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Management of Canadian Prairie Rangeland

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Summary

The natural grasslands, or native rangelands, of the Canadian prairies extend across the southern parts of Alberta, Saskatchewan, and Manitoba. They originally covered about 61 million hectares but now only occupy about 20% of the area. The policies implemented by the central government from 1870 to 1930 reduced the prairie grasslands by 50 million hectares. These natural grasslands are hardy, drought resistant, and evolved as highly adapted to the climate for the past 50 million years. Forage quality is high for livestock and wildlife grazing. The grasslands are equally important for their life-renewing essential ecological services, for habitat and forage for domestic livestock and wildlife on ranches, parks, and military facilities, and for conservation of rare and endangered ecosystems and species.

Today these remnant upland prairie natural grasslands primarily occupy soils unsuitable for crops. These rangelands are often too steep and hilly, or their soils are too saline, sandy, rocky, shallow, or impacted by frequent droughts to be used for crop production. The upland grasslands are primarily dominated by cool season grasses and forbs. In wetlands that cannot grow crops or are of great value as wildlife habitat, the riparian grasslands are composed of grasses, sedges, rushes, and cattails.

There are five prairie ecoregions: Dry Mixed Grass, Mixed Grass, Foothills Fescue, Parkland Northern Fescue, and Tall Grass prairie. The most favored soils for annual crop production are Black, Dark Gray, and Dark Brown chernozems and solods. Consequently, the soils of these areas have the lowest acreages of natural grassland remnants today. Currently, the natural grasslands in the Tall Grass, Parkland-Northern Fescue, and Mixed Grass prairie ecoregions are considered endangered, rare, or threatened ecosystems.

The policies developed in the 1870's required homesteaders to cultivate most of their property and grow cereal crops in order to receive the free land. The settlers were familiar with annual crops and perennial forages from eastern Canada and Europe. They had no experience with the prairie natural grasslands that their horses and cattle grazed. To this day, there is a preference by some prairie farmers for introduced, grain, oilseed, and tame perennial forages over hardy, productive native grasslands. Others recognize and manage the native grasses and forbs because they are drought tolerant and nutritious for livestock and wildlife. Well managed natural grasslands still grow during droughts, while the more heavily grazed, introduced perennial grasses tend to go into dormancy.

Natural grasslands offer more to our planet than high quality forage. Grasslands are involved in oxygen production, carbon sequestration, biodiversity, erosion management, watershed management, nitrogen fixation, and filtering out contaminants. These essential ecological resources and services are necessary for human societies to survive on earth. However, these services do not yet have a market value in our economy, Prairie natural grasslands are in high demand by ranchers for livestock grazing, by wildlife enthusiasts for flora and fauna, and as habitat for rare and endangered species, such as the burrowing owl, piping plover, and swift fox. In addition, prairie grasslands provide nesting cover for waterfowl, recreational areas for hikers, hunters, and photographers, and natural settings for those seeking peace and quiet away from busy lives in the city.

The prairie climate is continental and highly variable. The Rocky Mountains to the west act as a barrier to the prevailing northwesterly flow of weather systems. Drought has always been a frequent visitor to the prairies. Tree-ring studies reveal that, over the past 400 years, two major droughts per century were normal. Another major drought is now overdue. The high frequency of drought on the prairies, and particularly in the Dry Mixed Grass prairie ecoregion, is important for ranchers and park and wildlife range managers to recognize and address in their management planning.

There is still much scope left to develop knowledge for natural prairie grasslands. These grasslands are generally best managed by moderate grazing using specific types of grazing systems. The native grasslands of uplands and wetlands are particularly vulnerable to heavy spring and early summer grazing pressure, regardless of whether foraging is by livestock or wildlife. Riparian grasslands and shrub lands constitute a small part of the landscape, but they require specialized management systems to remain healthy and productive.

Today, ranchers and livestock farmers often have a combination of forage types for grazing, including some natural grasslands, tame perennial grasslands, annual forages, forested rangelands, stubble crop residues, annual crop windrows, and occasionally irrigated pastures. Some tame perennial grasses, such as crested wheatgrass and smooth bromegrass, can provide quality spring to early summer pasture. Forested rangeland is most frequently available and nutritious in mid-summer. The ecological health of native grasslands is most favored by late summer, fall, and winter grazing.

Brush expanded into thousands of hectares of mesic grasslands, parklands, foothills and Tall Grass prairie after humans stopped setting and controlling prairie fires. Carefully managed prescribed burns followed by specific kinds of grazing practices can reduce the brush encroachment. This brush can be economically used for grazing and browsing, thus reducing grazing pressure on grasslands. In contrast, most mechanical and herbicide practices to reduce brush are usually not economical.

Unique management challenges occur in various prairie natural grassland ranges. The Canadian military has four large training bases; they are mostly composed of natural grasslands and parkland. Wildlife, some livestock grazing, and conservation

are generally compatible with military objectives. Other natural upland grasslands and wetland grasslands are reserved for conservation, waterfowl habitat, and park purposes. Park range managers face real challenges to meet conservation objectives and effectively manage large herds of showy, wild ungulates. Left to their own devices, large wild ungulates tend to overgraze preferred areas, leaving them in poor ecological health.

Oil and gas exploration, pipelines, utility corridors, roads, and highways all pass across natural grasslands. Reclamation in the past has favored the use of introduced forage species. Now more use of native grasses and forbs is developing; however, more management and research are required to protect these rare ecosystems.

In the future, there will be more interest in expanding these productive, biologically diverse, hardy, drought resistant, natural grasslands. There will also be greater use of local native grasses and forbs for reclamation and reseeding purposes. Canada's prairie will become multi-use in the future as the needs and demands for recreational use, oil and gas, conservation, wildlife, environmental benefits, ecological services, and livestock grazing increase. All Canadians need to do their part in developing policies to keep Canada's native grasslands sustainable for future generations.

Additional information on grazing management can be found at **www.Foragebeef.ca**; this Web site summarizes all applicable forage and beef research in Canada. To find more useful information, go to the section called "Range"; sub section "Range Management Basics"; sub section "Fact Sheets".

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Highlights

- The management and conservation of ancient natural grasslands on the prairies is the primary emphasis of this publication.
- Livestock and wild ungulate grazing management is important, as is the management of habitat and other interests required by a wide variety of stakeholders.
- Among the topics discussed are conservation of endangered ecosystems including individual plants and animals, health issues of ecosystems and animals, biodiversity, ecosystem services, and the effects of various recreational uses, military training, and oil and gas exploration and livestock production interests on natural grasslands.
- Grazing practices by livestock and wildlife affect the sustainability of grassland ecosystems, as well as rare and endangered species, birds, reptiles, and fisheries and entire ecosystems.
- Disturbances made by industry, recreation, grazing, and military training need to be managed in a way that contributes to the well-being of these rare, and increasingly endangered, ancient, natural prairie grasslands. All of the users have the potential to disrupt the ecological health of the ecosystems. These disruptions may cause erosion, overgrazing, trampling and compacting soil, and wildfire. In addition, the grassland ecosystems may be exposed to invasive weeds, reduced ecological services or biological diversity or forage productivity, that further threaten the existence of these rare grassland ecosystems. These disturbances can be threats to specific rare or endangered native plant and animal species.
- High stocking rates, excessive spring-summer grazing practices, inappropriate grazing systems and their applications and excessive disturbance by industry, oil and gas, certain damaging recreational practices, and tillage by crop agriculture continue to reduce the area of natural grasslands, or reduce its ecological health.

Management of Canadian Prairie Rangeland

Chapter 1: Introduction

Canadian prairie rangelands or grasslands are composed mostly of ancient natural grasslands, some forest ecosystems, as well as introduced, semi-permanent grasslands developed by ranching and farming interests. The 50 to 80 million-year-old natural grasslands are widely distributed. They occur on well-drained uplands, plains, steep slopes, sand dunes, and in moist, low-lying riparian landscapes.

The ancient natural grasslands of the Canadian prairies have adapted and evolved for about 50 to 100 million years as the Rocky Mountains arose. This chain of mountains created a rain-shadow on the prairies and modified the climate and the effects of weather systems from the Pacific. As the drier continental climate developed over centuries, there was a shift in vegetation from moisture-loving forests to more drought tolerant, prairie grasslands, shrub lands and deciduous forests.

The Canadian prairies stretch about 1,800 km from southeastern Manitoba to northwestern Alberta. The natural grasslands of both uplands and riparian (wetland) areas were the traditional habitat for grazing herds of wild ungulates, including bison, horses, and wild camels. These habitats provided nesting cover for waterfowl and song birds. The grasslands are also the preferred habitat for various predators, small mammals, birds, reptiles, amphibians, insects, arthropods, and microorganisms.

The present area of natural grasslands is a fraction of what it was a century ago. The policies developed by the federal government between 1870 and 1930 resulted in annual crop agriculture occupying virtually all of the Canadian prairies, regardless of whether that land use was, or was not, adapted to the climate, soils and landscapes. Many errors were made in the race to settle the Canadian prairies. Now, modern society desires more roads, pipelines, railways, utility corridors, cities, towns and rural acreages. These priorities continue to reduce the area of natural grasslands. Industrial interests and military training facilities also are found on the ancient natural grasslands in addition to recreational opportunities for hikers, photographers, hunters, fisheries, families, and off-trail experiences. Underlying many prairie rangelands are geological formations containing oil and gas sand, gravel and mineral deposits. The exploration and discovery of these underground resources provide substantial income to federal and provincial governments sometimes without adequate reclamation or renewal of the native grasslands.

Range management refers to the management of rangeland components to obtain the optimum combination of goods and services for society on a sustained basis (Holechek *et al.* 2004). It is recognized that the natural grasslands provide various kinds of goods, resources, and services of value to many interests. There is a continuing demand for the provision of forage and habitat for livestock, wild ungulates, small mammals, birds, reptiles, amphibians, insects, arthropods and microorganisms. In various areas, specialized management is required because of certain high priorities. These include livestock and wild ungulate habitat, management for endangered plants and animals, conservation of the landscape, plants and animals in national and provincial parks, and provision of training areas and facilities for military personnel. In addition, modern range management requires an approach that provides a sustainable rangeland for diverse recreational pursuits and the need for reclamation protocols following oil and gas exploration and other industrial activities.

Natural grasslands provide the earth with various complex services and processes that enable life to be sustained on this planet. These are called ecological goods and services and they include such services essential to life on earth as the provision of oxygen by plant photosynthesis. There would not be enough oxygen for animal life to exist on earth without plant photosynthesis. Natural grasslands provide water and watershed function and a multitude of other ecological services. These services include storing carbon (carbon sequestration), nitrogen fixation, the filtration of contaminants and sediments, watershed management, and erosion control.

The management of Canadian prairie natural grass rangeland has become much more complex. Previously, the emphasis was on managing these natural grasslands for grazing. Both livestock and wild ungulate grazing of these grasslands remains a major resource use, but there are now many other users. These remnant grasslands also have heritage value and high biological diversity. The plants and animals that have evolved in these grasslands over millions of years provide important ecological, genetic, and possibly medicinal resources.

More demands are being placed upon natural grasslands by modern society. For example, in addition to the needs for grazing on public and private lands, some of the larger areas of remnant natural rangelands are managed by the Department of National Defence for the training of military personnel or for conservation purposes in national or provincial parks. Every year oil and gas exploration companies search below the ground surface of grassland ranges for additional hydrocarbon resources. All of these land uses have unique needs and risks. They create opportunities for invasion of disturbed grassland and forest areas by alien plants and require appropriate management and reclamation procedures to stabilize and sustain the ecosystems. There is a continually expanding demand for a variety of recreational activities. Some recreational activities may be destructive to natural grasslands, while others are not. All activities require monitoring and some level of supervision.

The emphasis in this bulletin is on the effective range management of grazing by wild ungulates and livestock. Introductions are made to the specialized needs of range management for interest groups such as the Canadian military training facilities and the national and provincial parks. An emphasis will be placed on how to maintain a high level of ecological health on natural grassland ranges regardless of which interest has highest priority for a specific landscape unit.

Prehistory

The natural grasslands developed and evolved over thousands of years in response to a dry continental climate, the characteristics of the dominant soils, prairie fire, grazing animals, and insects, in addition to the management practices of early humans. In the northern Great Plains, frigid temperatures in winter and warm to cool summer temperatures are the norm. Periodic cycles of drought and non-drought, wind, thunderstorms and tornadoes, under-grazing, overgrazing, and trampling influenced the plant communities that exist today. Over thousands of years, grass-eating animals and their predators evolved with the prairie plants. They included various species of bison, elk, deer, antelope, horses, camels, big horn sheep, small mammals, insects, and birds. The array of predators included wolves, grizzly bears, aboriginal peoples, and more recently, eastern Canadian, European, and American settlers.

The natural grasslands of the prairies are of ancient forest origins and evolved following the rise of the Rocky Mountains millions of years ago. As the mountains increased in height, less precipitation occurred on the prairies. Thus, a rain-shadow developed east of the new mountain range causing drier growing conditions. Moisture-loving plants declined and those adapted to drier conditions flourished. Today, most of the plants are cool season grasses, forbs, sedges, shrubs, and trees. In the southern Canadian prairies, some warm season grasses and forbs grow intermingled with cool season plants.

The prairie grasslands endured four or more major glaciations over the past one million years. The repeated movement across the prairie landscape of continental glaciers caused the extinction of plant and animal species, while other species survived in unglaciated patches or in areas south of the glaciers. It remains unknown what proportion of the pre-glacial flora and fauna became extinct due to glaciation. What little evidence there is suggests perhaps one-third of the plant species disappeared (Moss 1955 and Bailey 1999). Biological diversity is an important ecological issue today. Natural grasslands are almost always more diverse than cultivated tame pastures or annual cropland, because of the wide variety of species that comprise the ancient grasslands.

Remnant Natural Grasslands Today

Traditional rangelands of the Canadian prairies occupied about 61.5 M ha (152 M ac.) of the northern Great Plains (Clayton *et al*. 1977). These natural grasslands were maintained by conservative grazing and other range management practices rather than by tillage, fertilizers, herbicides, or energy intensive plantings of alien annual or perennial crops. Since the last continental glacier left about 12,000 to 15,000 years ago, carbon sequestration in prairie soils of the Brown, Dark Brown and Black soil zones of chernozem and solonetz soils elevated the fertility levels in the upper soil horizons. During the last 100 years, this rich resource has been depleted by intensive agricultural cropping practices for the growth of cereal grains and oilseeds. These agricultural practices also contributed to climate change, erosion, soil salinity, and a reduction in both soil fertility and carbon sequestration (Gameda *et al*. 2007, Raddatz, 1998).

Prairie grasslands stretch from a few remaining Tall Grass prairie stands in southeastern Manitoba northwestwards through the aspen parkland and plains rough fescue grasslands of Manitoba and Saskatchewan to central Alberta. The Mixed Grass prairie occurs south of the parkland, mostly in southern Alberta and southern Saskatchewan. Small acreages of natural grasslands remain in the Peace River region of northwestern Alberta and adjacent British Columbia.

Riley *et al*. (2007) estimated that there were approximately 7.8 M ha of native grasslands in the Canadian Prairie Provinces. In this publication, we are using data supplied by Statistics Canada (2006), Horton (1994), and McCartney and Horton (1999) and supplemented with information from several other sources.

The Statistics Canada Census for 2006 revealed the estimated area of natural lands (uncultivated land) used for livestock pasturing (Table 1). The information from Statistics Canada is presented near the top of Table 1 under the heading “All Lands Grazed: grassland and forest range”. These statistics do not differentiate grazing use of natural grasslands from grazing use of forested rangelands. Other sources were used to estimate the proportion of natural grassland and forested grazing lands in the Canadian prairies. The area estimated to be in natural grassland is presented in Table 1 under the heading “Natural Grassland Only”. Additional sources were used to supplement the census statistics to provide an estimated area of remnant natural grasslands not being administered for livestock grazing purposes, such as in parks and military bases.

Substantial acreages are administered by the military and by parks. There are about 11.4 M ha (28 M ac.) of natural grasslands remaining in the three Canadian Prairie Provinces (Table 1). Clayton *et al*. (1977) indicated there were about 61.5 M ha (152 M ac.) of prairie soils occupied by natural grasslands prior to their tillage by crop farmers. There were about 60.7 M ha (150 M ac.) of chernozem and solonetz soils in the three Prairie Provinces and another 0.81 M ha (2 M ac.) of natural grasslands under Dark Gray luvisol soils. These chernozem and solonetz soils evolved under natural grasslands, whereas the Dark Gray luvisol soils evolved under a varying vegetative cover of grasslands (during some time periods) and forests (during other time periods). In a span of 50 to 90 years, crop agriculture cultivated about 50 million ha (124 million ac.), thus destroying over 80% of the ancient natural grassland ecosystems.

Of the 11.4 million hectares (28.2 M ac.) of natural grassland and rangeland that remain on the Canadian prairies, about 10.9 M ha (26.8 M ac.) are grazed by domestic livestock and wildlife. Another 324,000 ha (800,000 ac.) are under management for military training and about 243,000 ha (600,000 ac.) are grazed by wildlife within provincial and national parks.

Table 1. Estimated hectares of Canadian natural prairie rangeland by province.

	Alberta	Saskatchewan	Manitoba	Canadian Prairies
All Lands Grazed: grassland & forest range				
Natural land for pasture*	6,529,916	5,175,864	1,548,223	13,254,000
Crown & PFRA pasture**	921,884	808,975	167,137	1,897,996
Military rangeland***	419,487	18,000	44,516	482,000
Natural Grassland Only				
Natural grassland*	4,832,120	4,140,707	636,008	9,908,835
Crown & PFRA pasture**	460,942	404,488	83,568	948,998
Military grassland***	299,471	12,000	24,281	335,752
Parks grassland***	80,938	109,266	72,844	263,049
Total natural grassland	5,673,471	4,666,461	1,116,702	11,456,634

*Statistics Canada Census 2006 refers to natural lands that are used for livestock pasture. No information is reported for areas of natural grassland not being grazed by livestock, as found in parks, military bases, and other conservation areas. **From Horton 1994, and McCartney & Horton 1999. ***Estimated by the authors.

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Chapter 2: Climate, Soils, Ecological Services, and Climate Change

Highlights

- The prairie climate is continental with cool to warm summers, cold to frigid winters, and most precipitation occurs in the critical growing season of May to July.
- Cycles of drought and above average precipitation are common.
- The driest ecoregion is the Dry Mixed Grass prairie, followed by the Mixed Grass prairie, the Foothills Fescue, Parkland Fescue and Tall Grass prairie in the order of dry to mesic climatic conditions.
- Climate is always changing and the prairie climate has warmed over the last century because of two principle factors: greater solar energy input from the sun and the warming effect following tillage of 50 M ha of natural grasslands.
- Only one major drought cycle occurred in the 20th century compared to the normal two to four cycles per century typical of the past four centuries.
- Humans need to prepare for a higher frequency of major drought.
- Prairie natural grasslands provide the planet with critical ecological services, including oxygen, carbon sequestration in topsoil, forage, wildlife habitat, biological diversity, water, and prevention of soil erosion, plus a filtration system to catch sediments, recycle nutrients, and detoxify chemicals and wastes. The grasslands also provide social services by offering wide open spaces that supply varied recreational opportunities to calm the soul and provide peace of mind for both urban and rural residents.

Prairie Landscape

The western Canadian Great Plains stretch from the Rocky Mountains in Alberta and northern British Columbia eastwards to Manitoba. The plains are dissected by valleys created by ancient rivers that flowed following the melting of glaciers. The highest elevations on the plains are near the Rocky Mountains in southwestern Alberta; elevation decreases to the east and the north.

The topography of the northern Great Plains is highly diverse. Local landscapes vary from flat plains that occur in ancient glacial lake bottoms to deep valleys, gently rolling plains, or moderate hills to high escarpments.

Climate

The Canadian prairies have a continental climate. Freezing temperatures and periods of extreme cold are common in mid-winter. In summer, the climate can be warm to hot in the south and cooler further north. Thunderstorms are frequent in the growing season. In western parts, the maritime pacific air masses modify and often shorten periods of extremely cold temperatures during winter and high temperatures during summer.

The most common weather systems come from the northwest, bringing precipitation and cool to mild temperatures. During summer, Manitoba and southeastern Saskatchewan benefit from air masses originating in the Gulf of Mexico that bring both warm air and precipitation. In winter, frigid air masses originate in the Arctic and sweep southwards across all of Canada. Air masses from the southwest during winter bring warmer temperatures and high winds to southern Alberta.

The driest part of the prairies is the Dry Mixed Grass prairie ecoregion in southeastern Alberta and southwestern Saskatchewan (Tables 2 and 3). This ecoregion has an average annual precipitation of 300-350 mm (Anonymous 2007). Most plant growth happens from May to July when about 150 mm of rainfall occur. Precipitation varies widely from year to year due to the high frequency of droughts. The Dry Mixed Grass prairie coincides with the area also described as the "Palliser Triangle"; there was a drought in progress during 1857-1860 when Captain John Palliser described these arid prairies as "forever comparatively useless" for cultivated agriculture (Palliser 1859-60:21).

Average annual precipitation for the period of 1971-2000 was higher west, north, and east of the Dry Mixed Grass ecoregion (Table 2). In the Mixed Grass prairie ecoregion,

Table 2. Average annual temperature, annual precipitation, and May-July precipitation for selected stations in all three Prairie Provinces.

	Annual temperature (°C)	All Provinces annual precipitation (mm)	May-July precipitation (mm)
Dry Mixed Grass	4.1	327	153
Mixed Grass	3.3	395	174
Foothills Fescue	4.2	502	199
Parkland Fescue	2.1	412	196
Tall Grass	2.7	541	225

annual precipitation averages about 395 mm, while the May to July precipitation averages 174 mm, or about 20 mm more than in the Dry Mixed Grass prairie. The average annual temperature in the Alberta Mixed Grass prairie is cooler than in the Dry Mixed Grass ecoregion.

The Foothills Fescue ecoregion is located in the southwestern Alberta foothills and also the Cypress Hills of southwestern Saskatchewan and adjacent Alberta. Annual precipitation averages about 500 mm. In the southwestern Alberta foothills, average temperatures are warmer than in the adjacent Mixed Grass prairie. Warm, strong, and gusty chinook winds often blow from the southwest during winter. They melt snow on the rangeland and often enable grazing for 12 months per year. May to July precipitation averages about 200 mm, about 25 mm higher than the Mixed Grass prairie and 50 mm higher than the Dry Mixed Grass prairie. The northern boundary of the Foothills Fescue ends approximately where chinook winds diminish northwest of Calgary, Alberta.

The Parkland Fescue ecoregion, also called the Aspen Parkland, meets the northern boundary of the Foothills Fescue ecoregion northwest of Calgary and extends northeastwards to the North Saskatchewan River and southeastwards until it blends into the Tall Grass prairie and Mixed Grass prairie ecoregions in southeastern Saskatchewan and adjacent Manitoba. Average annual temperature and precipitation are lower in the Parkland Fescue ecoregion than in the Foothills Fescue ecoregion. Average precipitation in May to July is about 200 mm for both the Parkland Fescue and Foothills Fescue ecoregions.

The Tall Grass prairie ecoregion extends northwards from Texas to southern Manitoba. The Black chernozem soils are deep and fertile, and growing season precipitation and temperature are so favourable to crop agriculture that most of the region is cultivated. Only a few relic stands of this natural grassland remain, generally located on sandy soils or riparian areas in Manitoba. The summer climate in the Tall Grass prairie ecoregion is warmer and moister than in the Parkland Fescue ecoregion (Table 2).

There are noticeable differences in average annual daily temperature and precipitation from province to province for the period 1971-2000 (Table 3). Generally, Manitoba and Alberta have both higher annual precipitation and annual temperature than Saskatchewan. Average annual temperatures in both the Mixed Grass and Parkland Fescue (Aspen Parkland) ecoregions are higher in Alberta, the most westerly Prairie Province, than in Saskatchewan. Alberta is exposed to more Pacific maritime weather systems that arrive on westerly winds. These air masses cool and drop less precipitation in Saskatchewan. Southern Manitoba benefits from the moisture and warmer air from southern weather systems that originate in the Gulf of Mexico.

The Parkland Fescue, Foothills Fescue and Tall Grass prairie ecoregions generally receive more than 400 mm of annual precipitation. Aboriginal burning practices maintained these ecoregions in prairie grassland. Starting in the 1920's and continuing today, the European immigrant's fear and ignorance of both prairie wildfire and prescribed burning caused an invasion of drought tolerant shrubs and trees, such as snowberry and aspen. Over time, this woody vegetation will cause the organic matter content to deteriorate in the Black, Dark Gray, and Dark Brown chernozem and solonetz soils.

Soils

Soils of the western Canadian plains (Figure 1) are considered young because the last continental glacier only melted 12,000 to 15,000 years ago. Soils that developed under natural grasslands in cool temperate prairie regions accumulated high levels of organic matter in the Ah horizon, the upper soil horizon. They are very fertile and are called chernozems, or if there is high sodium in the B horizon, they are described as solonetz.

The Dry Mixed Grass prairie ecoregion is in the Brown soil zone and is also the driest part of southern Alberta and adjacent Saskatchewan. The adjacent Mixed Grass prairie ecoregion is a somewhat moister area with mostly Dark Brown soils. The Foothills Fescue and Parkland Fescue

Table 3. Average annual daily temperature, annual precipitation, and May-July precipitation for 3 to 5 locations in each Prairie Province by ecoregion.

	Alberta			Saskatchewan			Manitoba		
	Annual daily temp (°C)	Annual precip (mm)	May-July precip (mm)	Annual daily temp (°C)	Annual precip (mm)	May-July precip (mm)	Annual daily temp (°C)	Annual precip (mm)	May-July precip (mm)
Dry Mixed Grass	4.5	331	147	3.7	322	159			
Mixed Grass	4.5	374	156	2.0	415	191			
Foothills Fescue	4.2	502	199	2.4	607	243			
Parkland Fescue	2.4	442	212	1.7	381	180	2.6	495	212
Tall Grass prairie							2.7	541	225

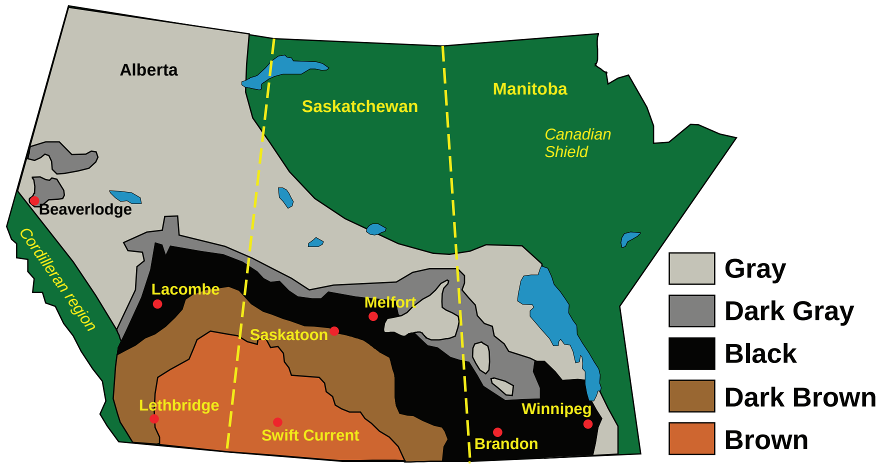

Figure 1. A generalized soil map of the Prairie Provinces.

(Aspen Parkland) ecoregions are in comparatively moist areas and have mostly Black chernozem or solonetz soils. Deep, black Ah horizons were lain down by decomposing grass roots under the cool, mesic climate. Solonetz soils have high amounts of sodium in the B horizon that originated from underlying geologic formations. These solonetz soils occur throughout the prairies.

The early settlers preferred the Black, Dark Gray and Dark Brown over the Brown soil zones for cultivated agriculture because of the higher soil moisture, higher organic matter, and higher soil fertility. The deeper soils of the solonetz soil order, particularly the solods, were also cultivated.

In chernozem soils, the quantity of organic matter is highest in the Ah horizons of the Black soil zone, intermediate in the Dark Brown soil zone, and lowest in the Brown soil zone. The riparian (wetland) grassland soils associated with the wet grasslands are primarily humic gleysols. They usually have a black Ah horizon containing high levels of organic matter.

Over time, wild fires had an effect on the type of vegetation found on the prairie landscape. The frequency of fire on the prairies was high in prehistory because of the predominantly dry conditions, periodic lightning from thunderstorms, and aboriginal land management that used frequent controlled burning. In the absence of fire following European settlement, drought tolerant species like aspen and snowberry encroached into the grasslands over millions of hectares.

Climate Change: Overview

- The past century has been unusually drought free. This is not expected to continue.
- The risk of prolonged drought is probably higher now due to climate change.
- No one knows for sure how much the climate will change in the next 50-100 years, but the last 750 years of tree-ring records indicate when and for how long drought occurred in the past. This information indicates that land managers must be prepared to deal with longer periods of drought in the future than occurred in the past century.

Currently, there is concern regarding climate change and specifically about the effects of global warming. Climate is always changing and that will continue. One of the major natural factors in climatic fluctuation is the quantity and quality of energy from the sun. There are periodic cycles of energy output from the sun, such as the increased output since about 1850 (Francis and Hengeveld 1998). Some of this additional energy is attributed to high sunspot activity, but in June 2008, NASA reported no sunspot activity (Hathaway 2009). If there is reduced sunspot activity for the next few years, there may be less energy output from the sun. This may result in cooler temperatures on earth for a period of years. For example, the Little Ice Age occurred from 1645-1715 during a period of low sunspot activity. Other short-term effects on climate include the El Nino effect which causes short-term warming in winter for a few years at a time (Cutforth *et al.* 1999).

Average surface air temperature has increased over Canada as a whole by about 1°C in the last 100 years (Skinner & Majorowicz 1999). Shen and Yin (2005) indicated that Alberta's daily minimum surface temperature has increased about 1.3 to 2.1°C from 1895 -1991. Zhang *et al.* (2000) found that between 1990 and 1998 the temperature was warmer in the west and cooler in the northeastern parts of Canada. The greatest warming occurred recently in the western part of Canada during spring and summer. Thus, the amount of snowfall has decreased while rainfall has increased. Accompanying that warming trend has been a general increase in precipitation across southern Canada of about 5 to 35%.

A general warming trend over the past century has been compounded across the Canadian prairies by a century of land use changes (Skinner and Majorowicz 1999, Raddatz 1998). Akinremi *et al.* (2001) argued that the Canadian prairie region may be unique in its response to climate change because of the effects of large-scale changes in land use. Cultivation (and thus removal of 50 M ha, or 80%, of the prairie natural grasslands) and replacement with annual cereal crops have contributed to a rise in temperature in the region. The average increase in surface minimum temperature due to land use changes is approximately 1 to 1.5°C. When one flies across the prairies in winter and early spring and observes the vast expanses of exposed dark soil in cultivated areas, as compared to the lighter colors in grassland areas, one can understand how more heat is absorbed into the exposed surface soil, thus contributing to global warming.

The conversion of this vast region from natural grassland into annual crops in the 20th century likely contributed significantly to increases in temperature and to changes in pattern and intensity of thunderstorms (Raddatz 1998). Regional evapotranspiration has declined in spring and fall annual crops, particularly wheat. Raddatz (1998) and Raddatz and Cummine (2003) have found that more severe thunderstorms and tornadoes coincide with the peak growth period of annual crops.

The use of summer fallow on the Canadian prairies declined from over 11 million hectares to 5.4 M ha by 2001, and it is projected to decline further to about 3.4 M ha (Gameda *et al.* 2007). From 1976 to 2000, the climate trends in the Black, Brown and Dark Brown soil zones have shown a reduction in maximum temperature of 1.7°C per decade, solar radiation of 1.2 MJ/m^2, and also an increase in precipitation of 10 mm per decade during the mid-June to mid-July period when annual crop growth would be highest. These findings are in opposition to the expected trends under global warming. This suggests a substantial association between reduction in summer fallow and changes in climate of the prairie region. Trends in climate toward higher temperatures and more intense thunderstorms may be reduced during mid-June through July as the use of summer fallow and traditional tillage on prairie grain lands is replaced by: 1) planting marginal croplands to native perennials, and 2) minimizing tillage in cropland, or 3) using zero tillage or no tillage by one-pass seed and fertilizer placement, and packing each furrow while retaining the surface residue (litter).

The climate of the Canadian prairies has been an anomaly during the 20th century because of the absence of prolonged drought periods (Sauchyn *et al.* 2003). That is not normal for the Canadian prairies. Since settlement in the early 1900's only one decade, the 1930's, had a prolonged drought. However, seventy years later, a severe but short-term drought during 1999 to 2002 caused a significant reduction in forage and pasture production in the Parkland Fescue ecoregion (Aspen Parkland) of Alberta and Saskatchewan. Many ranchers depended upon the generosity of eastern Canadian farmers for emergency shipments of hay to maintain a part of their breeding herds. In the future, managers will need to be better prepared for such severe drought conditions. They will require more conservative grazing management practices and greater quantities of stored forages than is the norm in the Parkland Northern Fescue ecoregion today. Range managers will need to be more adaptable in the future to survive more long-term droughts than in the 20th century.

Table 4. Periods of prolonged drought on Canadian prairie rangeland over four centuries as approximated by tree-ring data from one Douglas fir tree.

Century	Drought Period	Years of Drought
1900 -1999		
	1929 -1941	12
1800 -1899		
	1891 -1898	7
	1860 -1873	13
	1841 -1854	13
	1809 -1825	16
1700 -1799		
	1791 -1804	13
	1713 -1722	9
1610 -1699		
	1677 -1693	16
	1633 -1643	10

Adapted from Sauchyn (2007)

How does the severe short-term drought of 1999 to 2002 compare to previous droughts? Many would conclude that it was quite minor compared to the findings of Sauchyn and his associates (Table 4). Tree-ring and other historical data indicate much more variability in precipitation from the 1600's to the 1800's than in the 20th century. Sauchyn *et al.* (2003) cited the 1790's drought at Fort Edmonton, in the Parkland Fescue region, as being so severe that the North Saskatchewan River water levels were too low in some years for fur-laden canoes to navigate downstream during spring runoff. Similarly, 65 years later, the Palliser Expedition surveyed Canadian prairies (1857 to 1860) during another drought. Captain John Palliser declared the arid prairies "forever comparatively useless" (Palliser 1859-60:21) for crop agriculture. Sauchyn (2007) used tree-ring data (Table 4) to indicate a total of four droughts from 1791 to 1873. These droughts coincided with the low waters on the North Saskatchewan in the 1790's and the arid conditions found by the Palliser Expedition in the Dry Mixed Grass prairie. Over the 400 year period between 1600 and 2000, Sauchyn (2007) observed that there was one long-term drought approximately every 50 years.

Range managers on the prairies are frequently exposed to extreme weather events, such as short or longer duration droughts, abnormally high precipitation, lightning and thunderstorms, and extreme heat and cold. A highly adaptive capability within the ranching industry has enabled their survival through droughts, the recent BSE (bovine spongiform encephalopathy) crisis, and brush encroachment in the absence of natural prairie fires.

Ecological Goods and Services

Ecological goods and services are derived from the ecological functions of healthy ecosystems. Some examples of these are the oxygen we breathe, clean air, forage, food, habitat, and abundant fresh water. Both rangeland and cropland ecosystems contribute ecological goods and services. Natural grassland plants photosynthesize during the growing season by taking in carbon dioxide, water, and light energy to produce plants that serve as both habitat and forage. Oxygen is a byproduct of photosynthesis that all animal life depends upon for survival. Other examples of grassland ecological resources and services include carbon sequestration in topsoil, nitrogen fixation, purification of air and water, and pollination of plants. Additional ecosystem services include decomposition of wastes, groundwater recharge on uplands and wetlands, greenhouse gas mitigation by photosynthesis and other means, vegetation growth and renewal providing groundcover, forage and habitat, seed dispersal, and maintenance of biological diversity.

Costanza *et al.* (1997) indicated that goods and services from ecological systems are essential to life on earth as we know it. These services contribute to human welfare, both directly and indirectly, and to economic functioning through the sustainability of healthy ecosystems worldwide. The estimated value of ecological goods and services is about 33 trillion (USD) per year for the entire biosphere. Most of that economic value is for essential goods and services that are not valued in the normal economic market place, such as carbon sequestration. Other sources of information regarding ecological goods and services can be found at www.ecosystemvaluation.org, prairie habitat joint venture, Balmford *et al.* (2002), and www.stewardshipcanada.ca.

In the Canadian natural grasslands, an example of an ecological good is forage for livestock and wildlife. An example of an ecological service is the photosynthesis that provides oxygen to all living animal species. Under the cool climate of the Canadian prairies, as the range plants grow, die, and replace themselves, grassland soils gradually accumulate more organic matter. The accumulation of organic matter in the Ah layer is described as carbon sequestration. This prairie topsoil layer is one of earth's most important carbon sinks and it is typically quite fireproof. Fire on the prairies rarely consumes the sequestered carbon. In contrast, when a crown fire burns through a forest, this important above-ground carbon sink releases a lot of carbon into the atmosphere.

For most of the 20th century, farmers cultivated approximately 50 M ha of prairie topsoil, permanently modifying the ancient prairie grasslands and the complex biological diversity that had developed over about 100 million years of evolution. The European settlers' actions reduced topsoil fertility and organic matter. Loss of carbon contributed to global warming. The introduction of minimum till or no till crop farming methods has reduced some of the negative effects of crop agriculture by maintaining some vegetative cover. Vegetative cover reflects a high proportion of incoming solar radiation, helping to reduce the soil surface temperature and also losses of soil organic matter and soil carbon.

The maintenance or reclamation of natural prairie grasslands contributes to the replenishment of oxygen, nitrogen, nitrogen fixation, carbon sequestration, reduces greenhouse gases, minimizes soil erosion, filters sediment and chemicals from water, and detoxifies certain contaminants. The natural grasslands act as a sponge, taking in and then slowly releasing water, and then fostering year-round runoff from watersheds.

Conservative grazing practices on natural grasslands help maintain higher levels of ecological goods and services by increased forage production and spatial diversity in grazing patches across the landscape, while maintaining high biological diversity. Conservative grazing also contributes to the maintenance of taller forage plants, better nesting cover for birds, deeper root systems, and more ground cover and diverse habitats for wildlife and livestock. It also promotes increased carbon sequestration because it promotes deeper plant roots, higher oxygen production, and more carbon dioxide utilization. Tall vegetative cover traps more snow and acts as a sponge to better absorb water. The higher organic matter that develops in the topsoil helps maintain more reliable water flow patterns. In contrast, overgrazed rangelands realize a rapid loss of water after each snowmelt or rainfall event, more soil erosion, and a greater loss of sediment. This is because there is nothing to trap either the sediment or water.

Ecological Goods and Services Specific to Natural Grasslands

1. Forage: for grazing ungulates, wildlife, birds, and insects

2. Habitat: for large and small mammals (including livestock), birds, insects, reptiles, and amphibians
   - natural grasslands provide a home, shelter, and food for animals, birds, reptiles, and insects
   - nesting cover for birds, animals, and insects

3. Biological diversity: conservative grazing provides spatial, genetic, and biological diversity for 50 million-year-old, rare, and endangered natural grasslands
   - higher quality nutrition for herbivores (regardless of the season of grazing) due to the greater diversity of plants for diet selection

4. Carbon sequestration: stored in topsoil of the Black soil zone and lesser amounts in the Dark Brown, Dark Gray, and Brown soil zones
   - a major carbon sink
   - natural grasslands store more carbon in the soil under sustainable range management than does adjacent cropland, or most single species stands of introduced perennial grasses, or forested vegetation
   - rangeland soils are important soil carbon storage mechanisms world-wide

5. Nitrogen fixation:
   - nitrogen fixation is provided by various rangeland plants, including both legumes and certain non-leguminous herbs, shrubs, and trees
   - nitrogen is usually the first nutrient to become deficient during plant growth

6. Vegetative cover protects soil:
   - from water and wind erosion
   - from increased soil temperature
   - from degradation
   - traps sediment
   - sustains the vast carbon sink of temperate grassland soils

7. Filtration and neutralizer system:
   - filters soil sediments and nutrients
   - neutralizes many harmful agents
   - filters and neutralizes many toxins

8. Stores and manages water-flow patterns:
   - rangelands store water like a sponge
   - releases water slowly all year long, providing a more reliable water source for plants, livestock, and wildlife

9. Recycles nutrients:
   - filters nutrients from rainwater and run-off water
   - absorbs nitrogen from lightning and other sources
   - cleans watersheds

10. Open spaces:
    - for people, mammals, birds, and insects
    - a sense of refuge and peace from a busy, demanding world
    - an opportunity to reflect about nature and self
    - recreational opportunities that provide non-monetary value, including a sense of peace and well-being

11. Biodiversity
    - genetic reserves of native species (largely untapped)
    - nutraceutical and nutracine resource (for examples of indigenous uses see: Johnston, A. 1987. Plants and the Blackfoot. Lethbridge Historical Society)
    - risk of decreased production caused by multi-use of the grassland and soil resource

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Chapter 3: Rangeland Ecoregions and Plant Communities

Highlights

The major ecoregions and their locations within the Canadian prairies are as follows:

1. Dry Mixed Grass prairie is the driest ecoregion and is located in southeastern Alberta and southwestern Saskatchewan.

2. Mixed Grass prairie surrounds the Dry Mixed Grass prairie and is located in southern Alberta and southern Saskatchewan and extends eastwards into southwestern Manitoba.

3. Foothills Fescue prairie is located in southwestern Alberta with an outlier at higher elevations in southeastern Alberta and adjacent southwestern Saskatchewan.

4. Aspen Parkland-Northern Fescue is located in the central regions of Alberta and Saskatchewan; it extends southeastwards to southern Manitoba.

5. Tall Grass prairie is located in southeastern Manitoba; some of the flora extends westward to southeastern Saskatchewan.

Introduction

Ecologists have divided the Canadian prairies into ecological regions, or ecoregions, based upon similarities in climate, vegetation, and soils. Within each ecoregion there are various ecosystems, also called range plant communities or range types. Each ecosystem or range type is associated with specific kinds of soil, landscapes, and microclimates. In order to understand the forage productivity potential or other habitat characteristics, it is essential to understand the climate, soils, and vegetation within each ecoregion. This knowledge is vital in developing an understanding of this field of rangeland ecology whether the land is used for ranching, parks, or conservation areas.

The most recent publications concerning prairie grassland ecoregions or natural subregions and their range plant communities are three publications by Adams *et al.* (2005) for Alberta and also one by Thorpe (2007) for Saskatchewan. Adams *et al.* (2005) identified the range plant communities by the dominant and subordinate plant species and related them to the ecological range site (ecosite) based upon plants, landscape, soils, and climate. Thorpe (2007) identified the ecosites by landscape, soil characteristics, and climate.

In this publication, we have divided the prairies into ecoregions and then chosen to use primarily plant, soil, and climate characteristics to describe the various plant communities (ecosystems) rather than using the landscape and soil characteristics alone.

The range types are named using the dominant native plant species found in each rangeland plant community. Common plant species found in some of the range types are listed in Appendix 1 by common name and also by scientific name. The sources of plant names are mostly from Smoliak *et al.* (1982), Moss (1983), Barkworth *et al.* (2007), Harms (2003), and Tannas (2004 Volumes 1 and 2).

There are five ecoregions in the natural grassland areas of the Canadian prairies (Figure 1). Within the ecoregions are several range communities growing on specific types of soil, moisture, and topographic regimes. Each ecoregion is named after certain plants, climate, or landscape features.

The five Canadian prairie ecoregions are:

Dry Mixed Grass prairie: the driest part of the Canadian prairies is in the Brown soil zone. Montana and North Dakota also contain this type of ecoregion.

Mixed Grass prairie: is a somewhat moister ecoregion than the Dry Mixed Grass prairie; it is located in the Dark Brown soil zone, and also in Montana and North Dakota.

Foothills Fescue prairie: this ecoregion is moister than the two Mixed Grass ecoregions, and it is located in the Black soil zone in the southwestern foothills of Alberta adjacent to forested ecoregions. It is also located in Montana and southwestern Saskatchewan.

Parkland-Northern Fescue: this ecoregion is moister and cooler than the Mixed Grass ecoregions, being part of the Black and Dark Gray soil zones. It is adjacent to the boreal forest ecoregion.

Tall Grass prairie: this ecoregion is warmer and moister than the adjacent Parkland-Northern Fescue. It is part of the Black soil zone in southern Manitoba. This grassland is a northern extension of the U.S. Tall Grass prairie ecoregion that extends southwards as far as Texas.

The Foothills Fescue ecoregion only occurs in southwestern Alberta and in the Cypress Hills of Alberta and Saskatchewan where the climate is moister and cooler than in the two Mixed Grass prairie ecoregions. The Tall Grass prairie ecoregion only occurs on moister and warmer areas of southern Manitoba. The Aspen Parkland-Northern Fescue ecoregion stretches across the middle of the three Prairie Provinces (or about 1,800 km) and forms the interface, or broad ecozone, between the boreal forest to the north and the grasslands to the south.

Within each ecoregion are several ecosystems which we describe as rangeland plant communities or range types. Each range type is named after two to four plant species that are ecologically important in the plant community.

Dry Mixed Grass Prairie Ecoregion

The driest and warmest part of the prairies is the Dry Mixed Grass prairie in southeastern Alberta and adjacent southwestern Saskatchewan (Table 2) (Adams *et al*. 2005a). The soils are mostly Brown chernozem or solonetz (Figure 2). This is the prairie ecoregion most prone to frequent and prolonged periods of drought. The frequent presence of drought dictates the application of very conservative range management of the grazing resources, whether for livestock or wild ungulates, and to other kinds of habitat management. The reclamation of sites following soil or plant disturbance requires a high level of resource management skill because of the high frequency of drought.

Adams *et al*. (2005a) estimate that 43% of the original 5.4 million ha (11.8 million ac.) of this ecoregion remains intact in southern Alberta.

The most widely distributed grasses are needle-and-thread, June grass, western and northern wheatgrass, and blue grama grass. The first four grass species are cool season grasses, but blue grama grass is a warm season grass that rarely starts growth until late May. The most common shrubs are silver sagebrush and winterfat.

Three widely distributed major rangeland plant communities are described below. Adams *et al*. (2005a) provide a more complete description of many other range communities in this ecoregion.

An estimated ecologically sustainable stocking rate is given for most range types. For example, this rate is about 0.20 AUM/acre for the needle-and-thread-June grass-blue grama grass range type (below). That indicates it requires five acres to provide the forage needed for one animal unit (i.e., one 1,000-pound cow/calf pair). If the grazing season on natural grassland is six months long, then 30 acres of grassland is required on average to provide the grazing resources for one AUM, one cow-calf unit, for one year.

Needle-and-thread-June grass-Blue grama grass range type

This is the most common plant community found on loamy, or medium soil texture, range sites over extensive areas of the Dry Mixed Grass prairie. Three dominant grass species provide most of the canopy cover and forage production in this important rangeland plant community (Adams *et al*. 2005a). Soils are orthic Brown and Brown solonetz. Forage production on a healthy range averages 560 kg/ha (500 lb/ac.), forbs are low averaging 22 kg/ha (20 lb/ac.), and the litter cover averages 390 kg/ha (350 lb/ac.).

An ecologically sustainable stocking rate is about 0.08 AUM/ha or 0.20 AUM/ac.

Silver sagebrush / Northern wheatgrass-June grass range type

This is the common plant community for moderately drained blowout range sites. Eroded pits are associated with the solonetz soils, also known as “hardpan” or “burnout” soils. Soil texture is clay to clay loam. Silver sagebrush is the major shrub in most stands. Northern wheatgrass has the highest canopy cover, and bare soil averages 28%. Soils are Brown solod or Brown solodized solonetz. Conservative stocking

Figure 2. Upper left: Fescue Prairie in the foothills of the Rocky Mountains. The nearly continuous grass phase is shown; grazing carrying capacity decreases as trees and shrubs encroach on the grassland. Upper right: *Stipa-Agropyron* type of Mixed Prairie, which is transitional between Mixed Prairie and Fescue Prairie. Lower left: *Stipa-Bouteloua-Agropyron* type. Lower right: *Stipa-Bouteloua* type of Mixed Prairie, commonly called the Shortgrass Plains.

rates are recommended, particularly during drought, and if grazing is during the growing season. Moss and lichen cover averages 45%, while total vegetation cover is 55%.

The ecologically sustainable stocking rate is very low at 0.04 AUM/ha or 0.09 AUM/ac.

Wild rose / Needle-and-thread-Sand grass-Low sedge range type

This range community is commonly found on choppy sandhills. An example would be the Suffield area of southeastern Alberta and adjacent Saskatchewan. It occurs on high relief (choppy) dunes of sand. This range community represents a relatively stable ecological state on both gentle and steep slopes.

Wild rose and snowberry are the principle shrubs. Needle-and-thread and sand grass are the primary mid-grasses, while low growing grasses include blue grama and June grass, along with low sedge. There are a number of forbs, including scurf pea, pasture sage, and golden aster. Bare soil averages 25%, total vegetation 65%, and moss/lichen cover only about 1%.

The ecologically sustainable stocking rate is low at about 0.06 AUM/ha or 0.15 AUM/ac.

Mixed Grass Prairie Ecoregion

The Mixed Grass prairie surrounds the Dry Mixed Grass prairie ecoregion to the west, north, and east. It is located in Alberta, Saskatchewan, and southwestern Manitoba. The soils are mostly Dark Brown chernozem and Dark Brown solonetz. Annual precipitation is about 70 mm greater than in the Dry Mixed Grass prairie. Further west, north, and east are plant communities on moister sites of the Black soil zone that are usually dominated by rough fescue on healthy rangelands.

Drought is an important part of the climate of the Mixed Grass Prairie ecoregion, although the severity is usually not as extreme as in the Dry Mixed Grass prairie. Adams *et al.* (2005b) estimate about 31% of the original 2 million ha (4.6 million ac.) of Mixed Grass prairie in Alberta remain in natural grassland today. Saskatchewan has a larger area in Mixed Grass prairie than does Alberta.

Wheatgrass-Needle-and-thread range type

The Wheatgrass-Needle & Thread community was originally widely spread across southern Alberta and southern Saskatchewan. This rangeland community was described by Coupland (1950, 1961) as the *Stipa-Agropyron* type. It was one of the most common plant communities to be plowed under a century ago. The high quality dark brown soils are very suitable for annual cereal production. Forage production is unusually high in the residual native grasslands that have escaped cultivation.

This reference community for loamy range sites on orthic Dark Brown soils is dominated by western wheatgrass, needle-and-thread, and northern wheatgrass. Winterfat is a common shrub in the community. Most of this productive native grassland has been cultivated. It was originally widely spread across southern Alberta and southern Saskatchewan. On healthy range sites, forage production is about 1,680 kg/ha (1,500 lb/ac.) of grasses, 90 kg/ha (80 lb/ac.) of forbs, and litter production is about the same as grass production (Adams *et al.* 2005b). Total vegetative cover is about 95% on excellent health ranges, moss/lichen cover is 25%, and there is no bare soil.

The ecologically sustainable stocking rate is about 0.12 AUM/ha or 0.30 AUM/ac.

Snowberry / Northern wheatgrass-Needle-and-thread range type

This is the reference community for loamy to sandy range sites on orthic Dark Brown soils. Northern wheatgrass and needle-and-thread are the common grasses, but western snowberry averages about 10% cover and is conspicuous. Total vegetative cover is about 85%, soil cover is about 5%, and moss/lichen cover is under 1%. This was once considered to be the most extensive natural grassland community on the Canadian prairies by Coupland (1961), but most of the area is now cultivated.

The ecologically sustainable stocking rate is about 0.10 AUM/ha or 0.25 AUM/ac.

Idaho fescue-Northern wheatgrass-Needle-and-thread range type

This is the reference plant community at upper elevations (1,100-1,300 m) in southwestern Alberta along uplands close to the Foothills Fescue ecoregion. It is found on loamy range sites on the upper ridges of the Milk River Ridge where precipitation is higher than for most of the Mixed Grass prairie. There is a diverse mixture of grasses and forbs. Idaho fescue, northern wheatgrass, and needle-and-thread provide most of the cover and forage production, but there are many forbs: silvery lupine, golden bean, pasture sage, and tufted white aster. Western snowberry and prairie and woods rose are abundant shrubs. On healthy range sites, grass production averages 1,900 kg/ha (1,700 lb/ac.), forbs 400 kg/ha (360 lb/ac.) and litter 1,340 kg/ha (1,200 lb/ac.). The total vegetative cover is 80%, moss/lichen cover is 10%, and bare soil is 5%.

The ecologically sustainable stocking rate is about 0.16 AUM/ha or 0.40 AUM/ac.

Plains rough fescue-Western porcupine grass-Sedge range type

On the moister parts of the Mixed Grass ecoregion, plains rough fescue becomes the dominant grass along with western porcupine grass. This range type is common on slopes of the Cypress Hills on loamy and shallow-to-gravel range sites found on orthic Dark Brown and regosolic Dark Brown soils above 1,000 m elevation. Plains rough fescue is sensitive to spring and early summer grazing. As grazing pressure increases during spring or summer, plains rough fescue declines and western porcupine grass increases. The highest plant cover on healthy rangelands is composed of plains rough fescue and western porcupine grass, along with lesser amounts of low sedge, June grass, and needle-and-thread. This community type is productive and on healthy range sites expect grass production of about 1,340 kg/ha (1,200 lb/ac.), forbs of 340 kg/ha (300 lb/ac.), and litter of about 1,570 kg/ha (1,400 lb/ac.).

The ecologically sustainable stocking rate is about 0.16 AUM/ha or 0.40 AUM/ac.

Foothills Fescue Prairie Ecoregion

The Foothills Fescue prairie ecoregion occurs along the southwestern Alberta foothills and in parts of the Cypress Hills at higher elevations, where there is higher annual precipitation than in the adjacent Mixed Grass prairie ecoregion (Adams *et al.* (2005c). Annual precipitation averages about 500 mm. Warm chinook winds during winter often melt the snow enabling winter grazing. Soils are mostly orthic Black chernozems. The topography is composed of hilly slopes and valleys in the foothills (east of the Rocky Mountains) as well as in the Cypress Hills.

Foothills Fescue prairie once occupied about 1.7 million ha (3.8 million ac.) in southwestern Alberta, but today there is only about 17% remaining. Most of the residual natural grassland remains on ranches and is highly prized for winter grazing by livestock, elk, deer, and bighorn sheep.

Foothills rough fescue-Parry oatgrass range type

This is the most common natural grassland community growing on orthic Black chernozem soils of a loam texture in the Foothills Fescue prairie ecoregion. Foothills rough fescue and Parry oatgrass provide about 50% of the canopy cover and much of the available forage. Shrubby cinquefoil, Idaho fescue, silky lupine, and golden bean are common associates. Forage production averages about 2,240 kg/ha (2,000 lb/ac.) of grasses and 390 kg/ha (350 lb/ac.) of forbs, with about 2,460 kg/ha (2,200 lb/ac.) of litter. This is one of Canada's most productive natural grassland communities. Many stands of this community can be found in valley bottoms, lower and mid-slope positions, with even some on upper slope positions. Under conservative grazing practices, there is virtually no bare ground. Under moderate to heavy spring and summer grazing, Kentucky bluegrass can become abundant and timothy can also appear. When this range type is used for winter grazing, foothills rough fescue frequently becomes the dominant forage producer. Foothills rough fescue is a favorite winter forage for both livestock and elk.

The ecologically sustainable stocking rate is 0.26 AUM/ha or 0.65AUM/ac.

Kentucky bluegrass-Timothy range type

This community results from overgrazing the Foothills rough fescue-Parry oatgrass range type. It becomes quasi-permanent following decades of heavy spring and summer grazing when the native grasses, foothills rough fescue, and Parry oatgrass are replaced by the grazing resistant alien plant species Kentucky bluegrass, timothy, white clover, Canada thistle, and common dandelion. This range type is found on orthic Black chernozem soils.

With an appropriate rotational grazing system, this community can be quite productive, but the plant species are mostly suitable for spring or summer grazing. These soft grasses and forbs senesce, or degrade, rapidly in late summer and fall, resulting in reduced forage availability for late season grazing.

It is not known if the native grasses can increase in cover and forage production once timothy and Kentucky bluegrass become the major forage species due to heavy spring-summer grazing. Ranchers and researchers have successfully used prescribed burning at low fire intensities followed by light grazing use in Tall Grass prairie communities in some U.S. states in an effort to reduce Kentucky bluegrass and smooth bromegrass and promote the growth of warm season native grasses (Wright and Bailey 1982). No research has been conducted to determine if fire and grazing systems can be developed to effectively reduce these tame forage grasses and replace them with native grasses in prairie communities, such as the Kentucky bluegrass-Timothy range type.

Many range managers may wish to develop a deferred rotation grazing system in spring and early summer as indicated in Chapter 5. Moderate grazing of about 40% use of foliage in any one paddock may be tried by using a duration of stay of no more than three weeks per paddock. During drought years when the rancher is seeking extra forage sources, a quick rotation through these paddocks in fall or winter should provide additional forage without damaging the grasslands.

The ecologically sustainable stocking rate is 0.16 AUM/ha or 0.40 AUM/ac. Stocking at 0.20 AUM/ha or 0.50 to 0.26 AUM/ha or 0.65 AUM/ac. will maintain the existing community.

Foothills rough fescue-Northern and western wheatgrass range type

Adjacent to the Mixed Grass prairie ecoregion, along the eastern edge of the southwestern Alberta foothills, is this reference rangeland plant community. Foothills rough fescue is the co-dominant grass in a range type that is the driest major community in the Foothills Fescue ecoregion. Other co-dominant grasses are northern and western wheatgrass. Minor grasses in this range type include June grass, fringed brome, green needle grass, western porcupine grass, and bluebunch wheatgrass.

Creeping juniper, western snowberry, prairie rose, and pasture sage are naturally present in many stands of this grassland. The common soils are loamy textured orthic Black chernozems.

This range community type is often used for winter grazing since chinook winds often keep it free of snow. This grazing practice benefits foothills rough fescue, a winter forage favored by both livestock and elk. When spring and summer grazing is practised, foothills rough fescue declines and western wheatgrass areas expand. If overgrazing is applied in spring-summer, the native grasses decline, and Kentucky bluegrass, dandelion, Canada thistle, and other alien species gain a foothold.

The ecologically sustainable stocking rate is about 0.16 AUM/ha or 0.40 AUM/ac.

Foothills rough fescue-Idaho fescue range type

Foothills rough fescue and Idaho fescue provide most of the canopy and forage for this common plant community. It is found on well drained, loamy textured, orthic Black chernozem soils. Northern wheatgrass, western porcupine grass, Parry and California oatgrass, and sedges are also important constituents of this range type.

This community is common in the southern part of the Foothills Fescue ecoregion where summer temperatures are higher and winter chinook winds expose the landscape, enabling winter grazing by livestock and elk. Winter grazing maintains foothills rough fescue in the stands. Forage production averages about 1,460 kg/ha (1,300 lb/ac.) of grasses and 225 kg/ha (200 lb/ac) of forbs, with litter being about 1,230 kg/ha (1,100 lb/ac.). There is normally little exposed soil under conservative grazing management.

The ecologically sustainable stocking rate is 0.22 AUM/ha or 0.55 AUM/ac.

Riparian Ecosystems in Foothills Fescue Prairie

Beaked willow / Sedge-Tufted hairgrass range type

This is a reference plant community found in the riparian areas of the Foothill Fescue ecoregion. It is in moist valley bottoms, wetlands, on lower slopes, and sub-irrigated range sites. Beaked willow, other willows, tufted hair grass, sedges, and reed grasses provide the most plant cover and forage. Kentucky bluegrass, timothy, Canada thistle, and dandelion are common invaders and will expand if heavy continuous grazing is practiced during the growing season. Season-long grazing is not an option if this native riparian ecosystem is to be conserved.

This highly productive range type can be effectively managed by using an appropriate rotational grazing system. It is recommended that only moderate use of 40-50% of the forage be grazed at any one time. It is preferable for the duration of stay in any one paddock to be no more than three weeks during the forage growing season. Longer grazing durations are less harmful during late fall or winter. At all times the amount of browsing of palatable willows needs to be limited to about 30% of current growth to keep them healthy and productive. The willows provide critical browse for some species of wildlife in winter.

The ecologically sustainable stocking rate is about 0.53 AUM/ha or 1.3 AUM/ac.

Parkland-Northern Fescue Prairie Ecoregion

The authors combined the Aspen Parkland and Northern Fescue prairie ecoregions. The two ecoregions intermingle so intimately in central Alberta and Saskatchewan that it is reasonable to combine them into a single entity. The Aspen Parkland usually overlays the Black soil zone, while the Northern Fescue is found in Dark Brown soils. Both chernozem and solonetz soil orders are found in this ecoregion.

The Parkland-Northern Fescue ecoregion extends from about Calgary northwards into central Alberta and then south-eastwards through Saskatchewan and into Manitoba where it meets the Tall Grass prairie ecoregion. Annual precipitation is about 370-450 mm. The average annual temperature is about 2°C lower than the Foothills Fescue ecoregion. The soils are Black and Dark Brown chernozem or Black and Dark Brown solonetz. Parkland is transitional, always occurring between prairie and forest. Historically, lightning and managed fires by aboriginal peoples, in combination with winter and early spring grazing by bison, favored the growth of grasslands over forests. Since European settlement, fire has been suppressed. As a consequence, aspen forests have encroached into grasslands in most areas with greater encroachment closest to the lower boreal forest ecoregion.

This parkland-grassland ecoregion contains natural grasslands interspersed with groves of trembling aspen in northern and central areas. In the southern portion of the ecoregion, closer to the boundary with the Mixed Grass prairie, the aspen groves occupy only 5-30% of the landscape rather than the 60-90% coverage in more mesic areas further north. Grassland occupies the southerly and drier locations, while trembling aspen occurs on the moister and more sheltered northerly-facing sites. The northern part of this vegetative type is mostly forest with occasional patches of grassland, whereas the southern part is mostly grassland with occasional groves of trembling aspen.

A high proportion of this ecoregion now contains annual crops and introduced perennial forages. On the best Black chernozem soils, there is often less than 5% of the native plains rough fescue grasslands left. Only on steep, stony, saline, sandy, or gravelly land or on lands reserved for the military, public grazing, or railway right-of-ways are natural grasslands still found. In the northern portions of the ecoregion, in the parklands, it is estimated by the authors that only 5-10% of the area is dominated by plains rough fescue (in uplands and in wet grasslands, and sedges in riparian areas). In the southern portions where there is less aspen forest, only about 20% of the area is still in plains rough fescue grassland. The associated wet grasslands may be found in the riparian areas.

Plains rough fescue-Western porcupine grass range type

The most abundant natural grassland in the Aspen Parkland-Northern Fescue ecoregion on orthic Black chernozem and Black solonetz soils is dominated by plains rough fescue and western porcupine grass. Low sedge is an important part of the community. Common forbs are buffalo bean, golden aster, and purple aster, along with pasture sage. Snowberry and wild rose are common shrubs. This community can also be found on orthic Dark Brown solonetz and chernozem soils.

The ecologically sustainable stocking rate varies with soil type and annual precipitation from 0.12 AUM/ha or 0.30 AUM/ac. to 0.14 AUM/ha or 0.35 AUM/ac.

Western porcupine grass-Plains rough fescue range type

Western porcupine predominates over plains rough fescue as the dominant species under conservative grazing practices on coarse-textured soils, including rocky, gravelly, sandy soils and on hilltops throughout the ecoregion. June grass, low sedges, northern and western wheatgrass, blue grama grass, and needle-and-thread are common subordinate plant species along with pasture sage, prairie rose, prairie sage, golden bean, purple aster, common white aster, and moss phlox.

The ecologically sustainable stocking rate varies with soil type and annual precipitation from 0.08 AUM/ha or 0.20 AUM/ac. to 0.10 AUM/ha or 0.25 AUM/ac.

Snowberry / Northern wheatgrass-Needle-and-thread range type

This is the reference community for loamy to sandy range sites on orthic Dark Brown soils. Northern wheatgrass and needle-and-thread are the common grasses, but western snowberry averages about 10% cover and is conspicuous. This was once considered to be the most extensive plant community on the Canadian prairies by Coupland (1950). Most of this ecosystem is now in annual crop production.

The ecologically sustainable stocking rate is 0.08 AUM/ha or 0.20 AUM/ac.

Riparian community in Parkland-Northern Fescue

The most common riparian community in the aspen parkland is in shallow sloughs, often in knob-and-kettle topography. There is often a ring of willows around the slough perimeter; near the center is a wet grassland composed of sedges and moisture-adapted grasses, including reed grasses, tufted hairgrass, and several species of sedge. Forage productivity varies considerably.

The ecologically sustainable stocking rate is about 0.41 AUM/ha or 1.0 AUM/ac.

Southeastern Canadian Prairies

Manitoba is different from other parts of the Canadian prairies. The most common soil is Black chernozem in all ecoregions represented in southern Manitoba. Most of the region was originally dominated by three ecoregions: Tall Grass prairie, Mixed Grass prairie, and Parkland-Northern Fescue prairie.

The northern extension of the Tall Grass prairie was the predominant ecoregion in southeastern Manitoba. It was composed of mostly warm season grasses, such as big bluestem and little bluestem, and associated warm season forbs. Intensive agriculture has removed this native vegetation and replaced it with annual crops. Only a few relic stands remain.

The Mixed Grass prairie ecoregion is most common in southwestern Manitoba and adjacent Saskatchewan, but it does still contain some interfacing Tall Grass prairie species, such as little bluestem. Further north in western Manitoba and adjacent Saskatchewan are relic stands of natural vegetation composed of mostly Aspen Parkland-Northern Fescue Prairie. Plains rough fescue, western porcupine grass, and many-flowered aster are common species.

The common soil for all ecoregions in Manitoba is Black chernozem, but there are other soils. There are regosols underlying grasslands where there is less soil profile development, either due to coarse-textured sand subsoils or shallow to bedrock high lime soils.

Tall Grass Prairie Ecoregion

The Tall Grass prairie occupied a huge region along the humid eastern perimeter of the northern, central, and southern Great Plains of the United States, as well as southeastern Manitoba. The climate in the Tall Grass prairie is warmer and moister than in Parkland-Fescue and Mixed Grass prairie ecoregions (Table 2).

The dominant grasses of this ecoregion are of warm season origin. They are growing at their northern-most range of adaptation. These grasses do not start growing until about a month after the cool season grasses of Mixed Grass prairie and Parkland-Fescue ecoregions begin growth. The warm season grasses grow throughout the summer, whereas cool season grasses slow down in mid-summer. The forage quality of Tall Grass prairie species is good early in the growing season but declines steadily from August through the fall. The forage quality of the cool season grasses is generally higher than that found in warm season species.

Some floral elements, particularly little bluestem, are important in southern Manitoba and southeastern Saskatchewan. Few relic stands of Tall Grass prairie remain today on fertile loam soils of the Black soil zone in either southern Manitoba or southeastern Saskatchewan. Most relic stands grow on sandy soils too coarse for crop agriculture or on the shallow high lime soil in the Parkland-Fescue ecoregion of western Manitoba. Livestock graze these stands in the growing season. A few relic stands are now managed by conservation agencies.

If global warming continues over subsequent decades, it can be expected that the warm season grasses and forbs will expand northward and westward from Manitoba and North Dakota into the native grasslands of Canadian southern prairie ecoregions.

Porcupine grass-Sand dropseed range type

The Porcupine grass-Sand dropseed range type occurs along the eastern edge of the Mixed Prairie ecoregion and the southeastern edge of the Aspen Parkland-Northern Fescue ecoregion. Most of the land of this type has been plowed and used for production of cereals and forages, except for the high lime soils of the Interlake district of Manitoba and the sandy soils and areas of rough topography along the Manitoba Escarpment. This range type has a high carrying capacity during the growing season. Major grasses are warm season species that do not cure on the stem. The nutritive value of the forage decreases in late summer and after fall frosts.

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Chapter 4: Land Use History of Natural Grass Rangelands

Highlights

- Following millions of years of evolution, grazing, and burning, ancient natural grasslands are well adapted to herbivore grazing and the variable prairie climate.
- In about a 50 year period, 50 M ha of natural grassland was eradicated by cultivation because land use was changed from grazing perennial native grasslands to annual crop agriculture by farmers of European descent. This change in land use occurred as a result of political decisions made by the federal government between 1870 and 1930. For example the Dominion Lands Act of 1872 opened all cultivatable land to homesteaders.
- The bureaucratic decisions and assumptions made by politicians and the federal Department of Interior are considered to have affected the prairie natural grasslands resulting in these grasslands now being considered one of the most endangered natural habitats.
- Decisions were made to settle, 'improve', and plow the prairies regardless of whether the land was suitable for crop agriculture. As a result of these policy decisions about 5 to 10 M ha of natural prairie were lost.
- There were tragic social consequences in the 1920's and 1930's for many farm families homesteading in the Dry Mixed Grass prairie ecoregion where prolonged drought eliminated any possibility for successful grain farming during the settlement era. These areas should never have been cultivated since the soils were unsuited for annual crop production because they were too sandy, saline, shallow, stony, or solonetzic.
- European settler grazing management practices were inadequate or non-existent, in part, because the prairie grasslands were viewed as "wasteland". Continuous grazing of these grasslands was the norm.
- Under continuous grazing, the grassland areas close to water were overgrazed while grasslands distant from water were in a higher state of ecological health.
- Today, the general attitude of crop agriculture towards ancient prairie grasslands has not changed as noted with grasslands in Census Canada questionnaires being described as unimproved lands.
- Recent research recognizes the need to place limits on planted areas of crested wheatgrass and other tame grasses because these monocultures reduce soil quality. Soil sustainability is more important for land management than short-term forage productivity.
- Recent research recognizes that the productivity of native grassland forages is at least comparable to the planted tame forages. Furthermore, there is much more biological diversity in stands of natural grasslands.
- High biological diversity is crucial to sustained high forage productivity during periods of drought. Many native species have larger and deeper root systems than tame forage monocultures. Thus, many native grasslands are able to draw nutrients and moisture from greater depths in the soil when needed to survive years of drought. This large root mass increases the overall forage productivity of the native prairie grasslands.

Grazing Managers in Pre-history

The ancient natural grasslands of the Great Plains evolved along with the climate and grazing animals over millions of years. As climate fluctuated over the centuries, so did the areas of the ancient grassland, grazing animals, and the soils. About a million years ago, the most profound climatic extremes arrived and stayed for almost a million years. Like slow-moving bulldozers, the four or more giant continental glaciers pushed across the Canadian prairies, ripping out vegetation and soil and leaving behind glacial moraine, glacial lakes, ice dams, and eventually giant rivers during the ice melts. As the glaciers receded, the first colonizers were tundra plants, and then as the temperature increased, cool season grasses again colonized the plains and the grazing animals returned.

For millions of years, grazing, drought, and fire influenced the grasslands of the prairies. Drought and fire both strongly influenced the formation of ancient natural grasslands. Grazing has always been a part of the Great Plains grasslands. During the ice age, there were horses, camels, and mammoths, but bison were the dominant grazer in the Canadian plains grassland ecosystem (http://esask.uregina.ca/entry/prehistory_southern_saskatchewan.html). Overgrazing occurred when the populations of grazing animals exploded, when there was drought, and when too many fires removed too much of the forage resource. These factors would have also reduced rangeland ecological health. Subsequently, many grazers would have died due to starvation, lack of water, or disease. Afterwards, for a period of years, the rangelands would gradually have recovered to a healthier state because of the reduced grazing pressure.

Aboriginal peoples inhabited the Canadian prairies about 11,000 years ago. They used the plains grazing animals for food, clothing, fiber, and shelter. They learned to manipulate the grazing animals and the natural grasslands using fire, herding, buffalo jumps, and other means. These communities survived for millennia in the challenging environment of the Northern Great Plains because they learned to to adapt to changing conditions (Binnema 2001).

Historical Managers

Some of the aboriginal peoples represented on the Canadian prairies were Blackfoot (Piegans, Bloods and Siksikas), Assiniboine and Cree. Bison were the principle source of food and clothing. Each aboriginal community interacted with its neighbors by trading, diplomacy and warfare (Binnema 2006).

The arrival of the horse, gun and the trading posts changed the circumstances for First Nations people. They reacted to the transformed conditions by analyzing the situation on the ground and acting to advance their interests. However, some of the whites exposed these plains peoples to unfamiliar contagious diseases. Smallpox in particular decimated these aboriginal communities, thus reducing their ability to defend their territory fron encroaching Europeans.

The First people of the Canadian prairies were skilled land managers and possessed a highly developed knowledge of the Great Plains ecosystems. The Native people's rangeland management practices were part of a comprehensive strategy to promote the interests and security of bands or groups of bands (Binnema 2001). In Alberta, the surveyor Peter Fidler spent a winter in 1792-93 with Piegan Indians (Fidler 1793). He recorded how they managed the rangeland and the wildlife using methods unfamiliar to Europeans. Fidler quickly learned that his fear of fire was out of step with their knowledge and skills. Many aboriginal groups had learned the benefits and risks associated with managed prairie fire (Lewis 1985). Some of the purposes for burning were to manage bison food resources, promote berry and root crops, renew growth in wetlands, remove forage before winter on enemy hunting areas, and maintain trails through brush.

A high proportion of bison on the prairies were slaughtered between 1791 and 1873. During this 82 year period, there were 55 years of drought (see Chapter 2, Table 3). The droughts reduced the supply of water and forage and had a negative effect on both bison and humans. The combined effects of drought and the excessive harvests by buffalo hunters decimated the bison herds nearly to extinction.

Settling of the Prairies

Ecologically sound resource management was not a priority in 1670 when Great Britain granted the Hudson's Bay Company the rights to Rupert's Land, without consulting with the people who resided there (Bailey et al., 2010). Similarly, in 1870 the Hudson's Bay Company sold Rupert's Land to the young country of Canada, when Canada consisted of four eastern provinces. Neither sound resource management nor the will of the people residing on the land was a consideration (Martin, 1920). Rather, the eastern provinces of Canada saw Rupert's Land as the natural expansion of its territory. George Brown, one of the fathers of Confederation, described it as "the vast and fertile territory which is our birthright—and which no power on earth can prevent us occupying" (http://history.cbc.ca/history/).

The historian Chester Martin (1920) argued the Government of Canada did not follow established British constitutional practice of ceding control of natural resources whenever a colony attained responsible government. He reasoned the federal government had taken control of these lands in 1870 "…at the expense of the constitutional rights of Manitoba …the federal government construed the administration of the public lands into … "ownership" which was regarded as a warrant to alienate them without accountability to the inhabitants of this province" (Martin 1920, p. 75). The lack of recognition by Eastern Canada of the land rights and the political rights of Metis, Aboriginal, and First Nation peoples during the transfer of land ownership from the Hudson Bay Company precipitated both the Red River Rebellion in 1869-1870 and the Northwest Rebellion in 1885. The historian Gerald Friesen's book (1987) describes the original four province country of Canada as 'Old Canada' to differentiate it from the new country that included Rupert's Land.

The federal government of 'Old Canada' retained ownership of public lands in the Province of Manitoba and the Northwest Territories, which became Alberta and Saskatchewan in 1905. This policy decision transformed Canada into a federation of five equal provinces (Ontario, Quebec, Nova Scotia, New Brunswick, and British Columbia) and made a colony of the Canadian prairies (Martin 1938, 1973). The first federal minister of the Department of the Interior, Alexander Campbell, referred to his new position as that of 'Secretary of the Colonies' (Lewis 1975, p. 2). The Department of the Interior was created to administer the Dominion Lands Act (1872). From 1870 to 1930, a period of 60 years, the primary purpose of the Department of the Interior was to establish an orderly manner of settlement and 'development' for the Canadian prairies. To do this, the Department of the Interior "assisted in the removal of native peoples from the open plains. The department settled Metis land grievances, surveyed and subdivided the region and then proceeded to promote and settle these holdings through a massive immigration campaign" (Library and Archives Canada, http://mikan3.archives.ca/pam/public_mikan /index.php).

In 1930, after settlement and cultivation of 80% of the native grasslands, the Dominion of Canada transferred ownership of the natural resources to Manitoba and the fledgling Prairie Provinces of Alberta and Saskatchewan. Coincidentally, this occurred right at the beginning of the worst drought of the 20th century.

While the Canadian prairies were settled, the political and economic goals of the current government seemed to have been of greater importance than resource management. "The Dominion of Canada wanted repayment for the 300,000 pounds they paid for Rupert's Land, rather than it being charged against the people of the provinces of Ontario, Quebec, Nova Scotia, and New Brunswick" (Martin 1973, p. 10). The historian Gerald Friesen (1987) put it this way:

"The millions of acres of western real estate were expected to serve the interests of 'Old Canada'. After all, the 3.5 million citizens of the four eastern provinces (in 1871) had paid for the land.---Their hopes lay with the pioneer farmer who would initiate an economic takeoff, by buying lumber, groceries, and agricultural implements on the one hand and shipping grain, on the other. To encourage western settlement, a railway must be constructed."

Once the railway was operational, federal policy allowed tariffs to be lower to ship manufactured goods from eastern Canada westwards to the prairies, whereas the tariff costs were higher for prairie farmers to ship grain and cattle eastwards. The decision regarding unequal rail tariffs contributed significantly towards the growing feeling of alienation in Canada's western provinces regarding the government of central Canada and its citizens.

The findings of the British-funded Palliser Expedition during the 1850's (Spry 1968) were essentially ignored by Dominion of Canada politicians and discounted by the Ontario botanist John Macoun (1882). In addition, Macoun surveyed the Canadian prairies during wet years of the 1880's. In contrast, the Palliser Expedition experienced the prairies in a drought during the 1850's.

The Department of the Interior gifted prairie grasslands to settlers for crop farming with strings attached. Federal department policy required residency on the homestead and a large portion be cultivated before the settler would receive title to a free quarter section of land (Martin 1973). Other land could be purchased nearby. A century later, few question the merits of growing large acreages of grains, oilseeds, and other annual crops on arable prairie lands. However, the implementation of policies by the Department of the Interior to require settlement and cultivation of native grassland soils, as if they were in the humid climate of southern Ontario and Quebec, created enormous ecological and social disruption, frequent settler abandonment, and family failure. It also contributed to global warming on the Canadian prairies. Wind-blown soil erosion became rampant in the drought of the 1930's and the lives of countless families were disrupted or destroyed (Jones 1987).

The actions of distant federal decision makers contributed to the destruction of about 5 to 10 million ha of natural grasslands that grew on soils unsuitable to crop agriculture during the settlement era. There was a needless destruction of diverse native grasslands growing on sandy, rocky, saline, shallow, and infertile soils as well as in drought-prone areas such as the Dry Mixed Grass ecoregion. These areas were only suitable for grazing and the perpetuation of natural grasslands. Instead they were plowed and fallowed; the topsoil eroded even in normal years. In the 12 years of drought in the 1930's the topsoil blew away in the wind, soil salinization occurred, soil organic matter declined, nutrients were lost, natural carbon sequestration was undone, and climate change was initiated. Large portions of the Dry Mixed Grass prairie ecoregion that had been cultivated became a dust bowl; the topsoil that had been lost has not been replaced 80 years later.

It is important to understand that even in 1905, the terms "normal settlement", "normal agricultural purposes", and "agricultural purposes" were being interpreted by Department of the Interior officials who were familiar with the crop agriculture terminology of humid southern Ontario, Quebec, and the Maritime Provinces. Eastern Canadian leaders needed prairie settlers to grow grain for shipment east and they wanted the settler to buy agricultural machinery and other supplies from central Canada (Friesen 1987). In fact, much of the grazing use of natural grasslands in settlement areas was to feed the draft horses that were required for pulling the eastern tillage and harvesting agricultural implements. Department of the Interior policy provided for a settler to be entitled to up to 4 square miles (4 sections) of natural prairie located adjacent to his homestead (Martin 1938, 1973).

The federal bureaucracy was slow in accepting that certain areas of prairie grassland were suitable for grazing and ranching, and not for crop agriculture (Martin 1973, p.178-183). Grazing leases for settlers were authorized in the First Dominion Land Act of 1872, and revised in 1876, 1881, 1887, and 1905. Grazing leases were granted to ranchers subject to cancellation with two years notice if the lands were required for agricultural settlement (Martin 1938, 1973). It was not until 1905, 35 years after settlement began in Manitoba, that closed leases were introduced for certain areas deemed unfit for "normal" crop agriculture settlement. The areas were often in the Dry Mixed Grass ecoregion (Palliser Triangle) of southeastern Alberta and adjacent Saskatchewan, or in the southern Alberta foothills. Leases were to be granted only subject to an official report by the Inspector of Ranches that the land was unfit for "normal" agricultural purposes. Here again 'normal' agriculture referred to annual crop agriculture and not to ranching which should have been the norm for the Dry Mixed Grass ecoregion of southern Saskatchewan and Alberta.

Many areas of natural grassland that were unsuited for crop agriculture were surveyed and opened for settlement as cropland. At times, when settlers realized how unsuitable the climate and soils were for grain farming, they abandoned the land a few years later. This was the best course of action for both settler and the land. An example followed from one of the driest regions of southeastern Alberta. In 1919, the federal government's settlement strategy placed 2,283 registered farmers on a huge region of Dry Mixed Grass prairie that is now the military training complex known as CFB Suffield. It was a very dry area of primarily sandy soils within the Palliser Triangle. Five years later, 72% of the farmers had abandoned their lands. By 1941, when the land was expropriated to establish the military training base, only 125 families remained.

The policies of the federal government and the administration of a vast prairie landscape by distant bureaucrats unfamiliar with the climate and the region caused enormous suffering amongst farm families in the dry southern regions. The drought of the 1930's created a social and ecological disaster for crop farmers and the soils they cultivated. Whole municipal districts were disrupted by settlers abandoning their homesteads in the driest regions of the prairies. In 1938, Alberta passed the Special Areas Act to establish the Special Areas Board, a provincial crown agency that would manage the affairs in a 1.2 million hectare region that included 0.57 M ha of tax recovery land and 0.61 M ha of crown land (www.specialareas.ab.ca). A quote clarifies the reason why this board was needed from 1938 until now: "Broad land use control powers are still needed due to the fragile and sensitive nature of these lands". This period was called the "Dirty Thirties" for good reason. A dustbowl was created by the topsoil that was blowing off the cultivated land; Jones (1987) described it as an "Empire of Dust".

Traditionally, the replacement of Mixed Grass prairie by crested wheatgrass and Russian wildrye grass was considered an improvement (Dormaar *et al*. 1995). Many crop farmers and ranchers still believe that introduced grass monocultures produce more forage than do native species. Recent research has questioned the wisdom of removing prairie native grasslands. Jefferson *et al*. (2005) suggest that these sentiments of farmers and ranchers need to be re-examined. Initial work done by Schellenberg (2008) indicated no differences in forage production between introduced and native grasses in the first four years of newly seeded stands. Recently, Willms *et al*. (2009) reported on a study that lasted 12 and 13 years. They asked the question "Do introduced grasses improve forage production on the Northern Mixed Prairie?" The short answer to their question was 'no'. The study compared the annual forage production on ungrazed native range, harvested native range, seeded crested wheatgrass, and seeded Russian wildrye grass in the Dry Mixed Grass and Mixed Grass prairie ecoregions. The sites studied were needle-and-thread-blue grama on Brown soils near Manyberries and needle-and-thread-wheatgrass-blue grama on Dark Brown soils near Lethbridge. The introduced grasses were planted into recently cultivated native grassland soils. The study lasted for 12 years on Brown soils and 13 years on Dark Brown soils. Only crested wheatgrass produced more forage than native grasslands, but only about half the time. In the remaining years, herbage production was about the same as ungrazed native grassland. In contrast, Russian wildrye grass produced less herbage on Dark Brown soils most years and about the same in Brown soils as native grasslands. The highest herbage production of both introduced grasses was in years 2, 3, and 4 which the authors attributed to the effects of soil mineralization following cultivation. Willms *et al*. (2009) concluded that "the belief that seeding native grassland to introduced agronomic species would increase forage production was not supported by this study".

The research cited above questions the wisdom of eliminating any more of the remaining prairie natural grasslands. Furthermore, Dormaar *et al*. (1995) found crested wheatgrass and Russian wildrye monocultures reduced soil quality due to increased nutrient export, reduced energy flow, and decreased organic matter input. This leads to reduced carbon sequestration. They argued that forage breeding had eradicated the sustainability characteristics of these introduced grasses. The authors recognized the value of these introduced forages to the livestock industry but recommended that there be limits placed on acreages since soil sustainability is ultimately more important than short-term forage production.

During the settlement era there was a lot of experimentation by government policy makers and settlers. It took 50 million years for the natural grasslands to evolve, adapt, and become sustainable. It took less than 50 years to destroy 50 million hectares of grasslands because of the decisions made by 'Old Canada' colonial policy makers (Martin 1938, Friesen 1987, Bailey *et al*. 2010). The federal policies apparently had worked in the high rainfall, temperate climates of eastern Canada where drought was rare, but they were not appropriate for the Canadian prairies. 'Old Canada' did not understand the serious consequences of prairie drought. Jones (1987) chronicled the dramatic and tragic consequences of these land practices during the 1920's and 1930's on the southern Alberta and Saskatchewan dry belt.

History of Grazing Practices

The first cattle brought to the Canadian prairies were a bull and yearling heifer named Adam and Eve, brought from England via Hudson's Bay by boat and canoe to the Selkirk Settlement along the Red River in 1813 (Deveson 1995, Johnston, 1970). Others followed from Europe and the United States. Cattle arrived in Alberta and Saskatchewan in the late 1870's (Kelly 1980, Brado 1984).

Domestic livestock production began to expand in the eastern prairies in the 1860's in Manitoba and in southern Saskatchewan and Alberta in the 1880's. On the rest of the prairies, settlement, cultivation, and livestock grazing occurred following construction of railroads.

The cattle ranching industry in western Canada in the late 1880's was typically a low input, extensive grazing operation. In southern Alberta, cows grazed all year, fended for themselves against predators, and consumed dormant forage during winter (Brado 1984). Local ranchers considered cutting and storing hay for winter use to be foolish. During the severe winters of 1886-87 and 1906-07, a high percentage of the cattle either starved or froze to death. After those severe winters, more ranchers stored hay and fed it to cattle as needed in winter.

Grazing management expertise was virtually non-existent on residual natural grasslands during the homestead era. Horses were allowed access twelve months per year, while cattle were usually turned out after snowmelt in spring. They then grazed from spring until fall when snow covered the grasses. Most settlers were too busy managing cropland to worry about managing the rangeland growing on their "wasteland areas". The residual grasslands normally occupied areas that could not be easily plowed. They included steep coulees, stony, saline, sandy, or shallow soils, or wetlands (riparian) that could not be put into annual crops. The natural grassland ecosystems were rarely considered valuable. Overuse and ignorance of the consequences contributed to the dust bowl effect on some grazing lands in drier regions. As the farming practices contributed to climate change, overgrazing of rangelands by livestock also caused declines in forage production and the death of many productive grasses, forbs, and sedges; these species were subsequently replaced by unpalatable or low-growing plants. Overgrazing also enabled the invasion of certain alien, unpalatable, or grazing-resistant species, such as Kentucky bluegrass and dandelion.

Absence of Grazing Management

The absence of livestock grazing and low stocking rates on other rangelands in the settlement era helped maintain a higher level of ecological health on these lands. On grasslands distant from water or on steep slopes, where livestock rarely grazed, there were healthier grassland stands compared to the overgrazed grasslands closer to water. The absence of grazing on some of these rangelands and the concentration of settler attention on cropland helped preserve these habitats for wildlife and maintain a higher biological diversity on the lands considered "wastelands". The greater biological diversity of natural grasslands helps provide habitat for a wide variety of wildlife and a higher quality level of forage production during drought.

Today, the absence of grazing on most natural grasslands is not recommended because they evolved with grazing and are adapted to it. A high litter cover creates a fire hazard. Species diversity decreases year by year as a dense litter accumulates. Wildlife are provided with a more diversified habitat under a moderate livestock grazing regime. Moderate stocking rates and periodic long periods of rest from grazing are recommended rather than a complete absence of large ungulate grazing from prairie natural grasslands.

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Chapter 5: Managing Natural Grass Rangelands

Highlights

- Natural grasslands are vulnerable to repeated heavy grazing pressure. The consequences of such grazing practices are presented.
- The serious overgrazing management practices that occur on many ranches, farms, and parks leave these ecosystems at risk of devastating losses during droughts, and the rangeland in poor health.
- Light to moderate grazing, adequate animal distribution, and the use of an effective grazing management system contributes to high forage productivity, high habitat values, and to sustainable health of these valuable natural ecosystems and to sustainable forage resources.
- Light to moderate grazing use, adequate animal distribution and the use of an effective grazing management system can also contribute to minimizing the load of potentially harmful microorganisms that cause outbreaks of foot rot, calf scours and other contagious diseases.
- Successful management of riparian areas of natural rangelands is necessary but very challenging.
- Grazing systems under which natural grasslands evolved can be mimicked by using various grazing system options.
- Grazing systems presented herein include the three main types: continuous, seasonal, and rotational. The four types of rotation systems include switchback, deferred rotation, short duration rotation, and complementary.

Introduction

Range managers, ranchers, range scientists, and wildlife managers have learned much over the past century regarding the management of Canada's remaining natural grasslands for use by livestock, wildlife, and people. Today, several prairie natural grassland ecosystems and associated animal and plant species are either at risk, threatened, or endangered. The early explorers found grizzly bear on the Great Plains, but today they only roam freely in the Rocky Mountains and far north. Bison almost became extinct, but they too are now abundant in various parks and ranches. However, the Tall Grass prairie, Parkland Northern Fescue, and Mixed Grass prairie ecoregions are endangered ecosystems in Canada because crop agriculture has eliminated most stands.

The question each range manager must ask is: "Which grazing system or systems when well managed, will meet the economic requirements, sustain the health for rangeland and livestock herd, while also providing an opportunity for the other wild animals and plants on the rangeland to flourish?"

Naeth *et al.* (1990a, 1990b), have demonstrated that heavy stocking rate compacts the soil and reduces water infiltration rates, thus reducing forage production. There is always heavy grazing near watering facilities and riparian areas and other favored grazing sites under continuous grazing. Other well managed grazing systems using moderate stocking rates and effective distribution methods, can be used to minimize the areas negatively affected by heavy grazing in spring and early summer.

Different grazing systems or methods can be used to successfully manage various types of grazing lands.

Principles of Grazing Management

There are four basic range management principles that apply to both livestock and wildlife. All ungulates and most animals require water, forage, habitat (a place to live, reproduce, and overwinter), and security. Livestock are fed and cared for in winter by humans and are frequently protected from predators. On the other hand, wild animals must survive on their own, escape predation, and avoid or adapt to the effects of winter or drought. Wildlife tactics for success include migration, hibernation, or being able to survive the extremes of weather on the plains in sheltered valleys or forests where there is some form of protection from the elements.

For livestock and wild ungulates, the critical factors that govern the effect of grazing animals on natural grasslands are:

- stocking rate
- season of grazing
- adequate animal distribution.
- drought

For rangeland plants, the critical factors are:

- weather cycles of temperature and moisture (drought versus adequate soil moisture)
- ability to resist negative effects from spring-summer grazing
- managing forage plants in a sustainable environment enabling leaf and root growth as well as plant reproduction
- managing the soil by maintaining plant cover, minimizing erosion, and enabling carbon sequestration to continue through healthy root turnover rates.

How are Grazing Animals Attracted to Preferred Range and Preferred Plants?

Preferred Rangeland

As range livestock enter a new field or wild ungulates enter a new region, they first select areas most favorable to them. The favorite areas are called primary range. For cattle, these areas are usually the ecosystems with desirable, palatable plants that are close to water, are on gentle slopes, and have high quality forage. Other areas that are further away from water, or are on steeper slopes, or have less preferred forages, or are ecosystems grazed later than the primary range are referred to as secondary range. There are reasons why some areas are less preferred. It may be due to the season of grazing (which affects the growth stage, palatability, and nutrient quality of plants), abundance of unpalatable dead herbage (litter), heavy shading, or physical barriers such as steep cliffs, fallen trees, or brush that restricts access.

The last category, non-use range or tertiary range, refers to range that is not preferred by livestock or wild ungulates because of the lack of palatable plants, steep slopes, absence of drinking water or vulnerability to predation. Additionally, there may be barriers that keep out grazing animals.

Wild ungulates select their primary range based on the distance to escape cover or escape terrain, distance to water, as well as the availability of high quality forage or browse. They must be alert to the possibility of attack by predators. Thus, big horn sheep stay close to cliffs and steep, rocky terrain. Elk often seek their primary range on the upper portion of long grassy slopes close to ridges and woodlands. Bison behave similar to cattle as they prefer to graze on lower slopes close to riparian areas where water is accessible

Preferred Plants

Animals are attracted to plants that taste good, smell good, and are nutritious. Young green plant parts are more tender and nutritious than dry, dead plants. Green plants are higher in protein, minerals, and digestible carbohydrates than dead plants. Some plants are palatable and are preferred by grazing animals, while other plants are unpalatable. These plants are ignored and not grazed. Often the unpalatable plants are not chosen because they taste bitter, are hairy or thorny, or they have strong odors. Also, mature plants with higher amounts of fiber are not as preferred in the growing season as young, tender, succulent plant parts. In winter, grazing animals depend upon both stored reserves, such as body fat, and either hay, silage, or grazing. They eat primarily to obtain sufficient energy to survive. Consequently, they tend to be less selective while grazing on winter pastures – they often eat diets higher in fiber and lower in nutritional value than in summer.

Key Range Management Principles

Before Europeans settled the prairie landscapes, the natural grasslands were often subjected to short periods of intense grazing by herds of bison or elk. Then the herds moved on and often did not return for several years. Ecosystems were maintained by alternating periods of intense grazing episodes with long periods of rest. Some rest periods lasted for years when drought or disease caused significant die-offs in the herds thus reducing animal stocking rates.

Today, on prairie ranches, domestic livestock graze each year in fenced fields. The natural grazing regimes and migrating herds no longer exist. This requires more planning and attention to range management principles that are, in a sense, an imitation of the natural grazing systems. The management goals are to maintain plant vigor and vegetative cover, thereby protecting the soil, perpetuating the grassland and the forage resource, insuring new growth of forage for grazing livestock, and also providing habitat and food to wild ungulates that depend upon the same rangeland for sustenance.

Four key range management principles are:

- Balance livestock demand with the available forage supply
- Distribute livestock grazing pressure evenly
- Defer grazing during sensitive or vulnerable periods
- Allow effective rest periods after grazing

Balance Livestock Demand With Forage Supply (Proper Stocking Rates)

- The principal consideration of any rangeland grazing system is to balance livestock needs with the available forage supply through proper stocking rates. This is the number of animals that may safely graze a defined area without degrading soil or vegetation and allows range in poor health to improve. This balancing act is referred to as "proper use".
- Proper use considers the allowable proportion of forage produced during the growing season that may be grazed. This is generally set at 40 to 50%, but may be more or less, depending on stage of growth, climate, range site, and plant community type. The remainder, called carryover, is left to act as protective cover. Carryover serves to maintain root and crown vigor, conserve scarce moisture, protect soil, and provide emergency forage. For example, infertile prairie sandhills can often endure a maximum of 30% use of forage because of possible damage from litter removal, soil erosion, and trampling. On moist soil areas, allowable use may be 50 to 60%. In addition, different plant species in these communities will have varying tolerance levels due to different plant structures and growth patterns.

Distribute Livestock Evenly

- Range utilization and health are improved by more effective livestock distribution.
- If animal distribution is not a problem, reducing stocking rate improves range health more than any other grazing strategy.

Even with proper stocking rates, some animal's selective grazing habits will establish patch grazing patterns across each landscape unit. These animals will create localized overgrazing in one area, while leaving other areas either ungrazed or under-utilized. Many factors contribute to grazing distribution problems. The main ones are location of water sources, type of topography, and palatability of the vegetation. Cattle favor forage close to watering sites or riparian areas in spring and summer. They usually avoid steep slopes and dislike tall, coarse, and less palatable vegetation. Range managers use a variety of practices and tools to modify the grazing habits of livestock and to better distribute the grazing load across the rangelands.

Grazing systems can be useful when applied effectively. Even with good grazing distribution practices, utilization is rarely uniform. This provides for much of the spatial biodiversity found on well managed rangelands.

Provide Effective Rest

- Managers must provide effective rest periods when there is sufficient moisture and growing conditions to produce adequate root and leaf re-growth. This allows for the replenishment of plant growing points (meristems), stem bases, and energy reserves held in roots needed to survive each winter season.
- A single grazing period is normally recommended for natural prairie and foothill grasslands, given the relatively short Canadian growing season.
- Like grazing deferral, effective rest is normally provided through a planned grazing system. Drier regions require longer periods of rest from grazing than do the moister regions where soils are often deeper and have richer topsoil.

A paper by James Romo (University of Saskatchewan, 2006) explains the necessity of effective rest periods following grazing. Selected key points from his paper "Resting forage plants: a beneficial grazing management practice on native rangeland" (Romo 2006) follow:

- There is little risk of over-resting forage plants, but there is a high risk of overgrazing if plants are not adequately rested before grazing.
- The amount of rest needed by plants to recover vigor and forage production must be adjusted according to season of grazing, soil zone (or ecoregion), and range site.
- Heavily grazed forages recover slower than plants that are moderately or lightly grazed.
- Adequate rest during the growing season must be incorporated in all grazing systems to prevent overgrazing.

What happens if these principles are inadequately applied and create overgrazing?

If range management practices are not sensitive to the plant and soil requirements of the range ecosystem, the forage supply will be threatened and decline, often being replaced by unpalatable weeds. Overgrazing occurs when inappropriate

management practices are applied or occur by default. Overgrazing can be described as a regime where range plants are grazed too intensely, too frequently, or at a vulnerable period. Each facet of overgrazing is presented and discussed below.

Season of Grazing: Managed Grazing During Vulnerable Periods

- Protect cool season Canadian prairie natural grasslands during vulnerable periods of growth or reproduction.
- The six to eight week period of spring to early-summer produces about 80% of yearly forage growth. That is the period when natural grasslands and many tame perennial grasses and forbs are most vulnerable to overgrazing.
- A moderate stocking rate, light grazing use, and a grazing system that allows for periodic deferral of grazing during spring or early summer enables range plants to grow and reproduce year after year.
- When combined with other practices, such management will allow the range manager to achieve optimum forage yields from healthy natural grasslands, even during drought.

Grazing Intensity

Grazing too much creates many problems on rangeland. This is illustrated in the next figure. Johnston (1961) used clipping height to simulate the effect of grazing intensity on foothills rough fescue (Figure 3). The plant on the left was not clipped (e.g., the control); the three on the right were clipped at 12 cm (4.7 in.), 7.5 cm (3 in.), and 4 cm (1.5 in.) to simulate moderate, heavy, and very heavy grazing. The "moderately" grazed plant had nine times the weight of top growth and 12 times the weight of root as the "very heavily" grazed plant. When Johnston applied the principles of this greenhouse study to a long-term Foothills Fescue prairie grazing intensity (e.g., stocking rate) study in southwestern Alberta, he found similar results. One notable difference was that lightly grazed plants had more roots than did heavily grazed plants at each depth increment to a depth of 137cm (54 inches). Thus, a light grazing intensity (e.g., up to 40% use of leaves) is not only beneficial to the Foothills Fescue ecosystem during normal rainfall years but during drought there are rough fescue roots more than a meter deep to access deep soil moisture and nutrients. The longer light grazing is practiced, the greater are the benefits because abundant deep roots, high carbon sequestration, and high soil biomass produces more fertile soils as these roots die and breakdown.

Deep roots may help some native grasses grow more forage than some tame grasses during adverse conditions such as drought. Dormaar *et al.* (1995) argued that tame grasses have fewer roots than many native grasses because plant breeders have selected them to have more top growth and less root mass. During high rainfall years, it seems reasonable to argue that a higher proportion of tops as compared to roots is advantageous for higher forage production by tame grasses. During drought years, however, more and deeper roots are needed to extract soil moisture and nutrients from deep in the soil.

Some of the problems with overgrazing for many years or even decades are:

- Overgrazing removes too much leaf matter, lowering photosynthesis rates, reduces root growth, and prevents plant reproduction through tillering, rhizomes, and by seed (Figure 3).
- Overgrazing reduces and eventually eliminates the palatable, taller grasses and forbs that normally produce 60-80% of the forage and cover in healthy prairie grasslands. These taller plants are replaced by low growing or unpalatable grasses, forbs, and sedges that provide only about 25-35% of normal forage and cover.
- Taller plants are usually deep rooted and low growing plants are often shallow rooted. Thus, during drought, less than 25-35% of the forage production can be expected if shallow rooted species dominate the pasture.
- Leaving 40, 50, or 60% of the leaf area at the end of the grazing period is critical for the good health of the major range plants for three reasons. First, the remaining leaf area will allow photosynthesis to continue, permitting plants to survive the stresses of grazing and drought. Second, residual leaf area retains active leaf tissue needed to feed and replenish plant tops and roots after each grazing interval. Third, the residual leaf area provides the energy needed by plant roots to keep them alive.
- Leaf tissue remaining after grazing will eventually become litter (dead plant material). Litter contributes to range health in several ways. It keeps the soil cooler, improves water infiltration, prevents erosion, and shades weed seedlings. In the Dry Mixed Grass prairie, where the rangeland is being grazed, there is rarely "too much" litter. In contrast, under the higher rainfall of Foothills Fescue or Parkland Northern Fescue prairie ecoregions or ungrazed Mixed Grass prairie, excessive litter can reduce grass tillering, young plant regrowth, and smother forage seedlings. Excessive litter also creates a fire hazard.
- The effect of removing plant litter and altering the microclimate is immediate and the effects can be long lasting (Willms and Jefferson 1993). Plant litter moderates

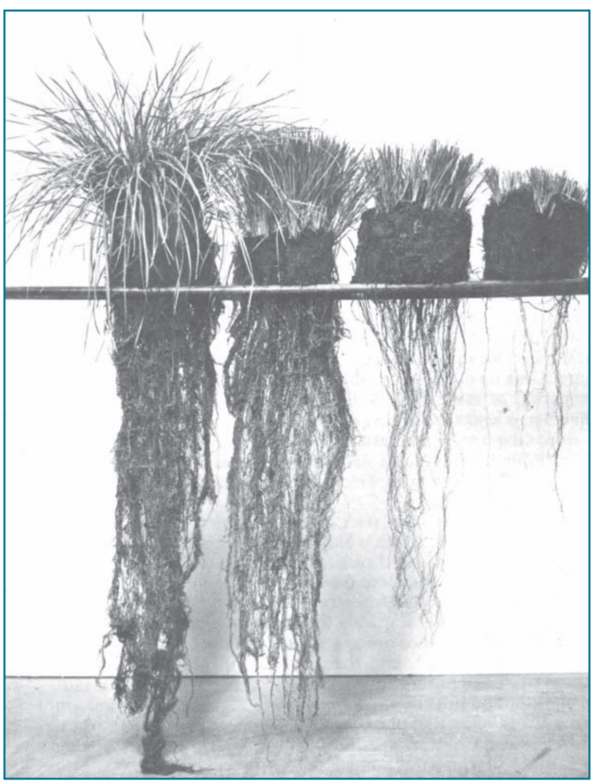

Figure 3. Effect of simulated grazing (clipping height and frequency) on Foothills rough fescue. Sods of rough fescue clipped in the greenhouse at various heights every four weeks for five months. Left to right: Not clipped; clipped to 12.5, 7.5, and 3.8 cm, respectively. The decrease in food reserves is shown by the decrease in root volume as the intensity of clipping is increased.

the soil environment by reducing soil temperature and thus, evapotranspiration, and by increasing available soil water. (Facelli and Pickett 1991).

- Many desirable and productive range plants, including grasses, forbs, or shrubs, have elevated growing points; hence, repeated heavy grazing removes these growing points. Over time, such a practice will kill these desirable, productive forage plants and promote the increase or invasion of low growing weedy plants. Low growing plants may not be as affected by close grazing because their growing points may be below the bite of the grazing animal.
- Too intense grazing reduces soil water infiltration and compacts the soil causing higher run-off of rainfall and melting snow. Naeth *et al.* (1990a, 1990b) studied the effects of infiltration and soil compaction in long-term natural grassland grazing studies in three prairie ecoregions. Their conclusions were that long-term heavy grazing reduced water infiltration rates and increased soil compaction. Lightly grazed sites had about twice the infiltration rates of heavy or very heavy grazing. Thus, long-term heavy and very heavy grazing created a human induced drought situation due to less litter, less plant growth, reduced soil moisture infiltration, more run-off, and more soil compaction.
- Too intense grazing not only reduces litter and increases soil temperatures (Irving *et al.* 1994) but it also increases the evaporation rate of water from the soil surface. Thus, minimal litter caused by repeated overgrazing contributes to reduced soil water infiltration, increased soil surface temperatures, increased evaporation from the soil surface, and reduced forage production.

Grazing Too Often is Detrimental

- Annual heavy, season-long grazing from early spring to fall over many years will cause desirable range plants to decline in vigor and eventually die. These species will be replaced by low growing or unpalatable plants.
- Grazing the entire length of the growing season for Canadian prairie natural grasslands, is questionable and requires low stocking rates and diligent management otherwise the long-term plant and soil health will decline.
- Frequent grazing, or grazing for long periods, in spring-summer does not provide effective rest periods. Over many years, this practice will kill the most productive native forage plants. This has led to a major reduction in forage production in the Northern Fescue portion of the Parkland Northern Fescue ecoregion (Irving *et al.* 1994). This reduction in forage (and thus, lack of livestock gain/acre) is associated with the lack of litter, warmer soils, reduced soil water infiltration, too much evaporation, and a reduced root mass. All of these factors contribute to the creation of human induced drought and reduced forage productivity.
- After grazing, native grasses benefit from a period of non-grazing sometime during the growing season (Romo 2006). This is called rest from grazing. For rest from grazing to be effective, the range plants must be able to re-grow leaves, roots, seedheads, and restore energy reserves. The rest period needs to be longer during drought or cold temperatures. Growth and recovery will not occur when soils are dried out or when it is too cold for leaf growth.
- Range plants rely on adequate root and leaf tissue to achieve maximum forage production. They use up most stored food reserves to produce spring root and leaf growth. Once the plant starts growing in spring, the amount of ungrazed leaf tissue determines the rate of growth of forage plants.

Effect of Winter versus Summer Grazing on Native Grasslands

Grazing by livestock or wildlife in winter, when plants are dormant, is considerably easier on native grasslands than is spring and summer grazing. That is because the forage plant's "manufacturing center" is not being continually sheared off and the soil is often frozen. These rangelands are well adapted to winter grazing, and they often produce enough forage for the taller plants to be partly exposed even under moderate levels of snow. Native rough fescue grasslands were the major source of forage in winter for the vast herds of plains bison and elk. Now, some of these native grasslands can only be grazed in winter because there is no available water during the rest of the year. Willms *et al.* (1993) showed that cattle perform well when snow is the only water source.

Winter grazing is a lower-cost alternative than feeding hay, silage, or grain and straw to livestock. When practised at appropriate stocking rates, it can enhance grassland production and will improve the ecological health of the rangeland as compared to spring and summer grazing. There are other positive features. Winter grazing maintains a high biological diversity, provides habitat features appropriate for some birds and small mammals, and enables most rainfall to soak into the ground during spring and summer.

Willms *et al.* (1993, 1997, 1998a, and 1998b) studied cattle grazing during winter on a Foothills Fescue grassland ecosystem. They also reported that forage losses were much less over winter on good to excellent health rangeland than on poor condition rangeland. When good to excellent health grasslands were grazed in winter, about 90% of the cattle diet was foothills rough fescue, the dominant forage species. On excellent ecological health ranges, the forage losses due to weathering were lower because foothills rough fescue is a hard grass that is able to resist the winter elements. The soft grasses, timothy and Kentucky bluegrass, grew on poor ecological health rangelands. Much of the foliage of these plants broke down and disappeared in early winter. As much as 60% of total biomass was lost due to weathering of these soft grasses on poor ecological health grasslands (Willms *et al.* 1998b).

Soft grasses planted in tame pastures are often more palatable in spring and early summer. Many ranchers and farmers graze mostly tame pastures in spring and early summer and save the natural grasslands for late season grazing. Fall and winter grazing of natural grasslands is a desirable and appropriate use to maintain both high forage yields and excellent ecological health. It also can help producers to be more profitable by reducing winter feed costs.

Spring or early summer grazed natural grasslands usually have lower forage production, ecological health, and litter cover than those grazed in winter. Spring grazing is a particularly vulnerable time to utilize the native grasslands. However, spring is the best time to use grazing to reduce brush encroachment. Bailey (2008) explained how to use grazing with or without other methods to manage brush on Canada's prairie rangelands. More information can be found in this reference in the "Reference" section of this chapter.

Where it is possible for the rangeland manager to use a rotational grazing system, a modest amount of light-moderate spring-summer grazing of native grasslands for one year out of a four or five year rotation, accompanied by several years of fall-winter grazing, can sustain higher forage production, nutrient quality, biological diversity, and ecological health.

Some of the guidelines recommended for maintaining healthy spring-summer grazed natural grasslands follow:

- Rest must be provided to natural grasslands after spring or early summer grazing. Only in extreme emergencies should natural grasslands be grazed a second time during the same year.
- Early grazing of spring calving fields every year generally reduces forage production, root production, and ecological health.
- Heavy grazing of the same spring calving ranges year after year is destructive to the ecosystem and to livestock production. It cannot be recommended because the dominant, productive cool season grasses will lose most of their leaves to grazing; thus their root mass will decrease about 50-75% due to lack of energy and nutrients. Water infiltration will decrease by at least 50% during rains and the soil surface evaporation will increase, thus creating a semi-permanent human induced drought in those paddocks.
- Light to moderate grazing use and light to moderate stocking rates are recommended
- The switchback rotation grazing system using light to moderate rates of grazing should be considered for spring calving fields. The forage production and ecological health of the range can only be maintained under light to moderate stocking rates. This method alternates spring calving amongst two fields. Calving would occur in Field 1 in years 1 and 3. Field 2 would be used for calving in years 2 and 4. This grazing procedure would help assure a healthy rangeland and likely reduce the level of disease organisms that may infect young calves.

Management of Riparian Natural Grasslands: Grazing Strategies

Riparian areas are vegetation zones having moist to wet soils adjacent to ponds, lakes, muskeg, streams, and rivers. Although riparian areas often occupy only a small proportion of the total landscape, such as 2 to 5%, they are of disproportionate forage production value for their size. For livestock, wild ungulates, birds, and other wildlife, they are important areas for watering, habitat, shelter, abundant forage, nesting, and escape cover. Good stewardship of riparian areas is crucial to safeguard important societal values like water quality, watershed functioning, biological diversity, and recreational opportunities.

Riparian areas are easily damaged by unmanaged grazing, whether from livestock or wild ungulates. Impacts include overuse of vegetation and reducing the plant residue available to trap and hold sediment. Banks are easily compacted and trampled, reducing water holding capacity and altering the normal channel structure of the water course. With prolonged trampling, woody species that provide deep binding root mass and plant community structure will be weakened and eliminated.

Riparian soils vary from nutrient poor peat to nutrient rich, clay textured gleysols on the Canadian prairies. Most riparian grasses are soft grasses that have high forage quality and palatability at early stages of growth and grow tall and become fibrous, less palatable and unpalatable as they mature. Wetlands can provide grass and sedge regrowth from spring until fall. When the adjacent uplands have dried out and produce no green forage, regrowth in many riparian areas is readily available to grazing animals.

The maintenance of natural riparian grasslands and shrub lands in a productive state of high ecological health is challenging. The very fact that the riparian areas occupy only 2, 5, or 10% of the area in a prairie landscape, and that the area can produce lush, green growth from spring to fall, challenges the management of every land manager. The key to the management of riparian areas is to graze these areas for a short time period followed by a longer period of rest. The abundance of soil moisture provides a greater opportunity for riparian vegetation to regrow quickly after grazing during the growing season.

Effective riparian grazing strategies tend to focus on two key management objectives:

- limiting animal impact to riparian vegetation and soils, and
- mitigating those impacts to facilitate recovery of health and function.

Riparian Grazing Strategies

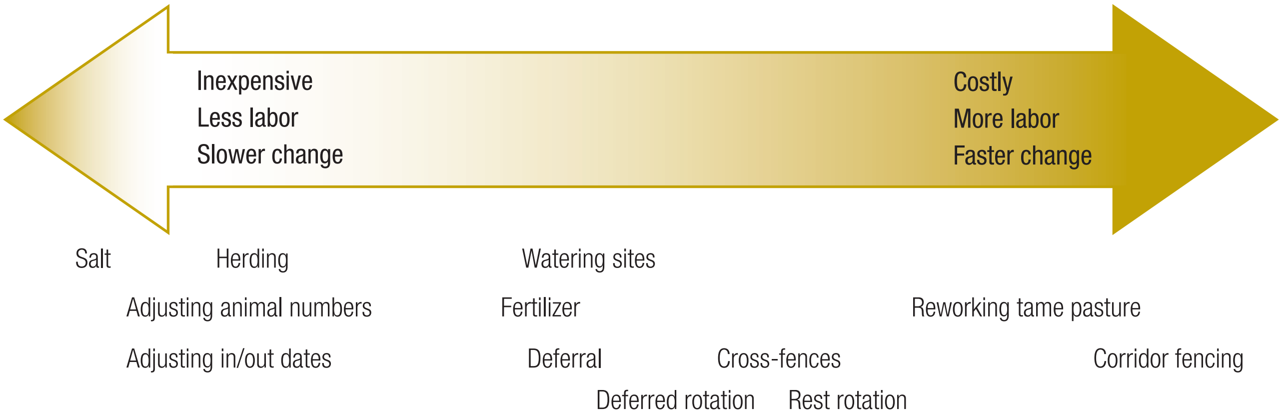

Figure 4. Options for maintaining and restoring riparian health and function arranged from lower cost and slower change pathway to more costly approaches that will produce more rapid recovery.

Tools that limit animal impact are ones that reduce livestock selection of riparian habitat for grazing and resting. Tools in this category include the use of salt and attractants to draw animals away from riparian areas, herding practices, and development of off-stream watering facilities. A change in livestock genetics may also prove effective. A rule of thumb is that properly designed off-stream water developments may be favored eight times out of ten over natural drinking sources. These sources of water have a cumulative benefit in reducing animal impacts on riparian areas. Timing of grazing can also be an effective tool to alter seasonal selection patterns of livestock. Livestock and wild ungulates, such as elk, tend to actively disperse into the uplands during winter grazing more so than during summer. Limiting access with stream bank fencing can be costly; however, where stream bank fencing is deemed essential, a corridor fencing design is recommended, allowing the wetland to be managed as a distinct riparian pasture. Corridor fences are built further from the riparian area in a less costly location. Most negative impacts of grazing on riparian health are associated with prolonged trampling of moist to wet soils, and the repeated defoliation of riparian vegetation. Longer periods of rest during the growing season are "effective rest" because the weather and favourable soil moisture conditions permit rapid re-growth and recovery of plants.

Simple deferral of spring grazing is effective in limiting livestock access to stream banks when they are soft and vulnerable to trampling. The simplest type of rotation grazing practice is called a switch back rotation. This system simply alters the early grazing between two fields from year to year. When switching from season-long use to a switchback, the early grazed field receives a much shorter grazing period followed by a rest period after grazing. The late field receives beneficial deferral through much of the available growing season. An even more specialized system is rest-rotation grazing where a riparian pasture may receive one or more years of rest to accomplish more specialized objectives like the restoration of woody plant species before it is grazed again.

Tools are available to help assess the current health of riparian areas and to provide grazing management options that can limit or mitigate the impacts of livestock grazing on riparian areas. For more information, see: Fitch, Adams, and O'Shaughnessy. 2003. *Caring for the Green Zone: Riparian Areas and Grazing Management* (www.cowsandfish.org/greenzone.html) or similar publications.

Grazing Systems Suitable for Management of Natural Grasslands

The management of any grassland is of utmost importance when looking at sustainability. Some grazing management systems are effective in minimizing overgrazing while sustaining reasonable levels of livestock productivity and high ecological diversity. Ineffective implementation of any grazing management system may fail to maintain a sustainable grazing resource. This is often due to too high a stocking rate, which causes overgrazing, and inadequate livestock or wild ungulate distribution across the grasslands. Poor livestock distribution creates serious overgrazing in one area and no grazing in other areas.

Contemporary grazing systems are management plans that enhance the efficient use of rangelands by livestock (Adams 1992, Bailey 2008). They can help maintain natural grasslands in an ecologically sustainable state. They are also useful in repairing damage created by past inappropriate grazing/browsing practices by either livestock or wild ungulates.

Contemporary grazing systems are feasible and effective when proper stocking rates and effective distribution of livestock are managed to maintain sustainable rangeland ecosystems. Features of effective grazing systems include:

- Plans and schedules for managing when, where, and how much livestock graze in a management unit. Occasionally, these plans can be successfully applied to bison management in provincial or national parks.

- Strategies for making use of the available grazing/browsing resources in a fruitful manner that allow reasonable livestock production goals to be met while maintaining rangeland health, animal health, and higher ecological diversity.
- Effective stockmanship skills that enable more uniform distribution of grazing across the landscape.

Highlights of Grazing Management Systems Presented

Many grazing systems have been devised. The eight grazing systems listed below have been selected for their potential for application to Canadian prairie or adjacent foothill native grasslands:

- Natural grazing systems: for plains and mountains
- Continuous system: for grazing winter ranges
- Seasonal system: for mountainous and foothills ranges
- Rotation systems: to simulate natural systems
- Switchback rotation system: two fields
- Deferred rotation system: four to six fields
- Short duration rotation system: eight to 20+ fields
- Complementary rotation system: tame grass and natural grassland.

There are many different grazing systems available; only a few examples of selected grazing systems are included here.

Selection of Grazing Systems for Natural Grasslands

The first two months of growth, usually from May and June (in the southern prairies) and May 15 to July 15 (in the parklands), produce about 80% of the total annual plant growth. Rapid growing plants also provide the highest forage quality, and the highest animal gains. Since most of the plant growth occurs in a very short growing season a well planned and managed grazing system is essential to maintain productive, ecologically healthy, grazing lands over the long term. These systems may apply to a) natural grasslands, b) natural grasslands and forested rangelands, and c) natural grasslands and tame pastures.

The early spring growth period of Canadian prairie natural grasslands is most vulnerable to heavy grazing and to too early livestock turnout year after year. Similarly, sustained high stocking rates all growing season long result in overgrazing, a depletion of forage productivity, and decreased native forage species. These high stocking rates also contribute to increased soil compaction, reduced water infiltration, increased loads of harmful microorganisms, reduced ecological sustainability and more alien weeds.

Natural Grazing Systems of Prehistory

During pre-European history of the Canadian prairies, wild ungulate herds on the plains and foothills were limited by drought, deep snow, and long winters. These weather related factors restricted supplies of forage and drinking water. Any one of these factors would temporarily reduce bison and elk populations. Periodically, contagious diseases or high predation (including by humans) reduced the herds. In years of good rains and little disease, ungulate populations increased. In riparian areas, a herd of about a million bison could trample, overgraze, and denude the plants in spring, summer, or fall. Several years later, drought, disease, predation, or severe winters, either singly or in combination, would reduce bison and elk populations. The population reduction would allow the grassland range ecosystems to rest and recover ecological health during the following years of minimal grazing. In subsequent years, the cycle of herd buildup and decline would be repeated.

A natural grazing system on the Canadian plains evolved over pre-settlement time. Bison migrated into the parklands and foothills to graze productive and nutritious rough fescue grasslands in fall and winter. Typically, they were attracted to the parklands by judicious use of aboriginal created fires. In spring, they dispersed in long migrations into the Mixed Grass and Dry Mixed Grass prairie, returning to the rough fescue grasslands once again before winter.

The natural grazing system was different in the foothills and mountains. When spring came, the wild ungulates (elk, big horn sheep, deer, and moose) would start to move out of valleys and foothills to higher and higher elevations as new grass and woody growth began in spring and early summer. The herds would gradually migrate upwards in elevation until they reached the summer ranges high in the mountains. When late summer or fall snows arrived, the herds would return to the grasslands in the foothills and valleys to over-winter.

Issues Relevant to Management of Natural Grassland Ranges

In prehistory, wild ungulate population size likely changed frequently in response to human predation, drought, disease, severe winters, and water and forage supply. Today, range livestock populations rarely change, due to:

- Ranchers and farmers feed grain, silage, hay, and mineral supplements to livestock in winter, and salt, mineral supplements, and creep feed to calves in summer.
- The creation of new water developments, trails, fences, and other management tools enable a higher proportion of forage to be used by livestock on natural grasslands, as compared to prehistoric conditions.
- Since European settlement, ranches and grazing have been permanently placed in fixed areas. There is little livestock migration today that simulates "natural migration systems". On a smaller scale, however, today's grazing systems can contribute to a simulation of the effects of natural grazing systems on natural grasslands, associated grazed forests, and tame pastures.
- Since European settlement, parks have also been permanently placed in fixed areas. In the larger parks there is

still migration occurring amongst some wild ungulate herds but migration is minimal in smaller parks.

What Should Contemporary Grazing Management Systems Accomplish?

Grazing management systems allow the land manager or rancher to balance or manage the livestock needs with those of the range ecosystem. In spring, livestock producers are short of green grass. Too frequent and too heavy grazing during this season is most harmful to range plants and soils. Any effective grazing management system must resolve this basic dilemma.

- A well-designed grazing system can achieve optimum livestock production and, at the same time, maintain the ecological health of the rangeland including the livestock, wildlife and rare or endangered native plants and animals.
- An effective grazing system manages livestock grazing to provide adequate periods of rest and recovery so that grazed plants regain vigor, set seed, and store food reserves in their roots and stems during the year following grazing.
- Aim to achieve uniform distribution of livestock within each grassland area, recognizing that as pasture size increases, even grazing becomes almost impossible in actuality. However, the patchy grazing patterns that result are beneficial to a wide variety of wildlife species.
- Carefully manage grazing to minimize negative effects on ecological health. For example, do not feed livestock bales of hay or straw on native grass lands. When this happens the grasslands are exposed to the risk of invasion by both tame hay species and weeds from dung or directly from seeds falling out of the bales. Instead, feed out bales only on tame pasture, hay or stubble fields, thus preserving the health and productivity of the native grasslands.
- Provide an effective management system for riparian areas to renew and sustain this critically important part of the landscape.
- Provide animals quality drinking water, wherever possible, away from or at the edge of the riparian zone.
- Apply moderate stocking rates enabling wildlife and rare plant species to flourish, forage to grow, minimize erosion, and maintain water resources in a clean, healthy state.
- Modify grazing systems to adjust to complex terrain and ecosystem types in mountainous and very hilly terrain.
- Many grazing systems focus on improving animal gain per acre by maximizing forage production and optimizing its use. This single use strategy focusing on livestock may be acceptable on private lands, but it is not sound management of publicly owned Canadian prairie natural grasslands, whether they be in parks, public grazing lease lands, or military training bases.
- It is important to accommodate the non-livestock users on public grasslands. They also are entitled to use and enjoy these natural grasslands. Many of the remaining natural grasslands occupy only a small fraction of the original area and will need to be managed accordingly.

Key Principles for Use of a Grazing System in Natural Grasslands

- The grazing system will match the needs of the range ecosystem to the needs of the grazing animals. This is a balancing act. In spring the rancher needs green forage, which is in short supply, while at the same time the palatable forages are vulnerable to damage due to overgrazing or continuous (season-long) grazing.
- A grazing system will permit some grazing when the grasses are at their most vulnerable state in some years. At later stage, a period of rest is required during the growing season when there is enough soil moisture for regrowth and replacement of forage leaves, shoots and roots, and a recovery of plant stored energy reserves.
- The types of deferred rotation grazing systems recommended in this chapter provide opportunities for grazing throughout the grazing season, while also providing a period of rest and recovery before the next grazing. This practice permits shoot and root regrowth and enables long-term survival and ecological health of natural grasslands when appropriate stocking rates are applied.
- Grazing systems can be relatively simple in the arid Dry Mixed grass prairie. In contrast, in moist native grasslands and tame pastures, where rainfall and forage production are usually higher, more complex and expensive grazing systems are favoured by some range managers.
- Grazing systems alone will not be sustainable. They must be well managed with proper stocking rates to meet the objectives of the grazing operation.

Matching Range Management Principles with Grazing Practices

There are some basic principles that are necessary for the successful application of a grazing prescription to a natural grassland ecosystem. These include:

- Use appropriate stocking rates. No sophisticated grazing system can overcome the consequences of overgrazing when the stocking rate is too high. All too often range managers have been led to believe that stocking rate can be ignored if some miraculous specialized grazing system is applied (Holochek *et al.* 2005).
- Usually a moderate stocking rate is required, but occasionally for brush management purposes, a brief period of temporary, short-term heavy grazing may be required

to realize a specific brush control objective in a brush management plan (Bailey 2008).

- Be aware that if grazing starts too early in spring, before the grasses are about 6 inches (15 cm) high, and are at the three leaf stage or more, then every day grazed in spring is equal to three days of grazing loss in the fall.
- When implementing a rotation grazing system, cross-fencing subdivides the range and concentrates livestock in smaller paddocks; this forces livestock to achieve a more uniform distribution while grazing.
- Provision of quality drinking water, salt, and mineral supplements in every paddock.
- Modify grazing systems to adjust to complex terrain and complex grassland and brush landscape patterns.
- Develop a process to alternate the sequence of grazing of fields from year to year, enabling the field grazed first in year 1 to be deferred in year 2 to mid-summer or later. This will minimize the negative effects of spring grazing.

Unplanned grazing usually yields unplanned results, many of which are detrimental to the long-term sustainability of the grazing resource. Planned grazing assists the range manager to more adequately understand and meet the requirements of forage plants, livestock, and soils, thus enabling sustainable grazing practices. Planned grazing can also assist in providing the habitat requirements of some endangered animal and plant species.

Methods to Improve Livestock Distribution within a Grazing Management Unit

Under minimal management, cattle prefer to graze, drink, and rest in valley bottoms or flat areas close to water. It takes a lot of planning and stockmanship skills to change such habits. Contemporary grazing systems are one of the tools that we can use to more efficiently manage rangelands on both plains and foothills. The operation of one or more grazing systems within a ranch operation must consider a number of factors. Some of the major factors include:

- Topography: The more complex the topography, the more difficult it is to manage rangeland and range livestock efficiently. The grazing system must be adapted to the needs of each property or disposition.
- Water: Distribution, quality, quantity, and seasonal availability of water are key parts of each management system. Where water is not available, graze only in winter when snow is plentiful so that snow can be used as a winter water supply.
- Fencing: Subdivide large range units into smaller ones that can influence the distribution of livestock within the field (paddock). Locate the fencing to follow the natural topographic features in hilly or mountainous areas. Fencing animals out of prime riparian areas is now a recognized practice to provide for the recovery of these valuable parts of landscape units.
- Salting: Salt and minerals may be placed as much as 1 to 2 km away from water. Placing salt and minerals away from water promotes more uniform grazing across a field.
- Stockmanship: Cattle that are handled more often become easier to manipulate in a grazing system. Younger cattle are easier to train than are older cattle (which may have been inadvertently encouraged to loaf around water sources in the past). Herding and "placing" of cattle can improve distribution. Herding of cattle into areas of poor accessibility will improve uniformity of grazing use. Livestock that are adapted to the local environment usually graze the range more effectively.
- Trail development: Building trails through natural barriers, such as dense forest, rough topography, or wetlands, can facilitate better distribution of livestock.
- Timing of grazing use: In Foothills Fescue grassland, "skim graze" areas of timothy, Kentucky bluegrass, and smooth brome in the spring at a moderate level of use (50%) when livestock prefer to eat them. At that time of year, they are more palatable than native grasses. This enables good livestock gain and grazing use of alien grasses at a time when they are palatable. This provides some livestock gain from tame grasses scattered in patches amongst the natural grasslands.
- Animal health especially in the new born calf is extremely important in a grazing operation. In order to reduce the possibilities of neonatal diarrhea or calf scours and other contagious diseases (Smith *et al*. 2003) it is highly recommended that the new-born calf have access to clean pastures that were not used as a calving field the previous year.

The Relationship of Animal Health to Grazing Systems

Biosecurity is critical in every herd of livestock grazing on natural grasslands. The planning and management of grazing systems can also contribute to good or poor livestock health and probably also to the health of wild ungulates on the range.

During the calving season calving should be done in a clean area, separated from the rest of the herd because it helps to reduce calfhood disease, especially calf scours. For large herds, it is recommended there be several small calving pastures that allow regular rotation to avoid buildup of disease-causing organisms. Studies have indicated that neonatal calf diarrhea or scours are the cause of 15-20% of all calf deaths prior to weaning. Neonatal calf diarrhea can be caused by bacteria (*E. coli*, Salmonella, viruses, (coronavirus, rotavirus) and protozoa (*Cryptosporidium parvum*, coccidia). Both Smith *et al.* (2003) and Shulaw (2007) and the Lacombe Research Centre Agriculture and Agri Food Canada in Alberta recommend dividing the herd into smaller, more manageable groups for calving. Smith *et al*. (2003) developed "The Sandhills Way" of pasture-calving. It is a system to reduce the frequency of calf scours by:

1. Segregating calves by age group to prevent direct and indirect transmission of pathogens from older to younger calves,

2. Routinely moving pregnant cows to new calving pasture to minimize pathogen dose-load and contact time,

3. Routinely preventing the later born calves from exposure to an overwhelming dose-load of pathogens.

One of the key points of this calving system is to not introduce any new-born calves to a paddock that has a calf in it that has neonatal calf diarrhea.

The grazing system that is selected by the range manager does have an effect on the load of potential pathogens on the range. The continuous grazing system does provide an opportunity for pathogen loads to accumulate. This is a man-made system that can contribute to a higher level of disease amongst livestock ranging from new-born calves to adult cattle because of the presence of disease organisms in the areas most heavily used year after year. This is true for young calves' risk of obtaining scours and also all cattle, young and old, getting foot rot in the mud used over and over for livestock watering.

Rotation grazing systems offer periods of grazing in each paddock followed by longer periods of rest from grazing. With the absence from grazing the level of pathogens in the soil should fall. In the deferred rotation grazing system, in areas where disease may strike during spring calving, it is quite feasible to defer a field that was grazed in spring of Year 1, when calves might have dropped feces loaded with a specific pathogen like *Cryptosporidium* or *E. coli* , until the fall of Year 2. This will provide a 15-month window for these organisms to decline to low levels. This would likely not happen under either Continuous grazing or Seasonal grazing systems. Similarly, such a deferral would allow the foot rot-causing organisms around watering cites to also decline during the long rest period between spring grazing in year 1 and fall grazing in Year 2.

Research at Lacombe Research Centre has shown that newly weaned calves are less prone to respirator disease if they are allowed to graze regrowth on a high quality fall pasture rather than being confined to feedlot pens with high animal density. Calves can successfully graze into the late fall and early winter with an adequate water source and some form of shelter.

Grazing Systems

Continuous Grazing System

This traditional grazing system is also called season-long grazing. The livestock stay in a single large field for the entire grazing season. The system was very popular with pioneer settlers and also with some landowners today. However, these priorities do not appear to be consistent with ecologically sustainable management of Canadian natural grasslands.

In a continuous grazing system, livestock are given complete access to all of the grazing land available for the grazing year. The manager basically turns out the herd, provides water, salt, and mineral, and checks the fences periodically. Cattle in this type of system are usually not handled very much.

During the 60 to 90 day growing season common on the Canadian prairies, under continuous grazing, livestock and bison will selectively graze preferred forages close to water repeatedly. Only when the forages close to water become depleted will they move away from water in search of forage. This practice causes overgrazing year after year on the areas most preferred by grazing animals. Gradually the overgrazed range changes from palatable native grasses to weedy plants, and water runoff accelerates during each rainstorm. This causes the forage production to plummet, soil infiltration to decrease producing a localized artificial drought. Management of stocking rates and the movement of salt and mineral licks to distant areas will help alleviate this situation. Effective grazing management is still required in continuous grazing systems to promote sustainability of the grazing lands.

Late fall and winter grazing is the one practical and effective way to use a continuous grazing system without damaging natural grasslands. When plants are dormant minimal harm will occur to the health of the grasslands provided the stocking rate is moderate and the grazing animals are removed before the spring thaws begin. Livestock distribute themselves across the rangeland throughout the winter so long as forage is available for grazing and snow is available to provide the animals' need for water. Fall and winter grazing of natural grasslands are successfully practiced in southwestern Alberta, where strong Chinook winds regularly blow snow off the slopes throughout most winters.

If it is in the resource manager's interest to create a wide diversity of grazed and ungrazed patches across the landscape, as is important in some provincial and national parks, then a continuous system may be acceptable provided stocking rates are low. Continuous grazing by wildlife is often the only grazing system in parks. There may be no other alternatives available to park rangeland managers. However, this management system invites invasion of alien weeds into the overgrazed patches. If the ecological sustainability (range health) of the natural grasslands is not a serious issue, and low stocking rates are in effect, and good animal health management is effective then this practice may be possible.

Seasonal Grazing System

The first type of seasonal grazing system used by pioneer settlers and ranchers alike included:

- a spring calving pasture close to the homestead
- one or more summer paddocks farther from the homestead
- a fall field for weaning calves from their mothers, as well as for grazing
- a winter field that was often inadequately supplied with water (since cattle could eat snow)
- the winter field was usually in excellent ecological health because it was only grazed in the dormant season when plants were resistant to grazing use
- calving fields and summer-grazed fields were usually in poor to fair ecological health with riparian areas being trampled, overgrazed, and showing signs of erosion

A second type of seasonal grazing system was developed for mountainous and nearby foothills areas. This system is not recommended for ranches or parks on the plains.

The second seasonal grazing system follows the same basic pattern as wild ungulates. The livestock are grazed in mountain valleys in spring until after calving. Then the herd is gradually moved up the slopes from lower elevation ranges to mid-ranges, and then later still to higher-elevation ranges by mid-summer. As winter approaches, the livestock are moved down the mountains through a series of rangeland types and elevation changes.

Important differences between this system and wild ungulate usage of the range include:

- Higher stocking rates of livestock with poor distribution of grazing use can cause overgrazing in specific areas compared to wildlife roaming and grazing the whole area.
- When left alone, cattle grazed riparian areas and the lower slopes of grass rangelands. Often, the cattle did not distribute themselves well on steeper slopes or forested rangelands.

Today, ranchers in foothills and mountainous areas still use the seasonal grazing system. Some do it very well because they manage the stocking rate carefully and distribute livestock effectively. Ranchers can develop off-stream water sources and fence out riparian areas where appropriate. Livestock distribution can be made more effective by increasing the stock density but reducing the grazing time, judicious placement of cross-fences, salt placement, and herding cattle away from water and primary ranges into secondary ranges.

Where possible and practical at each stage of elevation, the switchback (rotation) grazing can be implemented by splitting large fields into two parts. Then, in alternate years, there can be deferred rotation grazing so that when paddock number 1 is grazed first in year 1, then in year 2 it will be rested while paddock number 2 is being grazed first. This modification enables range forages grazed first last year to be grazed second this year, permitting more leaf and root growth early in the growing season every second year.

By making such changes, deterioration in ecological health of mountain grassland ranges can be reversed, soil erosion can be stopped, and the most palatable plants can recover. Animal weight gain per acre will also increase.

Rotation Grazing Systems

Rotation grazing systems can be used as a management tool to help maintain the forage productivity, ecological health, and biological diversity of natural grasslands, associated forested ranges, and tame pastures. Effective rotation grazing systems can simulate natural grazing systems that occurred on the ancient natural grasslands for millions of years. These grasslands are adapted to being grazed and then the herd moving on, so the grassland is rested from grazing, enabling leaf and root growth and seed and rhizome production. During the rest period when there is no livestock grazing, there is an opportunity for the soil structure to recover and for animal disease organisms to be reduced.

Specialized grazing systems of today are designed to utilize rangeland for livestock grazing while sustaining the natural rangeland resources because:

- Only natural grassland ranges and other grazing lands can supply the forage required for grazing both livestock and wild ungulates.
- Outside environmental interests encourage range managers and ranchers to manage rangelands in a sustainable manner that minimizes erosion and the deterioration of natural upland grasslands, riparian grasslands, and shrublands.
- There is much interest in maintaining habitat for nesting birds, small mammals, reptiles, and amphibians and providing habitat for species at risk.
- Managing livestock grazing to maintain high ecological health and a high level of biological diversity at the landscape, field, and grazing patch level will help provide the wide diversity of habitats required by many wildlife species in both riparian and upland grasslands.

Switchback Grazing System

The simplest rotation system is the switchback grazing system. It consists of two fields. One field is grazed while the second is ungrazed, enabling growth of leaves, roots, and seed production in the second field. A moderate stocking rate is required for the use of this simple rotation grazing system.

Field 1 is grazed in spring, permitting 30 to 40% use of the green foliage, and then the herd is switched to field 2. Animals can remain for a longer period in the second field, until 50% of the foliage has been grazed. When grazing is completed in field 2, the herd is moved elsewhere for the rest of the grazing year.

The switchback grazing system is an appropriate addition to the seasonal grazing system that many ranchers practice in foothill and mountainous areas.

Deferred Rotation Grazing

In planning and implementing a deferred rotation grazing system, deferral means to delay grazing to enable vulnerable plants to regrow and recover from a previous grazing event. Such deferral is intended to permit leaf, root, and tiller development, seed production, and seedling establishment. Deferral, along with moderate rates of stocking, promotes the full growth potential of range vegetation. This will result in a gradual improvement in forage productivity, ecological health, and habitat qualities of natural rangelands. Usually, the first field to be deferred in spring is the one that was grazed first during the previous year. Once the first paddock is grazed in early spring and the herd removed, there is a long rest period from grazing and this enables plant regrowth and replenishment of energy reserves.

In the deferred rotation system, usually the first field grazed in spring of year 1 would not be grazed until late summer, fall, or winter of year 2. Thus, this field has been deferred for the entire plant growing season to allow the forage plants to recover from the previous spring's grazing effects.

Deferred rotation grazing can help the manager sustain the forage resources while still realizing good animal weight gains. The grazing system is designed for a field to be grazed and then rested from grazing. Typically, the field is not re-grazed in the rotation for a whole year.

A contemporary rotation grazing system is an effective means of implementing key range management principles. Consider the following example:

- Moderate stocking rates are set to reflect range health and vigor and to allow adequate carryover to maintain plants and soil.
- Cross fencing of the range allows part of the range to be grazed in spring (when they are most vulnerable to defoliation and trampling), while the forage in all other fields continues to grow free from grazing.
- The process of alternating the sequence in which pastures are grazed from year to year minimizes the negative effects of spring grazing.
- The implementation of cross fencing within the rotational grazing system, combined with water development, salting practices, and herding concentrates livestock; this may encourage greater livestock use on both secondary and non-use rangelands.

About four to five fields of approximately equal size are recommended to implement a deferred rotation grazing system. Since the first two months of spring grazing are the most vulnerable period for natural grasslands to suffer damage by grazing, it is also the period when periodic deferment can enable plant recovery.

In practice, grazing deferral refers to allowing the vegetation in a spring-grazed paddock (in year 1) a rest from grazing at that season the next year (year 2). An example of a deferred rotation grazing system is presented in Table 5. The first field grazed each year is in bold font. Field 1 is grazed first in year 1, third in year 2, second in year 3, and last in year 4. This sequence completes a four year rotation. In year 5, a new grazing rotation begins with field 1 being grazed first, and then the entire rotation is repeated.

In year 1, fields 1 and 3 were grazed in the most vulnerable months of late May, June, and part of July. In year 2, both fields 1 and 3 were deferred and not grazed until the second half of the grazing season.

The first field grazed in spring should have a long period of rest the next year. In year 4, field 1 had a long deferral and was grazed last, before being grazed first again in year 5. The goal of this design is to defer grazing of the first and second fields until later in the growing season.

A practical example is shown in Table 6. In this example, we are assuming that there is enough forage available in field 1 for three weeks to provide for the herd without overgrazing the grassland. Then by late June, and on through September, the assumption is that the quantity of forage available for grazing is enough to sustain the herd for about four to five

Table 5. An example of a four field deferred rotation grazing system.

Field No.	Year 1	Year 2	Year 3	Year 4	Year 5
1	**graze first**	third	second	last	**graze first**
2	last (fourth)	**graze first**	third	second	last
3	second	last	**graze first**	third	second
4	third	second	last	**graze first**	third

Table 6. An example of a four field rotation grazing system with dates of grazing by field.

Field No.	Year 1	Year 2	Year 3	Year 4	Year 5
1	**graze first June 1 - 21**	third Jul 21 - Aug 28	second Jun 21 - Jul 21	last Aug 28 - Sep 30	**first June 1 - 21**
2	last (fourth) Aug 28 - Sep 30	**first June 1 - 21**	third Jul 21 - Aug 28	second Jun 21 - Jul 21	last Aug 28 - Sep 30
3	second Jun 21 - Jul 21	last Aug 28 - Sep 30	**first June 1 - 21**	third Jul 21 - Aug 28	second Jun 21 - Jul 21
4	third Jul 21 - Aug 28	second Jun 21 - Jul 21	last Aug 28 - Sep 30	**first June 1 - 21**	third Jul 21 - Aug 28

weeks without harming the grassland. Managers can use recommended stocking rates to project whether the proposed plan is appropriate for the paddocks.

This grazing system requires adequate planning, a sufficient number of fields (paddocks), and access to drinking water, salt, and mineral supplement. A good distribution of livestock in each field is necessary and may require changes to fencing, water facilities, and the placement of salt and mineral away from water. Herding livestock may also be required in certain fields to enhance animal distribution.

Short Duration, Deferred, Rotation Grazing

Short duration, deferred, rotation grazing is a more complex type of deferred rotation grazing system that can rarely be justified for use on arid prairie rangelands. It may be useful as a management tool for higher rainfall areas when forage productivity is also high. Instead of having about four fields in the grazing scheme, there are eight, 12, 20, or more fields. This allows the duration of grazing days per field to be shorter, while the duration of rest is increased. The cost of fencing and watering facilities is much higher. Some ranchers merely split existing fields using electric fencing and existing/portable water facilities, thus reducing costs.

A careful manager can use this grazing system to advantage for special range management purposes simply by varying the season and intensity of grazing. For example, if it is appropriate to encourage the herd to use a higher proportion of their diet as brush in a particular year, then by delaying the movement of the herd out of the paddock by only a few days, one can enable a greater utilization of the brush and the grasses in a specific field. Then, the next year, the manager can choose either a lower intensity of grazing or to defer grazing of that paddock until later in the summer.

Recent work has shown that this grazing system can be used to reduce brush or Canada thistle encroachment. To be specific, the short duration, deferred, rotation grazing system can be easily modified to become a high intensity, low frequency (HILF) grazing system. The range manager develops a grazing prescription to intentionally use a high stocking rate and a heavy grazing intensity to overgraze a selected paddock for a few days to intentionally heavily graze "problem plants".

In the Aspen Parkland ecoregion, Bailey (2007), www.foragebeef.ca, and Bailey (2008) used the short duration, high intensity (HILF) grazing system with high stocking rates of cattle and 60 to 70% use of grasses. This method was applied to a paddock for one to two weeks of intensive grazing to reduce the cover of aspen and other palatable brush and to remove various weeds. The herd was then rotated into another field that also had a brush cover, and the grazing strategy was repeated. After such grazing, each intensively grazed field was rested at least six to eight weeks before being grazed again. Also in the Aspen Parkland, the HILF and continuous grazing systems were compared by Bork *et al.* (2008) to assess the potential of managed grazing to reduce Canada thistle. In spring, cattle grazing in the HILF system consumed as much 1,400 lb/acre of Canada thistle, whereas, under a continuous grazing system, they hardly touched it. Over a three-year test period of short duration, heavy grazing, the paddocks in the HILF grazing system had Canada thistle reduced to nearly zero, while under continuous grazing the Canada thistle continued to grow vigorously.

Brush regrowth and Canada thistle are both of high nutritional quality in spring. Cattle can experience adequate gains while intensively grazing these species for a few weeks. Nevertheless, some managers are reluctant to use grazing as a means of controlling brush invasion, Canada thistle, or other weeds for fear of losing live weight gain on the cattle. If this is a concern, normally cattle will quickly gain back any weight loss through compensatory gain once the herd is moved to the next high quality grazing area. The costs of brush and weed control need to be weighed off with cattle prices. However, brush and weeds are most economically controlled by cattle in almost all cases.

Complementary Rotation Grazing System

This grazing system uses both tame pasture and natural grasslands in a managed grazing system. This is one of the most productive grazing systems available, but it is also one of the most expensive (due to the high cost of developing tame pasture). The tame pasture is grazed early in the spring,thus

Table 7. An example of a complementary grazing system.

	Tame	Pasture	Natural	Grassland	
Year	Field 1	Field 2	Field 3	Field 4	Field 5
1	May	June	July	August	September
2	June	May	September	July	August
3	May	June	August	September	July
4	June	May	July	August	September

deferring the grazing of natural grasslands (native range) until summer, fall, and winter. An example is presented in Table 3. This table illustrates the use of a switchback rotation system for tame grasses and a deferred rotation grazing system for natural grasslands. Note that the monthly grazing interval given in Table 3 is not to be considered as being the recommended time interval. Each manager will need to decide what is the appropriate duration of stay in each paddock based upon forage available, tolerable level of grazing use, and resistance to grazing.

The objective of a complementary grazing system is to utilize the forage resources at a time when they are both palatable and grazing resistant. On the Canadian prairies, crested wheatgrass in the Dry Mixed Grass and Mixed Grass ecoregions and smooth bromegrass in the Parkland Fescue ecoregion are tame grasses that are palatable in spring and early summer, but less palatable and nutritious later in summer and fall. They can be maintained in a healthy condition for many years by practising moderate grazing in a switchback rotation system, using a grazing sequence as recommended in Table 7.

Most natural grasslands, whether in Dry Mixed Grass, Mixed Grass, Foothills Fescue or Parkland Fescue, maintain a higher level of ecological health (range condition) and a higher forage production with fewer invasive alien weeds when not grazed in spring. Grazing in summer, fall, or winter helps maintain them in a good health.

A Grazing Management System for the Semi-Arid Southern Canadian Prairies

On the Canadian plains, the southern prairies are mostly in the Dry Mixedgrass prairie range type. Drought and low rainfall (aridity) are the dominant environmental factors controlling forage production. The management of grazing in these semi-arid areas is not simple and is site specific. The stocking rate is of great importance and vast areas are required to support each ranch. (Briske *et al*. 2009) have suggested that there is very little difference in plant and animal productivity between continuous and rotational grazing of semi-arid and arid sites in the central and southern United States. However, this fact might not apply to the Canadian prairies where most plant growth occurs over a 60-90 day period from early spring until mid-summer. Growing native range plants are more vulnerable to grazing in that 90 day period than in the remainder of the year.

Well managed continuous grazing systems can be used in site specific locations but the stocking rate is the most important factor for sustainability for a diverse plant community. On the other hand deferred rotation grazing or complimentary grazing systems are management tools that can assist the grazing managers to meet specific goals in the southern semi-arid prairies. These two grazing systems are especially applicable to spring to mid-summer grazing because it minimizes the chance of livestock eating the same grass plants more than once during rapid plant growth during two or more years in a row. It also eliminates the opportunity for widely distributed heavy grazing on primary ranges near watering facilities year after year. Thus, the reason for greater soil compaction caused by localized high stocking rates observed by (Naeth *et al*. 1990a) on Mixed prairie rangeland as well as the reduction in soil water infiltration (Naeth *et al*. 1990b). Most southern prairie ranches have 6 to 12 existing fields or so that they can use to create a deferred rotation grazing system. Thus, only a few fields would need to be grazed each spring, allowing the rest to be deferred until after the main 60 day growth period during most years.

What Grazing System is Best?

- Designing the appropriate grazing management system will depend upon the available forage resource types, the level of skill of the manager, their management goals, and the ecological health requirements of the existing grassland communities. On larger properties, several grazing systems may be more appropriate than a single one.
- Planning and testing, careful observation, and on-going adjustments in response to weather cycles and rangeland and livestock health are necessary for managing grazing systems effectively.
- Grazing systems do not replace the judgment of an experienced range manager's ability to evaluate and respond to the effects of drought, localized overgrazing, snow, slow plant growth, poisonous plants, and special needs of livestock or wild ungulates.

- Some planned grazing systems can be used to manage specific livestock health issues better than can other systems.
- Experienced, knowledgeable managers can be more flexible by reacting appropriately to difficult circumstances to benefit natural grasslands, livestock, and other resource interests during each grazing season.
- Where there are substantial differences in elevation, topography, and range community types in one ranch property or grazing disposition, the grazing system selected will need to be modified to fit the topography and rangeland community distribution. More than one grazing system may be needed on specific kinds of landscapes.
- An application of one or more grazing systems to sensitive riparian areas and associated upland grasslands challenges managers and may require much planning, testing, and adjustment to reach the goals desired.
- There is no "best" grazing system. Each ranch, farm, park, or other conservation area is unique. It will require planning and testing to determine which grazing system is effective in meeting the land manager's goals.
- In the final analysis, a grazing management system is only one of many tools a range manager uses to manage natural grasslands on an ecologically sustainable basis. The management of the rangeland and the stocking rate are the most important factors for sustainability. An excellent summary and view point on grazing methods for semi-arid rangelands can be found in the Society for Range Management's October 2009 edition of Rangelands.

What Forage Type is Best?

This bulletin emphasizes the management and value of Canadian prairie natural (native) grasslands. These grasslands are ecologically diverse following 50 million years of adaptation to a changing prairie climate and different grazing and fire regimes. Today these grasslands only occupy about 18%, or 11.4 M ha, of the 61 M ha of Canadian prairies. About 50 M ha of original natural grassland are now in annual crop agriculture, perennial tame forages, cities, towns, acreages, highways, and other industrial uses. Each ranch or park manager usually has various forage types on their management units.

There is no ideal forage available to range managers. There are, however, a series of options to be selected, based on the species choices and funding available. Natural grasslands are one option; forested rangeland, perennial tame forages, annual forages, irrigated forages, and swath or stubble grazing are also common options available on farms and ranches. The choices available vary with the ecoregions and land use practices. More natural grasslands are present in Dry Mixed Grass prairie than in other prairie ecoregions. More forested rangeland grazing opportunities are available in higher rainfall regions including the Foothills Fescue, Parkland Northern Fescue and Tall Grass prairie ecoregions.

Natural grasslands on upland areas are best adapted to grazing in late summer, fall, and winter since they tend to be less resistant to heavy grazing in spring soon after plant growth starts. Good range managers, however, have always been able to successfully graze upland natural grasslands and keep them in good ecological health in all prairie ecoregions at any time of the year by using good management practices. Lightly grazing these ranges during spring and early summer, and then rotating that paddock to graze at a different season the next year or later, is an important part of an effectively executed grazing system. Such a livestock grazing system will maintain higher biodiversity and more cover. This helps to prepare for recurring drought and benefits upland spring nesting waterfowl, burrowing owls, wild ungulates, and rare or endangered species.

Riparian areas vary considerably in plant composition with some being composed of wet grasslands, including grass and sedge species; others have willows and other shrubs, while still others are in deeper water and have cattails and related plants. The range management must be tailored to the vegetation and the grazing or browsing animals. Managers should refer to publications such as Fitch, Adams, and O'Shaughnessy (2003) for more specific advice regarding how riparian areas can fit into ranch and park forage management plans.

Park managers have fewer options available to them for choices of forage and browse than do ranchers. They usually have at least natural upland grasslands, riparian wetlands, and forested rangelands as a source of grazing, browsing, and habitat for wildlife.

The success of range management is often related to the willingness of the ranch or park manager to maintain rangelands within the carrying capacity of the landscape unit. Too many animals grazing too small a range unit will result in overgrazing. Overgrazing does not only occur on ranches grazed by livestock, it is also apparent in most parks where there are either too many elk, bighorn sheep, bison, Rocky Mountain goats, or rodents. Prolonged overgrazing creates a human induced drought whenever the available moisture falling on the soil runs off because there is too little vegetative cover to absorb it.

Drought is a natural part of the Canadian prairie climate and long droughts have occurred approximately twice per century over the past 400 years (Sauchyn 2007). It has been about 70 years since the last major drought, and so another major drought could come at any time. When the next one occurs, forage availability will decline and as it declines, alternate forages need to be found or the numbers of grazing animals using the range must be reduced.

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Chapter 6: Managing Prairie Natural Grasslands under Special Conditions

Highlights

- Drought is a constant concern to the manager of prairie natural grasslands. It is not known when the next decade long drought will begin, but research indicates that it will occur.
- Since natural grasslands have evolved with drought, healthy well managed ecosystems are best able to cope with shortages of soil water. Overgrazed rangelands provide much less forage and cover because of smaller, shorter plant roots and reduced infiltration of water into the hotter and compacted soils.
- The Canadian military has four large training bases in the prairies and special rangeland management is required for these grasslands.
- Various conservation areas, including provincial, federal, and private parks, require special rangeland management to maintain healthy prairie natural ecosystems, associated wildlife, and landscapes.
- Unique management considerations need to be implemented to limit the spread of invasive alien plant species and encroaching woody species into natural grasslands. Specific prescription grazing techniques are effective on reducing encroaching aspen, shrubs, and perennial weeds into natural grassland or tame perennial pasture.
- The reclamation of natural grasslands following oil and gas exploration, pipelines, highways, industrial activities, and various construction projects requires the implementation of specialized procedures to ensure maintenance of high ecological health of remnant prairie natural grasslands. Invasive weeds and aggressive, tame perennial forage species often challenge the restoration of natural grasslands following industrial disturbances.

Introduction

The unique requirements for managing natural grasslands under special situations are addressed in this chapter. Each situation discussed highlights special challenges to the land manager because of unique circumstances or requirements.

This bulletin emphasizes the management of natural grasslands on the Canadian prairies. The first three sections address issues pertaining to the management of natural grasslands and other forage resources during drought. Since natural grasslands are interspersed with other land uses, the management of natural grasslands needs to be integrated with the management of three other common forage sources on the prairie landscape: forested rangelands, perennial tame pasture, and annual crops for pasture. The management of rangelands on military training bases, parks, and during reclamation are also discussed in this chapter.

Managing Rangeland during Drought Cycles

The Canadian prairies are located in the middle of the continent and drought is a normal part of the climate. In Chapter 2, the frequency of droughts and their duration are presented in Table 3. Natural grasslands on the prairies are ancient ecosystems that evolved with drought, grazing, and fire. During a drought, drinking water, soil moisture, forage production, cover, and root mass decline while bare ground and soil temperatures rise. Every range manager needs a plan to be able to respond to recurrent drought.

In prehistory, as drought developed on the Great Plains, many bison and other grazing animals would have migrated elsewhere seeking forage and water; otherwise they perished. Today, all the rangeland is taken. All the ranches and farms are occupied and they need annual cash flow whether there is drought or not. Therefore, if the drought is too severe and water or forage are in short supply, the animals must be either moved to distant areas, the forage and water brought to them, or they are sold.

Drought can be managed most effectively by having plans in place to deal with a shortage of both drinking water and forage before it occurs. Ranchers and range wildlife managers will need a plan to utilize all their options when the next major drought occurs. Water and forage are the most precious commodities and their conservation and availability needs to be planned in advance, as preparation for the next drought.

The Dry Mixed Grass and adjacent Mixed Grass prairie ecoregions in the southern prairies receive the least precipitation. Fewer droughts occur in the Parkland Northern Fescue, Foothills Fescue and Tall Grass prairie ecoregions. The ranchers of the driest ecoregions have more experience managing rangeland and livestock during drought than do ranchers and park managers in moister climates like the parklands. Ranchers in the driest areas usually have to manage rangeland more conservatively so there is more carryover of lightly or ungrazed forage. This is often not the management approach in the moister ecoregions, such as the Parkland Northern Fescue ecoregion.

In much of the Parkland Northern Fescue ecoregion, heavy grazing is commonly practiced by ranchers and park managers alike. Grazing use rates of 60% to 80% are common. This leaves many ranches vulnerable to a sudden drought because the intense grazing pressure over a long period of time has reduced root mass and depth of rooting (Johnston 1961, see Chapter 5). Heavy grazing also reduces soil water infiltration to about one-half of normal, and the soils become compacted (Naeth *et al*. 1990a, 1990b), causing scarce rain during drought to run off rather than soak into the soil. Lightly grazed sites had about twice the infiltration rates of heavy, or very heavy,

Table 8. Nutritional quality factors of shrubs grown over a period of years at the Semiarid Prairie Agricultural Research Centre, Swift Current, Saskatchewan. The numbers are averages for material collected in August to September, normally the driest and hottest period.

Species	Organic matter digested	Acid detergent fibre	Neutral detergent fibre	Crude protein	Calcium	Total plant phosphorous
	----------------------------------- % -----------------------------------					
Winterfat	64.0	34.0	54.0	12.2	14.4	1.9
Leadplant	50.1	30.2	43.6	16.2	13.0	2.4
Antelope bitterbrush	49.9	24.2	32.3	10.0	----	1.6
Gardner's saltbush	62.4	26.8	42.6	13.9	13.9	1.6

grazed fields. Thus, long-term heavy and very heavy grazing created a human induced drought situation due to reduced soil moisture infiltration and increased run-off and soil compaction. The situation becomes even more dire during a long drought. In addition, heavy grazing reduces litter and increases soil temperatures (Facelli and Pickett, 1991) and it also increases the evaporation rate of the water from the soil surface (Irving *et al*. 1994). Thus, the lack of litter, caused by repeated overgrazing, contributes to 1) reduced soil water infiltration (drier soils), 2) increased soil surface temperatures (warmer soils), 3) increased evaporation from the soil surface (less soil water), 4) reduced forage production due to heavy defoliation and decreased soil water, and 5) heavy grazing then magnifies the negative effects on forage and rangeland production and health during a prolonged drought.

The Parkland Northern Fescue ecoregion of Alberta and Saskatchewan experienced a short, moderately severe drought from 1999 to 2002. The grazing management practices in that ecoregion generally emphasize higher stocking rates and about 60-80% grazing use of tame perennial grasses as compared to lower stocking rates and 40-50% grazing use in the Dry Mixed Grass prairie further to the south. Thus, for much of the parkland region, the normal grazing practices already had created a human induced drought (Naeth *et al*. 1990a, 1990b, Irving *et al*. 1994) during normal rainfall years. The sudden appearance of a four-year drought caused many problems for these land managers. Tame grasses, such as smooth bromegrass, usually have a higher leaf to root ratio (Dormaar *et al*. 1995). Thus, they tend to produce less forage during drought. Soon many ranchers found themselves without forage, and many times, without drinking water. Under this short, moderately severe drought, plants that had been overgrazed for years produced little forage from the small root masses (Johnston 1961, in Chapter 5, Figure 1). With minimal growing season precipitation, forage production crashed to low levels. Ranchers used up hay reserves and were forced to sell livestock when prices were already low. Some gladly purchased shipments of hay from eastern Canadian farmers, enabling them to preserve a part of their breeding herd.

The drought of the 1930's lasted for twelve years rather than the four year 1999-2002 drought. What will happen next time when a 10-20 year drought arrives in the Parkland Northern Fescue or Tall Grass prairie ecoregions? Will there be plans in place and will the pastures be in good ecological health? Will there be more reliable water sources developed than during the 1999-2002 drought?

Use of a combination of grasses, shrubs, and forbs (such as those found in naturally occurring native rangeland) is suggested as a means of providing high quality forage sources through periods of declining forage availability. Drought would be one such circumstance. The advantage of multiple species forage plantings, or in the form of natural grasslands, is an adaptation to extreme environmental conditions such as drought. Alberta Research Council (www.arc.ca), University of Manitoba, Agriculture and Agri-Food Canada, and Ducks Unlimited Canada have developed programs to propagate native grass seed, including plains rough fescue and green needle grass, for future use in re-establishing native grasslands (Coulman *et al*. 2008).

Shrubs have the potential to provide high protein forage (Table 8) during periods when grasses and forbs are low, they have been found to provide a more consistent year round source of nutrients (Rowe and Corbett 1999; Welsh 1989). Under drought conditions, the shrubs' advantages exist in their ability to extract water and minerals at soil depth.

In the Parkland Northern Fescue ecoregion, aspen, balsam poplar, willows, western snowberry, silverberry, saskatoon, choke cherry and pin cherry, wild raspberry, and wild gooseberry are all available for browsing by livestock and wild ungulates (FitzGerald *et al*. 1986, FitzGerald and Bailey 1984). Only balsam poplar, western snowberry, silverberry, and some willow species are not preferred browse for livestock or wildlife during the growing season. During a drought, hungry cattle are known to eat much more western snowberry than when other forages are abundant. It is recommended that the parkland range manager take full advantage of forested rangelands for grazing and browsing during drought.

Most of the area in the Parkland Northern Fescue ecoregion is under annual crop farming and perennial tame pasture, but there are a few fields of natural rough fescue grasslands and considerable aspen forest. The farmers in this ecoregion have traditionally favored introduced grasses over native grasses. The introduced grasses produce less forage during drought because of their reduced root mass (Dormaar *et al.* 1995) and a typical grazing use of 70 to 80% during long periods of stay per field. These practices leave the grasses with fewer energy reserves available for survival during drought. These are not the grazing practices recommended in Chapter 5.

On the southern Canadian prairies, a number of shrub species have both good forage potential and high nutrient quality. They include leadplant (*Amorpha canescens*), winterfat (*Krascheninnikovia lanata*), Gardner or Nutall's saltbush (*Atriplex gardnerii*), and antelope bitterbrush (*Purshia tridentata*). Leadplant, winterfat, and antelope bitterbrush are all highly palatable. Winterfat has been suggested as a forage plant needing development since 1890. Winterfat is noted from work at the Semiarid Prairie Agricultural Research Centre of AAFC as having a crude protein value average of 12% in August under semiarid drought conditions and a digestibility of 64% (Table 8).

Managing Natural Grasslands in Drought Cycles

Natural grasslands have evolved with drought over thousands of years. However, it has been only after European settlers arrived that so many grazing animals were resident in drought-prone areas at all times of the year. Drought frequently arrives when the range manager is not prepared.

Management practices have been presented in Chapter 5 that promote good to excellent ecological health in advance of drought. There are four major range management principles that apply to rangeland management during drought (see Chapter 5):

- Balance livestock demand with the available forage supply
- Distribute livestock grazing pressure evenly
- Defer grazing during sensitive or vulnerable periods
- Allow effective rest periods after grazing.

In a drought, both livestock and wildlife require water, forage, habitat, and security. Under prehistoric conditions, the arrival of a drought would have reduced drinking water availability, thus restricting bison and other wildlife to grazing near larger streams, lakes, and rivers. When the forage was grazed off, the herds would have migrated elsewhere. The herds in the Dry Mixed Grass and Mixed Grass prairie would have migrated into Foothills Fescue grasslands, Parklands Northern Fescue and Tall Grass prairies where there was normally more water and forage. When drought occurred there also, the herds would have migrated into forests to graze and eventually, many animals would have starved to death. Today, ranchers will use every effort to keep their livestock on the "home place" trying to find water and forage before selling surplus livestock at low market prices.

The principles of range management outlined in Chapter 5 still apply during drought. If possible, defer grazing natural grasslands in spring; use them instead from late summer through winter. Where both native and tame forages are available, a complementary grazing system can be effective in maintaining the use of natural grasslands later in the grazing season. This grazing system is effective for managing the soft grasses such as tame pastures in spring, then forested or brush-covered rangeland in spring and summer when they are most nutritious and at the highest level of forage productivity. There are also drought guidelines outlined in Chapter 5. Longer rest periods are required during drought because plant growth is slower due to low soil moisture conditions. Riparian areas grow mostly soft grasses that are adapted to mid-to-late summer grazing patterns.

During drought, stocking rate, season of grazing, and animal distribution are even more critical management factors than during better rainfall conditions. Rangeland plant survival and growth is absolutely required. Maintaining plant cover is needed to minimize erosion.

During drought, it is still practical to:

- Protect cool season natural grasslands during the vulnerable spring period of growth.
- It makes sense to graze soft grasses in spring and summer when they are palatable and nutritious. If left ungrazed, about 60% of the soft grass foliage has disappeared by early fall.
- The hard grasses on upland natural grasslands remain palatable in summer, fall, and winter. They make good late summer and fall-winter grazing.
- A moderate stocking rate, lighter grazing use, and a grazing system that allows for periodic deferral of grazing during the vulnerable spring growing period enable native range plants to grow foliage for grazing and reproduce shoots and roots during drought.

Grazing too much creates the following problems on rangeland during drought:

- Overgrazing removes too much leaf matter, reduces root growth, and therefore reduces plant survival.
- After a period of grazing, residual foliage leaf area is critical for several reasons. First, in the growing season, the residual leaf area feeds the range plant tops so they can regrow and produce more tillers, while recovering from grazing. Second,

Table 9. Planning checklist for maintaining range in good health during drought (modified from Adams 2000).

1. Assess all options before drought occurs.
2. Maintain a one to two year supply of winter feed for all essential livestock.
3. Moderately graze all pastures and maintain high ecological health.
4. Use a grazing system that incorporates adequate plant rest in each pasture.
5. Maintain plant litter cover that is capable of protecting the soil and potentially acting as emergency feed.
6. Reduce stocking rates early by weaning calves earlier and culling older cows.
7. Keep the best, healthy, fertile, productive, younger and middle aged cows.
8. Find or rent alternate pastures and buy more feed if available and economical.
9. Sell or place in feedlots all non-essential animals.
10. If the drought continues, graze cereals and hay lands.
11. If the drought intensifies, attempt to maintain the basic herd and sell the rest.
12. After drought, be sure to increase stocking rate slowly while the rangeland recovers.

the residual leaf area feeds energy into plant roots enabling them to remain deep underground, collecting both soil moisture and mineral nutrients. Third, the residual leafage fuels both top and root growth and maintenance, preventing death of the forage plants.

- Residual leaf area is required even in winter because foliage protects the soil surface from erosion, traps snow, and stores energy in stem bases needed for spring regrowth.
- Too intense grazing reduces root mass and depth of rooting, reduces soil water infiltration, and magnifies the effect of drought, eventually killing many forage plants.
- Remaining leaf tissue will eventually become litter. Litter contributes to range health during drought by covering the soil, keeping it cooler, improving water infiltration, and preventing erosion.
- In Figure 3 of Chapter 5, the authors reviewed how severe clipping reduces root growth. When severely clipped (or grazed), there was not enough leaf area left to feed the many deep roots, so the deep roots died (Johnson 1961). Only a few short roots survived and grew. During a drought, it is critical for grasses and shrubs to have many long roots in order to access water at deeper soil depths. On Foothills Fescue grassland, Johnson found that lighter grazed plants had more roots at each depth increment to a depth of 54 inches (137cm) than did heavier grazed plants.

Grazing too often during drought is an unacceptable management practice:

- Grazing continuously all growing season is not recommended for Canadian prairie natural grasslands, even at a moderate level of grazing use. The long-term plant and soil health will decline. Such grazing management during drought will kill plants faster.
- Frequent grazing, or grazing for long periods, in spring-summer on native rangeland does not provide effective rest periods. This practice will kill the most productive natural forage plants.
- After grazing, natural rangeland grasses require a period of non grazing during the growing season. This is called a period of rest from grazing.
- For rest to be effective, the range plants must be able to regrow leaves, roots, seedheads, and restore energy reserves. The rest period needs to be longer during drought.

Range livestock distribution is always a challenge to the manager. The secondary range and non-use ranges may have more forage present during drought because they are normally unused or lightly used. The most common cause of restricted livestock distribution is lack of water. Cattle prefer to graze only a short distance from water.

Drought challenges range managers to develop practical solutions to permit access to forage that is normally not being grazed. Remote, unused natural grasslands can be grazed if water is provided by a new well, pipeline, or truck and by redesigning grazing systems to more efficiently utilize what forage is available. For example, the Rutledge Ranch near Consort, Alberta, faced such a problem during drought in the 1990's, and they came up with an innovative solution (Irving *et al.* 1995). After a search, they drilled a deep well in excellent health plains rough fescue grassland that was previously too far away from water. Then a short duration (HILF) rotation grazing system composed of electric fencing and narrow 3 km long fields was designed and constructed. A large herd of cattle was given access to one day's worth of forage each day using electric fencing and cross-fencing. The herd grazed the field in sequence until the most distant area 3 km away from drinking water was grazed (Irving *et al.* 1995). During the period of stockwater scarcity, this modified grazing system enabled adequate animal gains and access to forage far from water. It also contributed to the rancher being able to retain the cattle until the drought ceased.

Integrating Use of Prairie Forage Resources during Drought

This section is devoted to considering some alternatives available to rangeland managers during prairie droughts.

Natural grasslands are not the only source of forage for livestock and wildlife on prairie rangelands. Most prairie settlers were eager to plant introduced annual crops, hay, and tame pasture while underrating the merits of grazing natural grasslands and forested rangelands. Today, many ranchers still prefer tame pasture, annual crops, and irrigated forage rather than natural grasslands and forested rangelands. During a drought, it is imperative to not overlook the use of any forage resource.

The production of all forage types will be lower during drought. Normally, tame forage yields decline more rapidly than do native grasslands. Tame pastures are often less resistant to drought because they are usually more heavily grazed than natural grasslands. Their roots become shorter under heavy grazing. Thus, they produce less forage because most introduced grasses root more shallowly than drought-adapted natural grasses (Domaar *et al.* 1995). Also, continual heavy grazing causes a decrease in forage production due to the removal of plant litter, a decease in soil water due to less infiltration, more compaction, more evaporation, increased soil temperature, a decrease in foliage production from the major forage species, and a decrease in plant roots (Johnston 1961, Naeth *et al.* 1990a, 1990b, Facelli and Pickett 1991, Irving *et al.* 1994, Willms and Jefferson 1993).

Nevertheless, perennial tame pastures are the logical first fields to be grazed in spring, preferably using a complementary grazing system that defers the use of natural grasslands until later in the grazing year. These pastures need to be grazed using a type of rotation grazing where the first field grazed in the spring in year 1 is not grazed first in year 2 (see Chapter 5, Tables 6 and 7). If there is forested rangeland available, then it can be grazed from late spring through summer. Lastly, the natural grasslands can be safely grazed from late-summer, fall and winter where available.

When the rancher realizes a drought has begun, various choices need to be made as indicated in Table 9. The order of priority will vary from ranch to ranch. Some other choices during difficult times include:

1. Sell part of the herd to reduce demand for grazing and winter hay supply.
2. Use forested rangelands more because there may be more soil moisture for understory growth than in grasslands, and hungry animals will eat more woody leaves and stems when other forage resources are in short supply. Even less palatable shrubs like western snowberry (buckbrush) may be eaten during forage shortages.
3. If there are mid-summer rains, seed annuals, such as barley or oats, for summer grazing or fall-winter swath grazing.
4. Move the herd to another area where pasture is available.
5. Keep as much of the breeding herd as available water, forage and feed permits.

By maintaining high biological diversity in each plant community, the land manager retains forage that has the ability to respond to short precipitation events and long periods without precipitation. A diversity of species and plant communities means that there are plants that have shallow roots with rapid response times, as well as deeper rooted species with access to moisture reserves deep in the soil. Biodiversity enhances the reliability, efficiency and sustainability of livestock fodder (Tilman *et al.* 2006). Studies have shown a long-term resistance to drought in a diverse grassland (Grime *et al.* 2008). Biological diversity in types of plant species, heights of plants, rooting depths, and growth forms (i.e., grasses, forbs, half shrubs, and shrubs) adds stability to a rangeland community (Frank and McNaughton 1991).

To retain native prairie in good health will require decreasing grazing pressure in years of drought to allow for future recovery. One alternate source of grazing is the use of annual crops. Annuals have great potential for providing excellent spring pasture, or for extending the grazing season, during a drought. Oats or barley, spring seeded fall rye, winter triticale, winter wheat, or Italian rye grass can be seeded early in the spring and used for rotation grazing throughout the summer and fall. When soil moisture is available in August or early September, seeding fall rye will ensure that forage will be available the following spring. It must be grazed early and heavily, however, or it will quickly produce seed and not grow leaves.

In periods of drought, crop management is of utmost importance. Before seeding annuals for grazing, there must be sufficient moisture available. Seed early and spray early. Increase production by using direct seeding equipment that conserves moisture. By controlling weeds before they reach the size of a “loonie”, forage yields will increase and less herbicide is required. Annuals should be fertilized and managed using a suitable rotation grazing system. They are to be grazed to a height of no less than 4 inches (10 cm); this practice will promote much regrowth. After grazing, each paddock will need a 30-40 day rest period between grazing rotations.

The addition of suitable fertilizer enables annual crops or tame pastures to use the available moisture more effectively. Research in northeastern Saskatchewan showed that during drought perennial tame pastures fertilized the previous fall provided extra late summer and early fall grazing. Those pastures not fertilized only grew enough grass for one grazing rotation instead of two or three. By fertilizing tame pastures, plants are able to take up more water by extracting it from greater soil depths due to their longer, deeper roots. When there are three or four consecutive very dry years, then fertilizer won't be of benefit because plants still need moisture to grow.

In the Mixed Grass prairie ecosystem, nitrogen is not lost or leached out as fast as it is in more humid ecosystems. Adding fertilizer to western wheatgrass keeps it green and metabolizing during a drought. Western wheatgrass becomes drought tolerant, whereas crested wheatgrass growth ceases and the leaves turn brown as a means of escaping drought. However, grazing management is still the key. If animals continually graze everything off year after year, it will take many years for the range to recover.

Normally, 80 to 90% of the rainfall on the Canadian Prairies is received by July 1 to July 15, producing the majority of the year's forage growth. Ranchers need to make decisions about keeping livestock when forage is available or selling them early if the rains have failed. Waiting for rain through July and August will usually not produce a lot of additional forage growth. If the May-June rains have failed, July is the time to decide to ship the herd to a different region where good rains have produced more forage. The alternative is weaning calves early and selling both calves and part of the cow herd well ahead of the normal time of livestock sales in the fall.

Russian wildrye and Altai wildrye, noted for their deep roots, are drought tolerant introduced grasses. At the Saskatoon Research Centre, researchers found a big difference in these grasses by mid-summer. In the drought years, they were still green and growing whereas all the other tame grasses had turned brown. In the Aspen Parkland ecoregion on Black soils, Russian wildrye provided excellent early spring and late fall pastures and allowed an extension of the grazing season. However, on Gray luvisol soils, Kentucky blue grass out competed the Russian wildrye after two to three years.

Crested wheatgrass can be successfully used for early spring and late fall pasture in the Aspen Parkland as well as in the drier areas of the prairie. Crested wheatgrass displays a drought-escape tendency by initiating growth early in the spring and then shutting down as soil moisture decreases. It produces seeds earlier and undergoes more rapid leaf senescence than smooth bromegrass and western wheatgrass. Crested wheatgrass stops growing during the hot dry summers and reinitiates growth in the fall if soil moisture is available. Thus, crested wheatgrass needs to be grazed in the spring, left to regrow over summer, and grazed last thing in the fall. Used with fertilizer, the crested wheatgrass at a research site in the Aspen Parkland provided grazing about 10 days to two weeks earlier in the spring and later in the fall, as compared to the rest of the tame pasture grass species. In the Aspen Parkland, the native plains rough fescue grew about one-half a crop in the drought of 1999-2002, while smooth bromegrass grew very little due to a lack of soil moisture and its smaller root mass.

Native range, tame pasture, and bush pastures respond well to rain. Some form of rotation grazing with a rest period is essential. Refer to Chapter 5 for a discussion of grazing systems. Fertilized perennial tame forages or annual cereal pastures can be used for early season grazing prior to grazing the bush pastures. The natural grasslands are well adapted to late summer, fall, or winter grazing at moderate stocking rates. Additional information regarding the use of annual cereal pastures and the application of fertilizer to perennial tame forages can be found at www.foragebeef.ca.

Grazing of oats, barley, or triticale is another option when forage is in short supply during drought, provided there is enough soil moisture for the annuals to grow. These annual forages can be used during mid to late summer when perennial forages are not available or during winter or early spring as an alternative to feeding hay or silage. If the annuals are to be used for winter grazing, seed them in late May or early June and swath them at the soft dough stage prior to frost, about mid-September. At AAFC's Melfort Research Farm and Lacombe Research Centre, studies were conducted successfully enabling cows to swath graze oats, barley, or spring seeded triticale during the winter in snow as deep as 2 feet (0.6m). After calving in March in a calving facility, the cows plus calves swath grazed the entire month of May on swathed material that had been saved for early spring grazing. The nursing cows were supplemented with extra grain. On the first week in June, the herd started to graze perennial tame pastures. By that time, these perennial pastures had a chance to grow beyond the three-leaf stage. There was lots of forage available for spring grazing. In contrast, farmers who had turned their cattle out in late April and continuously grazed their pastures had minimal forage available for grazing the rest of the summer and fall. Bale grazing on seeded pastures, stubble grazing, or grazing chaff piles on grain fields are other cheap options.

There are other things cattle producers can do to reduce the impact of drought. Leave as many options open as possible. Be flexible. Make the important drought management decisions early in the year. Match herd size to the amount of grazing during a drought year, not just in a productive grass year. Reduce the herd by selling it before everyone else. Purchase alternate feed supplies early in the drought year rather than wait until the feed supply has run out and prices have risen. In years of excess forage, store hay under cover or make silage and keep them as long-term emergency feed sources.

Early weaning is another method of reducing the effects of drought. Research has shown that cows with calves early weaned in late August weighed more at the start of winter than cows with calves weaned in late October. The early weaned cows could then be wintered on less feed due to their increased body condition. Early weaning is especially important in a drought year when there is limited fall pasture and good dry feed. Dry cows could then graze the limited forages available. Weaned calves could be sold, moved to the feedlot, or grazed on annual cereal pasture regrowth or other forage options.

Availability of drinking water for livestock can be a major limitation on pastures during drought. Dugouts surrounded by brush and trees capture more runoff water in the spring than those with no snow trapping capabilities. Strategically placed snow fences around dugouts have proved effective. Fence off the water supply to keep the integrity and capacity of the dugout or water body. Solar powered water pumps and other systems can pump water into troughs rather than allowing cattle to trample and drink directly from the dugout, pond, slough, or stream. Research has shown that cows and calves will gain more weight by drinking water that has been pumped into a trough, as opposed to drinking directly from the dugout. Cattle usually willingly choose troughs with clean water when given a choice.

Drought is a fact of life in a prairie climate. Thus, every range manager must prepare a personal drought management program for their property and have it ready to implement when drought occurs. This should include the storage of hay and other feeds in long term dry storage facilities for emergency use during the next drought. The question is not if there will be a drought, it is when, how long it will last, and how severe will the drought be. The 1999 to 2002 drought in central Alberta and Saskatchewan was a warning to range managers to be better prepared for the next long drought. It will happen again.

Water is still the world's most precious resource. We need it every day.

Rangeland Management of Prairie Grasslands on Military Training Bases

Summary

- Canadian Forces Bases on prairie rangelands were established for the training of military personnel. Their existence also provides opportunities for some other rangeland uses.
- Each of the four bases (Suffield, Wainwright, Shilo, and Dundurn) provides some level of protection for natural grasslands and associated ecosystems, including wildlife, rare and endangered species, and unique dune complexes.
- Wildlife co-exists with military operations and limited hunting is permitted in some areas. CFB Suffield supports a large National Wildlife Refuge.
- Livestock grazing is allowed in some portions of military bases, but field sizes are generally kept large so as to facilitate large training exercises. Low stocking rates and later dates of cattle entry are used because of the absence of internal fencing and this helps to promote better ecological range health.
- The presence of livestock and wild ungulates during some training exercises adds another level of reality for troops.
- Visitors are usually not allowed for reasons of national security and safety.

The Canadian military maintains three large military training bases on prairie rangeland in Alberta and Manitoba and one smaller base on prairie rangelands in Saskatchewan (www.dnd.ca, www.army.gc.ca). In Alberta, CFB Suffield is a large base of 2,690 km^2 and CFB Wainwright is 609 km^2; CFB Shilo in Manitoba occupies about 450 km^2 and CFAD Dundurn is a 120 km^2 base near Saskatoon. All four military training areas provide the natural rangeland ecosystems a level of protection from cultivation not found under private ownership. These military bases include some of the largest tracts of relatively intact natural prairie rangeland on the Canadian prairies. CFB Suffield is the largest and most ecologically intact natural grassland found anywhere in the Dry Mixed Grass prairie ecoregion. CFB Wainwright is composed of mostly aspen groves interspersed with plains rough fescue grasslands and some riparian areas within the Parkland Northern Fescue prairie ecoregion. CFB Shilo is a combination of Parkland Northern Fescue and Mixed Grass prairie ecoregions. CFAD Dundurn is in the Parkland Northern Fescue ecoregion with a predominance of dune sand ridges. Its primary purpose is to serve as an international ammunition storage facility, as well as being a military training facility. The four military training areas all have predominantly sandy or sandy loam soils. Military training includes the use of ground troops, heavy armoured vehicles, and air support.

The large area of CFB Suffield also supports a 458 km^2 National Wildlife Area where military training exercises are not conducted. This National Wildlife Area has about 1,100 species including 462 plant species, 244 vertebrate species, and 436 invertebrate species. Of these, there are 14 listed species at risk and 78 species of plants and animals listed in the Status of Alberta Wildlife 2000 as "at risk" or otherwise "sensitive" (www.army.forces.gc.ca/CFB Suffield). Elk from Elk Island National Park have been released in the National Wildlife Area. Although it has status as a National Wildlife Area, oil and gas extraction continues to be permitted under special rules.

The mandate of each military base is to provide specific training facilities for military personnel and equipment. Military training creates specific kinds of land use disturbance on rangeland. Live fire exercises from pistols to artillery, grenades, tank, and fighter bombers create a high risk of wildfire when dry fine fuels are abundant. At Camp Wainwright, the risk of summer wildfires during training exercises is reduced by conducting prescribed burning in spring (Anderson and Bailey 1980, Loonen 2008) and by livestock grazing. Both the low intensity spring prescribed burns and cattle grazing reduce the fuel load, and thus the risk of high intensity wildfires from military activities.

Tanks and other heavy military vehicles impact grassland vegetation and soils. At CFB Shilo, Wilson (1988) found that military tank traffic was more detrimental in spring than in summer on Mixed Grass prairie vegetation. The more frequent the tank traffic, the more damage occurred to the actively growing vegetation and soils during spring. More bare ground was exposed by frequent spring tank traffic. The alien plant species, leafy spurge, invaded tank track areas driven on during May. In 1994, Thompson and Morgan (1996) assessed the experimental areas that had received tank traffic between 1986 and 1989. The leafy spurge was spreading rapidly and needed to be controlled. Low frequency tank tracks had disappeared in many areas after five to six years, but they were still present where there had been heavier tank traffic. The early growing cool season species, needle-and-thread (spear grass), was most negatively affected by spring tank traffic. The later growing warm season species, blue grama grass, was most negatively affected by summer tank traffic.

Livestock grazing is permitted on parts of CFB Suffield, CFB Wainwright, and CFAD Dundurn (Loonen 2008). In some cases, livestock grazing does occur in some areas when military exercises are proceeding. This creates specific range livestock management challenges, but the presence of livestock during exercises does add a realistic component to the training of military personnel since people and livestock are often found where live military actions are taking place.

Loonen (2008) presented an evaluation regarding rangeland management practices related to livestock grazing in Camp Wainwright. The military places some restrictions on the tools available for managing livestock grazing. The primary challenge is the policy dealing with fencing. No internal cross-fences are allowed; thus within its borders the area is grazed as open range. In order to maintain forage productivity and ecologically healthy rangeland, the primary tools used are turn in dates, placement and control of water sources, and stocking rates. No spring grazing is permitted. The turn in date for livestock ranges from July to early August, a time when about 90% of the growth of native cool season grasses has been completed. The target roundup date is October 31. At that time, cattle are rounded up and herded to a variety of corrals along the outer perimeter for transport away to private ranches and winter ranges. Without internal fences, and due to the sheer size of the area grazed, it is important that stock be distributed throughout the range and not allowed to congregate along the perimeter or on preferred ranges. This is achieved by maintaining a low stocking rate and by developing water sources, whether natural, dugouts, or wells. The recommended guideline is one water source per square mile. One practice that has helped distribute grazing use more uniformly has been to truck cattle to a water site inside the base and release them there, rather than turning them in at the perimeter. Another practice is to open and close watering sites, thus training cattle to move to another grazing area that has drinking water available.

The forage productivity of much of the Camp Wainwright area is low due to the sandy soil. Topography varies among undulating plains, choppy sandhills, knob and kettle glacial moraine, and riparian areas. Stocking rates are kept low to minimize interference with military training. A question frequently asked is "How do the cattle deal with the military training?" They become habituated to the traffic, the activity, and the noise. If artillery or troop activity bothers the herds, they drift out of the area for the time being. There have been occasional incidents of livestock injury. Nevertheless, average losses of livestock in Camp Wainwright are within the normal range of expected losses found on other crown land grazing permits.

Range burning is an annual occurrence on Camp Wainwright (Anderson and Bailey 1980). It is also a frequent occurrence at Suffield and Dundurn. Burning occurs for two reasons. Prescribed burning is done in the spring (late April to early May) to intentionally reduce the fuel load of an area or to reduce the wooded cover within an area. The use of low intensity, spring prescribed burns is effective in reducing the risk of wildfires during training exercises. The wildfires commonly occur from June to August as a result of military training activity. For example, fires can be started by flares, artillery, bombing exercises, and occasionally, unexploded shells or bombs. Dry, hot conditions increase the extent and intensity of wildfires. Numerous fireguards and trails divide the base into smaller units and are used to limit the spread of wildfire when it occurs.

Within the base, there are areas burned in spring. These include the various firing ranges. The dominant grassland species under frequent burning regimes consist of needle-and-thread, June grass, upland sedges, and sand reedgrass. A few single trees and some shrub patches also resist the frequent, low intensity spring fires. There is usually low litter cover and more bare soil on these areas than in unburned grasslands. The other extreme also exists where areas have never or have rarely been burned. These are locations outside the firing ranges. Often they are near the periphery of the base or are isolated from fire because of some landscape feature. Vegetation in the unburned areas is mostly parkland forest composed of aspen poplar and understory shrubs.

At Camp Wainwright, burning regimes vary from once per year to once every 15 years or so, depending upon topography, plant communities, and the military training exercises planned for each part of the base. Due to the variety of situations present and a regular threat of fire, the intensity of burns is also highly variable. Areas that have a regular history of spring prescribed burning will have relatively low intensity, grass fires skimming across the top and not burning to the mineral layer. This is in contrast to a very intense wildfire that occurred in July 2002 during a drought period. An aspen forest that had not burned for at least 40 years burned in a wildfire under high fire intensity. Two years later there was still exposed mineral soil under the burned-out aspen forest.

The result of this wide variety of influences on the landscape is a diverse parkland dominated by natural vegetation. There are also some tame forage species and several alien perennial weeds. The large block of natural landscape at CFB Wainwright provides habitat for a thriving wildlife population, including whitetail and mule deer, moose, elk, fox, and coyotes. There have also been sightings of antelope, wolf, and bear. Birds include sharp-tail grouse, crows, magpies and ravens, red-tail hawks, downy woodpeckers, and a whole suite of songbirds. Other frequently seen species are beaver, porcupine, red squirrels, and Richardson's ground squirrel.

In addition to military exercises, livestock grazing, and wildlife, recreational hunting has been allowed for over four decades at CFB Wainwright. The oil and gas industry has been active and about 200 active gas wells and associated pipelines extract energy from the area. Periodic surveys are conducted to ensure the ecological sustainability of the rangeland grazing resources for large ungulates and also for breeding birds, small mammals, species at risk, sharp-tail leks, waterfowl, fish, and amphibians.

Rangeland Management for Natural Grasslands in Parks and other Wildland Conservation Areas

Summary

- Conservation areas are defined as entities whose purpose is to maintain the area in a wild, natural state. The area is usually representative of a much larger part of the region that is being managed by people for commercial purposes.
- Management of the grazing/browsing resources is a challenge since there are rarely internal structures to aid in the distribution of wild grazing animals.
- Low stocking densities are required to maintain the ecological health of these ecosystems, but that is in direct conflict with the wishes of the public to observe spectacular wildlife on a frequent basis.

Conservation areas are selected and placed in special legal status to insure the maintenance of the natural state of the ecosystems under protection. As Hummel (1995) argued "… We have a once-only opportunity to ensure that significant parts of our country remain in a wild, natural state, changing only at the hands of nature, and serving as benchmarks for measuring the changes we are making to so much of the rest of our lands and waters." Two hundred years ago, there were about 61 M ha of natural grasslands on the Canadian prairies. Now there are only about 11.4 M ha remaining. Most of the 50 M ha of chernozem and solonetz soils that once supported natural grasslands on the Canadian prairies have been lost to crop agriculture, roads, rural acreages, and the urban-industrial complex, in addition to unmanaged conservation areas.

The preservation, conservation, and wise utilization of natural grasslands within national and provincial park boundaries should be of foremost consideration in parks and conservation areas. There are many competing objectives placed on park management. The argument of Hummel (1995) that we should have significant parts of the country "… in a wild, natural state changing only at the hand of nature, and serving as benchmarks for measuring the changes we are making …" is true in theory. In reality, there are considerable practical constraints regarding park management of natural grasslands that affect our ability to truly manage for ecological health and sustainability.

This section deals only with the rangeland management and ecological health and sustainability issues governing the management of natural grasslands in parks. Rangeland management is required within conservation areas to conserve the ecological health of the plant and animal communities and landscapes being grazed and browsed by wild animals, whether large ungulates or small rodents. Particular attention should be placed to insure that wildlife species do not congregate in large numbers in localized areas of habitat critical to the existence of rare and endangered plant or small animal life. In general, the large herbivores that are so popular with tourists in national parks are not endangered, but their presence in high numbers in localized areas may threaten certain rare species simply by their excessive trampling or heavy grazing activities.

The temperate natural grasslands of the Canadian Great Plains evolved for millions of years under environmental and ecological conditions that were always dynamic and never static (Bailey 2000b). These conditions changed a great deal over time. Climate change has always been a constant on the Great Plains. It is not a new phenomenon. Periodic cycles of drought have been followed by cycles of above average precipitation. Cycles of several years where winters were long and had deep snows have been followed by winters with reduced snow depth. There were periods of time where buildups of high populations of herbivores occurred, such as bison, until overgrazing became common almost everywhere. Then drought, long hard winters, starvation or disease, and even human predation reduced populations of grazing animals to low levels. This was usually followed by a period of low herbivore population which allowed the ecological health of the grasslands to gradually improve over time. Today, these natural cycles are not usually allowed to occur within parks. Beneficial effects of fire have been suppressed for the last century and tourists expect to see large herds and trophy animals with huge antlers.

It is essential for park administrators and managers to understand that the principles of range management (presented in Chapter 5) do apply to the management of natural grasslands within conservation areas. It is a goal of parks and other preservation areas that the environment be maintained in its "natural state". It is important that representative areas of these ancient natural grasslands remain intact and available for future generations to enjoy. It is also important to provide ecologically healthy habitat and sustenance for wildlife whether ungulate, predator, bird, mammal, reptile, amphibian, insect, or microbe. In addition, it is important for people to learn more about the science and appropriate management of these ecosystems.

Four key principles are presented below in a slightly different form than in Chapter 5. The word "livestock" has been removed and replaced by "wild ungulate":

1. Balance wild ungulate forage demand with the available forage and habitat supply

2. Distribute wild ungulate grazing pressure evenly

3. Defer grazing during sensitive or vulnerable periods

4. Allow effective rest periods after grazing.

When parks and natural reserves were established in the past, one of the goals was to maintain the wild ungulate populations within park boundaries since they no longer had available about 60 million hectares (150 million acres) across the Prairie Provinces in which to roam, graze, and reproduce. Today these herds of wild animals have expanded into the farming and grazing areas outside the parks and natural areas and are causing overgrazing of specific areas, severe damage in hay and feed storage yards, and numerous traffic accidents. The wild ungulate populations require management and, at times, restrictions to herd growth because of the limited forage and habitat resources available. It is not practical in the relatively small size of parks to allow the extreme fluctuations in large ungulate populations that occasionally happened in past centuries. If this was allowed, there would be too much damage to the ecological health of the upland and riparian natural grasslands during periods of high populations of grazing wild ungulates.

Park management needs to have a mechanism to reduce or remove surplus populations of large herbivores to prevent widespread or localized overgrazing, since they have a mandate to maintain healthy ecosystems in conservation areas. For example, in Alberta, Elk Island National Park personnel periodically round up, corral, and remove surplus bison and elk from the park. This is necessary to sustain the ecological health of grasslands and forests that provide the habitat and food supplies for these wild ungulates. There have also been prescribed burning programs in various parks to limit the expansion of forest into grasslands, thus helping to maintain areas of grassland that they depend on to provide forage and habitat year long. It is essential to maintain the wild ungulates within the carrying capacity of each park's ability to provide habitat, forage, browse, and water resources without continuous overgrazing or overbrowsing.

Critical parts of the landscape within parks and conservation areas include the riparian (wetland) zones. On the Great Plains, wetlands often represent only 2-5% of the landscape but are essential in conservation areas as a source of water for ungulates, a habitat for fish and aquatic life, and habitat for many birds and insects (Fitch *et al.* 2003, www.cowsandfish.org). Often under park management, and also on many ranches and crown grazing allotments, the riparian area is in poor ecological health. Large ungulates and predators like to congregate there, and soil erosion is common. The naturally dominant plant species are often scarce because of overuse. Within parks, it may be important to provide some protection of crucial riparian resources from constant use by large ungulates. Wildlife like bison should not be permitted to trample stream banks or edges of lakes and sloughs, stirring up mud, causing erosion, and overgrazing of herbs and shrubs. Perhaps there may be opportunities to promote good ecological health in the future by providing more off-stream water developments for large herd animals, such as bison and elk (refer to www.cowsandfish.org/riparian/caring).

The final two range management principles are related to deferring grazing in sensitive periods and allowing a period of rest after grazing. If a sustainable carrying capacity for each large wild ungulate population is identified and maintained within each conservation area, perhaps most of the primary rangelands used by these species would remain in an ecologically sustainable condition. All the foraging needs of ungulate species must be included in the range management plan. In smaller parks, such as Elk Island National Park, the herds of bison are moved from large field to large field, while the elk and moose travel over or under most fences. In the future, more consideration may be given to fencing off primary watering sources in order to restrict large wild ungulates such as bison to grazing near the available watering facility for a period. Then when the level of grazing use had been achieved, open a different watering site and close the first watering source. This is a method potentially applicable to some areas of some parks that may enable a type of deferred rotation grazing especially important during the 60 to 90 day spring growing period. More information is provided in Chapter 5 regarding grazing systems.

Many visitors come to national parks and wetland conservation areas to see "showy" wildlife, such as brightly colored waterfowl, big ungulates with spectacular antlers (elk, moose) or horns (bighorn sheep), and hope to glimpse predators (grizzly and black bears, wolves, cougars). Relatively few visitors are interested in the hundreds of species of native grasses, forbs, sedges, rushes, rodents, snakes, amphibians, insects, spiders, ants, and microbes that also share the habitats and communities with the "showy" wildlife. There is a great need to educate visitors about the dependence of the "showy" animals on plant species, plant communities, and complex ecological processes within the ecosystems in which they reside. Most parks do not have staff trained in the principles of rangeland management. After all, the traditional emphasis in many parks has been to study the biology of the big fauna (bison, caribou, elk, moose, grizzly bear, black bear, bighorn sheep, and Rocky Mountain goats). In summary, a broader based understanding of the ecosystem components in conservation areas and their proper management is needed.

Management of Invading Woody Plants into Natural Grasslands

Fire and grazing by bison and other wildlife restricted the growth and expansion of shrubs and trees within the Canadian grasslands, parklands, and boreal forest fringe until European settlers interfered with these natural ecological processes. By the 1920's, after the elimination of both fire and bison, the rough fescue grasslands of foothills and parklands were being invaded by brush, as was the Tall Grass prairie ecoregion in Manitoba.

Brush and weed encroachment is an ongoing challenge for range and park managers. Grazing, fire, mechanical, chemical, timber harvesting, and other means are used to manage the affected rangelands. Moss *et al*. (2008) and Bailey (2006, 2007, 2008) in www.forage.beef.ca have reviewed current methods of managing woody vegetation on rangelands. One of the more economical and promising methods is the use of certain prescription grazing procedures to manage brush and Canada thistle in parkland and foothills natural grasslands, as well as perennial tame pastures (Bork *et al*. 2008). Often prescribed burning followed by prescription grazing is more effective than is either treatment alone in managing woody plants or for landscape management of parks and conservation areas.

Tall shrubs and aspen can be burned, logged, dozed, mowed, or treated with herbicide (Moss *et al*. 2008) prior to being grazed. When the aspen or shrub suckers emerge, the shoots are grazed by cattle in June or July after a spring burn, or the next year after mowing, logging, dozing, or applying herbicide. Bailey (2008) described the prescription grazing system needed to effectively manage these woody suckers. They are to be heavily grazed in June to 60 to 70% use of the forage and woody suckers at high stocking rates for a short duration of a few days to two weeks per paddock until the forage has been removed; the herd is then moved to another paddock where the grazing treatment is repeated. Do not graze these paddocks a second time in the year, so that the grasses and forbs are allowed to regrow. The grazing window of opportunity is between June 1 and July 15 during most years. By August, the current growth of woody stems has become too hard for cattle to break off the stem. This is the reason that the technique cannot be used effectively in August or September. The next year the grazing can be repeated using this technique in the same paddocks. The normal grazing system used is short duration, high intensity grazing called HILF (high intensity, low frequency). Refer to Bailey (2008) for managing brush suckers using prescription grazing and to Bork *et al*. (2008) for managing Canada thistle using a similar method.

Intensive, short duration grazing using the appropriate grazing prescription can be effective for managing brush suckers, Canada thistle, and some other weeds. The key for the range manager is to understand at what time of the year the target plant species is vulnerable to heavy grazing, and then to know how many years in a row to repeat the treatment before heavy spring grazing begins to threaten the ecological health of natural grasslands. What is being advocated is the use of short duration overgrazing to accomplish a specific objective. The reader should understand that any long term overgrazing is not being recommended because the results are always the same. The health of the rangeland will deteriorate rapidly, forage production will also fall rapidly, and the soils will start to erode.

Management of Invasive Weeds in Natural Grasslands

There are many alien invasive species in prairie natural grasslands. Some introduced forage species, including smooth bromegrass, Kentucky bluegrass, timothy and crested wheatgrass, are frequently considered as unwanted weeds when growing or invading natural grasslands. These grasses do have forage value for some livestock and wildlife, but they also continue to invade natural grasslands. This is particularly the case where there is overgrazing during the spring and summer or where these species occur in the upwind direction from natural grasslands. Other alien plants were brought in for flower gardens and they too have invaded natural grasslands. They include leafy spurge, toadflax, baby's breath, and chrysanthemums. Canada thistle, sow thistle, stinkweed, and several species of knapweed arrived in western Canada as impurities in seed imported for agricultural use. There is a need for much more information about how to prevent the invasion of natural grassland by alien species, whether by introduced forage species or by alien noxious weeds.

Bork *et al*. (2008) revealed that an effective biological control method to virtually eliminate Canada thistle was short duration, high intensity, rotation grazing. Only two or three years of this grazing treatment was effective on Canada thistle since cattle ate the young shoots early in the spring as a part of their forage supply. It is not recommended that such intense heavy grazing treatments be applied every year because heavy spring grazing of the same field each year for many years will reduce the health and forage production of the desireable perennial species, the amount of forage will decline, and other weeds will invade the fields.

Grazing, mechanical pulling, mowing, herbicides, biological control using insects or plant pathogens, and specialized range management techniques have the potential to restrict the invasion of some alien plants in prairie natural grasslands. Much more research, practical application, and testing are required to reduce the populations of alien forage and weed plant species growing in Canadian natural grasslands.

Reclamation of Natural Grasslands following Disturbance

Oil and gas exploration and development, agriculture, mining, construction and maintenance of roads, pipelines, and power lines, and various other activities disrupt natural grasslands and associated topsoil. The reclamation of these sites after they are disturbed is essential.

An example of recent work is the following: Fitzpatrick (2007) prepared a report regarding the rangeland health of four treatments in an oil well revegetation trial in the Northern Fescue section of the Aspen Parkland-Northern Fescue ecoregion. Nine years after seeding, three treatments having various seed mixtures of native species had more cover of native grassland species than the no seeding (i.e., natural recovery) treatment. The no seed, natural recovery treatment had the most cover of perennial invasive species, including smooth bromegrass, Kentucky bluegrass, and Canada thistle. Agricultural crops, tame forages, and perennial weeds are a serious threat to reclaiming rangeland disturbed by oil and gas exploration and other kinds of construction within the prairie natural grasslands.

This is a vitally important area for more work to be done to identify the most effective means of successfully reclaiming natural grasslands following disturbance by either industry or agriculture.

Most provinces have regulations that require certain procedures be followed during the construction and reclamation phases of oil and gas development. Many publications are available from provincial and private sources. For example, Neville (2002) described best management practices for pipeline construction through native prairie. The following books are recommended: Sinton-Gerling *et al.* (1996) and Smerciu *et al.* (2002). Several Web sites provide additional information; for example, Alberta Native Plants Council provides a current Native Plant Source list for the prairies: http://www.anpc.ab.ca/content/index.php.

Alberta native revegetation guidelines can be found at: http://srd.alberta.ca/ and there is the Prairie Conservation Forum at http://www.albertapcf.org/occasional_papers.htm.

Re-establishment of Natural Grasslands

It is reasonable to assume that the interest in the management and restoration of natural grasslands on the Canadian prairies will accelerate. Native prairie plants are usually more resistant to drought than tame perennial forages. Plant breeders normally select grasses that grow more leaf and less roots (Dormaar *et al.* 1995). That is not what is required during a prairie drought. Native prairie grasses and forbs have evolved with drought over 50 million years. They are productive and nutritious (Jefferson *et al.* 2004). Research under semiarid conditions at Swift Current has found no production differences between native and introduced grasses. Research has indicated that there is increased production potential if the grasses were grown in mixtures (Schellenberg 2008). Seeding of a mixture of native grasses, including warm season grasses and the native legume purple prairie clover, has been shown to maintain average daily gains for cattle during the late summer; this is typically a time when animal daily gains tend to decline (Iwaasa and Schellenberg 2005).

Only a few attempts have been made to re-establish natural grasslands by removing sod from one area and re-planting it in a well prepared seedbed somewhere else. There was a successful transplant of a native grassland near Grande Prairie, Alberta. About nine acres were successfully transplanted from a new highway right-of-way to another part of the same farm (Bailey 2000a). The positive part of this method of restoration of natural grasslands is that most organisms in the grassland ecosystem were transplanted successfully. Forbs, sedges, arthropods, microorganisms, and grasses were moved as each deep slice of soil was cut, lifted, and transported. However, this process is expensive and time consuming and is suitable for only certain types of soils. It requires that the grass sod be cut horizontally at depth and vertically on all sides into manageable pieces. These pieces are then loaded on a pallet by large forklift or other means, placed on a truck or trailer, and transported. Then they are unloaded at a suitable, thoroughly cultivated receiving site, and fitted at the transplant site piece by piece. The pallet is removed, the cracks are filled with soil, and then the sods are watered frequently during the first growing season. This promotes good grass and forb root growth into the new soil substrate. Normally, only loam or clay textured soils are suitable mediums for this transplantation method. Very sandy or stony soils would be too difficult to use as a mechanism for transplanting because the soil and sod would break apart too easily. Similarly, the presence of many shrub or tree roots in the sod pieces would make it difficult for the transplantation equipment to operate without tearing apart the soil and grass sod.

During the last two decades, promising work has been undertaken to develop new cultivars (varieties) of locally grown, adapted native grasses for the Canadian prairies. One new variety is Grouse Green Needlegrass produced by the research team at Alberta Research Council (Woosaree and Golka 2008). Other cultivars, including plains rough fescue and foothills rough fescue, will be released in a few years (Woosaree 2004). The germplasm development effort involving Agriculture and Agri-Food Canada (AAFC), the University of Manitoba, and Ducks Unlimited has made the following available as ecological varieties (i.e., Ecovars): western wheatgrass (W.R. Poole), northern wheatgrass (AC Polar), green needle grass (AC Mallard), needle-and-thread grass (AC Sharptail), slender wheatgrass (AC Sprig, AC Pintail), little bluestem (Taylor), and Bromus porteri (AC Marten). This program also has the following species under development for release: Bromus richardsonii, prairie sand reed, blue grama, side oats grama, June grass, blue bunch wheatgrass, Canadian milkvetch, and purple prairie clover (Coulman *et al.* 2008). Work with native species of grasses, legumes, and shrubs continues at the University of Saskatchewan and AAFC's Semiarid Prairie Agricultural Research Centre.

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Notes:

Appendix 1. Common Canadian Prairie Range Plants

Common Name	Scientific name
Grasses	
Awned wheat grass	*Elymus trachycaulus* ssp. *subsecundus* (Link) A.& D. Löve
Big bluestem	*Andropogon gerardii* Vitman
Blue grama	*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths
Canada wildrye	*Elymus canadensis* L.
Creeping red fescue	*Festuca rubra* L.
Crested wheat grass	*Agropyron cristatum* (L.) Gaertn.
Desert salt grass	*Distichlis spicata* (L.) Greene
Foothills rough fescue	*Festuca campestris* Rydb.
Foxtail barley	*Hordeum jubatum* L.
Fringed brome	*Bromus ciliatus* L.
Green needle grass	*Nassella viridula* (Trin.) Barkworth
Hairy wildrye	*Elymus innovatus* Beal
Idaho fescue	*Festuca idahoensis* Elmer
Indian grass	*Sorghastrum nutans* (L.) Nash
Indian rice grass	*Achnatherum hymenoides* (Roemer & J.A. Schultes) Barkworth
Intermediate wheat grass	*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey
June grass	*Koeleria macrantha* (Ledeb.) J.A. Schultes
Kentucky bluegrass	*Poa Pratensis* L.
Little bluestem	*Schizachyrium scoparium* (Michx.) Nash
Manna grasses	*Glyceria* spp.
Marsh reed grass (blue joint)	*Calamagrostis canadensis* (Michx.) Beauv.
Needle and thread	*Hesperostipa comata* ssp. *comata* (Trin. & Rupr.) Barkworth
Northern (thickspike) wheatgrass	*Elymus lanceolatus* ssp. *lanceolatus* (Scribn. & J.G. Sm.) Gould
Nuttall's salt meadow grass	*Puccinellia nuttalliana* (Schultes) Hitchc.
Parry oat grass	*Danthonia parryi* Scribn.
Plains reed grass	*Calamagrostis montanensis* Scribn.
Plains rough fescue	*Festuca hallii* (Vasey) Piper
Porcupine grass	*Hesperostipa spartea* (Trin.) Barkworth
Prairie cord grass	*Spartina pectinata* Link
Prairie muhly	*Muhlenbergia cuspidata* (Torr.) Rydb.
Reed grasses	*Calamagrostis* spp.
Russian wildrye	*Psathyrostachys juncea* (Fisch.) Nevski
Sandberg's blue grass	*Poa secunda* Presl.
Sand dropseed	*Sporobolus cryptandrus* (Torr.) A. Gray
Sand grass	*Calamovilifolia longifolia* (Hook.) Scribn.
Slender wheatgrass	*Elymus trachycaulus* ssp. *trachycaulus* (Link) Gould ex Shinners
Slough grass	*Beckmannia syzigachne* (Steud.) Fern.

Common Name	Scientific name
Smooth bromegrass	*Bromus inermis* Leyss.
Spangletop (whitetop)	*Scolochloa festucaea* (Willd.) Link
Switch grass	*Panicum virgatum* L.
Timothy	*Phleum pratense* L.
Tufted hair grass	*Deschampsia caespitosa* (L.) Beauv.
Western porcupine grass	*Hesperostipa curtiseta* (Hitchc.) Barkworth
Western wheatgrass	*Pascopyrum smithii* (Rydb.) A.Love
Wild oat grass	*Danthonia intermedia* Vase
Sedges	
Awned sedge	*Carex atherodes* Spreng.
Blunt sedge	Carex obtusata Lilj.
Low sedge	*Carex eleocharis* Bailey
Sun loving sedge	*Carex heliophila* Mack.
Thread leaved sedge	Carex *filifolia* Nutt.
Forbs	
Alfalfa	*Medicago sativa* L.
Alsike clover	*Trifolium hybridum* L.
Bastard toadflax	*Commandra umbellate* (L.) Nutt.
Ball (purple) cactus	*Escobaria vivipara* var. *vivipara* (Nutt.) Buxbaum
Bbroomweed	*Gutierrezia sarothrae* (Pursh) Britt. & Rusby
Canada thistle	*Cirsium arvense* (L.) Scop.
Dandelion	*Taraxacum officinale* Weber
Death camas	*Zigadenus venosus* S. Wats
Diffuse knapweed	*Centaurea diffusa* Lam.
Field chickweed	*Cerastium arvense* L.
Golden bean	*Thermopsis rhombifolia* (Nutt. ex Pursh) Nutt. ex Richards
Little (dense) club moss	*Selaginella densa* Rydb.
Leafy spurge	*Euphoria esula* L.
Loco weed	*Oxytropis sericea* Nutt.
Low (prairie or Missouri) goldenrod	*Solidago missouriensis* Nutt.
Low larkspur	*Delphinium bicolor* Nutt.
Moss phlox	*Phlox hoodii* Richards.
Narrow-leaved milkvetch	*Astragalus pectinatus* (Hook.) Dougl. ex G. Don
Northern bedstraw	*Galium circaezans* var. *circaezans* Michx
Pasture (fringed) sage	*Artemisia frigida* Willd.
Plains prickly pear	*Opuntia polycantha* Haw.
Prairie crocus	*Pulsatilla patens* ssp. *multifida* (Pritz.) Zamels
Prairie sage	*Artemisia ludoviciana* Nutt.
Pussytoes	*Antennaria* spp.

Common Name	Scientific name
Purple prairie clover	*Dalea purpurea* Vent.
Red clover	*Trifolium pratense* L.
Seaside arrowgrass	*Triglocin maritima* L.
Silvery lupine	*Lupinus argenteus* Pursh
Smooth aster	*Symphyotrichum laeve* var. *laeve* (L.) A.& D. Löve
Spotted knapweed	*Centaurea biebersteinii* DC.
Three flowered avens	*Geum triflorum* var. *triflorum* Pursh
Tall larkspur	*Delphinium glaucum* S. Wats
Tufted (white or many flowered) aster	*Symphyotrichum ericoides* var. *pansum* (Blake) Nesom
Two groove milkvetch	*Astragalus bisulcatus* (Hook.) Gray
Water hemlock	*Cicuta maculata* var. *maculata* L.
White camas	*Zigadenus elegans* ssp. *elegans* Pursh
White clover	*Trifolium repens* L.
White prairie clover	*Dalea candida* Michx. ex Willd.
Shrubs and Trees	
Aspen (trembling aspen)	*Populus tremuloides* Michx.
Balsam poplar	*Populus balsamifera* L. ssp. *balsamifera*
Buffalo berry	*Shepherdia canadensis* (L.) Nutt.
Chokecherry	*Prunus virginiana* var. *virginiana* L.
Bur oak	*Quercus macrocarpa* var. *macrocarpa* Michx.
Creeping juniper	*Juniperus horizontalis* Moench
Greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.
Jack pine	*Pinus banksiana* Lamb.
Lodgepole pine	*Pinus contorta* Loud. var. *latifolia* Engelm.
Paper birch	*Betula papyrifera* var. *papyrifera* Marsh.
Pin cherry	*Prunus pensylvanica* var. *pensylvanica* L. f.
Prairie rose	*Rosa arkansana* Porter
Prickly rose	*Rosa acicularis* Lindl.
Nuttall's (Gardner's) saltbush	*Atriplex* gardneri (Moq.) Dietr.
Saskatoon	*Amalanchier alnifolia* Nutt. var. *alnifolia* (Nutt.) ex M. Roemer
Shrubby cinquefoil	*Dasiphora floribunda* (Pursh) Kartesz, comb. nov. ined.
Silverberry (wolf willow)	*Elaeagnus commutata* Bernh. ex Rydb.
Silver sagebrush	*Artemisia cana* Pursh
Western snowberry	*Symphoricarpos occidentalis* Hook.
White spruce	*Picea glauca* (Moench) Voss
Willows	*Salix* spp.
Winterfat	*Krascheninnikovia lanata* (Pursh) Meeuse & Smit.
Wood's rose	*Rosa woodsii* Lindl

Common Name	Scientific name
Alien Plants and Weeds	
Altai wildrye	*Leymus angustus* (Trin.) Pilger
Alfalfa	*Medicago sativa* L.
Alsike clover	*Trifolium hybridum* L.
Canada thistle	*Cirsium arvense* (L.) Scop.
Creeping red fescue	*Festuca rubra* L.
Crested wheatgrass	*Agropyron cristatum* (L.) Gaertn.
Downy brome, cheat grass	*Bromus tectorum* L.
Dandelion	*Taraxacum officinale* Weber
Diffuse knapweed	*Centaurea diffusa* Lam.
Foxtail barley	*Hordeum jubatum* L.
Kentucky bluegrass	*Poa pratensis* L.
Leafy spurge	*Euphoria esula* L.
Red clover	*Trifolium pratense* L.
Russian wildrye	*Psathyrostachys juncea* (Fisch.) Nevski
Smooth bromegrass	*Bromus inermis* Leyss.
Spotted knapweed	*Centaurea maculosa* Lam.
Timothy	*Phleum pratense* L.
White clover	*Trifolium repens* L.
Common Plants Poisonous to Grazing Animals	
Broomweed	*Gutierrezia sarothrae* (Pursh) Britt. & Rusby
Death camas	*Zigadenus venosus* S. Wats.
Diffuse knapweed	*Centaurea diffusa* Lam.
Greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.
Leafy spurge	*Euphoria esula* L.
Low larkspur	*Delphinium bicolor* Nutt.
Loco weed	*Oxytropis sericea* Nutt.
Narrow-leaved milkvetch	*Astragalus pectinatus* (Hook.) Dougl. ex G. Don
Seaside arrowgrass	*Triglocin maritima* L.
Spotted knapweed	*Centaurea maculosa* Lam.
Tall larkspur	*Delphinium glaucum* S. Wats
Two groove milkvetch	*Astragalus bisulcatus* (Hook.) Gray
Water hemlock	*Cicuta maculata* var. *maculata* L.