental data collection. This office does not conduct in any environmental data collection that could be used for environmental indicators for beef cattle/forage production.

6.508 Manitoba Cattle Producers Association

Ms. Wanda McFadyen (1999) of the Manitoba Cattle Producers was contacted regarding information for potential data sets for environmental indicators. The Manitoba Cattle Producers is a non-government organization involved with public participation and conducts consultation workshops. The Association also works with government organizations and non-government organizations on joint projects regarding cattle research. This organization does not partake in any environmental data collection that could be used for environmental indicators for beef cattle/forage production.

6.509 Manitoba Forage Council

Mr. George Bonnefoy (1999) of the Manitoba Forage Council was contacted in relation to prospective data sets for environmental indicators. The Manitoba Forage Council is also a non-government organization who works with other government and non-government agencies on co-operative projects regarding forage research. This organization also does not partake in any environmental data collection that could be used for environmental indicators for beef cattle/forage production.

6.5010 Ducks Unlimited

Dr. Henry Murkin (2000) was contacted regarding data/information for the environmental issue of wildlife habitat. Dr. Murkin mentioned a study performed in the late 1980s by Ducks Unlimited concerning the impact of nutrient addition to wetlands in the Interlake region. These experiments were performed in the Narcisse Wildlife Management Area. He also mentioned a study performed in the mid-1980s concerning an evaluation of five wetlands on crown land near the Narcisse Wildlife Management Area in the Interlake region by Ducks Unlimited, outside of the boundaries of Statistics Canada Manitoba Agricultural division No. 14. The information from these studies could be used for the wildlife species indicator.

Table 19 shows the aquatic bird species observed in the five wetlands in 1984 and 1985. These species were observed on wetlands on Crown land, not on beef cattle/forage production areas. This information regarding wildlife species cannot be linked to beef cattle/forage production; however, this information can be used on a land area basis. Any information regarding vegetation species catalogued in the wetlands in 1984 and 1985 can also be used on a land area basis.

6.6 Outcome of Data Search

Data were located for three environmental indicators for beef cattle/forage production in the Statistics Canada Manitoba Agricultural division No. 14:

1) Land in use for forage crops and pasture (Land in use indicator) (Tables 3 & 4);
2) Breeds of beef cattle and variety of forage crops (Crop & livestock genetic preservation indicator) (Table 6);
3) Presence of vegetation species and one avian species observed, killdeer (*Charadrius vociferus*) in land used for beef cattle/forage production (Wildlife species indicator) (Tables 7-17).

Other results of the research for environmental data sets demonstrated that there are other data sets available from other sources including the Manitoba Department of Conservation, Manitoba Water Resources Branch, Ducks Unlimited and Canadian Wildlife Service. However, the data from these sources is not specific enough to be used for the environmental indicators for beef cattle/forage production in the Statistics Canada Manitoba Agricultural division No. 14. Other sources such as Statistics Canada, contained data regarding fertilizer and pesticide application in the division, but the data is also not specific enough to be used for beef cattle/forage production. In other cases, the environmental data is inaccessible because the data is privately collected and analysed by beef cattle/forage operators and is not available to the public.

Chapter Seven: Conclusions and Recommendations

7.1 Feasibility of Environmental Indicator Usage for a Specific Agriculture Practice

A great deal of difficulty exists in applying environmental indicators for a specific agricultural practice, relying on previously collected data based on the results for this project. Data sets were located for only 3 out of 41 indicators for the agricultural practice of beef cattle/forage production in Statistics Canada Manitoba Agricultural division no.14.

The data for the first applicable indicator, land in use, are from Census of Agriculture section of Statistics Canada which is Census performed every 5 years. Available data for this indicator are from 1976 to 1996, concerning acreage/hectares of forage varieties in Table 3 and acreage/hectares of lands for pasture in Table 4. However, there are only 5 data points per table. Therefore, the available data for this indicator is limiting due to the fact there are few data points, only 5.

The data for the second applicable indicator, breeds of beef cattle and types of forage crops for crop and livestock genetic preservation indicator are listed in Table 6. In Table 6, there is only one data point for the cattle breeds from Manitoba Agriculture while there only 5 data points for the types of forage crops from Census of Agriculture section of Statistics Canada. Therefore, the available data for this indicator is limiting due to the fact there are also a low number of data points.

The data for the third applicable indicator, wildlife species, consist of the presence of vegetation species and one avian species observed in land used for beef cattle/forage production. This information has been collected only in the last 2 years and there have not been any data collected concerning population numbers or distribution of these vegetation species and the avian species. Therefore, the available data for this indicator is limiting due to the fact there are few data points, only 2. In conclusion, previously collected environmental data were found for only three indicators for assessing environmental sustainability of beef cattle/forage production. The available data for the land in use and crop and livestock genetic preservation indicator are limited since there are few data points. The data available for the third indicator, wildlife species, consist of only the presence of vegetation species and one avian species. There is no data available concerning the population or distribution of vegetation species. Thus, there are too few indicators that can be used to monitor/assess environmental sustainability of beef/cattle forage production due to limited data information. Therefore, it is not feasible to use environmental indicators to monitor/assess environmental sustainability of beef cattle/forage production.

7.2 Benefits of Study

One positive aspect of this study is that it has been determined that environmental indicators cannot be used to monitor/assess environmental sustainability of beef cattle/forage production using previously collected data. Another positive aspect of this study is that it highlighted the difficulties in applying indicators to a specific agricultural practice including:

- the level of which the available data were collected cannot be focused enough to be used for a specific agricultural practice, more suited to be used on a different level, such as land area basis; and
- a lack of historic data or little data collection;
- data inaccessibility.

Therefore, it is not feasible to use environmental indicators to monitor/assess environmental sustainability of a single agricultural practice using previously collected data. However, it could be possible to use environmental indicators to monitor/assess environmental sustainability of all agriculture practices instead of a single agricultural practice.

7.3Recommendations

7.31 Assessment of Environmental Sustainability of all Agricultural Practices

It is recommended that environmental indicators should not be used to monitor environmental sustainability of a single agricultural practice. There appears to be an interest to use environmental indictors for agriculture, therefore, it appears to be more feasible to use environmental indicators to monitor/assess all agricultural practices in a particular region.

7.32 Methodology for the Usage of Environmental Indicators

The following methodology can be used to monitor/assess the progress of all agricultural practices using environmental indicators towards the goal of environmental sustainability:

1) Identify all stakeholders involved in all agricultural practices in study region;
2) Through consensus from all participating stakeholders, identify the environmental issues concerning agricultural practices;
3) Stakeholders develop indicators that will monitor/assess progress of agricultural practices towards the objective of environmental sustainability;
4) Stakeholders identify and review previous collected data and/or collect the data/information per indicator and analyze the trend from the data/information in the indicator;
5) From the analysis of the trends in the indicators, stakeholders assess whether or not if there is progress towards the goal of environmental sustainability;
6) From the assessment of progress towards environmental sustainability, stakeholders can make effective and efficient decisions regarding what steps should be taken to attain the goal of environmental sustainability.

7.4 Future Research Studies

The following research studies are recommended for future research:

1) The methodology proposed in section 7.32 could be used to develop a list of environmental indicators for agriculture in the Interlake region of Manitoba. This list of environmental indicators could be used to determine whether agriculture is being conducted in an environmentally sustainable basis in this region. It would also determine the feasibility of using the methodology proposed in section 7.32 to develop environmental indicators for agriculture in the Interlake region.
2) The methodology proposed in section 7.32 could be also used to develop a list of economic and social indicators for agriculture in the Interlake region of Manitoba. This list of economic and social indicators could be used to determine whether agriculture is being performed on a

sustainable economic and social basis in this region. This could possibly indicate the feasibility of the methodology proposed in section 7.32 in developing economic and social indicators for agriculture in the Interlake region.

3) The methodology proposed in section 7.32 could be used to develop a list of environmental, economic and social indicators for agriculture in other regions of southern Manitoba. This list of environmental, economic and social indicators could be used to determine whether agriculture is being conducted on a sustainable environmental, economic and social basis in other regions of southern Manitoba. This should determine the feasibility of the methodology proposed in section 7.32 in developing environmental, economic and social indicators for agriculture in other regions of southern Manitoba.

Literature Cited

Aaker, Jerry. 1994. Livestock for a Small World: The Role of Animals in a Just and Sustainable World. Contributors: James DeVries, Dan Gudahl, Jim Hoey, Robert K. Pelant and Jennifer Shumaker. Seven Locks Press. Washington, D.C. 110 pp.

Acton, D. F. 1995. Development and Effects of Farming in Canada IN The health of our soils: Toward sustainable agriculture in Canada. Centre for Land and Biological Resources Research, Research Branch. Agriculture and Agri-Food Canada. Ottawa, Ontario. pp. 11-19.

Acton, D. F. and L. J. Gregorich. 1995. Understanding Soil Health IN The health of our soils: Toward sustainable agriculture in Canada. Centre for Land and Biological Resources Research, Research Branch. Agriculture and Agri-Food Canada. Ottawa, Ontario. pp. 5-11.

Agricultural Guidelines Development Committee. 1994. Farm Practices Guidelines for Beef Producers in Manitoba. Manitoba Agriculture. Winnipeg, Manitoba. 62 pp.

Anderson, Bill. 1994. Sustainable Agriculture Development and the Environment: Toward an Optimal Solution: a Report on Global Resource Use Issues. Agricultural Institute of Canada. Ottawa, Ontario. 32 pp.

Anderson, Jay. 1997. Biophysical Sustainability in a Mountain Ecosystem: Resource Use in the Columbia River Valley. Natural Resources Institute. University of Manitoba. Winnipeg, Manitoba. 137 pp.

Armitage, David G. 1990. Forage Production in the Interlake region of Manitoba. The Department of Geography. University of Manitoba. Winnipeg, Manitoba. 160 pp.

ARTEE (Alberta Round Table on Environment and Economy). 1994. Creating Alberta's Sustainable Development Indicators. Environment Council of Alberta. Edmonton, Alberta. 35 pp.

Baydack, Richard K., James H. Patterson, Clayton Rubec, Allen Tyrchniewicz and Ted W. Wiens. 1995. Management Challenges for Canadian Prairie Grasslands in the 21st Century. Transactions of the Sixtieth North American Wildlife and Natural Resources Conference. pp. 386-396.

Beacom, S. E. 1991. Forage Crops in the Aspen Parklands of Western Canada "Feeding Forage Crops". Research Branch. Agriculture Canada. Ottawa, Ontario. 109 pp.

Bergh, Jeroen C. J. M. van den and Jan van der Straaten. 1994. The Significance of Sustainable

Development for Ideas, Tools and Policy IN Toward Sustainable Development: Concepts, Methods and Policy. Jeroen C. J. M. van den Bergh and Jan van der Straaten eds. International Society for Ecological Economics. Island Press. Washington, D.C. pp. 1-22.

Berkes, F., G. S. Chauhan, I. Davidson-Hunt, K. Davidson-Hunt, C. Duffield, J. S. Gardner, L. Ham, B. W. Pandey, J. Sinclair, R. B. Singh and M. Thakur. 1995. Sustainability of a Mountain Watershed Ecosystem in the Himachal Pradesh Himalaya: Background and Overview. Technical Report No. 1. University of Manitoba. Winnipeg, Manitoba. 19 pp.

Bird, Peter M. 1986. State of the Environment report for Canada. Environment Canada. Ottawa, Canada. 263 pp.

Bregha, Francois. 1993. Reporting on Sustainable Development in Support of National Decision-Makers. National Round Table on the Environment and the Economy. Ottawa, Ontario. 37 pp.

Brundtland, Gro Harlem. 1991. Sustainable Development: The Challenges Ahead IN Sustainable Development. Olav Stokke ed. Frank Cass and Company Limited. London, England. pp. 32-42.

Canada, Government of Canada. 1990. Canada's Green Plan: Canada's Green Plan for a healthy environment. Ottawa, Ontario. 174 pp.

Canada. 1995. Report of Canada to the United Nations Commission on Sustainable Development. Minister of Supply and Services Canada. Ottawa, Ontario. 88 pp.

Canada. 1997. Building Momentum: Sustainable Development in Canada. Department of Foreign Affairs and International Trade. Ottawa, Ontario. 21 pp.

Canada, Agriculture and Agri-Food Canada. 1997a. Agriculture in Harmony with Nature: Strategy for Environmentally Sustainable Agriculture and Agri-Food Development in Canada. Agriculture and Agri-Food Canada. Ottawa, Ontario. 72 pp.

Canada, Agriculture and Agri-Food Canada. 1997b. Profile of Production Trends and Environmental Issues in Canada's Agriculture and Agri-food Sector. Agriculture and Agri-Food Canada. Ottawa, Ontario. 46 pp.

Canada's Beef Cattle Producers. 1993. The Canadian Cattle Industry and the Environment. Agriculture Canada. Ottawa, Ontario. 24 pp.

Canada, Regional Economic Expansion. 1978. FRED: 1967 –1977, A Decade of Development in the Interlake/Regional Economic Expansion, Manitoba Department of Agriculture. Manitoba Department of Agriculture. Winnipeg, Manitoba. 60 pp.

Carroll-Foster, Theodora. 1993. A guide to Agenda 21: Issues, Debates and Canadian Initiatives. International Development Research Centre. Ottawa, Ontario. 124 pp.

Clay, R. T. and S. Nickels. 1986. 1985. Progress Report Interlake, Manitoba. Biological Services Group. Unpublished report. Ducks Unlimited Canada. 35 pp.

Clay, Robert T. 1987. Final Complete Project Evaluation Report for the Interlake Biome of Manitoba. Biological Services Group. Unpublished report. Ducks Unlimited Canada. 53 pp.

Clement, Philippe, S. R. L. 1993. National Overview of Strategic Planning of Sustainable Development in Canada's Provinces and Territories. National Round Table on the Environment and the Economy. Ottawa, Ontario. 16 pp.

Crown, Robert W. and Earl O. Heady. 1972. Policy Integration in Canadian Agriculture. The Iowa State University Press. Ames, Iowa. 238 pp.

Dahl, Arthur Lyon. 1995. Measuring the unmeasurable. Our Planet 8:29-33.

Dakers, Sonya. 1992. Sustainable Agriculture: Future Dimensions. Science and Technology Division. Minister of Supply and Services Canada. Ottawa, Ontario. 27 pp.

Davies, H., K. Muzyk and E. Reimer. 1999. Rural Municipality of Rosser: Natural Resources Survey. Critical Wildlife Habitat Program. Manitoba Department of Natural Resources. Winnipeg, Manitoba.

Duffield, Colin E. 1995. Sustainability Indicators for villages in forested mountain watersheds: Upper Beas River Himachal Pradesh, India. Natural Resources Institute. University of Manitoba. Winnipeg, Manitoba. 138 pp.

Dumanski, J., L. J. Gregorich, V. Kirkwood, M. A. Cann, J. L. B. Culley and D.R. Coote. 1994. The Status of Land Management Practices on Agricultural Land in Canada. Research Branch Technical Bulletin 1994-3E. Agriculture and Agri-Food Canada. Ottawa, Ontario. 46 pp.

Ekins, Paul. 1994. The Environmental Sustainability of Economic Processes: A Framework for Analysis IN Toward Sustainable Development: Concepts, Methods and Policy. Jeroen C. J. M. van den Bergh and Jan van der Straaten eds. International Society for Ecological Economics. Island Press. Washington, D.C. pp. 25-55.

Environment Canada. 1991. A report on Canada's Progress towards a National set of Environmental indicators. SOE Report No. 91-1. State of the Environment Reporting. Environment Canada. Ottawa, Ontario. 98 pp.

Environmental Indicator Working Group of Agriculture and Agri-Food Canada. 1993. Developing Environmental Indicators for Agriculture. Agri-Environmental Indicator Project. Report No. 1. Agriculture and Agri-Food Canada. Ottawa, Ontario. 29 pp.

Faculty of Agricultural and Food Sciences, University of Manitoba. 1994. Sustainability of Canada's Agri-Food System – A Prairie Perspective. International Institute for Sustainable Development. Winnipeg, Manitoba. 168 pp.

Faeth, Paul. 1997. Sustainability and U.S. Agriculture IN Frontiers of Sustainability: Environmentally Sound Agriculture, Forestry, Transportation and Power Production. Dower, Roger, Daryl Ditz, Paul Faeth, Nels Johnson, Keith Kozloff and James J. MacKenzie eds. World Resources Institute. Island Press. Washington, D.C. pp. 47-120.

Francis, Charles A. and Garth Youngberg. 1990. Sustainable Agriculture—An Overview IN Sustainable Agriculture in Temperate Zones. John Wiley & Sons Inc. New York, Chichester, Brisbane, Toronto, Singapore. pp. 1-16.

Gabor, T. Shane. 1991. Nutrient Addition Experiments in the Interlake Region of Manitoba: Effect of Single Pulse Addition in Spring. Department of Renewable Resources. McGill University. Montreal, Quebec. 88 pp.

Gabor, T. S., H. R. Murkin, M. P. Stainton, J. A. Boughen and R. D. Titman. 1994. Nutrient additions to wetlands in the Interlake region of Manitoba, Canada: effects of a single pulse addition in spring. Hydrobiologia 279/280:497-510.

Gibbons, Jack, Paul Muldoon and Marcia Valiante. 1989. Sustainable Development: Its Implications for Energy Policy in Canada. The Canadian Institute for Environmental Law and Policy. Toronto, Ontario. 36 pp.

Giles, Jack. 1968. ARDA in Manitoba. Minister of Agriculture. Winnipeg, Manitoba. 47 pp.

Gillies, Ian and Paul Nickel. 1977. Regional Development in Manitoba's Interlake Designing, Managing and Evaluating a Regional Plan IN Regional Development in Manitoba's Interlake: Two Perspectives. Ian Gillies and Paul Nickel eds. University of Manitoba. Winnipeg, Manitoba. pp 1-119.

Girt, J. 1990. Common Ground: Recommendations for Policy Reform to integrate Wildlife habitat, Environmental and Agricultural Objectives on the Farm. Wildlife Habitat Canada. Ottawa, Ontario. 56 pp.

Government of Canada. 1991. The state of Canada's environment. Environment Canada. State of the Environment Reporting. Ottawa, Ontario.

Government of Canada. 1996. The state of Canada's environment. Environment Canada. State of the Environment Reporting. Ottawa, Ontario.

Government of the Federal Republic of Germany. 1997. Towards Sustainable Development in Germany. Federal Ministry for the Environment. 86 pp.

Gregorich, L. J. 1995. Introduction IN The health of our soils: Toward sustainable agriculture in Canada. Centre for Land and Biological Resources Research, Research Branch, Agriculture and Agri-Food Canada. Ottawa, Ontario. pp. 1-3.

Gross, A. T. H. 1975. Forage varieties for hay and pasture. Manitoba Agronomists' Annual Conference. pp. 34-41.

Guttormson, Kim. 1998. The Interlake IN The Way We Live. Winnipeg Free Press. Winnipeg, Manitoba. pp. 62-87.

Hardi, Peter and Laszlo Pinter. 1995. Models and Methods of Measuring Sustainable Development Performance. International Institute for Sustainable Development. Winnipeg, Manitoba. 34 pp.

Hardi, Peter, Stephen Barg, Tony Hodge and Laszlo Pinter. 1997. Measuring sustainable development: review of current practice. Industry Canada. Ottawa, Ontario. 124 pp.

Harwood, Richard. R. 1992. A History of Sustainable Development IN Sustainable Agricultural Systems. Clive A. Edwards, Rattan Lal, Patrick Madden, Robert H. Miller and Gar House eds. Soil and Water Conservation Society. Ankeny, Iowa. pp. 1-20.

Herdt, R. W. and R. A. Steiner. 1995. Agricultural Sustainability: Concepts and Conundrums IN Agricultural Sustainability: Economic, Environmental and Statistical Considerations. V. Barnett, R. Payne and R. Steiner eds. John Wiley & Sons Ltd. Chichester, New York. pp. 3-13.

Horner, W. H., J. A Brown, J. C. Gilson, G. Lee, F. V. MacHardy, H. D. McRorie and C. L. Sibbald. Western Canadian Agriculture to 1990: A Canadian West Foundation Special Task Force Report. Canada West Foundation. Calgary, Alberta. 302 pp.

Howarth, R. E. and B. P. Goplen. 1987. Forages on the Prairies. Agrologist 16:15-16.

IISD, Pro-Habitat and S2. 1997. Communities for Environmentally Sustainable Development. Final Report to the Commission on Environmental Cooperation. The International Institute for Sustainable Development (Canada), Pro Habitat (Mexico), Sustainable Seattle (United States of America). 54 pp.

IISD. 1999a. About IISD. Available: http://iisd.ca.

IISD. 1999b. Great Plains Program. Available: http://iisd.ca/about/gplains.htm.

IISD. 1999c. Measurements & Indicators Program. Available: http://iisd.ca/about/m&i.htm.

Jacobs, Michael. 1993. The Green Economy: Environment, Sustainable Development and the Politics of the Future. UBC Press. Vancouver, British Columbia. 312 pp.

Janzen, H. H., R. L. Desjardins, J. M. R. Asselin and B. Grace. 1998. The health of our air: toward sustainable agriculture in Canada. Research Branch. Agriculture and Agri-Food Canada. Ottawa, Canada. 98 pp.

Johnson, A. M. 1978. Forage Seed Production in Manitoba. Manitoba Agronomists' Annual Conference. pp. 63-66.

Kerr, A. 1994. National Environmental Indicators: Summary Status Report. Environment Canada.

Ottawa, Canada. 4 pp.

Knutson, Ronald D., J. B. Penn and William T. Boehm. 1990. Agricultural and Food Policy. Prentice-Hall Inc. Englewood Cliffs, New Jersey. 437 pp.

Kraft, Daryl F. and Terry Lynn McPhee. 1995. An Analysis of How Transportation and Agricultural Subsidies Affect Prairie Land Use and the Beef Cattle Industry. University of Manitoba. Winnipeg, Manitoba. 90 pp.

Land Resource Unit, Department of Soil Science and Manitoba Soil Resource Section. 1999a. Rural Municipality of Rockwood: Information Bulletin 99-11. Agriculture and Agri-Food Canada, Research Branch, Brandon, Manitoba, Faculty of Agriculture and Food Science, University of Manitoba, and Manitoba Agriculture. Winnipeg, Manitoba. 26 pp.

Land Resource Unit, Department of Soil Science and Manitoba Soil Resource Section. 1999b. Rural Municipality of Rosser: Information Bulletin 99-4. Agriculture and Agri-Food Canada, Research Branch, Brandon, Manitoba, Faculty of Agriculture and Food Science, University of Manitoba, and Manitoba Agriculture. Winnipeg, Manitoba. 26 pp.

Land Resource Unit, Department of Soil Science and Manitoba Soil Resource Section. 1999c. Rural Municipality of Woodlands: Information Bulletin 99-12. Agriculture and Agri-Food Canada, Research Branch, Brandon, Manitoba, Faculty of Agriculture and Food Science, University of Manitoba, and Manitoba Agriculture. Winnipeg, Manitoba. 26 pp.

Lautenschlager, R. A. 1998. From rhetoric to reality: using specific environmental concerns to identify critical sustainability issues. Ecosystems 1:176-182.

MacGillivray, Alex. 1991. Assessment Principle #7: Effective Communication IN Assessing Sustainable Development: Principles in Practice. Peter Hardi and Terence Zdan eds. International Institute for Sustainable Development. Winnipeg, Manitoba. 166 pp.

MacRae, Rod J., Stuart B. Hill, Guy R. Mehuys and John Henning. 1990. Farm-Scale Agronomic and Economic Conversion from Conventional to Sustainable Agriculture. Advance in Agronomy 43:155-198.

Manitoba Agriculture. 1982. 100 years of Agriculture in Manitoba 1881 to 1980. A Statistical Profile. Manitoba Agriculture. Winnipeg, Manitoba. 128 pp.

Manitoba Agriculture. 1998. Manitoba Agriculture Yearbook, 1998. Manitoba Agriculture. Winnipeg, Manitoba. 195 pp.

Manitoba Environment. 1993. State of the Environment, report for Manitoba: Conditions and Trends, Facts and Figures, Problems and Solutions. Manitoba Environment. Winnipeg, Manitoba. 167 pp.

Manitoba Environment. 1995. State of the Environment, report for Manitoba: Focus on Agriculture. Manitoba Environment. Winnipeg, Manitoba. 183 pp.

Manitoba Environment. 1997. State of the Environment, report for Manitoba: Moving toward Sustainable Development Reporting. Manitoba Environment. Winnipeg, Manitoba. 174 pp.

Manitoba Interlake Study Team. 1968. Manitoba Interlake Land Allocation Study. Manitoba Government. Winnipeg, Manitoba. 55 pp.

Manitoba Round Table on Environment and Economy. 1990. Towards a Sustainable Development strategy for Manitobans. Development in Harmony with Our Environment. Manitoba Government. 32 pp.

Marquardt, Martin. 1971. The Interlake: A Land and its People. 93 pp.

May, Cheryl. 1981. Cattle Management. Reston Publishing Company, Inc. Reston, Virginia. 333 pp.

McEwen, F. L. 1990. Opening Comments IN Sustainable Agriculture: Its Policy Effects on the Future of Canada and Ontario's Agrifood System. Department of Agricultural Economics and Business, University of Guelph. Guelph, Ontario. pp. 1-6.

McPhee, Terry Lynn. 1996. Prairie Agricultural Production Decisions Under Changing Grain Transportation Policies and Safety Net Support Levels. University of Manitoba. Winnipeg, Manitoba. 165 pp.

McRae, Terence and Nadia Lombardi. 1994. Report of the Consultation Workshop on Environmental Indicators for Canadian Agriculture. Agri-Environmental Indicator Project. Report No. 2. Agriculture and Agri-Food Canada. Ottawa, Ontario. 79 pp.

McRae, T., N. Hillary, R. J. MacGregor and C. A. S. Smith. 1995a. Role and Nature of Environmental Indicators in Canadian Agricultural Policy Development. Agri-Environmental Indicator Project. Report No. 7. Agriculture and Agri-Food Canada. Ottawa, Ontario. 32 pp.

McRae, T., N. Hillary, R. J. MacGregor and C. A. S. Smith. 1995b. Design and Development of Environmental Indicators with reference to Canadian Agriculture. Agri-Environmental Indicator Project. Report No. 9. Agriculture and Agri-Food Canada. Ottawa, Ontario. 32 pp.

Milon, J. Walter and Jason F. Shogren. 1995. Economics, Ecology, and the Art of Integration IN Integrating Economic and Ecological Indicators: Practical methods for Environmental Policy Analysis. J. Walter Milon and Jason F. Shogren eds. Praeger Publishers. Westport, Connecticut. pp. 3-9.

Morita, Tsuneyuki, Yasuko Kawashima and Isamu Inohara. 1993. Sustainable Development – its definitions and goals. Mita Gokkai Zasshi 85(4):1-22.

Murkin, Henry R., Michael P. Stainton, John A. Boughen, J. Bruce Pollard and Rodger D. Titman.

1991. Nutrient Status of Wetlands in the Interlake Region of Manitoba, Canada. Wetlands11(1):105-122.

National Round Table on the Environment and the Economy. 1991. Discussions on Decision Making Practices for Sustainable Development. National Round Table on the Environment and the Economy. Ottawa, Ontario. 134 pp.

National Round Table on the Environment and the Economy. 1993. Toward Reporting Progress on Sustainable Development in Canada, Report to the Prime Minister. Ottawa, Ontario. 52 pp.

Neave, Peter and Erin Neave. 1998. Agroecosystem Biodiversity Indicator: Habitat Component. Review and Assessment of Concepts and Indicators of Wildlife Habitat and Habitat Availability in the Agricultural Landscape: Concept Paper. Agri-Environmental Indicator Project. Report No. 26. Agriculture and Agri-Food Canada. Ottawa, Ontario. 88 pp.

Neumann, A. L. and Keith S. Lusby. 1996. Beef Cattle. Eighth Edition. John Wiley & Sons Inc. New York, Chichester, Brisbane, Toronto, Singapore. 326 pp.

Nickel, J. G. and W. L. Pringle. 1983. Forage production and potential from fringe are of the Prairie Provinces IN Proceedings of the National Forage Symposium 1981. Agriculture Canada. Ottawa, Canada. pp. 49-56.

OECD. 1991. Environmental Indicators: a preliminary set. Head of Publications Services, OECD. Paris. 77 pp.

OECD. 1994. Environmental Indicators. Head of Publications Services, OECD. Paris. 159 pp.

OECD. 1997. Environmental Indicators for Agriculture. Head of Publications Service, OECD. Paris. 64 pp.

Opschoor, Hans and Lucas Reijnders. 1991. Towards sustainable development indicators IN In Search of Indicators of Sustainable Development. Onno Kuik and Harmen Verbruggen eds. Kluwer Academic Publishers Group. Dordrecht, The Netherlands. pp. 7-29.

Pretty, Jules N., John Thompson and Fiona Hinchecliffe. 1996. Sustainable Agriculture: Impacts on Food Production and Challenges for Food Security. Gatekeeper Series No. 60. International Institute for Environment and Development. Washington, D.C. 27 pp.

Reichelderfer, Katherine H. 1990. Environmental effects on farm programs in developed countries IN Sustainable Agriculture: Its Policy Effects on the Future of Canada and Ontario's Agrifood System. Department of Agricultural Economics and Business, University of Guelph, Guelph, Ontario. pp. 32-51.

Reid, Walter V., and Roger Dower. 1997. Introduction IN Frontiers of Sustainability:

Environmentally Sound Agriculture, Forestry, Transportation and Power Production. Dower, Roger, Daryl Ditz, Paul Faeth, Nels Johnson, Keith Kozloff and James J. MacKenzie eds. World Resources Institute. Island Press. Washington, D.C. pp. 1-45.

Richtik, James Morton. 1964. A historical geography of the Interlake Area of Manitoba from 1871 to 1921. University of Manitoba. Winnipeg, Manitoba. 347 pp.

Saskatchewan State of the Environmental Report. 1992. Saskatchewan State of the Environmental Report: The Need for Environmental Indicators. Regina, Saskatchewan. 34 pp.

Science Council of Canada. 1992. Sustainable Agriculture: The Research Challenge. Science Council of Canada Report 43. Minister of Supply and Services. Ottawa, Canada. 46 pp.

Shaw, Roderick W. 1990. Indicators of Environmentally Sustainable Development: using Regional and Global models for Guidance. International Institute for Applied Systems Analysis. A-2361 Laxenburg, Austria. 9 pp.

Sheehy, Greg. 1989. The Use of Indicators to show the State and Recent Trends in Sustainable Development: A Forestry Pilot Study. No. 11. Strategies and Scientific Methods, SOE Reporting Branch, Canadian Wildlife Service, Conservation & Protection, Environment Canada. Technical Report No. 11. Ottawa, Ontario. 58 pp.

Smoliak, S. and D. B. Wilson. 1983. Forage crops in the prairies IN Proceedings of the National Forage Symposium 1981. Agriculture Canada. Ottawa, Ontario. pp. 35-39.

Statistics Canada. 1978. 1976 Census of Canada: Agriculture Manitoba. Statistics Canada. Ottawa, Ontario.

Statistics Canada. 1982. 1981 Census of Canada: Agriculture Manitoba. Statistics Canada. Ottawa, Ontario.

Statistics Canada. 1987. 1986 Census of Canada: Agriculture Manitoba. Statistics Canada. Ottawa, Ontario.

Statistics Canada. 1992. Agricultural Profile of Manitoba, Part 1. Statistics Canada. Ottawa, Ontario.

Statistics Canada. 1997. Agricultural Profile of Manitoba. Statistics Canada. Ottawa, Ontario.

Strategic Planning and Co-ordination Branch. 1997. Safeguarding our Assets: Securing our future, ensuring the sustainable development of Canada's natural resources: a discussion paper. Natural Resources Canada. Ottawa, Ontario. 46 pp.

SARD (Sustainable Agriculture and Rural Development). 1994. Strategies for Sustainable Agriculture and Rural Development: New Directions for Agriculture, Forestry and Fisheries. Food and Agriculture Organization of the United Nations. Rome. 64 pp.

Sustainable Development/State of the Environment Reporting Branch. 1990. Sustainable Development Initiatives in Canada: Activities in Progress. Environment Canada. Ottawa, Ontario. 29 pp.

Sustainability Manitoba. 1998. Sustainable Development Strategy for Manitoba. Sustainable Manitoba. Winnipeg, Manitoba. 36 pp.

Taff, Steven J. 1989. Sustainable Agriculture: If it's so great, why isn't everybody doing it? Department of Agricultural and Applied Economics. University of Minnesota. St. Paul, Minnesota. 7 pp.

Thomas, Ron. 1992. Sustainable Agriculture: Economic Perspectives and Challenges. Science Council of Canada. Ottawa, Ontario. 18 pp.

Tietenberg, Tom. 1994. Environmental Economics and Policy. HarperCollins College Publishers. New York, New York. 432 pp.

Tyrchniewicz, A. and A. Wilson. 1994. Sustainable Development for the Great Plains: Policy Analysis. International Institute for Sustainable Development. Winnipeg, Manitoba. 35 pp.

United Nations Conference on Environment and Development. 1993. Agenda 21: programme of action for Sustainable Development; Rio Declaration on Environment and Development; Statement of Forest Principles; the final text of agreements negotiated by governments at the United Nations Conference on Environment and Development (UNCED), 3-14 June 1992, Rio de Janeiro, Brazil. United Nations Department of Public Information. New York, New York. 294 pp.

Verbruggen, Harmen and Onno Kuik. 1991. Indicators of sustainable development: an overview IN In Search of Indicators of Sustainable Development. Onno Kuik and Harmen Verbruggen eds. Kluwer Academic Publishers Group. Dordrecht, The Netherlands. pp. 1-7.

Wilson, A. and A. Tyrchniewicz. 1995. Agriculture and Sustainable Development: Policy Analysis on the Great Plains. International Institute for the Sustainable Development. Winnipeg, Manitoba. 106 pp.

Winfield, Mark. 1995. Environmentally Sustainable Agriculture in Canada: An Overview and Assessment of Critical Needs. Canadian Institute for Environmental Law and Policy. Toronto, Ontario. 73 pp.

WCED (World Commission on Environment and Development). 1987. Our Common Future. Oxford University Press. Oxford, New York. 400 pp.

Young, D. A. and J. S. Scarth. 1984. Waterfowl and habitat investigations at five wetlands in the Interlake area of Manitoba. Unpublished report. Ducks Unlimited Canada. 99 pp.

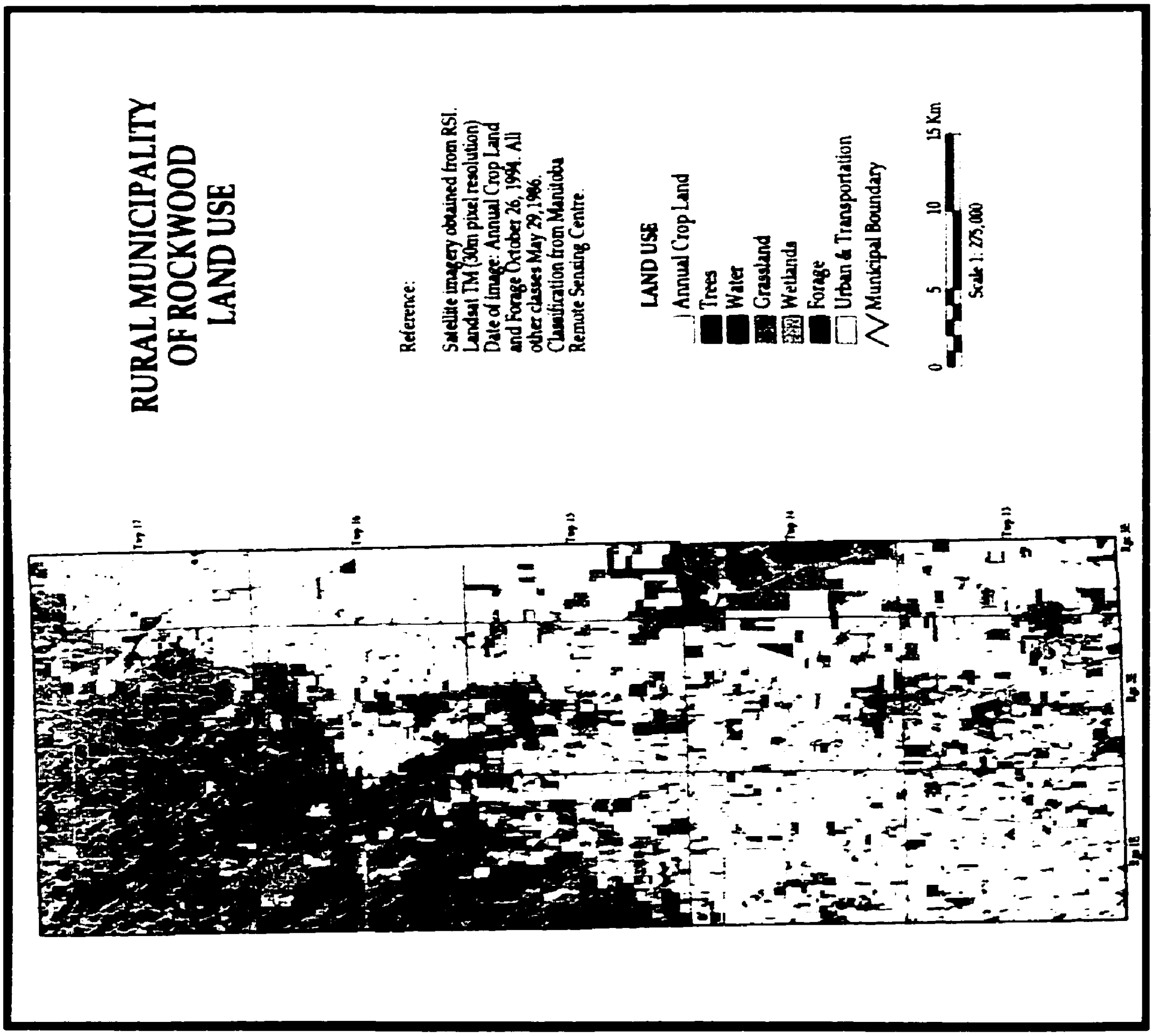

Figure 6. Rural Municipality Rockwood Land Use (Land Resource Unit et al. 1999a).

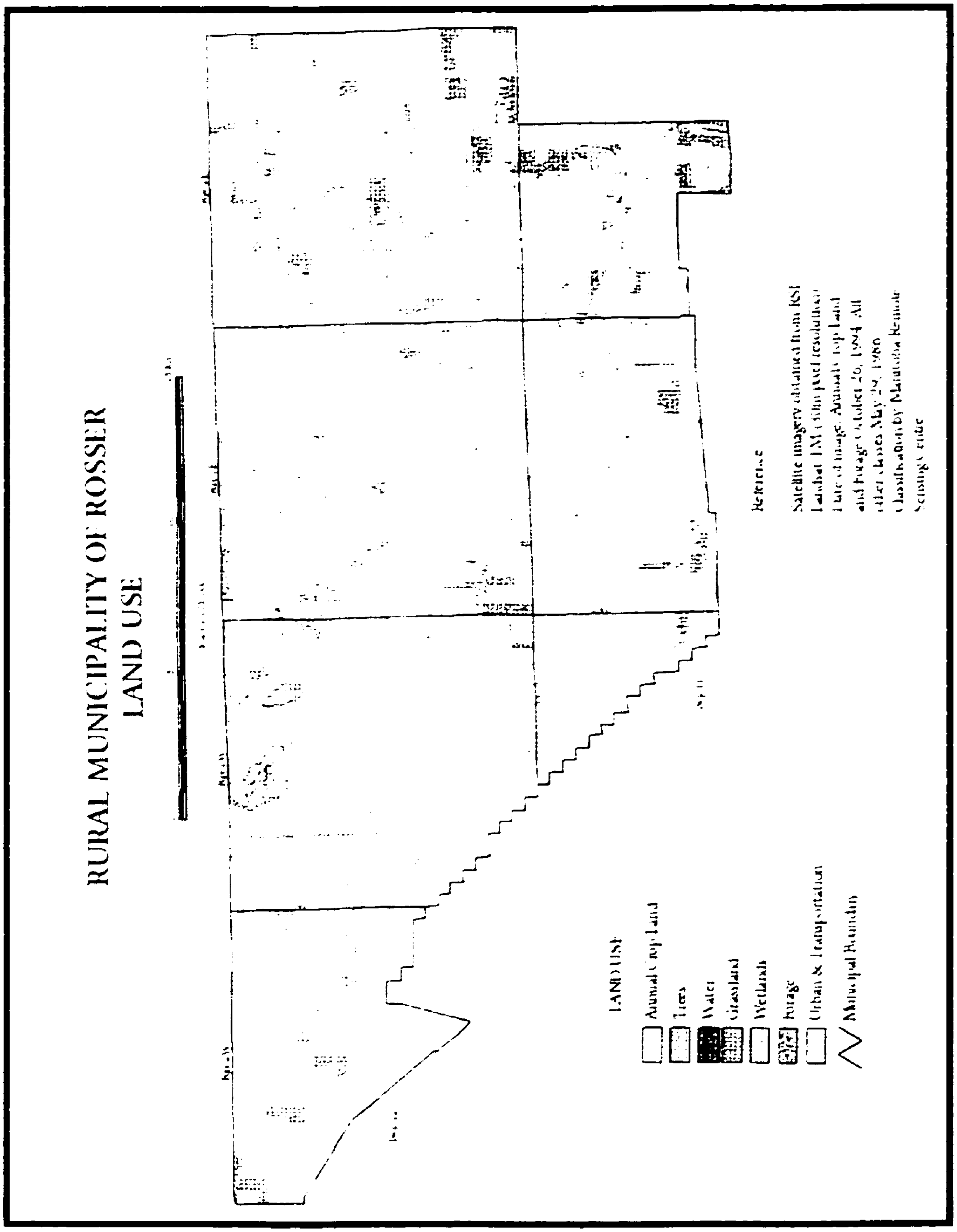

Figure 7. Rural Municipality Rosser Land Use (Land Resource Unit et al. 1999b).

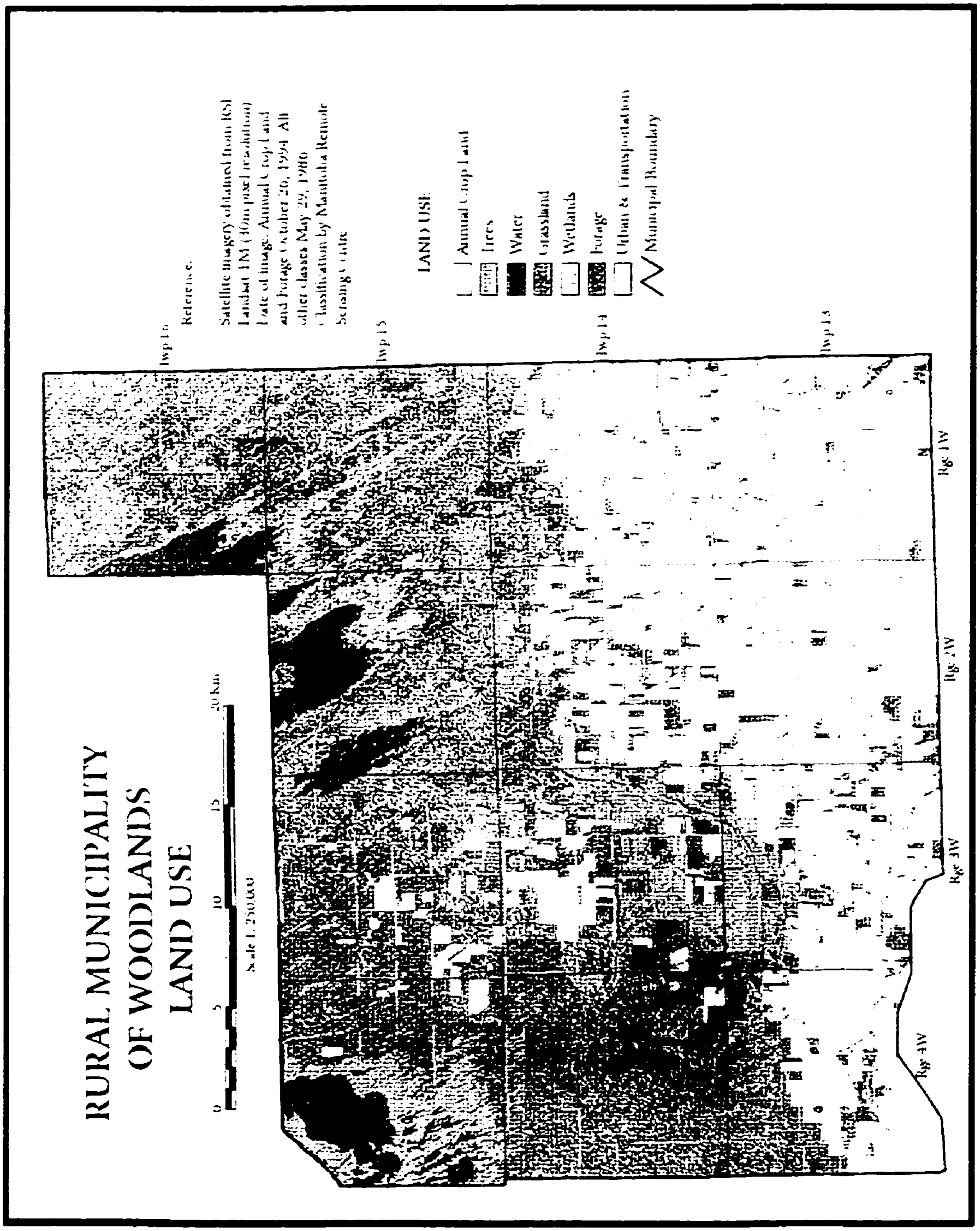

Figure 8. Rural Municipality Woodlands Land Use (Land Resource Unit et al. 1999c).

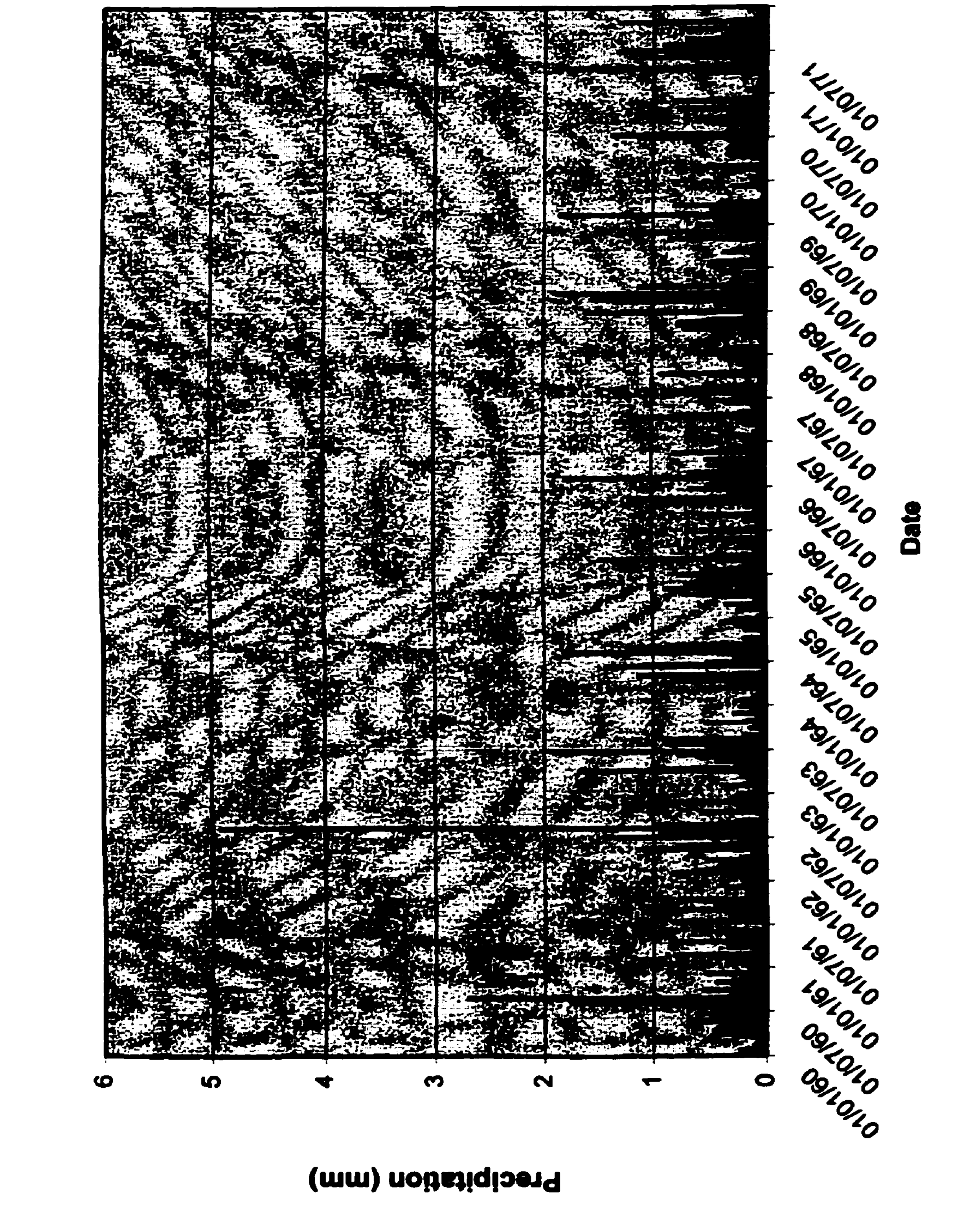

Figure 9. Precipitation for RM of Rockwood (Manitoba Water Resources Branch).

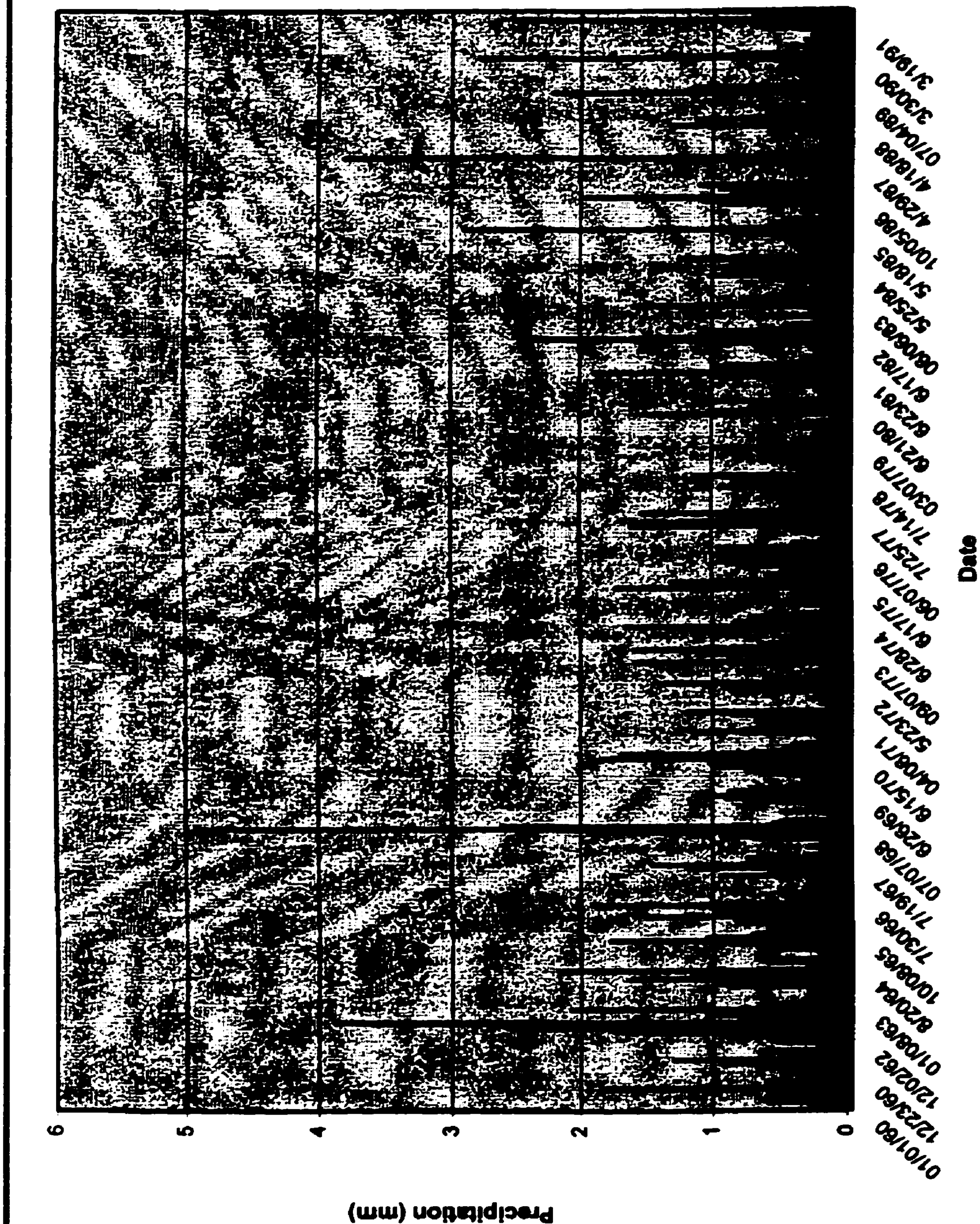

Figure 10. Precipitation for RM of Rockwood and Woodlands (Manitoba Water Resources Branch).

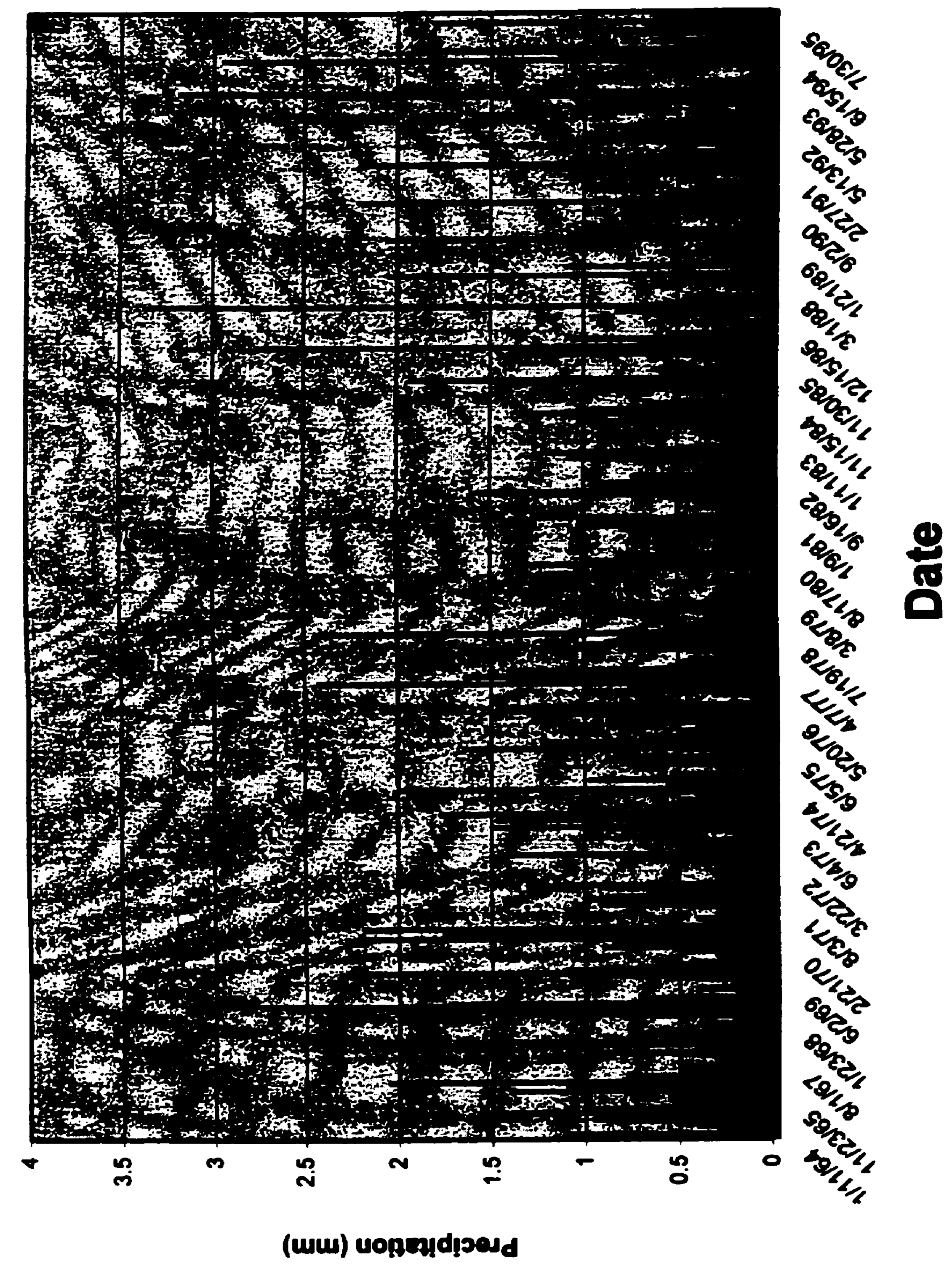

Figure 11. Precipitation for RM of Rosser (Manitoba Water Resources Branch).

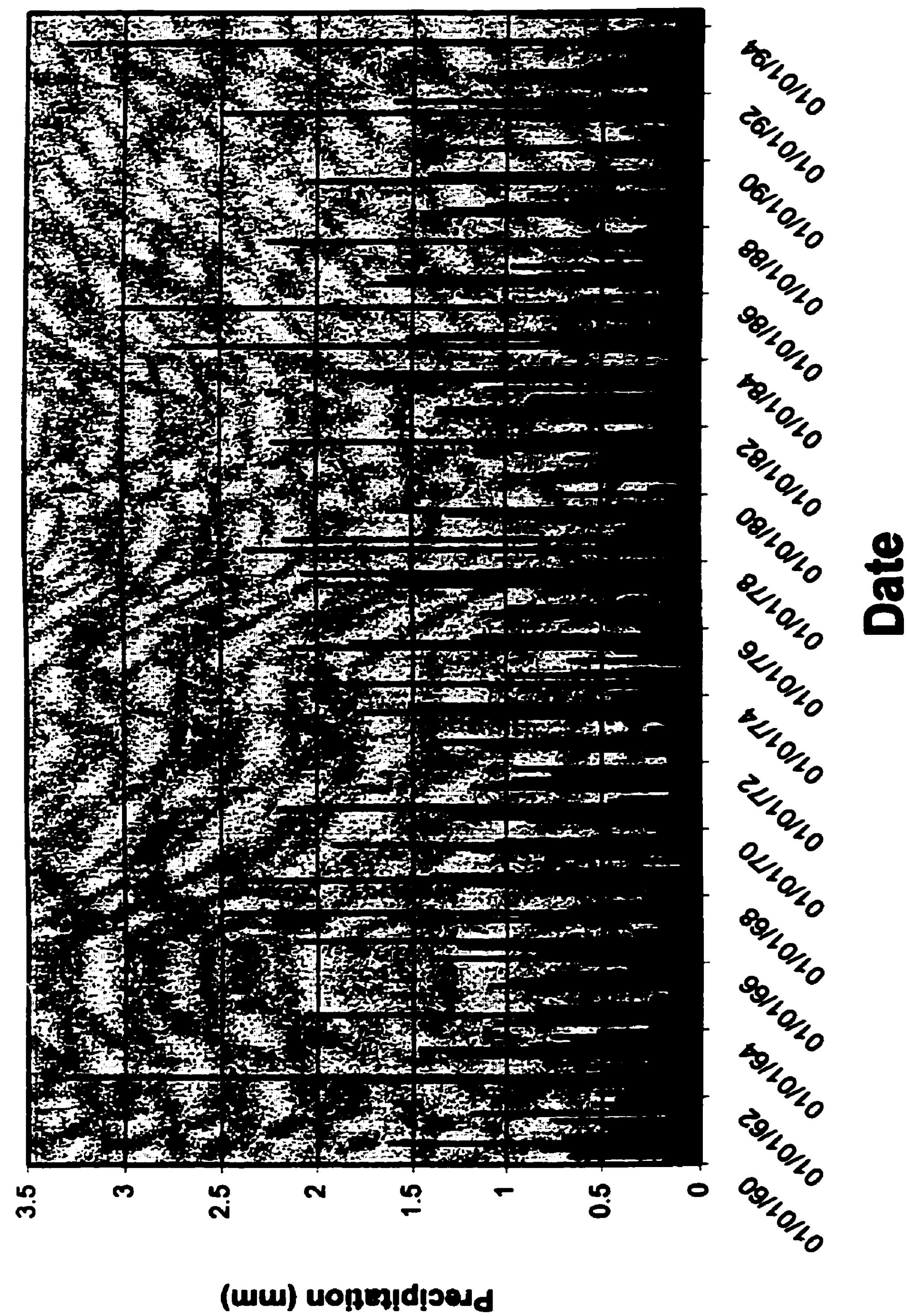

Figure 12. Precipition for RM of Rosser (Manitoba Water Resources Branch).

Table 3. Forage Acreage/Hectares in Statistics Canada Manitoba Agricultural Division No. 14.

Year	Forage type	Acres	Hectares	Source: Statistics Canada, Year
1976	Tame hay	49,004	19,831	1978
1976	Alfalfa & alfalfa mixtures	35,392	14,323	1978
1976	Other tame hay	13,612	5,509	1978
1981	Tame hay	51,306	20,763	1982
1981	Alfalfa & alfalfa mixtures	39,651	16,046	1982
1981	Other tame hay	11,655	4,717	1982
1986	Tame hay	56,931	23,039	1987
1986	Forage seed	1,096	443	1987
1991	Alfalfa & alfalfa mixtures	54,848	22,196	1992
1991	Other tame hay	10,231	4,410	1992
1991	Forage seed for seed	2,703	1,094	1992
1996	Alfalfa & alfalfa mixtures	61,832	25,023	1997
1996	Other tame hay & fodder crops	17,729	7,175	1997
1996	Forage seed for seed	1,707	691	1997

Table 4. Pasture Land in Statistics Canada Manitoba Agricultural Division No. 14.

Year	Improved pasture (acres)	Improved pasture (hectares)	Unimproved pasture (acres)	Unimproved pasture (hectares)	Source: Statistics Canada, Year
1976	24,026	9,723	165,478*	66,967*	1978
1981	26,611	11,413	154,855*	62,668*	1982
1986	21,952	8,883	146,145	59,142	1987
1991	26,318	10,651	137,283	55,556	1992
1996	19,707	7,975	154,682	62,598	1997

*Unimproved pasture is referred as unimproved land in the Statistics Canada publications

Table 5. Management Plus Program Database's Results (Manitoba Crop Insurance Corporation).

Municipality	Crop Type	Soil	Year	Acres	Yield	Nitrogen	Phosphate	Potassium	Sulphur
Rockwood	Alfalfa	E	1996	452	3.51	0	25	46	12
Rockwood	Alfalfa/grass mix.	D	1996	355	2.26	24	49	0	1
Rockwood	Alfalfa/grass mix.	F	1996	228	3.13	46	37	14	6
Rockwood	Alfalfa/grass mix.	G	1996	260	1.82	36	40	6	2
Rockwood	Alfalfa/grass mix.	H	1996	580	1.78	20	32	3	5
Rockwood	Ped. Timothy seed	E	1996	360	398.3	77	24	8	6
Rockwood	Alfalfa	E	1997	544	3.08	20	40	34	16
Rockwood	Alfalfa/grass mix.	E	1997	362	2.36	33	33	1	1
Rockwood	Alfalfa/grass mix.	G	1997	220	1.81	30	42	18	2
Rockwood	Alfalfa/grass mix.	H	1997	567	1.72	17	31	12	2
Rockwood	Ped. Timothy seed	E	1997	310	254.7	75	31	8	4
Rosser	Alfalfa/grass mix.	C	1996	206	2.59	16	74	0	0
Rosser	Ped. Timothy seed	C	1996	400	262.6	60	15	0	10
Woodlands	Alfalfa	F	1996	373	3.01	8	49	9	5
Woodlands	Alfalfa	G	1996	690	2.04	8	52	10	4
Woodlands	Alfalfa	H	1996	1180	3.84	9	50	53	4
Woodlands	Alfalfa/grass mix.	G	1996	350	2.26	18	36	9	4
Woodlands	Alfalfa/grass mix.	H	1996	910	2.88	12	54	24	14
Rosser	Alfalfa	C	1997	470	1.89	7	58	0	0
Rosser	Alfalfa	D	1997	277	1.91	3	50	0	0
Woodlands	Alfalfa	F	1997	225	1.96	9	52	8	3
Woodlands	Alfalfa	G	1997	263	2.18	9	44	6	2
Woodlands	Alfalfa	H	1997	1199	1.42	9	54	48	9
Woodlands	Alfalfa/grass mix.	E	1997	250	2.89	15	69	20	10
Woodlands	Alfalfa/grass mix.	G	1997	265	1.56	1	54	24	1
Woodlands	Alfalfa/grass mix.	H	1997	875	1.78	10	62	16	3

Table 6. Beef Cattle breeds and Forage Crop types in Statistics Canada Manitoba Agricultural Division No. 14.

Beef cattle breed	Data Source	Forage crop type	Data Source
Charolais/Hereford cross	Stan Stadnyk 1999	Alfalfa & alfalfa mixtures	Statistics Canada 1978, 1982, 19871992,1997
Simmental/British cross	Stan Stadnyk 1999	Tame hay	Statistics Canada 1978, 1982, 1987, 1986, 1992 , 1997
Limousin/British cross	Stan Stadnyk 1999	Forage seed	Statistics Canada 1987, 1992, 1997
Charolais	Stan Stadnyk 1999, Marquardt 1971	Alfalfa & alfalfa-grass mixtures	Management Plus Program
Hereford	Stan Stadnyk 1999, Marquardt 1971	Ped. Timothy seed	Management Plus Program
Simmental	Stan Stadnyk 1999		
Limousin	Stan Stadnyk 1999, Marquardt 1971		
Angus	Marquardt 1971		
Shorthorn	Marquardt 1971		

Table 7. Vegetation Inventory for site 30007 in RM of Rosser (Davies et al. 1999).

Legal description: SE7-12-1E
Land use: Hayland
Ownership: Private

Size: 18 hectares
Habitat: Disturbed grassland

Comments: This vegetation on the land was hayed sometime between July 10 and July 16/98.

Native species	
Common Name	Scientific Name
Many-Flowered aster	*Aster ericoides*
Slough grass	*Bechmannia syzigachne*
Sunflower	*Helianthus* sp.
Wild barley (D)	*Hordeum jubatum*
Reed Canary grass	*Phalaris arundinacea*
Canada goldenrod	*Solidago canadensis*
Veiny meadow-rue	*Thalictrum venulosum*

Non-native species	
Common Name	Scientific Name
Quack grass (D)	*Agropyron repens*
Smooth brome	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Alfalfa	*Medicago sativa*
White sweet clover (D)	*Melilotus alba*
Yellow sweet clover	*Melilotus officinalis*
Timothy	*Phleum pratense*
Common plantain	*Plantago major*
Kentucky blue grass	*Poa pratensis*
Dock	*Rumex* sp.
Perennial sow-thistle	*Sonchus arvensis*
Dandelion	*Taraxacum* sp.
Clover (D)	*Tribolium* sp.

(D)=Dominant vegetation

Table 8. Vegetation Inventory from site 30018 in RM of Rosser (Davies et al. 1999).

Legal description: SW27-12-2E
Land use: Idle
Ownership: Commercial

Size: 0.6 Hectare
Habitat: Aspen/Willow/Manitoba Maple woodland

Comments: This area is a small woodland patch located in the northeastern corner of pasture land that is comprised of sow-thistle, alfalfa, wheatgrass, smooth brome, timothy, willow, poplar and Canadian thistle. The shrub layer of this area is dense with Manitoba maple saplings. In the centre of the woodland is an open area that is quite wet and is dominated by species such as reed canary grass, stinging nettle and various members of the mint family.

Native species	
Common Name	Scientific Name
Manitoba maple (D)	*Acer negundo*
Common water-plantain	*Alisma plantago-aquatica*
Canada anemone	*Anemone canadensis*
Slough grass	*Beckmannia syzigachne*
Red-osier dogwood	*Cornus stolonifera*
Philadelphia fleabane	*Erigeron philadelphicus*
Green ash	*Fraxinus pennsylvanica*
Wild licorice	*Glycyrrhiza lepidota*
Narrow-leaved sunflower	*Helianthus maximiliani*
Marsh vetchling	*Lathyrus palustris*
Common mint	*Mentha arvensis*
Virginia creeper (D)	*Parthenocissus quinquefolia*
Reed Canary grass	*Phalaris arundinacea*
Smartweed	*Polygonum* sp.
Trembling aspen (D)	*Populus tremuloides*
Chokecherry	*Prunus virginiana*
Macoun's buttercup	*Ranunculus macounii*
Poison ivy	*Rhus radicans*
Prickly rose	*Rosa acicularis*
Peach-leaved willow	*Salix amygdaloides*
Basket willow (D)	*Salix petiolaris*
Marsh skullcap	*Scutellaria epilobiifolia*
Canada goldenrod	*Solidago canadensis*
Meadow sweet	*Spiraea alba*

Native species continued Common Name	Scientific Name
Marsh hedge-nettle	*Stachys palustris*
Western snowberry	*Symphoricarpos occidentialis*
Stinging nettle	*Urtica dioica*
Early blue violet	*Viola adunca*
Violet	*Viola* sp.

Non-native species Common Name	Scientific Name
Burdock	*Arctium* sp.
Wormwood	*Artemisia absinthium*
Smooth brome (D)	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Bull thistle	*Cirsium vulgare*
Alfalfa	*Medicago sativa*
Timothy	*Phleum pratense*
Kentucky blue-grass (D)	*Poa pratensis*
Curled dock	*Rumex crispus*
Perennial sow-thistle	*Sonchus arvensis*
Dandelion	*Taraxacum* sp.

(D)=Dominant vegetation

Table 9. Vegetation Inventory for site 30031 in RM of Rosser (Davies et al. 1999).

Legal description: SE30-12-1E
Land use: Idle, former pasture land
Ownership: Private

Size: 1.5 hectares
Habitat: Disturbed grassland

Native species Common Name	Scientific Name
Ragweed	*Ambrosia* sp.
Smooth wild strawberry	*Fragaria virginiana*
Northern bedstraw	*Galium boreale*
Canada hawkweed	*Hieracium canadense*
Wild barley	*Hordeum jubatum*
Wild peavine	*Lathyrus venosus*
Chokecherry	*Prunus virginiana*
Bur oak	*Quercus macrocarpa*
Raspberry	*Rubus idaeus*
Dewberry	*Rubus pubescens*
Canada goldenrod	*Solidago canadensis*
Late goldenrod	*Solidago gigantea*
Low goldenrod	*Solidago missouriensis*
Western snowberry	*Symphoricarpos occidentalis*
Veiny meadow-rue	*Thalictrum venulosum*
Stinging nettle (D)	*Urtica dioica*

Non-native species Common Name	Scientific Name
Quack grass	*Agropyron repens*
Burdock	*Arctium* sp.
Smooth brome (D)	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Black medick	*Medicago lupulina*
Alfalfa	*Medicago sativa*
Timothy	*Phleum pratense*
Common plantain	*Plantago major*
Kentucky blue grass (D)	*Poa pratensis*
Perennial sow-thistle	*Sonchus arvensis*
Dandelion	*Taraxacum* sp.

(D)=Dominant vegetation

Table 10. Vegetation Inventory for site 30037 in RM of Rosser (Davies et al. 1999).

Legal description: NE19-12-1E
Land use: Idle, former pasture land
Ownership: Private

Size: 6 hectares
Habitat: Disturbed grassland

Comments: none

Native species	
Common Name	Scientific Name
Slender wheat grass	*Agropyron trachycaulum*
Prairie sagewort	*Artemisia frigida*
Many-flowered aster	*Aster ericoides*
Western snowberry	*Symphoricarpos occidentalis*

Non-native species	
Common Name	Scientific Name
Quack grass	*Agropyron repens*
Wormwood	*Artemisia absinthium*
Smooth brome (D)	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Kentucky blue grass (D)	*Poa pratensis*
Perennial sow-thistle	*Sonchus arvensis*
Yellow goat's beard	*Tragopogon dubius*
Goat's beard	*Tragopogon pratensis*

(D)=Dominant vegetation

Table 11. Vegetation Inventory for site 30051 in RM of Rosser (Davies et al. 1999).

Legal description: NE8-12-2E
Land use: Recreation/some grazing
Ownership: Private
Wildlife viewed: squirrel, white-tailed deer, hawk

Size: 6.9 hectares
Habitat: Aspen/Oak Woodland

Comments: The shrub layer and understory are sparse in patches due to heavy grazing by deer.

Native species	
Common Name	Scientific Name
Manitoba maple	*Acer negundo*
Common yarrow	*Achillea millefolium*
Saskatoon	*Amelanchier alnifolia*
Canada anemone	*Anemone canadensis*
Spreading dogbane	*Apocynum androsaemifolium*
Wild sarsaparilla	*Aralia nudicaulis*
Western mugwort	*Artemisia ludoviciana*
Harebell	*Campanula rotundifolia*
Sedge	*Carex* sp.
Red-osier dogwood	*Cornus stolonifera*
American hazelnut	*Corylus americana*
Smooth wild strawberry	*Fragaria virginiana*
Northern bedstraw	*Galium boreale*
Sweet-scented bedstraw	*Galium triflorum*
Pale vetchling	*Lathyrus ochroleucus*
Two-leaved Solomon's-seal	*Maianthemum canadense*
White-grained mountain rice grass	*Oryzopsis asperifolia*
Smooth sweet cicely	*Osmorhiza longistylis*
Trembling aspen (D)	*Populus tremuloides*
Chokecherry	*Prunus virginiana*
Wintergreen	*Pyrola* sp.
Bur oak (D)	*Quercus macrocarpa*
Seaside buttercup	*Ranunculus cymbalaria*
Poison ivy	*Rhus radicans*
Rose	*Rosa* sp.
Raspberry	*Rubus idaeus*
Dewberry (D)	*Rubus pubescens*
Snakeroot	*Sanicula marilandica*
Western snowberry	*Symphoricarpos occidentalis*
Veiny meadow-rue	*Thalictrum venulosum*

Native species continued	
Common Name	Scientific Name
Nannyberry	*Viburnum lentago*
High-bush cranberry	*Viburnum opulus*
American vetch	*Vicia americana*
Wild vetch	*Vicia* sp.
Violet	*Viola* sp.

Non-native species	
Common Name	Scientific Name
Smooth brome	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Bluebur	*Lappula echinata*
Black medick	*Medicago lupulina*
Kentucky blue grass	*Poa pratensis*
Prickly sow-thistle	*Sonchus asper*
Dandelion	*Taraxacum officinale*
Clover	*Trifolium* sp.

Others	
Common Name	Scientific Name
Cinquefoil	Potentilla sp.

(D)=Dominant vegetation

Table 12. Vegetation Inventory for site 30062 in RM of Rosser (Davies et al. 1999).

Legal description: NW30-11-1E
Land use: Pasture
Ownership: Private
Wildlife viewed: cattle, killdeer

Size: 9.6 hectares
Habitat: Disturbed grassland

Comments: A patch of willow shrubs occurs within the pasture. Cows have made paths through the shrubs.

Native species	
Common Name	Scientific Name
Common yarrow	*Achillea millefolium*
Rough hair grass	*Agrostis scabra*
Pink-flowered onion	*Allium stellatum*
Great ragweed	*Ambrosia trifida*
Canada anemone	*Anemone canadensis*
Thimbleweed	*Anemone cylindrica*
Pussytoes	*Antennaria* sp.
Western mugwort	*Artemisia ludoviciana*
Many-flowered aster	*Aster ericoides*
Smooth aster	*Aster laevis*
Sedge	*Carex tenera*
Sedge	*Carex utriculata*
Rough fleabane	*Erigeron asper*
Northern bedstraw	*Galium boreale*
Gumweed (D)	*Grindelia squarrosa*
Wild barley	*Hordeum jubatum*
Blue lettuce	*Lactuca tatrica*
Water-horehound	*Lycopus americanus*
Fringed loosestrife	*Lysimachia ciliata*
Reed Canary grass	*Phalaris arundinacea*
Trembling aspen	*Populus tremuloides*
Buttercup	*Ranunculus* sp.
Western dock	*Rumex occidentalis*
Basket willow	*Salix petiolaris*
Water parsnip	*Sium suave*
Canada goldenrod	*Solidago canadensis*
Stiff goldenrod	*Solidago rigida*
Prairie cord grass	*Spartina pectinata*

Native species continued	
Common Name	Scientific Name
Long-leaved stitchwort	*Stellaria longifolia*
Western snowberry	*Symphoricarpos occidentalis*
Cattail	*Typha* sp.
Heart-leaved alexander	*Zizia aptera*

Non-native species	
Common Name	Scientific Name
Quack grass	*Agropyron repens*
Smooth brome	*Bromus inermis*
Lamb's quarters	*Chenopodium album*
Canada thistle	*Cirsium arvense*
Kentucky blue grass (D)	*Poa pratensis*
Mustard	*Sisymbrium* sp.
Dandelion	*Taraxacum officinale*
Alsike clover	*Trifolium hybridum*

Others	
Common Name	Scientific Name
Cinquefoil	*Potentilla* sp.

(D)=Dominant vegetation

Table 13. Vegetation Inventory for site 30067 in RM of Rosser (Davies et al. 1999).

Legal description: NW32-12-2E
Land use: Pasture
Ownership: Private
Wildlife viewed: livestock

Size: 3.1 hectares
Habitat: Oak woodland

Comments: Oak trees dominate the area, however, there is very little understory due to the effects of grazing.

Native species	
Common Name	Scientific Name
Manitoba maple (seedling)	*Acer negundo*
Common yarrow	*Achillea millefolium*
Saskatoon	*Amelanchier alnifolia*
Canada anemone	*Anemone canadensis*
Thimbleweed	*Anemone cylindrica*
Lindley's aster	*Aster ciliolatus*
Milk-vetch	*Astragalus* sp.
Sedge	*Carex* sp.
Sedge	*Carex tenera*
Red-osier dogwood	*Cornus stolonifera*
Hawthorn	*Crataegus* sp.
Rough fleabane	*Erigeron asper*
Northern bedstraw	*Galium boreale*
Wild peavine	*Lathyrus venosus*
Two-leaved Solomon's-seal	*Maianthemum canadense*
Solomon's seal	*Polygonatum biflorum*
Chokecherry	*Prunus virginiana*
Silverleaf psoralea	*Psoralea agrophylla*
Bur oak (D)	*Quercus macrocarpa*
Canada goldenrod	*Solidago canadensis*
Meadow sweet	*Spiraea alba*
Western snowberry (D)	*Symphoricarpos occidentalis*
Veiny meadow-rue	*Thalictrum venulosum*
Stinging nettle	*Urtica dioica*
Violet	*Viola* sp.

Non-native species	
Common Name	Scientific Name
Smooth brome	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Common plantain	*Plantago major*
Kentucky blue grass (D)	*Poa pratensis*
Perennial sow-thistle	*Sonchus arvensis*
Common chickweed	*Stellaria media*
Dandelion (D)	*Taraxacum officinale*
Alsike clover	*Trifolium hybridum*

Others	
Common Name	Scientific Name
Bluegrass	*Poa* sp.

(D)=Dominant vegetation

Table 14. Vegetation Inventory for site 30072 in RM of Rosser (Davies et al. 1999).

Legal description: NW16-12-2E
Land use: Pasture
Ownership: Private
Wildlife viewed: cattle

Size: 19.6 hectares
Habitat: Aspen woodland

Comments: Side-oats grama grass, a rare plant in Manitoba was found on this site. The understory below the aspen canopy is sparse. The area was part of the original Winnipeg to Stonewall trail. Ruts can still be seen running through the pasture.

Native species	
Common Name	Scientific Name
Manitoba maple	*Acer negundo*
Common yarrow	*Achillea millefolium*
Large-flowered false dandelion	*Agoseris glauca*
Wheatgrass	*Agropyron* sp.
Saskatoon	*Amelanchier alnifolia*
Leadplant	*Amorpha canescens*
Little bluestem	*Andropogon scoparius*
Canada anemone	*Anemone canadensis*
Pussytoes	*Antennaria* sp.
Lindley's aster	*Aster ciliolatus*
Smooth aster	*Aster laevis*
Side-oats grama	*Bouteloua curtipendula*
Blue grama	*Bouteloua gracilis*
Hawthorn	*Crataegus* sp.
Wolf willow	*Elaeagnus commutata*
Northern bedstraw	*Galium boreale*
Gumweed	*Grindelia squarrosa*
Narrow-leaved sunflower	*Helianthus maximiliani*
Two-leaved Solomon's-seal	*Maianthemum canadense*
Witch grass	*Panicum capillare*
Trembling aspen (D)	*Populus tremuloides*
Chokecherry	*Prunus virginiana*
Bur oak	*Quercus macrocarpa*
Poison ivy	*Rhus radicans*
Rose	*Rosa* sp.
Blue-eyed grass	*Sisyrinchium montanum*
Golden	*Solidago* sp.

Native species continued	
Common Name	Scientific Name
Meadow sweet	*Spiraea alba*
Western snowberry (D)	*Symphoricarpos occidentalis*
Tall meadow-rue	*Thalictrum dasycarpum*
Veiny meadow-rue	*Thalictrum venulosum*
Wild vetch	*Vicia* sp.
Crowfoot violet	*Viola pedatifida*
Heart-leaved alexander	*Zizia aptera*

Non-native species	
Common Name	Scientific Name
Tumbleweed	*Amaranthus graecizans*
Burdock	*Arctium* sp.
Wormwood	*Artemisia absinthium*
Common mouse-ear chickweed	*Cerastium vulgatum*
Mallow	*Malva* sp.
Black medick	*Medicago lupulina*
Common plantain	*Plantago major*
Kentucky blue grass (D)	*Poa pratensis*
Wild buckwheat	*Polygonum convolvulus*
Green foxtail	*Setaria viridis*
Perennial sow-thistle	*Sonchus arvensis*
Dandelion (D)	*Taraxacum officinale*
Alsike clover	*Trifolium hybridum*
Red clover	*Trifolium pratense*

Others	
Common Name	Scientific Name
Thistle	*Cirsium* sp.
Cinquefoil	*Potentilla* sp.

(D)=Dominant vegetation

Table 15. Vegetation Inventory for site 30074 in RM of Rosser (Davies et al. 1999).

Legal description: N1/2 17-11-1E
Land use: Haying
Ownership: Commercial
Wildlife viewed: ducks

Size: 26.9 hectares
Habitat: Disturbed grassland

Comments: Reed Canary grass is dominant near the water.

Native species	
Common Name	Scientific Name
Manitoba maple	*Acer negundo*
Canada anemone	*Anemone canadensis*
Indian hemp	*Apocynum cannibinum*
Milkweed	*Asclepias* sp.
Many-flowered aster	*Aster ericoides*
Smooth aster	*Aster laevis*
Purple milk-vetch	*Astragalus agrestis*
Common beggarticks	*Bidens frondosa*
Harebell	*Campanula rotundifolia*
Hedge bindweed	*Convolvulus sepium*
Rough fleabane (D)	*Erigeron asper*
Wormseed mustard	*Erysimum cheiranthoides*
Black ash	*Fraxinus nigra*
Wild licorice	*Glycyrrhiza lepidota*
Gumweed	*Grindelia squarrosa*
Narrow-leaved sunflower	*Helianthus maximiliani*
Blue lettuce	*Lactuca tatarica*
Duckweed	*Lemna minor*
Reed Canary grass (D)	*Phalaris arundinacea*
Fowl blue grass	*Poa palustris*
Silverweed	*Potentilla anserina*
Rose	*Rosa* sp.
Arrowhead	*Sagittaria* sp.
Great bulrush	*Scirpus lacustris*
Canada goldenrod	*Solidago canadensis*
Goldenrod	*Solidago* sp.
Prairie cord grass	*Spartina pectinata*
Western snowberry	*Symphoricarpos occidentalis*
Golden-pea	*Thermopsis rhombifolia*
Cattail	*Typha* sp.

Non-native species	
Common Name	Scientific Name
Quack grass	*Agropyron repens*
Wild oats	*Avena fatua*
Burdock	*Arctium* sp.
Smooth brome (D)	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Lobed prickly lettuce	*Lactuca serriola*
Persian darnel	*Lolium persicum*
Wild chamomile	*Matricaria chamomilla*
Black medick	*Medicago lupulina*
Alfalfa	*Medicago sativa*
Yellow sweet clover	*Melilotus officinalis*
Kentucky blue grass	*Poa pratensis*
Narrow-leaved dock	*Rumex salicifolius*
Dock	*Rumex* sp.
Perennial sow-thistle	*Sonchus arvensis*
Dandelion	*Taraxacum officinale*
Field pennycress	*Thlaspi arvense*
Yellow goat's beard	*Tragopogon dubius*
Red clover	*Trifolium pratense*
Siberian elm	*Ulmus pulmilla*

(D)=Dominant vegetation

Table 16. Vegetation Inventory for site 30078 in RM of Rosser (Davies et al. 1999).

Legal description: NW27-12-2E
Land use: Haying
Ownership: Private

Size: 1.0 hectares
Habitat: Disturbed grassland

Comments: Some native prairie species grow in the ditch south of the creek.

Native species	
Common Name	Scientific Name
Manitoba maple	*Acer negundo*
Common yarrow	*Achillea millefolium*
Saskatoon	*Amelanchier alnifolia*
Big bluestem	*Andropogon gerardii*
Little bluestem	*Andropogon scoparius*
Western mugwort	*Artemisia ludoviciana*
Many-flowered aster	*Aster ericoides*
Smooth aster	*Aster laevis*
Purple milk-vetch	*Astragalus agrestis*
Wolf willow	*Elaeagnus commutata*
Common horsetail	*Equisetum arvense*
Smooth wild strawberry	*Fragaria virginiana*
Green ash	*Fraxinus pennsylvanica*
Northern bedstraw	*Galium boreale*
Wild licorice	*Glycyrrhiza lepidota*
Gumweed	*Grindelia squarrosa*
Narrow-leaved sunflower	*Helianthus maximiliani*
Smartweed	*Polygonum* sp
Rose	*Rosa* sp.
Western dock	*Rumex occidentalis*
Canada goldenrod	*Solidago canadensis*
Stiff goldenrod	*Solidago rigida*
Prairie cord grass	*Spartina pectinata*
Veiny meadow-rue	*Thalictrum venulosum*
Golden alexander	*Zizia aurea*

Non-native species	
Common Name	Scientific Name
Burdock	*Arctium* sp.
Wormwood	*Artemisia absinthium*
Smooth brome	*Bromus inermis*
Canada thistle	*Cirsium arvense*
Black medick	*Medicago lupulina*
Alfalfa (D)	*Medicago sativa*
White sweet clover	*Melilotus alba*
Timothy	*Phleum pratense*
Common plantain	*Plantago major*
Kentucky blue grass	*Poa pratensis*
Dandelion	*Taraxacum officinale*
Red clover	*Trifolium pratense*

(D)=Dominant vegetation

Table 17. Animal sightings during vegetation surveys for RM of Rosser (Davies et al. 1999).

Specific Sightings	
Common name	Scientific name
White-tailed deer	*Odocoileus virginianus*
Red squirrel	*Tamiasciurus hudsonicus*
Jackrabbit	*Lepus townsendii*
Eastern cottontail	*Sylvilagus floridanus*
Blue jay	*Cyanocitta cristata*
Morning dove	*Zenaida macroura*
Red-winged blackbird	*Agelaius phoeniceus*
Killdeer	*Charadrius vociferus*
Blue-winged teal	*Anas discors*
Wood frog	*Rana sylvatica*

General Sightings
Squirrels
Chipmunk, Fox, Waterfowl, Ducks, Blackbirds, Meadowlark, Hawks, Frogs, Wasps, Grasshoppers

Table 18. Species of Concern in the Manitoba Interlake (Manitoba Conservation Data Centre).

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	PROVINCIAL RANK
ACCIPITER COOPERII	COOPER'S HAWK	G5	S4B,SZN
ALLIUM CERNUUM	NODDING ONION	G5	S2?
AMORPHA FRUTICOSA	FALSE INDIGO	G5	S1S2
ARALIA RACEMOSA	SPIKENARD	G5	S2
ASCLEPIAS VERTICILLATA	WHORLED MILKWEED	G5	S2
ASTER SERICEUS	WESTERN SILVERY ASTER	G5	S2
ASTRAGALUS ABORIGINUM	INDIAN MILKVETCH	G5	S1?
ASTRAGALUS PECTINATUS	NARROW-LEAVED MILKVETCH	G5	S2S3
ATHENE CUNICULARIA	BURROWING OWL	G4	S1B,SZN
ATRIPLEX ARGENTEA	SALTBRUSH, SILVERY ATRIPLEX	G5	S2
BOLTONIA ASTEROIDES VAR RECOGNITA	WHITE BOLTONIA	G5T?	S2S3
BOTRYCHIUM MULTIFIDUM	LEATHERY GRAPE-FERN	G5	S3
BOUTELOUA CURTIPENDULA	SIDE-OATS GRAMA	G5	S2
CALOPOGON PULCHELLUS	SWAMP-PINK	G5	S2
CAREX CRAWEI	CRAWE'S SEDGE	G5	S3S4
CAREX DOUGLASII	DOUGLAS SEDGE	G5	S3?
CAREX FLAVA	YELLOW SEDGE	G5	S2S3
CAREX HYSTERICINA	PORCUPINE SEDGE	G5	S3?
CAREX LIVIDA	LIVID SEDGE	G5	S3
CAREX MURICATA	INLAND SEDGE	G?	S2?
CAREX PARRYANA	PARRY'S SEDGE	G4	S3?
CAREX PROJECTA	NECKLACE SEDGE	G5	S2?
CAREX TETANICA	RIGID SEDGE	G4G5	S2
CHARADRIUS MELODUS	PIPING PLOVER	G3	S2B,SZN
CLADIUM MARISCOIDES	TWIG RUSH	G5	S2
CORALLORRHIZA STRIATA	STRIPED CORALROOT	G5	S3?
CYPERUS ERYTHRORHIZOS	RED-ROOT FLATSEDGE	G5	S1
CYPRIPEDIUM CANDIDUM	SMALL WHITE LADY'S-SLIPPER	G4	S1
DROSERA LINEARIS	SLENDER-LEAVED SUNDEW	G4	S2?
ELEOCHARIS ENGELMANNII	ENGELMANN'S SPIKE-RUSH	G4?	S1
GENTIANA PUBERULENTA	DOWNY GENTIAN	G4G5	S2
GERARDIA TENUIFOLIA VAR PARVIFLORA	SLENDER AGALINIS	G5T4	S2S3
HESPERIA DACOTAE	DAKOTA SKIPPER	G2G3	S2S3
HETERANTHERA DUBIA	WATER STAR-GRASS	G5	S2
INLAND LAKE COBBLE-GRAVEL SHORE SPARSE VEGETATION COMMUNITY	INLAND LAKE COBBLE-GRAVEL SHORE SPARSE VEGETATION COMMUNITY	N/A	S3

Table 18 Continued.

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	PROVINCIAL RANK
KRIGIA BIFLORA	DWARF DANDELION	G5	S1
MYOTIS LUCIFUGUS	LITTLE BROWN MYOTIS	G5	S2N,S5B
ONOCLEA SENSIBILIS	SENSITIVE FERN	G5	S3S4
PARNASSIA PARVIFLORA	SMALL GRASS-OF-PARNASSUS	G4	S1
PELLAEA GLABELLA SSP OCCIDENTALIS	CLIFF-BRAKE	G5T?	S2
PLATANTHERA LACERA	FRINGED ORCHID	G5	S2
POLYGALA VERTICILLATA VAR ISOCYCLA	WHORLED MILKWORT	G5T?	S2
RANUNCULUS CYMBALARIA VAR SAXIMONTANUS	SEASIDE CROWFOOT	G5T5	S1S2
RHYNCHOSPORA ALBA	WHITE BEAKRUSH	G5	S3?
SNAKE HIBERNACULA	SNAKE HIBERNACULA	N/A	N/A
SPOROBOLUS ASPER	TALL DROPSEED	G5	S1
STIPA RICHARDSONII	RICHARDSON NEEDLE GRASS	G5	S1
STRIX VARIA	BARRED OWL	G5	S3S4
TAXUS CANADENSIS	CANADA YEW	G5	S3
THELYPTERIS PALUSTRIS VAR PUBESCENS	MARSH FERN	G5T?	S4
THUJA OCCIDENTALIS-(PICEA MARIANA, ABIES BALSAMEA)/ALNUS INCANA WETLAND FOREST	EASTERN WHITE CEDAR-(BLACK SPRUCE, BALSAM FIR)/SPECKLED ALDER WETLAND FOREST		S2
WATERBIRD COLONY	AMERICAN WHITE PELICAN (as the most at risk species in the colony)	N/A	N/A
WATERBIRD COLONY	DOUBLE-CRESTED CORMORANT (as the most at risk species in the colony)	N/A	N/A
WATERBIRD COLONY	GREBES (as the most at risk species in the colony)	N/A	N/A
WATERBIRD COLONY	GULLS (as the most at risk species in the colony)	N/A	N/A
WATERBIRD COLONY	HERONS (as the most at risk species in the colony)	N/A	N/A
WATERBIRD COLONY	TERNS (as the most at risk species in the colony)	N/A	N/A

Table 18 Continued.

Global, National and Provincial Definitions:

Listed below are brief definitions for the basic global, national and provincial (subnational) element ranks denoted as GRANK, NRANK and SRANK respectively:

#	Numeric Rank: A numeric rank (1 through 5) of relative endangerment based on the number of occurrences of the element throughout its current/former range. Please note that factors other than the number of occurrences are considered when assigning a rank, so the number of occurrences suggested for each numeric rank below are not absolute.
G1/N1/S1	Very rare throughout its range/country/subnation (typically 5 or fewer occurrences or very few remaining individuals or acres). May be especially vulnerable to extirpation.
G2/N2/S2	Rare throughout its range/country/subnation (typically 6 to 20 occurrences). May be vulnerable to extirpation.
G3/N3/S3	Uncommon throughout its range/country/subnation (21 to 100 occurrences).
G4/N4/S4	Widespread, abundant, and apparently secure throughout its range/country/subnation, with many occurrences, but the Element is of long-term concern (100+ occurrences).

Breeding Status:

B	Breeding: Basic rank refers to the breeding population of the element in the province.
N	Non-breeding: Basic rank refers to the non-breeding population of the element in the province.

Qualifiers:

?	Inexact or uncertain: for numeric ranks, denotes inexactness, e.g., SE? denotes uncertainty of exotic status. (The ? qualifies the character immediately preceding it in the G/N/SRANK)

Additional National/Provincial Definitions:

NZ/SZ Zero occurrences: Not of practical conservation concern in the country/subnation, because there are no definable occurrences, although the taxon is native and appears regularly in the country. An NZ rank will generally be used for long distance migrants whose occurrences during their migrations are too irregular (in terms of repeated visitation to the same locations) or transitory. In other words, the migrant regularly passes through the country/subnation, but enduring, mappable Element Occurrences cannot be defined.

Table 20. Aquatic birds in Interlake region of Manitoba in 1984 and 1985 (Young & Scarth 1984, Clay et al. 1985, Clay 1987).

Common name	Scientific name
Common loon	*Gavia immer*
Pied-billed Grebe	*Podilymbus podiceps*
Horned Grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisegena*
Eared Grebe	*Podiceps nigricollis*
American White Pelican	*Pelecanus erythrorhynchos*
Double-crested Cormorant	*Phalacrocorax auritus*
American Bittern	*Botaurus lentiginosus*
Great Blue Heron	*Ardea herodias*
Tundra Swan	*Cygnus columbianus*
Snow Goose	*Anser caerulescens*
Canada Goose*	*Branta canadensis*
Wood Duck	*Aix sponsa*
Green-winged Teal*	*Anas crecca*
Mallard*	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal*	*Anas discors*
Northern Shoveler*	*Anas clypeata*
Gadwall*	*Anas strepera*
American Wigeon*	*Anas americana*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck*	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
White-winged Scoter	*Melanitta fusca*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullantus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*
American Coot	*Fulica americana*
Sandhill Crane	*Grus canadensis*

*same waterfowl species viewed during Canadian Wildlife Service May ground surveys.