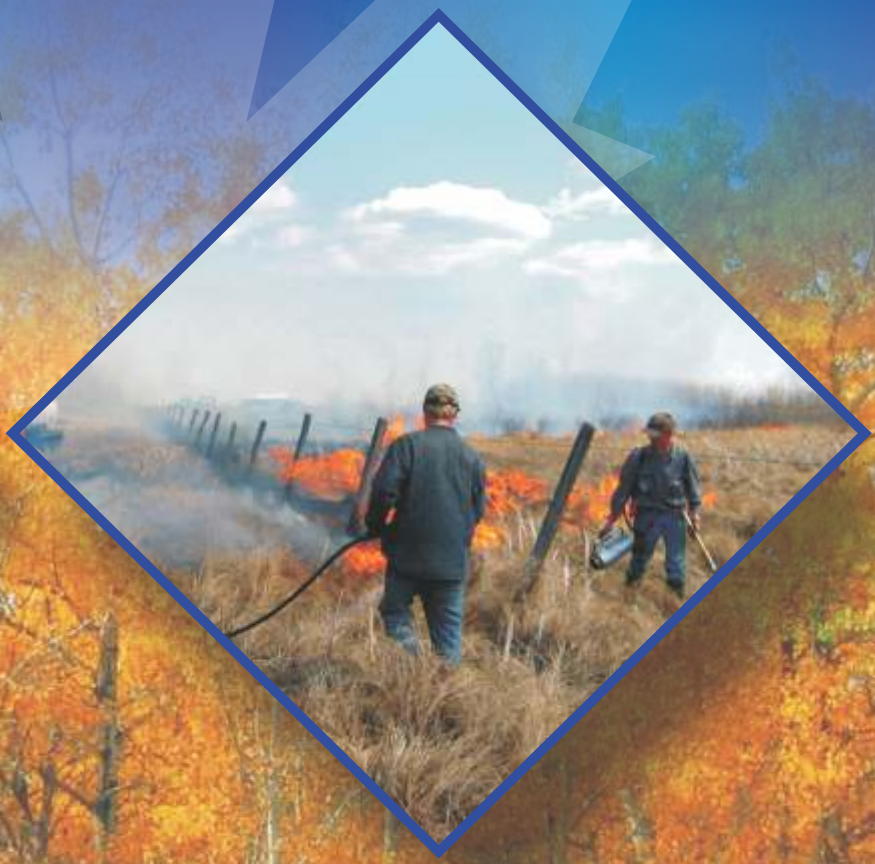
A GUIDE TO INTEGRATED

Brush Management

ON THE WESTERN CANADIAN PLAINS



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For information about ordering this publication, contact:

MANITOBA FORAGE COUNCIL
c/o Wayne Digby
125 Patterson Crescent
Brandon, Manitoba
Phone: (204) 726-9393
Fax: (204) 726-9703
Email: mfc@mbforagecouncil.mb.ca

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Contributors

Integrated Brush Advisory Group

Alberta Range Management Branch, Alberta Lands and Forest

Dr. Arthur W. Bailey

Dow AgroSciences

Ducks Unlimited Canada

Manitoba Agriculture, Food and Rural Initiatives (MAFRI)

Prairie Farm Rehabilitation Administration (PFRA), Agriculture and Agri-Food Canada

Saskatchewan Agriculture and Food

Saskatchewan Land Branch

University of Alberta

Western Forage Beef Group

Reviewers

Dr. Barry Irving – *Dept. of Agricultural, Food and Nutritional Science, University of Alberta*

Gerry Ehlert – *Alberta Range Management Branch, Alberta Sustainable Resource Development*

Duane McCartney – *Forage and Beef Specialist, Agricultural and Agri-Food Canada*

Michael Willoughby – *Alberta Sustainable Resource Development*

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The following people generously provided information, offered suggestions, reviewed drafts, helped obtain photographs or otherwise helped in manuscript preparations:

Al Switzer

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Douglas Krefting

Jason Kosowan

Laura Poppy – *Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada*

Jane Thornton – *Manitoba Agriculture, Food and Rural Initiatives*

Shane Tornblom – *Manitoba Woodlot Association*

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Barry Irving
Art Bailey
Ron Moss
Steve Dewey
Chris Hutton
Brian Baron
USDA
AAFC-PFRA
L. Allen
H.W. Phillips

Production

KREATIVE•ENERGY

Koralea R. Read - Kreative Energy
kreative.energy1@gmail.com

Table of Contents

Chapter Four
Brush Management Using Herbicides

RON MOSS
Technology Transfer Coordinator, Agriculture and Agri-Food Canada, Dauphin, Manitoba

BARRY GIBBS, P. Ag.
Product Registration Manager, Dow AgroSciences Canada Inc., Calgary, Alberta

BILL GARDINER
Farm Production Extension – Range & Pasture, Manitoba Agriculture, Food and Rural Initiatives, Dauphin, Manitoba

Part I - Methodology

Part II- Herbicide Guide

Chapter Five
Prescribed Fire: A Brush Management Option

ARTHUR W. BAILEY
Professor Emeritus, Rangeland Ecology and Management, University of Alberta, Edmonton, Alberta

BRANT KIRYCHUK, Manager
Sustainable Agriculture Development Project, PR China

Chapter Six

Timber Harvesting

BILL GARDINER
Farm Production Extension – Range & Pasture, Manitoba Agriculture, Food and Rural Initiatives, Dauphin, Manitoba

Chapter Seven

Prescription Grazing for Brush Management in Canadian Aspen Parkland, Foothills and Lower Boreal Forest

ARTHUR W. BAILEY
Professor Emeritus, Rangeland Ecology and Management, University of Alberta, Edmonton, Alberta

Chapter Eight

Monitoring

MAE E. ELSINGER
Range Management Specialist, Agriculture and Agri-Food Canada, Brandon, Manitoba

Chapter Nine

Conclusion
Developing a Co-ordinated Brush Management Plan

ARTHUR W. BAILEY
Professor Emeritus, Rangeland Ecology and Management, University of Alberta, Edmonton, Alberta

Chapter Ten

Brush Management Economics Summary

ARNOLD MATTSON
Range & Biodiversity Division, Agriculture and Agri-Food Canada, Edmonton, Alberta

CHAPTER ONE

Introduction

Ms. Gerry Oliver
Wild Horse Communications,
Carberry, Manitoba
gerry@spiritsands.ca

OVERVIEW

An Integrated Guide to Brush Management on the Western Canadian Plains was proposed by a group of scientists, land and range managers, farmers and ranchers, as a needed resource for the ever expanding problem of brush encroachment. While aspen removal has been carried out for over 100 years, in today's world, these methods have become too costly. Alternatives are needed to ensure lower costs and longer periods between treatment times but at the same time are environmentally sensitive, more productive and carried out in an appropriate manner for the landscape.

Grazing has been shown to be the most cost effective management technique, when used following another form of treatment. For this reason, the manual presents mechanical, herbicide, timber harvesting and fire as initial treatments, followed by deferred rotational grazing. Regardless of which treatment is used, a management plan should be designed prior to starting.

The manual has been designed to present a wide variety of options for controlling or managing woody plant growth. Each chapter details the method, timing of application, equipment needed, costs, impacts on biodiversity, and some actual examples. Finally, the monitoring chapter provides step-by-step guidelines on how to evaluate brush encroachment and the success of control efforts.

"Buffalo on the March: A Drawing from Eye-Witness Account," a crude but dramatic attempt to picture the countless numbers of buffalo blanketing the land. M.S. Garretson drawing.
~ Courtesy Kansas State Historical Society.

INTRODUCTION

Trembling aspen (Populus tremuloides), also known as aspen, aspen poplar or white poplar, is the main focus of discussion throughout this manual. It is one of the most common and persistent invasive woody species in North America, covering tens of millions of acres.

The Aspen Parkland is a tension zone between treed areas of the boreal forest, and open grasslands of the plains. It stretches from northeastern British Columbia to central and southern Manitoba. While aspen is found throughout the North American prairies, it grows especially well in Manitoba, Saskatchewan, Alberta and Minnesota because of the calcareous (limestone) soils.

For over 12,000 years, there has been an ongoing struggle between forest and grassland. Once managed by fire and browsing of large grazers, aspen was held back to the cooler, moister regions of the prairie. Depending on factors such as fire, extremes of weather, insect infestations or plant disease, wildlife activities and more recently, human activities, the aspen forest has advanced for a period of time, then fallen back.

Generally, aspen grows in the moister, fertile black Chernozemic soils, which developed under the grasslands. Aspen bluffs were originally interspersed with grasslands, dominated by fescue grasses.

FACTORS THAT AFFECT SUCKER PRODUCTION AND SURVIVAL

Climate	Periods where annual precipitation is adequate for tree growth, will have a steady expansion rate
	Droughty periods will see dieback of mature trees, with a corresponding increase in expansion rate through suckering.
	Regions in the western prairies are subject to more fluctuations than eastern areas, which have a greater and steadier supply of available moisture
	Insect damage can induce dieback of established trees, with a corresponding increase in expansion rate through suckering
Soil Capability	Soils in depressed locations, except where the soil is saturated, will have higher expansion rates than on uplands
	Expansion rates on coarse soils will be subject to fluctuations in available moisture; possible periods of dieback and suckering
	Expansion rates on deep, fertile soils will be higher than on infertile or shallow soil
	Salinity will limit brush expansion
Land Use	Brush that is frequently damaged by land use pressures such as haying, tillage and grazing with high stock density will have low expansion rates
	Pastureland in larger parcels will have a higher expansion rate in areas less preferred for grazing
	Pastures with steep topography and heavy brush cover will have higher expansion rates because cattle won't put enough grazing pressure on the suckers in those areas
	Brush on public lands will expand more rapidly than on private lands because there are land restrictions placed on range improvements and the priority of lessees is to improve lands of their own first
Previous Treatments	Areas that have never had brush will have slower expansion
	Expansion rates will be higher on sites adjacent to existing brush stands
	Areas that have recently had brush treatments will have an excessive rate of re-growth unless follow-up treatment is applied
	Ineffective follow-up treatments (i.e. under 90% kill rate) will result in a higher re-growth rate, than areas with full kill rates

Worlds Largest Living Organism

In Utah, near the Wasatch Mountains, a single aspen grove (nicknamed “Pando” – meaning “I spread”) has been labeled the world's largest living organism. It is a single plant that covers nearly 200 acres and is estimated to weigh about 6,600 tons. Scientists now estimate, based on fossilized remains, that an aspen clone could be a million years old or more.
(www.extremescience.com)

Since settlement began in grassland regions around 1880, followed by removal of fire and large browsing animals, aspen encroachment has accelerated and now covers millions of acres of former grassland. Shading provided by the trees eliminates many grass species dependent on sunlight for survival. Shade-tolerant herbaceous plant species soon replace them. As the forest canopy develops, woody brush species such as American hazelnut, saskatoon and chokecherry begin to establish along the bush edges. Within a relatively short number of years, an open grassland area can evolve into woodlands. Its value for grazing is greatly reduced.

Over the last 125 years, aspen expansion has advanced exponentially. Encroachment of aspen on grasslands is a slow process, but in time, its effect is significant. One study has shown that the annual loss of grasslands to brush is approximately 5.3% or 140,000 acres over 4,000,000 acres of native pastureland in Manitoba. The considerable economic impact of aspen encroachment to livestock producers utilizing native grasslands continues to accelerate at a rate of between 1-5 percent annually.

To preserve the balance between trees and grass, land managers need to develop a management plan that somewhat mimics what the natural forces used to do, in reducing aspen expansion, such as herbicide application, prescribed burning, mechanical clearing and grazing.

Literature provides a broad range of values for rates of brush expansion into open areas. It appears to depend heavily on climate, soil capability, land use, and previous brush treatments on a site. Analyses of brush expansion on 28 PFRA Community Pastures across western Canada by Dr. Garry Bowes (1997) determined an average annual brush expansion rate of 5.4% for those pastures.

Beneficial Aspects of Aspen

In traditional aspen regions, the tree plays a major role in the functioning of natural systems. It provides cover and food to a large number of bird and animal species. Large animals such as black bear, whitetail deer and elk feed on the young saplings and buds. Birds such as ruffed grouse, use all ages of aspen for food, brooding, breeding and over-wintering. Beaver utilize aspen for

building dams and lodges, plus they eat the bitter inner bark. Moose and porcupine eat the twigs and foliage.

Aspen provides shade to regenerating tree species such as maple, spruce and balsam. It aids in water filtration, water quality and soil stabilization. Other benefits include fire prevention, buffered forage supply in drought times, and sheltering for livestock.

Wood products produced from aspen include pulp, particleboard, oriented strand board (OSB) and dimension lumber.

Detrimental Aspects of Aspen

Some land owners may want to minimize brush cover to increase workable acreage for hay and crops, increase grazing capacity, improve stock movement, preserve grassland habitat, or reduce insect problems resulting from wind reduction.

Research is required on the production increases (cost/benefit) with the different methods mentioned in this book. Most of the work that has been done is monitoring the amount of regeneration after a treatment but no monitoring of the increase in palatable forage. These are estimates based on soil type and moisture because there will be huge variations.

The technology of brush management will continue to develop in the future. Sequencing of treatments must reflect the goals and objectives of individual management plans. Targets need to be established that answer the question – how much bush do we want and how much is manageable?

REFERENCE

Bowes, G. 1997. Increase in Forage Yield after Brush Control in Aspen Parkland: Summary of Progress to 1996. Saskatoon Research Centre.

CHAPTER TWO

Climate, Soils and Brush Encroachment

ARTHUR W. BAILEY, PROFESSOR EMERITUS,
RANGELAND ECOLOGY AND MANAGEMENT,
UNIVERSITY OF ALBERTA, EDMONTON, ALBERTA.
E-MAIL: AWBAILEY@UALBERTA.CA

OVERVIEW

- The management of brush in the aspen parkland and the northern bush (southern boreal forest) is the principle focus of this bulletin; these eco-regions surround the drier prairie to the west, north and east.
- Brush encroachment is pronounced on black and dark brown chernozem soils and on gray luvisols and gleysols.
- Much of the brush that has encroached into grasslands is palatable to livestock and in future droughts it will provide emergency forage.
- After top-killing, most plains shrubs and trees re-sprout from buds at the base of the tree trunk, and from roots to grow new stems.
- The past century has been unusually drought free but there were seven drought periods in the 200 years prior to it.
- The risk of prolonged drought is probably higher now as the climate changes.
- No one knows for sure how much the climate will change in the next 30 to 50 years, but the last 750-year tree ring records indicate that land managers must plan to deal with longer periods of drought than in the past century.
- If more conservative grazing practices are not implemented many ranchers will not survive during future periods of severe drought.
- The risk of prolonged drought makes it more difficult for land managers to decide how much brush to remove and how much to keep.

The western Canadian Plains and foothills stretch from the Rocky Mountains in Alberta and northeastern British Columbia eastwards towards Hudson Bay. The plains are dissected by valleys created by ancient rivers that flowed following the melting of

Photo: G. Oliver

various continental and mountain glaciers during the one million-year Pleistocene era. These plains have the highest elevation near the Rocky Mountains in southwestern Alberta and the elevation decreases towards the north and east.

Climate

There is a continental climate in the western Canadian plains and foothills. In summer, the climate can be warm but the further north one goes the cooler it becomes. Freezing temperatures and periods of extremely cold temperatures are the norm in mid-winter. In western Alberta, the ameliorating effects of the maritime pacific air masses often shorten periods of extremely cold temperatures.

DRY MIXED GRASS PRAIRIE

The driest grassland regions of southeastern Alberta and adjacent Saskatchewan have average yearly precipitation of 300-350 mm (Anonymous 2007). Little brush grows in this region, which is described as the dry grass mixed prairie. It is also called the "Palliser Triangle". To the west, north and east, the precipitation and amount of brush increases. At the time of settlement, natural grasslands occurred on moist prairie areas having 400-500 mm annual precipitation. Today these regions are covered mostly by trees or shrubs that have encroached into the parklands and grasslands (Table 1).

There are noticeable differences in average annual daily temperature and precipitation from province to province. Generally, Manitoba and Alberta have higher annual precipitation than Saskatchewan. The boreal forest region has the lowest daily average temperatures. Alberta, the most westerly prairie province, is exposed to warmer Pacific maritime weather systems that arrive with the westerly winds. They modify temperatures in the western and southern halves of the province. In spring and summer, southern Manitoba benefits from the moisture and warmer air from southern weather systems that originate in the Gulf of Mexico.

Table 1. Average annual daily temperature and annual precipitation for aspen parkland and forest regions, 1971-2000 climate normals.

	Alberta		Saskatchewan		Manitoba		Regional Averages	
Ecological Regions	Temp. C	Precip. mm	Temp. C	Precip. mm	Temp.	Precip mm	Average daily. Temp. C	Average annual Precip. mm
Boreal forest (northern bush)	1.5	475	0.5	441	0.7	493	0.9	470
Aspen parkland	2.2	453	2.1	441	2.3	514	2.2	469
Foothills forest	3	570	3.6	607			3.3	589
Foothills rough fescue	4.6	479					4.6	479

Only the ecological regions that have substantial cover of brush or forest are presented in Table 1. Woody cover is common where annual precipitation is greater than 400 mm.

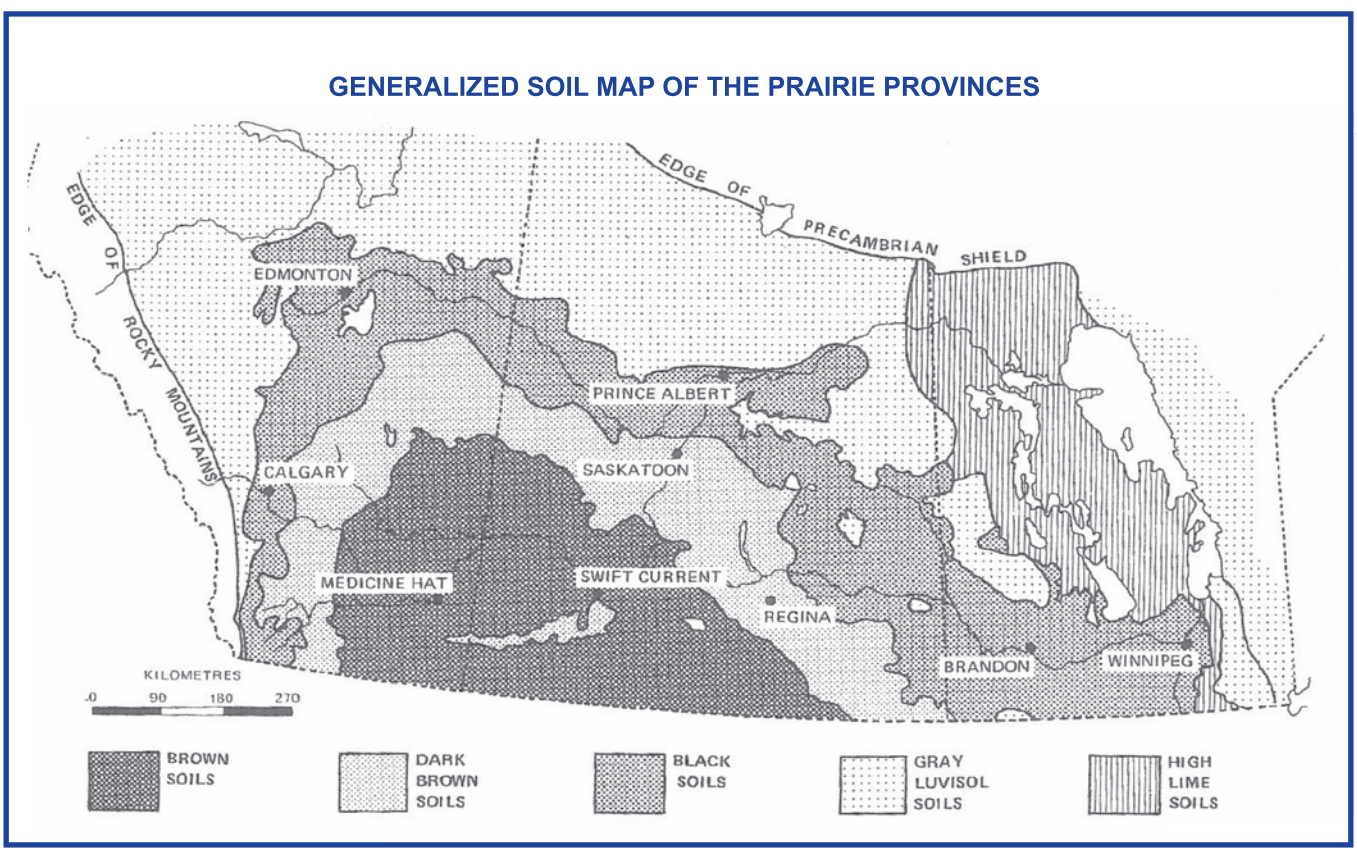
Soils

The last continental glacier that covered the western Canadian plains only melted 10,000 to 15,000 years ago. Thus, the soils of the region are considered to be young. The Chernozemic soils originated under natural grasslands that grew in the comparatively dry, cool growing season climate (Figure 1). The driest areas in southern Alberta and adjacent Saskatchewan developed Brown Chernozem soils; somewhat moister areas developed Dark Brown Chernozems (Clayton et al. 1977). Both of these areas were in grasslands at the time of settlement.

Black Chernozem soils developed under the moist grasslands of the foothills fescue grasslands and the aspen parklands where annual precipitation ranged from 400-550 mm. Deep, black Ah horizons were lain down by decomposing grass roots under these cool, mesic weather conditions. Settlers preferred the Dark Brown and Black Chernozem soils for cultivated agriculture because of high organic matter and fertility.

In the regions where annual precipitation is in the range of 440-600 mm, forest grew and the soils that originated under them were mostly Luvisols on uplands and Gleysols and Organics (peat) in cooler, wetter landscape positions. At the grassland forest transition zone, soils under forest closest to the prairie grasslands are Dark Brown, Black, and Dark Gray Chernozem intermingled with Dark Gray and Gray Luvisols. In colder, higher

Figure 1. A generalized soil map of the Prairie provinces (from Smoliak et al. 1982).



precipitation upland areas the Gray Luvisols are common.

The quantity of organic matter is highest in the Ah horizons of Black Chernozem soils and decreases towards the driest prairie areas under Brown Chernozems. In the higher precipitation areas, deciduous or coniferous forests occur and the organic matter is mostly stored in tree roots, trunks, branches and leaves rather than in the soil.

The wetland soils associated with the grassland are primarily Gleysol. There are also Gleysols in the forest but in wetter, colder regions of the forests, Organic (peat) soils occur in the lowlands.

SHRUBLAND AND FOREST ECOLOGICAL REGIONS

Aspen Parkland

The aspen parkland flanks the natural grassland region of the Canadian prairies to the west, north and east. This parkland area is the transition zone between grasslands and forests. It has sufficient precipitation under average conditions to sustain shrub or tree growth on at least the coolest northerly- or easterly-facing slopes. The soils are primarily Black with some Dark Brown and Dark Gray Chernozems, and Dark Gray Luvisols. In the riparian or wetland areas are Gleysols that originated under conditions of low oxygen levels.

On the driest soils of the aspen parklands, during drought periods, aspen trees died and grasslands encroached. In wetter, cooler cycles, aspen tended to encroach on the grasslands. The amount of tree and shrub cover varies widely within the aspen parkland. The least tree cover is near the natural grasslands where the climate is warmer and drier. Closer to the boreal and foothills forests, where the climate is cooler and wetter, there is a higher proportion of aspen parkland covered by trees and shrubs.

To the west, north and east of the aspen parkland are boreal, foothills and escarpment forests in zones of climate, soils and vegetation that are moist enough to provide for the needs of native trees on all but the driest slope positions.

Foothill Forests of Alberta

To the west and north of the aspen parklands in the foothills of Alberta and northeastern British Columbia are forests of aspen, pine and spruce. The soils are primarily Gray Luvisols, while Gleysols are in wetter areas. Annual precipitation is usually higher than in the aspen parkland, ranging from about 600mm in the south to about 500 mm in the north. This forest has warmer average daily temperatures than the boreal forest.

Prairie Highland Forests

Throughout the prairie region are hills, mountains and higher elevation escarpments that receive more precipitation than surrounding prairie. They are often covered by forests on northerly-facing slopes, while natural grasslands grow on the driest southerly-facing slopes. The Cypress Hills forests are closely related to the Foothills Forests to the west. The annual precipitation at Cypress Hills, Saskatchewan averaged 607 mm with a 3.6°C average daily temperature. This compares to a representative boreal forest area such as Cold Lake, Alberta which averaged 427 mm precipitation and 1.7°C average daily temperature. In this example, the foothills forest at Cypress Hills in a prairie highland escarpment had 180 mm more precipitation and the average daily temperature was about 2°C warmer. Further east and north, the higher elevation forests usually grow in a climate similar to the Boreal Forest.

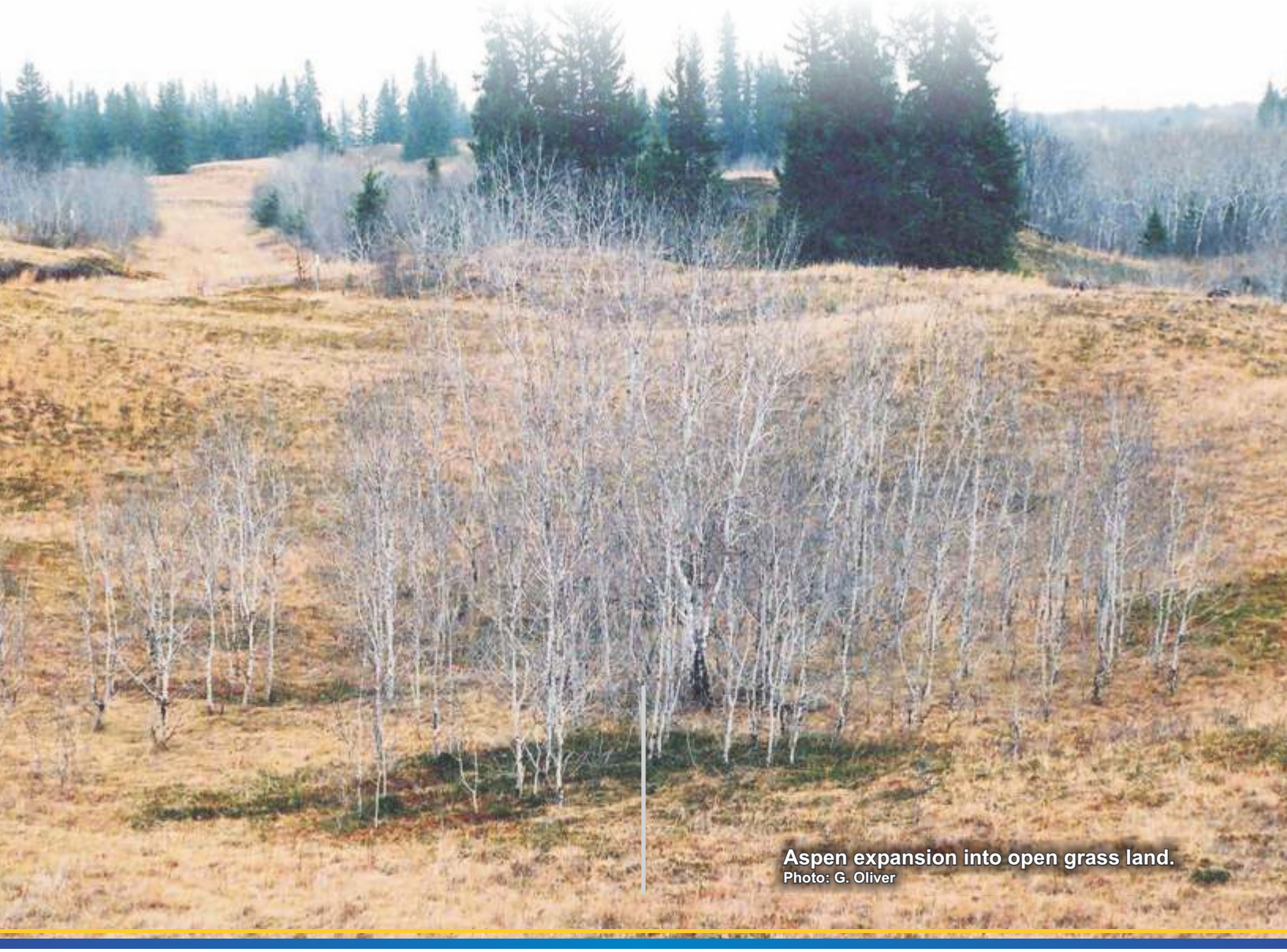
Southern Boreal Forest (Northern Bush)

To the north of the aspen parkland lies the southern Boreal Forests. The local people often call it “the northern bush”. Aspen, balsam poplar, and white spruce forests, grow on Gray Luvisol soils in the better drained areas. In wetlands black spruce, larch and willow forests grow and the soils are Gleysols or Organics (peat). On sandy ridges and other coarse-textured soils, jack pine grows in eastern parts and lodgepole pine in the western foothills.

BRUSH ENCROACHMENT

The native shrub and tree-covered areas of the Canadian prairies and plains provide considerable challenges in brush management because these woody plants are very hardy and are well adapted to the climate and soils. They have evolved under the varying and cyclical nature of the North American continental climate.

In the Northern Great Plains, the aboriginal people managed the grasslands and surrounding forests primarily using fire and



Aspen expansion into open grass land.
Photo: G. Oliver

Table 2. Tree cover (%) in the Alberta aspen parkland from the decades of 1900 to 1980.

Decade	Southern Parklands	Central Parklands	Northern Parklands
1900	5**	7*	15***
1960	8**	52*	70***
1980	15***	80***	95***

* Scheffler (1976) **Bailey and Wroe (1974) ***Estimates by A.W. Bailey

grazing by huge herds of bison, to favour grasslands over forests (Fidler 1793, Nelson and England 1971). Similarly, in the northern bush the aboriginal peoples burned each spring to fireproof their villages from the lightning-caused, intense summer forest fires; to make trails for traveling; to provide forage for moose and horses; and to provide a supply of dead, standing wood for fuel (Lewis 1982).

The Europeans started to settle the west and they vigorously suppressed prairie fires. The first legislation passed by the new Northwest Territories government in 1877 was for the prevention of prairie fires in the region now within the provinces of Alberta and Saskatchewan (Nelson and England 1971). Europeans and eastern Canadians were unfamiliar with how to manage prairie fire. Neither federal government administrators nor settlers understood the important role that prairie fire and bison grazing had on woody shrubs and trees of the western Canadian plains. In Alberta, the botanist E.H. Moss observed the encroachment of shrubs and trees into the prairie grasslands in the 1920's (Moss 1955).

In the 100 year absence of prairie fire and periodic intensive grazing by bison, brush encroachment has been rampant. This has been particularly so in grasslands growing on Dark Brown, Black and Dark Gray Chernozem soils, and also on Dark Gray Luvisol and Gleysol soils in aspen parkland and forest regions. Millions of acres of grassland have been encroached by brush since the suppression of prairie fires.

Woody encroachment is most common and difficult to manage on pasture and rangeland rather than on cropland that is cultivated annually. Annual cultivation prevents the establishment of woody plants.

The Dominion of Canada legal land surveys started in the prairies about 1880. Land surveyors recorded the amount of brush along each survey line. Johnston and Smoliak (1968), Bailey (1972), and Bailey and Wroe (1974) used these legal land surveys and compared the amount of brush cover on specific one mile segments, with that found in recent aerial photographs. In Alberta, the drier parts of the southern aspen parkland had the least encroachment of brush over a period of 60-80 years, while the higher rainfall areas had the greatest brush cover (Table 2). In the southern parklands, there was some shrub cover but very few trees in the decade of 1900 and by 1980 this had increased to a cover of about 15% (Table 2). In the central Alberta parklands in 1900,

the 7% woody cover was mostly willows with a few clones of aspen but by the 1960's the aspen tree cover had exploded and by 1980 it had expanded to about 80% cover. There is little published information for the northern edge of the aspen parkland. The author estimated a woody cover of about 15% in 1900 rising to nearly complete tree cover in 1980.

PFRA (Prairie Farm Rehabilitation Administration) manages over 2.2 million acres (900,000 ha) of grazing lands in 87 community pastures; aspen is a serious management problem on 32 of the 87 pastures (Luciuk et al. 2003). The areas affected by brush encroachment are in the aspen parkland or boreal forest transition. Other woody species of concern are balsam poplar, western snowberry, wild rose, willows and bur oak. On 28 of the 32 pastures affected by woody encroachment, 40% of the area was covered by brush (Bowes 1996, 1998). Brush was expanding at an average rate of 2.2% per year. As the area covered by aspen increased, the expansion rate increased. The pastures with the highest rate of brush expansion were previously treed areas that had been cleared. Thus, the rate of aspen expansion was related to the previous brush treatment practices (Luciuk et al. 2003). The brush expansion after clearing was also related to the grazing management practices employed following clearing.

In the settlement era, the Canadian prairie view of the natural landscape was one of man against nature. Today, a different view for the prairie, parkland and northern forest is that the adapted native brush species need to be managed because they are not going to disappear. Much woody vegetation is good forage and all of it is able to catch blowing snow in winter. The brush provides shelter, habitat and some forage for wildlife and livestock alike. Brush does provide greater biological diversity and much needed forage during years of drought.

CLIMATE CHANGE

Climate is always changing and many factors affect it. The climate data reported in this chapter is for the 1971-2000 climate normal period. That was a period of relatively stable precipitation. That is not normal for the Canadian prairies. In the prairies, the climate since European settlement has been an anomaly because of the absence of prolonged periods of drought (Sauchyn and Skinner 2001, Sauchyn et al. 2003).

Tree ring and other historical data reveal much more variability in precipitation from the 1700's and 1800's. For example, during the drought of the 1790's, at Fort Edmonton the North Saskatchewan River water levels were too low to support a canoe laden with furs (Sauchyn et al. 2003). In the drought of the 1850's, the Palliser Expedition surveyed the Canadian prairies and declared the area in southwestern Saskatchewan and adjacent Alberta “forever comparatively useless” (Palliser 1859-60:21). That area is now known as the Palliser Triangle. For that area, Sauchyn and Skinner (2001) indicated there were 7 drought periods between 1690 and 1900, specifically in the 1690's, 1750-1760, 1790-1800, 1820's, 1850-1860, 1890's.

The 1790's droughts coincided with low waters in the North Saskatchewan, and the drought found by the Palliser Expedition occurred between 1850 and 1860. In the 100 years since settlement, only the 1930's had a serious drought.

Global climate models suggest average temperature on the Canadian prairies will continue to rise (Sauchyn (in press)). There also may be continued drying in some areas. This time however, the warming and drying may expand into both aspen parkland and boreal forest (Hogg and Hurdle 1995). If this prediction does occur, the aspen parkland may move northward into part of the boreal forest. The southern grasslands may expand

into the aspen parkland and the trees would disappear.

Prairie agriculture is exposed to extreme weather events such as short and longer duration droughts; abnormally high precipitation; extreme heat and cold. Prairie agricultural production systems are also sensitive to climatic changes (Sauchyn 2007). If the climate change models correctly point towards warmer conditions and more droughts, then ranchers and pasture managers need to re-evaluate their brush management strategies. Not all brush should be removed. Brush can provide emergency forage and shelter to livestock and wildlife. It acts as a barrier to wind-blown snow, conserving scarce moisture resources in winter during drought. The storage of more water in higher rainfall years, and the storage of more forage when it is abundant may be of higher priority in the future.

HOW BRUSH GROWS

The high frequency of fires for thousands of years on the Canadian prairies has contributed to the unique way many trees and shrubs survive burning or mechanical shearing. These hardy plant species rarely depend upon seed for reproduction. Most plains shrubs and trees re-sprout following a disturbance by fire, tent caterpillars, windstorm, browsing, mowing or clearing. Should the top be destroyed, there are dormant buds in the trunks and roots that will develop into new shoots.

Woody plants grow differently than perennial grasses. In shrubs and trees, the growing points (buds) at the ends of each branch produce new shoot growth each spring. In grasses, the growing points (meristems) are at or near the ground. New grass tillers (shoots) emerge each spring and summer and grow to maturity, then die in about 90 to 120 days, to be replaced by other emerging tillers. Some of these new grass tillers survive the winter and continue growing in the spring. In contrast, new woody growth of shrubs and trees survives the winter. Next spring the buds at the tips of each branch burst and grow more woody shoots.

First year aspen sucker.
Photo: Arthur Bailey

Aspen, western snowberry and saskatoon grow in clones of genetically identical stems and roots. They often grow in tight clusters that shade understory plants. One genetically identical clone of aspen may include hundreds of stems and cover several acres of land. The root systems are much more extensive than the trunks and branches. If the tops are destroyed, the root system normally has adequate stored energy for production of many woody suckers.

The method of shoot growth for grasses is different from the method of shoot growth in deciduous shrubs and trees. Woody plants that have shoot growth within the reach of livestock and wildlife are more vulnerable than the grasses. Severe browsing/grazing of the young woody growth can eliminate the growing points (new buds) required for the next year's growth. This is however, not quite as serious as it appears. In a study of aspen shoot growth in clear-cuts, Dockrill et al. (2006) found that the force required for cattle to shear the current year's growth of an aspen stem was too great by August. It had been observed by Dockrill et al. (2004) that in late summer, cattle often stripped the leaves from young aspen suckers and saplings, leaving the stems intact. They did not eat the young woody stems because they were too hard to chew or break off.

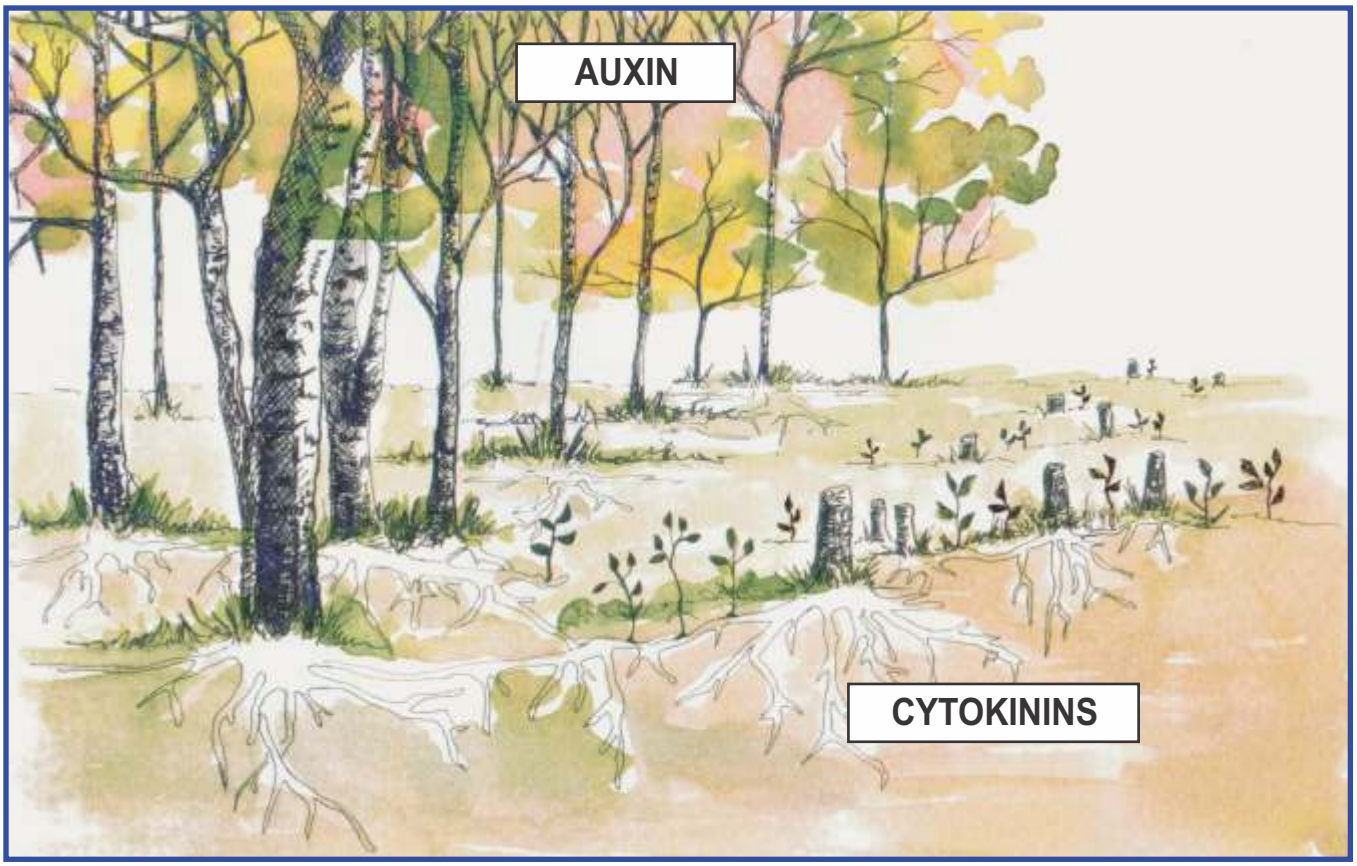


Figure 3. An illustration of an aspen forest (left) and a clearcut (right), where young aspen suckers are emerging. Illustration by: G. Oliver

Hormones control most suckering in woody plants. The aspen tree produces auxin from the tips of tree branches and root-tips produce the hormone cytokinin. Auxin suppresses bud expansion and sucker development. The cytokinins do the opposite; they promote suckering. As illustrated in Figure 3, in the mature aspen forest, auxin from the tree tops suppresses most suckering. When trees are harvested or burned, there is no source of auxin so the cytokinins in the roots promote rapid suckering.

CONCLUSIONS

Prairie brush is highly adapted to the Canadian continental climate, soils and disturbance whether by shearing, herbicides, fire or grazing. Most species readily re-sprout and most sprouts are palatable forage to livestock. Balsam poplar, alder, snowberry, hazelnut and oak are unpalatable. Browse is an important source of nutrition for livestock and wildlife. Brush is habitat and shelter for wildlife and livestock, and it catches blowing snow in winter. One of the challenges land managers face is determining how much encroached brush should be removed, and how much to keep as habitat for wildlife and livestock, and how much to keep as an emergency supply of forage during future prolonged droughts.

The prairie climate is always changing and that will continue. Land managers must prepare for longer periods of drought in the near future because that has been the norm for hundreds of years.

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CLIMATE, SOIL AND BRUSH ENCROACHMENT GLOSSARY

Chernozemic Soils: Usually occur in association with mesophytic grasses and forbs, or with mixed grass, forb and tree cover. They are the zonal soils of the Parkland Prairie and True Prairie grasslands of Western Canada and the Fescue grasslands of the sub-humid parts of the Palouse Prairie in British Columbia. The climate is typically cold, rarely mild but humid with occasional periods of moisture deficits during the growing season.

Brown Chernozemic Soils: Occur in the driest regions of the Mixed Grassland prairies.

Dark Brown Chernozemic Soils: Are associated with the Moist Mixed Grassland region which is cooler and moister, resulting in a higher level of organic matter in the soil.

Black Chernozemic Soils: Developed in the Aspen Parkland region – with aspen groves interspersed with grasslands. It is cooler and slightly moister.

Dark Grey Chernozemic Soils: Found in the transition zone of the boreal forest, where trees are the dominant vegetation. They have a lower organic content than the darker soils.

Gleysol Soils: Found in areas that are frequently flooded or permanently waterlogged.

Luvisol Soils: Another type of soil that developed under forested conditions. This soil has a calcareous parent material which results in higher pH.

Organic Soils: Soil mainly composed of organic matter in various stages of decomposition. They are common in fens and bogs. There is an obvious absence of mineral soil particles.

A horizon: The mineral horizon near the soil surface, characterized by eluviation of materials in solution or the accumulation of organic matter, or both. Usually the most fertile part of the soil profile.

Ah: Enrichment with organic matter.

Eluviation: The movement of dissolved materials through the soil.

Mesophytic: A plant growing under well-balanced moisture conditions.

CHAPTER THREE

Mechanical Control of Brush Encroachment

Ron Moss
Technology Transfer Coordinator
Agriculture and Agri-Food Canada /
Agriculture et Agroalimentaire Canada
PFRA Community Pastures, Dauphin, Manitoba
mossr@agr.gc.ca

OVERVIEW

- Mechanical methods remove or injure top growth of trees and shrubs.
- They stimulate re-growth and increase livestock utilization of treated areas.
- Canopy removal increases forage production.
- Livestock can be used to manage re-growth.
- Wildlife and livestock will graze first year re-growth.
- Drought proofing may be increased.
- There is little change in the incidence of livestock injury.
- Livestock monitoring and herding may be more difficult.
- Best control occurs when trees are in full leaf and terminal leaf has just emerged.
- Re-treatment of areas should be delayed until year two or three.

INTRODUCTION

A mechanical treatment is any technique causing physical damage to the top growth of trees or bush, including tramping, scraping or cutting. Impeding top growth triggers bud formation and sucker regeneration from the base of the trunks and along roots. Usually, the density of stems and suckers will increase 5 to 10 times following mechanical disturbance.

The management of brush using mechanical methods has developed over a 100 years in western Canada. This subject was first reviewed by Friesen et al. (1965). Bulldozers and related equipment have been designed primarily for industrial applications such as

Photo: Ron Moss

road construction. For the management of brush, modifications to dozer blades and associated equipment are often required to adapt to the specific needs of pasture and rangeland development. Rollers, roller-choppers, drags, herbicide sprayers and other equipment are often modified or constructed to meet the unique needs of pasture and rangeland development on wooded landscapes.

ISSUES

Equipment

Ranchers, farmers and pasture managers often use whatever mechanical equipment is available, economical and effective to restore grasslands or for pasture development. For example, in the 1960's & 70's, Prairie Farm Rehabilitation Administration (PFRA) and the Saskatchewan Lands Branch dragged a ball & chain between two bulldozers to open large areas when developing pastures. At Dauphin, Manitoba, one landowner used a road grader blade to clear 10-15 foot trees, when he was establishing a new fence line.

As with all the techniques presented (see Table 1), the longer distance the machine is working in the bush without turning in the open, the greater number of acres completed per hour at a reduced cost.

Roller chopper consists of two offset drums with angled steel paddles. It weighs 28,000 lbs empty & 58,000 with water. Photo: Ron Moss

Choice of mechanical equipment will depend on whether the area is:

- To be cleared or mown only.
- Further developed (i.e. land breaking and seeding).
- Include follow-up treatments that will be used to control re-growth.

Size of trees

Larger trees require heavier and stronger equipment, so the cost per acre for any mechanical treatment will be higher. However, subsequent brush treatments are usually less costly.

Timing

Timing of treatments affects the results and subsequently follow-up treatments. Current thinking is that a mechanical treatment completed in late May or early June, is the most effective. When the terminal leaf has broken bud or is in full leaf, the tree is at its lowest level of root reserves. Mechanical treatments are followed the next few growing seasons by grazing during the first half of the growing season. This procedure will help to manage regeneration of palatable brush suckers and saplings. Usually grazing during the growing season can reduce stem density and keep palatable woody stems smaller. This extends the number of years between mechanical treatments, and reduces brush management costs.

The land value or potential returns per acre will also dictate how much the land can or should be developed. Most cow-calf operations in western Canada are established on marginal land. Since they are normally low return production units, high development costs per acre often are not economically justified.

Risks

Concern over the possibility of additional injuries to cattle from debris is another factor to consider. Recent work by producers has shown no increased incidence of injuries to livestock or incidence of footrot.

The reduced ability to treat and handle cattle with horses and quads is a negative factor on these high debris areas. Horse owners are reluctant to use their horses in these sites, fearing injury to their animals. Using a quad in these areas can contribute to punctured tires and other repairs. Other means of enticing a cattle herd to move out of the pasture when the manager wishes to move them, needs to be considered. Forage on a treated pasture is only useful if the livestock can graze it, gain weight, and then move on to graze another field in the grazing rotation.

Carrying Capacity

The carrying capacity of bush is highly variable, depending upon soil fertility and moisture-holding capacity, density of the canopy and amount of sunlight reaching the ground. As a general rule of thumb, the carrying capacity of bush is calculated at 25%

Table 1. Mechanical control techniques

Method	Advantages	Disadvantages
Bulldozer Blade	Further development possible, little debris, dense piles make fire cleanup easier	High cost, erosion on fragile soils
Ball & Chain	Large acreages lower the cost compared to clearing. Usually the trees were piled later.	Difficulty of moving equipment, large scale acreages may not be acceptable to the public
Break & Seed	Cropping for a few years before seeding to perennials controls re-growth; introduce tame or native species; smooth pastures	High cost; erosion on fragile lands
Broadcasting/sod seeding	Forage available to attract cattle for bush control; low cost	Success of seeding will not be as high as with conventional seeding; incorporating legumes limits re-growth control options
Drum	Unit pulling the drum will limit tree size; lays trees on the ground allowing faster decay	High debris which hampers treating or handling livestock; harder than piles to clean up with fire; small diameter trees spring back up
Drum-Chopper	Faster decay of debris than with the drum; broadcasting seed at the same time	Turning in the open can cause major mulching of the ground. Can not be used in areas with rocks
Drag	Smashes up old debris on the ground; acts as a bark scraper	More power needed
Gyro-mowing	Mulches debris; debris will disappear in a short period; reasonable cost of rotary mowers that can be pulled by small farm tractors	Possibility of injury to livestock feet, high maintenance with gear boxes, blades, u-joints, etc.; rocks and humps can be hard on blades
Bark Scraping	Low cost	Leaves a lot of snags sticking up
Timber Harvest	Minimal cost for clearing top growth	Usually only available for commercial size aspen, spruce and pine
Grazing	Zero to low cost	Requires special knowledge to manage it appropriately

of open grassland, therefore, if an open quarter will handle 40 cows, then an adjacent bush quarter will only supply forage for 10 animals. The carrying capacity may increase to provide forage for 30 to 40 head, depending upon the amount of debris on a treated quarter section, forage productivity and cattle accessibility to the forage.

Cattle are attracted to cleared areas to graze, stage and camp. Photo: Bill Gardiner

Some producers using mechanical brush removal techniques have observed cattle being attracted to cleared areas to graze, stage and camp. The new grass/legume forage as well as woody forages in these areas appears to be more palatable than those growing under a tree canopy. When grazing is managed appropriately in newly opened-up areas, palatable woody regeneration can be used as forage.

Matching the size of the herd to the treated area allows producers to take advantage of this opportunity. The cattle will not have a chance to control the woody re-growth if the area is too large. Recommendations are from 2 to 5 animals per acre, depending on the soil type, precipitation, forage production and re-growth potential of the tree suckers and saplings.

Ranchers and pasture managers have observed that debris-strewn areas provide a lot of forage during drought. This might be due to snow trapping or to higher organic matter levels in the topsoil. The combination of higher soil moisture and fertility levels, plus the shading action of debris probably contributes to the higher forage productivity during drought.

TECHNIQUES

Land Clearing

Due to the high cost of caterpillars, fuel and the amount of time to do the operation, costs can be prohibitive for large acreages. The exception would be for land which can give you a high return and warrants additional development. Clearing for new fence lines, management strips and other operational requirements may be necessary to improve livestock distribution, etc. For example, in 2007, the range in cost of custom clearing in the Dauphin PFRA pastures was $240 - $290 per acre.

A bulldozer "walks down" the trees and pushes them into piles. Photo: Bill Gardiner

Two different methods of brush clearing are cutting (shearing) and walking down. Normally, a second operation is done right angles to the first operation. The machine goes back and forth, pushing trees into piles. The bigger the bush, the bigger the bulldozer required.

Clearing is normally done in the winter time to minimize soil disturbance. The tree is cut off or broken at ground level. If the ground is not frozen, roots will be lifted out of the ground, often making a hole. In summer, soil from the roots and scraping action of the blade on the ground will also be pushed into the piles.

In agriculture and forestry, the topsoil is the source of water, nutrients and stability for all plant life. It is critical that as much topsoil as possible be left intact during brush management operations.

In winter, when soils are frozen, land clearing for range and pasture development will have minimal impact. Tree and shrub stems are brittle and can be sheared or snapped off near ground level without removing topsoil. Clearing in winter however, stimulates sprouting the following spring, resulting in heavier re-growth. Wet soils prevent clearing as a summertime operation.

Factors to be taken into consideration when choosing a clearing method:

- Cutters are the preferred method where the bush is light and depending upon the size of cat and cutter, can work well in medium to heavy trees.
- If a cat with a cutter can not keep moving without backing up or trying to cut the tree from more than one direction, the time-cost advantage is lost.
- In large, dense bush, the walking down (tramping) method is usually used.
- There are two kinds of cutters, either side angled or V-cutter.
- In light to light-medium bush, a side-angled cutter works well while the V-cutter works better in medium to heavy bush.
- In light cover, the side-angle can cut and pile in one operation.
- Cutters do not work well on uneven ground or where there are rocks.

Some producers have simply tramped (walked down) the trees without piling. This method leaves more debris, but greatly reduces costs. With light to medium bush density, this method can be a viable option.

A roller chopper. Photo: G. Oliver

The disadvantage of not piling bush is the difficulty in burning debris later. When trees are pushed into dense piles in winter, it is relatively safe to burn them 1-2 years later, when snow surrounds them. Usually, the less soil in the pile, the more complete the burn.

For detailed information refer to Barber and Taylor (1990).

Drum Chopper

PFRA used roller-cutters in the 1960's and early 1970's. They were 5 foot diameter drums, 10 foot long with full length lugs welded at intervals of 16 inches (40.6 cm). These did the cutting. Filled with water or a

This aerial photo shows an area cleared using a roller chopper near Holland, Manitoba.
Photo: Rob Graham

non-freezing fluid during winter, the unit weighed approximately 12 tons (10.9 tonnes). Trees up to four-inch diameter (10 cm) at the base were rolled when the ground was hard or frozen. This made it easier to cut or notch the trees. Cutting or notching speeded up the decay of larger trees facilitating better burn of debris.

Two manufacturers from Florida build roller choppers - Marden Industries Inc. and Lawson Cattle and Equipment. The Lawson model is a drum with self-sharpening paddles in a spiral around the drum. Marden Industries Inc. retails one model with paddles and a second model with full-length lugs across the drum.

PFRA purchased one of the Lawson units, with two offset drums. The angle of the drums could be changed to make the machine more aggressive (more ripening action). The unit had wheels which could be put down for transport. It could be filled with fluid, such as water, to increase the weight from 28,000 (10.6 tonnes) to 58,000 pounds (26.3 tonnes). If the higher weight was desired for winter operation, then a non-freezing fluid was required. The paddles were designed to cut trees into two-foot lengths. The roller chopper worked best on non-rocky, sandy soil. It was pulled by a Steiger tractor, resulting in a cost range from $35 to $65/acre. As mentioned above, the longer the distance the machine is working in the bush without turning in the open, increases the number of acres per hour and decreases costs. [1] [2] [3]

Smooth drum on a demonstration project at Ashville, Manitoba, 2002. Photo: Bill Gardiner

If the unit is turned in an open area without tree debris, the soil will be mulched.

Smooth Drum

Many regions in the parkland are too rocky for use of a drum chopper, making the smooth drum a more viable option.

The following are some recommendations or observations based on work with this treatment: [4]

- The drum should be a minimum of 12,000 pounds (5.4 tonnes).
- If the pulling unit has a blade, it can be used to knock the trees down, scraping bark at the same time. The heavy drum pushes trees into the ground as well as pulls out roots, if the soil has enough moisture.
- If conditions are too wet, the trees will not lay on the ground. A certain degree of moisture is required, but more likely dependant on the soil type and depth of the tree roots.
- Debris flat on the ground will likely decompose faster than material sticking up and be less of a hindrance for follow-up treatments.

1. Rob Graham of Holland, Manitoba built a single drum unit using the same design. Producers renting it have also rented D7 cats to pull it for an average price of $70 prior to 2005. Even though it is very hilly topography in that area, producers have averaged 3 acres/hour (2.5 to 4 acres) which puts their costs at $33/acre. Rob estimates the increase in fuel prices in 2005 probably would add another $20 to the cat prices bringing it up to $40/acre.

2. Manitoba Agriculture, Food and Rural Initiatives followed changes in the vegetation cover in one of Rob Graham's roller treatment areas and found forage production increased to 85% of ground cover, compared to 1-5% in the bush area along side.

3. Based on Rob Graham's stocking rate and roller chopper costs, the pay back for the treatment using 2005 figures is 3.5 years.

4. Based on work done by Manitoba producer Lyle McKay with a 14 foot smooth drum unit, since 1994. (PFRA has found that conditions can be too wet for trees to lay flat on the ground.)

- Proper timing of the treatment. It works best when the tree has the least food reserves, usually right after full leaf. Followed by proper grazing, can result in little need for follow-up treatments.

- This treatment, as with other mechanical treatments, can be done in seasons not optimum for killing the trees, but when ground conditions are favourable or the producer has more time.

- Increasing roller width or hooking two rollers abreast can decrease costs substantially where the pulling unit has sufficient power.

- Small trees with little stem strength do not flatten to the ground. Winter rolling while frozen may reduce their tendency to spring back.

- Four-wheel drive tractors move faster and are smoother than a cat but need guard plating. Sharp spikes from burnt trees can present a problem, unless the tractor has forestry tires.

- With good working conditions, 3 acres per hour is a realistic goal.

- Flattening the trees in a fire-killed area, allows follow-up ground treatment of regeneration.

- Making a number of side-by-side passes in the same direction, points snags in the same direction making follow up treatments easier.

Bark Scrapers

A bark scraper is a mechanical device, which when pulled over trees, peels off or damages the bark.

Bark scraping involves dragging a heavy, abrasive tool over the trees, causing damage

Cat Track Drag

The following describes a producer-built bark scraper that would have the weight to break off a lot of aspen at the crowns.

In 2005, Lyle McKay at Glenella, Manitoba built a drag that consisted of a large beam in front with two perpendicular rows of cat tracks, seven in the front and six in the back row. Each bulldozer track, with the pads still on, was 11 feet long and attached together with high strength industrial chain. The unit was 18 feet wide.

He dragged this unit with a cat over a previously rolled bush area that had re-growth coming back. The unit not only did a good job of scraping the re-growth, but also smashed up the old debris from a previous drum roller treatment.

Lyle mentioned the unit was harder to pull than a drum but using a cat at a cost of $100/hour, averaging 3.5 mph, the cost per acre was only about $26/acre.

Bark scraper made out of used bulldozer tracks.
Photo: Ron Moss

Bark scraper on the second pass on a demonstration project at Ashville, Manitoba, 2002.
Photo: Bill Gardiner

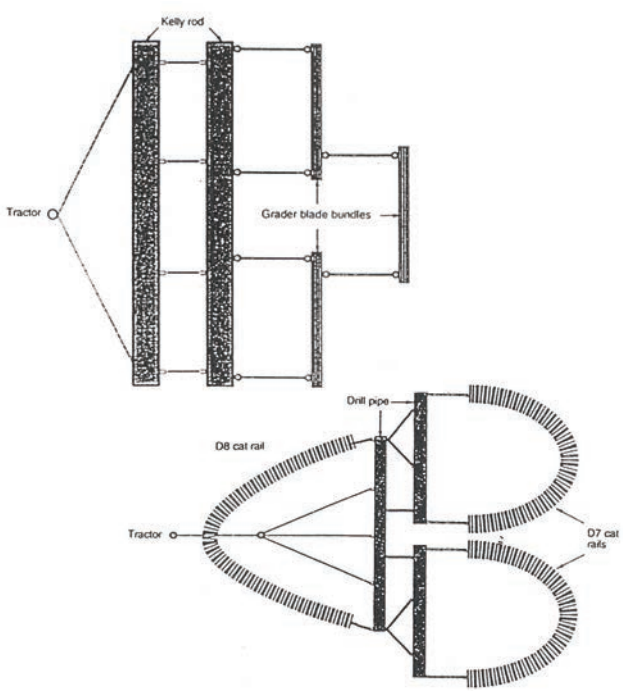
to the outer bark. The cambium of the tree, which lies just under the bark, is exposed or damaged. This reduces or stops the flow of nutrients and water to upper parts of the tree.

Bark scrapers, designed to remove bark from the stems of aspen trees, have been used successfully in Alberta to control aspen.

Findings of recent research:

- Best time to scrape is from June 15 to the end of July.
- In small aspen, 3-4 cm in diameter and 2-3 meters high, 91% kill can be obtained in good growing conditions and with smaller juvenile aspen, up to 75% kill.
- Small aspen are easier to kill than juvenile since they do not have sufficient wood strength for the scraper to remove bark; larger trees protect smaller ones from contact with the bark scraper.
- In poor growing conditions, 73-83% kill of small aspen is achieved.
- More effective at reducing aspen canopy cover on a good growing area, than one in poor condition.
- In small balsam, (3 cm diameter, 2-3 meters tall) 74% kill can be obtained in good growing conditions.
- Death of aspen and balsam increased for two years after treatment.
- Aspen die better when stems are broken off instead of just bent over.
- Breaking the stem at the crown kills juvenile aspen more effectively.
- If canopy cover is high one year after the treatment, (which can happen when the original aspen and balsam density is high), repeat the treatment.
- Second scrape should be at right angles to the first scrape.
- Do not scrape aspen and balsam over 2.5 meters because dead wood remains on the soil surface for a long time and can hinder any future scrapes.

Figure 1. Construction of two different scrapers. (Bowes 1995)



Bark scraping exposes the cambium (under the bark), interrupting nutrient flow from the aspen roots to the leaves. Photo: Bill Gardiner

- Forage yield increased on a site with good growing conditions but not on the sites with poor growing conditions.
- Bark scrape every 5-7 years.
- The key to the successful use of a grader blade scraper is keeping the blades sharp to get good scrapes.
- Scraper is most effective for control of aspen when diameter is small and density is low.

Girdling

This method is done by hand to remove a strip of bark around the circumference of a mature, single-trunk tree or shrub. The removed strip must be cut deep enough into the trunk to remove the vascular cambium, or inner bark, which is the thin layer of living tissue that moves sugars and other carbohydrates between areas of production (leaves), storage (roots), and growing points. The inner cambium layer also produces all new wood and bark. This technique does not affect the production of auxin (see Chapter 2) while the tree is being killed, so suckering is not stimulated.

How to girdle a tree:

- Cut parallel lines approximately 3 inches (8 cm) or more apart, around the circumference of the tree (Tu et al. 2001).
- These cuts can be made using a knife, axe, or saw and should be slightly deeper than the cambium (a hand tool is available from True North called “The Barkblaster”, which makes a 1 inch cut).
- Strike the trunk sharply between cuts, using the back of an axe or other blunt object. The bark should come off in large pieces and prevent the tree from any further growth. It is important not to cut too deeply into the trunk because this could cause the tree to snap and fall in high winds.
- To determine the depth of the cambium, make two short test cuts and strike the bark between the cuts. After several strikes, the bark should come off intact, exposing the cambium and wood (xylem) below.

**The mechanical technique described in this section has been summarized from the “Weed Control Methods Handbook, The Nature Conservancy” (Tu et al. 2001)

Photo: Barbara Westfall

Girdling is effective against aspen, pines, some oaks and some maples. This technique is unsuitable with some tree and shrub species. Their response is to produce more fast-growing root and stem sprouts.

Positives and negatives:

- Requires less labour than cutting and removal.
- Inexpensive and kills only targeted plants.
- Labour intensive and not widely accepted for larger acreages.

Gyro Mower

Gyro mowers (rotary mowers) consist of one or more powered blades that are designed to sever and shred above-ground vegetation. Mowers are available as pull-type, integral (three-point hitch or front mounted), boom attachments or self-propelled models. They range in size from small mowers suited to cutting grass and the occasional shrub, to large machines capable of mowing and mulching trees up to 4 inches (10 cm) in diameter.

Pull-type brush mowers are used to control woody growth up to 2 inches (5 cm) in diameter.
Photo: Bill Gardiner

Pull-type and three-point hitch mowers are most common. They are economical, available in several sizes and may be used with most standard farm tractors. Control of woody growth up to 2 inches (5 cm) in diameter is their main use.

They vary from rotary mowers, with a single gear box, with a cutting width from 5-7 feet (1-2 meters) to multi-rotor (triplex models) with three gear boxes, cutting swaths from 15-20 feet (4.5-6 meters). The large, triplex models are hinged with two rotor sections, that fold up for transport or when a narrower swath is desired.

Specialized mowers for clearing in less accessible locations are also available. Some have been developed for trimming bush under fence-lines.

Self-propelled models are the most powerful, heavy-duty rotary mowers available. Specifically designed for mowing brush, these mowers are not just attachments but an integral part of the tractor unit. Mowers are front mounted and usually consist of two hydraulically-driven rotors. Self-propelled models are more expensive but more suited to rougher terrain and larger vegetation (up to 4 inches (10 cm) in diameter).

Front-mounted tractor mowers and self-contained, self-propelled models have brush bars attached to the mowing table. These help push the vegetation over and feed it under the blades, as the machine moves forward. The mower deck can be lifted and progressively lowered until the trees are trimmed to the desired height. As with any of the mowers, one or more passes may be needed to mow/mulch the woody material to the desired height.

Ground crews with chain saws sometimes accompany the machine, to hand fall larger trees.

The main advantage of rotary mowers is the minimal soil disturbance of their mode of action. They also eliminate the need for piling trash, since the above-ground vegetation is mulched and spread. Rotary mowers work well for shrubs and small trees. Once the tree stems become too large (over 10 cm) it takes

too long to mulch the trunks. It is more economical to use different bush management techniques.

Degelman Wetblade mower at the Nature Conservancy "Yellow Quill" site, Aweme, Manitoba, fall 2007. Photo: Ron Moss

Two manufacturers have developed a method of incorporating herbicide at the same time the mower is mulching. One unit is called a "Brown Brush Monitor" and sells as a self-contained unit. This machine has a separate chamber with a spray nozzle and wick (drape) on the back of the machine. The second system is called a "Wet Blade" and the company either sells it as a complete unit called a "Diamond Mower" in the United States and in Canada, the herbicide application system has been added to Degelman mowers. The herbicide comes through the center (shaft) of the blade and is forced out along the edge of the blade by its spinning action. The chemical is applied to the stump.

Rotary cutters can be easily damaged by stumps, rocks and frozen anthills. Chains instead of cutting bars can be an advantage. The Prairie Agricultural Machinery Institute (PAMI) tested the use of chains instead of blades. PFRA tried using chains and operators had the following comments:

- Chains worked well in lighter brush; however, there was more stress on the machinery than with blades, in the heavier bush.
- The chains had a tendency to wrap around trees causing the rotary mower to shake more than with blades.
- The stumps were smashed more than with a blade and this probably would increase the rate of decomposition.
- Chains had a tendency to throw more debris and a shield was required on the back of the tractor to protect the operator.

Several ranchers and range managers in Alberta preferred a dull blade (flail) over a sharp blade. They felt more stems died if they were shattered rather than cut. They were also concerned about hoof and leg injury to livestock from the sharp points of cut stems. Some preferred the mower cut height somewhat higher, at about 8-10 inches (20-25 cm) high. Alberta has a lot of western snowberry in the Parkland region and many ranchers depend on the gyro-mower to manage these mostly unpalatable shrubs.

Operator observations and comments included the following:

- When the bush was about one inch in diameter at the base, they could move along at 3 mph covering 2 acres/hour. In the 3-4 inch (7-10 cm) diameter bush, they would only be able to do about 1 acre/hour. If they were in a lot of rock, it slowed down the operation considerably.

The 7 foot mower had more torque and didn't pull down the rpm's, allowing the operation to go much faster. The "push bar" on the 7 foot mower pushed down the trees ahead, making cutting easier.

- Trees up to 6 feet, are shredded after mulching.
- Cutting, between June 15 and July 15, will inhibit regeneration or suckering.

FOLLOW-UP TREATMENTS

As mentioned in the above sections, with the exception of bark girdling or a mower applying herbicide at the same time, a re-treatment will be required.

Regeneration will be inhibited and surviving re-growth reduced in height, if:

- The first treatment is done during the critical time for the trees or when the root supplies are at their lowest level.
- Followed by intensive grazing in the year of treatment and at least the following two years.
- In most cases, a follow-up treatment will be required, other than livestock grazing.

Breaking and Seeding

Breaking and seeding has been used to knock down and chop up regenerating aspen or following land clearing. Normally, it does not control re-growth unless the land is seeded to annual crops for several consecutive years before it is seeded to perennial pasture.

A second option is to wait until at least the second growing season, apply herbicide to kill the tree regeneration, then break and seed. Legumes are killed by the herbicides used to control re-growth, therefore seeding before the re-growth is controlled, limits the options to fire, a second mechanical treatment or applying herbicide with a wiper. New seedlings are vulnerable to grazing, so livestock can only be used for re-growth control before the seedlings emerge.

1. Land clearing Photo: Jason Kosowan

2. Seeding Photo: Jason Kosowan

3. Incorporation of seed using harrows
Photo: Jason Kosowan

4. Forage growth Photo: Jason Kosowan

Broadcast Seeding

After a mechanical treatment, some pasture managers have broadcast seed on the newly-opened areas. This provided forage for livestock. Even if the broadcast varieties were short-lived, it was incentive for the cattle to be in the area, augmenting control of re-growth.

Seed has been broadcast using airplanes, quads, or broadcasters on the back of tractors. In other cases, sod seeders or old drills have been used.

With any broadcasting or sod seeding, the results are variable, depending on weather conditions and how much ground cover already exists. If

there has been little soil disturbance by the bulldozer during clearing, there will probably be a good forage ground cover the first grazing season. Usually, these areas have a good seed bank already in the soil, just waiting to grow when conditions are right. If managers wish to increase the legume content, this should be done as soon as possible after the area has been opened up and before seed varieties already present in the soil create too much competition.

As mentioned in the breaking and seeding section, the options of re-growth control are limited due to the legumes. The use of chemical by spraying to control the regeneration will kill the legumes. Chemical can be incorporated with a wiper to selectively kill the re-growth without harming the legumes.

Keeping the legume component high in a forage stand is important. It provides higher protein content than grass alone, which is important for growth and milking ability in the cattle. Secondly, most legumes have a symbiotic relationship with specific bacterial organisms in the soil. The bacteria produce nitrogen, which is released into the soil and utilized by the grasses. Nitrogen provided by the legumes is a low cost method of increasing the production of the forage stand.

Table 2. Summary of treatments.

Method	Size of Trees	Timing	Most Effective control of re-growth	Follow up Treatments Required	$Cost/acre 2006 - 07
Clearing - walking down	2-14 inch	all year	at full leaf stage	yes	$140 - 290/acre
Clearing - V cutter	2 -8 inch				
Ball & Chain	2 - 8 inch	all year	at full leaf stage	Yes	*$60 - 75/acre
Break & Seed				Yes	
Broadcasting/sod seeding		spring, fall or dormant seeding	best before competition	Yes	
Drum	up to 8 inch	all year	At full leaf	Yes	$40 - $72
Drum Chopper	up to 4 inch	all year	at full leaf stage	Yes	$40 - $72
Drag	up to 2-3 inch	all year	at full leaf stage		$20-30
Gyro-mowing	best up to 2 inch but could do to 4 inch	all year	at full leaf stage	Yes	$39 - $100 $300 per acre with big self propelled
Bark Scraping	Up to 2 m high		At full leaf stage	Yes	$15 - $30

* based on 1965 publication "Brush Control in Western Canada" - ball & chain 1/4 to 1/5 cost of bulldozer. Burning & piling added another approximately 25 % to the cost depending upon success of the burn.

Chemical

If a chemical treatment is chosen to follow the mechanical treatment, it should be done within 2-4 years, before it gets too tall for the equipment you will be using.

The important point is to apply the appropriate chemical in sufficient amounts to kill the majority of re-growth. If not, you will have to repeat the treatment within a few years.

- If aspen cover is greater than 10% of soil surface one year after the herbicide treatment, then in fifteen years, aspen will cover 80% of the site.
- If aspen covers 2-5% of the soil surface, then it will take 42 years to cover 80% of the area.
- If aspen cover is 0.5-2%, it takes 63 years for aspen canopy to cover 80% of the soil surface. (Bowes 1996)

If a chemical treatment is chosen to follow the mechanical treatment, it should be done within 2-4 years. Photo: Ron Moss

Burning

Sufficient forage fuel must be available in order to carry out a successful burn. It has been determined that at least 1000 pounds/acre is required. Burning should be left until at least the third year following a mechanical treatment. Grazing early in high moisture areas can be done during the second year. However, there should be no grazing in drier areas, in order to obtain sufficient fuel for the burn in fall of the second year or spring of the third year.

Burning should be left until at least the third year following a mechanical treatment. Photo: Bill Gardiner

Normally, since there is a lot of debris, a fire guard should be bladed around the site. As mentioned before using fire to clean up the site is difficult since the debris is scattered and not in a dense pile unless a cat was used.

Follow up-burns, two to three years apart, or some other form of treatment will likely be required to hold the ground cover density of trees in check.

Mechanical

As mentioned above, the follow-up treatment can be another form of mechanical treatment. It will be less costly and more effective if done when re-growth is small. With small diameter trees and shrubs, a rotary mower can remove the re-growth. Once it is larger, a bark scraper or a drag could be used.

Depending on the operator's success using livestock to control re-growth, a third treatment will be required in the future.

Some producers may not want to use chemicals. If this is the case, they will have to

be particularly vigilant to prevent re-growth getting too high for mechanical methods. Mechanical treatments will not hurt the forage underneath.

WILDLIFE HABITAT

A mix of open grasslands and treed areas are beneficial for both wildlife and domestic livestock. Photo: Ron Moss

Removing mature trees or older re-growth, using mechanical treatments will enhance edible tree forage for big game animals. A mix of open grasslands and treed areas are beneficial for both wildlife and domestic livestock. There is a greater amount of re-growth along the edge available to wildlife by leaving a portion of the grazing lands in forest. The residual forest provides shelter in winter and summer to both livestock and wildlife.

As long as treed areas are left in a pasture, re-growth will spread out from the edge of the tree lines, creating forage and habitat for browsing ungulates.

GRAZING

Grazing is a mechanical treatment involving shearing or breaking grasses and browse (leaves and twigs). It is often an overlooked, important part of the brush management program. Many trees and shrubs have palatable leaves and current year's growth of stems. Livestock use these as forages when managed appropriately. When palatable brush is combined with grasses, forbs and sedges as a part of the diet, it can be converted into food for livestock.

CONCLUSIONS

Selection of mechanical treatments should be based on the size of the trees and whether there will be follow-up treatments. For large trees, 6 inch (15 cm) diameter and up, a bulldozer may be the only option unless herbicide and fire are used before the mechanical treatment. For large re-growth,(twenty feet in height and up to 6 inch (15 cm) diameter), the roller chopper or smooth drum is an option, as long as the equipment can walk over the trees, flattening them to the ground. As the tree density and diameter increases, the amount of debris left on the ground will increase.

Grazing is often an overlooked, important part of the brush management program. Photo: Bill Gardiner

In smaller re-growth, especially if it does not have sufficient wood strength for the bark scrapers, the use of rotary mowers may be a good option. If the diameter is over 1-2 inches (up to 5 cm) or the area is very rocky, the time required for a rotary mower will be increased considerably. Bark scrapers work best for low density re-growth up 2 meters, simply because of the debris left on the surface.

The important thing is to use a bush management tool on re-growth while it is between 2-3 meters high. If it is a site where top growth has been removed and/or contains a lot of balsam poplar, it may become too large for most ground equipment to be used, by the third year. It is critical that the bush in a pasture be monitored and a management plan is in place. Even with a lot of debris on the ground, livestock will use an area. Once the bush becomes too high and dense, livestock grazing is reduced. Open grasslands will have 3 to 4 times the carrying capacity for livestock compared to forested areas.

The final point to keep in mind is that an integrated brush management plan can save a lot of time and money. Mechanical controls are management tools that must be used in a timely manner to provide effective, long-term results.

Photo: Bill Gardiner

Mechanical Economics

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height Ft. Diameter-In.	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr.) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
1. Mowing	8-10 ft. 3 in.	$40-100	2150	$14		
3. Bark Scraping	8-10 ft. 3 in.	$15-30	2150	$14		
4. Drum/Roller Chopper	12-15 ft. 4-8 in.	$40-75	7100	$45		
5. Mechanical Clearing	mature	$150-300	7100	$45		

* 25 lbs forage = 0.80¢

Mechanical methods will normally require a follow up treatment.

Equipment Sources:

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Degelman Industries, Regina – retailer for the "wet blade"

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MECHANICAL CHAPTER GLOSSARY

Apical Dominancy – Terminal buds control apical dominance on buds that grow farther back on the limb. They produce a hormone called auxin that inhibits growth of lateral buds. Apical dominance determines a plant's natural branching habit and its response to pruning. It produces orderly, controlled growth and gives plants their characteristic shape. When the terminal bud is gone, apical dominance is eliminated and growth of the plant is altered as other buds begin to grow.

Ball and Chain – PFRA's ball and chain for knocking down trees, consisted of a 4-4½ ton ball, with 80-130 feet of chain attached on either side. The chain weighed 50 pounds per foot. A 150 hp dozer, was attached to each end of the chain. The unit was pulled through the trees, knocking them down in a 40-70 foot swath. The Saskatchewan Provincial Pastures used a chain with four 1500 pound weights spaced out on the chain. This worked equally well for them.

Carrying Capacity – The long term or average number of animals a field or pasture can accommodate and still leave adequate residue, litter or forage.

Drag – A very heavy bark scraper made of materials the producer or land manager has available. Some are made of grader blades or I-beams. Most have a larger beam with attachments behind such as vertical or horizontal bulldozer tracks, railway steel rails, etc.

Gyro Mower (Rotary Mower) – Heavy duty rotary mowers for cutting brush and trees. Models are three-point hitch, pull type, mounted to front loaders or self-propelled units, varying in width from 5-20 feet.

Flail Mowers – A gyro mower with a dull blade or cable, which shatters the shrub and tree stump, instead of cutting it off smoothly.

Rollers (Smooth Drums) – A heavy drum, varying in diameter, from 4-8 feet. The rollers used for bush are basically the same as ones used as packers by crop farmers. They do require stronger hitches, because of the physical abuse from rolling down the trees. The drums are usually made out of heavy metal to prevent denting from rocks and possible leaking of fluid, if they are filled (for extra weight).

Roller Choppers (Drum Choppers) – Same as roller or smooth drum, but have many individual cutting blades perpendicular to the drum or full length lugs or blades across the width of the drum, which chop the trees into smaller pieces.

Shear Blades (Cutters) – Sharp bulldozer blade, mounted on a bulldozer, for cutting the tree off at ground level, leaving the below-ground level material intact in the soil.

Side Cutter – Blade is angled one way, cutting the trees off and pushing debris to the side. Can be hard on the bulldozer, since it is pulling one way all the time and the operator is always correcting with the same steering clutch, causing wear.

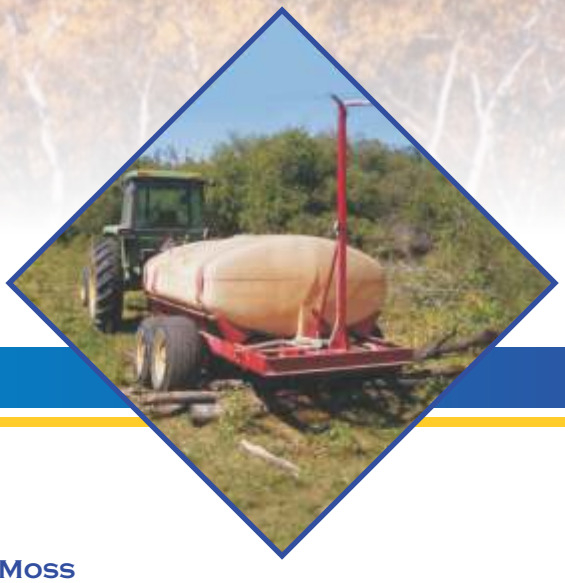
Terminal Leaf – The leaf at the end of a stem or branch on a plant.

Walking Down (Tramping) – The power and weight of a bulldozer pushing trees down. When a smaller bulldozer is being used, the operator will have the blade up high and the machine will climb up the tree, using its weight to push it down.

V-cutter – The dozer blade is V-shaped or forms a point. The blade cuts off the trees pushing, them horizontally or to the side, as the caterpillar moves along.

CHAPTER FOUR

Brush Management Using Herbicides



Bill Gardiner
Farm Production Extension – Range & Pasture
Manitoba Agriculture, Food and Rural Initiatives
Dauphin, Manitoba
bill.gardiner@gov.mb.ca

Barry Gibbs, P. Ag.
Product Registration Manager
Dow AgroSciences Canada Inc.
Calgary, Alberta
bkgibbs@dow.com

Ron Moss
Technical Transfer Coordinator
Agriculture and Agri-Food Canada/
Agriculture et Agroalimentaire Canada
PFRA Community Pastures
Dauphin, Manitoba
mossr@agr.gc.ca

OVERVIEW

- All herbicides sold in Canada are licensed for use under regulations of the Pest Control Product Act. The Pest Management Regulatory Agency (Health Canada) is responsible for implementing those regulations.
- Herbicide use can be an effective method of brush management and is most effective when combined with other techniques and/or follow-up treatments (which could include herbicides) in a long term integrated vegetation management plan.
- Stage of growth is an important factor in herbicide selection.
- Most chemicals work best if they are applied when the plants are actively growing and at an early stage of growth.
- Weather conditions and water solution play an important role regarding effectiveness.
- Herbicides may be applied via aerial or ground application.

Photo: Bill Gardiner

- Aerial application has been the most common method and is generally more feasible for large areas, inaccessible and/or rough terrain areas and in areas with high density brush. Ground application is generally more feasible for smaller acreages and for areas with spotty or low density brush.

- The main disadvantage of ground application methods has been the unavailability of specialized equipment.

- Boomless nozzles have enhanced the feasibility of ground applied herbicide.

- Wipers have the ability to apply the herbicide selectively, thereby not affecting the underlying vegetation (i.e. grasses, forbs and legumes) and can be used in areas of high density or low density brush.

- Tracking and measuring devices are extremely important to ensure proper coverage for both aerial and ground application.

- To best manage any particular site the proper herbicide and method of application must be matched.

INTRODUCTION

Herbicides have been used for brush management purposes since the 1960's when 2,4-D was the predominant chemical used. Several new registered products have become available for use on a variety of brush species and at various stages of their growth.

All herbicides sold in Canada are licensed for use under regulations of the Pest Control Products Act. The Pest Management Regulatory Agency, Health Canada is responsible for implementing those regulations.

Different herbicides are recommended for various species of brush. In addition, some herbicides offer fairly long term control for some bush species while others act more as a suppressant for other species. Studies and research have shown that herbicides do provide increased forage yields (Bowes 1996) and that herbicide can be effective in itself, but is most effective when combined with other techniques in a long-term, integrated vegetation management plan.

Wipers have the ability to apply herbicide selectively, thereby not affecting the underlying vegetation including grasses, forbs and legumes.
Photo: Dow AgroSciences

Aspen cover as a percentage of soil surface following treatment	Number of years for aspen to regrow to cover 80% of soil surface
10%	15 years
2 – 5%	42 years
0.5 – 2%	63 years

Herbicide and its application is costly. It is extremely important to attain long term control. Herbicides should be combined with proper grazing management (refer to Grazing Chapter for more information) and other tools such as fire to lengthen the interval between applications. Bowes (1996) estimated the timing for aspen re-growth, based on the percentage of aspen cover (i.e. suckers) following a herbicide treatment.

In this chapter, herbicides are identified by the active ingredient. Companies will market the active ingredient in one or more formulations under one or more brand names. As an example, glyphosate is an active ingredient. Several companies market branded glysophate products like Roundup Transorb® (360 g/L) by Monsanto or Vantage Forestry® (356 g/L) by Dow AgroSciences.

Table 1 provides general information relative to available registered products and application equipment options. More detailed information on the specifics of the various products and application options is provided in the appendix of the Herbicide Chapter.

Stages of Growth

Choice and effectiveness of a herbicide treatment is dependent on growth stage. Growth stages are defined in 3 categories as follows:

Full Canopy

Trees are at or near full mature height.

Note: Herbicide application has not been common at this stage. Some applications have been done in conjunction with timber harvesting. The mature trees are sprayed prior to harvesting as a pre-harvest method of controlling regeneration.

Table 1. Registered herbicide and application equipment options

	Broadcast Application		Selective Application Equipment			
				Hose & Hand gun, Backpack, ATV		
Herbicide	Ground	Aerial	Wiper	Individual plant	Cut Stump	Basal Bark
	Sprayer; boom or boom less	Fixed wing or helicopter				
2, 4-D	X	X		X		
Dicamba	X	X*		X		
Glyphosate	X	X*	X	X	X	
Picloram	X	X		X	X	
Triclopyr	X	X		X	X	X
Metsulfuron	X			X		

* Not registered on all labels. Read label before using.

Choice of herbicide should be based on identified target species.

Sapling

Trees are 10-15 feet tall and still actively growing.

Note: Herbicide application is used and can be effective at this stage, although the height of trees may restrict some types of ground application (i.e. aerial application is more commonly used).

Overall Note: *The majority of bush vegetation is generally characterized as having an upper and lower canopy. Treatment of the upper canopy can stimulate growth of low growing shrubs in the lower canopy, re-emphasizing the importance of a well balanced long term vegetation management plan incorporating such things as fire, grazing, follow-up herbicide treatments, etc.*

Suckering

Trees spread out from an existing mature stand and grow into an area which is open (commonly referred to as "edge effect").

Aspen will respond to an event such as fire, clearing or harvesting. After 2-3 years, suckers are between 5-8 feet tall (depending on location, soils, moisture).

Note: Herbicide application is commonly used at this stage as most chemicals work best when the plants are actively growing and at an early stage of growth. It is important that application does not take place too soon (i.e.1 year) after an event (i.e. fire, clearing, harvesting) as suckering is not yet complete.

Weather Conditions

Weather conditions play an important role relative to the use and effectiveness of herbicides. Weather factors to consider with the application of herbicides include temperature, wind velocity, absorption time requirement before a rain, frost, etc.

Herbicide application is used and can be effective at this stage. Photo: G. Oliver

Note: It is important to follow all label instructions with regard to any/all restrictions pertaining to weather conditions.

Water Solutions

Water quality, water volume, spray pattern and droplet size (mist vs. droplet) are all important factors relative to herbicide use and effectiveness.

Water quality is an important factor in the effectiveness of certain chemicals. For example, hard water ties up a percentage of the glyphosate and reduces effectiveness.

Most chemicals require a minimum of 20 gallons/acre to be effective. This volume ensures adequate coverage, as well as reducing potential re-drift. Spray pattern can also be an important factor as some chemicals such as Remedy® (active ingredient, triclopyr) require a finer mist like spray with coverage of the whole plant to be effective.

Note: It is important to follow all label instructions with regard to recommendations pertaining to water solution.

Nozzles

Nozzle selection is a very important factor in herbicide applications. Selection will vary depending on things such as herbicide, type of equipment, water volume and type of vegetation. (See Appendix 2)

METHODS OF APPLICATION

Application is particularly challenging on rangeland and pasture because of typical circumstances such as rough terrain, vegetation height and variation in vegetation height. It is therefore very important to match the herbicide and the method of application for best results. Also, the applicability of the various methods of application will be dictated by the vegetation management plan for the particular site.

As shown in Table 1, there are two main methods of herbicide application, ground vs. aerial. As a general rule, aerial application is more applicable or feasible on large areas or on areas of rough terrain. Ground application is more applicable for smaller areas and/or for selective or spot spraying. In addition, there are other types of selective application that are available for smaller scale purposes.

One of the limiting factors associated with ground application has been the unavailability of specialized commercial equipment, and the resulting requirement for the land managers to construct their own.

Ground application of herbicide is applied usually by one of the three following methods:

1. Sprayer with boomless nozzle

2. Sprayer with a boom

3. Wick (wiper)

This section will deal with the applicability of the various methods of application and their advantages and/or disadvantages relative to the vegetation management plan for that particular site.

- **Aerial Application**
- **Boomless Sprayer**
- **Boom Type Sprayers**
- **Wick (wiper)**
- **Individual Plant Treatments (hand wands)**
- **Cut Stumps**
- **Basal Bark Application (spraying of tree trunks)**

Photo: Ron Moss

Aerial Application

Aerial application (fixed wing or helicopter) has been the most commonly used method for brush management. It has been used successfully since the 1960's when 2,4-D was the predominant herbicide used.

Advantages	Disadvantages
Application time required (i.e. can cover a large area in a short time) and within a window of opportunity	Drift potential is higher than with ground application
Availability of numerous professional applicators (fixed wing and helicopter)	Wind can restrict ability to spray
Has application for inaccessible and rough terrain	Availability of professional applicators at window of opportunity may be limited during peak times of crop spraying
Can be used for all sizes of brush	Less able to spot spray or spray selectively
Helicopter is more flexible for spot spraying than fixed wing	
Can be used in areas with high density brush	
Uniform application can be achieved using GPS technology	

Photo: Bill Gardiner

Boomless Sprayer

The boomless nozzles have made construction of rugged pasture sprayers much easier and at a reduced cost compared to boom type sprayers. There are many boomless nozzles available on the market today. There are a number of companies making nozzles with different spray widths, spray patterns and volume capabilities.

The sprayer itself is generally built from old fertilizer carts or crop sprayers equipped with walking axles to smooth the ride.

Many different pumps can be used depending mainly on the pulling equipment used (i.e. hydraulic pump, if using a tractor). Gas pumps and diaphragm pumps are also available.

Advantages	Disadvantages
Lower maintenance cost than boom type sprayer due to reduced equipment damage associated with rough terrain	Specialized commercial equipment often unavailable
Can be used to spray higher vegetation than boom-type sprayer	Drift potential is higher than a boom-type sprayer
Capable of spraying into and across fence lines and areas boom-type sprayers are unable to traverse	Rough terrain, steep topography, stumps/debris and/or wet conditions can make ease of application extremely difficult and potentially unsafe
Ability to spot/select spray	GPS capabilities available, however uptake of technology is at early stage of adoption

Photo: Bill Gardiner

Boom Type Sprayers

The boom type sprayers are designed and built in a similar fashion to the boomless sprayer (i.e. old fertilizer cart or crop sprayer with walking axle) and usually have a reinforced boom to withstand the rough terrain. Most booms have height adjustment and break-away capability.

Advantages	Disadvantages
Drift potential is less than with boomless sprayer Ability to spot/select spray	Specialized commercial equipment often unavailable Higher maintenance cost than boomless sprayers due to higher equipment damage associated with rough terrain Rough terrain, steep topography, stumps/debris and/or wet conditions can make ease of application extremely difficult and potentially unsafe GPS capabilities available, however uptake of technology is at early stage of adoption

Photo: Ron Moss

Wick (wiper)

Wipers have been mounted on a variety of vehicles including skidders, ATV's, tracked vehicles and farm tractors.

The carpet itself is basically a non-rubber back carpet made of tough porous material. The carpet hangs in a loop from a frame and has chemical applied via nozzles which can direct the spray either up or down inside the carpet. The most durable carpet on the market is one called "ozite", however this carpet has to be specially ordered, since carpet retail outlets in Canada do not normally stock it.

This application method transfers the herbicide to the brush through physical contact between the carpet (wick) and the brush species. This method selectively controls some species and not others based on how tall each species is. The ability to adjust the height of the carpet to control only the taller species is crucial. Be sure to maintain a highly saturated carpet. This will ensure adequate uptake of herbicide, while minimizing dripping.

This technique has been used most often with the herbicide glyphosate, although some testing has been done with other products. Trials conducted to date suggest that this application is most effective for brush under 10 feet tall, mainly due to increased potential for equipment damage. Trials indicate that 1.5 L/acre of glyphosate is sufficient to obtain high kill ratios, however there will be some variation depending on the density of trees. A ratio of $^{1}/_{3}$ glyphosate to $^{2}/_{3}$ water is the most common mix used. A managed grazing prior to application to lower the height of the non-targeted desirable vegetation will also improve the effectiveness of the treatment (i.e. by allowing the carpet to be lowered and improve coverage on targeted species).

Advantages	Disadvantages
Selective application which controls the brush but avoids damage to grass, forbs and legumes	Limited acreage can be treated compared to aerial
Effectively eliminates off-target drift	Any dripping will kill underlying vegetation
Can be used in windier conditions than ground sprayers or aerial applications	Equipment maintenance and repair including wear and tear on carpet
Less water to haul	Limited availability of commercial wiping equipment
Wide window of application with glyphosate	GPS capabilities available, however uptake of technology is at early stage of adoption
Offers a ground application alternative when brush gets too tall for broadcast spray boom application	
Ability to spot/select spray	

Wick (Wiper)

Photo: Bill Gardiner

Photo: Ron Moss

Photo: Ron Moss

Individual Plant Treatments (hand wands)

This technique is commonly used in small or sensitive areas (i.e. fence lines, along trails, transmission lines) to control brush as part of an integrated brush management plan. The most common application equipment is an ATV-mounted sprayer or a backpack sprayer.

Advantages	Disadvantages
Effective technique in small or sensitive areas	Very labor intensive
Risk of damage to desirable species is greatly reduced	Not feasible for large areas

Cut Stumps

Both glyphosate and triclopyr are registered for this use. Directions for each herbicide are different so read label instructions before using. Hand wands are the mode of application.

Advantages	Disadvantages
Stops re-growth or suckering which eliminates need for re-treatment	Very labor intensive
Low environmental impact	Locating and/or keeping track of all the stumps can pose a problem, although use of a dye can help
Risk of damage to desirable species is greatly reduced	Application timing is crucial; must be applied the same day as tree cutting.
Minimal drift potential	
Wide window of application	

Note: *Two gyro mowers (Brown Brush monitor and wet blade) are available. They cut the trees and apply herbicide in the same operation.*

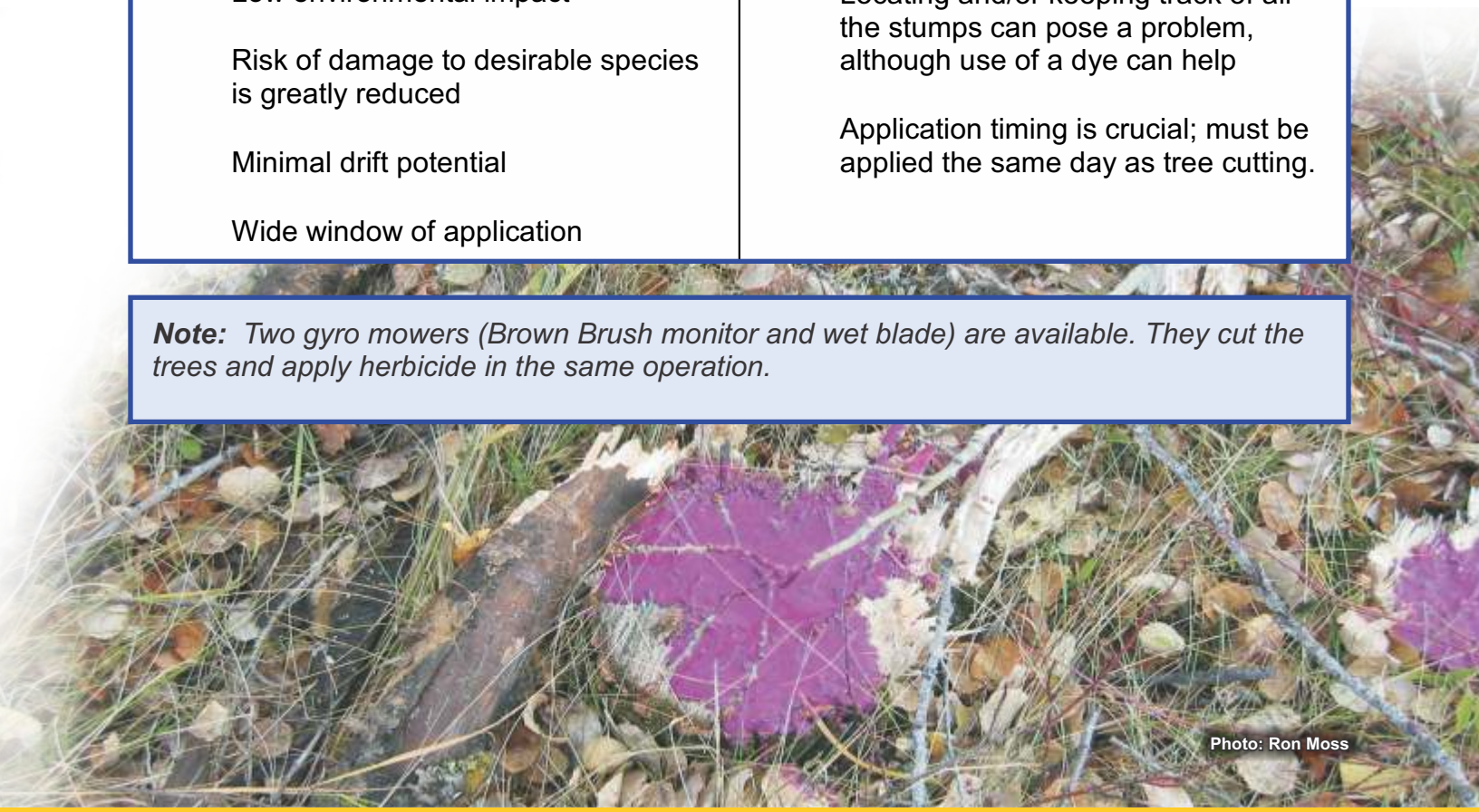


Photo: Ron Moss

Basal Bark Application (spraying of tree trunks)

This method involves spraying of tree trunks whereby a mixture of triclopyr and mineral or vegetable oil is applied (i.e. hand wand) to the base of the tree trunk. This type of application can be used along fence lines or along shelterbelts to remove the undesirable vegetation.

Advantages	Disadvantages
Long term control (i.e. stops suckering)	Very labor intensive
Minimal drift	Requires a supply of mineral or vegetable oil
Low environmental impact	
Risk of damage to desirable species is greatly reduced	
Wide window of application (i.e. can be done in wintertime)	

ENVIRONMENTAL CONSIDERATIONS

As different labels have different impacts, it is very important to read and follow all label restrictions and precautions before using any herbicide. In this regard, it is extremely important to observe all buffer zones to sensitive aquatic and terrestrial habitats.

With specific reference to wildlife and biodiversity, it is equally important to ensure that the herbicide does not leave the targeted area. It is the responsibility of the applicator to make management decisions to reduce the potential for spray drift.

CONCLUSION

Herbicide use can be an effective method of brush management. It is most effective when combined with other techniques or follow-up treatments. The goals and objectives of a long term integrated vegetation management plan will dictate the best treatment or combination and sequence of treatments.

Development of technology for ground application methods is essentially in the developmental stage. To a lesser degree, the best combination or sequence of treatments in the integrated vegetation management plan is also in the developmental stage. Improvements in the area of technology development will assist in all aspects of integrated brush management.

Herbicide Economics

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height-Ft./ Diameter-In.	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr.) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
2, 4-D	6-8 ft. 2 in.	$45	5500	$35		
Grazon®	8-10 ft. 3 in.	$80	5500	$35		
Round-up®, Wiping	8-10 ft. 3 in.	$30	5500	$35		

* 25 lbs forage = 0.80¢

- Very effective control (i.e. 98%) is necessary to increase the time interval before re-growth starts and maximize long term grass production.
- No long term research has been completed, which compares control and documents forage productivity of various herbicide options.
- Check label instructions for herbicidal effectiveness on targeted species. For example, if conditions are right 2, 4-D can be effective on 2-4 year old trembling aspen (white poplar), but not on balsam poplar (black poplar).

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Bowes, G., Aspen Sucker Control With Herbicides, 1996, Saskatoon Research Centre, Agriculture and Agri-Food Canada, Saskatoon, Saskatchewan

Bowes, G., Increased Forage Yield After Brush Control in Aspen Parkland, 1996, Saskatoon Research Centre, Agriculture and Agri-Food Canada, Saskatoon, Saskatchewan

Bowes, G., Wiper applied Herbicide to Manage Brush, 1994, 1996, Saskatoon Research Centre, Agriculture and Agri-Food Canada, Saskatoon, Saskatchewan

Dow AgroSciences, Basal Bark Application with Garlon *4® and Release*® Herbicide Fact Sheet

PART TWO
Herbicide Guide

The following information on herbicides is organized by active ingredient. There are often multiple branded products, manufacturers and selected use patterns by branded products.

2,4-D

Dicamba

Glyphosate

Metsulfuron

Picloram

Triclopyr

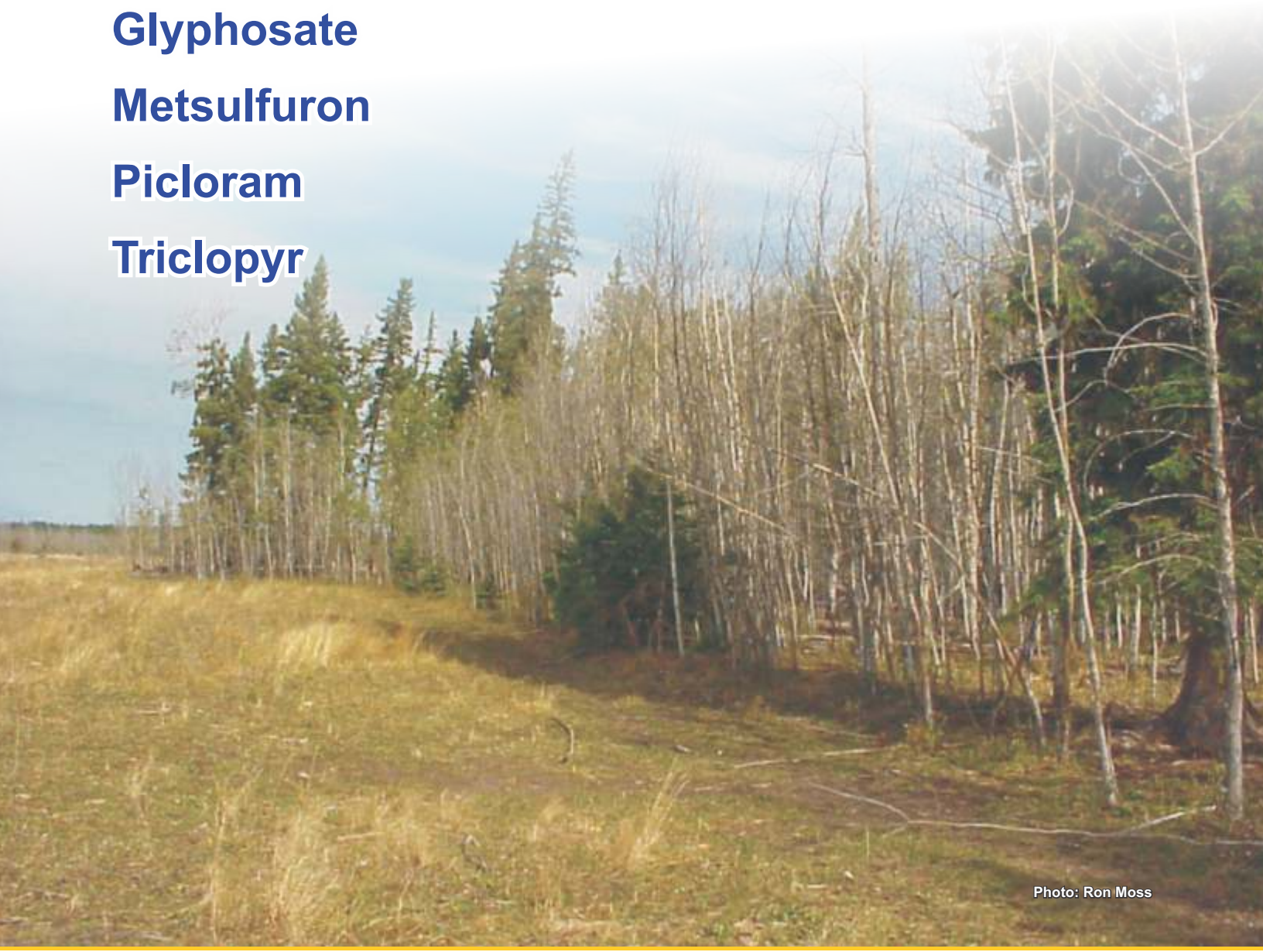


Photo: Ron Moss

2,4-D

Advantages	Disadvantages
Aerial registration	Short term results
Low Cost (rate dependent)	Forbs and legumes are controlled
Readily available	Not effective against Black Poplar
Degrades in soil rapidly	Most effective on young rapidly growing plants
Wide window of application	No residual effect on re-suckering aspen in the duration required for a follow-up treatment
Grasses are tolerant	
No residual effect on legumes	

1.Mode of action

- 2,4-D is a “growth regulator-type” herbicide (Group 4).

2. Timing of treatment

- Apply from the time leaves are fully open till 2-3 weeks prior to normal first frost. Best results are achieved when there is adequate soil moisture and good growing conditions.
- Best time to apply is early in the season; just after leaves are fully open.
- Apply to trees less than 3 meters tall. Taller trees should be cut and sprayed once re-growth has reached at least 0.6 meters.

3. Equipment requirements

Broadcast Ground

- 100-300 litres of water per hectare.

Broadcast Aerial

- 55 to 165 litres of water per hectare.

4. Effect on woody species

- Effects on a wide range of brush species.

5. Effect on herbaceous species

- Safe on grass species.
- Damages or controls a wide range of broadleaf plants including many weeds and legumes.

6. Impacts on wildlife and biodiversity

- Do not apply to any body of water.
- Buffer all aquatic, terrestrial and wildlife habitats.

7. Re-treatment period

- Expect to retreat.
- Described as a “chemical mowing” on many species (kills the above ground portion of the plant but leaves the root system alive to re-sucker).

8. Implications of using treatment

- 2,4-D is generally a short term solution in duration. Use must be part of a longer term strategy, incorporating other control techniques.
- 7-day grazing restriction.

9. Registered herbicides

Application	Rate	Species	Timing
Broadcast Ground & Aerial	845 g/ha - 3,102 g/ha***	Wide range of weed and brush species	After full leaf development

***Check label for correct rates.

Brand Names	Manufacturer	More Information
Numerous brands	Inter-provincial Cooperative Limited	www.ipco.ca phone local CO-OP
Numerous brands	Nufarm Agriculture Inc.	www.nufarm.ca 1-800-868-5444
Numerous brands	United Agri Products Canada Inc.	www.uap.ca 1-800-561-5444

Dicamba

Advantages	Disadvantages
Controls a wide range of weeds and brush species	Not registered on all labels
Widely available	Many forbs and legumes are controlled
Tank mixable with 2,4-D	Requires follow-up treatment
Grasses are tolerant	Most effective on young rapidly growing plants
Degrades relatively rapidly in soils	No residual effect on re-suckering aspen
Controls many 2,4-D tolerant plants	
No residual effect on legumes	

1. Mode of action

- Dicamba is a growth regulator type herbicide (Group 4).

2. Timing of treatment

- Dicamba, in tank mixes with 2,4-D, should be applied in spring or early summer, once leaves have fully expanded.
- Brush over 2 meters tall should be cut and re-growth treated when it develops.
- Apply when air temperatures are between 10°C and 25°C. Do not spray when temperatures are dropping in the evening or forecast to become hot (>28°C) during the day.

3. Equipment requirements

Broadcast Ground application

- 220-230 litres of water/hectare.

4. Effect on woody species

- Dicamba in a tank mix with 2,4-D, will control a very wide range of woody species.
- Spray drift must be controlled.

5. Effect on herbaceous species

- Dicamba in tank mix with 2,4-D is safe to grass, but will control or damage a wide range of forbs, especially legumes.

6. Impacts on wildlife and biodiversity

- Grazing restriction - delay grazing for 14 days after applying 2.3-4.6 litres of dicamba.

7. Re-treatment period

- Expect to re-treat, but at a greatly reduced density.

8. Implications of using treatment

- A dicamba/2,4-D tank mix application is generally short term in duration. Use must be part of a longer term strategy, incorporating other control techniques.

9. Registered herbicides

Application	Rate	Species	Timing
Ground	2.1 L of dicamba/1000 L of water + 2,4-D *either 4 L of amine 500 or 3.3 L of 2,4-D LV (600 g/l formulation)*	Alder, aspen poplar, cherry, western snowberry (buckbrush), wolf willow (silver willow) or wild rose	Spring or early summer
Ground	3.25 L/ha dicamba + 2,4-D *either 4.4 L/ha of 2,4-D amine 500 or 3.75 L/ha 2,4-D LV ester (600 g/L formulation)*	Aspen poplar	Spring or early summer

Brand Names	Manufacturer	More Information
Banvel II® herbicide	BASF Canada Inc	www.agsolutions.ca 1-877-371-2273
Oracle®	Gharda USA	www.uap.ca 1-800-561-5444

Glyphosate

Advantages	Disadvantages
Economical and widely available	Non-selective, kills grass
Wiper can be used for selective control of brush species	Glyphosate is a contact herbicide with no residual control
Broadcast applications: Non-selective, affects all plants, including grasses	Not registered for aerial application on rangeland or pasture, on any Canadian product label
Active on most plant species; grass, forbs and brush	Moderate to poor control of willow, red osier dogwood and alder
Cut stump application method	Aerial application registered on forestry glyphosate products only (Vision®, Vantage Forestry® & Forza®) but not for range and pasture use
Injection application method	Needs clean water as a carrier
Some authorities consider glyphosate an acceptable production tool for organic production (check before using)	Reduced herbicidal activity may result from applications to dusty leaf surfaces
Rapid deactivation on contact with soil	
No residual effect on legumes	

1. Mode of action

- Group 9 Herbicide. Glyphosate moves throughout the treated plant causing it to wilt and brown off. Activity is slow, taking 4 to 5 days or more for symptoms to appear.
- For brush, the slower-acting glyphosates are used with lower concentration of active ingredients (i.e. 356g/L).

2. Timing of treatment

- Wide window of application (June to end of August).

3. Equipment requirements

- Broadcast Applications: Ground (boom or boomless).
- 100-300 litres of water per hectare, using no more than 275 kPa pressure.
- Spray coverage should be uniform and complete.

Selective Applications: *Wiper*

- Adjust height of wiper to ensure contact with brush species.
- Avoid contact with desirable species, as they will be damaged.
- Avoid dripping the solution onto desirable plants, as they will be damaged.

Selective Applications: *Cut Stump*

- Use low pressure equipment.

4. Effect on woody species

- All woody species will be affected by glyphosate.

5. Effect on herbaceous species

- All grass species are susceptible.
- All broadleaf plants or forbs are susceptible.

6. Impacts on wildlife and biodiversity

- Buffer zones: for ground application, 15 meters to both terrestrial and aquatic habitats.

7. Re-treatment period

- No residual control is provided by glyphosate.
- Subsequent management plans will need to be developed and implemented.
- Expect to retreat within 3-5 years but at a reduced brush density.

8. Implications of using treatment

- No grazing restrictions.

9. Herbicides, species controlled, rates & timing (table)

Application	Rate	Species	Timing
Broadcast ground	2-4 L/ha	Birch, Cherry, Poplar, Western Snowberry, Willow	Summer through early fall, before leaf drop
Hand held high volume	0.67%-1.34% solution	Birch, Cherry, Poplar, Western Snowberry, Willow	Summer through early fall, before leaf drop
Broadcast ground	4 L/ha	Maple, Raspberry, Salmonberry, Alder	Late summer through fall. Fall is optimum
Hand held high volume	1.34% solution	Maple, Raspberry, Salmonberry, Alder	Late summer through fall. Fall is optimum
Wiper	22% solution	Birch, Cherry, Poplar, Western Snowberry, Willow	Summer through early fall, before leaf drop
Wiper	22% solution	Maple, Raspberry, Salmonberry, Alder	Late summer through fall. Fall is optimum
Cut Stump Application	0.33 L for every 5 cm DBH (DBH = diameter at breast height) (undiluted or diluted 1:1 with water)	Woody species Partial list of species controlled: Alder, Birch, Cedar, Cherry, Douglas Fir, Hemlock, Maple, Pine, Poplar, Willow	Freshly cut stumps, (within 5 minutes), any time of year except periods of heavy sap flow and freezing temperatures

Brand Names	Formulation	Manufacturer	More Information
Credit®	356 g/L	Nufarm	www.nufarm.ca 1-800-868-5444
Factor®	356 g/L	IPCO	www.ipco.ca 1-204-233-3461
Glyfos®	360 g/L	Cheminova	1-800-316-6260
Maverick®	356 g/L	Dow AgroSciences	www.dowagro.ca 1-800-667-3852
Renegade®	356 g/L	Monsanto	www.monsanto.ca 1-800-667-4944
Roundup WeatherMax®	540 g/L	Monsanto	www.monsanto.ca 1-800-667-4944
Touchdown iQ®	360 g/L	Syngenta	www.syngenta.ca 1-800665-9250
Vantage Plus Max®	480 g/L	Dow AgroSciences	www.dowagro.ca 1-800-667-3852
*Vantage Forestry®	356 g/L	Dow AgroSciences	www.dowagro.ca 1-800-667-3852
Vantage®	356 g/L	Dow AgroSciences	www.dowagro.ca 1-800-667-3852
*Vision® (Forestry)	356 g/L	Monsanto	www.monsanto.ca 1-800-667-4944
*Vision Max® (Forestry)	540 g/L	Monsanto	www.monsanto.ca 1-800-667-4944

*Registered for aerial broadcast application on the following forestry labels:
Monsanto - Vision® - 356 and Vision Max® - 540
Chemi-Nova - Forsa® - 360

Metsulfuron

Advantages	Disadvantages
Registered for control of some brush species	No aerial application registration
Safe for grass species	Legumes and some broadleaf plants (forbs) susceptible Residues prevent re-establishment of legumes for a number of years Limited to brush less than 2.5 meters in height Cost

1. Mode of action

- Metsulfuron is an ALS-inhibitor herbicide (Group 2).

2. Timing of treatment

- Apply when actively growing, after full leaf out and before turning colour in the fall (mid-June to mid-August). Apply to brush less than 2.5 meters tall.
- For brush, over 2.5 meters, cut down and spray re-growth.

3. Equipment requirements

- Broadcast ground: apply with a surfactant & 100-150 litres water/hectare.
- High volume directed spray: Mix with water and apply at rates up to 2000 litres/hectare.

4. Effect on woody species

- Registered for control of Western snowberry, rose, balsam poplar, willow, cherry and trembling aspen.

5. Effect on herbaceous species

- Controls a number of forbs (broadleaf plants).

6. Impacts on wildlife and biodiversity

- Aquatic and wildlife habitats require 15-45 meter buffer zones.
- Do not apply to bodies of water.

7. Re-treatment period

- Rate dependent. Residues provide extended control.

8. Implications of using treatment

- No grazing restrictions.

9. Registered herbicides

Application	Rate	Species	Timing
Low & high volume foliar broadcast	25 g/ha	Western Snowberry (buckbrush)	Mid-June to mid-August
	30 g/ha	Wild rose	Mid-June to mid-August
	100 g/ha	Balsam poplar (black poplar) & willow	Mid-June to mid-August
	150 g/ha	Cherry & trembling aspen	Mid-June to mid-August

Brand Names	Manufacturer	More Information
Escort®	DuPont	www.dupont.ca/ag

Picloram/2,4-D

Advantages	Disadvantages
Effective on a wide range of brush species, including basal sprouting and root-suckering species	Most forbs and legumes are susceptible and will be affected
Slow degradation means relatively long lasting brush control	Cost for brush control
Safe to grass species	Residues prevent the re-establishment of forage legumes for up to 5 years
Aerial application	Effects of unintended off-target drift can be long lasting
Highly active	
More effective than triclopyr on larger trees (greater than 1.5 meters)	

1. Mode of action

- Only registered brush control use for picloram is a co-formulated liquid herbicide containing picloram and 2,4-D.

- Growth regulator type herbicide (Group 4).

2. Timing of treatment

- Apply following full leaf development and during periods of active growth for best results. Late summer application or application during dry weather when plants are not actively growing may result in unsatisfactory results.

3. Equipment requirements

Broadcast Ground application

- Apply with a minimum of 200 L/ha of water.

- Use nozzles that produce large droplets and use no more than 207 kPa pressure when spraying.

Broadcast Aerial application

- Fixed wing or rotary wing (helicopter) aircraft.
- Apply with a minimum of 50 L/ha of water.

4. Effect on woody species

- Picloram/2,4-D liquid affects most woody species.

5. Effect on herbaceous species

- Safe on grass.
- Has activity on most forbs and legumes.

6. Impacts on wildlife and biodiversity

- Do not spray any body of water.
- Maintain buffers around all desirable or non-target terrestrial and aquatic habitats.

7. Re-treatment period

- Picloram/2,4-D liquid provides residual weed control for several years.
- Expect to retreat every 5-7 years, at greatly reduced densities.

8. Implications of using treatment

- Picloram residues pass through animals unchanged and are still herbicidal active.
- Clippings (hay) from treated vegetation should not be used for composting or mulching or application to fields to be planted to sensitive crops.
- Manure from animals grazing treated areas should not be used around susceptible plants.

9. Registered herbicides

Application	Rate	Species	Timing
Broadcast: ground & aerial	10 L/ha	Aspen, alder, birch, maple, pine, poplar, willow and other species	Active growth period following full leaf development Trees less than 1.5 meters tall
Broadcast: ground & aerial	15-25 L/ha	Aspen, alder, birch, cedar, maple, pine, poplar, spruce, willow and other species	Active growth period following full leaf development Trees greater than 1.5 meters tall

Brand Names	Manufacturer	More Information
Grazon®	Dow AgroSciences	www.dowagro.ca 1-800-667-3852

Triclopyr

Advantages	Disadvantages
Registered for aerial application	Cost
Individual plant treatments-basal bark & cut stump	No control of new germinating seedlings
Excellent efficacy due to translocation	Poor buckbrush control (Western snowberry)
Five years before re-treatment	Not effective when used in a wiper
Safe to grass species	
Controls a wide range of brush species	

1. Mode of action

- Triclopyr is a "growth regulator-type herbicide" (Group 4).

2. Timing of treatment

Broadcast Ground, Broadcast Aerial and Single Stem Foliar applications

- For most species, apply after full leaf development and while actively growing. Apply up to 10 days before fall leaf colour change.
- For Balsam poplar (black poplar) and hardwood species, apply early in the season, after full leaf expansion and before the leaf cuticle thickens and the leaves become waxy/leathery.

Individual plant treatments; basal bark and cut-stump

- Apply any time during spring, summer and fall, except when snow or water prevents spraying at the proper height.

3. Equipment requirements

Broadcast Ground Applications

- Uniform coverage is critical for consistent, long term results, 40 g/ac minimum.

Single Stem Foliar (ground) Application (trees less than 2.5 meters)

- Use a hose and hand gun to spray all foliage to the point of run-off.

Broadcast Aerial Applications

- Uniform coverage is critical, only the parts of trees sprayed will die.
- Both fixed wing and rotary (helicopter).
- Use a boom length of less than 75% of the wing span or rotor length.
- 5 gallons/acre minimum water volume.

Individual Plant Treatment Applications

- Basal bark and cut-stump.
- Backpack or knapsack sprayer.
- ATV-mounted hose and hand gun.

4. Effect on woody species

- Triclopyr can be used on full canopy, saplings and re-growth.

- Most effective when used on uniform stands of actively growing aspen from 2-4 meters tall.

5. Effect on herbaceous species

- All grass species are tolerant.
- Seasonal control of legumes and some broadleaf weeds.

6. Impacts on wildlife and biodiversity

- Toxic to fish, aquatic plants and aquatic invertebrates.
- Do not apply to any body of water.
- Insure adequate buffer zone around all aquatic habitats.

7. Re-treatment period

- 3-5 years, depending on rates used, species and grazing management.

8. Implications of using treatment

- 14 day grazing restriction for lactating dairy animals.

9. Herbicides, species controlled, rates & timing (see table)

Application	Rate	Species	Timing
Broadcast: ground & aerial	1.6-3.2 L/ac	Alder, Ash, Aspen, Basswood, Beech, Birch, Blackberry, Buckthorn, Cherry*, Chokecherry*, Cottonwood, Dogwood, Elderberry, Elm, Hawthorn, Maples, Oak*, Poison Oak, Pine*, Poplar, Red maple, Raspberry*, Sumac, Tamarack, Wild rose, Willow	After full leaf expansion, plants actively growing and before autumn colour appears
Individual plant treatments - basal bark or cut stump	20-30 L/100 L of oil	Woody plants	Apply at any time, including winter, except when snow or water prevents spraying at the desired location
Single stem foliar	4-8 L/1000 L of water	Woody plants up to 2.5 meters tall	After full leaf expansion, plants actively growing and before autumn colour appears

Brand Names	Manufacturer	More Information
REMEDY® GARLON®	Dow AgroSciences	www.dowagro.ca 1-800-667-3852

Trademark	Trademark Owner
Radiarc**	Waldrum Specialties Inc.
Grazon®, Remedy®, Maverick®, Vantage®, Vantage Plus®, Vantage Plus Max®	Dow AgroSciences LLC
Oracle®	Gharda USA Inc
Banvel II®	BASF Corporation, under license to BASF Canada Inc.
Roundup Original®, Roundup Transorb®, Roundup WeatherMax®, Renegade®	Monsanto
Nufarm 2,4-D Ester LV 600, Nufarm 2,4-D Amine 500, Nufarm 2,4-D Ester LV700, Credit®	Nufarm Agriculture Inc
2,4-D Ester 700, 2,4-D Ester 600, 2,4-D Amine 600, 2,4-D 500	United Agri Products Canada Inc
Factor®	IPCO
Glyfos®	Cheminova
Touchdown iQ®	Syngenta

Photo: Gateway Helicopters Ltd.

APPENDIX 1

MAKING SENSE of New Nozzle Choices

Introduction

Spray drift is becoming an increasingly important aspect of every spray operation. With greater diversification of crops, more highly active or non-selective herbicides, and a greater awareness of pesticides in the environment, spray drift management has become everybody's business. Nozzles can play an important role in drift management. They are inexpensive but could be the most important sprayer components because the range of droplet sizes in a spray determines how effective the spray deposit is, and how much spray will drift.

Whether or not a low-drift nozzle has a fit on your farm depends on how you currently spray. Most applicators are under time pressure, and struggle to achieve the correct staging under typical weather conditions. Some have had a drift complaint, and want to avoid future problems. Many need to protect sensitive areas down-wind, including shelterbelts or neighbouring fields. For those, and others, low drift spray methods provide an important option that can mean the difference between spraying in a timely manner or causing drift damage.

Are Low-Drift Nozzles for You?

- Struggle to get spraying done
- Have had drift complaint
- Have diversified farm
- Worry about environment, exposure
- Farm near urban areas

Since there are more nozzle types on the market now than ever before, applicators may have trouble deciding which nozzle best fits their needs. This fact sheet summarizes the main characteristics of major low-drift nozzles, and shows each nozzle overlayed

Figure 1: Conventional spray at 40 psi

Figure 2: Venturi nozzle spray at 70 psi

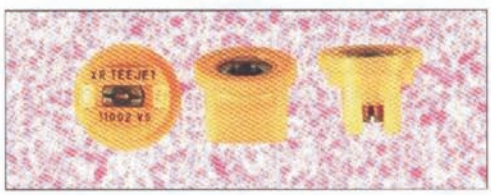
on the image of the spray deposit produced by that nozzle. Deposit images were produced using water volumes of 40 L/acre (9 gal./acre) for all nozzles. For XR, DG, and TT tips, pressure was approximately 35 psi at a standard flow rate designation of 02 (0.2 US gal./min. or 0.75 L/min.). For the venturi tips, pressure was approximately 60 psi at a standard flow rate designation of 015 (0.15 US gal./min. or 0.56 L/min.). Standard flow rates are established at 40 psi. Quoted prices are approximate, per nozzle tip.

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada — Canada

Saskatchewan Agriculture and Food — Manitoba Agriculture — Alberta — Dow AgroSciences

Conventional Nozzles

Extended Range Flat Fan:



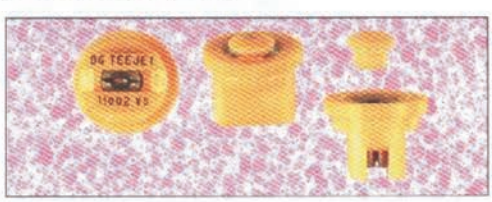
Technology: Standard nozzle currently used for pesticide application in western Canada. Available in a wide range of sizes and fan angles to fit most application needs. Nozzles with an 80º angle pattern produce coarser droplets than those that produce a 110º angle at the same flow rate. Minimum effective height of 80º tips is 18" above the target, whereas 110º tips can be operated at 14".

Pressure / Spray Quality: Spray quality is Fine to Medium. Produces a uniform spray pattern between 15 to 60 psi. Lower pressures and higher flow rates produce coarser spray that reduces drift. Optimum pressure is 40 psi.

Price: Costs between $5.00 and $6.00 for TeeJet (e.g. XR8002) or ComboJet (e.g. ER 80-02) or $1.57 for Lurmark (e.g. 02 F 80) and are widely available from a variety of suppliers.

Pros / Cons: Main drawback of these nozzles is that they are very prone to drift at higher pressures and in the smaller sizes.

Pre-Orifice Flat Fan:



Technology: A pre-orifice reduces the internal operating pressure of a standard tip, producing a coarser spray at standard pressures. The pressure gauge on the sprayer reads the external pressure, but the pressure drop in the nozzle body reduces the amount of fine droplets exiting the spray tip. Sizes range from 80015 to 8005 - also available in 110º angles.

Pressure / Spray Quality: Spray quality: Medium to Coarse. Narrower pressure range compared to a conventional flat fan tip - pressures should not drop below 30 psi nor exceed 60 psi. Optimum pressure is 40 psi.

Price: Costs $7.75 for TeeJet (Drift Guard, e.g., DG8002), or $3.57 for Lurmark (e.g. SD-02-110).

Pros / Cons: Reduce drift by 50% from extended range flat fans, but are more difficult to clean.

Turbo TeeJet:

Technology: A unique flooding-type nozzle with a turbulence chamber produces a wide-angle (150º) spray. Sizes range from 11001 to 11008.

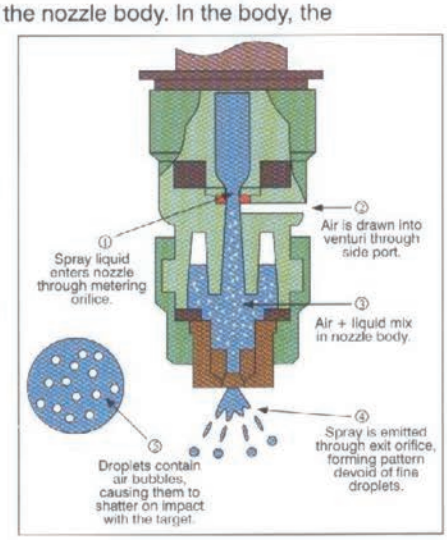
Pressure / Spray Quality: Spray quality: Medium to Coarse. A wide pressure range (15 to 90 psi) makes these nozzles very compatible with automatic rate controllers that use pressure to adjust flow rate in response to travel speed. Optimum pressure is 40 psi.

Price: $5.00 from Spraying Systems dealers. (e.g. TT11002)

Pros / Cons: Produce coarser spray, reducing drift by 50% compared to extended range tips. Can be difficult to unplug, so carry a few extras in the field.

Venturi Nozzles:

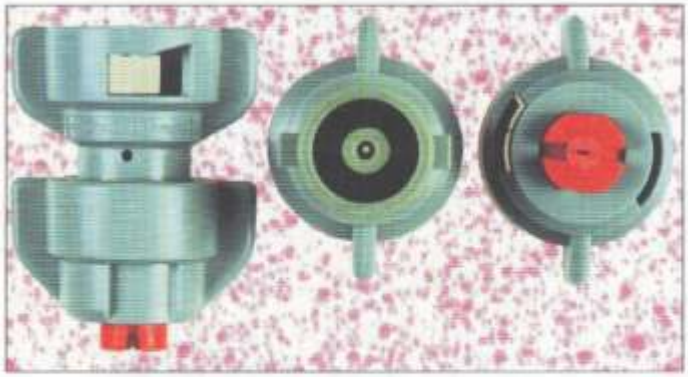
There are currently eight different venturi nozzles on the market. All have the same basic design feature: they have two orifices, one to meter liquid flow, the other, somewhat larger, to form the pattern. In between these two orifices is a venturi or jet, used to draw air into the nozzle body. In the body, the air mixes with liquid and forms an air-amended spray. The resulting spray pattern is low pressure and can be described as a very coarse spray containing large, air-filled droplets and virtually no small, drift



prone droplets. Venturi nozzles differ from conventional low pressure sprays by being coarser and containing fewer fines.

Venturi nozzles are also known as "air induction", "air inclusion" or "foaming" nozzles. Dramatic drift reductions have been observed with these tips while good spray coverage has generally been maintained. The reason is that the droplets are filled with air bubbles which cause the droplets to shatter on impact with the leaf, providing similar coverage to finer, conventional sprays. But getting the maximum benefit from these nozzles requires careful selection of the right nozzle for your needs, and proper operation. Features to watch are pressure range, ease of cleaning, and the ability to fit onto existing hardware.

Greenleaf TurboDrop:



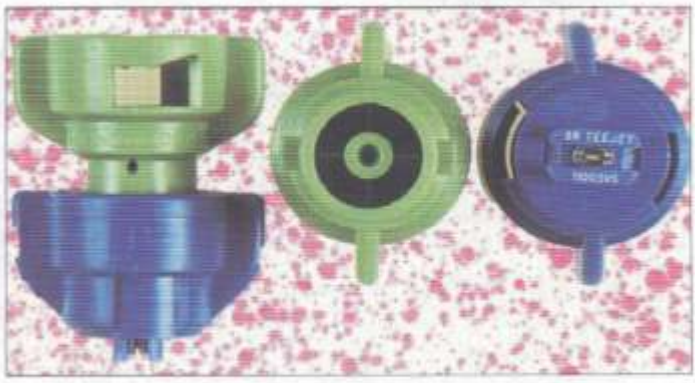
Technology: The first and most proven venturi nozzle. The exit tip is separate from the nozzle body and can be exchanged with other tips to fit specific needs. For example, a Turbo TeeJet exit tip can be used to increase spray coarseness, widen the spray angle, and improve pressure range. Exit tips must conform to the manufacturer's flow rate recommendations, and be extended range 110° models. Sizes range from 110005 to 11010.

Pressure / Spray Quality: Produces intermediate spray coarseness among the venturi tips. Good patterns are achieved between 30 and 150 psi. Optimum pressures for pesticide effectiveness are 60 to 80 psi.

Price: $25.00 for complete nozzle from Westward Parts dealers.

Pros / Cons: Integrated nozzle cap fits Spraying Systems QuickJet adapters. Long-lasting ceramic metering orifice is easily detachable for cleaning.

Greenleaf TurboDrop XL:



Technology: A lower pressure, all plastic version of the TurboDrop. Sizes range from 110005 to 11010.

Pressure / Spray Quality: Good patterns are produced between 15 and 120 psi. Pressures up to 75 psi provide a coarser spray than the original TurboDrop, while pressures over 75 psi create a somewhat finer spray. Optimum pressures are 60 to 80 psi.

Price: $12.00 for complete nozzle from Westward Parts dealers.

Pros / Cons: Integrated nozzle cap fits Spraying Systems QuickJet adapters. Best suited for those sprayers requiring a lower, wider pressure range.

Billericay Farm Systems Air Bubble Jet:

Technology: All plastic construction. Less air induction than other venturi nozzles, with a removable metering orifice for easy cleaning. Sizes range from 110015 to 11005.

Pressure / Spray Quality: Good patterns are produced between 20 and 90 psi. Unlike most other venturi nozzles, optimum pressures are 30 to 45 psi. Emits a finer spray than other venturi nozzles, but still offers good drift protection.

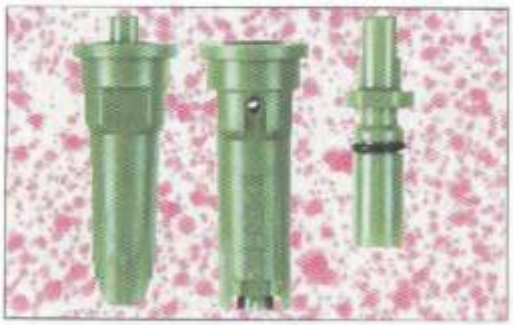
Price: $8.95 from ABJ Agri Products, Brandon, MB (204) 726-9201.

Pros / Cons: Due to slightly finer spray quality compared to other venturi nozzles, this nozzle offers an intermediate solution for applicators. Fits Spraying Systems nozzle caps.

Lechler ID:

Technology: All-plastic construction, with a removable venturi insert. Sizes range from 110015 to 11004. Also available under the Hardi Injet name.

Pressure / Spray Quality: Good patterns are produced between 40 and 100 psi. Generates intermediate spray coarseness compared to other venturi nozzles. Optimum pressures are 60 to 80 psi.



Price: $10.54 from AgDepot

Pros / Cons: Has a wider body than a standard nozzle and requires a special nozzle cap ($0.70). Removal of insert requires needle-nosed pliers. Narrow pattern may require raising of boom.

TeeJet Air Induction (AI):

Technology: Similar in design to the Lechler ID, but utilizes a steel exit tip. Available in an "Even" pattern for banding applications. Sizes range from 110015 to 11005.

Pressure / Spray Quality: Good patterns are produced between 40 and 100 psi. Optimum pressures are 60 to 80 psi. Generates intermediate to slightly coarser spray quality compared to other venturi nozzles.

Price: $10.90 from Spraying Systems dealers.

Pros / Cons: A special nozzle cap is required to accommodate its wider body ($0.70). Removal of venturi insert requires needle-nosed pliers.

SprayMaster Ultra:

Technology: Plastic body and steel exit tip. Re-designed in early 1999, with no technical information available at time of printing. An earlier version of this tip is depicted.

Pressure / Spray Quality: Good patterns are produced between 40 and 100 psi. Optimum pressures are 60 to 80 psi. Generates the coarsest, lowest-pressure spray of the venturi type nozzles, and spray patterns need close attention to maintain proper nozzle overlap.

Price: $9.73 from John Deere Dealers.

Pros / Cons: Venturi-orifice is removable for cleaning. Fits Spraying Systems nozzle caps.

Sprays International:

Technology: This nozzle has not yet been widely adopted in North America. Sometimes called the "Kematal" tip because of the material it's made of.

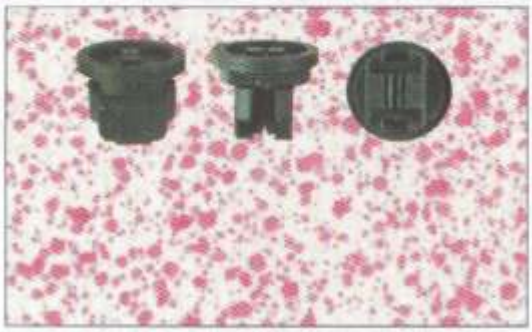
Pressure / Spray Quality: Good patterns are produced between 40 and 100 psi. Optimum pressures are 60 to 80 psi. Similar in appearance to the Air Bubble Jet, but produces a coarser spray. This nozzle has the narrowest fan angle of the venturi tips. Patterns and overlaps must be watched closely to ensure good coverage.

Price: $9.22 from Sprayer Parts Warehouse dealers.

Pros / Cons: Single-piece construction; venturi is not removable. Fits Spraying Systems nozzle caps.

Lurmark Ultra-Lo-Drift:

Technology: The most compact of the venturi tips, it closely resembles a conventional spray nozzle. All plastic construction, with two pre-orifice holes to meter the liquid through the body of the nozzle.



Pressure / Spray Quality: Good patterns are produced between 30 and 100 psi. Optimum pressures are 60 to 80 psi. Spray quality is intermediate compared to other venturi nozzles. Produces a wider angled spray and slightly wider pressure range than most other venturi tips.

Price: $9.79 from Retail Co-op outlets.

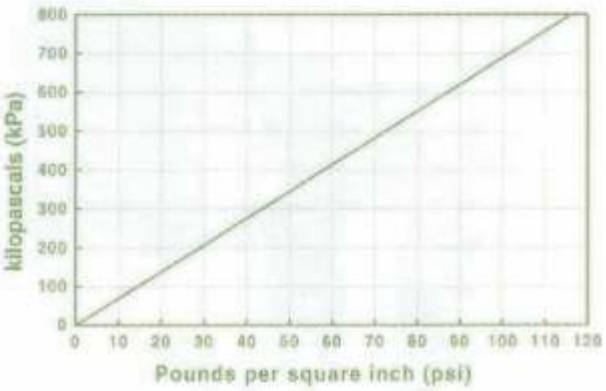
Pros / Cons: This tip can be disassembled for cleaning if necessary using a nozzle cap or screwdriver. Fits Spraying Systems nozzle caps.

Issues to Consider

Spray Pressure with Venturi Tips: Although most venturi tips are rated at minimum pressures of 30 to 40 psi, they need to be operated at higher than normal pressures to give optimum performance over a range of conditions. The exception is the Air Bubble Jet, which is designed to work at conventional pressures. Even at pressures of 60 to 80 psi, the remaining venturi nozzles still provide excellent drift protection. Using lower than the recommended pressures may cause the pattern to collapse, and will reduce the activity of the air-induction mechanism. Without the inclusion of air in the droplets, the ability to maintain proper coverage can be reduced. Check the boom pressure of your sprayer and the ability of your pump to operate at high pressures. If your system has trouble exceeding 50 psi, consider the TurboTeeJet, Air Bubble Jet or the Greenleaf TurboDrop XL. When using an automatic flow regulator, monitor your boom pressure and sprayer output closely when you change speeds. Poor patterns are the number one reason for performance complaints.

Nozzle Size Selection: Since venturi nozzles should be operated at higher pressures, you may need to choose a nozzle with a lower flow rate from the one you are currently using to maintain the correct water volume without increasing travel speeds. For example, if you currently use a conventional 02 size nozzle at 40 psi, a venturi 015 tip operated at 70 psi will provide the same flow rate, drift less, and give you some pressure latitude if you need to slow down. If you use a 03 tip at 40 psi, conversion to a 025 nozzle at 60 psi, or a 02 nozzle at 90 psi will give the same flow rate. The smallest size for most venturi nozzles is 015, except for the Greenleaf TurboDrop and TurboDrop XL, which come in sizes as small as 005 and 01. Check manufacturer guidelines for recommended pressures, and calibrate your sprayer at the start of every season.

Boom Height: Although venturi nozzles are sold as 110° fan angles, their spray pattern is closer to 80°, and quickly becomes narrower at lower pressures. This is because the exit tip has a greater flow rate than the metering orifice, causing a significant pressure drop. Even at a gauge pressure of 80 psi, the exit tip pressure may only be 20 or 30 psi. The lower spray pressure at the exit tip causes a narrowing of the fan. Watch patterns carefully, and place your boom at the height needed to achieve proper overlap.



Nozzle Wear: Most venturi nozzles are constructed of plastic. Plastic has very good wear characteristics, and can outlast stainless steel. Plastic is, however, prone to deformation if handled with hard objects, so care must be taken during cleaning.

Nozzle Plugging: Even with clean water and screens, nozzles will occasionally plug. A venturi nozzle should present less plugging problems than conventional nozzles because the metering orifice is round, allowing larger particles to pass through. The exit orifice typically has about twice the flow rate of the metering orifice, reducing the likelihood of plugging. If this orifice plugs, the nozzle will have to be taken apart for cleaning.

Adjuvants: Air bubble inclusion in droplets is a function of formulation and pressure. Air bubbles may not form without a surfactant or at lower pressures. Remember that almost all post-emergent pesticides sold in western Canada either have surfactants in the formulation, or call for them to be added. No special additives are required. Low-drift adjuvants such as Nalcotrol or 38-F should not be used with venturi tips, as the spray will not atomize properly. Always check your patterns after adding any adjuvant.

Efficacy: Venturi tips are best known for their dramatic ability to reduce drift. Many of these tips are new to western Canada, and information on pesticide efficacy when they are used is still scarce. Initial data suggest that these tips perform well at conventional carrier volumes, travel speeds, and product rates.

Some weeds are more difficult targets than others, particularly the difficult-to-wet weeds, such as lambsquarters, cleavers, wild oats, and green foxtail. These weeds generally require finer sprays to maintain effective coverage. When using venturi nozzles on these weeds, make sure your pressure is high enough to achieve good coverage. Larger weeds and reduced product rates typically make chemical control more difficult, and these conditions may also reveal some performance differences between nozzles.

According to preliminary results, herbicides that belong to herbicide Groups 2, 4, 9 and 22 perform well with venturi nozzles, even at normal pressures (40 psi). Application of herbicides in resistance groups 1, 6, 8, and 10 may require higher pressures with venturi nozzles to maintain good performance, especially under challenging conditions. Studies are continuing, and more information will be available at the end of 1999.

Check with your chemical representative to see if the manufacturer supports the use of low-drift nozzles with their products.

The Bottom Line

As with any new technology, venturi nozzles should be introduced carefully. They have tremendous promise for reducing drift while maintaining good efficacy, and have been used successfully by hundreds of western Canadian applicators under a variety of conditions. But they can be used improperly - make sure you pay attention to pressure and your herbicide / weed combination before you spray.

You may not want to or need to use venturi nozzles under all conditions. Start thinking in terms of using the ***"right spray for the conditions"***. This means that you may want to use conventional tips under good conditions, but choose low-drift tips for the outside rounds or when winds come up.

Finer sprays are also more appropriate for most insecticides and fungicides, and for grassy weeds. Coarser sprays will work well for broadleaf weeds, and when penetrating a cereal canopy. You may also want to consider having two different flow rates available – for example, 5 gallons/acre (23 L/acre) will improve performance for glyphosate, and 10 gallons/acre (45 L/acre) is required for Liberty and most contact products.

Nozzle Selection Guidelines

Coarser Sprays	Finer Sprays
• Easy-to-wet broadleaf weeds (pigweed, smartweed, thistles, etc.)	• Grassy weeds (wild oats green foxtail, etc.)
• Cereal canopy penetration	• Difficult-to-wet broadleaf weeds (lambsquarters, cleavers, kochia, etc.)
• Group 2, 4, 9, 22 or products with soil activity	• Broadleaf canopy penetration
• Outside rounds and windy conditions	• Group 1,6, 8, 10
	• Insecticides
	• Good weather conditions

Remember that nozzles are still the most important parts of your sprayer. It makes sense to invest in them to make sure the job gets done right.

For More Information: This Fact sheet will be available at the provincial Web Sites for updated information when it becomes available.

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CHAPTER FIVE

Prescribed Fire:

A Brush Management Option

ARTHUR W. BAILEY, PROFESSOR EMERITUS,
RANGELAND ECOLOGY AND MANAGEMENT,
UNIVERSITY OF ALBERTA, EDMONTON, ALBERTA

BRANT KIRYCHUK, MANAGER
SUSTAINABLE AGRICULTURE DEVELOPMENT PROJECT
PR CHINA

OVERVIEW

- Prescribed burning of prairie grazing lands can be an economical and effective part of an integrated brush management strategy.
- Many land managers today are afraid to use prescribed burning, although such fires should only be ignited under moderate weather conditions.
- Rangeland managers must learn to use prescribed burning responsibly and effectively, or they should not attempt to use this brush management practice.
- Every prescribed burning event develops through a series of planned stages. There are pre-burn, burn, and post-burn stages. Special grazing management practices are implemented after a burn for 2-3 years to optimize sustainable forage production.
- Crucial parts of every successful prescribed burn are the development of an appropriate perimeter firebreak, suitable fuel load, weather conditions, equipment and personnel, and suitable management of the burn and post-burn operation.
- A stable weather system, a predictable wind direction, a specific range in relative humidity, wind speed, air temperature, fuel type, and fuel load must meet certain criteria for each prescribed burn.
- One experienced fire boss supervises ignition and suppression crews who stay on the prescribed burn from the time it is lit until mop-up is completed. Monitoring to insure the fire is out occurs over a period of several days after the fire.
- Brush management after the burn will include managed grazing to maintain a productive forage supply, and managing emerging woody suckers with a combination of grazing, burning, mechanical means and herbicides.

Photo: Bill Gardiner

FIRE ON RANGELANDS

Prescribed burning can be part of an effective and economical brush management strategy on aspen parkland and adjacent northern bush (boreal forest) grazing lands. Most ranchers and pasture managers were taught as children that fire was "bad" and "dangerous". That is a good place to begin, because wildfire is dangerous and it can be destructive. A planned fire needs to be thought through, with the risks and benefits weighed appropriately. Effective prescribed burning can be learned, however, and the consequences can be one more economically efficient tool for the progressive rangeland manager.

"Prescribed burning is both a science and an art. It requires a background in weather, fire behaviour, fuels, and plant ecology along with the courage to conduct burns, good judgement, and experience to integrate all aspects of weather and fire behaviour to achieve planned objectives safely and effectively" (Wright and Bailey 1982).

Managed fire can be used to good advantage in many brush management applications if:

- Each application is well planned and executed.
- The implementation of the prescribed burn is effective and responsible.
- The crew is well trained and knows how to execute burning during the fire and in the mop-up operation afterwards.
- An effective post-burn management plan takes advantage of good grazing management practices prevent serious overuse of vulnerable young forages too soon after fire.

History of Prairie Fire

Fire and bison played a significant role in maintaining aspen parkland and fescue prairie as grassland-dominated ecosystems for thousands of years before European settlement. Regular fire and intense grazing by large herds of bison reduced aspen and other woody species. As European settlers moved into the west, rangeland fire was eradicated along with bison herds unfamiliar to European culture. The lack of natural fire, and unmanaged livestock grazing practices, set up conditions favourable for the expansion of woody species.

Lightning was a major source of fire on prairie grasslands, particularly in late summer as the landscape became drier. It was common for these fires to cover large areas, and not stop until the fire ran into a barrier such as a river or rainfall. In the aspen parkland, these fires would often burn the dry upland grasslands but the green grass and sedges in lower lying wetlands were protected. The landscape was a varied tapestry of grassland uplands, aspen/willow dominated bluffs, and wetlands in the lower areas. Generally, the aspen parkland/fescue prairie historically had about 5-30% tree cover with the remainder being grassland or wetland.

An engraving of a prairie fire near Fort Ellice, 1859. Published in Harpers Monthly 1860. Glenbow Archives NA-1406-2

It has now been recognized that fire is a "natural" tool which can be used by the land manager to help manage aspen expansion. Burning can be dangerous but when safely applied, can be a practical and inexpensive management tool.

Prescribed Fire versus Wildfire

Wildfires are a danger to everyone. They are unplanned events and the largest and most dangerous ones occur under extreme weather conditions that include low relative humidity (RH), high winds and very high fuel loads. Some of these wildfire events are given so much media attention that the average citizen is easily swayed to believe that fire has no place in natural resource management.

Prescribed fires are only allowed to burn within pre-planned boundaries under controlled conditions. Photo: Ron Moss

Prescribed burns are planned events that take place under moderate weather conditions. They should never occur under extreme weather conditions. Prescribed fires are only allowed to burn within pre-planned boundaries under controlled conditions. On the western Canadian plains, most prescribed burns are conducted in the early spring when herbaceous vegetation is dry, dormant, and the soils are moist. Moist soils will not burn but the dry herbaceous vegetation acts as fine fuel that ignites readily and can scorch small aspen and other small brush. Prescribed burning can also be applied to large aspen groves, but these fires require dry fuel conditions, low relative humidity and have a higher risk of fire escape. They should only be conducted by a well trained, experienced burning crew. Highly mobile, effective ignition and suppression equipment is also required.

EFFECTS OF FIRE

A well-planned and managed fire occurs when plants are dormant, burns the dry, herbaceous vegetation as fuel and has a minimal effect on the moist soil. Prescribed burns do have both short and long term effects on vegetation.

Herbaceous Plants

The first growing season following a burn, forage yield is reduced in cool season grasslands by about 25-35%. The dark soil surface will warm faster than unburned areas, which tends to cause an artificial drought. This is due to the absence of litter and the blackened surface results in more evaporation, reducing water availability for plant growth. Following a fire in grasslands, there are more forbs and fewer grasses for about 3 years, depending on post-burn management. Grasses and forbs are more palatable and digestible following a fire. This creates some management challenges because livestock and wild ungulates prefer to graze the burned areas.

Woody Plants

Variable fuel loads and fire intensities cause many of the effects on woody plants. If there is consistently high fire intensity, the top growth of smaller diameter trees and shrubs are killed. Larger trees require longer-lasting, high temperatures to penetrate the bark to kill them. Most deciduous shrub and tree

species sucker after fire. Often there are 5 - 10 times more woody shoots following a fire.

Soil

Soil moisture content is a critical factor when planning a prescribed burn. During drought years, the range manager should not burn. If burning occurs on dry soils because the surface organic matter will ignite; there is a serious risk from smouldering, holdover fires that may continue for weeks.

There is the potential risk of burning the soil surface if prescribed burns are ignited when prairie grassland soils are too dry. Photo: G. Oliver

If the soil moisture content is adequate, a fast moving high-intensity head fire rarely does long term damage to the soil. The short residence time is too brief to damage soil fauna or ignite organic material. Slow moving backfires, with longer residence times, may result in increased soil temperatures to a greater depth. If the soil moisture content is too low, backfires can do more damage to both plants and soils. This is particularly so, if there are high fuel loads and very dry soil conditions.

There is the potential risk of burning the soil surface if prescribed burns are ignited when prairie grassland soils are too dry. This is especially relevant to low moisture conditions in dark brown, black chernozem, and peat soils. It is recommended that these types of soils not be burned during droughts, or during a dry spring or autumn.

Animals

Native animals are well adapted to survive fire because they have evolved with it over millions of years. If the fire is used to keep brush at a level that is natural to the area, and mimics traditional habitat, there will be benefit to wildlife. On the other hand, if fire substantially changes the traditional habitat, particularly the tree/grassland balance then local wildlife will need to adjust to the new habitat. Many prescriptions try and accomplish both habitat and livestock production goals, by striving to maintain the proportion of brush to grassland, consistent with the history of the area.

Fire usually diversifies plant structure and modifies habitat. If groves of larger trees survive the fire, while moderate and smaller trees are killed, this will create more open grassland, and also retain thermal and protective cover. There is also the potential to increase habitat edge areas critical for many animal species. The suckering of woody species following a fire will create palatable browse. It has also been documented that many wildlife species are attracted to burned areas as the grasses and forbs tend to be more palatable than adjoining unburned areas.

Biodiversity and Ecological Sustainability

Biodiversity should be unaffected if prescribed burns are planned to maintain brush and grasslands close to historic levels. Prairie grasslands evolved with fire and are

dynamic in nature. There are short term changes in diversity. A burned aspen grove - grassland ecosystem will have increased biodiversity. Most research has shown that grassland communities have a greater diversity of plant species following a fire. The increase in plant diversity, variety of habitat, early greening and increased palatability of plant species, will also attract more fauna.

PRE-BURN PLANNING

The development of a formal written plan is a critical requirement for most prescribed burning. It is important for inexperienced range managers, ranchers and farmers to go through each step in the planning process to develop a prescribed burn starting with a listing of objectives, right through to the mop-up of the prescribed burn itself. Finally, they must develop a grazing management plan to deal with plant re-growth following the burn.

The written prescribed burning plan will cover all of the necessary steps and resources that must be accounted for during each step of the process. It also helps the fire boss to find and schedule equipment and personnel.

Objectives and Goals for Prescribed Burning

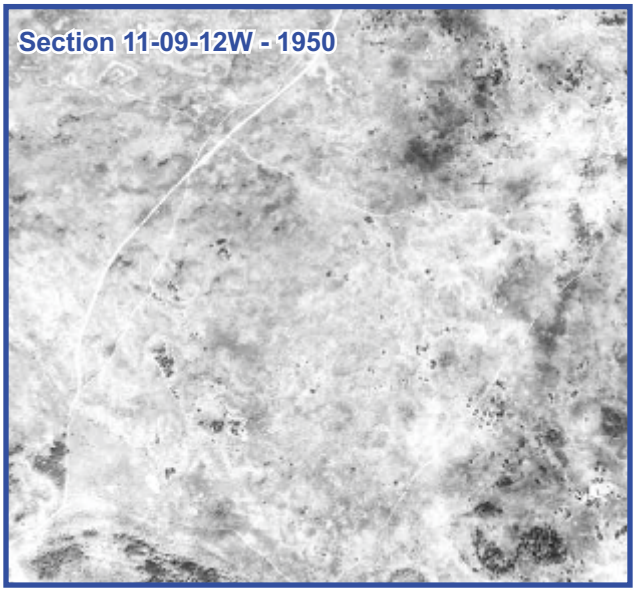
Fire is used for a number of management objectives. The land manager must clearly define the goals of a prescribed burn to insure that they are practical and can be achieved. The objectives also affect timing of the burn, equipment required, and how the burn is conducted. The most common objectives for prescribed burns are presented below:

1. Increased forage production and reduced brush cover

   Fire can be used to reduce unwanted brush so the grasses and forbs become more productive. Removing woody plant species allows for a 50-300% increase in grass and forb production. Sometimes the goal of a series of prescribed burns is to return tree cover to the amount occurring at the time of European settlement. Often that was about 5-30% coverage of a quarter section instead of the 60-90% levels common today.

2. Improved livestock utilization

Vegetation comparison between 1950-1994



Photos supplied by: Rob Graham

There are preferred and less preferred areas in large pastures. The areas not preferred by livestock often have unpalatable plants, mature grass, too much litter (mulch), too much brush, are too far from water, or have fallen trees or other barriers to grazing. Prescribed fire can be used to promote higher palatability re-growth. Some land managers use prescribed burning to attract livestock to under-utilized areas.

3. Remove excess litter

   Ungrazed rangeland builds up large amounts of litter. This reduces the productivity, palatability, and diversity of the sites. Fire can remove the litter and stimulate the growth of palatable plants.

4. Reduce cover of invasive or unwanted plants

   There have been attempts made to use fire to remove weedy or invasive plants from native grasslands. Most commonly it has been tried as a tool to remove smooth brome or Kentucky bluegrass. Rarely is fire alone able to eliminate unwanted perennial plants.

5. Improve habitat

   Wildlife and conservation area managers use certain burning prescriptions to favour nesting birds and other wildlife. Fire is also used as a tool to manage the ratio of woodland to grassland. In natural areas, attempts to use only prescribed burns to control invasive plants usually fail.

6. Remove debris

   Fire is often the clean up tool of choice to remove debris from brush clearing or logging operations. It also has been used to burn debris following brush control treatments by mower, bark scraper, roller-chopper, or where trees have been walked down.

REQUIREMENTS FOR PRESCRIBED BURNS

While planning for a prescribed burn one must determine what burning prescription will be required to achieve the objectives. The time of year, safety requirements and intensity of the fire will all affect how and when the burn is conducted. There will need to be definitive parameters set regarding: fine fuel loads, coarse fuel loads, weather, equipment, personnel, timing, and smoke management.

Fuels

Fuel is the combustible material. For managed fires, dry grass litter, dry leaf litter, dry wood or conifer branches that ignite are fuels. Green grass, wet dead grass and green shrubs and trees that won't ignite are not fuel. *Only combustible material is fuel.*

Fine fuels are dead and dry herbaceous plants such as grasses, forbs or sedges. They are the most important fuel type to use in managing most prescribed fires, because

Fine fuels are important to use in managing most prescribed fires, because they "carry the fire" across the ground surface. Photo: Bill Gardiner

they “carry the fire” across the ground surface. They burn quickly, completely and then go out. Rarely are flaming or smouldering firebrands given off by fine fuels. A light rain can turn a fine fuel into a non-fuel very quickly.

Woody fuels are different from fine fuels. They are coarse, dense fuels that ignite slowly, burn hotter and longer, and often produce *firebrands* (woody embers) that smoulder or flame and can be carried by wind. They can be deposited more than 1000 feet away. *Firebrands are very dangerous.* If they land outside the burn perimeter, they may create a *spot fire*. It is temporarily beyond control of the fire suppression crew. It must be extinguished immediately, before it becomes a rapidly spreading wildfire. *Spot fires often start in dried dung.*

Many woody fuels have a high proportion of resins, fats, and volatile oils that virtually explode when ignited. These are called *volatile fuels*. This term distinguishes them from the *non-volatile fuels*, such as the fine fuels of dried grasses that do not explode when ignited. Some hardwoods are also non-volatile fuels and burn slowly for a long time.

Fire will not burn without enough combustible fuel. That means there must have been enough days of drying so the fuel moisture content is low enough for it to burn. For fire to spread there must be an adequate quantity and distribution of fuel across the landscape. In practice, it is easier for fire to burn across rough fescue grassland, where the fuel is continuous, than through a live, dense aspen forest where the understory fuels are discontinuous. About 1000 kg/ha of dry herbaceous fuel, such as dry grass, is required to carry a fire across the landscape (Bailey 1988). As a result of the

Photo: Ron Moss

discontinuous nature of fuels on the ground in a live aspen forest, it may require about 2,000-3,000 kg/ha of fuel to carry a fire through that forest type.

Where there is a mature, decadent aspen forest, there is often a continuous coverage of about 1500 kg/ha of dried grasses and tree leaves and about 2000 kg/ha of dead woody fuels. When dry in spring, this fuel type burns readily, produces a high intensity fire and many firebrands. This is a dangerous fuel type to burn and only experienced burning crews should manage such a prescribed fire.

The grasslands of the aspen parkland are composed mostly of a continuous carpet of fine fuels. These fuels dry fast in spring after snowmelt and burn readily.

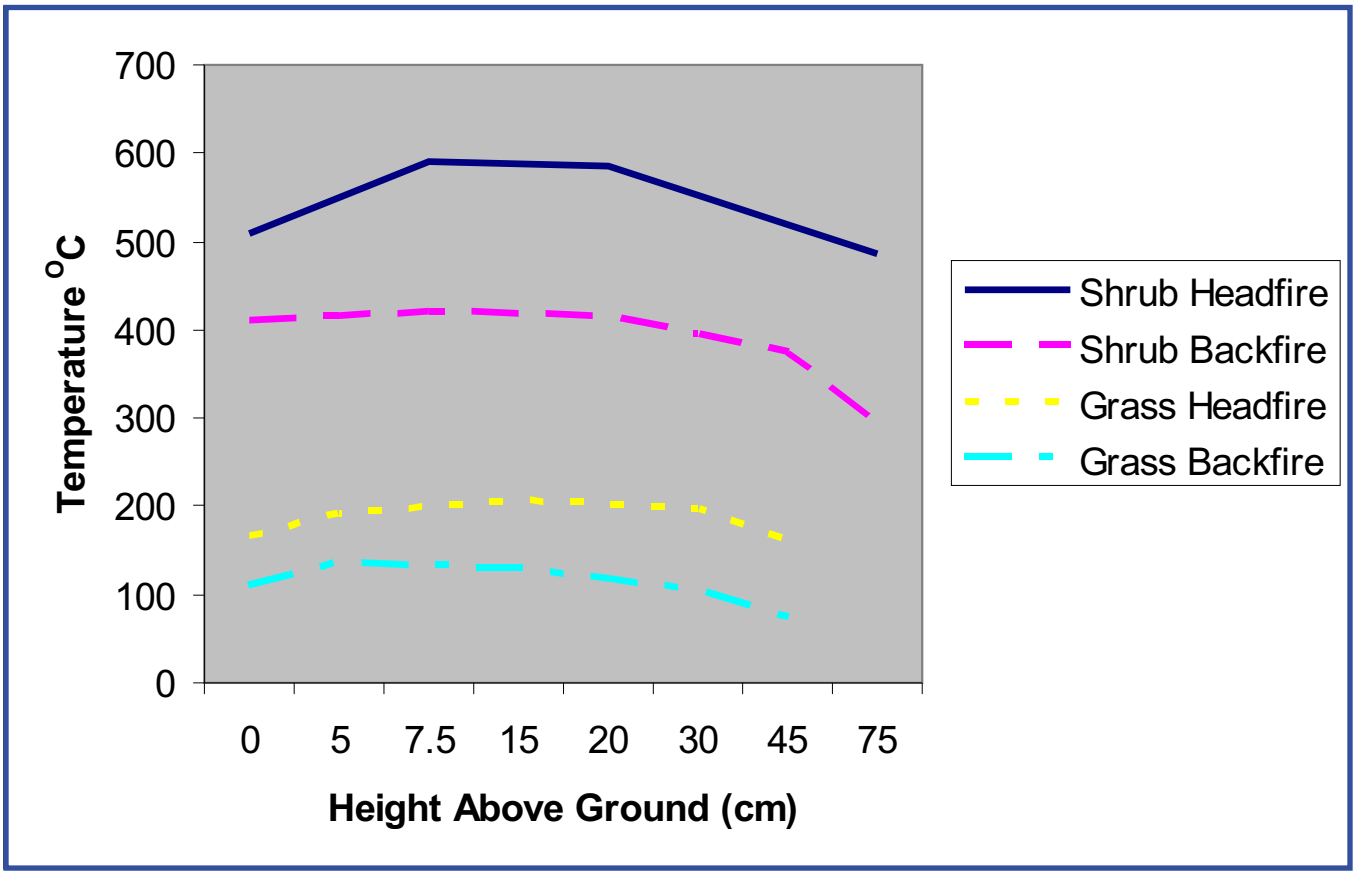
Fire Temperature

The fire temperature required to kill live plant tissue is 60°C, but in reality, the death of plant tissue is an exponential function between temperature and time (Hare, 1961). In practice, the higher the fire temperature, the shorter the period of time required to kill woody top-growth. It should be noted, however, that many trees take 1-3 years to die.

Fire temperatures are lowest in grassland and highest in shrub lands and forests (Figure 1). Temperatures are higher where fuel loads are greater. Fuel loads are usually highest in shrub lands and forests.

Young, actively growing aspen forests are often difficult to burn because there is too little

Figure 1. Fire Temperature for shrubs and grasslands at various heights (adapted from Bailey and Anderson, 1980)



fine fuel in the understory to “carry” the fire from one concentration of dead, dry tree branches to the next. More mature aspen forests that have considerable concentrations of dead shrubs and trees are easier to burn.

Environmental Conditions

A working knowledge in how weather affects prescribed burning is essential to the effective and safe use of fire. Wind, relative humidity, temperature and precipitation determine if and how a fire will burn. These factors are also directly related to the safety of the fire, and hence the precautions needed for safe and effective managed fire.

Temperature

Temperature has a direct effect on flammability of fuels. The higher the temperature of the atmosphere and fuel, the less heat is required to raise fuel temperature to the ignition point. The temperature of fuels is affected by: air temperature, topography, shading, surface properties of the fuel, wind and air movement.

Topography plays a role in plant temperature by influencing the angle at which the sun hits the surface. A slope receives the most heat when it is perpendicular to incoming radiation. Level surfaces reach their maximum temperature near noon. East-facing slopes reach maximum temperature early in the day, while west-facing slopes peak later in the afternoon. Generally, the highest surface temperatures are found on slopes facing southwest.

Absorption, transparency and conductivity of fuels will influence the temperature they achieve. Dark coloured material, such as forest litter, absorbs more heat than lighter coloured material, such as grass litter. Wood and leaf litter are poor conductors of heat, which means the surface reaches a higher

Dr. Barry Irving explaining the importance of relative humidity (RH) and wind speed during a burning workshop. Photo: G. Oliver

temperature than the interior of the material. This is one reason why tree bark may scorch during fire, but the interior is undamaged. This is an adaptation to survive fire.

Vegetation moderates air temperature within the plant canopy by intercepting both incoming and outgoing radiation. This influences the ability of fine fuels to ignite under a forest or shrub canopy. On sunny days, air temperatures under a forest canopy are 5-8°C cooler than nearby grasslands. Cooler temperatures in the fine fuel fraction result in fuel being more difficult to ignite or there may be incomplete fire coverage under the forest canopy.

Air temperature influences the rate of drying and ease of ignition of fuel during burning. The higher the temperature, the drier the fuel becomes, and the more readily the fuel will ignite. High temperature has the effect of lowering the energy required to raise fuel to the ignition point. As air temperature rises above 24°C, the chance of spot fires increases. Woody plants require a higher temperature to allow for ignition due to their

size and density. If the temperature is below 19°C, there is a tendency to have incomplete combustion of woody fuels. Most fuels don't burn well when frozen.

Relative Humidity

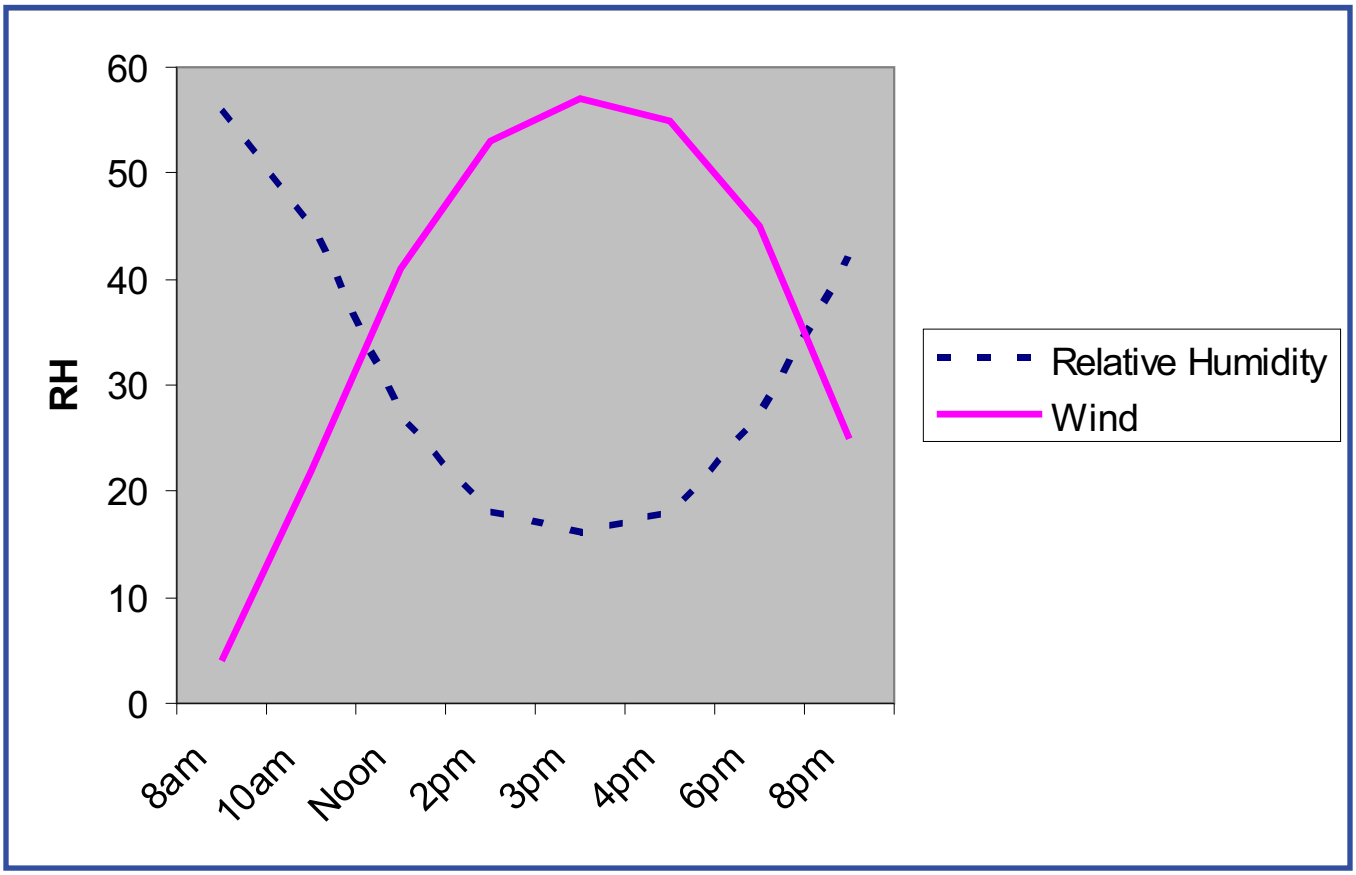
Relative humidity (RH) refers to the moisture content (%) of the air. *Understanding how relative humidity affects the ignition of fuels and the management of fire is essential to everyone who wishes to conduct prescribed burns.*

At high RH, the fuel has a layer of moisture on its surface, making ignition difficult. Moisture content of air affects moisture content on the surface of fuels. It also influences the rate of drying of fuels. The drier the fuel, the more easily it will ignite. Wright (1974) indicated fine fuels reach 80% of equilibrium with RH within 1 hour. There is a time lag in fuel moisture conditions dependent upon changes in RH.

There is a continuous exchange of moisture between the atmosphere and fuels. Fine fuels in particular respond quickly to changes in moisture content of air. RH and temperature work together to influence the ignition of fuels. Dry air, that is low RH air, tends to dry out the surface of fine fuels, whereas, higher RH air raises the moisture content of these fuels.

Understanding when and how fine fuels (dry grass or dry leaves) are affected by the moisture content of the air (RH) is crucial to understanding one of the basic principles of prescribed burning (Figure 2). Early on a

Figure 2. Normal wind and relative humidity at various times during the day (adapted from Bailey, 1978).



typical spring morning on the western Canadian plains, when the relative humidity (RH, moisture content of the air) is 70%, the "dry" dead grass isn't actually dry, it has a coating of moisture on it. *It will not ignite.* Allow the sun to shine and warm the dead grass, let the RH drop below 70% for an hour, and the bright sunshine dry off surface moisture, then the dead grass will ignite. During an average day, the RH is high in the morning, and as the air temperature rises, the RH declines. Experienced burning crews can safely use backfires to burn firebreaks in fine fuels (grass) in the morning under relatively high RH and low wind. Next, between noon and 4 pm, when the RH is acceptably low, the temperature high, and wind speed is moderate and blowing in one direction, the main burn is conducted. By late afternoon, as the prescribed fire is being completed, the RH rises as temperature and wind speed decline. The risk of losing control of the fire declines as RH rises, and both wind speed and temperature decline.

Relative humidity must be lower than 60-65% to ignite fine fuels in grassland. In forest or shrub land, the RH must be lower than 50% for wood to ignite (Table 1). The RH required is much lower when burning a young, healthy aspen forest having low amounts of fine fuel on the ground. Low RH aids in ignition and spread of fire through the forest. Nevertheless, the risk of fire escape, due to spot fires caused by firebrands, becomes high whenever RH is below 30%.

Wind

Wind speed, variability, and direction are important in prescribed burning. First, in relation to temperature and RH, it plays a role in drying fuels by assisting in the evaporation of moisture. Second, wind aids in combustion by supplying oxygen to the fire. Third, it is the primary force dictating direction and rate of fire spread. It will carry heat and firebrands to fuels, as well as bending the flame towards unburned fuels. Finally, wind has a strong influence on the level of risk of a fire escaping the boundaries of a prescribed fire. The stronger the wind, the further firebrands can be carried over non-target areas. Wright (1974) reported that in volatile fuels, firebrands can easily travel 1000 feet. High wind speeds will increase this distance substantially.

Some wind is required to fan the fire, but wind speeds above 15 km/h increase the danger of fire escape to an unacceptable level. Low wind speeds reduce the risk of glowing firebrands igniting spot fires. If wind speeds are below 5-6 km/h when burning forest or shrub land, usually the fire will not spread fast enough to maintain an actively burning fire front. Also, some wind is required to carry the fire through the patches of sparse fuel and add oxygen to the flames to aid in ignition of plant materials.

Table 1. Weather conditions recommended for various fuel types (adapted from Bailey 1988).

Fuel type	Minimum temperature (°C)	Range of wind speed (km/h)	Maximum RH (%)	# of drying days after snowmelt
Grassland	7	3-15	62	1-3
Deciduous Shrubland	13	3-15	50	3-5
Deciduous Forest	18	6-15	30	8-10

Firebrands

Burning plant material, branches, punky wood and dry dung can yield airborne flaming or smouldering firebrands. Firebrands can travel long distances in the updraft created by a prescribed burn. They are a serious risk to the unwary and the inexperienced fire boss and crew. After a burn, firebrands have been known to smoulder for at least 24 hours. If this happens beyond the fire break, and the smouldering dung or wood turns into flames and start a wildfire down wind from the site of the prescribed burn.

Weather Conditions for Prescribed Burns

The weather conditions recommended by Bailey (1988) have been modified and presented in Table 1. Grasslands are normally burned at about 40-55% RH in temperatures and wind speeds as indicated in Table 1. Snowberry shrub land is usually burned when the RH is 30-45%. A healthy aspen forest is a challenge and should only be burned by a very experienced fire boss and crew. The more successful burns of this forest type are at 15-30% RH with a wind of 6-15 kmh and a temperature of 18-25°C. The risks of firebrands causing spot fires while burning snowberry and aspen forest are very high especially at RH levels of 15-35%.

The principle modification made to Table 1 is a reduction in the recommended maximum wind speed from 20 kmh in Bailey (1988) to 15 kmh. The reason for this is to recognize that management-size prescribed burns create a substantial updraft that adds approximately 5 kmh to the wind speed within the fire. Thus, with a 15 kmh wind speed at ignition, burning snowberry shrub land or aspen forest will add about 5 kmh to the wind speed bringing it up to about 20 kmh. It is strongly recommended that no prescribed burns be started that create a wind speed over 20 kmh. At higher wind speeds, the risk is too great for firebrands from the prescribed burn to travel very long distances, creating more spot fires than a burning crew can safely suppress.

Equipment

Each prescribed burn requires an assortment of equipment and materials (Table 2). In general it can be categorized into the following:

- Crew safety and personal needs: food, drink, clothing, masks, hats, first aid.

Table 2. Equipment and materials checklist for prescribed burning.

Matches, sparkers, fusies		Wire cutters	
Ignition torches and extra fuel		First aid kits	
Two-way radios, cell phones		Hard hats	
All Terrain Vehicles with sprayers		Maps or aerial photos of burn area	
Flappers/large shovel/rakes		Drinking water, food	
Backpack pumps		Smoke masks/respirators	
Water tanker unit		Chemical goggles	
Fire pumper unit		Binoculars	
Foam Unit		Tool kits and spare parts	
Tractor and disk, or grader		Chain saw	
Fire extinguisher (all vehicles)		Tow chain, rope and cable	
Portable weather kits		Access to water	
Safety clothing			

Putting out smouldering embers or fire brands after a burn. Photo: Bill Gardiner

- Communications: cell phones, two way radios, binoculars, maps, photographs.
- Mobility: ATV's, trucks, tractors.
- Fire ignition: ignition torches, matches, fuel.
- Fire suppression: foam, grader or big tractor and heavy disk.

Filling the drip torches. Photo: G. Oliver

An equipment check list assists the fire boss to have all necessary equipment available and serviced prior to the burn. The type of vegetation, fuel load, topography, area to be burned, and unique risks associated with each fire, will determine the amount and type of equipment required. It is advisable to have extra equipment, materials and personnel along when planning for a big fire, since it is not possible to obtain missing equipment once burning has started.

The equipment required for a small, low intensity grass fire may only include a pair of drip torches, matches, extra fuel and a few backpack hand pumps, with an extra supply of water. The equipment required, however, for a management-size prescribed burn with brush as the fuel, is much greater because burning brush produces many firebrands. Wider firebreaks and more equipment are required. Engine-powered pumpers mounted on a combination of ATV's, tractors, and 4x4 trucks are needed to suppress any unwanted spot fires or fire escapes. A foaming unit may be useful to put up a temporary barrier around a fire escape. Access to water in ponds, dugouts, wells or tanks is essential in case of an emergency

Personnel for the burning crew

Safely conducting prescribed burns is a labour intensive initiative. The burning crew is made up of the fire boss, ignition and suppression teams. The fire boss makes all decisions and informs everyone. The fire boss must have prescribed burning experience, must have good judgement and be able to make decisions quickly and efficiently. Decisions cannot be made by committee once the fire is started, since things happen quickly. It is very important to have good communication and a crew willing to take and execute instructions immediately. Instant communication amongst the crew is critical. Two way radios, or the equivalent, are essential to the success and safety during prescribed burns. In large burns with sizable crews, there may be an ignition and suppression team leader, who is responsible for each team's activities and is accountable to the fire boss. While it is useful to have the whole team involved in planning the burn, it can only be successfully carried out if the crew fully cooperates with the fire boss the day of the burn. The fire boss will give a detailed briefing to the crew prior to the beginning of any burning activities and will give further instructions as the fire develops.

Although conducting prescribed burns are straight forward for experienced burning crews, each burn has its own complications. It is not essential for all members of the team to be formally trained or have experience in conducting a burn. As a minimum, the fire boss should have at least 4 years of field experience in conducting prescribed burns. It is also desirable for the fire boss to have formal training in fire fighting. There are a number of avenues where personnel can take fire fighting training, and it is highly recommended. These courses teach the science of fire behaviour, and methods to manage and control fire. This training is invaluable when the fire boss must react quickly to an emergency situation. When there are inexperienced personnel on a burn, there should be a briefing on their role in the burn, as well as training in operating equipment prior to the burn. On the day of the fire, each inexperienced member should be assigned to an experienced crew member. If the ranch or crown range manager plans to make prescribed burning a regular part of a grazing management operation, it is a worthwhile investment to have members of the fire crew receive formal training in prescribed burning.

The number of people required for a prescribed burning crew is dependent on the type and size of burn and the experience of the crew. There is likely not a situation where it would be safe to burn with a crew smaller than 4 people. Once wide fireguards (fire breaks) are in place surrounding the area to be burned, the main burn is often conducted safely with a burning crew of 6-10 participants.

Window of Opportunity to Burn

The burning prescription should outline the conditions required to meet objectives of the burn (Table 3). These conditions can be determined well in advance, and are based on average climatic conditions and local knowledge of the area. An approximate date can be planned in advance, but specific weather conditions are required for the day of the main burn. The fire crew will need to be available over about a two week window, since it is not possible to predict in advance a specific day when suitable weather conditions will occur. When conducting higher risk spring prescribed burns designed to top-kill woody plants prior to green-up, there may only be about 4-5 days of suitable weather each spring.

Smoke Management

Every prescribed burn produces smoke. It can affect human health and safety by limiting visibility near the burn. The impact of smoke on the surrounding land, and communities, must be considered and managed. The goal is to minimize smoke impacts on others. Smoke attracts attention and it may attract people who want to watch the fire. It is important to provide advance notice to the

Table 3. An example of conditions required for a spring prescribed burn

Factor	Conditions Required For Prescribed Burn
Days after snowmelt	
Status of plant growth	
Acceptable range of air temperature	
Acceptable range of relative humidity	
Acceptable range of windspeed	
Acceptable wind direction	
Dates burning crew is available	

neighbourhood about an upcoming prescribed burn. It may also be important to warn people who approach the prescribed burn area to stay far away, for their personal safety and for the safety of the burning crew.

There are some general principles which affect the amount and direction of smoke:

- Moist fuels make more smoke than dry fuels.
- Head fires produce more smoke than back fires.
- Stable air masses may cause temperature inversions, which reduce smoke dispersion, and can result in it hanging in the immediate burn area.
- Smoke remaining during the night is more dangerous and affects visibility more than during the day.

Plan to minimize smoke impacts by:

- Being aware of the weather forecast prior to the burn regarding wind direction, speed and stability of the air mass.
- Conducting the prescribed burn when the appropriate wind direction will move smoke away from neighbours, highways, and other sensitive areas.

The impact of smoke on the surrounding land, and communities, must be considered and managed.
Photo: Bill Gardiner

- Determining all sensitive areas in the event of wind shifts.
- Estimating the length of time to conduct the prescribed burn, including a margin of error for unforeseen circumstances.
- Notifying neighbours, local municipalities, emergency services, and post notices around the area to be burned.
- Prepare large warning signs well ahead of time and place them along the side of roads where smoke may linger.

Emergency Preparedness

The fire should be planned to cover all eventualities and not be allowed to escape. The unforeseen, however, occasionally happens and one has to plan for it. A fire might start up several days after it was thought to be out. It should be in the plan for a mop-up crew to at least patrol the burn site every afternoon for a number of days. If smoke is sighted, a mop-up crew needs to be available for immediate dispatch to the burn site.

It is important to notify the local municipality and their fire department prior to the prescribed burn. There is the remote possibility that they may be asked to help out in an emergency. It is also wise to plan ahead of time where one would obtain, or have on hand equipment, such as a grader, if it was necessary to create another firebreak in an emergency.

In the planning phase, consideration needs to be given regarding how to communicate with the local fire department, if an emergency arises. It is ideal if cellular service is available but if it is not, then alternative solutions need to be found. One may need to prepare substitute radio communications. The bottom line is: *be prepared for the unexpected!*

THE BURNING PRESCRIPTION

The burning prescription will be completed well in advance of the planned burn. *It will not be completed the day of the burn.*

Example: For prescribed burning of grassland, with invading small trees or shrubs, or for training an inexperienced burning crew.

The low intensity fire

- Fire boss has 2 or more years experience working on burns with an experienced mentor. Half of the other 4 crew members have some burning experience; the rest have no experience. They are all physically fit.
- Two 20 acre areas were prepared for the training exercises within a 40 acre block. Vegetation is aspen parkland with ¾ grassland and ¼ shrubland or small aspen groves.
- A 50 meter wide cultivated fire break was installed around each 20 acre block.
- Last year in late September, temporary electric fencing was erected in a 100 meter wide strip of grassland outside the burn perimeter and was intentionally overgrazed.

Low intensity burn. Photo: Bill Gardiner

- Spring burn - snow melt occurred 4-6 days ago in the brush patches, and longer in grassland. There is no plant growth.
- Weather system is stable, there may be some clouds, wind is steady from northwest with forecast high of 8 kmh, and the acceptable range is 3-10 kmh.
- Forecast high temperature is 16°C, acceptable range is 10-20°C.
- Forecast low relative humidity (RH) is 45%, acceptable range is 40-55%.
- Ignition and suppression practices to be followed are outlined. Ignition system to be used is the "strip head fire" technique.

Example: Spring prescribed burning of an aspen forest by an experienced burning crew

The high intensity fire

- Fire boss has 4 or more years experience burning aspen forest and has a crew of 6 people (7 in total). Four crew members have 1 or 2 years of burning experience. All crew members are physically fit.
- A ¼ section (160 acres) of aspen parkland forest has been selected; it comprises about 100 acres of forest and 60 acres of grassland with some shrub patches.
- A 50 meter wide cultivated strip bare of fuel was prepared last fall as the firebreak on the burn perimeter.
- Last year in late September, temporary electric fencing was erected in a 200 meter wide strip of grassland outside the burn perimeter; and was intentionally overgrazed.

Following a high intensity burn. Photo: Barry Irving

- Snow melted from the grassland 12 days ago, from the bush 8 days ago, although 2% of the NE slopes have patches of snow. There is no plant growth.
- Yesterday the burning crew burned as a backfire a 50 meter wide strip inside the cultivated strip on west and north sides of the burn perimeter.
- A stable weather system is forecast; it is to be sunny for today and tomorrow.
- Wind direction is forecast to be from the southeast, maximum wind speed is 10 kmh with gusts to 15 kmh, acceptable range is 6-15 kmh.
- Forecast high temperature of 20°C, acceptable range is 18-26°C.
- Forecast low relative humidity of 25%, acceptable range is 20-35%.
- Ignition and suppression practices to be followed are outlined. Ignition system to be used is the "strip head fire" technique.

CONDUCTING THE PRESCRIBED BURN

The prescribed burn will be conducted once the five conditions listed below have been met:

- Suitable amount and condition of fuels within the burn perimeters.
- Weather is within the burning prescription.
- Pre-burn field preparation, including the preparation of firebreaks, has been met.
- All ignition and suppression equipment is serviced, operational and in place.
- Fire boss, ignition and suppression crews are available and most have received training.

Weather forecasts

Telephone a qualified weather forecaster the day before the burn and the day of the planned burn, to obtain the latest spot weather forecast for the area to be burned. Request the following information for the day of the burn and the day after the burn:

- Stability of the current air mass.
- Current and forecast low relative humidity.
- Current and forecast high temperature.
- Current and high wind speed; speed of wind gusts.
- Current and forecast wind direction.
- Level of risk of unexpected changes in any of the weather factors.

An accurate local spot weather forecast is critical to implementing a prescribed burn safely and effectively. The fire boss will monitor wind speed and direction, air temperature and relative humidity, using a

portable weather kit throughout the day of the burn *(NOTE: Kestrel and Brunton are two suppliers of such weather instruments)*. This will help determine whether the predicted conditions are within the parameters of the burn prescription. The stability of the weather system in the local area will also be monitored. If practical, just before ignition of the main burn, phone and obtain an updated spot weather forecast for the area.

Fire Breaks

Fire breaks (fire guards) are used to contain the prescribed fire within planned perimeter boundaries. The fire break is the main defence against escape. Make it wide and remove all fuel prior to igniting the main prescribed burn. The fire break should be widest on the down wind edge of the burn perimeter. The width of a fire break depends upon the objectives, fuel type, weather conditions and level of experience of the fire boss and burning crew. Fuel type is very important in deciding how wide the fire break is to be. Volatile brush fuels such as conifers, western snowberry and live or dead aspen produce large quantities of firebrands. They require wide fire breaks. The more volatile the fuels, the lower the RH, the higher the wind and temperature, the wider the fire break should be to contain the fire.

Another measure that will reduce the risk of fire escape can be applied the fall before the planned spring burn. Overgraze the field downwind from the planned burn to reduce the fuel load adjacent to the burn. If it is a very large field and that is not desired, then install temporary electric fencing and overgraze a 200 meter wide strip of the field downwind from the planned burn area to reduce the fuel load to almost zero.

The burn perimeters usually start out as a relatively narrow width and free of fine fuel.
Photo: Bill Gardiner

It is necessary to widen the fire break and take extra precautions in danger areas near dwellings, farmyards, roads and highways. The amount and type of fuel on the edge of the burn area will influence the fire break. Of particular danger are trees close to the perimeter or woody species with volatile fuels, which have the potential to launch fire brands or flames high into the air. If such fuels are near the downwind side of the burn, it is necessary to remove them prior to conducting the main prescribed burn. Some of the options for fire breaks are described below.

Burn Perimeters

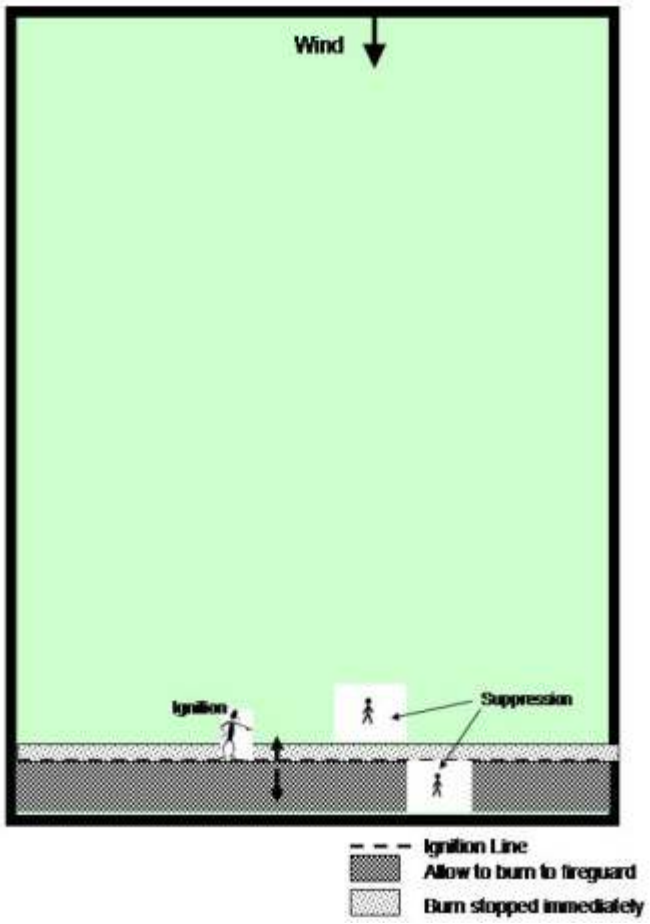
The burn perimeters often starts out as a relatively narrow width free of fine fuel. The perimeter may be a road, trail or disked strip all the way around the area chosen for burning.

Back-fire – In most situations, use a backfire to remove fuel and widen a fireguard from a disked or mowed strip, road or trail (Figure 3). This is commonly done the day before, or the morning of the fire, when burning conditions are quite safe, and there is little chance of escape. In practice that means the RH is 40-55%, wind is less than 8 kmh and the temperature is less than 20°C. Widening the firebreak by burning the morning of the main prescribed burn is an inexpensive, yet efficient way, to develop a wide firebreak around the burn perimeter using the burning crew. One technique to use when backfiring is illustrated in Figure 3.

Roads or trails – Grid roads are effective firebreaks, as they have no fine fuel on them. Trails may or may not have fine fuels. Both roads and trails need a black line burned against them. By the road, backfire and remove the fuel from the ditch some distance into the field to minimize the amount of heat generated under the fence row. If using a road as a firebreak, post warning signs at each end of the area to be burned, or if possible, prevent traffic from using the road during the prescribed burning event.

Bare soil – It is common to cultivate or disk a narrow firebreak, as it removes fine fuel. The bare soil is used as a base to back fire against to widen the firebreak.

Figure 3. A back-firing technique to use while expanding the perimeter firebreak



Chemical fire retardant foam. Photo: Jason Kosowan

Chemical retardant – Chemical fire retardant foams are used in place of a blackened strip of soil to build a wider firebreak. This retardant is expensive and is normally only used on small fires because of the high cost.

Streams or wetlands – Standing water is ideal for stopping a fire. The ecological situation in the riparian area, however, should be carefully assessed before burning into it. Fire has temporary ecological impacts, such as removal of nesting cover for waterfowl. If there are dry peat (organic) soils present, do not burn. The risk of ground fires in dry peat is too high.

Wet line – Fine fuel can be wet down and used as a temporary firebreak. A wet line will act as barrier and along it a backfire can be ignited. The risk in using this method is that it takes a lot of water and fine fuels dry out quickly. *Extreme caution* must be taken to insure the back fire is completely out before leaving the area.

Extinguish back fires on widened firebreaks

Before igniting the main fire, completely extinguish all backfires set to expand the firebreak around the burn perimeter. All fuel must be burned in the firebreak and then the

backfire completely extinguished. The greatest danger area for fire escape is at the perimeter of the burn. In the past there have been escapes when backfires were allowed to smoulder and slowly make their way across residual fuels on a burn perimeter.

Fire Suppression

Effective fire suppression requires a trained crew and reliable equipment. Also, it is essential to have access to substantial quantities of water as in ponds, dugouts, wells or water tanks.

Fire Suppression Equipment

The type of equipment required will vary with the size and level of risk of fire escape. Where brush is being burned, there is a substantial level of risk associated with burning volatile fuels under low RH and moderate wind. Firebrands will be released and may start spot fires. Also, fire escapes occasionally occur across the burn perimeter.

Engine powered fire suppression pumps mounted on ATV's, trucks and tractors are required. Match the equipment to the terrain; have large capacity pumps and be able to get to and put out spot fires or fire escapes quickly. A big tractor and disk, a grader, or a foaming unit are useful to have on hand to make a temporary barrier around a fire escape. Back-pack hand pump units are highly mobile and can go wherever a man can walk or go on an ATV. They are useful emergency backup units for both patrolling and putting out spot fires in less accessible parts of the burn.

There must be a plan for the worst case scenario. Water and appropriate suppression equipment must be on site. This is often a challenge, as many prescribed burn sites are remote and have no water. Nevertheless, if an emergency does develop, it is essential to

The type of equipment required will vary with the size and level of risk of fire escape. Photo: Ron Moss

have enough water on site. Where required, transport it to the site the day before the burn. There should be enough capacity to fill all fire suppression equipment several times. Large tanks mounted on trucks or pulled by tractors can be used for small and medium burns. For large burns, it is recommended that there be access to a water body and high capacity pumps so tankers and suppression equipment can be filled quickly.

When planning the prescribed burn, insure that suitable suppression equipment is matched to the terrain. ATV-mounted tanks with small pumps are efficient getting quickly to the site of a spot fire or fire escape. Truck and tractor-mounted fire fighting equipment is larger and less mobile. They are often only used on the perimeter of a fire. Ideally, the burn is planned so the larger fire control equipment can access all perimeters of the fire. If this is not possible, there must at least be access to the down wind perimeter of the burn area.

Ignition Procedure

A planned approach to ignition is required to maintain safe and effective methodology. The ignition procedure follows a series of steps.

Steps to take leading up to the main prescribed burn

1. Plot wind direction to locate downwind section of burn perimeter

Plot wind direction on a map or aerial photograph the morning of the main burn. Note the point where the end of the plot line intersects the farthest downwind point of the burn perimeter. This becomes the baseline. A baseline marker should be drawn perpendicular to the wind direction 30-100 meters or more into the burn. Widen the downwind fire break to the width indicated above. The width of this expanded fire break is dependent upon burning conditions and volatility of the fuels. The drier (lower RH), warmer, windier, and more volatile the fuels, the wider the downwind firebreak should become.

2. Expand baseline fire-break

Most burn perimeters will have a narrow firebreak developed before the day of the main burn. Either the day before or the day of the burn, these firebreaks should be widened to a predetermined width, based on volatility of the fuels and the current environmental conditions, as indicated above. Widening must be done on the downwind side of the burn perimeter and also on each flank side. Where the risk is high for a change in wind direction, the upwind burn perimeter must also be widened. Expanding the firebreak shall be done when the RH is 40-55%, wind is less than 8 kmh and the temperature is less than 20°C.

Ignition. Photo: Ron Moss

The firebreak should be widest at the downwind side of the area to be burned. The firebreak is expanded with an ignition person and suppression crew working in tandem. To expand the firebreak, start a fire line as a strip headfire a few meters from the established firebreak on the downwind side of the burn perimeter (Figure 3). The fire will begin to expand in 2 directions, toward the firebreak as a headfire and towards the center of the burn area as a backfire. Monitor the fire that is moving backwards into the field and let the narrow head fire burn into the existing firebreak. Have members of the suppression crew patrol the downwind perimeter of the firebreak to monitor and suppress any escapes across the firebreak, and any smouldering or flaming spot fires caused by firebrands. Ignite a second strip headfire several more meters out into the field to be burned and monitor it. Now that a wider firebreak exists, go more meters into the field and do a third strip headfire. Continue until a firebreak of satisfactory width exists on the downwind side of the burn perimeter. Then develop a wider firebreak along the flanks of the field using similar methods.

Ignition procedure for main prescribed burn

There are several steps to take before igniting the main prescribed burn.

1. Test Burn

The test burn should be conducted at the target time for ignition of the main burn when weather and fuel conditions are within the

burning prescription. First, take a field weather kit and record air temperature, RH, wind speed and direction. The weather conditions must be within the requirements of the burn prescription.

Develop a bare strip or wet line around a representative area of fuel within the burn perimeter. Ignite the upwind side of the bare or wet strip, observe wind direction, ease of fuel ignition, rate of spread of the fire and intensity of the burn. Let the test fire burn out all fuel, then wet down the area thoroughly.

The test fire should respond as the fire boss expected. If not satisfactory, the main burn must be deferred until conditions are better. These conditions may be satisfactory ½ hour later, 2 hours later, 24 hours later, or more, depending upon circumstances. Occasionally, one may be able to adjust the burning prescription and immediately proceed with the main burn.

2. Final crew briefing

Conduct a final crew briefing at the baseline. Review weather conditions and risks, wind speed and direction, then verify procedures for the main ignition. Verify where the fire boss will be during the burn, where ignition crews are to start and where suppression crews will be located. Check operational status of all communication, ignition and suppression equipment.

Ignition of Main Burn

The pattern of ignition is critical to the effectiveness of a prescribed burn. Most western Canadian brush species produce firebrands. Usually a higher fire intensity is required to top-kill live brush and to spread the fire through patches of low fine fuels under shrub or tree canopies. At the same time, firing must be conducted in a manner that minimizes the risk of fire escape.

There are two techniques most commonly used to conduct prescribed burns to manage woody species: the strip headfire technique and the surround technique.

Strip Head Fire Technique

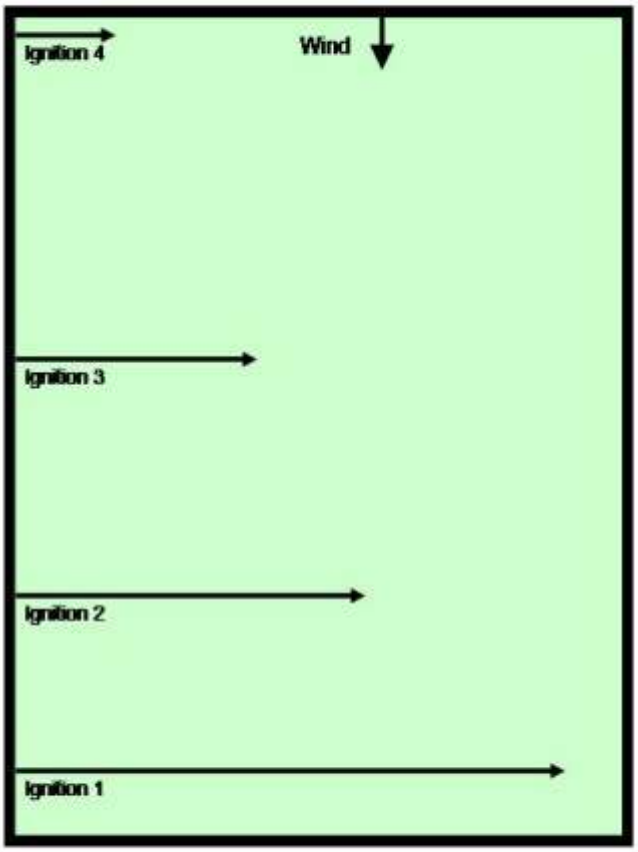
The strip head fire technique is a useful combination of safety and effectiveness. The

Photo: Bill Gardiner

method enables members of the ignition crew to leap-frog each other, starting on the downwind side and rapidly igniting the entire area within the burn perimeter (Figure 4). The illustration shows four separate ignitions. That is only an example. More or fewer ignition strips may be implemented in specific burns.

This procedure requires a well-trained ignition crew. The fire boss must pay attention to the safety of the ignition crew while the various ignition strips are underway. Any shift in wind direction or wind speed could cause danger to one or more of the ignition crew. The fire boss must be in radio contact with each ignition crew member while they are actually igniting a strip headfire.

Figure 4. Ignition using the strip head-fire technique



Ignition crew member 1 is to walk fast to get the first ignition strip completed as quickly as is practical. Ignition Strip 1 is done from one side to the other side to widen the downwind firebreak even more and to evaluate the effectiveness of the first headfire. The fire boss then delays the departure of ignition crew member 2. Once the fire boss knows the ignition of Strip Headfire 1 has been satisfactory, and there is no fire escape across the downwind fire break, then the fire boss instructs ignition crew member 2 to light Ignition Strip Headfire 2 as rapidly as possible. Once ignition crew member 2 is at least ½-way across, the fire boss instructs ignition crew member 3 to start lighting Ignition Strip 3 as rapidly as possible. Once ignition crew member 3 is at least ½-way across, the fire boss instructs ignition crew member 4 to start lighting Ignition Strip 4 as rapidly as possible. Once ignition crew member 4 is at least ½-way across, the fire boss instructs ignition crew member 5 to start lighting Ignition Strip 5 as rapidly as possible. The ignition process will proceed as above until all strip headfires have been ignited.

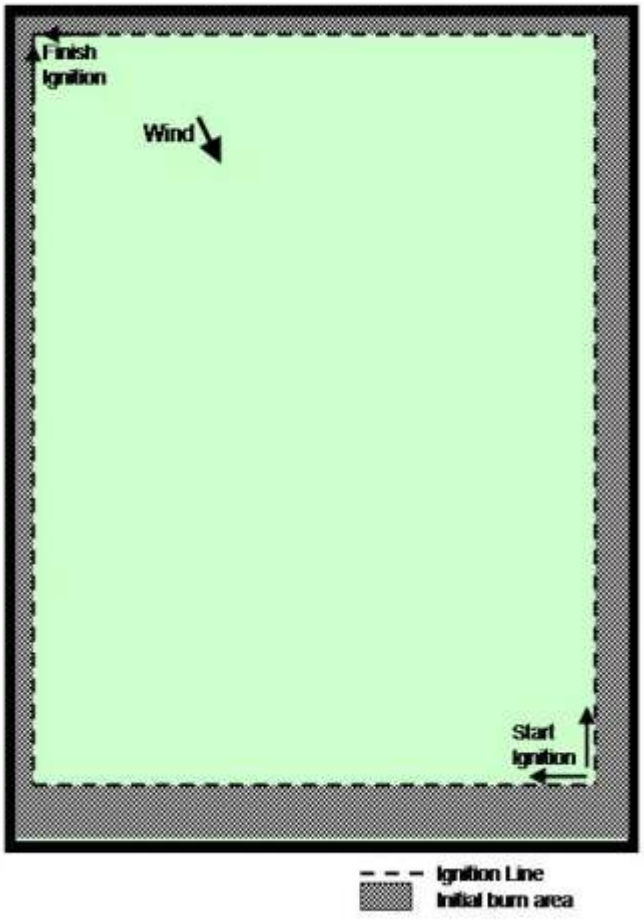
With such rapid ignition of a large burn area at a moderate wind speed, a column of heat soon establishes, that draws the burning embers towards the center from all sides of the burn perimeter.

The suppression crew patrols the downwind and flank sides outside of the burn perimeter, observing wind direction, wind speed, and smoke patterns to evaluate where firebrands are likely to fall. The fire boss should be in contact with them throughout the ignition process. The suppression crew is responsible for putting out any fire escapes across the burn perimeter and for putting out all spot fires and smouldering dung piles. Particular attention must be paid to smouldering dung piles. The crew should roam a wide area downwind from the burn perimeter and be in continuous radio contact with each other and the fire boss.

Surround Technique

This technique is generally used for dense tree stands with lower fine fuel loading (Figure 5) and when the wind speed is at a moderate rate of 8-12 kmh. Surround fires should be conducted only where there is a significant safety zone surrounding the perimeter boundary of the area being burned. This technique requires wide firebreaks on all sides. Ideally, the area will be bordered by cultivated land, or temporarily overgrazed grassland. The potential for very long flame lengths, high intensity fire, many fire brands and spot fires developing, is a reality. Implementation requires two members of the ignition crew to start to ignite the full perimeter of the field at the downwind edge of the burn, as illustrated in Figure 5. Igniter 1 walks rapidly to the left of the downwind boundary perimeter while Igniter 2 walks rapidly to the right. They each walk and ignite as they go, half way around the perimeter, meeting at the upwind edge of the burn perimeter, to complete the surround ignition pattern.

Figure 5. Surround Fire Technique



The suppression crew needs to concentrate at first on preventing any fire escape across the firebreak on the downwind side of the burn. Then, they will roam a wide area downwind from the fire to put out any smouldering or flaming spot fires outside of the burn perimeters. Particular attention will be paid to smouldering dung piles.

Fire Suppression Procedure during Main Prescribed Burn

Controlling the fire and having the ability to suppress any potential trouble spots is the most important aspect of conducting a prescribed burn.

1. Patrol the perimeter

Once the main prescribed fire has been ignited, the burn is patrolled only outside of the perimeter. It is too dangerous and impractical for either ignition or suppression personnel to be inside the burn area. Once the burn is ignited, everyone's job is to monitor the fire and immediately put out fire escapes. All escapes should be reported to the fire boss, even if one or two feel they can control it. If the need arises, the fire boss can allocate other crew members to assist in rapidly extinguishing the fire escape. As the burn moves towards the perimeter, fires smouldering close to the firebreaks should be closely monitored to reduce the chance of fire escape. Patrols need to be continuously looking for spot fires and escapes outside the burn perimeter, until the fire boss orders the suppression crew to stop patrolling.

2. Be sure the fire is out before leaving the site.

Once the prescribed burn has spread over and burned out within the burn perimeter, it is time for the whole burn crew to wait on the fire to draw to a close. Reconnaissance will continue looking for spot fires and smouldering dung or wood piles until the fire boss gives further instructions. Then the mop-up operation begins.

Mop-up procedures

A reconnaissance will be made of the entire area within the burn perimeter by some of the burning crew to evaluate how much smouldering and flare-up continues. While this is underway, the remainder of the burning team will make a wide survey through the downwind area outside the burn perimeter, and on the flanks as well, wherever firebrands might have fallen during the burn.

Inside the burn perimeter, it is important to assist any smouldering fuel to burn out. Smouldering material on the perimeter should be picked up and moved at least 50 meters away from the firebreak on the burn perimeter. Place it in piles so it will flare-up and burn out. Return later and soak these piles completely with water if they continue to smoke and smoulder.

Backpack sprayers can be used to put out small flare-ups. Photo: G. Oliver

Some members of the burn crew continue looking for spot fires and smouldering dung piles after the main burn is over. Photo: Bill Gardiner

Any smouldering material outside the burn perimeter shall be thoroughly soaked and extinguished, or if larger pieces, they will be picked up and moved well inside the burn perimeter to burn out. *Allow nothing to smoulder or smoke outside the burn perimeter.* If major logs or other large pieces of wood are smoking, use hand tools or a tractor and loader to remove them to at least 50 meters within the burn perimeter. Mark any such locations and return later to insure no further combustion is occurring.

As evening progresses, it is common for the RH to rise, temperature to go down, and wind speed to decline. Most smouldering will go out on its own, due to the higher moisture in the air. Once conditions are safe, the fire boss will declare the prescribed burn complete, and he/she will set up a plan for follow up monitoring over the next one, two or more days. Weather conditions can change, however, and flare ups can happen during the night, the next day or even longer.

The crew shall not leave the prescribed burn area until the fire boss gives permission to allow most of them to leave. It may be necessary for someone to stay on site well into the evening or overnight to monitor for flare-ups. Monitoring may be required for

one, two or even more days after the prescribed burn. In most cases, all smoking and smouldering is completed within 24 hours, but there are exceptions where large pieces of wood continue to smoulder. The usual solution is to bury them in wet soil about 24 hours after the burn.

POST FIRE MANAGEMENT

Evaluation of Effectiveness of the Fire

When new growth has begun a few weeks after a spring burn, the range manager can make a preliminary evaluation of the effectiveness of the fire kill of brush. It should be noted that the amount of tree and shrub mortality does not start to reveal itself adequately until a year later. The woody species top-killed by the fire will not have new leaves. Bailey and Irving (1984, 1985) studied aspen tree mortality following a moderate intensity burn in the aspen parkland. In year 1, only 3% of the trees were dead, this rose to 34% in year 2 and 57% in year 3. By year 3, only 8% of the trees showed no damage by fire.

The more intensely burned areas will have a reduced growth of grasses and forbs the first year. Expect about a 25-35% reduction in grass and forb production the first year after a spring or previous fall burn. The abundance of young, succulent woody suckers will offset reduced grass production. Young aspen suckers are readily grazed by cattle, sheep, goats, deer, elk and moose.

Impacts of fall burns cannot be reasonably evaluated until after the first winter. The next spring, monitor the burn as described above.

Application of Grazing Systems with Other Brush Management Techniques

Following a prescribed fire, the brush species will sucker profusely. Follow-up management

Grazing is the least expensive treatment in brush management and it is often the most profitable one because input costs are low.
Photo: Pam Iwanchysko

is required. In the Grazing Chapter, prescription grazing systems 1 and 2 are designed to assist the range manager use brush suckers and saplings as forage for grazing livestock. One system emphasizes how to use grazing to reduce the amount of brush and promote more grass and forb production. The other system emphasizes how to use more brush as nutritious forage, and to maintain a productive brush-grass mixture for livestock. Refer to the grazing chapter for more details.

There are a number of combinations of treatments available to the range manager following the first prescribed burn. Examples are presented in Table 4. Grazing is the least expensive treatment in brush management and it is often the most profitable one because input costs are low. Most native brush is very hardy and adapted to being grazed. The brush usually re-sprouts many times under livestock grazing. That may be quite acceptable to some ranchers in forested areas who want to use the young brush suckers as forage for many years. In other areas, however, some brush species are not very palatable to cattle. Sheep and goats may be able to browse the brush not liked by cattle.

Three brush management options are presented in Table 4. Choice 1 is to graze for

a number of years, followed by a second prescribed burn once enough fine fuel has accumulated at about year 4 or 5. In Choice 2, graze for two years, then apply herbicide using a specific application technique, then more grazing. For Choice 3, graze for two years followed by mowing or dragging to reduce brush re-qrowth in year 3, followed by more grazing. The last option is not displayed in Table 4. Some ranchers may be able to use various intensities of grazing alone for many years without applying other brush management techniques.

Another example is as follows:

Community pastures and other ranches often have very large fields. Livestock often prefer only part of such fields and the remainder is ungrazed. During years of normal to above-normal rainfall, establish a perimeter firebreak (following the procedure in "burn perimeters") around the part of the field that is ungrazed or under-utilized. Use the burning prescription for a low intensity fire. The next spring conduct a low intensity prescribed burn to remove dead grass and top-kill small diameter brush. Then, 6-8 weeks later place a large herd in the field at twice the normal stocking rate. Place salt, molasses, mineral supplement, and also temporary water in the

Post burn forage re-growth. Photo: Bill Gardiner

burned area far from any other source of water. If the old cows go back to their favoured places outside the burned area, herd them back into the farthest corner of the burned area. As soon as 60-70% of the grass has been grazed, move the herd out to another field. Rest the field from grazing until next spring. Repeat the grazing practice of year 1 starting about June 1-15th of the second year. Again use twice the normal stocking rate. Rest the field for the remainder of year 2. In year 3 and in subsequent years, return to the normal stocking rate and graze only 50% of the grasses and brush. In about year 5-6, consider repeating the practice with another low intensity prescribed fire.

Light burning of distant parts of a large field will attract livestock to the burned areas for several years. The livestock will also use more of the young brush suckers following

Table 4. Examples of options available after a spring burn.

Year 1	Year 2		Year 3		Year 4		Year 5
Choice 1: burn, graze	graze spring	graze summer	graze June	graze August	light graze spring	no graze summer, grow fuel	prescribed burn
Choice 2: burn, graze	graze spring	graze summer	wiper or aerial herbicide	light graze summer	graze spring	graze summer	normal rotation
Choice 3: burn, graze	graze spring	graze summer	mow or drag	light graze summer	graze June	graze August	normal rotation

the burn. This practice may not be as effective as using a deferred rotation grazing system in smaller fields as in Table 4, but it will provide some use of a forage resource that is usually left untouched.

Some ranchers prefer to develop their own methods of brush management following a burn. The options available following the first prescribed burn are only limited by the land manager's imagination, ingenuity and limitations of sustainable grazing management.

Other considerations that will influence the brush management decisions following the first prescribed burn will include soil type, terrain, vegetation, manpower and availability of equipment, dry or wet years.

Evaluation of Prescribed Fire as a Brush Management Tool Now and in the Future

Prescribed burning is a useful natural tool, and with proper management and education of both the public and practitioners, it can have a promising future.

Society has a justifiable fear of fire. While managed burning is a valuable range management tool, many people are not comfortable with its use by ranchers and pasture managers. Many urban dwellers don't understand why brush should be managed at all. They think it is all quite “natural” and should be left alone. Also, there are interest groups who wish to prevent the use of managed fire. They have their own reasons, including the belief that trees are “sacred” and more important than grasslands.

There is danger and liability associated with planned burns. This should be acknowledged. Anyone wanting to use prescribed burning must have respect for fire and understand the risks associated with its use. It is crucial they learn how to use it properly, by becoming very well trained.

There may be opportunities for practitioners to work together, and share expertise and equipment. It is important that the utmost care be taken with prescribed burning, as the risk of fire escape is very real. Knowledgeable fire bosses know that and take the precautions required to prevent it.

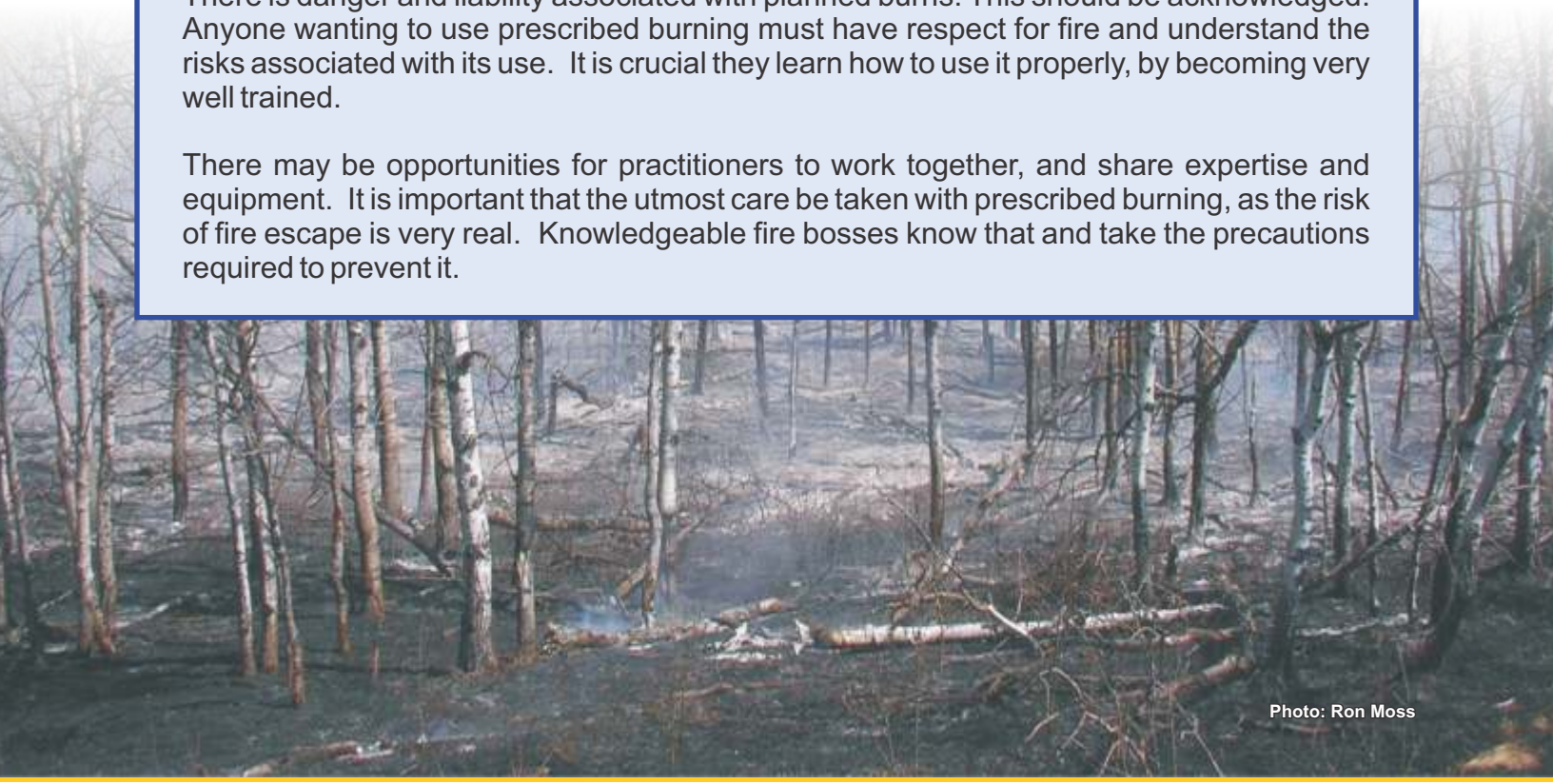


Photo: Ron Moss

Prescribed burning to top-kill shrubs and small encroaching poplars

The prescription is for the training of inexperienced burning crews. The same prescription, however, is also effective in removing the accumulated litter from lightly-grazed grasses and forbs, and to top-kill small diameter shrubs, willow and poplar.

Our experience indicates that firebrands rarely cause spot fires when the RH (relative humidity) is 45% or higher. Inexperienced crews should start practising prescribed burning as a team using an RH of 45-55%, with a wind of 3-10 kmh in grasslands. As the crew gains more experience, they can start burning at an RH of 35-55% in a mixed vegetation of grassland, smaller patches of shrubs, and also small groves of aspen.

Fire crews monitor a prescribed burn designed to top-kill small diameter aspen. Photo: Ron Moss

Experienced crews burning small diameter brush would use a burning prescription with the RH at 35-45%, with wind in one direction and a wind speed of 6-12 kmh. Many small shrubs and poplars would be top-killed using that burning prescription with 1500-3000 lb/ac of fine fuels.

Fire killed aspen and subsequent re-growth. Photo: Ron Moss

For relatively inexperienced burning crews, it is recommended they establish burn perimeters around small areas of 20-40 acres. As they gain experience and learn to successfully manage the burn and also the firebrands, spot fires and smouldering dung piles, they can reduce the width of the cultivated perimeter and expand the width of the burned fire break that is established the day before, or the morning of the main burn. They can also expand the area burned, first to 80 acres, and later to 160 acres. Only very experienced burning crews should attempt to burn more than 160 acres per day.

Prescribed burning using high intensity fire to top-kill aspen forest

A high intensity fire is effective for spring burning of aspen forest by very experienced burning crews. Detailed recommendations were presented earlier in *The Burning Prescription* section for the application of a high intensity fire.

If most of the trees have died by the third year, expect some of the dead trees to fall by Years 4 and 5. The fallen trees will create barriers to grazing livestock. Also, they will frustrate the round-up and herding of cattle. Nevertheless, within a year the livestock will make new paths and successfully graze about 80- 90% of the burned forest.

In a subsequent year, it may be useful to intentionally over graze the area in late summer or fall. Then, the next spring use an experienced burning crew to selectively burn only the areas having the greatest accumulations of fallen trees. Prepare a 200 meter wide fire break on the downwind burning perimeter and follow a modified burning prescription of a high intensity fire. Burn with an RH of 30-40%, a wind speed of 4-12 kmh. Expect many firebrands and some spot fires.

Only moderate rates of grazing should be allowed six or more weeks after the second fire.

Photo: Bill Gardiner

Prescribed Burning Economics

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height (Ft.)/ Diameter (In.)	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr.) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
Prescribed Burning (Low Intensity)	4-6 ft. 1-2 in.	$30	1050	$7		
Prescribed Burning (High Intensity)	mature	$60	8600	$55		

* 25 lbs forage = 0.80¢

- Burn costs were actually $60/acre for high intensity and $30/acre for a low intensity fire but have been averaged over the 20 year period.

- High intensity burn conducted on mature timber and followed up by 3 low intensity burns every five years. The high intensity fire cost $60/acre initially and subsequent burns cost $15/acre. Over a 20 year period, there was a burn every 5 years ($60+$15+$15+$15 / 20 years = $5.25/acre).

- Low intensity burn conducted on brush encroaching into grassland, and followed up by 3 low intensity burns every five years. The same treatments were done with the low intensity fire except the initial cost was $30/acre. As with the high intensity fire, 3 subsequent burns were done at $15/acre. ($30+$15+$15+$15 / 20 years = $3.75/acre). These cost estimates come from research projects that normally burn smaller areas. the cost per acre would decline on management sized burns of half sections (320 acres) or more.

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APPENDIX 2 – An Example of a Prescribed Burning Plan

(This prescribed burning plan was prepared by Jason Kosowan, PFRA, Range Management Division for a planned high intensity fire in Paynton Community Pasture, October 2007. The author of Chapter 5 have made minor modifications to the original burning plan.)

Contacts:

Pasture Manager:	Ph. ( )_____	Cell. ( )_____
Land Manager:	Ph. ( )_____	Cell. ( )_____
Range Management Division:	Ph. ( )_____	Cell. ( )_____

In August 2006, patches of aspen in this field were roller chopped. The roller chopper is a mechanical brush management treatment where the trees are rolled with a heavy drum and paddles on the drum chop the trees.

Objective: The objective of the fire is to consume chopped trees and control aspen re-growth. This will increase forage production and reduce the old tree snags and fallen trees within the chopped area.

Prescription: Fire intensity will need to be high in order to consume chopped trees. A series of strip head fires will be lit starting on the downwind side, then the flanks will be lit to create a circular fire to complete the burn.

Wind Speed - 12-15 km/hr*
Relative Humidity - 15-30%
Temperature - 15-20°C

**In a high intensity fire expect the fire itself to increase wind-speed by approximately 5 kph greater than wind-speed measured at the beginning of the burn.*

Public Notification: The pasture manager will contact all persons that are either directly or indirectly involved in the burn. These will include:

- Land Manager
- Rural Municipality (RM may wish to contact local residents)
- Local Fire Department
- Local media, if practical
- Local RCMP, at your discretion
- Adjacent landowners

Site Specifications (refer to attached map): The prescribed burn will take place in field B1B The total burn area will be 345 acres. This field is located directly to the west of the pasture headquarters with good vehicle access. Legal Land Location: SW 46-21-16 W3 and SE 46-21-17 W3.

Fireline: Prior to burning the chopped area a fire guard will be burned around parts of the perimeter. The field is surrounded by PFRA managed land except for the SW corner and north side of the field. Fire guards will be placed in the SW corner, the north side of the field, and the west side of the field. Areas with higher fuel loads will be focused on when burning the perimeter. Initially a wet line or foam line will be used to burn to on the perimeter. These areas are shown on the attached map as a dark blue.

Project Resources:

Fire Crew:	Name:	Phone:
Fire Boss		
Truck Operator		
Truck Pump Operator		
ATV Operator (Sprayer)		
ATV Operator (Sprayer)		
Ignition Person		
Ignition Person		
Ignition Person		
Suppression Person		
Suppression Person		
ATV Foam Unit Operator		
ATV Foam Unit Pump Operator		

Equipment Checklist:

- [ ] Matches or butane lighters
- [ ] Maps of burn unit and locale (ideally, a small one for each participant)
- [ ] Two-way radios (vehicle and portable)
- [ ] Flappers
- [ ] Torches (drip or propane)
- [ ] Extra torch fuel
- [ ] Backpack water pumps
- [ ] Fire extinguishers (all vehicles)
- [ ] Extra engine fuel and oil
- [ ] Wire cutters (all vehicles)
- [ ] First aid kits
- [ ] Drinking water
- [ ] Smoke masks, respirators, binoculars (1 per vehicle)
- [ ] Fire water pumper units (i.e. Wajax) mounted on 3/4 ton truck
- [ ] Water tanker unit or stock-tank on gooseneck (minimum 1200 gal; for refilling backpacks etc.)
- [ ] Gas generators to pump water (with accompanying hose)
- [ ] Tool kit(s)
- [ ] Tractor and plow (on standby) or other
- [ ] Tow chains, cables, or ropes (for downer vehicles)
- [ ] Handyman jacks
- [ ] Safety clothing (no steel-toed boots or synthetic clothing)
- [ ] Quad for each person not driving a vehicle (ideally)
- [ ] All trucks and quads must have full tanks of gas
- [ ] Environment Canada detailed weather forecast for that day
- [ ] Cell phone and phone numbers of local Fire Department, neighbors etc.

Ignition Plan:

Any areas of the perimeter that were not previously fire guarded by burning will be burned out in the morning prior to the ignition of the main prescribed burn.

When prescribed conditions of wind speed, relative humidity, and temperature are met, burning will commence as follows:

In order to build enough fire intensity the burn area may be reduced into smaller sections. This will be decided in the field the day of the burn. The initial plan is to burn three sections shown by light blue circles on the attached map, Area A, B, C

The first area that will be burned will be in area A, on the east side of the field. Strip headfires will be ignited from the east to west then the north and south will be lit, this is shown by the red lines 1, 2, 3, 4 and 5 on the attached map. After this is burning, Section B will be lit in the same manner.

It is important to get a hot fire, therefore more ignition strips may be required than is shown on the map. After ignition of the main fire is completed, spot firing will proceed to clean up material that was not burned.

It is important to light quickly and effectively as relative humidity rises quickly during late afternoon in fall. Have ample drip torches and spare jerry cans with gas and diesel. When time permits between the start of one ignition strip and the next one, always refill the partially full drip torches. Do not start a new strip ignition line with a half full drip torch.

Contingency Plan:

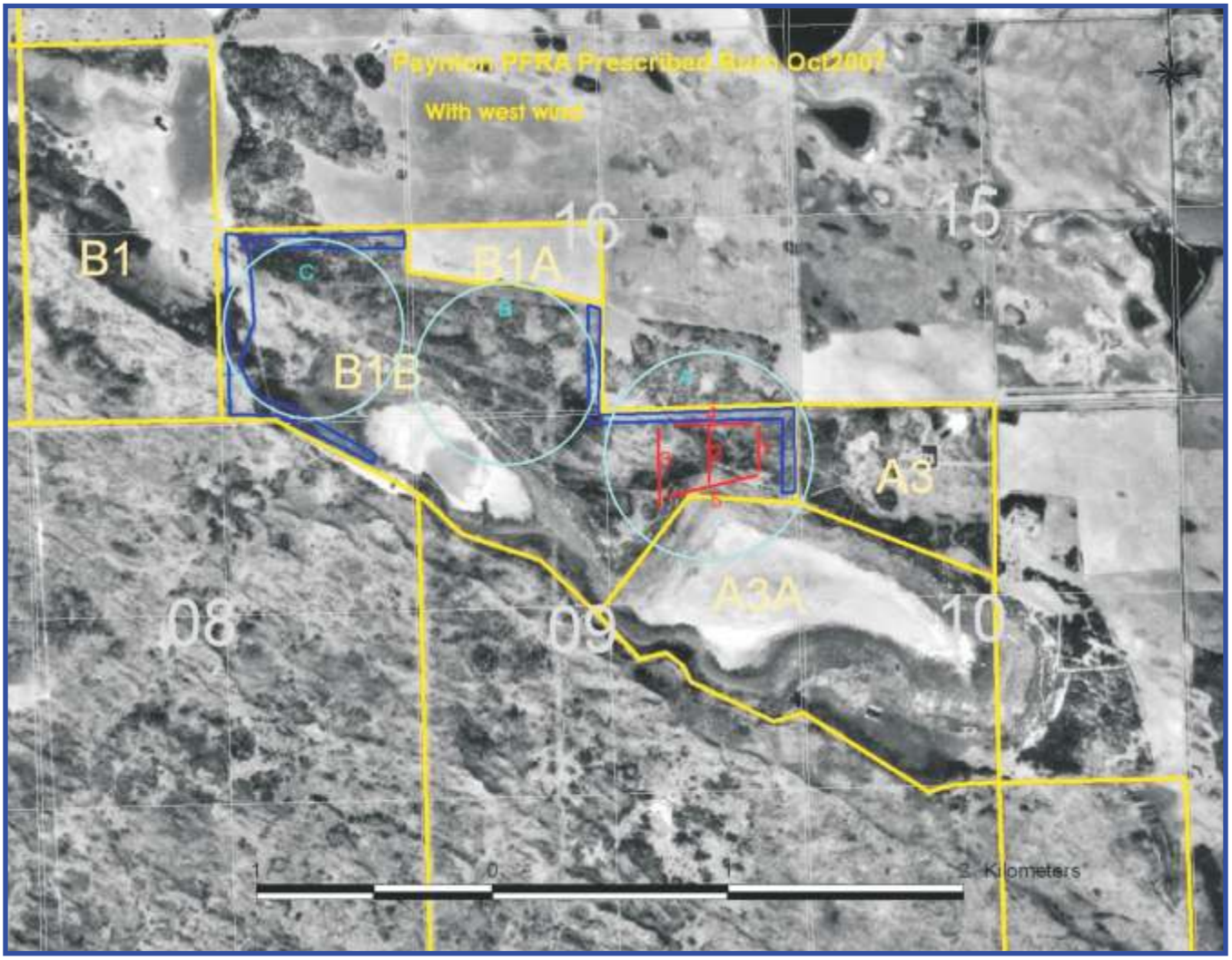
Minor Escape - in the event a fire should start outside the project area the fire boss will be notified. The fire boss will dispatch necessary personnel and suppression equipment. The prescribed burn will continue as planned.

Moderate Escape - Fire boss will be notified. All suppression equipment will be dispatched to escape area. Prescribed burn will cease.

Complete Loss - Prescribed burning will cease immediately. Fire boss will dispatch all suppression equipment to escape area. Back up suppression forces will be dispatched to project area.

Mop-Up:

The prescribed burn should be completed by 5:00pm. A two person crew will monitor the project area for at least 48 hours following burning activities.



CHAPTER SIX

Timber Harvesting

Bill Gardiner
Farm Production Extension – Range & Pasture
Manitoba Agriculture, Food and Rural Initiatives
Dauphin, MB
bill.gardiner@gov.mb.ca

OVERVIEW

- Timber harvesting and livestock grazing have historically been perceived as conflicting resource use.
- Studies and research conducted over the last three decades relative to timber harvesting/livestock grazing interaction generally indicate that the two activities are compatible, when both forest and grazing management practices are carefully managed and monitored.
- Timber harvesting is often implemented as a management strategy for aspen control. Harvest strategies are designed to take advantage of aspen ecology and meet management objectives for a particular area.
- Woodlot planning is particularly important when the land management objective is to rejuvenate the stand for sustained timber production or integrate sustained timber production and livestock grazing.
- Timber harvested sites present many challenges relative to methods used for management of aspen re-growth.
- Managed grazing is the most economical method for management of aspen re-growth following tree harvest and can serve as a means to accomplish different land management objectives.
- Special conditions negotiated in a timber sale agreement will facilitate other methods for management of aspen re-growth including herbicide, mechanical and fire.

Photo: Bill Gardiner

INTRODUCTION

Note: *This chapter deals almost exclusively with hardwood harvesting.*

Timber harvesting and livestock grazing have historically been perceived as conflicting use. In recent years, integration of cattle and working forest systems has become even more contentious, due to increasing industrial forestry interest in hardwood harvesting within the agricultural zone or agriculture/forestry interface.

Whether the focus is on deciduous or coniferous forests, foresters are concerned about potential damage to trees as a result of grazing (trampling and browsing), including the opportunity created for pest or disease invasion. Additional concerns include the potential effects of cattle on soil quality (i.e. compaction), water quality, plant health and species diversity.

Conversely, ranchers perceive timber harvesting as a threat to future grazing in terms of reduced quality and quantity of forage, as well as the condition and usability of the land following harvest.

Timber harvesting is often implemented as a management strategy for aspen.
Photo: Bill Gardiner

Studies and research conducted over the last three decades addressing resource interaction generally indicate that the two activities are compatible, when both forest and grazing management practices are carefully managed and monitored.

A general review of literature relating to the integration of cattle into working forest systems can provide important management guidelines for ranchers and foresters. The results of each study are specific to site conditions and particular situations under which the research was conducted. The literature cited assumes that grazing management strategies (i.e. stocking rates, distribution, timing, etc.) and forest management practices (i.e. season of harvest) are developed to address regional site specific considerations and limitations.

Joint resource planning becomes particularly important when the objective is to ensure that lands are managed with both timber and grazing in mind. Such is the case with public lands, where general government policy objectives allow for sustainable joint benefits including forage, fibre, wildlife and recreation. Future work in the area of resource interaction and compatibility will help strengthen existing government land use policies.

Aspen Ecology and Timber Harvesting

Aspen is a pioneer tree species that reproduces on open sites under full sunlight. It is a clonal plant which produces numerous genetically identical stems, all sharing the same root system. One clone may occupy several acres.

In the absence of natural disturbances such as insect outbreaks or fire, timber harvesting is often implemented as a management tool for aspen. Harvest strategies are designed to complement the ecology of aspen and meet management objectives for a particular area. For example, harvesting all aspen trees and trampling shrub within an area can stimulate suckering and sapling development. On the other hand, individual tree or small group harvesting stimulates diversification of understory vegetation rather than regeneration of aspen. This type of harvesting simulates a pest outbreak which typically creates gaps in the upper canopy, increasing sunlight which warms the soil and stimulates suckering.

The season of harvest impacts aspen ecology. Winter harvests are generally implemented to minimize topsoil disturbance and compaction that in turn, could affect the success of aspen regeneration. High levels of carbohydrate reserves in the root system during winter months ensure successful and abundant sucker production during the first several growing seasons.

Summer harvests are generally implemented on drier soils, where the risk of disturbance, including topsoil removal (erosion), cutting and soil compaction are minimized. Less suckering occurs with a summer harvest.

Winter harvests are generally implemented to minimize topsoil disturbance and compaction. Photo: Bill Gardiner

Summer harvests are best implemented on drier areas to reduce soil disturbance. Photo: Bill Gardiner

Although summer harvesting might appear to be the better option where pasture management is the objective, landowners/managers need to understand the risks associated with soil disturbance, particularly under moist or wet conditions. Winter harvesting greatly reduces the problems associated with soil compaction and topsoil disturbance and/or erosion. It is also important to recognize that grazing strategies can be designed to reduce or minimize aspen regeneration and provide livestock grazing benefits, for both winter and summer harvested areas.

Woodlot Planning

Timber harvesting is the most appropriate management strategy in wooded areas that support mature trembling aspen and balsam poplar. Harvesting can provide the landowner with an opportunity to generate revenues from timber sales. However, it is important that the harvesting be conducted in a manner which is conducive with the land management objectives.

Land management objectives may include:

1. Multiple resource use objective

    - Rejuvenate a stand for sustained timber production, wildlife habitat and biodiversity.

- Integrate sustained timber production and livestock grazing.

2. Single resource use objective

   - Converting land use from timber production to pasture for livestock grazing.

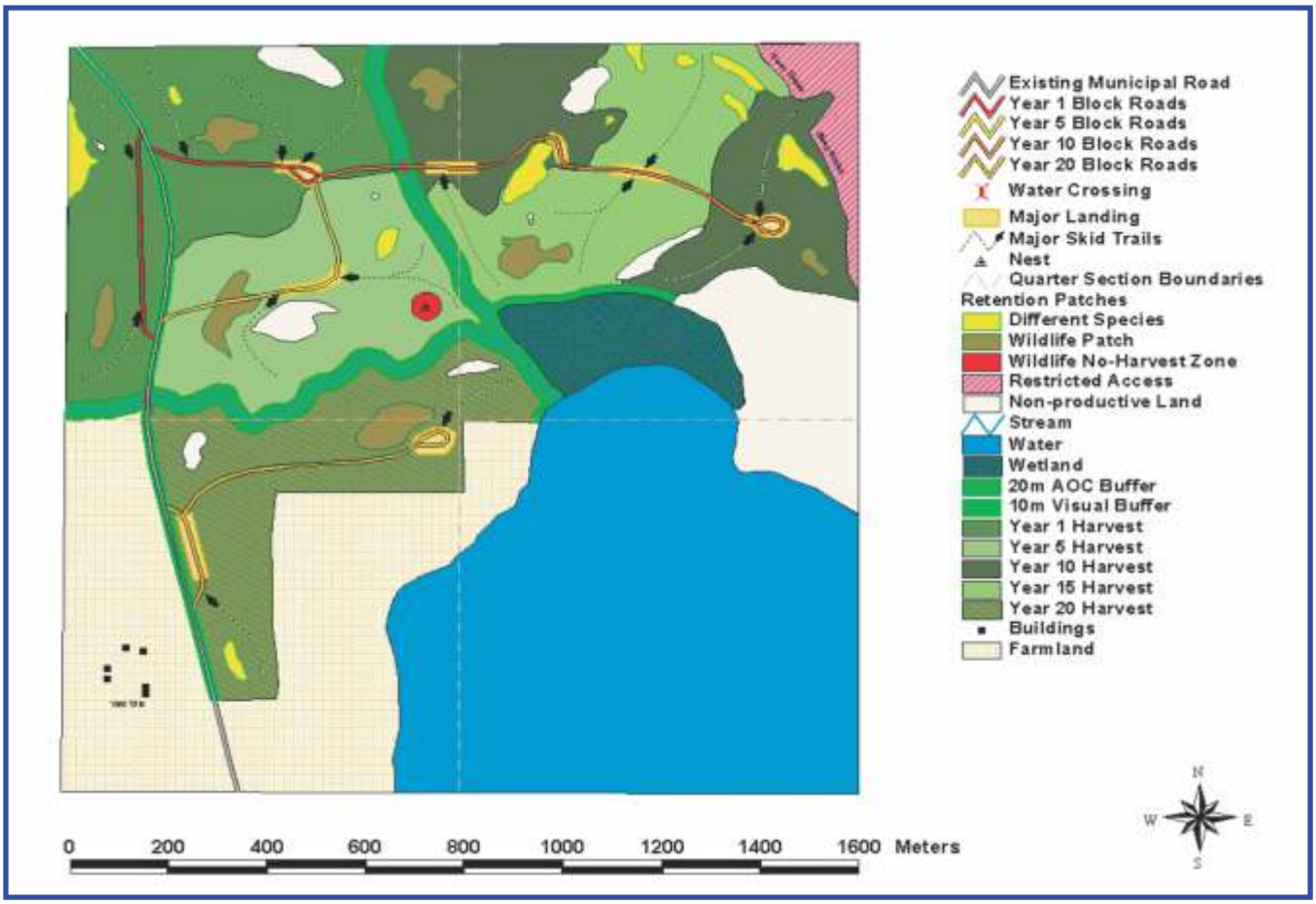
If the objective is to sustain timber production or to attempt an integrated forestry-livestock grazing strategy, then land managers/owners should consider accessing professional technical support to develop a woodlot management plan. The plan helps identify a strategy based on a combination of:

- Landowner/land manager objectives
- Timber volume
- Stand health
- Market options
- Areas of environmental risk
- Forage productivity under the new forest

THE TIMBER SALE AGREEMENT

Once a decision has been made to harvest the timber, woodlot owners should seek out advice from other landowners or woodlot service agencies about reputable logging contractors. Before signing a timber sale agreement, the landowner and logger should walk the site in order to negotiate and agree on all operating restrictions. It is critical that all cut blocks, trails and landings, as well as

Figure 1. A simplified layout of a planned logging operation is illustrated as follows.
Figure provided by Shane Tornblom



all restricted operating areas be clearly marked and mapped.

A timber sale agreement along with site maps outline mutually agreed upon conditions for the harvest. This should include:

- Volume/area to be harvested
- Time of access
- Road design
- Condition of site following harvest
- Beneficial management practices
- Price and payment schedule

The agreement provides protection for both the woodlot owner and the logging contractor, should any condition not be met during or following harvest.

The condition of the site following harvest is an important factor and can be negotiated with the logging contractor. If, for example, the wooded area is to be converted to forage production, then high stump height may be negotiated for ease of removal. Slash distribution is also an important consideration, particularly when the planned use following harvest is grazing.

Regardless of the objective for the woodlot, harvesting should be responsive to environmentally-sensitive areas. Riparian areas and wetlands should be safeguarded against erosion and degradation of water quality, while light textured (sandy) soils need protection from soil disturbance and/or risk of subsequent damage from erosion. Implementation of beneficial management practices can ensure that timber harvesting meets management goals, while maintaining water quality, biodiversity and wildlife habitats.

METHODS FOR MANAGEMENT OF ASPEN RE-GROWTH FOLLOWING TIMBER HARVEST

The objectives and management strategy on private land generally differs considerably from that on public lands which are directed by government policies and designed to ensure forest regeneration and sustainability. On private woodlots, many ranchers and farmers choose to adopt strategies which reduce aspen and shrub re-growth in favour of grasses and forbs.

The following treatments are recommended relative to post-timber harvest management of aspen suckers, saplings and other woody re-growth.

Note: *As mentioned above, the methods generally apply to private land only. Refer to the appropriate chapter in this manual for more detailed and specific information.*

Livestock Grazing

Grazing is widely recognized as the most practical and economical method to manage aspen re-growth following tree harvest. Timber harvested areas are generally characterized by regenerating shoots of aspen, shrubs, grasses, sedges and forbs. These areas lend themselves quite well to a managed grazing system. This can include intensive management with cattle, sheep or goats, either individually or in combination with one another.

Grazing is a practical and economical method to manage aspen re-growth following tree harvest.
Photo: Bill Gardiner

Managed grazing can serve as a means to accomplish different land management objectives. Chapter 7 outlines different managed prescription grazing systems, including the following:

System 1: Prescription grazing to reduce brush and increase production of grass, sedges and forbs.

System 3: Prescription grazing to regenerate aspen forest and provide forage for livestock.

System 3A: Grazing following winter logging of aspen forest.

System 3B: Grazing following summer logging of aspen forest.

System 1: Has application to hardwood timber harvested areas and is supported by a substantial research base. This system also has more application for private than public lands.

In this option, the woodlot owner chooses to reduce the density of aspen suckers by heavy deferred rotation grazing. Production of approximately 500-1200 lbs/acre of forage (browse and herbaceous growth) is estimated in Year 1 after winter logging. This is followed by a steady increase in Years 2-4 to approximately 1000-2500 lbs/acre. With this system, a rancher uses a deferred rotational grazing system and ensures there is an excellent distribution of cattle. The cattle can browse the aspen and graze the underlying grasses and forbs up to 60% use in the first half of the growing season. This requires no more than a two-week stay per paddock to accomplish a 60% usage of the grasses and a 40% usage of the aspen suckers. The cattle can then be moved to the next paddock to repeat the process. The main objective then, is to allow the harvested aspen forest area to be rested from grazing for the second half of the summer. This will allow grasses, forbs, some aspen saplings and other shrubs the opportunity to re-grow and store adequate reserves in the roots to survive the upcoming winter. This process is repeated in subsequent years. A rancher/farmer should be able to keep the area producing a mixed shrub-grassland range at a level of approximately 1200-2000 lbs/acre or more for 5-8 years, before another management method (i.e. mechanical or herbicide) need to be considered.

System 3: Has application on hardwood harvested areas. As mentioned throughout this chapter, System 3 is primarily targeted for public lands, although private

Livestock are naturally drawn to timber harvested areas because of regenerating shoots and grass/forage. Photo: Bill Gardiner

A managed grazing system can include cattle and/or sheep and goats, individually or multi-species. Photo: Pamela Iwanchysko

landowners and managers may choose to adopt this system as well.

System 3A: (winter harvest) Forage production (browse and herbaceous) is estimated at levels similar to System 1 for the first 4 years. However, after Year 4 there will be a gradual decline to an average of 1500 lbs/acre in Year 5, to 1000 lbs by Year 8 and to 500 lbs/acre by Year 10. System 3A is also based on the assumption that cattle do not heavily graze the woodlot in the first half of the summer. The majority of grazing occurs in the later part of the grazing season. The key point is that by Year 5, forage production and cattle access to the understory forage declines. This continues until about Year 20, when natural thinning of the aspen enables cattle easier access to the understory forage once again.

Herbicide

There are several registered products available for control of woody re-growth. As a general rule, herbicide should be applied 2-4 years following timber harvest. Also, timber harvest sites are better suited for aerial rather than ground application.

Aerial application of Remedy®.
Photo: Bill Gardiner

Remedy® - Aerial treated area.
Photo: Ron Moss

Wiper application of glyphosate.
Photo: Bill Gardiner

Area that has been wiped with glyphosate. Photo: Ron Moss

Fire

Fire is a brush management method which has application on timber harvested areas, either as a single application or in combination with additional follow-up treatments.

For timber harvested areas, fire basically serves two purposes:

- To clean-up debris following the harvest.
- To kill aspen saplings and other woody plants.

Mechanical

Timber harvested sites are generally not well suited to most ground-applied mechanical methods of brush management. This is because cutover areas have stumps, debris and clumps of standing trees that restrict or prohibit ground application. If a mechanical method of control is being considered, then it is imperative that the landowner/land manager negotiate specific terms with the logging contractor in the Timber Sales Agreement. These terms would include such things as debris management, clear cut vs. selective harvesting and stump height.

Note: *Timber harvested forest sites are generally better suited to aerial application of herbicide. Cutover areas have stumps, debris and clumps of standing trees that impede ground application.*

For example, if the area is suitable for land improvement which involves conventional clearing using a bulldozer, high stumps will facilitate their removal. In all other cases, lower stump height should be negotiated to facilitate the movement and ease of working equipment, which could include mowers, bark scrapers, or rollers.

Forage Establishment

Establishing forage in a timber harvested area can also be considered as an option for management of aspen re-growth. This option would be considered in conjunction with grazing, where the forage could be established through a number of different ways (i.e. broadcast, drill, breaking/seeding).

Forage establishment is a consideration when the land management objective is to reduce brush and increase production of forages and is described in detail in Chapter 7 (Prescription Grazing).

Other

Pre-Harvest Herbicide Treatment of Bush

The objective with this option is to pre-treat the bush as a method of control. This has the advantage of salvaging the wood resource as part of the overall objective. (Refer to Appendix 1.)

Controlled burn of a timber harvested site

1. Burn on a timber harvested site.

2. Aerial view of the burn in progress.

3. Aerial view of the burn aftermath on the harvested block.

4. Forage regrowth one month after burn.

Photos: Bill Gardiner

Scarifying to incorporate broadcast forage seed

Scarifying to incorporate forage seed which had been broadcast via ground application.

Forage emergence on scarified site.

Photos: Bill Gardiner

Rotovating / Mulching at a timber harvest site

Mulching following timber harvest at Eddystone, Manitoba.

Rotovating harvested site.

Close-up of a mulched tree stump.

Rotovated area.

Photos: Bill Gardiner

Timber Harvest Economics

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height Ft. Diameter-In.	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr.) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
Timber Harvest	Mature	$0	7100	$45		

* 25 lbs forage = 0.80¢

Revenue from the timber was not calculated. Higher income values would result if it was taken into consideration.

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APPENDIX 3

Aerial Application of Glyphosate & Forage Seed to a Mature Forest

Manitoba Crown Lands, Louisiana Pacific Canada Limited, and Prairie Farm Rehabilitation Administration (PFRA) carried out a project, starting in 2002, of aerially applying glyphosate to mature trembling aspen and balsam poplar trees. The site was in the Lenswood PFRA pasture, located 25 miles northeast of Swan River, Manitoba.

On August 16, 2002, glyphosate was applied aerially to 40 hectares (100 acres). The trees were harvested in December/2002 – January/2003. The next year, glyphosate was applied to an additional 40 hectares (100 acres) on August 6th, with harvest of the trees in October, 2003. The purpose of applying glyphosate was to prevent poplar regeneration after harvest. Two different rates of Vision® (Monsanto aerial glyphosate), 4.9 l/ha (2 l/ac) and 9.88 l/ha (4 l/ac) were applied on half of each site. The total mix of water and chemical was 45 l/ha (17.8 l/ac).

In 2003, an 8.96 kg/ha (8 lb/ac) mixture of timothy, alfalfa, bird's-foot trefoil, red clover, alsike clover and white clover, was aerially seeded over the 40 hectares to be harvested, as well as the 40 hectare site harvested the previous winter. Climatic seeding conditions in 2003 were very favourable for forage establishment.

The 40 hectares harvested in 2003 had less tree limb debris, since the timber harvest was done prior to freeze-up. In a winter operation, the frozen limbs break off easily when the trees are skidded to a landing (area where the trees are prepared for transport to the mill or plant).

The quality of the timber, after being killed with glyphosate, was a concern. The trees were processed at the Louisiana Pacific Canada Ltd. oriented strand board (OSB) plant at Minitonas, Manitoba. Louisiana Pacific found no measurable difference in the quality of the wood, especially the moisture content.

PFRA set up 16 exclosure cages in July, 2002. The purpose was to measure the difference in forage yields between the forest and the two different chemical application sites. Eight control cages were set in the forest adjacent to the two chemical treatment sites and 4 in each of the treatment sites. In July, 2002, range staff began measuring the quantity of forage in the cages. Measurements at the site continue each July.

The table below summarizes yield data collected to date. One year after seeding, the 2004 clippings show the increase in yield in harvested areas was very significant, compared to the forest. Browse in the

Table 1. Forage production on harvested sites

Treatment	2002	2003	2004	2005
	kg/ha (lb/ac)			
2 litres of glyphosate*	611 (546)	161 (144)	2940 (2625)	3474 (3101)
Control adjacent to 2 litre site	377 (337)	383 (342)	629 (561)	1126 (1006)
4 litres of glyphosate*	308 (275)	56 (50)	5365 (4790)	6147 (5489)
Control adjacent to 4 litre site	328 (293)	490 (438)	383 (342)	295 (263)

*Monsanto, Vision®

forested area was not taken into consideration, only herbaceous forage.

As mentioned above, conditions were very favourable for seeding and it probably would be difficult to repeat the trial and get equally significant results. At the same time, it does show the potential of harvesting timber for revenue on private land, and increasing the livestock carrying-capacity at the same time.

As with any trial, questions or concerns arise that are not answered in the research. Some things a producer would have to take into consideration before using this method are as follows:

- Aerial forestry glyphosate (not approved for agriculture) will kill all existing vegetation, which could allow entry of invasive plants.
- Native grass/legume landscapes are a valued asset and seeding tame forages could diminish the biological integrity of the area (native seed, such as slender wheat grass, could be used instead of tame varieties).
- The grass/legume seed bank in the forest soils could be high, especially in the southern parkland or areas that were previously open prairie and seeding may not be necessary (previously cleared land in the area would give an indication of the seed bank in the soils).
- Revenue from timber sales on private land could offset treatment costs.

Additional data to be collected or analyzed from the experiment includes:

- Measure of the tree regeneration – visually the areas appear to have little re-growth except in a couple of strips that could have been missed or possibly had very large trees with more extensive root systems.
- PFRA has recorded the species composition in the cages, but this information has not been analyzed.

LENSWOOD 2002 TRIAL AREA

2003

Photo: Ron Moss

2004

Photo: Ron Moss

CHAPTER SEVEN

Prescribed Grazing

For Brush Management in Canadian Aspen Parkland, Foothills and Lower Boreal Forest

ARTHUR W. BAILEY, PROFESSOR EMERITUS,
RANGELAND ECOLOGY AND MANAGEMENT,
UNIVERSITY OF ALBERTA, EDMONTON, ALBERTA
E-MAIL: AWBAILEY@UALBERTA.CA

OVERVIEW

- Grazing can be the most economical part of a brush management strategy while also providing forage to livestock.
- Livestock eat brush naturally on aspen parkland, foothills, and southern boreal forest range and pasture lands because it is palatable and nutritious.
- Grazing is usually most effective as a brush management strategy when combined with either mechanical, herbicide or burning systems.
- It is not simple to use grazing as an effective brush management tool. It requires knowledge and determination to implement effectively.
- Grazing can be used to either remove brush or to manage and sustain brush as part of the forage supply.
- Light grazing in spring and early summer are most effective in maintaining brush as a sustainable forage resource with grasses and other forages.
- Heavy grazing in spring and early summer can be used to reduce palatable brush and to promote the production of grasses and other forages on range and pasture lands.
- Deferred rotation grazing is recommended for managing brush and grass rangelands on a sustainable basis.

Photo: Bill Gardiner

Four grazing prescription systems and several additional options are presented in this chapter to either:

- Reduce palatable brush and increase grasses and other forages.
- Sustain forage production of palatable brush and grasses as forage.
- Sustain growth and regeneration of young aspen while providing some livestock grazing, following either winter or summer logging.
- Sustain growth and regeneration of young coniferous forests while also providing some forage for livestock, in either tall larkspur free, or in tall larkspur-infested forested rangeland.

INTRODUCTION

This chapter deals with the role of grazing in managing brush. Grazing may have a major role or a minor role in this process, it depends upon the circumstances. Four decades ago, Friesen et. al. (1965) published a bulletin dealing with brush control in western Canada. Their primary emphasis was on mechanical or herbicide methods to control brush. The main consideration was to control or eradicate brush rather than to manage it. Times have changed. Now, there are many economic and ecological forces influencing agriculture, range and pasture management, forestry and ecosystem management. There are demands for new answers to old challenges. Part of the solution to some aspects of brush management is to use grazing in new ways. This is the challenge in the grazing chapter.

Grazing and browsing are economical and powerful forces to manage Canadian prairie, foothill, and boreal forest rangelands when the manager has the knowledge and will to apply basic principles. Plants have been grazed since the beginning of time and vegetation is well adapted when utilized in moderation (Bailey 1999). With good range and pasture management practices, browse and herbaceous forages can be managed for optimum productivity for both forages and livestock on a sustainable basis. Brush management using livestock, is challenging and complex but is worth the extra effort required by the manager. Grazing can be the least expensive component of a well-planned brush management system.

Each manager has to make a number of choices when deciding whether to implement grazing as part of their management strategy for dealing with brush species. Some of the choices are:

- To keep palatable brush species as a part of the forage resource, as livestock shelter and as habitat for livestock and wildlife.
- To reduce unpalatable tree and shrub components while encouraging high productivity of herbaceous forages.
- To remove all woody plants and replace them with herbaceous forages.
- To maintain both a timber resource of aspen or conifer and a grazing resource for livestock and wildlife.

Livestock grazing practices, which enhance brush management objectives as well as sustaining healthy forested rangelands, are recommended. Basic information about how brush reacts to defoliation is presented, as well as how to manage herd animals to realize predetermined objectives.

Strategies are presented for the range and pasture manager to consider in applying managed grazing to their own range and pasture resources. A sudden change in a grazing prescription will not contribute huge economic and biological rewards in one year.

It may take several years before actual changes in the forage supply become available to livestock. It is important to implement a new brush management plan sequentially on part of the property. Then, observe the rate of progress before adapting the principles to the entire ranch or farm.

Each range and pasture manager should recognize that their own property is unique. They are in the best position to develop a specific understanding of their rangelands and pastures. This will allow full advantage by using grazing strategies to optimize their forage production base on brushy rangeland.

Normally the term "browsing" refers to animals eating woody species while the term "grazing" refers to animals eating herbaceous forages, such as grasses, forbs or sedges. In this chapter, to simplify the terms used, we call both grazing of herbs and the browsing of brush simply "grazing".

Adaptation of Brush to Grazing

The aspen parkland, southern boreal forest, and adjacent foothill forests of the Rockies are about 30 million years old. These forested ecosystems have been browsed, grazed, rubbed, trampled and burned countless times during their evolution (Moss 1955, Roe 1970). They are well adapted to moderate grazing at any time of the year. It was only the extreme effects of vast herds of animals or epidemic outbreaks of tent caterpillars and other insects over a long period of time, that disrupted the growth patterns of some and caused others to die (Bailey 1999).

Native poplars, willows, silverberry, snowberry, saskatoon, wild cherries, wild roses, wild raspberry, wild gooseberry and similar species all re-sprout after burning, mowing or dozing. Usually, they do not need to reproduce from seed. Sprouting from an existing root system is a unique and effective adaptation to dealing with grazing and trampling.

For about 20,000 years, aboriginal people burned the Canadian plains frequently to manage the forage supply of wild animals they needed for food. Deciduous trees and shrubs that grew suckers and shoots were able to cope under a higher frequency of burning than the non-sprouting conifers. Today, after more than 100 years of settlers and foresters putting out prairie and forest fires, there is additional brush growing on former native grasslands and parklands.

GRAZING ANIMALS AND PLANTS IN ASPEN PARKLAND, FOOTHILLS AND SOUTHERN BOREAL FOREST

Grazing ungulates have been eating and trampling prairie shrubs, trees and grasses for millions of years. There are three general types of ungulates that graze and browse for their food. Most of them have the four part stomach called a rumen.

What Animals Eat Brush?

Grass eaters (grazers)

Cattle, elk, bison and horses eat grasses, sedges and forbs. The most dedicated grazers are bison and horses, which eat primarily grasses, sedges and forbs and infrequently brush. In the distant past, bison herds probably trampled and broke off the brittle, frozen stems of shrubs and small trees as they sought refuge from severe winter storms.

A browsed aspen sapling.
Photo: Arthur Bailey

Cattle and elk eat primarily grasses, sedges, and forbs but also periodically eat brush. Cattle may often choose to eat a significant amount of browse as a normal part of their diet. In winter, elk often depend upon browse for food when grasses are covered by deep snow.

Brush eaters (browsers)

Goats, moose, and deer prefer woody plants rather than grasses or forbs throughout the year. Browse is indispensable to moose and deer in winter when the snow is deep. During the growing season, these ungulates may act more like mixed feeders eating brush, forbs and some young grass. Now that moose have access to annual agricultural crops, they can be observed periodically eating canola in cropland, aquatic plants in wetlands, as well as palatable browse.

Moose and deer are of only passing interest because ranchers and farmers can rarely manage them. Similarly, domestic goats are not common on the Canadian prairies. However, where goats occur in sufficient numbers, they can be utilized to manage palatable brush.

Mixed feeders (grazers and browsers)

Domestic sheep are mixed feeders, as are cattle. Most cattle eat a diet of grass, sedges, forbs and browse and are capable of varying their diet according to the availability and palatability of various forages.

Sheep, being smaller animals with smaller mouth parts, can be more selective in choosing what plant part to eat. Cattle have wide mouths, are less selective, have a bigger gut capacity and are bulk feeders rather than being as selective as sheep. In the forested plains areas, however, cattle are quite capable of selecting and eating the palatable brush species, while avoiding the unpalatable ones.

RESISTANCE OF WOODY PLANTS TO GRAZING

Prairie and boreal forest plants have become adapted, and to some degree, are resistant to grazing and browsing by ungulates and insects. There are various ways in which this occurs.

New aspen twig growth is available to cattle browsing in the first two months of spring and into summer. Photo: Ron Moss

Palatable brush (browse)

Some brush is attractive to grazing and browsing animals and it is readily eaten (Table1). Range managers call palatable brush by the term "browse"; it is palatable for livestock or wild ungulates. However, not every part of each shrub or tree is eaten. The large stems are inedible and indigestible because they are too hard or big. Grazing animals do not try to eat large, hard stems unless they are starving.

The parts of palatable brush most frequently eaten by livestock are the tender young shoots and leaves that grow in spring and early summer. These young stems are called either "new growth", "current growth" or "current annual growth". Dockrill et.al. (2006) studied the force required to shear aspen stems of current growth, 1 year-, and 2 year-old growth from spring through to fall. They found that the shear force required increases in each age class from spring to fall. Apparently, these aspen stems lay down more lignin and other hardening agents in their cells from late spring through to fall in each of the 3 age classes tested. New aspen twig growth is available to cattle browsing in the first two months of spring and into summer. By August, stem hardening has occurred. It has proceeded to a stage where most current growth stems are too hard for cattle to tear off.

Table 1. A list of the common palatable and unpalatable plants for livestock in the Canadian plains.

PALATABLE	UNPALATABLE
aspen poplar	alder
choke cherry	balsam (black) poplar
pin cherry	buffaloberry
red osier dogwood	all conifers
saskatoon	hazelnut
wild gooseberry	oak
wild raspberry	shrubby cinquefoil
wild rose	silverberry (wolf willow)
most willows	snowberry (buckbrush)
	a few willows

Beaked Hazelnut is an unpalatable shrub species. Photo: William S. Justice

On the other hand, browsers such as moose, goats, elk and deer can break off and chew the young current growth of aspen and other browse species all year. Dockrill et al. (2004) observed, however, that cattle did strip off and eat aspen leaves in August and September when the hardened twigs were unavailable to them. Arthur (1983) and Bailey and Arthur (1985) found that the palatable brush in the aspen parkland was readily eaten by cattle as a normal part of their diet in June but by October after leaf fall, only the smaller twigs were browsed. They observed cattle eating fallen aspen leaves in September and October.

In this chapter we assume that the principles of stem hardening found in aspen by Dockrill et.al. (2006) are applicable to other woody forest species.

The first two months of the growing season are the key periods for livestock to graze young stems of palatable brush.

Unpalatable brush (not browse)

Unpalatable woody species are not usually browsed and thus are resistant to the effects of grazing animals. They include alder, balsam (black) poplar, buffaloberry, silverberry (wolf willow), snowberry (buckbrush), shrubby cinquefoil and hazelnut (Table 1). Grazing is then not an option to facilitate using and managing them. In winter, however, the brittle stems of many brush species can be trampled or broken by herds of cattle, horses or bison.

Western Snowberry

Sometimes, mowing of unpalatable brush can be used as a first treatment. Western snowberry stems can be mowed first and followed up with either a heavy livestock grazing or by applying herbicide to the new shoots. Adams and Richardson (1986) and Ehlert et al.(1988) demonstrated how to reduce western snowberry by mowing, spraying and grazing. Trampling, by placing salt or mineral, or hay in winter, on the patches, is also an effective management technique.

Use of browse by cattle

Livestock which grow up in a region have a distinct advantage over naïve animals brought in from a different area. If one is planning to use cattle in a brush management grazing scheme, wherever possible, it is recommended that locally raised animals be used.

Scientists and ranchers alike may be aware, but they frequently do not fully understand, why livestock from the dry southern prairies, for instance, generally do poorly for several weeks or months when pastured in the western or northern bush. By comparison, livestock raised in the area do well. This may be a result of the following:

- The animals do not know what is forage.
- They do not know the terrain or new hazards.
- Lack of suitable bacteria in the gut to digest the new forage.
- Stress and health issues associated with transporting livestock long distances.
- Social problems within the herd.
- Other causes that are poorly understood.

Note: If livestock must be shipped from a distant source to graze in the northern or western bush, they need to be acclimatized to their new forage supply. The cattle should be provided superior nutrition supplements and health management during this transition period. There may be a time-lag before the naive livestock accept that aspen and other browse is actually palatable and a nutritious forage that can be grazed. There may be a time-lag of several weeks before their gut can build up higher populations of brush-digesting and coarse grass-digesting bacteria. The manager needs to recognize

Livestock which grow up in a region have a distinct advantage over naïve animals brought in from a different area in their ability to recognize palatable forage. Photo: Arthur Bailey

that these naïve livestock will not perform as well for a period of a few weeks or months, as they would grazing on their home ranges and pastures.

One known cause of the poorer performance in naïve cattle is what they learned as young calves from their mothers (Anonymous, N.D., Provenza 2004). Young calves raised in the dry prairies, eat what their mothers eat. Since there is no aspen or red osier dogwood available on the dry, southern prairie, these young calves know nothing about them. When the cattle grow up and are possibly transported to pasture in northern or western bush, they don't know what is good to eat. Most of the forage plants growing on bush ranges, do not grow on the dry prairies. Naïve cattle will slowly learn what to eat, as they test out the new range or pasture land over several weeks and months (Grazing Behavior, www.foragebeef.ca).

HOW ARE GRAZING ANIMALS ATTRACTED TO PREFERRED RANGE AND PLANTS?

Selection of Plants to Graze

Animals are attracted to palatable plants that taste good, are attractive, and are nutritious. Young green plants are more tender, edible and attractive than older, dry or dead plants. They are higher in protein, minerals and digestible carbohydrates. Unpalatable plants are not chosen, because: they have a bitter taste; are coarse or fibrous; have hairs or thorns; they stink; or are poisonous. Mature, high fiber plants are usually not as preferred in the growing season as tender new growth or re-growth. In winter, grazing animals eat primarily to obtain sufficient energy to survive, so they tend to be less selective and often eat higher fiber diets.

Selection of Browse

Young, tender stems and leaves of browse plants are preferred by livestock in spring and summer at the same time as the grasses, sedges and forbs are most palatable. Stem hardening occurs primarily in late summer and fall. As hardening progresses, it becomes more difficult for cattle to break off and chew the stems. In the second half of the growing season, usually cattle can be found eating only tree and shrub leaves. Even the current year's stems have become too hard for them to chew, break off and digest. Two and three year-old stems are too hard for livestock to eat at any time.

The palatable brush species are most sensitive to heavy grazing pressure in early spring, when stem and leaf growth is rapid. Protein and phosphorus levels are highest and stem hardness is lowest at this time. Few of these species can withstand grazing in spring in excess of about 35% use of new stems and leaves.

This author knows of no studies in western Canada dealing with the proportion of browse that cattle may consume without negatively affecting animal performance. It is probably reasonable to assume that adapted animals may consume up to about half of their spring and early summer diet as browse with the rest being grasses, sedges and forbs. For

naive animals unfamiliar to having browse as a part of their diet, a lower proportion is advised for at least several weeks, until the animal's system becomes better adapted to having daily quantities of browse.

Selection of Preferred Grazing Areas

As range livestock enter a new field, they first select and graze the *primary range*. These areas usually have 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, on steeper slopes or have less preferred forages are referred to as *secondary range.* These are grazed after the primary range. There are many reasons why some areas are less preferred than other areas. It may be due to the season of grazing; the presence of too much dead, herbaceous litter (mulch); it may be heavily shaded; or there are barriers such as steep cliffs or fallen trees that act as a fence and reduces access.

The last category, *non-use range* or *tertiary range* is not preferred by livestock because of the lack of palatable plants, steep slopes or barriers such as fallen trees or canyons, that act as a fence. Another common barrier to grazing is absence of good drinking water.

When no grazing is occurring on palatable forages, the land manager should determine why the area is non-use range and where possible, correct the problem.

Table 2. A comparison of crude protein (%) and phosphorus (%) content of selected browse and native grasses (from Abouguendia 1998).

Crude Protein (%)	June	August	October	March	August vs October
Browse *	17.7	11.8	7.1	6.8	-4.70%
Grasses **	11	6.8	4.7	4	-2.10%
Phosphorus (%)					
Browse *	0.39	0.26	0.19	0.19	-0.07%
Grasses **	0.18	0.14	0.09	0.06	-0.05%

Nutritional guidelines: range livestock

Cows:	Cr. Protein %	Phosphorus %
maintenance	6 - 8	0.10 - 0.15
lactating	9 - 12	0.20 - 0.25
Yearlings (1.0 lb/day)	8 - 9	0.20 - 0.25

* aspen, red osier dogwood and saskatoon
** awned wheatgrass, green needlegrass, plains rough fescue

Primary range. Photo: Peggy Westhorp

Nutrients in Browse

An assessment of nutrient content of rangeland browse and grasses was made in a Saskatchewan study (Table 2). Abouguendia and associates sampled woody plants and grasses in four regions of the province. Protein and phosphorus are particularly important to lactating cattle and growing yearlings. The author revealed that not all standing dead grass was removed from samples of grasses, particularly fine-leaved grasses, such as plains rough fescue. Abouguendia (1998) indicated that " . . . the nutrient content reported here for such species may represent an underestimate of nutritive value." It is likely that the averages reported for grasses in Table 2 are lower than normal for both crude protein and phosphorus because of the inclusion of an unknown amount of dead grass in the samples. However, the general trends revealed in Table 2, reveals that browse is an important source of nutrition for livestock.

The current annual growth of woody plants is of highest nutrient quality when leaves are present in spring and summer. Browse is generally higher in crude protein and phosphorus than most grasses. Once the leaves fall from woody plants, there is a sharp decline in crude protein.

Cattle are selective feeders and they often select a higher nutrient quality forage supply than the averages indicated in Table 2. Whenever possible they select the most succulent and nutritious plant parts of browse and herbs, leaving less digestible plant parts untouched.

PRINCIPLES OF GRAZING BRUSH AND GRASSES

Balance forage supply with livestock demand

Every successful range manager should learn how to balance forage supply with livestock requirements. In range and pasture management, this is described as having the proper stocking rate. This means having the appropriate number of livestock units (animal units) on a property for a specified time without degrading the range.

Usually an animal unit (AU) is considered to be an average size cow (1200 lbs) with her calf. The forage required by one cow with calf (one AU) can be estimated for a day, a month, or a grazing season. For any field (paddock), the grazing manager can estimate the number of animal units (AU) that can be carried for a period of time. This is referred to as the appropriate number of animal unit months (AUM) per field (or per acre). Alternately, it can be referred to as the number of stock days per field.

A rancher will often describe a specific field that has a known acreage as being able to support a given number of animal unit months (AUM's) of forage for a particular season *of the average grazing year*. For example, a quarter section (160 acres) may be able to supply, on average, only 40 animal unit months (AUM's) if grazed in early spring, when growth is only 6 inches high. About 120 AUM's can be supported if grazed in mid-summer and about 160 AUM's if grazed when dormant in fall or winter.

Allow rest and recovery after grazing (duration of rest)

Palatable brush, grasses, forbs and sedges all need a period of recovery after being grazed. If this doesn't happen, forage production will decline and unpalatable brush and weedy plants will take over the range or pasture.

Manage or defer grazing during vulnerable periods (intensity of grazing)

Young tender stems and leaves of palatable brush and other plants are vulnerable to intense grazing pressure in early spring and summer. Managing grazing during these vulnerable times to meet the needs of the specific plant species is crucial to a sustainable forage supply. This can be done by periodically deferring spring grazing to allow the brush and grasses to grow unhindered by defoliation or by allowing only a very light grazing of approximately 25% use in spring. Grazing in fall or winter when plants are dormant generally is not as hard on palatable plants.

How often can brush and grasses be grazed? (frequency of grazing)

In an ideal world of maximum forage production, most palatable prairie brush and grass species would be grazed lightly or moderately once during the growing season. Then in fall or early winter, the grasses would be able to tolerate another moderate grazing. The key point is to understand how to achieve an optimal forage supply for livestock and to manage brush sustainably. Continuous, heavy grazing leads to lower forage production, an elimination of palatable brush and an occupation of the pasture by unpalatable, often invasive grasses, forbs and unpalatable brush. A system of deferred rotation grazing designed to enable rapid re-growth of plant parts in the growing season, will lead to the development of a more reliable and sustainable forage supply of higher forage quality brush, grasses and other forages.

HERD MANAGEMENT ON RANGES AND PASTURES

There are tools available to manage the livestock herd while grazing to maintain good animal gains and sustain forage resources (including the browse resources). Grazing animals are lazy and they prefer to eat in certain places and not in others. Once grazed, these preferred places re-grow lush new leaves. However, the ungrazed areas develop over-mature forage and much of the browse becomes too tall for livestock to reach. If the livestock remain in the same field, they will return to their most favored areas to graze the succulent, nutritious re-growth. Meanwhile, more distant areas not yet grazed have over-mature forage, that has now become coarse, less palatable and of lower nutrient value.

One of the most challenging decisions range managers have to make is deciding how to distribute livestock effectively within each field. The goal is to prevent the accumulation of tall, coarse forage and to prevent grazing of new re-growth in areas most favored by the livestock. The common tools to manage livestock distribution are: well-placed fencing, good water, salt placement, mineral supplements, riding and grazing systems.

The herd effect refers to the impact that a group (herd) of animals have on the vegetation and soils on an area being grazed. When managed with care, the herd effect can be used to enhance brush management. If serious and prolonged overgrazing is allowed, the vegetation and soils will suffer and livestock gains will decline. Usually, the herd effect is most pronounced when a large number of animals are concentrated in small paddocks. If the stocking rate is high, then the manager needs to have a suitable

rotation grazing management plan to prevent overgrazing and range deterioration. Higher stocking rates can be effective in managing a brush resource, but during spring and early summer the herd needs to be rotated to a new paddock more frequently. This allows the forage an opportunity to re-grow and replenish energy reserves before winter.

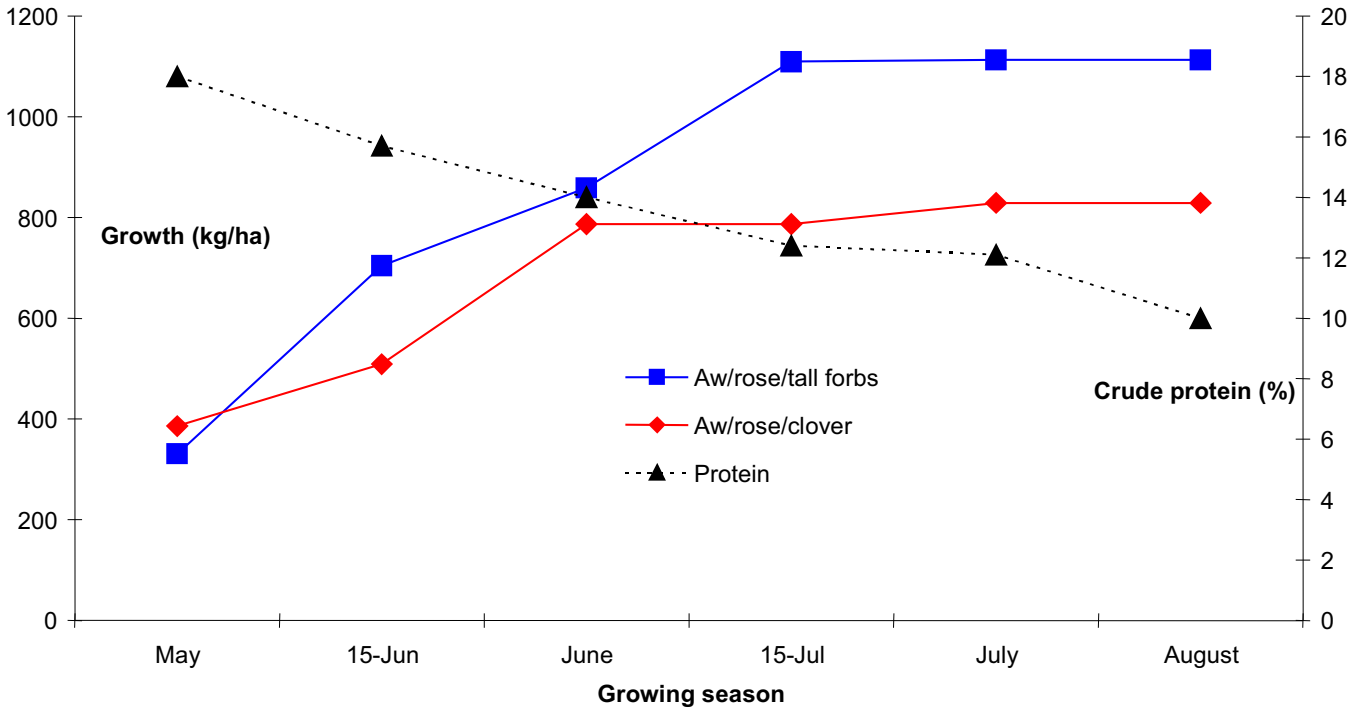
Managing the Forage Growth Cycle

The brush, grass and other herbs that livestock use for forage on rangeland are perennials and the native brush is well adapted to the continental (prairie) climate. Each year there is a general growth cycle of forage production and nutrient quality (Figure 1, from Willoughby and Lane 2004).

Every range manager should utilize the forage growth cycle and the cycle of forage nutrient quality to their best advantage. Growth is slow in early spring due to cold and frequent frosts, followed by a 6 to 8 week period of accelerated growth until mid-summer. By late summer, growth slows and then stops as plants go into dormancy. The graph (Figure 1) illustrates the amount of green biomass from spring until fall in two mature aspen forest understories in west central Alberta. The aspen/rose/tall forb community (blue color) is in excellent range health and yields 1100 kg/ha. The aspen/rose/clover community (red color) has been summer grazed for years and has considerable clover in the understory, the tall forbs are reduced. The forage production is decreased to about 800 kg/ha.

Summer livestock grazing often reduces range health from excellent to good to fair. This is frequently related to grazing management strategies. Continuous summer grazing frequently removes the

Figure 1. Total monthly forage growth and crude protein over two years for the Rose/Tall forb and Rose/Clover communities under aspen forest.



native tall forbs and replaces them with clovers and alien grasses. A deferred rotation grazing system would allow the growing plants some rest and recovery before being grazed later in the season or following year.

The availability of new growth is low in spring, while nutrient quality is high. In spring, crude protein levels are often about 14-18% in May and June. As plant growth continues into August, crude protein declines to 12%, then 10% (Figure 1). By fall, the protein level is between 4-5%.

The duration of stay of livestock in any one field is usually dictated in spring by low forage availability. Livestock grazing too early in spring will sharply reduce the forage available to the livestock herd later in the grazing season, particularly in the fall.

GRAZING SYSTEMS SUITABLE FOR BRUSH AND GRASS MANAGEMENT

When are woody plants most vulnerable?

Rapidly growing plants are most vulnerable to grazing by livestock. Palatable woody plants are especially vulnerable to grazing of the current growth in spring and early summer.

If grazing animals are present all the time, palatable brush and grass species will be grazed over and over again. Eventually they will die and be replaced by weeds or coarse, unpalatable plants.

A rotation grazing system allows palatable plants to be grazed to an appropriate level during part of the growing season and then be rested for at least 6-8 weeks. When there is good soil moisture, these grazed plants can re-grow and produce new shoots and roots. *The grazing system used is not as critical in the dormant season.* For instance, the continuous grazing system described below is usually an acceptable practice during fall and winter but it is not recommended for grazing during the growing season.

Key Principles for Use of a Grazing System in Brush Ecosystems

The grazing system will match up the needs of the brush range ecosystem to the needs of livestock. This is a balancing act. In spring, the rancher needs green forage, which is in short supply, while at the same time the brush and other forages are highly vulnerable to damage from overgrazing.

A grazing system will permit some grazing of forages at their most vulnerable period. Example: Field 1, which was just grazed, is rested for 6 weeks to 2 months. Next, the herd is moved into Field 2 for a period of grazing. Later the herd is moved into Field 3, etc. Following the grazing for each field, a period of rest during the growing season enables re-growth and replacement of leaves, shoots and roots and a recovery of plant-stored energy reserves.

The types of deferred rotation grazing systems recommended in this chapter provide a period of grazing in the growing season and then provide a period of rest and recovery permitting shoot and root re-growth to enable the long-term survival of browse and other perennial forages.

No grazing system can overcome the consequences of overgrazing when the stocking rate is too high. Photo: G. Oliver

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 rangeland property that includes brush ecosystems.

- Use the appropriate stocking rates. No sophisticated grazing system can overcome the consequences of overgrazing when the stocking rate is too high. Usually, a moderate stocking rate is required but occasionally for brush management, it may require temporary, short-term overgrazing to realize a specific objective in the brush management plan.

- Be aware that if grazing starts too early in the spring, (before the grasses are about 6 inches high, and are at the three-leaf stage or more), then for every day gained in spring, three days of grazing will be lost in the fall.

- When implementing a rotation grazing system, cross-fencing subdivides the range and concentrates livestock in smaller paddocks forcing a more uniform distribution while grazing.

- Provision for access to quality drinking water, salt and mineral supplements in every paddock.

- Modify grazing systems to adjust to complex terrain and complex brush distribution patterns.

- Develop a planned process to alternate the sequence of grazing of fields (paddocks) from year to year. If the paddock that is grazed first in Year 1 is deferred in Year 2 to mid-summer or later, it will minimize the negative effects of spring grazing.

- Planned grazing often assists the range manager to more adequately understand the requirements of forage plants, livestock and soils. This will facilitate grazing practices and forage use in a sustainable manner. Unplanned grazing usually yields unplanned results, many of which are detrimental to the long-term sustainability of the grazing resource.

Selection of Grazing Systems for Brush Management and Forage Productivity

Well-managed grazing systems are essential to maintain productive, healthy grazing lands, whether for livestock eating only grass or a mixture of grasses and woody forages. Three grazing systems are presented for consideration.

Continuous Grazing System

The land manager turns livestock into a field, checks the water availability and fences, provides salt and mineral supplement, and lets the livestock do the rest all growing season long. This results in the primary range being overgrazed year after year. Gradually the primary range changes to weedy grazing

plants. Often, forage production plummets and soils are compacted. Meanwhile, on secondary ranges large patches of vegetation are left ungrazed. Dead litter builds in these patches, smothers some forage and creates a fire hazard. Herd production is low and the brush remains unmanaged.

During the growing season, this is normally a poor choice of grazing system. However, if it is in the resource manager's interest to create a wide diversity of grazed and ungrazed patches that increase landscape biodiversity, as may be the case when managing wild ungulates, then occasionally this grazing system can be recommended, if the range or pasture health is not too seriously compromised.

The continuous grazing system can be used effectively once plants are no longer growing, as in late fall and winter. When plants are dormant, it is less serious if preferred ranges are grazed first and less preferred areas are grazed later in the winter because dormant plants are more resistant to grazing.

Deferred Rotation Grazing System

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 for a period of time. About 4-5 fields of approximately equal acreage are recommended to implement the system. Since the first two months of grazing are the most vulnerable stage for browse and herb forage, it is also the time when periodic deferment can protect these forages from harm.

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 3. (When designing this deferred rotation grazing system, it was decided to place the first field grazed in the rotation in a bold font in Table 3 for easy reference). Observe that Field 1 is grazed first in Year 1, third in Year 2, second in Year 3, last in Year 4. That is the complete four year rotation. In Year 5, a new

Table 3. An example of a 4-field deferred rotation grazing scheme.

Field No.	Year 1	Year 2	Year 3	Year 4	Year 5
1	**Graze first**	third	second	last	**first**
2	last	**first**	third	second	last
3	second	last	**first**	third	second
4	third	second	last	**first**	third

grazing rotation begins with Field 1 being grazed first. The grazing rotation in Year 5 is a repeat of Year 1. Note, for this example, 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, not grazed until the second half of the grazing season.

For Year 1, the first field grazed was Field 1. Note in Table 3, on the diagonal from Field 1 is Field 2. That field was selected to be grazed first in Year 2, then in Year 3 it was Field 3, etc. Thus, in the table the first field grazed each year is one field lower, on the diagonal, from the one grazed first the previous spring. Also, the first field grazed in spring should have a long period of deferral (rest) the next year. So the field grazed first in Year 1 was grazed third in Year 2, and not grazed in spring again until Year 5. Note that 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 was to defer grazing of the first and second fields until later in the growing season.

Now, in this example, let's place some dates into the fields (Table 4). In Year 1, Field 1 is grazed for three weeks in spring (June 1-21), in Year 2 grazing is deferred until July 21, in Year 3 grazing began June 21st, in Year 4 grazing starts August 28th, and then in Year 5, a new grazing rotation begins again with grazing starting in Field 1 on June 1st.

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 to promote better livestock distribution. In some cases, herding livestock within certain fields may be necessary to realize good animal distribution.

This grazing system may be applied to prescription grazing Systems 1, 2, 3 and 4.

Table 4. An example 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

Short-duration, Deferred Rotation Grazing System

This grazing system is a modification of the deferred rotation grazing system. Usually about 8 or more fields are required for the system to operate effectively (Table 5). In the example, the grazing rotation in Years 4 to 8 is intentionally left incomplete. The reader is invited to test their understanding by completing the table. This short-duration, deferred rotation grazing system shortens the length of stay in each field as compared to the system of Table 4.

Such a large number of fields require a suitable landscape, additional fencing, water development, salt and mineral placement and more herd movement from field to field. A short-duration grazing system usually results in more uniform grazing use of each small field. Effective implementation of a short-duration grazing system can be a challenge in many circumstances. Usually, this system is used on private land where topographic variation is not great. The system is rarely used in foothill and mountainous areas.

The beneficial potential of this grazing system to brush- or forest-covered rangeland is high but for practical reasons it is rarely attempted on forested crown rangelands. *This system is suitable on some private land but rarely for crown lease land. Too much fencing and management is required for use on remote, forested crown lands.*

Table 5. An example of a short duration, deferred rotation grazing system

Field No.	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
1	**first** **Jun 1-10**	seventh Aug28-Sep14	sixth Aug 9-28	fifth Jul7-21	fourth Jul 7-21	third Jun21-Jul6	second Jun11-21	last Sep14-30	**first**
2	last (8th) Sep14-30	**First** **Jun 1-10**	seventh						last
3	second Jun 11-21	last	**first** **Jun 1-10**	seventh					second
4	third Jun 21-Jul 6	second	last	**first** **Jun 1-10**	seventh				third
5	fourth Jul 7-21	third	second	last	**first** **Jun 1-10**	seventh			fourth
6	fifth Jul 21-Aug 9	fourth	third	second	last	**first** **Jun 1-10**	seventh		fifth
7	sixth Aug 9-28	fifth	fourth	third	second	last	**first** **Jun 1-10**	seventh	sixth
8	seventh Aug 28-Sep 14	sixth	fifth	fourth	third	second	last	**first** **Jun 1-10**	seventh

In the aspen parkland, Irving et. al. (1995) found that a short duration rotation grazing system, using a large herd of cattle at a higher stocking rate, could obtain a more uniform distribution of grazing over a long distance. At the end of the fifth day, in long-narrow paddocks, moderate grazing use had occurred 3 km away from drinking water.

A careful manager can use this grazing system to advantage for brush management simply by varying the season and intensity of grazing. In a particular year, it may be appropriate to encourage the herd to use a higher proportion of their diet as brush. 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 grasses in a specific field. The following year, the manager can choose either lower grazing intensity or defer grazing of that paddock until later in the summer.

Some cattle managers are reluctant to use grazing as a means of controlling brush invasion, for fear of loosing live weight gain on the cattle. If this is a concern, cattle will quickly gain back any weight loss through compensatory growth, once they are moved to a higher quality grazing area. Often, ranchers are surprised at what good gains their cattle experience while grazing on both brush and grass during spring and early summer.

This short-duration, deferred rotation grazing system may be applied to prescription grazing Systems 1 and 2, in primarily agricultural areas. It is usually impractical to attempt to apply the grazing system on remote commercially important forested lands.

Figure 2. Square or rectangular paddock layout. This layout has a central lane with waterers shared between two paddocks. Paddocks are separated by mobile or permanent fencing.
Diagram provided by: Manitoba Agriculture, Food and Rural Initiative.

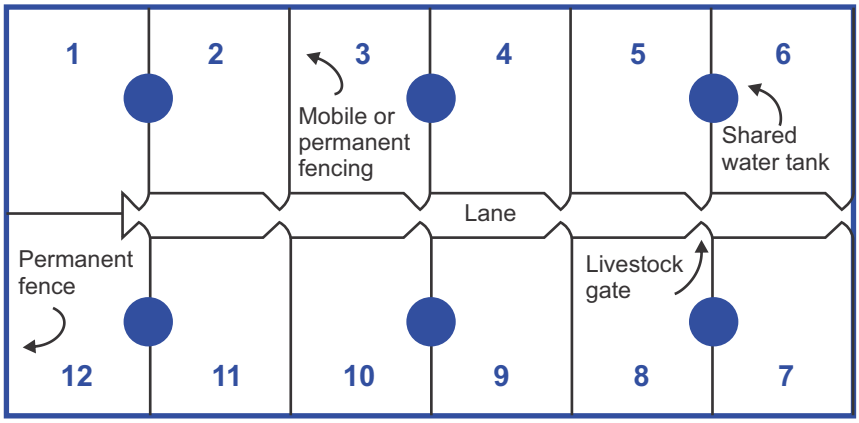
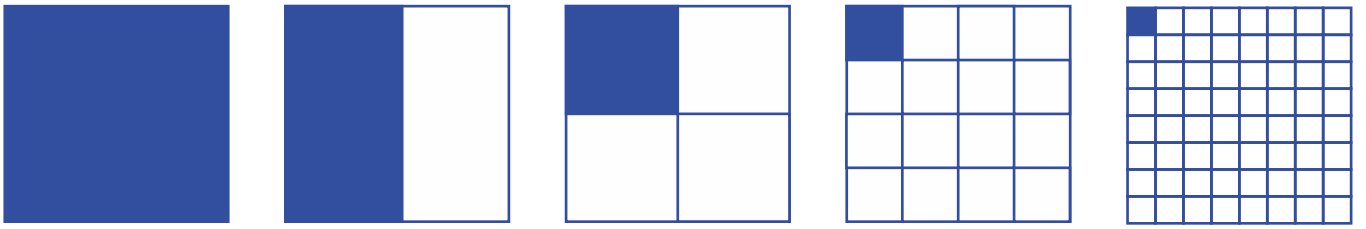


Figure 3. Relationship between paddock number and amount of rest per acre.



Prescription Grazing Systems

The prescription grazing systems are being written for the benefit of ranchers, farmers and crown grazing managers, from as far away as Fort St. John, B.C. in the west to southeastern Manitoba. The Canadian prairie and plains is a huge region that has substantial differences in climate, weather, soil and forage resource patterns from east to west and north to south. It is not possible in this chapter to provide all grazing options that a creative rancher or pasture manager can think of to manage brush by grazing.

Four prescription grazing systems are presented for the management of browse and associated herbaceous forage east of the Canadian Rocky Mountains in both prairie and forested rangelands. Each one has its own set of risks.

These recommendations are primarily applicable for implementation by knowledgeable grazing managers, who are skilled at utilizing rotation grazing management schemes to benefit range and pasture plants, livestock and soil.

The choices of prescription grazing systems are illustrated below and in Figure 4. There are two choices for the management of grazing within agricultural regions and another two choices for the management of forest regeneration, where commercial forestry is an important consideration. One involves the management of a regenerating commercial aspen forest while the other addresses management of a regenerating commercial conifer forest. In both scenarios, grazing is used to complement forestry objectives.

A large number of fields require a suitable landscape, additional fencing, water development, salt and mineral placement and more herd movement from field to field.
Photo: Ron Moss

Prescription grazing Systems 1 and 2 are primarily for range and pasture lands in agricultural areas. There is a substantial research base supporting the recommendations. Systems 3 and 4 apply to commercially important forested areas that are also important rangelands for grazing livestock, in order to compliment both forest and wildlife management options. There is a substantial research base supporting the recommendations regarding System 3. The last one, System 4, is less supported by research and field trials and it requires more testing in various parts of the Canadian lower boreal forest.

The following needs to be done to implement each prescription grazing scenario for brush management:

- Decide which part of the property is the highest priority to test a prescription grazing scenario, to determine if it will meet the rancher's brush management objective. Only a portion of a ranch or farm property should be used for a first test of the selected prescription grazing scenario. Once the first 3-4 year test has been made, and modified to the satisfaction of the user, then

GRAZING OPTIONS

System One: Prescription grazing to reduce brush and increase production of grasses, sedges and forbs.

System Two: Prescription grazing to maintain high forage production of both palatable brush and herbaceous plants.

System Three: Prescription grazing to regenerate aspen forest and provide forage for livestock.

3A: Grazing following winter logging of aspen forest.
3B: Grazing following summer logging of aspen forest.

System Four: Prescription grazing to assist in the regeneration of conifer plantations and to reduce fire hazard.

4A: Grazing in conifer plantations without tall larkspur.
4B: Grazing in conifer plantations with tall larkspur.

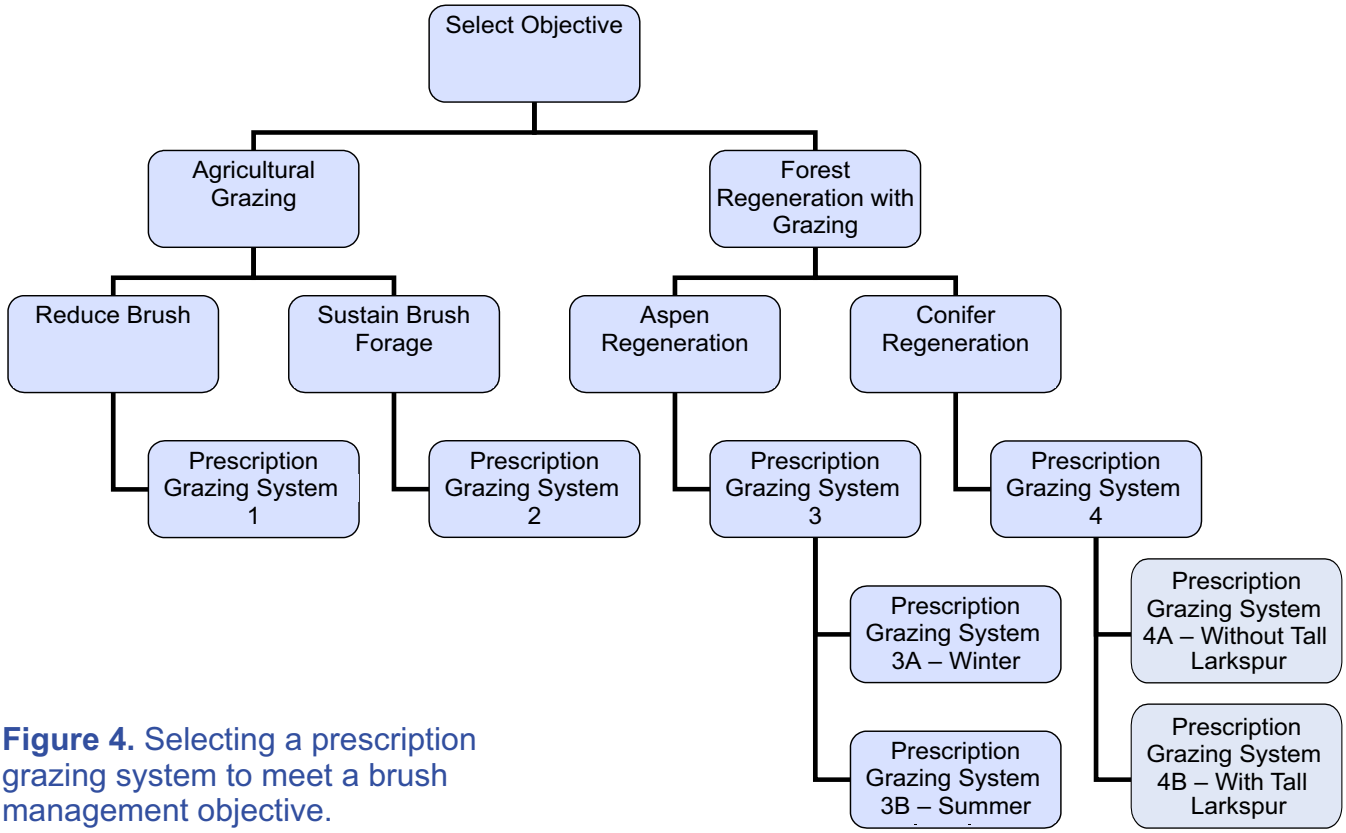


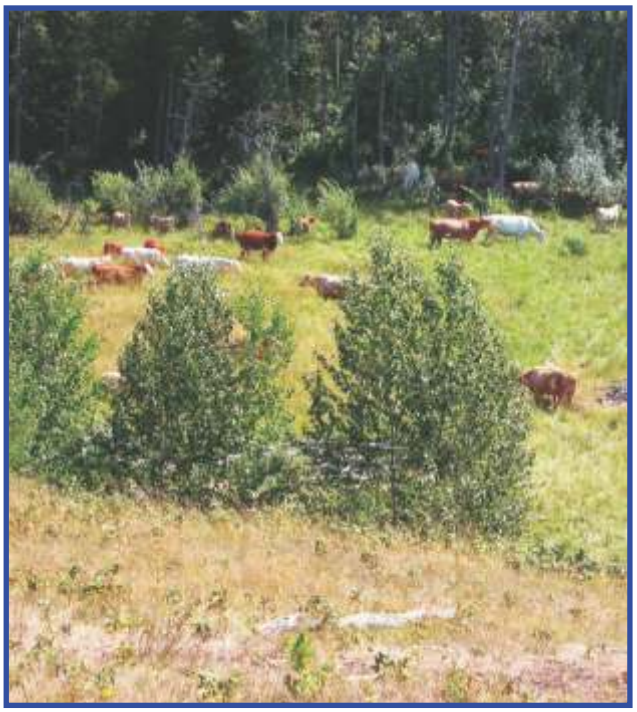
Figure 4. Selecting a prescription grazing system to meet a brush management objective.

plans can be made regarding how to systematically treat other parts of the property.

- Decide which of the four prescription grazing systems most closely fits the manager's brush management objectives.

- Determine if it is a one-step prescription grazing system (usually it is a two-step approach). A treatment of 1. logging or clearing (for trees), or mowing (for shrubs), or 2. an application of an herbicide, or 3. prescribed burning. The second step is to select and apply one of the four prescription grazing systems.

- Good livestock distribution across each field is essential. Use whatever method works effectively for you: fencing, water, salt and mineral supplement placement, trails, herding (by riding or dogs), or other effective options.



Prescription grazing systems are designed to address land management issues and economics.
Photo: Ron Moss

PRESCRIPTION GRAZING SYSTEM ONE: Brush reduction and increased production of grasses, sedges and forbs

Ranchers who pasture their livestock in the aspen parkland and southern boreal forest often wish to reduce aspen and shrub cover in favor of a grass - forb mixture.

The primary references for this scenario are research by Hilton and Bailey (1974), Arthur and Bailey (1983), FitzGerald and Bailey (1981, 1984), Bailey and Irving (1985), Irving and Bailey (1985) Bailey et al. (1990), and Alexander (1995).

Action 1: Once the planning phase is complete, the first step on the land selected for renovation is to remove the tree or brush canopy. These practices are covered in other chapters of this manual. In some instances, timber harvesting or an unplanned wild fire will remove the tree canopy. This will provide the land manager with an opportunity to then use prescribed grazing to develop a forage base, composed of smaller woody plants, grasses, sedges and forbs.

Action 2: Determine whether to:

1. Use existing grasses, sedges, forbs and woody plants of the forest understory to re-grow and provide livestock forage, OR

2. To apply forage seed by aircraft, broadcast or drill methods. If the choice is to apply forage seed, then there are several more choices to be made.

- *High cost option:* break the land, work down and then drill forage seed.

- *Medium cost option:* drill forage seed into the land wherever practical, using suitable ground equipment.

- *Low cost option:* in early spring, broadcast seed over the newly cleared land, spreading by hand, tractor-drawn or aircraft.

In the first spring, through the July period (after clearing), when grass and forb production is still quite low, the succulent young aspen and shrub stems and leaves are vulnerable to heavy grazing. Once hardening of the wood takes place by late July, cattle have difficulty breaking off and chewing the young stems (Dockrill et al. 2004, 2006).

Implementation:

Year 1: (see Table 3)

Step 1: Develop fencing and livestock watering facilities, implement a deferred rotation grazing system and graze following the process illustrated in Table 3. Normally, if the woody plants had been burned in the spring or a herbicide applied, grazing would begin within two months. *If clearing and seeding were done, there would be a delay of one year before grazing can begin.*

Step 2: It is preferable to limit grazing by the livestock herd to a few days to 2 weeks per field the first year after clearing and seeding, an application of herbicide, or burning. *Insure there is good distribution of the herd to all parts of each field.*

Step 3: In Year 1, when sufficient herbaceous forage is about 6 inches high, and aspen and other woody sucker growth has emerged, stock cattle at a normal to twice the normal stocking density. Allow them to graze Field 1 to 60% use of the grasses.

Step 4: Rotate the herd out of Field 1 into Field 3 and graze forage to 60% use of the grasses.

Step 5: Rotate the herd out of Field 3 into Field 4 and graze forage to 60% use of the grasses.

Step 6: Rotate the herd out of Field 4 into Field 2 and graze forage to 60% use of the grasses.

Step 7: After completing the first rotation of grazing in all fields, if there is little re-growth, rest the fields (no grazing) until the next year.

Step 8: If rainfall has been normal to above average and there is much re-growth available when grazing is completed in the last field, then following the example in Table 3, rotate herd to the first field grazed in Year 1, which is Field 1.

Step 9: For the second rotation of pasturing in grazing Year 1, allow grazing for only a few days with a light grazing use of grasses of only 20%. In each field in the rotation graze first Field 1, then Field 3, then Field 4, and then if there is adequate forage re-growth also graze Field 2 for a few days. Graze each field to no more than 20% use of the grasses.

Step 10: Move the herd out to another part of the property to complete the grazing season.

Step 11: Inspect each field thoroughly immediately after grazing ceases and determine if the palatable woody plants have been grazed and if livestock had distributed well. Also observe the health of the grasses and forbs and observe if they are beginning to spread into areas of bare ground.

Year 2:

Step 12: In the second year, forage production should be about twice as much as in Year 1. Thus the herd size needs to be adjusted upwards.

Step 13: Select the last field grazed in Year 1 to be grazed first in about mid-June. Following the model of Table 3, this would be Field 2. Allow grazing to 50% use of the grasses. Then rotate the herd to the second last field grazed in Year 1, Field 4.

Step 14: Graze Field 4 to 50% use of the grasses over a period of about two weeks per field, then rotate the herd to Field 1 and graze 50% use of the grasses.

Step 15: Continue until all fields are grazed in Year 2.

Step 16: Rest each field from grazing until the next growing season, if there is little re-growth available.

Step 17: If rainfall has been normal to above average and there is adequate re-growth available when grazing is completed in Field 3, then rotate herd to Field 2.

Step 18: For this second rotation of grazing in grazing Year 2, allow a few days of light grazing of only 20% use of grasses per field, starting with Field 2, then graze Field 4, then Field 1 and then Field 3.

Step19: Move the herd to another part of the property to complete the grazing season.

Year 3:

Step 20: In the third year, expect a markedly lower density of aspen suckers but more grasses and forbs to appear. Defer spring grazing by two weeks after initial spring green-up, to about June 1-15. Following the model in Table 3, graze Field 3 first to 40-50% use of herbaceous forage, using a normal stocking density. Rotate out of Field 3 and into Field 1.

Step 21: Graze Field 1, then Field 2, then Field 4 using 40-50% of the herbaceous forages during Year 3.

Step 22: Normally, do not allow a second rotation of grazing in Year 3, allow the palatable forages to re-grow and rest from grazing for the remainder of the growing season.

Step 23: If much unpalatable shrub growth develops in Years 1 to 3, mow, or mow and spray with an appropriate herbicide in the heaviest patches to remove or retard their growth. This would normally take place between June 1 and July 15th of the next year.

Year 4+:

Step 24: In years four and onward, utilize fields treated above in a normal sustainable, deferred rotation grazing management system using a moderate level of forage utilization (graze 40-50% of the grass) and graze each field only once per year. If there is an emergency situation as in the case of a severe drought, then the occasional light grazing in fall would not hurt the long-term sustainability of fields under Prescribed Grazing System 1.

Step 25: If much re-growth of palatable brush occurs, about once every 3-4 years, apply a grazing at a 60% level of grass use following the grazing system indicated in Steps 3 to 6 on page 153.

BENEFITS

- This grazing treatment develops a yield of more grasses, sedges and forbs and less palatable browse.
- Forage yield will increase by 3-4 times depending upon the area, soil quality and precipitation zone, as compared to a dense tree- or shrub-covered parkland or forest.
- The cost of implementing a prescribed burn followed by this prescribed grazing scenario ranges from about 3-4 times less expensive than mechanical land clearing, breaking, forage seeding and establishment.
- By establishing and maintaining either a deferred rotation grazing system or a short duration, deferred grazing system, more forage and livestock production can be expected in the longer term.

CHALLENGES

- Unpalatable western snowberry (buckbrush), balsam poplar, oaks, hazelnut, alder, and some willows may expand under this grazing scenario and they will require treatment as indicated above, in Step 23 and 25.
- It is likely that, periodically, there may be sufficient aspen sucker and other palatable woody re-growth in enough areas to merit a repeat heavy grazing treatment, as discussed above in Step 25. *Caution: this treatment does put the survival of some grasses and forbs at risk, so it should never be used during drought conditions.*

PRESCRIPTION GRAZING SYSTEM TWO: Sustaining forage production of palatable brush and herbaceous plants

Ranchers who graze livestock in the aspen parkland and southern boreal forest may wish to keep palatable brush and herbs as preferred forage for livestock. Grazing to sustain browse, grass, sedges and forbs, while attempting to reduce the proportion of unpalatable brush and forbs is a challenge. Land managers should appreciate that there is no specific model designed for their unique set of circumstances. Each user may need to refine this grazing system to suit their property's unique characteristics.

Where there is forested rangeland, the first action is to remove the tree or brush canopy using mechanical, burning or herbicide methods described in other chapters of this manual. When sawmills or OSB processing plants are nearby, commercial-size aspen and conifer trees can be sold for a profit in the lower boreal forest, northern aspen parkland and western Rocky Mountain foothills (see Chapter 6, Timber). If this is the case:

Step 1: Logging of the forests.

Step 2: Piling logging debris (slash), allowing it to dry, then burn the next winter.

Step 3: Establish a forage resource for livestock. There are several options, as indicated below:

Action 1: Allow existing grasses, sedges, forbs and woody plants to re-grow from roots, shoots, or seeds.

Photo: Pam Iwanchysko

Action 2: Apply forage seed by drill or broadcast methods. If the choice is to apply forage seed, then there are several options.

They are as follows:

- *High cost option:* break the land, work down and then drill forage seed.
- *Medium cost option:* drill forage seed into the land wherever practical using suitable equipment.
- *Low cost option:* broadcast the seed over the newly cleared land by hand, aircraft or ground spreader equipment.

Implementation:

Year 1:

Step 1: Develop fencing and livestock watering facilities. Then, implement a deferred rotation grazing system (Table 3), or the more complex short duration, deferred rotation grazing system (Table 5). Restrict the grazing period in each paddock to 7-10 days from early spring to late July. Good livestock distribution is essential especially in Years 1 to 5 of grazing, after the brush treatment. Use whatever method works to obtain excellent grazing distribution: fencing, water, salting, supplements, trail construction and herding.

Step 2: It is crucial to obtain a light grazing (30-40% use of grasses) over each paddock in Year 1. Light grazing early in the growing season will promote additional sprouting and shoot growth of all forages: aspen, palatable shrubs, grasses and forbs.

Step 3: For the purposes of this "textbook model" we are going to use the process illustrated in Table 3.

Note: *Ranchers who chose to develop the more complex short duration, deferred rotation grazing system should follow the grazing routine illustrated in Table 5.*

Step 4: In Year 1, when sufficient herbaceous forage is about 6" high and aspen and other woody sucker growth has emerged, (usually early to mid-June), stock cattle at a normal stocking density and allow them to graze Field 1 (Table 3) up to 30% use of the grasses. It is critical to limit grazing by the livestock herd to 7-10 days/ field in Year 1, in the first field grazed.

Step 5: Rotate the herd to Field 3, allowing up to 35% use of the grasses over roughly a 7-10 day grazing period.

Step 6: Then, rotate the herd first to Field 4 and then to Field 2, allowing up to 40% use of the grasses over approximately a 10-day grazing period.

Step 7: Move the livestock herd elsewhere for the remainder of the Year 1 grazing season. Rest each field from additional grazing until the next growing season. This allows the lightly-grazed browse and grass plants to spread out, re-grow and develop enough energy reserves and new buds to survive the winter.

Year 2:

Step 8: In Year 2, the rancher should expect forage production to be about twice as much as in the first year. Thus, the herd size needs to be adjusted upwards.

Step 9: Select the last field grazed in year 1, Field 2 (Table 3), to be grazed first in spring of Year 2 when the herbaceous forage is about 6" high. Graze as in Step 5 (above), to up to 40% use of the grasses in about a 10 day period.

Step 10: Rotate herd in order through Field 4, Field 1, Field 3 and repeat the same grazing practices in each paddock, allowing up to 40% use of the grasses over about a 14-day grazing period.

Step 11: Move the livestock herd elsewhere for the remainder of the Year 2 grazing season.

Step 12: **Note:** *if a drought or another emergency situation arises,* it is likely safe for the rancher to permit a second rotation of light grazing in the same grazing rotations as indicated in Steps 5 to 7 of up to 20% use of the grasses. *This should be done* during September or October, when the plants are dormant. If there is no emergency, do not graze in a second rotation.

Step 13: Once grazing is complete for Year 2, systematically go through each field and visually determine if there has been a significant increase in:

1. Ungrazed dead grass and forb litter (mulch)

2. Unpalatable brush or weeds

- If there has been an accumulation of dead, tall or coarse grasses or forbs in large areas of some paddocks, plan to distribute the livestock more effectively in Year 3.

- An alternate choice is to return the herd in late August-September of Year 2, in only the paddocks with serious accumulations of these plants. Using salt, molasses, water and riding to attract or herd the livestock into the worst areas enables a reduction of the dead litter or rank, coarse grasses and forbs. In fall, do not allow more than a 60% total grazing use by the end of grazing for that year.

Year 3:

Step 14: By Year 3, expect the density of aspen, other palatable woody saplings, grasses, forbs and sedges to stabilize at a somewhat lower level than in Year 2.

Step 15: Choose an appropriate stocking rate to graze each field, up to 40% use of herbaceous forage. Graze each paddock using a normal stocking density, allowing no more than 2 weeks per grazing unit in spring and 3 weeks per field in July and August.

Step 16: Using the model in Table 3, graze each field in the following order: Field 3, Field 1, Field 2 and last Field 4.

Step 17: Once grazing is completed for Year 3, systematically go through each field and visually determine if there has been a significant increase in 1. ungrazed dead grass and forb litter (mulch) and 2. unpalatable brush or weeds.

- If in Year 3 or subsequent years, an accumulation of dead or tall coarse grasses or forbs occurs in large areas of some paddocks, use a temporary, heavier stocking rate (larger herd size) in August and September. With modifications to fencing, water and salt placement far from water, trail construction, herding (riding), graze up to a 60% level of use to remove most litter. If there are still problems in some areas, wherever possible, use mowing or burning to reduce the build-up of litter.

Step 18: Rest grazed paddocks for the remainder of the 3rd year growing season.

Year 4+:

Step 19: In Years 4 and onward, utilize these paddocks in a normal sustainable, deferred rotation or short duration, deferred rotation grazing management system using a moderate (45%) level of forage utilization. Expect the average forage productivity to be about 75% of that found in Year 2 and 3.

Step 20: Once the first area selected for brush management has completed the 4th year of grazing, evaluate your results. If satisfied, select another area and treat it as indicated above. If refinements can be made, include them in your plans for the second area to be prescription grazed.

BENEFITS

- A burned, cleared, or sprayed, then deferred rotation grazed aspen forest in the aspen parkland can be expected to produce about 3 to 4 times the average productivity of a healthy, mature aspen forest. The mature forest would produce about 500-1000 lb/acre of forage, both grass and browse, and a 4-5 year old well managed, burned, rotationally grazed aspen forest would produce about 2500 lb/acre, or more, forage on a sustainable basis.
- In the second year after burning an average production of palatable browse and herbs would be about 4000-5000 lb/acre but that falls off sharply by Years 3-5 to about 2500 - 3000 lb/acre.
- The costs of a burned forest-deferred rotation grazing scheme are about $^1/_3$ the cost of land clearing, breaking and seeding. The ultimate forage productivity about 4 years after treatment is about the same.

CHALLENGES

- New technology usually requires refinement between the first application and the second.
- Unpalatable woody plants and inadequate livestock distribution both cause challenges to the range user.
- Herding livestock on horseback through a burned forest can be hazardous to both horse and rider. The use of dogs for herding is encouraged.
- Fallen trees act as a barrier to grazing but in a few years livestock are usually able to access most of the forage close to the fallen trees.
- If too many trees have fallen and significant unpalatable shrub growth or aspen sucker re-growth gets out of reach of livestock by Year 4 or later, then gyro-mowing, dragging, roller chopping, spraying herbicide or burning, may be needed to prevent the reduction in forage supply.

PRESCRIPTION GRAZING SYSTEM THREE: Regenerating aspen forest and providing forage for livestock

Modern forest technology permits aspen to be used to make oriented strand board (OSB) and other engineered wood products. Generally, foresters prefer that no cattle graze on commercial forested lands. There has been a number of failures in aspen regeneration that were attributed to overgrazing by cattle. There are continuing concerns amongst professional foresters, regarding the sustainability of aspen forests under livestock grazing (Navatril 1991, Petersen and Petersen 1992). Nevertheless, in many cases, ranchers have historically established grazing rights on forested public rangelands. It is possible to successfully manage both resources. The research cited in this section is that of Dockrill et al. (2004, 2006), Gardiner and Robinson (2007), and Willoughby and Lane (2004).

Forestry companies clear-cut (harvest) aspen forests in both the growing season (summer) and the dormant season (winter). Their need to supply OSB mills with newly cut aspen logs 12 months of the year complicates aspen regeneration. Harvesting aspen in the growing season results in a reduced supply of suckers. Aspen suckers regenerate more slowly after summer logging than after winter logging.

Usually, the drier woodlands in the Canadian prairies, whether in aspen parkland, boreal forests or foothills forests are also the traditional public grazing lands. When commercial forestry harvests such lands by summer logging, foresters tend to blame any reduction of aspen sucker regeneration on cattle grazing. Sometimes it is true, but often it is not. Frequently, it is because these forested sites are on drier, coarser-textured, soils. They are just slower to regenerate aspen suckers to a high density. This is frequently related to summer logging

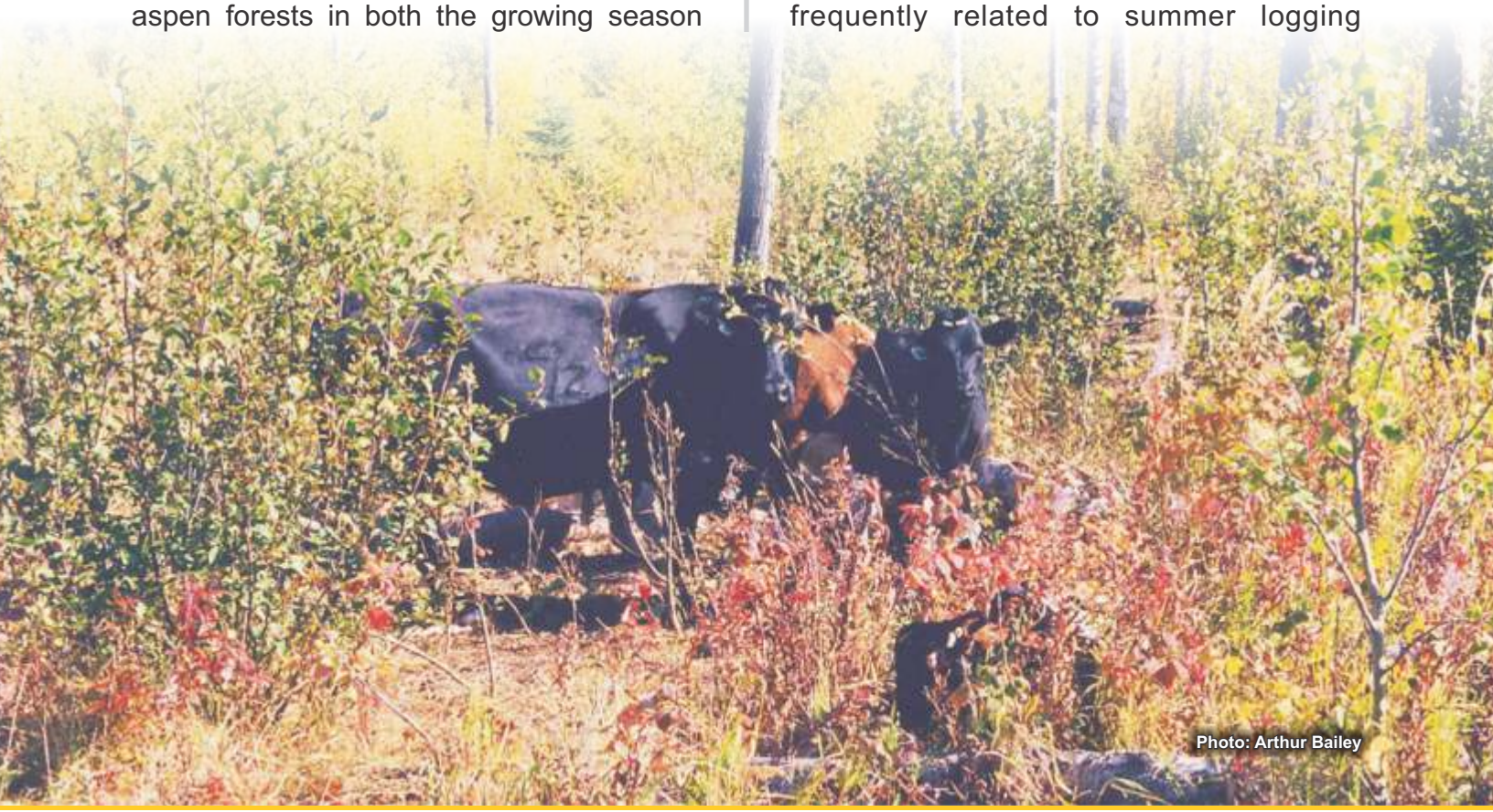


Photo: Arthur Bailey

because a lower density of aspen suckers emerge the next year.

Periodically, after clear-cutting, the aspen sucker density on coarse soils of the aspen parkland does not meet tough forestry-imposed stocking densities. Some of the problem lies with the lack of good ecological information available to foresters. They appear to expect these naturally lower-producing soils to yield aspen sucker densities as high as the moister soils of the boreal forest.

Forestry companies prefer to log the driest areas in the growing season. The fertile, finer soil-textured boreal forest lands have better summer moisture which favors aspen regeneration. Summer logging is more difficult or impossible on the wetter soils, so winter logging is more common. The more fertile, moister forest sites and winter harvesting are a combination that favors higher aspen sucker densities.

Prescription Grazing System 3A:
Grazing following winter logging of aspen forest

Aspen roots and crowns sucker more readily following winter harvesting than summer harvesting. Grazing practices following winter forest harvesting should be different from summer harvested areas

A deferred rotation grazing system is recommended and a model is presented in Table 6. (Note: the actual turn out dates each year will depend upon the specific spring weather conditions, geographic location and forage production.) During Year 1, following winter forest harvesting, aspen suckering and grass, sedge and forb re-growth will not be grazed until August 1. Forage production will be relatively low the first year of grazing, since understory plants are growing in full sunlight for the first time in many years. It takes them over a year to reach their full potential.

In Year 2, there will be a deferral until June 15th. The forage crop will be about 1½ to 2 times as much as in Year 1. The duration of stay in each paddock can increase for the paddocks grazed in late summer and fall. In Year 3, 4 and 5 grazing can start earlier in the season around June 8th.

Table 6. A four-field deferred rotation grazing plan of prescribed grazing - scenario 3, after winter harvesting of aspen.

Field	Year 1*	Year 2**	Year 3	Year 4	Year 5
1	Aug 1-15	Jul 16-31	July 1 - 31	Sep 1 - 30	June 8 - 30
2	Sept 16-30	Jul 1–-15	Aug 1 - 31	July 1 - 31	Sep 1 - 30
3	Aug 16-31	Aug 21-Sep 10	June 8 - 30	Aug 1 - 31	July 1 - 31
4	Sept 1-15	Aug 1-20	Sep 1 - 30	June 8 - 30	Aug 1 - 31

* Defer grazing until August 1 in Year 1.
**Defer grazing until June 15 in Year 2.

The principles are what count in providing an example (Table 6). Each land manager will need to modify this grazing plan to accommodate their specific situation.

Be prepared to implement the following:

- Develop electric or permanent fencing and provide water, salt and mineral in or available to each paddock (field) in the recently clear-cut aspen forest.
- Make a plan to distribute livestock grazing uniformly across each paddock by whatever means works, such as placing salt well away from water and if necessary, cut trails and herd livestock to poorly used areas.
- Fence each paddock in the logged area into a size that can be grazed Year 1, in 2 weeks or less, by the livestock herd available.
- During Year 1, the first growing season following winter clear-cutting, defer grazing until August 1, then graze each paddock lightly only 2 weeks or less (Table 6).
- During Year 2 defer grazing until July 1, then graze the first paddock about 2 weeks and the subsequent paddocks 3-4 weeks depending upon forage availability and level of forage use.
- During Years 2 to 5, more forage is expected than in Year 1 so adjust livestock numbers according to forage available.

Implementation:

Year 1:

Step 1: In Year 1, select the first field to be grazed, starting August 1, and allow up to 25% grazing use of forage grasses, forbs and sedges. Allow up to 15% use of aspen suckers (Table 6, Year 1, Field 1). Plan the grazing interval to be approximately 2 weeks (August 1-15). *Distribute livestock effectively throughout the paddock for uniform foraging.*

Step 2: When that has been achieved, rotate the herd to field 3 and once again allow grazing up to 25% use of the desirable forage grasses, sedges and forbs. *Distribute livestock effectively throughout. Plan this to take about 2 weeks* (August 16-31) (Table 6).

Step 3: Rotate the herd to the third field (Field 4). Continue following these recommendations through all of the paddocks having new aspen clear-cuts during Year 1. Continue either until the end of the grazing season, or until all fields within new clear-cuts are grazed. *Distribute livestock effectively throughout the paddock and maintain a forage use level on grasses of no more than 25%.*

Year 2:

Step 4: Beginning with Year 2, plan to revise the order of grazing the fields (Table 6). On July 1 graze one of the fields *grazed late in Year 1 (Field 2)* for about 2 weeks. *Distribute livestock effectively throughout the paddock.* When 25% of the desirable forage grasses, forbs and sedges have been consumed and no more than 15% of the aspen suckers have been grazed, rotate the herd to the next field (Field 1).

Step 5: *Distribute livestock evenly throughout the paddock.* When up to 30% of the desirable forage grasses, forbs and sedges have been consumed and no more than 15% of the aspen suckers have been grazed, rotate the herd to the next field. Continue this process during Year 2 until all paddocks in young clear-cuts have been grazed.

Year 3:

Step 6: At the beginning of the third grazing season (Year 3, Table 6), about June 8, when height of forage grasses is about 8 inches, plan to change the order of grazing of the various fields from that used in Year 2. In other words, in Year 3, first graze a paddock grazed at mid-to late season in the previous year (Field 3). *Distribute livestock effectively throughout the paddock*. When up to 30% of the desirable forage grasses and sedges have been consumed, about the end of June, and no more than 15% of the aspen sapling terminal shoots have been grazed, rotate the herd to the next field. Continue until all paddocks have been grazed.

Step 7: In Year 4 and subsequently, starting about June 8, when forage grasses are about 8-inches tall, first graze a field grazed in mid- to late- season the previous year. When up to 35% of the desirable forage grasses and sedges have been consumed and no more than 15% of the aspen sapling terminal shoots have been grazed, rotate the herd to the next field. Continue until all paddocks have been grazed.

Step 8: In subsequent years continue using the deferred rotation grazing system as indicated above and in Table 6.

Prescription Grazing System 3B: Grazing following summer logging of aspen forest

The vegetation growing in an aspen clear-cut one year after summer logging (Year 0), develops more slowly than after a winter logging operation. Aspen suckers, grass, forbs, sedges and small shrub regeneration growing in the clear-cut the first spring and summer of Year 1 are quite scattered, weak and vulnerable to spring and summer grazing. To compensate for this vulnerability, no livestock grazing is recommended in Year 0. This year-long deferral enables the aspen suckers, grasses and forbs to develop larger root and top systems before being grazed the next year, during Year 1.

Plan and develop a deferred rotation grazing system in the summer logged aspen forest. The deferred system requires about 4-5 fields (paddocks). Plan the fencing and grazing rotation. Then install electric or permanent fencing in a manner that enables livestock access to water in or near to each field. Fence each field in the logged area into a size that can be grazed in 2 weeks or less in Year 1 by the livestock herd. *Insure that grazing is evenly distributed across each paddock using water, salting, herding, riding or dogs to prevent over-use of aspen suckers and grasses in any one location.*

A deferred rotation grazing system is presented in Table 7 as an example. Land managers may need to modify what is illustrated in the table to accommodate the unique traits of their grazing land base and livestock management.

Observe the following in Table 7:

Grazing is deferred in Year 1 until August 1, in Year 2 until July 1, and in Years 3, 4 and 5 until June 15.

In Year 2 and in subsequent years, the duration of grazing in fields grazed in mid-to late season is about 3 to 4 weeks rather than less than two weeks.

There is more forage in later grazed paddocks than earlier in the growing season and the aspen stems have hardened by late July, thus aspen stems are not as vulnerable to being eaten.

Implementation:

Year 1:

Step 1: In the first year of grazing, Year 1, defer grazing until August 1. Allow cattle entry into Field 1 of the aspen clear-cut and stock at a normal stocking density to enable up to 25% use of the herbaceous forage and no more than 15% of the aspen suckers to be grazed within two weeks. Distribute water and salt well in each paddock and herd more than normal to prevent cattle overgrazing close to water, roads and major skid trails.

Step 2: Rotate herd to the second field once 25% of the desirable forage grasses and sedges have been consumed in Field 1. Continue following the recommendations in Table 7 rotating the herd into the next paddock until the end of the grazing season or the end of the fields on new clear-cuts.

Year 2:

Step 3: At the beginning of the second growing season (Year 2), change the order of grazing the fields from that used in Year 1 (Table 7). Grazing may begin in Year 2 about July 1, a month earlier than in Year 1. Expect the herbaceous forage production to have doubled from that in Year 1. Increase herd size, to accommodate higher yields. In Year 2, follow the order of grazing in Table 7. The first grazed field (Field 2) will be one that was grazed late in Year 1.

Step 4: When up to 30% of the desirable forage grasses and sedges have been consumed and no more than 15% of the aspen suckers have been grazed in Field 2, rotate the herd to the next paddock (Field 4). This field will also have been grazed later in Year 1. Rotate the herd to Field 1, when up to 30% of the desirable forage grasses and sedges have been consumed. No more than 15% of the aspen suckers should be grazed in the 2 week period in the first field grazed. Continue the grazing practices for each field in the recent clear-cut to the end of the Year 2 grazing period or until all paddocks are grazed.

Year 3:

Step 5: Start grazing about June 15. Change the order of grazing of the various fields from that used in Year 2 (Table 7). When up to 35% of the desirable forage grasses and sedges have been consumed and no more than 15% of the aspen sapling terminal shoots have been grazed, rotate the herd to the next paddock.

Step 6: This second field in Year 3 will have been grazed in the second half of Year 2. When up to 35% of the desirable forage grasses and sedges have been consumed

Table 7. A four field deferred rotation grazing plan for prescribed grazing scenario 3 after summer harvesting of the aspen forest

Field	Year 0	Year 1*	Year 2**	Year 3***	Year 4	Year 5
1	logged	Aug 1 - 10	Jul 26-Aug26	Jun26-Jul 16	Aug27-Sep30	June 15 - 30
2	logged	Sep 7 - 21	July 1 - 10	Jul 17-Aug20	July 1 -21	Aug27-Sep30
3	logged	Aug 11 - 22	Aug27-Sep27	June 15 - 25	Jul 22-Aug26	July 1 - 21
4	logged	Aug 23-Sep 6	July 11- 25	Aug21-Sep30	June 15 - 30	Jul 22-Aug26

* Defer grazing until August 1 in Year 1.

and no more than 15% of the aspen sapling terminal shoots have been grazed, rotate the herd to the next field. Continue the grazing practices for each paddock in the clear-cut.

Year 4+:

Step 7: In Years 4+, follow the guidelines outlined in Steps 5 and 6 for Year 3.

BENEFITS

- These prescribed grazing scenarios provide considerations for both aspen sucker-sapling regeneration, as desired by forestry interests, and for the forage needed by livestock, particularly in the early years of an aspen clear-cut.
- A source of forage is made available for livestock grazing.
- The regeneration of a new crop of aspen suckers and saplings for forestry.
- Livestock grazing will reduce the level of fine fuels each summer and fall, thus reducing fire hazard and enabling faster aspen stem diameter and tree height growth than without grazing.
- With conservative grazing practices as outlined, excellent cow and calf gains should be expected for the first 3 to 5 years.
- Livestock grazing will reduce competition between grasses and aspen saplings thus stimulating rapid growth of tree regeneration.
- More conservative livestock grazing regimes will also benefit wildlife, recreation, fisheries and nature conservation.

CHALLENGES

- Since shading of the grassy understory will be of serious consideration by Year 4, livestock distribution problems will develop and high accumulation of herbaceous litter will become more challenging.
- Use more trail cutting to distribute livestock more effectively.
- Once aspen saplings are 2 meters tall, about Year 4, seek cooperation from foresters to implement periodic higher stocking rates such as short-duration mob grazing events from July to September to assist in trampling tall herbaceous litter. This enables better cattle access to green growth and the reduced competition from forages facilitates more rapid tree growth.
- In Year 4 and subsequently, cut narrow trails to enable better access through the young aspen stands to understory forages.
- There is a need for excellent cooperation and coordination amongst ranchers, foresters, and crown land administrators, to enable better access of cattle to understory forage supplies from Year 4 until the next clear-cutting of the aspen forest.

PRESCRIPTION GRAZING SYSTEM FOUR:
Prescription grazing to assist in the regeneration of conifers in plantations and to reduce fire hazard

Many conifer plantations occur on crown lands in the boreal forest region and in the northern sections of the Rocky Mountain foothills. Clear-cut logging and wild fire are the primary disturbance factors. Industrial foresters and crown land administrators both want rapid regeneration of young conifers soon after logging or fire. Native grasses, sedges, forbs and brush are major competitors to conifer seedlings or transplanted conifer growing stock. These native forage competitors often shade out or slow down the rate of growth of young pine or spruce trees. They also create a fire hazard.

Prescription Grazing System 4 has been developed for the northern tier of forests in the foothills of the northern Canadian Rockies and the boreal forest. This grazing system is not intended for implementation in the southern foothills. In that area, there are usually too many complexities in attempting to implement this System 4 in a mountainous landscape of conifer forest, montane forest, parklands and native grasslands.

Prescription grazing with livestock in conifer plantations can reduce the fire hazard when grazing and trampling removes the tops of

Photo: Ron Moss

grasses and other herbs. This activity also reduces the grass-brush competition faced by young conifer regeneration (Sutherland 1987, O'Brien and Bailey 1989). Thus, good range management practices can help accelerate conifer regeneration, while also providing a summer forage supply for livestock. The emphasis in this grazing scenario will be regarding the use of cattle and other livestock to reduce grass and brush competition to young conifers, while also reducing fine fuel loads. Any reduction in fuel loading diminishes the risk of summer wildfires in conifer plantations.

In the southern boreal forest near Athabasca, Alberta, O'Brien and Bailey (1989) and Bailey (1990), and Sutherland (1987) in B.C., have studied the use of sheep to reduce brush and herbaceous competition to conifer transplants. Similarly, in Idaho Kingery et al.(1987) studied the effects of cattle grazing in young Douglas-fir clear-cuts. In the foothills of the Rocky Mountains near Hinton, Alberta, Irving (2001) studied horse use of conifer clear-cuts that were regenerating to lodgepole pine. Both Irving (2001) for horses, and Kingery et al.(1987) for cattle, found very low trampling losses of young lodgepole pine and Douglas fir saplings, respectively. Irving (2001) found no browsing of lodgepole pine by horses. O'Brien and Bailey (1989) found very low browsing and trampling losses of white spruce transplants due to sheep grazing.

This is a promising area for progressive ranchers and public range managers to cooperate with foresters to promote conifer regeneration in the boreal and northern foothills forests while making available another source of forage for selected livestock. Foresters, however, are reluctant to allow any livestock into conifer plantations.

So why are foresters suspicious of livestock in conifer plantations? First, they are reluctant to deal with another user of coniferous forest clear-cuts. Second, some foresters have had personal experience with livestock owners who used the forested lands as a “summer dumping area” for their untended livestock. In other words, not every owner of livestock is prepared to use the appropriate level of range management that promotes the rapid growth of young conifers in recently logged or burned plantations.

This potential use by livestock of coniferous regeneration areas will only happen in the future, if there is a high level of cooperation and trust amongst foresters, public range managers and ranchers. No practical range managers are known by the author to have attempted to use Prescription Grazing System 4. There is a higher than average level of risk involved in attempting to implement this grazing scenario. On forested crown lands there are poisonous plants such as tall larkspur and water hemlock, predators, including wolves, bears, cougars and coyotes. There are also water hazards and very few fences. These substantial challenges would deter many ranchers from even attempting to graze cattle on forested rangelands. In western Canada, however, there are ranchers who have grazing dispositions and do have experience grazing cattle in regenerating conifer clear-cuts. Many of them now have such grazing dispositions along the foothills of the Rocky Mountains in Alberta or in the lower boreal forests ranging from northeastern B.C. to central Manitoba. There is a lot of potential to

provide more opportunities for summer grazing of livestock and the more rapid regeneration of conifers on these temporary rangelands. This is the justification for including Prescription Grazing System 4 in this chapter.

It is recommended that various preparations be made before developing such a grazing trial:

- The conifer transplants should be established on the site at least two years prior to grazing in order for their roots to be firmly established in the soil.

- It is preferable that such grazing trials with cattle be applied where three-year-old transplanted white spruce growing stock is established in clear-cuts or recent burns, rather than where younger white spruce stock has been transplanted. Younger, smaller conifer regeneration can be more readily damaged (trampled) and are more readily overtopped by grasses and brush.

- It is recommended that temporary multiple wire, high voltage, low amperage electric fencing be installed around the perimeter area to keep livestock in and predators out. O'Brien and Bailey (1989) found that electric fencing did deter black bears from attacking sheep.

- Plan and build in the trial area four or more paddocks and use a deferred rotation grazing system.

- The size of each paddock would depend upon the size of the herd of cattle, sheep, goats or horses.

- Water, salt and mineral supplements should be readily available in or near each paddock.

- For sheep, only adult animals should be considered and they need to be contained in a corral at night that is predator-proof.

- Cull, adult dry cows or steers are the desired types of cattle for this grazing trial.

- It is recommended that only cattle or sheep whose rumen is adapted to forest native grasses, legumes, aspen, willow, and tall larkspur be used in such grazing applications.

- To increase the chances of a successful trial, it is recommended that an experienced handler (herder) be on site at all times and be provided with the appropriate deterrents to deal with potential predation, poisoning and livestock distribution problems.

The scenarios presented below have been developed with the limited information available to the author. More definitive prescription grazing scenarios can be developed in future following the completion of more field trials in several areas of the Canadian southern boreal and foothills forest regions.

Photo: Pam Iwanchysko

Prescription Grazing System 4A: Grazing in conifer plantations without palatable poisonous plants

Use cattle, horses or sheep as the preferred livestock for this grazing practice in a conifer plantation having minimal amounts of palatable poisonous plants, such as tall larkspur.

Steps to take in implementing Prescription Grazing System 4A:

Step 1: Start the grazing program in mid-spring (usually about mid-June to early July) of Year 1 allowing a fast first rotation. Graze and rotate Fields 1 to 4 the first time for about 2 weeks as indicated in Table 3 (page 146). Distribute the cattle well by placing salt away from water and herding livestock to less grazed parts of each paddock.

Step 2: When up to 30% of the grass has been eaten or trampled in Field 1 and some brush has been defoliated, move cattle to Field 3 (refer to Table 3).

Step 3: Repeat as in 2. (above) for each paddock until all fields are grazed.

Step 4: As the grazing rotation proceeds, evaluate each grazed field for:

- How much shading has been removed by comparing the grazed paddock with similar adjacent ungrazed areas?
- Determine if the number of conifer transplants broken or knocked down by livestock grazing is within acceptable pre-determined levels.
- Determine if poisoning or predation is a serious issue.
- Adjust the grazing and livestock management as the grazing year proceeds and as issues and problems develop and are solved.

Step 5: If there is time available for all or part of a second rotation, skip grazing Field 1 and start livestock grazing in Field 3 for about a week to remove up to 20% more grass and brush leaves, then move the herd.

Step 6: Repeat this practice through Fields 3, 4, 2, and 1 (last) to complete the second rotation.

Step 7: Expect to remove up to 50% of the grass in the two rotations and find much of the remaining herbage to have been trampled. Expect about 25% of the leaves to have been eaten from palatable browse like aspen, some willows, red osier dogwood, wild raspberry, wild rose and gooseberry.

Step 8: At the end of the first grazing season, assess the progress achieved in reducing grass, herbs and brush cover, reducing the fine fuels level and thus also the fire hazard. Discuss the progress and the problems with the cooperating forester. If satisfactory progress has been made, continue the grazing trial the next year. If modifications need to be made, then do so.

Step 9: In Year 2, defer first grazing of field 1. Start grazing Field 2 (see Table 3).

Step 10: When up to 30% of the grass has been eaten or trampled in Field 2 and some brush has been defoliated, move cattle to field 4.

Step 11: Repeat as in 2. (above) for each paddock until all fields are grazed in the rotation following the procedure in Table 3.

Step 12: As the grazing rotation proceeds, evaluate each grazed field for:

- How much shading has been removed by comparing the grazed paddock with similar adjacent ungrazed areas?
- Determine if the number of conifer transplants broken or knocked down by livestock grazing is within acceptable pre-determined levels.
- Determine if poisoning or predation is a serious issue.
- Adjust the grazing and livestock management as the grazing year proceeds and as issues and problems develop and are solved.

Step 13: If there is time available for all or part of a second rotation, skip grazing Field 2 and start livestock grazing in Field 4 for about a week to remove up to 20% more grass and some brush leaves, then move the herd to Field 1.

Step 14: Repeat this practice through Fields 4, 1, 3, and graze Field 2 (last) to complete the second rotation.

Step 15: If there is sufficient forage in rotation 2, keep livestock in each paddock for as much as 10 days in order to make a greater impact on the grass and brush competitors.

Step 16: In Year 3, follow the order in grazing each field as outlined in Table 3. Follow the grazing plan outlined above in Steps 1- 7.

Step 17: It is recommended that at the end of Years 3 or 4, the grazing and forestry cooperators should evaluate the progress of the grazing trials to determine if grazing has satisfactorily reduced enough grass and brush competition to allow more rapid growth of conifers, as well as reduced the fire hazard through the removal of fine fuels.

Step 18: The outcome may be one of the following:

- The trial is satisfactory and should continue.
- The trial is satisfactory and is finished. A new trial should be initiated in another location.
- The trial is unsatisfactory and some modifications need to be made before it continues.
- The trial is unsatisfactory and should be terminated.

Step 19: At the end of the first trial, determine if it is necessary to revise Prescription Grazing System 4A. When that is done, consider implementing a full scale field application using the principles above, if there is a willingness amongst the cooperators to continue.

BENEFITS

- The fine fuel load is reduced by about 40-50% when the grasses, other herbs and palatable brush are grazed.
- The fire hazard is reduced accordingly.
- Livestock trampling the vegetation also reduces the fire hazard.
- The rate of stem elongation in conifer seedlings and transplanted stock will start to increase starting in Year 2 due to less shading and reduced competition for light, soil water and nutrients.
- If there is successful cooperation between foresters and ranchers, and livestock are allowed access to conifer plantations, then more ranchers have access to another summer grazing resource. Also, the young conifers will be able to grow faster because of the reduced shading.
- The potential for a better understanding and willingness to cooperate between ranchers and foresters may emerge.

CHALLENGES

- Few ranchers have specific experience using a deferred rotation grazing system to realize the goals outlined for young conifer plantations.
- Minimizing the loss of weight and the occasional death in livestock under spring and fall grazing conditions. (This will be quickly learned and the necessary adjustments made as practitioners gain experience).
- Identify suitable areas that have little or no tall larkspur, a poisonous plant palatable to cattle in spring through July.
- The expense of installing adequate temporary fencing and watering facilities in remote areas.
- The expense of having an experienced livestock handler on site 24 hours/day.
- Having all interest groups cooperate fully to enable a successful outcome for both ranchers and forestry interests.

Prescription Grazing System 4B: Grazing in conifer plantations having palatable poisonous plants

Tall larkspur (*Delphinium glaucum)* or Duncecap larkspur (*Delphinium occidentale)* are both palatable and poisonous to cattle in the first half of the growing season. They are widely distributed along the eastern foothills of the Rocky Mountains and in the western boreal forest.

The grazing scenario assumes that the trial area has been inventoried during the previous growing season and high quantities of poisonous larkspur were found.

Option 1: use adult sheep rather than adult cattle since sheep are more resistant to tall larkspur poisoning. Then proceed with sheep grazing following Prescription Grazing System 4A following the steps outlined. If no sheep are available, use Option 2.

Option 2: use dry cattle or steers that have been raised in the region of the conifer plantation. Proceed with Prescription Grazing System 4A following the steps outlined, *but do not start grazing until about August 1 when tall larkspur is mature and less palatable to cattle.*

In preparation to implement Prescription Grazing System 4B, review and apply the steps listed in bullet format in 4A. As grazing begins do the following:

Observe how much tall larkspur the cattle are eating in the first field grazed. If it is a minimal amount, continue grazing through August and into September. Graze the paddock to about 30% utilization of grasses and some use of brush leaves within reach of cattle.

If at any time during this grazing trial, cattle show signs of larkspur poisoning, move them out to a larkspur-free area.

If cattle do not become sick, and if satisfactory progress has been achieved after several years of grazing, repeat the grazing trial in another area having much larkspur to determine if this prescription grazing scenario can be repeated successfully. At the end of this second trial, determine if a revised prescription grazing scenario is ready for full scale field application.

BENEFITS

- Livestock are able to forage in these areas for part of the grazing season.
- Grazing reduces the amount of shading and competition to young conifers.
- Grazing will stimulate more rapid growth of young conifers due to less competition for light.
- Grazing reduces both the fine fuel load and the fire hazard.

CHALLENGES

- Tall or Duncecap larkspur still has some poisonous properties when mature, although livestock rarely eat it because of low palatability.

Larkspur. Photo: Steve Dewey, Utah State University, Bugwood.org

Grazing Economics

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height Ft. Diameter-In.	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr.) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
Grazing	.5-4 ft. 1 in.	$10	3100	$20		

* 25 lbs forage = 0.80¢

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CHAPTER EIGHT

Evaluating Brush Encroachment and Success of Control Measures

MAE E. ELSINGER, RANGE MANAGEMENT SPECIALIST,
AGRICULTURE AND AGRI-FOOD CANADA,
PRAIRIE FARM REHABILITATION ADMINISTRATION,
BRANDON, MANITOBA

OVERVIEW

We encourage land managers to develop a program or timeline for brush management and a monitoring strategy should be built into this. Brush treatment is not a one-time effort. In many cases, it should be re-treated within 2 to 5 years in order to:

- Prevent forage loss resulting from accelerated re-growth and canopy closure.
- Use cheaper methods to control smaller brush.

Monitoring doesn't need special expertise. It can be as simple as taking a picture at the same location every July, or marking out a permanent square to count how many live stems of aspen are in it every September.

This section will demonstrate:

- Why monitoring is necessary.
- Suggested processes for monitoring.
- Information which can be collected to measure brush management success.

Photo: Ron Moss

WHY DO WE NEED TO MONITOR BRUSH?

Monitoring can answer questions such as:

- Is it time to treat a brush problem?
- Does my brush treatment method work?
- Is it time to re-treat or follow-up on a previously applied brush treatment method?
- Am I losing forage productivity by not taking action to reduce brush?
- How fast is brush taking over?
- Which brush treatment method gives me better productivity?
- Are grazing practices helping manage brush or are they encouraging more brush encroachment?
- Which brush treatment method costs less in the long run?
- Am I getting the value I want for my efforts?

Two years re-growth of aspen and hazel following winter timber harvest. Although forage production increased significantly after treatment, it is at risk of being lost again from woody canopy closure.
Photo: Ron Moss

Keeping Records

It is a good idea to keep detailed records of each brush treatments:

- Year and date of treatment.
- Acreage covered by brush treatment.
- Maps and aerial photography, if possible.
- Observations of effectiveness of treatment (percent kill, impact on forages, sucker production, increase in forage yield).
- Observations of conditions at time of treatment (rain, snow, wind, freezing temperatures, frost, late or early green-up, wet or frozen ground).
- Invoices for chemical, equipment rental, labour.
- Payments for timber harvest.
- Timber harvest agreements.
- Stocking rates (# of head for how long).
- Time of year grazed.
- % use of key grasses and brush species by cattle.
- Photographs

Monitoring pasture management by memory is difficult, especially when a number of brush treatments are being applied. Changes are hard to detect when they occur gradually over a period of years. People are amazed when they compare a photograph of a site taken just before a brush treatment, and one taken five years later. “I didn't think it changed that much,” they say. That is why it is important to keep both visual (photographs) and written records (in a notebook).

Table 1. The development of a plan for monitoring brush treatments

State purpose of the monitoring plan	The purpose of monitoring this site is to determine if timber harvest is an effective brush control method
State objectives or goals of monitoring	In five years, we hope to have as much or less brush in this pasture as there is on nearby grass pastures
Determine what qualities of the site will need to be monitored to determine success	Count stems of shrubs and trees, and compare them between timber harvest site and the pasture site
	Take photographs
Develop a monitoring program	1. August, before timber harvest
	2. August, after timber harvest
	3. August, two or three years after timber harvest
	4. August, five years after harvest

Are cattle using an area where brush treatment has taken place? Photo: Ron Moss

It is difficult to identify what causes changes in brush cover, unless the effect of the brush treatment method can be distinguished from ongoing effects of climate and post-treatment grazing methods. Records of stocking rates and climate information can help clarify this.

PLANNING TO MONITOR

When developing the monitoring portion of a brush management program, several things need to be considered (Table 1).

Baseline Evaluation (Pre-Treatment)

Pre-treatment evaluation is important because it allows you to compare what you started out with to what you get after applying brush treatment measures.

Choose a monitoring site that is typical of the brush cover on the area to be treated, in terms of, forage yield, exposure, soil type and available moisture. If you have already done a brush treatment, but didn't collect baseline information about that site, look for a nearby un-treated site that is similar in brush cover, forage yield, exposure, soil type and available moisture. Then collect information in both the brush treated site and the untreated site.

Mark sample sites with painted stakes and record the location. **Note:** Livestock will eat some coloured flagging, so avoid using it unless it is placed out of their reach. Stakes can disappear when some brush control measures are applied. If you have a GPS receiver available, you can record the location of the sample sites that way, or you can use reference points in the landscape to mark the location (for example, fifty paces at 45°C from the specific corner fencepost, or

Table 2. Example of data collected before timber harvest.

Brush Monitoring Record						
Date: August 15, 2008		**Treatment**: Before Timber Harvest			**Frame size:** 1 m²	
Location Number	1	2	3	4	5	
GPS (N)	51° 49' 29.2"	51° 49' 30.9"	51° 49' 31.8"	51° 49' 33.0"	51° 49' 34.4"	
(W)	102° 3' 3.1"	102° 3' 5.1"	102° 3' 6.3"	102° 3' 7.5"	102° 3' 8.9"	
Brush Species:	**Number of Stems:**					**Average**
Aspen	2	1	2	3	-	1.6
Hazel	2	-	-	-	-	0.4
Rose	2	-	1	-	4	1.4
Buckbrush	5	3	6	1	5	4.0
Comments: *samples in a line along edge of ridge, 15 years since brush was cleared, timber harvest expected in December, sampling sites marked with stakes, not much use by cattle*						

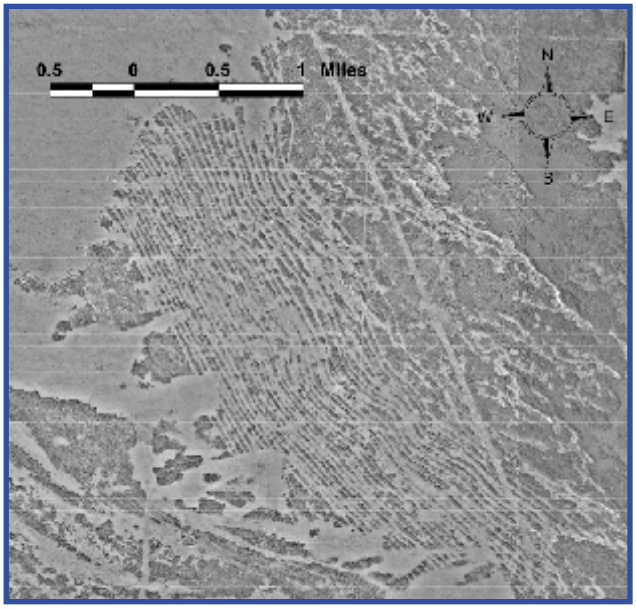
halfway up that ridge). Make sure you record the location on paper and take photographs. Then, do the measurements of the qualities that will satisfy your monitoring goals, as described in Planning to Monitor, and record them. Remember to record the date of the measurements and any other relevant observations.

Not all sites on the treatment area will give the same measurements, so you should pick 5 or 10 sites and average the results.

Post-Treatment Evaluation

Post-treatment measurements mean any measurements done after a brush control application, even if they are two or five years down the road. In brush management programs containing multiple control treatments, this can become confusing. For example, you might do measurements post-timber harvest, but pre-herbicide application. This is where it becomes handy to provide details and dates on your monitoring records.

The process used in post-treatment monitoring should be identical to the one you used in pre-treatment monitoring. You will return at a similar time of year, to the same sampling spot, marked by a stake or flag or recorded as a GPS reading or description, and perform the same measurements. That way, you can make a direct comparison of the values before treatment and after treatment. Table 3. Example of data collected after timber harvest.



Map showing areas that were ball-and-chained in the 1960s. Photo: PFRA

Table 3. Example of data collected after timber harvest.

Brush Monitoring Record						
Date: August 21, 2009		**Treatment**: After Timber Harvest			**Frame size:** 1 m²	
Location Number	1	2	3	4	5	
GPS (N)	51° 49' 29.2"	51° 49' 30.9"	51° 49' 31.8"	51° 49' 33.0"	51° 49' 34.4"	
(W)	102° 3' 3.1"	102° 3' 5.1"	102° 3' 6.3"	102° 3' 7.5"	102° 3' 8.9"	
Brush Species:	**Number of Stems:**					**Average**
Aspen	3	2	-	5	-	2
Hazel	6	2	3	3	5	3.8
Rose	3	1	-	-	2	1.2
Buckbrush	6	1	4	-	2	2.6
Comments: *younger aspen pushed over but not removed, some are still alive, height of suckers about 3 feet tall, flush of grass this year, cattle are spending time here*						

WHICH INFORMATION TO COLLECT

There are many variables on a site that can be measured in order to evaluate brush management success. The following is a list from which you can choose the most appropriate measurement for your application.

Mapping

Mapping is useful for determining locations and acreage of brush that needs to be treated. Mapping done in different years can illustrate how fast brush cover is expanding. Aerial photos and satellite imagery are handy for these purposes. Maps can also be built from ground measurements and/or locations recorded with a GPS receiver.

Photographs taken on the same date to compare two sites where cut aspen stumps were treated with roundup (left) and with biofungus applied to cut aspen stumps (right). Photos: Chris Hutton

Photographs

A picture is worth a thousand words! Photography is an excellent way to give a visual picture of brush management on an area. A photograph taken of different sites on the same date, allows you to compare different methods of controlling brush. Photos taken of the same site through time can demonstrate how fast a brush problem is growing, or how much the site has improved after brush control.

All photos should contain an item of known size, such as a spade or a person, to provide a scale to measure brush against. Photographs taken on different dates should be taken at the same point in the same direction. Photos taken of both the general area and

a specific sample plot give more information than just one photo of the area.

Brush and Herbaceous Species Composition

It is important to know what the major brush species are before a control method is decided upon. Some species are harder to kill using herbicides, while some are unpalatable to cattle, but not to sheep or goats. It is also worthwhile to know which major grasses and forbs (herbs) are returning to a site after treatment. For example, after brush treatment in a tame pasture, if not enough forage grasses or legumes are returning, the producer may decide to overseed the site with forages. Where wildlife habitat and biodiversity are goals of brush management, species inventories will determine if the brush treatment has produced a wider and more distinct variety of plants.

Forage yield

Production of forage is of particular interest in a grazing operation. It can be measured by visual estimates of pounds per acre, but the more reliable method is to clip, dry, and weigh the forage collected from a few samples taken from a given area. It is important to protect the area to be clipped from grazing, by installing a grazing cage or exclosure. Clipping should be performed as close as possible to the same date each year. Using a reference frame or hoop of known dimension (0.25 m^2 or 1 m^2 or 1 meter diameter) will allow the observer to calculate the amount of forage yielded in a given area and convert that value to a more standard value of pounds per acre or kilograms per hectare.

In addition to tracking forage yield changes through time, the values obtained from this exercise can be directly translated into appropriate stocking rates for that site. However, the producer must also consider the significant effects of moisture on the forage yield. For example, clipping during a wet year will yield a lot of forage. If this is directly translated into a stocking rate, that rate will be too high in a normal year or in a dry year.

Ground cover

Assessing what proportion of the ground is covered by herbaceous plants, plant residue, or bare ground is an easy way of judging improvement in forage supply. This is simply assessing how much of a small area, such as in the reference frame or hoop (0.25 m^2 or 1m^2 or 1 meter diameter), is covered by plants, residue or bare ground. If desired, the plant cover can be broken down into cover types (i.e. legumes, grasses, herbs, or moss) or by species (i.e. wheatgrass, bluegrass, peavine, clover, etc.). Note, there is no reliable way to convert this value to stocking rate.

Canopy cover

Percentage canopy cover of trees and shrubs is difficult to estimate accurately, but

Grazing exclosure, for measuring forage yield.
Photo: Ron Moss

can demonstrate how trees shade out grassland plants. Plants adapted to growing in full sunlight, such as forage grasses and legumes, produce much less forage under a tree or shrub canopy. Photographs can be used to compare canopy cover of woody species over time, but they should be taken as close as possible to the same date each year.

Stem density

Stem density of woody species is found by counting the number of stems of brush in a reference frame or hoop (i.e. 1 m^2, 4 m^2 or 1 meter diameter). It is often broken down by species and is usually an average of 5 or 10 samples, expressed as stems per m^2. Note that counting stems accurately in a pre-treatment situation is difficult due to the maturity and spacing of brush species. Larger frame sizes and more samples will improve the accuracy.

Counting woody stems in a 1m^2 frame.
Photo: Brian Baron

It is very easy to compare stem densities on the same site from one date to the next to determine how quickly brush is recovering from a treatment. Stem density usually increases significantly in the years after a brush treatment as a result of suckering. Each little stem can eventually grow into a mature shrub or tree if left unchecked by follow-up treatments or browsing by cattle. The producer needs to realize that forage loss will be prevented with smaller cost when brush stems are smaller.

Brush height and size

Brush height is important because the taller the brush and the more closed the overstory canopy, the more shaded is the ground. Forages produce very little in minimal sunlight.

A person can uncover the history of a brush stand by determining its size-class structure. This is simply documenting how much cover there is of each size category of tree. For example, if there is significant cover of aspen saplings or younger, but no older ones or deadfall, and no recent record of clearing, you may judge that a decrease in grazing intensity or timing has allowed rapid encroachment of aspen. A plan to reverse the change in management may then be in order.

Sprayed area on right. Percentage kill was almost 100%. Photo: Ron Moss

Percentage kill

Percentage kill measures the immediate effectiveness of the brush treatment. It is important to measure kill rate within one or two years after the treatment was applied. This can be judged by estimating the canopy cover of live trees in an area or by counting the number of live stems versus dead stems in a smaller representative area.

Stocking rates and season of grazing

Increased stocking rates are obvious indicators of brush control success. The value of the additional stock that land can carry as a result of brush control can be compared against costs of the treatment. Sometimes the treatment can result in reduced labour needed to move or round up livestock. This too can be compared against the cost of the brush control method.

Livestock eat more brush suckers in May, June and July than in late summer, fall or winter. Winter feeding in brush patches can result in many broken stems of brittle brush. Records kept of the season of year as well as stocking rate will help the producer to identify how grazing can contribute more effectively to assist the brush treatments in either reducing brush density or keeping it to a size where livestock can continue to graze it as a source of forage.

Costs

The costs of brush management measures can be added up through time and compared to the benefits received. All costs should be recorded, from cost of chemical or equipment, to hours of labour, and time that the land is taken out of production. If a producer or landowner does his/her own clearing or chemical application, the value of their equipment and time should be accounted for. It is also appropriate to document costs and benefits that are difficult to put a dollar value on, such as wildlife habitat and aesthetic value, because not all decisions made by producers or landowners come down to economics.

The costs and benefits of different brush control methods can be compared, so that the best management option can be determined. Because not all sites treated with different brush control methods will be of the same size, it is important that the costs and benefits be expressed in $/acre.

It is wise to consider comparing costs and benefits over a period of time. For example, clearing a patch of brush one winter, then applying herbicide to the re-growth two years afterwards, appears to be a heavy cost up front, but the increase in forage production will add value to a pasture operation for several years.

CHAPTER NINE
Conclusion
Developing a Coordinated Brush Management Plan

ARTHUR W. BAILEY, PROFESSOR EMERITUS,
RANGELAND ECOLOGY AND MANAGEMENT,
UNIVERSITY OF ALBERTA, EDMONTON, ALBERTA
E-MAIL: AWBAILEY@UALBERTA.CA

OVERVIEW

- Various methods and techniques are presented in this manual. Each land manager should choose a technique or series of techniques to use on their property.
- In the past, the use of one technique often led to failure because brush is hardy. No single brush management treatment will reach the goals most ranchers and farmers desire.
- A comprehensive brush management plan needs to be developed, that will use various techniques in a planned manner to reach the goals the landowner wishes to achieve on a specific property.
- Planning is an ongoing process, involving both brush and grazing management planning. The implementation process works side-by-side with the planning and monitoring process.
- Since every property is different, no specific series of brush treatments can be presented that will be appropriate for every reader.
- Some examples of brush management systems are presented simply as models of how to go about developing a brush and a grazing management plan for a property.

Photo: Ron Moss

INTRODUCTION

Brush management on the western Canadian plains will always challenge ranchers and pasture managers because the margin of return from grazing lands is low. The most productive lands are in cultivated crops, not in grazing lands. The range and pasture lands of the western Canadian plains occur on less productive lands that are too sandy, too shallow, rocky, steep, dry, saline or have too short a growing season to be in annual crops. There are a wide variety of soil types and vegetation covered by brush. The trees and shrubs are native plants, well adapted to the plains climate:

- Dry, cold winters
- Warm to cool summers
- Periodic droughts
- Wet years
- Storms
- Insect attacks
- Fire and grazing

The input costs associated with managing brush on these rangelands must also be low.

Mechanical – Bulldozer drag used to bark scrape aspen suckers every 2 to 4 years. Photo: Ron Moss

Chemical – Selective herbicide application using a wiper system. Photo: Ron Moss

The land clearing practices of the past are no longer an option. They are too expensive. Other lower cost techniques are emphasized in this manual.

Many past attempts to reduce brush on grazing lands had the goal of increasing grass and forb production by clearing the brush and planting forages. Then the livestock grazed the land and over time it gradually was encroached by the brush species that had been removed. Rancher and pasture managers were often disappointed with the results and many considered the whole exercise an expensive, unexplained failure. There have also been some successes, but usually the methods used are now too expensive for the productive potential of the land. The usual method of the past has been land clearing; piling; burning; breaking with heavy disks; working down with agricultural equipment; followed by drill seeding and then grazing. Later, as the brush grew back and reduced grass growth, various herbicide or mechanical methods were applied. The potential returns cannot pay for such high initial cost outlays. A brush management

systems approach for grazing lands is needed.

In this manual, a series of chapters have been presented that describe various brush management techniques, including the following options:

- **Mechanical treatments plus grazing.**
- **Herbicides plus grazing.**
- **Prescribed burning plus grazing.**
- **Timber harvesting plus grazing.**

Fire – Fire is an important tool in removing debris following timber harvest. Photo: Bill Gardiner

On range and pasture lands, each grazing period can be used to promote specific brush management goals. These goals may be to use more brush as forage, thus reducing the grazing pressure on grasses to enable more grass production. Alternately, if the effect of grazing is not understood, it can often promote the growth of more brush, including unpalatable species.

In this final chapter, we present some examples as models of how to go about developing a plan using selected brush treatments to realize specific goals.

A successful system of brush management requires the land manager to know enough about the brush species they wish to manage. It is important to establish goals while planning a series of brush management treatments. It is also critical to estimate the potential costs and returns realized by using various treatments. This will assist in the development and implementation of a long-term plan to realize their objectives.

In this manual, Chapter 2 provides background about soils, climate, climate change, nutrients in browse and how brush grows. Our climate is always changing and the specialists predict that for future decades there may be warmer conditions and more frequent droughts.

In Chapter 3, various mechanical methods used today are presented. An emphasis is placed on those that are effective and economically feasible. For instance, narrow strips can be cleared through a forest enabling grazing in remote areas; also, fill

Timber harvest – Timber harvest is a low cost technique for removing large areas of mature aspen. Photo: Bill Gardiner

can be used to construct an access road across a large wetland opening up new grazing opportunities. Chapter 4 deals with herbicides and different application methods to apply to brush on ranges and pastures. Prescribed burning is presented in Chapter 5. Prescribed fire is particularly useful to manage encroaching shrubs and small trees because they can be burned under safer conditions than can forests of larger trees. In Chapter 6 is a presentation regarding timber harvesting. Aspen can supply fiber for OSB (oriented strand board). Grazing is discussed as a brush management tool in Chapter 7. Many of the woody plants on the Canadian plains are palatable and nutritious to livestock and wildlife. The emphasis is upon using deferred rotation grazing in conjunction with other brush management techniques to fully utilize the most economical tool, livestock grazing, in a manner to help manage brush.

Very large fields can be managed more effectively using rotation grazing to promote greater use of brush by livestock. In such fields, low intensity prescribed fire can remove grass and brush litter in remote parts of each field. This will attract livestock to graze the highly palatable brush suckers and lush grasses in burned areas far from water. Mowing is a substitute for burning but it is not as effective. More uniform livestock grazing can be achieved by managing brush land and adjacent grasslands. This can be achieved by combining deferred rotation grazing, water developments, some low intensity burning, some lower cost or temporary fencing, trail construction, using salt, molasses, mineral supplements and herding. Uniform livestock distribution is a real challenge to most land managers.

Chapter 8 reveals how to monitor the brush management process. It is important to document the condition of brush and the forage yield before treatment, then follow up with more monitoring for several years after the treatment. Photographs of brush and grass production, and counts of brush stems, are useful tools to show results before and after. The cost of a brush treatment and any

Table 1. A model brush treatment system for small brush

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Field 1	**M, H, B**	Graze	Graze	Graze	**M, H, B**	Graze	Graze	Graze
Field 2	Graze	**M, H, B**	Graze	Graze	Graze	**M, H, B**	Graze	Graze
Field 3	Graze	Graze	**M, H, B**	Graze	Graze	Graze	**M, H, B**	Graze
Field 4	Graze	Graze	Graze	**M, H, B**	Graze	Graze	Graze	**M, H, B**
Note: M, H, or B refer to treatment that year by mowing or dragging, herbicide or burning								
Graze: refers to prescribed grazing following a system similar to those in the Grazing Chapter								

follow-up treatments, with the benefits gained is important. Monitoring change in treated pastures helps the manager to see where the successes are, and more importantly, where are the failures.

Each rancher and pasture manager can use this manual to provide the cross section of brush management techniques now available. It is then recommended that they develop a brush management plan in conjunction with a grazing management plan for their property. They need a written plan complete with goals, techniques and timetables. The goals for each rancher, farmer or pasture manager are uniquely their own. What we can do is present a few examples and make some suggestions of what might be possible.

Shrubs and encroaching small-diameter trees. Photo: G. Oliver

Forest of non-commercial trees. Photo: G. Oliver

Commercially-valuable aspen trees. Photo: Bill Gardiner

MANAGEMENT OF SMALL BRUSH

Small brush in the aspen parkland and northern forests are mostly shrub-like clumps of western snowberry, willows, or groves of small diameter aspen tress, which are encroaching into natural grasslands or seeded pastures. Specific kinds of grazing management systems are discussed in the grazing chapter (Chapter 7). Grazing alone is often not enough to restrict the coverage of brush in the parklands and northern forests to acceptable levels.

Presented in Table 1 is a proposed system of management of the small brush in a part of a ranch, farm, or community pasture. A deferred rotation grazing system involving the use of four fields is presented. Four fields are used to illustrate the principles, but it could be 3, 5 or 8 fields on someone else's management unit. This model can be adjusted to suit the needs of an individual property.

The brush of the Canadian plains can be classified into three groups as follows:

- Shrubs and encroaching small-diameter trees
- Forests of non-commercial trees
- Forests of commercially-valuable trees

Inadequate livestock distribution on grazing lands is a major challenge in western Canada. Brush on the range tends to act as a barrier to grazing. Low cost temporary fencing, such as electric fencing, often

enables deferred rotation grazing, better management and less overgrazing of the most favoured parts of a pasture. Additional water development, some low intensity burning, some trail construction, effective use of salt, molasses, mineral supplements and herding, help with distribution problems and assist with greater grazing of young brush. The grazing of brush is often an economical and effective part of a brush management system.

In this brush management system, it is assumed that one of the four fields should have a brush management treatment, plus grazing, applied each year. All or some of the brush patches in each field would be treated by mowing or dragging, herbicide, or prescribed burning once every four years. For Field 1, it would be in Years 1 and 5, for Field 2 it would be in Years 2 and 6, etc. This model assumes that the brush would need to be treated every four years. If there is not much brush re-growth for several years because of drought and the brush does not encroach as rapidly, then the timetable can be delayed. If on the other hand, the brush encroaches more rapidly in one field than in the other three, adjust the plan and treat that field more often. Also, rethink the grazing strategy in the field having more rapid brush encroachment.

Mowing, dragging, herbicide application and prescribed burning are the most obvious possibilities for treating small brush. Mowing and dragging are covered in Chapter 3, herbicides in Chapter 4 and prescribed burning in Chapter 5.

One somewhat higher risk brush treatment is the use of low intensity prescribed fire. Small brush can be burned under higher relative humidity and lower wind speed but the burning crew does need some prior training. By establishing a bare burn perimeter at the edge of a field, the fire boss of the burning crew can select a time of day to burn that has an RH of 40-55%, and wind speed of only 3-8 kmh. By using a higher RH and a lower wind speed, the risk of a fire escape is reduced considerably. A one time short-term, heavy grazing 6-8 weeks after a spring burn, mowing or dragging, may be effective in reducing brush sucker re-growth.

MANAGEMENT OF LARGE TREE FORESTS

There are two basic types of forests of interest to ranchers and farmers. The commercial forest provides both commercially important timber and also an opportunity for grazing by livestock in some cases, while only for grazing by wildlife in other cases. The forestry-wildlife only option is not discussed in this manual. The non-commercial forest has large trees and it is usually expensive to convert into productive grazing lands.

Management of Timber and Forested Rangeland

The management of timber is discussed in Chapter 6. These forests are mostly dominated by aspen that is harvested by forestry companies to make oriented strand board (OSB), a manufactured wood product. Once the trees are harvested, the aspen re-sprouts, as do grasses, sedges and forbs. If not grazed, the herbaceous plants compete with aspen suckers for moisture, light and nutrients. Carefully managed grazing by

livestock can reduce the tree-grass competition. The primary concern by foresters is the potential for serious livestock damage to aspen regeneration. A prescribed grazing system that has had preliminary testing on regenerating aspen clear-cuts is presented in Chapter 7. Prescription grazing system three is designed to enable aspen sucker regeneration while allowing livestock grazing. It is applicable to public forest lands where the primary emphasis is upon regenerating aspen suckers into saplings, while still providing restricted amounts of grazing for livestock.

The management of aspen forests on public land for both aspen regeneration after logging and livestock grazing, is still in its infancy. There will be a continuing need for more planning, tools, methods and monitoring that provides for healthy tree regeneration and some grazing opportunities on a sustainable basis. Compromises will usually have to be considered by both commercial forestry and livestock grazing to achieve a workable balance between potentially competing interests.

After timber harvesting on private land, where livestock grazing is preferred over aspen regeneration, follow Prescription grazing system one as described in Chapter 7. It is designed to reduce brush and increase grass and forb production.

Management of Non-commercial Forested Lands for Grazing

There are many areas in the northern aspen parkland where aspen encroached over the last century and established a deciduous forest of large trees. The forest understory often produces only 200-400 kg/ha of herbaceous forage for grazing.

Loading harvested aspen trees. Photo: G. Oliver

The use of the traditional mechanical brush management system of land clearing, piling, burning, breaking, working down with agricultural disks and levelers, and seeding of forages, are now considered too costly to establish grazing lands. Alternatives are presented:

- Chapter 3: Walking down with roller chopping, walking down with heavy drum, or just walking down.
- Chapter 4: Applying one of several herbicides available.
- Chapter 5: Using a high intensity, prescribed burn.
- Chapter 6: Timber harvesting as the first treatment.
- Chapter 7: Grazing would follow as the second brush management treatment for each of the above treatments. It is considered to be the most economical treatment available, but it must be managed to meet specific goals.
- Each brush treatment and management system should be monitored so the progress made towards the desired goal can be evaluated. Monitoring methods are covered in Chapter 8.

Too much tall brush on a pasture is a barrier to grazing. It also leads to the inefficient use of forage with substantial areas of the field left untouched or under grazed. An effective brush management system must be accompanied by effective grazing management. The livestock are on the pasture year after year so their stay in each paddock should be planned to facilitate more grazing of brush, and the development of an acceptable ratio of grassland to brush land. Low cost temporary fencing often enables deferred rotation grazing, better management and less overgrazing of primary range, the most favored parts of each pasture. Also, additional water development is useful, low intensity burning in ungrazed areas, more trails, salt, molasses, and mineral supplements. Herding will help solve specific livestock distribution problems in some fields.

Table 2. A model brush management system for a non-commercial forest

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Field 1	**M*, H, B**	Graze	Graze	**Treat**	Graze	Graze	Graze	**Treat**
Field 2	Graze	Graze	**M*,H,B**	Graze	Graze	**Treat**	Graze	Graze
Field 3	Graze	Graze	Graze	Graze	**M*,H,B**	Graze	Graze	Graze
Field 4	Graze	Graze	Graze	Graze	Graze	Graze	**M*,H,B**	Graze

M*: refers to various mechanical methods including walking down and roller-chopping, walking down with a drum behind, walking down alone
H: refers to using a herbicide method of top-killing the trees
B: indicates using prescribed burning to top-kill the forest of trees
Graze: refers to prescribed grazing following a system in the Grazing Chapter
Treat: refers to a second mechanical, herbicide or prescribed burning treatment

A model brush management system is illustrated in Table 2. There are four big fields that have been set up in a deferred rotation grazing system (see Chapter 7). The four fields will be treated to top-kill the trees over a 7-year period. Grazing will occur each year following prescription grazing system one at first, then later grazing system two will be used (Chapter 7). Three years after the trees are top-killed, it is assumed that in some parts of the field, there will be tall saplings that need to be treated again.

Let's follow the brush management plan for Field 1 over the first eight years:

- Year 1: Top-kill the desired proportion of trees by using roller chopper pulled by dozer, or a drum roller, or use either prescribed fire or herbicide.

- Years 2 and 3: Graze following Prescription grazing system one.

- Year 4: If the soil is fertile and tree saplings are too dense in many places, then use a drag, or herbicide, or a low intensity prescribed burn.

- Years 5, 6 and 7: Graze following Prescription grazing system two, not prescription grazing system one, using a lower grazing intensity than in years 2 and 3. This will promote a higher production of grasses, forbs and palatable brush.

- Year 8: If there are still too many tree saplings, or too much unpalatable brush, then apply another treatment using a drag, herbicide, or low intensity prescribed burn. If not, use only grazing system two.

The planning for Table 2 assumes that each field is quite large and there is enough capital to do the first treatment once every second year. By the end of the 8 year period, all four fields have received some top-kill of trees. Prescription grazing system one takes full advantage of using brush suckers as forage. If further brush management treatment is needed, it would be applied several years after the first brush treatment.

Brush management system models, as illustrated in Table 2, need to be flexible. On fertile soils, during normal or better rainfall years, a second brush treatment would usually be needed during Year 4. If drought had occurred, or the soils were shallow, or coarse textured sands or gravels, then the second treatment might be delayed several more years.

A cross-section of techniques and brush management strategies are presented in this manual. Some coverage of costs and potential returns are also discussed. The potential for ranchers, farmers and crown land managers to develop unique brush management systems is enormous. Some treatments presented in this manual will need to be modified for specific applications. The costs and returns apply to the date of publication of the manual. Future readers will need to update both the costs and the returns.

Too much tall brush on a pasture is a barrier to grazing. Photo: Arthur Bailey

CHAPTER TEN
Brush Management Economic Summary

ARNOLD MATTSON, P. AG.
RANGE & BIODIVERSITY DIVISION
AGRICULTURE AND AGRI-FOOD CANADA
AGRICULTURE ET AGROALIMENTAIRE CANADA
EDMONTON, ALBERTA

Before choosing a brush management practice, it's necessary to estimate the actual value of the improvement compared to the cost. Costs are fairly easy to determine, however the benefits are not as easy to reliably estimate. Any method of assessing the economics of brush management for planning purposes will have to rely a great deal on estimates and assumptions.

Partial budgeting is a useful tool for evaluating the different brush management practices. Partial budgets separate the positive results of the practice being assessed from the negative. Positive changes are increased returns or decreased costs; negative changes are increased costs or decreased returns.

Costs for each practice can be estimated most accurately by using contractor figures which we have done in this summary. Production improvement estimates resulting from the management practice varies from area to area and has to be estimated. We divided the estimated increase in production by 25, the number of pounds of forage consumed by an 800 lb yearling, times $0.80, the return/day to graze it.

Example

$$\frac{\text{(2000lbs.) Estimated increase in production/ac./year}}{25} \times 0.80 = \$64/\text{yr.}$$

Blank columns for costs and returns (income) have been left for your personal estimates and use in decision making.

Summary

Disclaimer: These partial budgets are only a guide and are not intended as an in depth study of the cost of brush management. Interpretation and utilization of this information is the responsibility of the user.

Method	Size of Trees Height-Ft./ Diameter-In.	Cost/ac. $/ac.	Increase in Production (5 yrs.) lbs/ac.	*Added Income (1 yr) $/ac/yr.	Personal Estimate (Cost) $/ac.	Personal Estimate (Income) $/ac.
Mowing	8-10 ft 3 in.	$40-100	2150	$14		
Bark Scraping	8-10 ft 3 in	$15-30	2150	$14		
Drum/Roller Chopper	12-15 ft 4-8 in	$40-75	7100	$45		
Mechanical Clearing	mature	$150-300	7100	$45		
2, 4-D	6-8 ft 2 in	$45	5500	$35		
Grazon®	8-10 ft 3 in	$80	5500	$35		
Round-up® Wiping	8-10 ft 3 in	$30	5500	$35		
Prescribed Burning (low intensity)	4-6 ft 1-2 in	$30	1050	$7		
Prescribed Burning (high intensity)	mature	$60	8600	$55		
Timber Harvest	mature		7100	$45		
Grazing	0.5-4 ft 1 in	$10	3100	$20		

* 25 lbs forage = $0.80
Mechanical methods will normally require a follow up treatment.

Estimated Production Increases After Tree Removal
(clearing, timber harvest or high intensity burn)
and Following Treatments

		TREATMENT METHODS				
	Lbs/acre	Herbicide Year 4	Gyro-Mower Year 4	Drum/Chopper Year 12	Grazing	Fire
Year 0 Cleared	400	400			400	400
Year 1	850	850			850*	850
Year2	1750	1750			1750	1750
Year 3	2000	2000			2000	2000*
Year 4	2500	2500*	2500*		2500	**2500**
Year 5	2000	**2500**	**2500**		**2500**	**2500**
Year 6	1500	**2250**	**2250**		**2250**	**2250**
Year 7	1000	**2250**	**1750**		**1850**	**1850**
Year 8	850	**2250**	**1000**		**1500**	**1500**
Year 9	650	**2250**	**650**		**1500**	1500
Year 10	400	1500	400	400*	1000	1000
Year 11	400	1000		**850**		
Year 12	400	850		**1750**		
Year 13	400	650		**2000**		
Year 14	400	400		**2500**		
Year 15	400			**2000**		
Year 16	400			1500		
Year 17	400			1000		
Year 18	400			850		
Year 19	400			650		
Year 20	400			400		

* Year of treatment
Highlighted areas to show production changes as a comparison to the control data in column 2.

Native Tree and Shrub Species Found on the Canadian Prairies

Photo: USDA

Balsam Poplar *Populus balsamifera* L.

Also called “Black Poplar”

Form: Medium-sized deciduous tree (25 meters) with long, cylindrical trunk and narrow, open crown or stout limbs, buds very sticky and fragrant with resin.

Bark: Smooth, becoming furrowed into thick ridges, whitish to grayish-brown; old bark dark and deeply furrowed.

Twigs: Alternate, moderately stout, round, shiny, smooth, reddish-brown. Terminal bud sharp pointed, ½-1 inch long, shiny, very gummy with a fragrant odour, chestnut brown.

Leaves: Alternate, simple, oval, tapering to tip, rounded at base; fine-toothed, 3-6 inches long, with a yellowish metallic luster on undersurface.

Flowers: Appear before leaves, in drooping dense catkins.

Fruit: Seeds small with tuft of cottony hairs.

Occurrence: Throughout the parkland, forested region, except in extreme north, in moist habitats.

Photo: G. Oliver

Bur Oak *Quercus macrocarpa* Michx.

Form: Small, deciduous tree with a broad, rounded crown composed of variously spreading stout branches.

Bark: Light brown, rough, divided by deep furrows into scaly, flaky plates.

Twigs: Alternate, stout, ridged, hairy at first but becomes hairless; terminal bud hairy, about 1/8 inch long, surround by five narrow bracts and two or more lateral buds; lateral buds same size.

Leaves: Alternate, simple, prominently lobed, 4-10 inches long; finely hairy beneath.

Flowers: After leaves, male in catkins, female single are few in a cluster.

Fruit: An acorn, ¾-1¼ inch long, covered by cap, maturing in one year.

Occurrence: Southern Manitoba, usually in dry habitats.

Photo: USDA

Willow *Salix spp*

(Approximately 75 species grow in North America, most occur in Canada)

Form: Most species remain shrub-like within their range.

Bark: Bitter taste.

Twigs: Usually slender and flexible, or often quite brittle and easily broken.

Leaves: Long and narrow; pointed at both ends, and have short leaf stalks in relation to the length of the leaf blades; mostly toothed with fine single teeth and are arranged alternately on the twigs.

Flowers: Appear before leaves; arranged along slender stems but with stems erect, not hanging limply as in poplars.

Fruits: Similar to poplars, small pod that splits in two parts when mature; release seeds surrounded by tufts of long, white, silky hairs.

Occurrence: Usually associated with swamps, riverbanks and streams, however there are some regularly found on well-drained upland soils.

Most common species:
Peachleaf Willow (*S. amygdaloides* Anderss.)
Pussy Willow, Diamond Willow (*S. discolor* Muhl.)
Sandbar Willow (*S. interior* Rowlee)
Bebb or Beaked Willow (*S. bebbiana* Sarg.)

Photo: Sten Porse

Manitoba Maple *Acer negundo* L.

Form: Small to medium-sized deciduous tree with spreading crown or thick limbs.

Bark: Light brown or dark gray; furrowed into irregular flat-topped ridges.

Twigs: Opposite; stout; smooth, densely fuzzy, near the tip; Terminal bud-blunt, about 1/8 inch long; hairy; lateral buds smaller.

Leaves: Opposite; compound, 6-15 inches, composed of 3-5 course-toothed or lobed, paired leaflets, 2-5 inches long.

Flowers: Before or with leaves, in yellow-green clusters; male flowers often with conspicuous red-tipped stamens.

Occurrence: Throughout the southern part of Manitoba, usually in moist habitats and along stream beds.

Photo: USDA

Photo: USDA

Swamp Birch *Betula occidentalis* Hook.

Also called “River or Water Birch”

Form: When tree size (5-10 meters), this species has a short, usually curved or leaning trunk and an irregular, broad, open crown or ascending slender branches, with somewhat drooping branchlets. It is more commonly shrubby (about 20 feet), with several spreading trunks.

Bark: Thin, lustrous, dark reddish-brown to nearly black on young trunks, with conspicuous horizontal markings (lenticels); does not peel readily like most birch species.

Twigs: Very slender, usually abundantly glandular, reddish-brown, sometimes with fine hairs; buds pointed, slightly gummy; greenish-brown with fine hairs or hairless.

Leaves: Broadly oval, but usually broadest below the middle, with a short taper to a blunt or sharp tip, rounded or wedge-shaped at the base, ¾-2 inches long, teeth sharp and distinctly of two sizes, but absent near the stalk; fewer than six pairs of veins, each extending to a large tooth on the margin, with smaller intervening teeth; deep yellowish green and shiny above, paler and finely gland-dotted beneath.

Flower: Catkin

Occurrence: Ranges through the forested areas of western Canada, growing usually in moist soils along streams, rivers, lake shores or springs but can be found occasionally in moist depression in sandhills. Dense pure thickets are common.

Photo: USDA

Trembling Aspen *Populus tremuloides* Michx.

Also called “White Poplar”

Form: Medium to tall deciduous tree with slender trunk and moderately stout ascending branches forming an open round-topped crown.

Bark: Smooth, greenish-gray to whitish, becoming rough and furrowed.

Twigs: Alternate, slender, flexible, shiny. Terminal bud about ¼ inch long, lustrous, usually without hairs, sharp-pointed, with several scales, slightly gummy.

Leaves: Alternate, simple, egg-shaped to nearly circular, abruptly pointed, fine-toothed with numerous rounded teeth, 1½-3 inches long and about the same width, on flattened stalks longer than leaf blade.

Flowers: Appear before leaves, in drooping hairy catkins.

Occurrence: Common throughout the parkland regions in moist to dry habitats.

Photo: G. Oliver

American Plum *Prunus americana* Marsh.

Form: More often found as a shrub, but it may grow to 30 feet.

Bark: Reddish-brown or dark grey to nearly black, with short horizontal markings. Splits vertically and curls horizontally.

Twigs: Slender, smooth, grayish to reddish-brown; 1/8-¼ inch

Leaves: Narrowly oval, but usually broadest slightly below the middle, tapering gradually to a long narrow sharp tip, fully rounded at the base or with a slight taper towards the leaf stalk; 3-5 inches long; fairly thin and fragile, doubly or singly toothed along the margin, with sharp-pointed teeth.

Flowers: Appear before or with leaves along the branchlets on the spur-like thorns and dwarf branches; usually five to a cluster, white, showy.

Occurrence: Native to southern Ontario, southern Manitoba and south eastern Saskatchewan.

Beaked Hazelnut *Corylus cornuta* Marsh.

Form: Shrubs or small trees, 1-3 meters tall, young twigs, leaves and bud scales covered in long white hairs; with much-branched stems and smooth bark after first season.

Leaves: Elliptic to egg-shaped, 4-10 cm, rounded to heart-shaped at base, sharp-pointed at tip; edges coarsely double-toothed; paler below than above, and somewhat hairy below; turn yellow in autumn.

Flowers: In catkins, appear before leaves, in April and early May.

Fruits: Thin-shelled, spherical, edible nuts enclosed in long, tubular husks; husks – light green, covered with stiff, prickly hairs, narrowly lobed at tip; in clusters of 2 or 3 at ends of branches.

Occurrence: Moist, but well-drained sites in thickets or woods; widespread across southern boreal forest and parkland.

Photo: AAFC-PFRA

Chokecherry *Prunus virginiana var. melanocarpa* (A. Nels.) Sarg.

General: Shrub or small tree, 1-6 meters tall.

Leaves: Thin, elliptic to obovate, 2-10 cm long; sharp-pointed to rounded at tip, blunt at base; bright green and hairless above, paler below; edges have fine, sharp teeth.

Flowers: In many-flowered, bottlebrush-like clusters (5-15 cm long) at ends of branches; white; appear in May to June.

Fruit: Shiny, red, purple or black cherries, edible but astringent.

Occurrence: Woods, clearings hillsides and river terraces; often on dry, exposed sites; widespread across the region.

Photo: L. Allen

Creeping Juniper *Juniperus horizontalis* Moench.

Also called “ground cedar”

General: Evergreen; prostrate or spreading shrub to 1 meter tall; bark thin, reddish brown, shedding, scaly.

Leaves: Needle-like to narrowly lance-shaped, 5-12 mm long; very prickly; whitish above, dark green below.

Fruits: Female cones – berry-like, 6-10 mm in diameter, bluish with white-grey bloom, fleshy, maturing in second season; male cones – smaller, catkin-like; sexes on separate plants.

Occurrence: Dry open woods, gravelly ridges, outcrops, sandy or open rocky slopes; throughout the region.

Photo: G. Oliver

Highbush cranberry *Viburnum trilobum* Marsh.

General: Upright shrub, to 4 meters tall; smooth, grey bark.

Leaves: Opposite; simple, with 3 long, pointed, spreading lobes; smooth, 6-12 cm long; irregularly toothed, deep green above, paler below, red in fall.

Flowers: In flat-topped clusters that are 5-15 cm across; white; outer flowers large, 1-2 cm across; sterile; inner flowers smaller, 3-4 mm across, fertile; appear from late May to July.

Fruits: Orange to red, 1-seeded, berry-like drupes, 8-10 mm across, in drooping clusters at branch tips; edible, juicy but acidic.

Occurrence: Poplar groves, river valleys and moist open woods across northern parkland and southern boreal forest or prairie provinces.

Photo: AAFC-PFRA

Pincherry *Prunus pensylvanica* L. f.

General: Shrub or small tree, 1-5 meters tall.

Bark: Reddish-brown, peeling in horizontal strips, with prominent, raised pores.

Leaves: Oval to lance-shaped, 3-10 cm long; gradually taper to point at tip, rounded at base; edges have small rounded teeth.

Flowers: In flat-topped clusters; white; appear same time as leaves.

Fruits: Bright-red cherries, 5-8 mm; sour.

Occurrence: Forest clearings, hillsides and riverbanks; usually on well-drained sites; widespread across region.

Photo: AAFC-PFRA

Rose spp. *Rosa acicularis* Lindl., *R. woodsii* Lindl.

General: Bushy shrub, 0.3-1.5 meters tall; stems stout, usually densely covered with many straight, weak bristles and straight, slender thorns.

Leaves: Compound, 3-9 (5) oblong leaflets, each 2-5 cm long; sharply double-toothed, usually somewhat hairy beneath.

Flowers: Single, on short, side branches; pink; showy, 5-7 cm across; appear late May to July.

Fruits: Scarlet, spherical to pear-shaped, fleshy “hips”, about 1.5 cm long.

Occurrence: Open forests, thickets, riverbanks and clearings; widespread and common across region; nearly circumpolar.

Photo: AAFC-PFRA

Red-osier Dogwood *Cornus stolonifera (Michx.) Rydb.*

Also called “Red Willow”

General: Erect to spreading shrub, 1-3 meters tall; branches opposite; lower branches often root in ground; young stems usually bright red.

Leaves: Opposite, oval to egg or lance-shaped; Rounded at the base and pointed at tips; 2-8 cm long; 5-7 prominent parallel veins converge towards tip.

Flowers: Many-flowered, dense, flat-topped clusters (2-5 cm across) at branch tip; white to greenish, small, appear late May to July.

Fruits: Berry-like drupes, white, 5-6 mm across.

Occurrence: Moist woods, thickets, clearings and riverbanks; widespread across region.

Saskatoon *Amelanchier alnifolia* (Nutt.)

Also called “Serviceberry, Juneberry”

General: Quite variable in height, 1-5 meters tall; usually much-branched at the top.

Leaves: Alternate; simple, stalked, round to oval, ½-1 inch (12-48 mm) long and finely toothed.

Fruit: A berry-like pome, variable in size, over 3/8 inch (1 cm) diameter, reddish-purple, sweet.

Flowers: White, 3/8-½ inch diameter; borne in multiple clusters at the ends of branches and appear in June.

Habitat: Margins and interiors of aspen poplar bluffs or scrubby areas of the parkland and forest edges on well-drained soils, as well as moist ravines of the prairies.

Photo: AAFC-PFRA

Silver Buffaloberry *Shepherdia argentea* (L.) Nutt.

General: A thorny shrub, 1-5 meters tall, with whitish branches.

Leaves: Oblong, 2-5 cm long and densely silvery scurfy on both sides.

Flowers: Unisexual; all on a plant are same sex; brownish, in small clusters at nodes formed in proceeding season.

Fruit: Rounded, 3-5 mm across, orange and very sour, but after a hard frost is good jelly fruit.

Occurrence: Common around sloughs, in coulees and on light soils.

Photo: www.colinherb.com

Soapberry *Shepherdia canadensis* (L.) Nutt.

General: An unarmed undershrub 0.5-3 meters high

Leaves: Opposite; oval or ovate 2-4 cm long; green upper surface but silvery star-shaped hairs on the underside.

Flowers: Yellowish, borne at leaf nodes; late April to early May, just before leaves.

Fruit: Female plant produces round or oval fruit, 3-5 mm long, red to yellowish and extremely bitter; soapy to touch.

Occurrence: Common in open woods and riverbanks in Parklands and Boreal forest.

Photo: www.cirrusimage.com

Speckled /River alder *Alnus incana* (L.) Moench

General: A course shrub, that grows 20-30 feet, with clumped and crooked trunks. Trunk is nearly always crooked and often bent in a wide curve at the base before rising to support a sparsely branched, round-topped, irregular crown.

Leaves: Oval, 2-4 inches long, thick-textured, not sticky, dull, upper surface wrinkled, lower surface hoary, teeth of two sizes; veins deeply impressed.

Flowers: Small, in catkins on previous year's twigs; appear before leaves.

Fruit: Small nutlets, wingless, with narrow ridge around edge.

Twigs: Moderately slender, reddish-brown; buds dark reddish-brown.

Habitat: Intolerant of shade and is confined to openings or sparsely populated stands. Usually found in wet situations such as along streams, in gullies and swamps that have some drainage.

Photo: AAFC-PFRA

Western Snowberry *Symphoricarpus occidentalis* Hook.

Also called buckbrush and wolfberry

General: An erect, broad-leaved shrub with creeping root system; grows 30-120 cm (12-48 inches) tall; stems are hollow and golden brown; older stems are gray-brown and shed bark; can form large colonies; begins growth in early May.

Leaves: Thick, grayish-green, opposite leaves 3-5 cm (1-2 inches) long; oval or almost round and may have rounded teeth on margins.

Flowers: Small pink and white bell-shaped flowers in dense clusters; blooms late June to August; small greenish-white, waxy berries that turn brown or purple with age.

Occurrence: A very common and widespread shrub in dry pastures, open woodlands and hillsides.

Forage Value: Generally not grazed much by cattle unless hungry.

Wild Gooseberry *Ribes oxyacanthoides* L. var. *oxycanthoides*

General: A low, bristly shrub or bush that grows to 1 meter.

Leaves: Lobed, 1-4 mm across.

Flowers: Purplish or white sepals and petals, that appear in June. Fruit – round berry, 10-15 mm; turns reddish when ripe.

Occurrence: Common in woodlands and shrubbery, especially in northern Parklands and Boreal forest.

Photo: USDA

Wild Red Raspberry *Rubus idaeus* L.

General: A large bush 1-2 meters tall, with brownish bristly stems. Probably the most common raspberry.

Leaves: Pinnate, with 5 leaflets. Leaflets – ovate, the terminal one being three-lobed, 5-10 cm long, dark green above and white, wooly beneath.

Twigs: Bristly, but not glandular.

Flowers: White, 8-12 mm across; fruit-round, light red, about 1 cm across.

Occurrence: Found in shady, wooded places, on burned-over woodlands, bluffs and riverbanks. Throughout the Prairies.

Photo: H.W. Phillips

Wolfwillow *Elaeagnus commutate* Bernh.

Also called Silverberry or silver willow

General: Upright, silvery-gray shrub (2-13 feet tall); spreading rhizomes and forms colonies; twigs covered with rusty-brown scales; root nodules fix nitrogen.

Leaves: Alternate; silvery with small scales; 2-8 cm (¾-3 inches) long; leaves wavy-edged.

Flower: Small, yellowish flowers with a strong distinctive aroma, about 3 mm (1/8 inch) long; oval. Leathery, silver berries about 1 cm (3/8 inch) long blooms June to July.

Occurrence: Widespread in prairies and parkland areas, where moisture is good.

Forage Value: Fair; moderate palatability.

Photo: USDA

Shrubby Cinquefoil *Potentilla fruticosa* L.

General: A much-branched shrub from branching rootstocks, 15-150 cm (12-48 inches) high. Used as an ornamental.

Leaves: Pinnate, alternate, gray-green, leathery, with 5-7 leaflets, 12-25 mm long, linear-oblong and pointed at both ends.

Flower: Yellow, 15-25 mm across. Borne in small dense clusters, mainly at the ends of branches, from June – August. Achenes densely hairy.

Occurrence: Low, moist areas of sandy soil and lower slopes of areas of the south and southwest prairies.

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Glossary of Terms	
Achenes	A 1-celled, 1-seeded, dry hard fruit that does not open when ripe
Acorn (nut)	A hard, dry, usually 1-seeded fruit that does not open at maturity; larger and thicker-walled than an achene
Catkin	A scaly spike of flowers of one sex
Compound Leaf	Composed of 2 or more leaflets; of a branch, composed of two or more parts, forming a common whole
Drupe	A pulpy or fleshy fruit containing a single seed enclosed in a hard shell or stone, such as the plum
Glandular	Bearing glands
Hip	The berry-like, enlarged calyx tube containing many achenes, found in roses
Nutlets	A small nut; very thick-walled achene
Obovate	Shaped like a long section through a hen's egg, broadest near the tip
Ovate	Shaped like a long section through a hen's egg, with the larger end toward the base
Pinnate	Feather-formed; of a compound leaf in which the leaflets are placed on each side of the common axis
Pome	A fruit with a core (i.e. an apple)
Scales	Any small, thin or flat structure
Terminal Bud	Bud at the end or top of a stem or branch