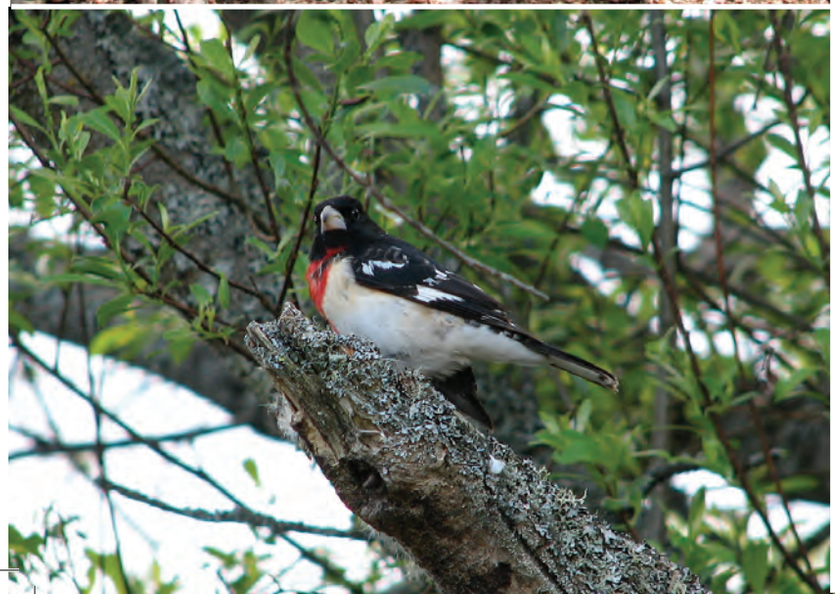
Woodlot Management Guide for Alberta



Published by:
Alberta Agriculture and Forestry
Crop Extension Branch
7000 – 113 Street
Edmonton, Alberta
Canada T6H 5T6

Prepared as information for Alberta Agriculture and Forestry, funding for this project was provided through *Growing Forward 2*, a federal-provincial-territorial initiative. The views and opinions expressed in this report are not necessarily those of Agriculture and Agri-Food Canada or Alberta Agriculture and Forestry.

WOODLOT MANAGEMENT GUIDE FOR ALBERTA

Table of Contents

Acknowledgments

This revised version of the The Woodlot Management Guide For The Prairie Provinces reflects the knowledge, expertise and efforts of many individuals and organizations. The Guide has been updated to reflect current practices. Although some segments of the original were kept intact, the revision process and the resulting document have an Alberta focus. Future editions may be revised to include other provinces that participated in the original version. Numerous sources of information were accessed during the revision process and in some cases material was directly extracted for inclusion in this version of the guide. Usually, sources are acknowledged in the selected readings section, but no attempt was made to directly reference the sources within the text. In most cases, written or verbal permission has been received from the original authors or their organizations.

This update of the manual was funded by the Agriculture & Food Council - Canadian Adaptation & Rural Development (CARD) Fund.

We would like to thank to Nancy and Bruce Lyle from the Farm Woodlot Association of Saskatchewan, and the Association for providing a digital version of the Guide, along with permission to use the materials to update the Guide.

We would also like to thank Jean Paquet, and Daniel Fillion, of Syndicat des producteurs de bois du Saguenay - Lac-Saint-Jean and the Federation des producteurs de bois du Quebec for allowing us to use material from their *Field Guide - Sound forestry practices for private woodlots* in this guide.

We would like to thank the people listed below for their time and effort to revise the older version of the Guide. Your help is truly appreciated.

Editor and Coordinator

Joe De Franceschi, *Consultant*

Revision Coordinators

Victor Brunette, *Alberta Agriculture and Forestry*

Toso Bozic, *Alberta Agriculture and Forestry*

Doug Macaulay, *Alberta Agriculture and Forestry*

List of Contributors to the Revision (in alphabetical order)

Gary Bank, *Prairie Farm Rehabilitation Administration*

Micheal Bock, *Agriculture and Agri-Food Canada*

Martine Bolinger, *Alberta Agriculture and Forestry*

Kelli-Lynn Claypool, *Alberta Agriculture and Forestry*

Alan Eagle, *Prairie Farm Rehabilitation Administration*

Janet Ficht, *Alberta Sustainable Resource Development*

Tom Goddard, *Alberta Agriculture and Forestry*

Derek Johnson, *Natural Resources Canada*

Chuck Kaiser, *Alberta Pacific Forest Industries*

Ordella Knopf, *Alberta Agriculture and Forestry*

Christine Kominek, *Alberta Sustainable Resource Development*

Dave Morgan, *Alberta Sustainable Resource Development*

Dave Moyles, *Alberta Sustainable Resource Development*

Greg Pohl, *Natural Resources Canada*

Sunil Ranasinghe, *Alberta Sustainable Resource Development*

Mike Undershultz, *Alberta Sustainable Resource Development*

Candace Vanin, *Agriculture and Agri-Food Canada*

Stacey Wabick, *Ducks Unlimited Canada*

Photos were provided by: Ducks Unlimited Canada, Prairie Farm Rehabilitation Administration, Alberta Sustainable Resource Development, Alberta Agriculture and Forestry, Doug Macaulay, and Toso Bozic. We greatly appreciate the help.

This guide is not meant to be read from cover to cover. It is a tool to provide landowners with information about how to manage their woodlot and find solutions when challenges appear. Each topic concludes with a list of selected readings, Internet sites and/or contact information. This list provides additional resources to readers who want to explore the topic in greater detail, or discuss related issues with someone with more experience. Even though we have provided our best knowledge in updating this guide, we recommend that landowners also consult other sources to make decisions.

This guide will be available on Alberta Agriculture and Forestry's website and is available for anyone to use with proper acknowledgments.

Agriculture & Food Council
The Catalyst

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Introduction

A woodlot is any track of land, regardless of shape or size that supports naturally occurring or planted trees. Most woodlots in Alberta are family owned and are often operated as part of an agricultural operation. These properties occupy over 3.6 million hectares (8.9 million acres) of forested land in Alberta's agricultural zone, or 4 per cent of the province's forested land base. Individual woodlots vary in size from a few hectares to several hundred, but the average lies between 20 and 40 hectares.

The value of woodlots is often measured by their ability to produce consumer goods and services such as forest products and tourist experiences, or to stimulate local or regional economies by creating or diversifying business activity and employment. However, even though woodlots provide significant amounts of timber to the forest economy, these harvests are not managed on a sustainable basis. For many woodlot owners, a timber harvest is a one-time income source; many harvests on woodlots are liquidation cuts where sustainable forest management is not practiced.

Woodlots also produce other goods and services, which are difficult to measure but may be much more valuable than the easily quantifiable goods that are produced. For example, forests protect soil from wind and water erosion, contribute to cleansing, filtering and stabilizing wetlands and water bodies, and provide habitat for a wide range of wildlife and plant species. Woodlots contribute to clean air and provide a place to commune with nature.

Woodlots have played a significant role in agriculture and rural development in the last 100 years. Historically, forested private land was cleared for agriculture purposes or to supply wood to local communities and industries. Forests were liquidated and little thought was given to the sustainability of the forest harvest. Today, the level of liquidation harvest has declined, although the sustainability aspect has not changed. However, progress is being made. Extension programs directed at woodlot owners, industry and governments are raising awareness of the importance of managing woodlots sustainably. The wide range of timber and non-timber benefits that can be realized from a healthy managed woodlot are better understood, and in some cases actions are being implemented to maximize those benefits. Information is needed to help woodlot owners, and society in general, to better understand the values and potential benefits that private woodlot owners in Alberta can realize.

Objectives and Use of This Guide

This woodlot management guide is an adaptation and updated version of *The Woodlot Management Guide For The Prairie Provinces*. This guide provides an introduction to basic woodlot management activities for landowners who have limited knowledge or experience with forestland management.

Most privately owned forestland is found in the general vicinity of populated areas or forest processing facilities, and are in areas with road access and other developed infrastructure. This means these privately owned forests potentially have a greater impact in their areas than do larger tracts of forested land. However, many landowners may not be aware of the value of the products, services and potential income that may be derived from their woodlot, and they may not be familiar with the management of small-scale forestry operations. As a result, woodlot owners may not be maximizing the potential benefits from their properties.

This guide is intended to provide basic knowledge of woodlot management so landowners can become better informed and make better management decisions. Information in this guide is designed to help landowners understand the resources on their woodlots and to encourage landowners to develop goals, objectives and a management plan for their land. This guide is not intended to be a one-stop information source. Landowners may want additional assistance or advice from forestry practitioners, including woodlot extension specialists, forestry consultants or local forest industry firms interested in working with private landowners. Additional information and assistance is also available from educational institutions and government agencies that have programs or expertise that may help the woodlot owner with forestland management. The Internet is an invaluable tool to access information from anywhere in the country or the world.

This manual is arranged into three main sections. Within each section a number of topics are discussed in varying levels of detail.

The first section is an introduction to forest resources. The ecology of the forest zones in Alberta, soil characteristics and the role of wetlands are presented. The section concludes with a description of common tree species found in the Alberta.

The second section discusses various aspects of forest management in the woodlot. The woodlot management plan is discussed, along with the woodlot inventory and pest management. Forestry activities, including silviculture and forestry operations are presented. Agroforestry and grazing are also included in this section because these activities can be an important component of a working woodlot that is integrated with an agriculture operation. Growing hybrid poplars is discussed to introduce the woodlot owner to current information on fast growing timber. The section concludes with information about the basics of business planning.

The final section covers the non-timber resources of the woodlot. The main topics of discussion are the wildlife and recreation components of woodlots and how these valuable resources can be managed.

Each topic presented in this guide is prefaced with the "Criteria and Indicators of Sustainable Forest Management" that are specifically relevant to that topic. Six criteria and numerous indicators of sustainable forest management are enshrined in the National Forest Strategy and endorsed by the Canadian Council of Forest Ministers. The strategy is a blueprint to guide Canada towards a state of sustainable development. Woodlots are a component of the national forest resource and as such can contribute to the sustainable development goal for Canada. Although all six criteria can be linked to each topic presented, only those most directly related to the topic are included. The indicators presented are examples of how woodlot owners can gauge their compliance to specific criteria, or how well the criteria are being addressed by their activities. The move toward certifying forests that are sustainably managed is gaining momentum in Canada and other countries. Market forces, rather than legislation, will increase that momentum. Woodlot owners should consider how they might be affected by those changes and how their activities relate to sustainable management of their forests.

Beneficial Management Practices (BMPs) are listed at the end of each topic. The term beneficial, rather than the more common term best, is used to recognize that forest practices evolve as new information or techniques are developed. Best implies practices have reached a plateau and can no longer improve. The list of BMPs for each topic is intended as a summary and quick reference of practices considered beneficial based on current knowledge.

Forest Ecology and Ecological Classification

Contents

Criteria and Indicators of Sustainable Forest Management related to Forest Ecology and Ecological Areas in Woodlot Forests

The Criteria and Indicators of Sustainable Forest Management have been developed to promote and assess the progress toward sustainability of communities, forests, and the environment. Forest ecology and ecological areas are imbedded in all six criteria in terms of the "Woodlot Forest" in various ways. The criteria are:

Criteria 1: ***Biological diversity. Conserving and maintaining the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes.***

Criteria 2: ***Ecosystem condition and productivity. Maintaining the health and biological productivity of the forest ecosystem.***

Criteria 3: ***Soil and water. Maintaining the forest quantity and quality to conserve soil and water.***

Criteria 4: ***Role in global ecological cycles. Implementing forest management practices to contribute to the health of global ecological cycles by utilizing the carbon sequestration capacity of forests.***

Criteria 5: ***Economic and social benefits. Including multiple benefits as a goal in the forest planning to benefit present and future society.***

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property.***

Indicators to measure accomplishment include the health, quantity and productivity of natural or planted forests in the woodlot. These managed woodlot forests contribute to water quantity and quality, to reductions in global warming, and to benefits to landowners and the community at large. The classification of forests based on an array of characteristics facilitates management of classified areas based on ecological principles. The application to forest management of ecological classifications and the ecological characteristics of the landscape and species it supports, are strong indicators of accomplishment toward sustainable development of the forest resource.

Forest Ecology

Forests are complex physical and biological systems in a constant state of change with countless numbers of factors interconnected in an infinite number of ways. Moisture, topography, soil properties, temperature, light and many other site factors all have an effect on what plant, animal and microorganism population will be found on a specific site at a specific time.

Forested areas support a wide range of vegetative and wildlife species. As conditions change, or specific site factors become limited, certain species develop advantages or disadvantages and their populations change accordingly. The combinations of species that inhabit an area are infinite. However, forested sites generally contain enough common characteristics to form areas that may be ecologically classified.

Classification takes into account various conditions such as soil, climate, moisture, and topography, but forests are dynamic systems. Natural or man-made disturbances constantly affect the relationships in the systems and influence how forested areas develop and in what stages they may be found.

Tree Basics

Trees are made up of three main parts: the roots, the trunk and the crown. Each part has its own purpose. The roots anchor and support the tree, while collecting water and nutrients. The trunk supports the crown, transports water, nutrients and food up and down the tree, while the crown manufactures the food used for the tree to grow.

The roots of a mature tree may cover a radius up to twice the tree's height. Roots branch into smaller and smaller fibres, ending up as small root hairs, which can absorb water and nutrients like a giant sponge.

Food is manufactured through a process called photosynthesis. Chlorophyll, the green pigment found in leaves and needles, captures energy from sunlight. Using this energy, the tree manufactures sugar from carbon dioxide and water, with oxygen given off as a by-product. More leaves and a larger crown surface area mean more food production. A large crown also helps keep the tree cool.

When trees begin to grow in the spring, a single row of cells called the "cambium" forms just under the bark. The cambium can grow inward and outward at the same time. Cells growing outward, towards the bark, form the inner bark phloem, which carries tree sap and sugar. These cells eventually thicken, die and become outer bark. Cells growing inward form the xylem, which carries the tree's water. This part of the tree is also called the sapwood. As the tree grows in diameter, the inner sapwood loses its water carrying abilities and becomes heartwood. The sapwood and heartwood act like a skeleton, holding the tree upright.

A cross section of the tree trunk shows a series of circles within circles, known as growth rings. Each ring is made of two bands of cells, the springwood and the summerwood, representing one year of growth. Springwood cells, which are formed in the spring when moisture is plentiful, are large and have relatively thin walls. Summerwood grows in the summer when conditions are less favourable, resulting in smaller, thicker and stronger cells. Counting growth rings can determine the age of a tree.

The width of each ring, including both springwood and summerwood, indicates the growing conditions of that year. Moisture, light or nutrient availability, plant competition, diseases, insects, frosts and fires all affect the tree's growth rate and the size of the growth ring produced each year.

Tree Groups

Trees initially fall into two groups, deciduous and coniferous, depending on whether they retain their foliage all year or shed it each fall. Each group is then divided into different families and species depending on the features of leaves, cones, seeds and bark. Coniferous trees are commonly called softwoods and deciduous trees hardwoods, however the wood of most prairie hardwoods is relatively soft compared to hardwoods in Eastern Canada. Distinguishing features of these two groups are:

Coniferous - softwoods

- leaves are needle or scale-like
- seeds develop in cones
- wood is soft and resinous
- evergreens - keep foliage for two or more years

Deciduous - hardwoods

- leaves are broad
- two broad seed leaves (di-cotyledon)
- seeds develop in flowers
- wood is hard and non-resinous
- shed their leaves before winter

A noteworthy exception to these distinguishing characteristics is Tamarack (Larix laricina), which is classified as a conifer even though it loses its foliage every year.

Table 1. Common Species In The Prairie Provinces

Coniferous	Deciduous	Shrubs
White spruce	Trembling aspen	Willows
Black spruce	Balsam poplar	Alder
Jack pine	Manitoba maple	Hazelnut
Balsam fir	White birch	Water Birch
Lodgepole pine	American elm	
Tamarack	Green ash	
White cedar	Bur oak	
Red pine	Basswood	
Douglas fir		

Forest Stands

Forests or woodlots can be broken into stands that represent areas with common characteristics. A stand is a community of trees sufficiently uniform in species, age, arrangement or condition to be distinguishable as a group from other tree communities around it. Each stand reacts in its own way to specific management practices, which influences how landowners may manage woodlots. The concept of a forest stand is discussed further in the Inventory section of this guide.

Stands may be described as even-aged or uneven-aged. Even-aged stands contain trees in the same general age class and height, though trees may vary in diameter. These stands usually occur after major disturbances, such as fire or logging.

Uneven-aged stands may contain a variety of tree species and have trees in more than one age class. Trees grow, mature, age and die at varying rates depending on species and other factors. Young trees able to tolerate shade grow to replace the trees that die. Stands may be managed differently, depending on whether they are even or uneven-aged.

Forest Succession

A forest follows a progression of steps from establishment to maturity to death and regeneration. This process is called forest succession, with the forest usually moving towards a state of stability.

Succession can begin with bare ground, after a fire, logging or other such event. Pioneer plants such as herbs, grasses or moss are often the first plants to grow. These often have a short life span, and return nutrients and organic matter to the soil when they die. Plants such as willows, alders, hazelnut and water birch may appear next. This intermediate stage is the shrub stage.

Pioneer tree species are usually next to become established. These species are fast growing, shade intolerant trees like aspen, birch and jack pine, which may grow from seed or from root or stem suckers. Pioneer trees dominate the stand for the next few decades, as the trees grow, mature and reach old age. Because these trees are shade intolerant, very few seedlings grow in the understorey. However, young shade tolerant trees, like white spruce and balsam fir, may be found.

As the pioneer trees grow old and begin to die, the shade tolerant trees start to take over the stand. With few seedlings, the numbers of pioneer trees drop and the stand becomes dominated by the shade tolerant species. Eventually, a single or group of species becomes established, forming a climax forest. Although individual trees in the climax forest die, seedlings developing in the understorey replace them.

The natural succession of forests may be interrupted by events like fire and insect or disease outbreaks. Management practices like thinning, clearcutting or selective harvesting are used to manipulate forest succession to benefit the woodlot owner. Succession can begin at any of the stages mentioned and entire stages can be skipped altogether.

Each stage of forest succession provides a change in the mix of plant species. For each community of plants, a community of wildlife exists to take advantage of the food and cover the plants provide. As the forest changes, so does the wildlife population, although many species are able to use more than one successional stage. Changing the habitat does not make a woodlot better or worse for wildlife. Rather, it changes the array of wildlife species using it.

Ecological Areas

Every forested area has its own unique characteristics. The plants and animals that live on a site are influenced by the soil, moisture, topography and climate of that site. Different combinations of site characteristics encourage different combinations of plant and animal species. Areas with similar characteristics may be classified as ecoregions, ecodistricts and even smaller units.

The goal of ecological classification is to group similar landscapes into identifiable ecosystems and improve the understanding of those landscapes. Knowledge gained is used to help understand and predict the impacts of various management activities in each specific situation.

Exact and complete classification is impractical if not impossible. Various combinations of specific conditions have been used to develop a number of different classification systems. One system may divide an area into temperature-based zones; another system may use a precipitation-evaporation relationship that represents the amount of moisture available for plant growth.

Within broad classification sites, specific local factors and other general conditions influence the composition of a forested area. South-facing slopes tend to be warmer and dryer than north-facing slopes; low spots or forest openings may be susceptible to frost; and the depth or drainage properties of soils may all combine to influence the establishment or growth of trees in an area. These factors interact to create small, unique areas within larger districts or regions.

Provinces have their own methods of dividing and describing ecoregions and ecodistricts. Detailed information is available from provincial sources. The following information provides a more general overview of forest regions and districts found in Alberta, taken from a Canada-wide forestry classification by J.S. Rowe.

Forest Regions

Boreal Forest Region

This region covers most of the forested area of the prairies. The forests are primarily coniferous, but the deciduous species, trembling aspen and balsam poplar, play an important role in central and southern parts, especially in the transition zone to the prairies. White birch is another important deciduous species in the region. White and black spruce, tamarack, balsam fir and jack pine are the most prominent conifer species, with sub alpine fir and lodgepole pine present in the north and western parts of the region.

Subalpine Forest Region

This is a coniferous forest found on the mountains of western Alberta and into British Columbia. Common species include Engelmann spruce, or a hybrid between Engelmann spruce and white spruce, subalpine fir and lodgepole pine. Trembling aspen, balsam poplar, white birch and black spruce are not part of the tree canopy in the subalpine forest.

Montane Forest Region

This region is predominantly in British Columbia, with a few small areas east of the B.C.-Alberta border. The interior form of Douglas fir is the characteristic tree of this region, along with lodgepole pine and trembling aspen. It developed in response to the dry climatic conditions in the region.

Forest Districts

Douglas-fir and Lodgepole Pine

Three small areas of similar Montane forest conditions appear on the east slopes of the Alberta Rockies. These warm, dry slopes contain stands of Douglas fir and lodgepole pine. Other locations are dominated by black and white spruce, along with some fir, pine and poplar species.

East Slope Rockies

This subalpine area is predominantly a coniferous forest. Lodgepole pine has replaced spruce over many areas following fires. At lower elevations, whitebark pine, spruce and lodgepole pine are common. As elevation increases, subalpine fir becomes more important. Engelmann spruce is the main tree found at higher elevations. Some interior Douglas fir is found near Banff, Jasper and Waterton. Transition areas on the south and east have a fringe of trembling aspen grove land. The mountainous area has steep slopes and deep valleys and is influenced by a wide range of climatic conditions.

Upper Foothills

The Upper Foothills area makes up the western part of the transition from boreal to subalpine forest. The foothills are forested with conifers such as lodgepole pine and white spruce, with some subalpine fir, black spruce and tamarack. There are only sparse stands of deciduous trees.

Lower Foothills

The Lower Foothills includes areas between the Boreal and Upper Foothills, areas in western Alberta, as well as remote areas on the Caribou Mountains in northern Alberta, the Pelican Mountains in central Alberta and the Cypress Hills on the southern part of the Alberta-Saskatchewan border. The forest is a transition between the Boreal and Subalpine Forest Regions. Lodgepole pine, along with trembling aspen and balsam poplar, are the dominant trees. White and black spruce, subalpine and balsam fir, birch and tamarack may also be found. The area has rolling topography, with some plateaus among its hills.

Aspen Grove

The Aspen Grove area represents a transition area between grassland and forest. It roughly coincides with the black and dark gray soil zones on the prairies. Trembling aspen is abundant, with balsam poplar found on moist, low sites and white birch scattered throughout the area. River valleys in the eastern areas support small stands of eastern cottonwood, green ash and Manitoba maple.

Mixedwood

The Mixedwood area is a large important forest on the prairies. It is a mixture, in varying proportions, of trembling aspen, balsam poplar, birch, white spruce and balsam fir, among other species. Trembling aspen covers the greatest part of the area, with jack pine found on drier soils and sandy areas. Wetlands support black spruce and tamarack. Small populations of American elm, green ash, Manitoba maple and bur oak may be found in the southeast part of the area.

Hay River

This area is a northern extension of the Mixedwood area, modified by a colder, drier climate and more level terrain. Black spruce covers much of the area, with jack pine abundant on the east side of the section. Some lodgepole pine may be found on the west side of the area.

Upper Mackenzie

White spruce and balsam poplar are the most common trees on the flood plains bordering the rivers. These areas represent some excellent timber producing land. Above the flood plains, sandy soils support jack and lodgepole pine and trembling aspen. Moist areas above the flood plains support black spruce and tamarack. Frozen ground becomes a problem in the northern parts of this area.

Athabasca South

Frequent fires and sandy soils favour the development of jack pine in this area. Moister flats and fine textured soils support black spruce and tamarack. Trembling aspen, balsam poplar and white spruce are seldom found, except along river valleys and lakeshores. Wide areas of dune sand are found near Lake Athabasca.

Northwest Transition

Most of the soils in this forest fringe area contain permanent ground frost (permafrost). Thin soils, harsh climate and frequent fires limit the opportunities for forest development. Black spruce is the most abundant tree, with white spruce growing on well-drained soils. Other species include birch and tamarack, with some stunted trembling aspen and balsam poplar. Jack pine is only common in the southern parts of the area.

Northern Coniferous

The Northern Coniferous area is located on the southwestern part of the Precambrian Shield. Climatic conditions allow reasonable tree growth wherever soil depth is adequate. Black spruce is the predominant tree in association with jack pine and tamarack. Birch is also scattered throughout the area. In areas with favourable soil and climatic conditions, white spruce, balsam fir, trembling aspen and balsam poplar can be productive.

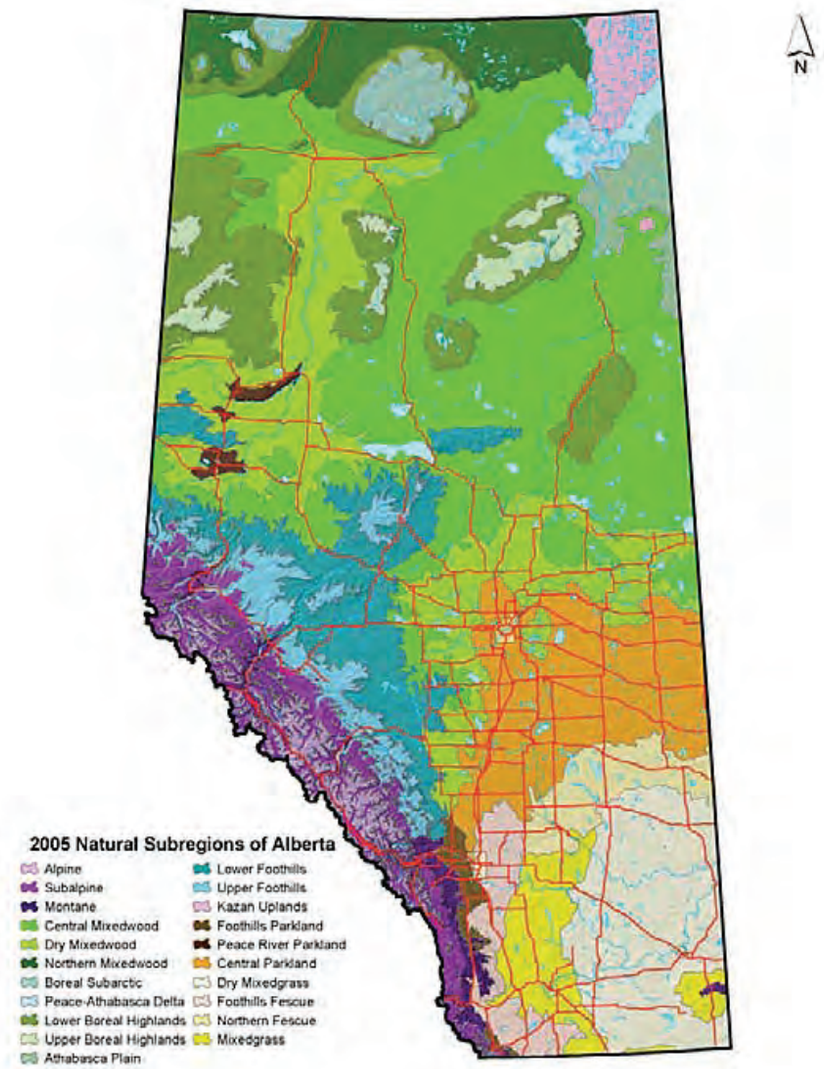


Figure 1: Map of Natural Regions and Subregions of Alberta
Source: http://environment.gov.ab.ca/info/library/8031.pdf

Beneficial Management Practices

- Forests will evolve based on ecological principals. Utilize these principals when implementing forest management activities.
- Develop (or use existing) maps that delineate forest stands based on characteristics that are practical to woodlot management. Use these maps along with ecological knowledge to manage the woodlot even at the forest stand level, where appropriate.
- Know and understand the dynamics of forest succession when managing the woodlot. Ensure succession principals are considered for all long-term objectives and for immediate activities that result in any change in the forest cover.
- Apply site classification information to forest management activities to ensure actions such as pre-harvest silvicultural prescriptions, harvest methods, and regeneration are consistent with the site's capability.
- Consult forestry practitioners knowledgeable in forest ecology and site classification to gain ecological knowledge about the woodlot. Consider preparing site classification maps for the woodlot.

Selected Readings

Ecoregions of Alberta. Alberta Forestry, Lands and Wildlife, Pub. No. T/245

Ecological Regions of Saskatchewan. Saskatchewan Forestry Division, Technical Bulletin No. 10

Forest Regions of Canada. J.S. Rowe. Canadian Forestry Service, Pub. No. 1300 Department of the Environment Ottawa, Ont.

Mixedwood Section in an Ecological Perspective. Saskatchewan Forestry Division, Technical Bulletin No. 8

Forest Soils and Woodlot Management

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Forest Soils

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Many woodlot activities have the potential to influence quality and quantity of water and protect and conserve soil. Indictors of accomplishment include:***

- Soil productivity is maintained by conducting harvest and other woodlot management activities to minimize rutting, erosion and soil compaction. Land taken out of production for uses such as landings, roads, trails and slash piles is kept to a minimum.
- Harvest methods based on stump processing systems are utilized to maintain well-distributed organic layers throughout the cutover.
- Activities on sensitive sites such as wetlands or riparian zones are restricted to dry periods or to winter months when soils are frozen.
- Measures are in place to prevent soils from being washed away and deposited in water bodies or in puddles where further soil damage can occur.
- Compliance with regulations established to protect soil and water, including operating ground rules and disposal of hazardous materials.

Introduction

All plant life in the forest originates from the thin layer of minerals, organic matter, water and air that we commonly call soil. A proper understanding of soil characteristics and their effect on plant growth and forest development is key to good woodlot management.

The majority of Alberta soils are developed from materials that were formed and deposited by glaciers. The grinding action of glaciers broke the bedrock into smaller pieces of rock, gravel, sand, silt, and clay that together or alone form the parent material from which the soils of the province have developed. The influence of other soil forming factors including biological activity (both plant and animal), climate (e.g., the action of wind, water, and freeze-thaw cycles), and topography eventually produced the soils we have today.

The distribution pattern of soil types in Alberta is strongly associated with regional climate and local parent materials (Figure 2). In southern Alberta, soils have developed under conditions of limited rainfall and maximum temperature and reflect the influence of grassland vegetation. Soil development in central and northern parts of the province reflects high moisture conditions, cool temperatures, low evaporation rates and a short growing season, as well as the influence of parkland (grassland-forest transition) or continuous forest cover.

The productivity of soil is influenced by many factors, including climate, nutrient status, moisture, drainage, and degree of soil degradation (e.g., water erosion and compaction).

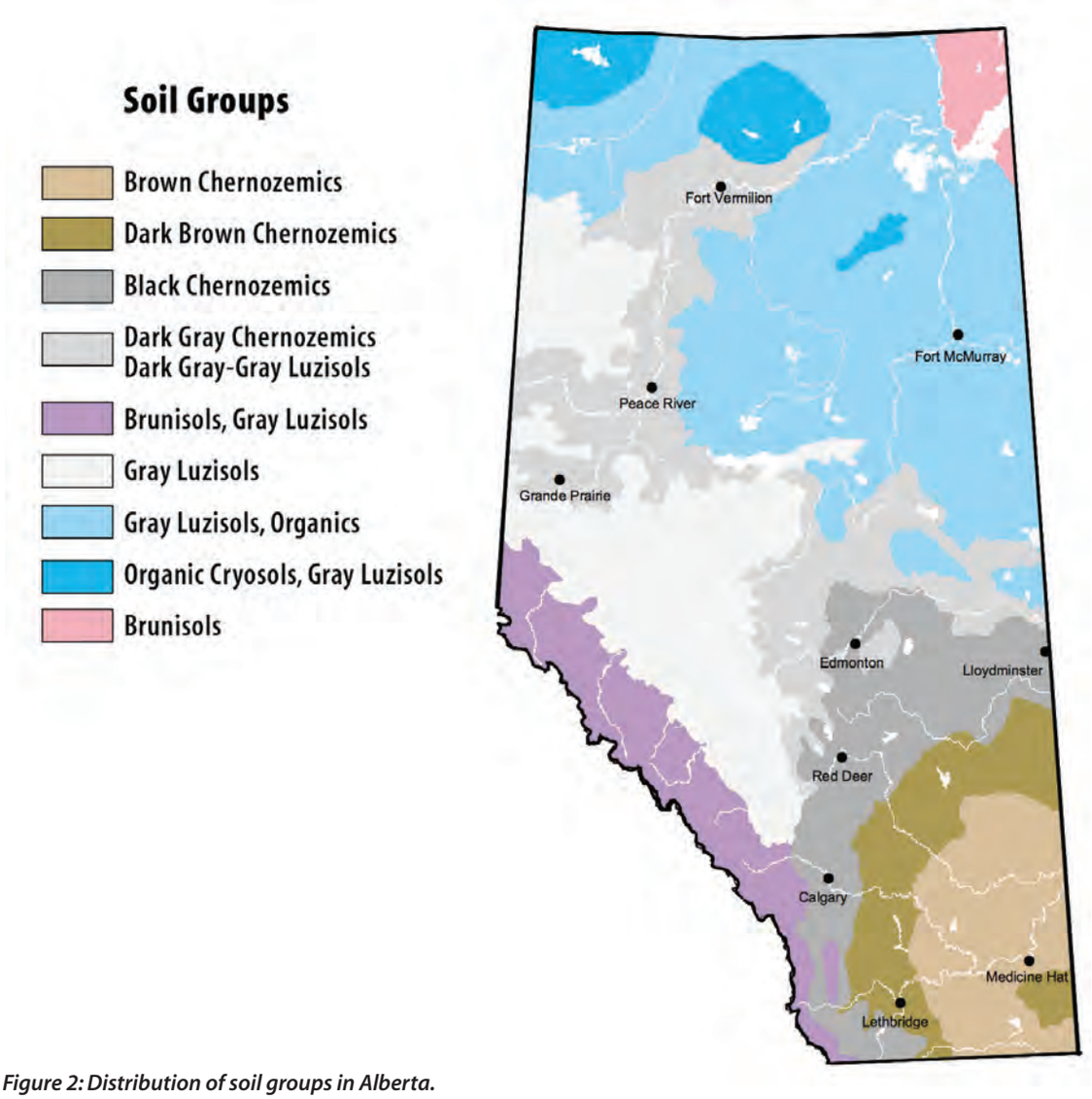


Figure 2: Distribution of soil groups in Alberta.
Source: *http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10307*

What Is Soil?

Soil is a complex mixture of various materials, including:

- Minerals - derived from the original parent materials. The mineral part of soil includes stones, gravel, sand, silt, and clay. Certain mineral elements - including phosphorus, potassium, calcium, magnesium, and most of the other micronutrients, are required for normal plant growth.
- Organic matter - the remains of plants and animals in various stages of decay. Organic or peat soils originate from the accumulated decay of sphagnum moss. Certain organic elements – including nitrogen and some phosphorus, are used as plant nutrients.
- Soil organisms - including bacteria, fungi, algae, insects, worms, and other creatures living in the soil. Their role in decomposition, aeration, compaction relief, and nutrient release is extremely important.
- Soil atmosphere - including carbon dioxide, oxygen, and nitrogen. Soil aeration is critical for good plant growth.
- Soil water - carries certain nutrients to plants, regulates the soil temperature, and maintains normal plant growth functions.

The arrangement and proportion of each component varies greatly depending on the influence of all the soil forming factors (i.e., parent material, climate, topography, organisms, and time). As the soil develops, chemical and physical processes at work in the soil produce layers, called horizons, which are visible when looking at the soil in vertical profile.

Under native or cultivated conditions, the grassland soils of southern and central Alberta typically have an organic-rich mineral soil horizon (A horizon) on the surface that is darkened by the accumulation of organic matter derived from the decomposition of grasses and forbs (Figure 3). In native forest soils of central and northern Alberta, the A horizon is covered by a surface layer of organic material – called the LFH, that is derived mainly from leaves, twigs, woody material, and some mosses. This organic layer typically includes a horizon of essentially undecomposed forest litter (L – "Litter" horizon) above a zone of accumulation of weakly (F – "Fermentation" horizon) to strongly (H – "Humic" horizon) decomposed materials. Under native forest conditions, the A horizon may be darkened slightly by the accumulation of organic matter, or more typically, may be lightened by the leaching loss of organic matter and other mineral constituents. Upon cultivation, the surface organic horizons are mixed - to various degrees depending upon their thickness and the depth of cultivation, with the underlying A horizon(s) resulting in an organic-rich mineral soil horizon.

Organic matter plays an important role in the maintenance of soil fertility and influences processes associated with the breakdown of soil minerals as well as soil profile development. Organic material on the surface (LFH) or as a component of the mineral A horizon increases the flow of water into the soil, reducing surface water movement and associated erosion. These soil horizons are the home of many soil microorganisms important in soil processes. They make up the layer in which many plant species have the majority of their roots, and in the case of the LFH, are a seed bank for many other plant species. Organic material on the surface also acts as a buffer against human disturbance, for example, that caused by heavy equipment traffic.

Under both grassland and forest conditions the A horizon can vary in thickness depending to a large degree on the effect of water movement on soil development. Water movement through the soil is influenced by factors such as per cent slope, slope position (e.g., upper vs. lower), aspect (e.g., north-facing vs. south-facing), and drainage. Under grassland conditions, for example, soils that have developed on lower slope positions that receive water from mid- and upper slope positions may have a much thicker organic-matter rich A horizon compared to soils on water-shedding upper slope and knoll positions. In forested areas, lower slope positions may display the effect of greater water leaching resulting in thicker, light-coloured A horizons compared to soils on upper slope and knoll positions.

The B horizon occurs below the A horizon and is characterized by the enrichment of organic matter, minerals, or clay; or by the development of soil structure; or by a change in colour denoting specific chemical processes. A grassland soil, for example, may have a B horizon with weakly prismatic structure indicating that some enrichment with small amounts of clay has occurred. These B horizons do not typically impede root growth. On the other hand, the B horizons of many forested soils can have a moderately to strongly prismatic or blocky structure that results from greater enrichment of clay and can severely retard root growth and the unrestricted movement of water through the soil when dry.

Figure 3: Example forest and grassland landscapes and soil profiles in Alberta.

The C horizon is the parent material that is comparatively unaffected by most of the physical and chemical processes at work in the A and B horizons. In some soil types, such as young soils that occur along active river floodplains, there may be little difference between the B and C horizons, or the A and B horizons may be very thin.

Plant Nutrients in Soil

Nutrients in the soil are found predominantly as constituents of the minerals and organic matter present in the soil. To a lesser degree, some nutrients in the soil water are weakly attached to the surfaces of minerals and organic matter may also be readily available to plant roots. There are 16 nutrients that are considered essential for various plant growth processes.

Hydrogen, oxygen, and carbon are non-mineral macronutrients that plants obtain from water and the atmosphere. The remaining essential mineral nutrients (macro and micro) are derived from the soil. Deficiencies of any one of the elements can result in reduced growth and poor plant health.

Mineral macronutrients: nitrogen, phosphorous, potassium, calcium, magnesium, and sulfur. All are required by plants in relatively large quantities (usually in excess of 1,000 parts per million (ppm)). Additions of nitrogen, phosphorus, and potassium are usually required first because plants use large amounts for their growth and survival. There is usually enough calcium, magnesium, and sulfur that regular additions of these nutrients are not required.

Mineral micronutrients: iron, boron, zinc, copper, manganese, molybdenum, and chlorine. Micronutrients are essential for plant growth but are needed in smaller amounts (usually less than 200 ppm).

Soil Texture

Texture refers to the relative proportions of sand (2.0 to 0.05 mm), silt (0.05 to 0.002 mm), and clay (<0.002 mm) in a soil. Soil textures are described by 13 classes as represented on a texture triangle (Figure 4). The per cent composition of sand and clay are represented along the horizontal and vertical axes, respectively, with the remainder (adding to 100%) representing the per cent silt. Texture classes can be combined into four more general groups – fine (heavy clay, silty clay, clay, sandy clay), medium (silty clay loam, clay loam, sandy clay loam, silt, silt loam, loam), moderately coarse (sandy loam), and very coarse (loamy sand, sand).

Soils high in sand content have reduced water and nutrient holding capacity and poor soil structure; however, because they have relatively large pore spaces, water applied to the soil surface in precipitation and runoff is able to infiltrate these soils relatively quickly. Fine-textured soils, on the other hand, have a high proportion of clay particles that are very small and electrostatically attracted to each other. Although these soils generally have higher water and nutrient holding capacities than coarser-textured soils, the very small pore size associated with them limits water infiltration at the surface and water flow through the soil.

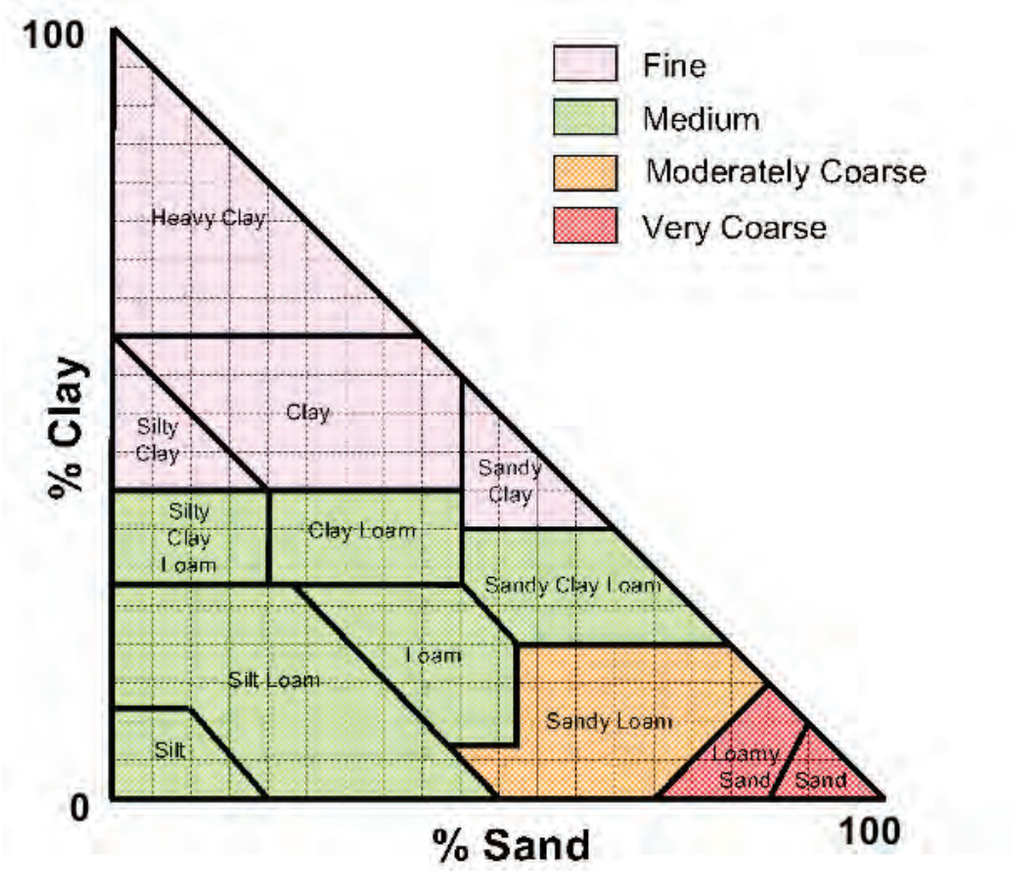


Figure 4: Soil texture triangle showing grouping of 13 texture classes into 4 more general groups.

Movement of clay particles downward through the soil over time can result in the development of pronounced soil structure and dense horizons that, in some cases, further restrict the downward flow of water. In some of these soils, deep cracks can develop that act as channels allowing water flow and root growth to a greater depth. Medium-textured soils with their mix of sand, silt, and clay-sized particles are generally able to support the most productive soils in the forest because of good moisture and nutrient holding capacities.

Soil Drainage

The availability of water is an important factor in controlling many of the biological, chemical, and physical processes occurring in the soil. Water is necessary for normal plant functioning. Soil water maintains plant cell turgidity as it is absorbed into the roots to replace water lost to the plant by transpiration. Another function of water is in mineral weathering and organic matter decay, processes that make available nutrients necessary for plant growth. Soil water also acts as the medium in which nutrients move to plant roots. Excess downward water flow can move mobile nutrients beyond the reach of most plant roots by leaching, while the upward movement of water may, for example, carry dissolved salts that may be harmful to plants at high concentrations, upward into the rooting zone. Excess water may also fill soil pore spaces, restricting the movement of air through the soil, denying plant roots necessary oxygen. Some of the physical characteristics of soil are a function of soil water content. An example of this is the ability of a soil to retain structural integrity under pressure. Moisture content has a large influence on the potential for soil compaction, rutting, and puddling to occur as a result of heavy equipment traffic.

Water moves through soil at various rates depending on climate, topography, soil texture, and structure. Soils with very high clay content can store large quantities of soil water that drains from the soil very slowly, producing low oxygen-high carbon dioxide levels for extended periods of time. Extremely dense layers within the soil profile may also act as an impermeable layer that restricts the downward movement of water.

Soil drainage classes are defined in terms of available water storage capacity and source of water:

- Very rapidly drained – Water is removed from the soil very rapidly in relation to supply. Soils are typically fragmental (stones, cobbles and gravel) or skeletal (>35% of particles 2-25 cm), coarse textured, and/or shallow over bedrock. Water source is precipitation.
- Rapidly drained – Water is removed rapidly from the soil in relation to supply. Soils are generally coarse textured and/or shallow over bedrock. Water source is precipitation.
- Well drained – Water is removed from the soil readily but not rapidly. Soils are generally intermediate in texture and lack restricting layers. Water source is precipitation.
- Moderately well drained – Water is removed from the soil somewhat slowly in relation to supply because of imperviousness, shallow water table, lack of gradient, or some combination of these factors. Precipitation is the dominant water source in medium- to fine textured soils whereas additional subsurface flow of water is necessary in coarse-textured soils.
- Imperfectly drained – Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Soils have a wide range of textures. Precipitation is the main source of water in fine-textured soils; contribution by subsurface or groundwater flow (or both) increases as textures become more coarse.
- Poorly drained – Water is removed so slowly in relation to supply that the soil remains wet for much of the time that the soil is not frozen. Soils have a wide range of textures. Subsurface flow or groundwater flow, or both, in addition to precipitation are main water sources. The water table seldom drops to more than 30 cm below the soil surface and root growth of many plant species is restricted.
- Very poorly drained – Water is removed from the soil so slowly that the water table remains at or on the surface for most of the time the soil is not frozen. Soils have a wide range of textures and are usually associated with wetlands and organic wetlands. Groundwater flow and subsurface flow are the major water sources. Plant populations are limited to very water tolerant species.

Long periods of soil saturation can severely reduce normal plant root growth. Many plant species that have a narrow range of oxygen and carbon dioxide sensitivity are unable to grow in areas of poor soil drainage (Table 2). Conversely, the presence of stones, gravel, and sand can increase the ability of water to move through soil because of the increased size of pore spaces. Very coarse textured soils can drain very quickly and plant roots may be unable to access adequate soil water to sustain normal plant processes.

Table 2: Trees common on soil types (texture and drainage) in Alberta

Site Conditions	Tree Species	
Dry, sandy, gravely or other rapidly- to well-drained soil	Jack pine Lodgepole pine Aspen	
Moist, well-drained clays and loams	Aspen Birch Elm Maple Balsam poplar White spruce	
Swampy Mucks and Peats	Black spruce Tamarack	

Soil drainage and moisture conditions also affect soil temperature and as a result, plant growth. Under wet conditions low soil temperatures persist longer into the growing season, becoming a major constraint on rooting depth and root growth. Organic layers on the soil surface provide an insulating effect to the soil and also act to reduce soil temperatures.

Soil Reaction and Salinity

Soil reaction refers to the activity of hydrogen ions in the soil as measured by their concentration, and is reported in units of pH. A pH of 7 is considered neutral, above 7 is alkaline while below 7 is acidic. Soil reaction regulates the activity of many organisms that populate the soil. Many of the organisms that mediate organic matter decay processes and the transformation of soil materials function only within a narrow range of pH. The form and availability of many chemical compounds found in the soil is often pH dependant. Some of the macro- and micronutrients necessary for normal plant growth become more or less available to roots within a narrow range of pH. Some elements, for example aluminum, can become available in toxic quantities to plants at low pH.

Forest soils are usually low in pH. The pH of the soil has a strong influence on the type of plant species that are able to grow on a site. Some species, for example blueberries, grow well only on the acidic soils of the northern boreal forest region. Many tree species have adapted to life under more acidic soil conditions.

Soil salinity refers to the accumulation of certain salts like sodium (sodicity) in the soil. Salts in the soil increase the electrical conductivity, EC. Lab measurements determine the EC value of a soil sample. Salts are a natural by-product of the soil parent material and/or weathering processes.

High soil salinity may limit the growth and survival of certain tree species (Table 3). Salinity affects both the appearance and survival of trees because excessive salts in soil will deprive plants of water and nutrients. Sap in plant roots contains a certain level of salt, which attracts water into the plant roots by osmosis. Salts dissolved in the soil water decrease the salt gradient between the root cells and the soil water, reducing the rate at which soil water enters the roots. At high salt concentrations, little water and nutrients are able to move into the plant roots. The plant is unable to extract water and

nutrients from the soil water and thus starves, even though there may be plenty of water and nutrients present in the soil. Salt damage includes stunting, fewer and smaller leaves, leaf burn, and needle yellowing. Pockets of saline soils occur across Alberta and are associated with high water tables and saline sub soils.

Table 3: Salt tolerant trees for saline areas

Tolerance	Electrical Conductivity EC (dS/m)*	Species (Trees, Shrubs and Ornamentals)	
High	16	Siberian salt tree Sea buckthorn Silver buffalo berry	Hawthorn Russian olive
	8	American elm Siberian elm Villosa lilac Laurel leaf willow	Spreading juniper Poplar Ponderosa pine
Moderate		Caragana Chokecherry Green ash Mountain ash	Common lilac Siberian crab apple Manitoba maple
Low	4	Colorado blue spruce Rose, Viburnum Douglas fir Siberian Larch Scots Pine Balsam fir Cottonwood	White spruce Aspen White birch Cotoneaster Dogwood Little-leaved linden

*Salt levels are measured by electrical conductivity, or dS/m. These measurements can be found on soil test results. Higher conductivity means higher salt levels. Adapted from: Transplanting Alberta Trees and Shrubs, Alberta Agriculture, Agdex 275/22-1.

Soil Hazards

Excess soil moisture is also a concern because operating heavy equipment on wet sites can cause serious compaction, rutting, and puddling damage, which should be avoided. Heavy equipment compacts and damages wet soil far more than dry soil. Compaction increases soil density and can negatively affect rooting depth and normal root growth. Ruts left in wet soil can be starting points for serious erosion problems. Soil puddling is the process by which the structure of the soil surface is destroyed, often leading to the formation of surface crusts and restricted drainage. On wet sites, the use of heavy equipment for construction of roads and landings, harvesting, and site preparation is recommended only when the ground is frozen and when snow cover is present to act as a disturbance buffer.

Soil Compaction

Usually a forest soil contains greater than 50 per cent pore spaces. Ideally, the pore spaces should contain equal volumes of water and air. Compaction of soil particles squeezes air and moisture out of the pore spaces. It may occur during grazing, timber harvesting, stand improvement, site preparation, or recreational activities. Sandy soils compact the least, while clays and loams are the most susceptible. Moist soils are more likely to compact than dry or frozen soils.

In compacted soils, water infiltration is slow and root penetration is difficult. In extreme cases, roots are forced to the surface, making the tree susceptible to insects, diseases, and mechanical damage. Trees growing on compacted soils are less vigorous and more stressed than trees growing on soils that have not been compacted. Furthermore, natural regeneration is slower and erosion is more of a problem on compacted soil.

Compaction can be minimized in a number of ways. Use heavy equipment only on dry or frozen ground and limit the number of passes over the same area. Using skid trails and felling trees towards the trails reduces the travel area of harvesting equipment. Machines with tracks rather than tires cause less compaction.

Refrain from activities on compacted areas for a number of years, to allow soil organisms and freeze-thaw cycles to help open pore spaces. This also allows the litter area to accumulate, decompose and improve the soil. In areas of severe damage, such as on skid trails, roads and landings, deep ripping plows may be necessary to break up compacted soil layers; however this may injure nearby shallow rooted plant species.

Soil Rutting and Puddling

Soil rutting involves the displacement of soil material by wheels and tracks. It results in depressions that act as mini-dams in the landscape, changing localized drainage patterns (Figure 5). Localized pooling of water can raise the water table of a site, increasing the overall wetness of the area and reducing long-term productivity. On sloping land, ruts can become channels that direct surface runoff, increasing soil erosion and sedimentation into surrounding water bodies.

Figure 5: Soil rutting destroys soil structure and changes soil drainage patterns.

Soil puddling most often occurs on soil surfaces where the organic layer has been removed by heavy equipment or by burning. Hydraulic pressure applied to the surface by heavy equipment causes particle movement in the soil. This movement destroys the normal soil aggregates and air-filled pores, and is the primary mechanism leading to surface crusting. Where surface soil aggregates are destroyed, clay and silt particles can be carried in surface runoff to local depressions where they settle to form dense, structureless surface crusts upon drying. Saturated soils high in clay and silt content with few coarse fragments, shallow organic layers, and weak structure are most susceptible to puddling.

Reducing harvesting related activities when soils are wet, protecting existing forest floor organic layers, retaining harvest slash on site, using low ground pressure equipment, and reducing the number of passes of heavy equipment over the soil are all useful practices that can reduce the risk of soil rutting and pudding damage to forest soils.

Soil Erosion by Water

Four major factors contribute to the erosion of soil by water. These are:

- The nature of precipitation – frequency, intensity, seasonal distribution, and the rapidity of snow melt.
- Soil properties – texture, type of structure, coarse fragment content, organic matter content.
- Landform properties – slope steepness and length.
- Amount and type of vegetation cover.

Water infiltration capacity and structural stability are perhaps the most important soil factors controlling susceptibility to water erosion. Soil compaction, rutting, and puddling by heavy machinery can reduce infiltration rates and concentrate surface water runoff in heavy traffic areas. Removal of surface organic matter as a consequence of forestry operations, forest fires, or intentional land improvement increases surface flow and exposes more of the mineral soil surface to the eroding action of rainfall and snowmelt.

When soil is washed away, it carries valuable nutrients with it, potentially decreasing soil productivity and reducing future forest regeneration and growth. Water erosion can lead to the formation of gullies and washouts in highly affected areas. Decreased water quality in streams, rivers, and lakes can result from increased turbidity. Since it is rich in nutrients, surface runoff encourages algae blooms and gives water an unpleasant taste, odor and appearance. Sediment from runoff may also fill in spawning sites or small pools in streams.

Water erosion along roads and landings is generally most serious because these areas can have compacted soils with low water infiltration capacities as well as sparse vegetation. Road grades should be minimized and cross ditches installed. Culverts and ditches should be unclogged to permit proper drainage. Streams should be crossed perpendicularly and water flow should not be disrupted. A buffer strip between roads and streams helps to filter runoff and maintain water quality. On roads with long slopes, drainage dips and waterbars should be installed to slow water flow.

To reduce the risk of erosion during harvesting operations, vegetative cover should be maintained on erosion-prone land. Logging in the winter when the ground is frozen and avoiding soil disturbance on high-risk areas such as steeply sloping land can reduce the potential for erosion (Table 4). Buffer strips between harvest blocks and streams, rivers, and lakes should be maintained to reduce the likelihood that eroded soil material enters these water bodies. The size of buffer strips depends on many factors including the size of the harvested area, the type of forest harvesting method (e.g., clearcutting vs. selective cutting), the amount of forest floor disturbance, and the type of landscape (slope gradient and slope length).

Table 4: Water erosion hazard (slope and moisture).

	Slope Gradient(%)												
Moisture Status	0	5	10	15	20	25	30	35	40	45	50	55	60
Dry or Frozen	L	L	L	L	L	M	M	M	M	H	H	H	H
Wet	M	M	M	M	M	M	H	H	H	H	H	H	H

Low	L	Normal operating ground rules apply.
Moderate	M	Appropriate harvesting methods should be used and detailed cut block plans prepared. Reforestation and reclamation plans should be prepared.
High	H	Alternative harvesting methods such as tracked skidding and cable yarding to remove timber should be considered.

Adapted from: Predisturbed Watershed Assessment Manual, Alberta Forest Service, ENR Technical Report No. T/100

Loss of Nutrients

Loss of the surface organic and mineral layers as a consequence of forest harvesting operations can negatively affect the potential productivity of the site for many years to come. Burning – as a result of naturally occurring forest fires or when used as part of a forest management plan (prescribed burning) can result in rapid loss of soil nutrients to the atmosphere by the process of volatilization or to groundwater due to enhanced soil leaching (Figure 6). Removal of organic matter and consequent loss of nutrients from the soil/site can also occur, for example, during road and landing construction, harvesting (e.g., limbing at the landing and whole tree harvesting), and site preparation (e.g., windrowing of logging debris and/or blading of the forest floor). Protection of the forest floor needs to be a prime consideration in any woodlot management plan to help ensure good regeneration, growth and productivity in future stands.

Figure 6: Windrowing and burning of organic material can reduce long-term soil productivity.

Soil Survey Maps and Aerial Photography

Soils information that may be of interest to landowners who currently have a farm woodlot, or to those planning to afforest areas of marginal or eroded farmland, is available from a variety of sources. Hard copy soil survey maps and reports are available for all of Alberta at a variety of scales and can be obtained by calling the Government of Alberta Publications Office or online through the Alberta Soil Information Centre (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6903). On the Alberta Soil Information Centre website you can also access AGRASID (Agricultural Region of Alberta Soil Information Database) and the Alberta Soil Information Viewer, which allows the user to query and view detailed soils information for the agricultural region of Alberta, over the Internet. Provincial agriculture extension service centres may also be sources of soils information and expertise. Soil testing services are available from a number of private soil testing labs.

Aerial photography is available for all of Alberta at a reasonable cost. Aerial photos are useful tools for land use planning. Tones showing different soil types or drainage are very evident from the air. Interpretation of aerial photos can aid in the identification of management zones. Once management zones are delineated, land owners can calculate the number and types of trees needed plan the planting and calculate productivity expectations. Likewise, aerial photos can be used to calculate the yield of timber from an area and develop forest harvest plans. Aerial photos can be purchased in hard copy and digital forms from government (Alberta Sustainable Resource Development – Air Photo Distribution http://esrd.alberta.ca/forms-maps-services/air-photos/air-photo-products/default.aspx) and private company suppliers.

Summary

Soil is a complex mixture of minerals, organic matter, soil organisms, soil atmosphere, and soil water. Soil development is determined primarily through interactions of the following factors: parent material (mineralogy, texture), climate (temperature, precipitation, freeze-thaw cycles), topography (slope gradient, aspect, and length), organisms (the importance of microorganisms in organic matter decay and nutrient availability), time (soil age), and human activity (soil degradation).

Soil texture and drainage largely control the potential productivity and species suitability of a soil/landscape. Soil pH and electrical conductivity (salinity) can also have a major influence on the growth of tree and shrub species.

Maintaining a healthy organic matter layer on the soil surface is critical in ensuring the long-term productivity of the forest.

Activities associated with forest harvesting can result in soil degradation (compaction, puddling, rutting, water erosion, loss of nutrients) if they do not adequately take into consideration existing site conditions.

Beneficial Management Practices

- Operating heavy equipment on wet sites will cause soil compaction, rutting, and puddle formation.
- Compaction increases soil density and negatively affects rooting depth and normal root growth;
- Ruts are starting points for soil erosion;
- Puddles destroy soil surface structures and may lead to the formation of surface crusts and restricted drainage.
- Use heavy equipment only on dry or frozen ground and limit the number of passes over the same area.
- Use of skid trails, and felling trees towards the trails, reduces the travel area of harvesting equipment.
- Tracked vehicles cause less soil compaction than do wheeled machines.
- Using deep ripping plows to break up the soil layers may rehabilitate areas of severe compaction damage.
- Reduce soil puddling and rutting damage by reducing harvesting related activities when soils are wet, protecting existing forest floor organic layers, retaining harvest slash on site, using low ground pressure equipment, and reducing the number of passes of heavy equipment over the soil.
- To reduce water caused soil erosion:
    - Minimize road grades and install cross ditches;
    - Ensure ditches and culvert are kept clear to allow free flow of water;
    - Cross stream perpendicularly without disrupting water flow;
    - Maintain vegetated buffer strips between roads and stream to help filter runoff;
    - Slow water flow on roads with long slopes by installing drainage dips and waterbars.
- Reduce the risk of soil erosion during harvest operations by:
    - Maintaining vegetative cover on erosion prone land;
    - Harvesting during winter;
    - Avoiding soil disturbance on high-risk areas such as sloping land.
- Protect the forest floor to ensure good regeneration, growth and productivity in future stands.
- Recognize and understand the different soil characteristics that affect tree growth or other woodlot management activities.
- Consider species suitability for different soil types.

Further Information

Canadian Soil Information System (CanSIS) provides soil information including soil maps, reports, and manuals for all of Canada. Publications available at the CanSIS website (http://sis.agr.gc.ca/cansis/) include The Canadian System of Soil Classification and Manual for Describing Soils in the Field.

The Agricultural Land Resource Atlas of Alberta (AGDEX 009-1) is a collection of agricultural resource maps that are useful in activities related to agricultural land management in Alberta. Copies of the publication are available through the Government of Alberta Publications Office, while individual maps are available at the Alberta Agriculture and Climate Information Service website (http://www.agric.gov.ab.ca/acis).

Selected Internet Sites

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6903- Alberta Soil Information Centre

http://esrd.alberta.ca/forms-maps-services/air-photos/default.aspx -
Alberta Sustainable Resource Development – Air Photo Distribution

http://sis.agr.gc.ca/cansis/ - Canadian Soil Information System

http://www.agric.gov.ab.ca/acis - Alberta Agriculture and Climate Information Service

Wetlands and Woodlots

Contents

Figure 7: Riparian Woodlot north of Hines Creek

Criteria and Indicators of Sustainable Forest Management for Wetlands

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes. Indicators of accomplishment include:***

- The woodlot management plan includes considerations for the importance of wetlands and their role in the ecosystem.
- Woodlot management activities are conducted in ways to conserve and maintain wetland areas.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Fertilizers, pesticides, and other toxic materials are not used in riparian areas.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Indicators of accomplishment include:***

- Strategies are developed to protect wetlands from deterioration. Natural inflows and outflows are not disturbed.
- Machinery and/or animal activities are avoided in wetland areas to prevent damage to soils and water.

Criteria 4: ***Role in global ecological cycles. Implement forest management practices to contribute to the health of global ecological cycles by utilizing the carbon sequestration capacity of forests and by maintaining the full function of wetlands. Indicators of accomplishment include:***

- The carbon sequestration capacity of wetlands is recognized by implementing strategies to conserve wetlands in the woodlot.
- Wetland resources such a peatlands are conserved for their carbon sink qualities.

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest plan to benefit present and future society. Indicators of accomplishment include:***

- Wetlands are recognized as resource able to provide multiple benefits including environmental, economic and social benefits to the woodlot owner and to the community.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- Wetlands are recognized for their value beyond the woodlot's boundaries. Management actions within the woodlot are conducted with full consideration given to the entire watershed and not just to local wetlands.
- The community is apprised of all woodlot activities that might affect wetland benefits.

Wetlands and Woodlots

Like woodlots, wetlands are precious natural resources that provide social, environmental and economic benefits. And, like woodlots, wetlands are being lost. Many landowners have recognized this loss and acknowledge the importance of wetlands to the ecosystem and are working to restore and protect this valuable resource.

Wetland Types

In general, a wetland is described as any area where the land is saturated with water, contains water-loving plants, and supports biological processes that require wet areas. Most of Alberta's wetlands are in northern parts of the province. Many of these are permanent, meaning they hold water year-round. In central and southern Alberta, wetlands are often temporary (ephemeral), holding water only in the spring or early summer, or semi-permanent, holding water all summer long in most years. The type and extent of wetlands are determined by climate, land features, surface and groundwater flows, vegetation, and soils.

Figure 8: Peatland – Lush larch fen near Fort Assiniboine

Alberta's wetlands can also be classified as peatlands and non-peatlands. Peat is the remains of partially decomposed plants such as sedges, rushes, grasses and mosses that pile up in deep layers over centuries. Peat accumulates in wetlands known as bogs and fens and forms peatlands. In marsh areas (sloughs), or in areas subject to drying because of shallow water, peat does not accumulate to a significant thickness. These areas are defined as non-peatlands.

Bogs and fens, often called muskeg, occur throughout northern Alberta in cool, wet areas where drainage is poor. The soil in bogs lacks oxygen and the water is strongly acidic. The lack of oxygen and cool temperatures prevents organic matter from fully decomposing. Bogs receive their water from rainfall and snow. Fens however are mainly fed with groundwater and the water table is usually at or above ground level. The water in fens is more alkaline and contains more nutrients than a bog.

Figure 9: Wetland surrounded by woodlots

Natural Wet/Dry Cycles

Wetlands neither occur nor function in isolation; rather, they are part of a larger working ecosystem. The surrounding riparian areas and adjacent landscapes are vital to the functioning and health of wetlands (and vice versa).

Depending on precipitation levels and snowmelt conditions, wetlands can change from time to time during what's called the wet/dry cycle. In these situations, a wetland can dry out completely and remain dry for a number of years. However, while the wetland remains dry, important biological processes continue to take place. For example, seeds of plants that were once under water in the middle of the wetland germinate and grow. The wetland remains alive, in a sense, until normal precipitation levels return. As water levels increase, plants that were growing in the middle of the wetland during the dry cycle become submerged and decay, enriching the aquatic food chain.

Wetlands as Part of a Watershed

All wetlands, lakes, and rivers that drain to a common destination are considered part of a watershed. A watershed may range in size from a few hundred to thousands of hectares. Like a wetland, a watershed can be considered a living ecosystem with complex interacting natural components. Upland plant communities, wetlands, riparian areas, rivers, lakes and streams are important natural features that affect surface and groundwater quality and quantity within a watershed.

Figure 10: Agricultural landscape

Land use, natural landscape features, and modifications to water systems have a direct influence on surface water bodies and groundwater. Water quality and quantity in a watershed are linked to natural processes that are part of the landscape and the water cycle. Both have a strong influence on how nutrients, chemicals and sediment are transported.

While nature determines how many wetlands are in a watershed, society is responsible to protect and enhance these landscape features to ensure the water quality and quantity and other benefits are retained.

Benefits of Wetlands

Wetlands are an important part of a healthy, functioning ecosystem and watershed. Aside from providing benefits to the environment, wetlands also provide important benefits to landowners and their woodlots by providing improved quality and quantity of water. During dry cycles, wetlands are a source of forage for livestock.

Wetlands can be compared to sponges that capture and hold water and then release it slowly. By doing so, wetlands can provide water supplies during periods of drought and control the effects of flooding during times of peak water flow. Water in wetlands can also permeate underlying soils and recharge underground aquifers, thus reducing the cost of developing new water supply and delivery systems. This is a particularly important benefit to woodlot owners and other rural residents who depend on wells as a major source of water for household and other uses.

Wetlands also serve as natural filters, removing and storing suspended solids, nutrients, and other pollutants from water. Excess nutrients, soil particles and pollutants are captured and carried by moving water, called runoff, into wetlands. Here, wetland vegetation disperses and reduces the water velocity and up to 70% of the sediment load is deposited. Furthermore, chemical processes and organisms associated with wetlands break down and retain many nutrients and pollutants, preventing them from traveling downstream.

Role of Vegetation in Wetlands

Wetland vegetation such as cattails, sedges and rushes, contributes to the function of a wetland. The vegetation helps to protect against soil erosion and provides habitat (food, nesting sites, and cover) for wildlife ranging from insects to mammals. These plants stabilize the soil, holding it in place against erosive forces and disrupting waves and currents that would otherwise impact on soil. By trapping sediments found in the water, wetland plants also help to reinforce soils against erosion.

Riparian areas, which can contain forbs, willows and trees, extend beyond the perimeter of the wetland and provide extra stability to the whole wetland system. The additional layers of vegetation that thrive in riparian zones ensure the wetland continues to function at its best and to provide its many benefits.

Other Benefits of Wetlands – Environmental, Economic, and Social

Wetlands are carbon sinks. This means wetlands store carbon in the vegetation and in the soil for long periods of time – many centuries in some cases. The relatively cool soil temperature and other factors combine to slow the decomposition of organic matter in the soil and therefore hold carbon rather than release it into the atmosphere. This characteristic of wetlands is particularly important because it presents a possible solution to reducing atmospheric carbon dioxide, which affects climate change and global warming. Working to keep wetlands intact and functioning may help agricultural producers to meet their targets for reducing greenhouse gas emissions.

Biological diversity is also maintained or enhanced by wetlands. A wetland environment provides habitat for many different kinds of plants, birds, animals, insects, microbes and fish that depend on water or wet soils to survive. About 80% of Alberta's wildlife relies on riparian areas for some or all of its lifecycle requirements.

Healthy wetlands on the landscape also provide economic benefits. Numerous recreation activities are conducted on or near wetlands. Such activities as tourism, boating, bird watching, nature photography, hunting, and fishing rely on healthy functioning wetlands for their existence. These activities contribute to provincial and local economies and can also provide business opportunities for woodlot owners.

Natural capital is often discussed in terms of renewable resources such as oil, gas and forestry, and perhaps even fisheries. But natural capital also includes well-functioning ecosystems. Like other forms of natural capital, these ecosystems provide goods and services, specifically ecological goods and services to society.

Healthy wetlands, the most important part of a functioning watershed, provide numerous benefits as described previously. These benefits are enjoyed by the woodlot owner and by society in general. Adequate supplies of clean water, retention of flood water, recharging of groundwater, prevention of soil erosion, and wildlife habitat, scenic vistas and other recreational values—all are the result of conserved, intact wetlands. This capital must be protected to maintain the flow of benefits to society. The cost associated with increases in flood damage, erosion and stream sedimentation, loss of wildlife habitat or even water shortages that result from the loss of wetlands would be substantial to individual woodlot owners and to society in general.

Figure 11: Beaver House

Sustaining Wetland Benefits

Wetlands are a dynamic component of an evolving ecosystem that is an integral part of the natural landscape. Changes to any component of the system will be reflected by changes to other parts of the system. As landscape features such as forest cover or drainage patterns change, characteristics of a wetland also change. The implications of any changes to the landscape on wetland systems must be understand and planned so the results can be predicted and managed to minimize their effects or optimize their benefits. The woodlot owner should always consider how management practices implemented on the property could affect wetlands both on and off the woodlot.

Consider the following actions to sustain wetlands:

- Keep wetlands intact. Do not drain or fill wetlands.
- Restore wetlands that have been drained.
- Maintain water levels. Do not interfere with natural inflows or outflows.
- Manage livestock access to water bodies or courses to conserve water and avoid damage to banks. Provide off-site watering.
- Locate livestock shelter, feed and mineral supplements away from riparian areas.
- Control and manage grazing duration in riparian areas.
- Avoid cultivating in riparian areas.
- Do not use fertilizers or pesticides in wetlands or riparian areas.
- Maintain a healthy buffer of native vegetation around wetlands.
- Avoid cutting or grazing wetland buffers until after mid to late July to protect nesting waterfowl.

Learn more about your local watershed group. No matter where you live, you live in a watershed. No matter how large or small your actions, they will contribute to the health of the watershed.

Beneficial Management Practices

- Include wetlands management and conservation in the woodlot management plan.
- Plant trees and shrubs around wetlands
- Keep wetlands intact. Do not drain or fill wetlands.
- Restore wetlands that have been drained.
- Maintain water levels. Do not interfere with natural inflows or outflows.
- Manage livestock access to water bodies or courses to conserve water and avoid damage to banks. Provide off-site watering.
- Locate livestock shelter, feed and mineral supplements away from riparian areas.
- Control grazing duration in riparian areas.
- Avoid cultivating in riparian areas.
- Do not use fertilizers or pesticides in wetlands or riparian areas.
- Maintain a healthy margin of native vegetation around wetlands.
- Avoid cutting or grazing wetland margins until after mid to late July to protect nesting waterfowl.

Selected Internet Sites and Information Sources

Internet Sites

http://www.whyte.org/time/riveroflife/wetlands.pdf - PDF version of the publication 'Focus on Wetlands', Alberta Environment.

http://www.ec.gc.ca/eau-water/ - Water, Environment Canada

http://www.southsaskriverstewards.ca/ckfinder/userfiles/files/ManagingSaskatchewanWetlands.pdf?PHPSESSID=hr-0j0knlod1uqiveg37873n1u0 - Managing Saskatchewan Wetlands: A Landowners Guide.

http://ec.gc.ca/ - Environment Canada

http://www.ducks.ca - Ducks Unlimited Canada

Information Sources

Alberta Environment Information Centre
Main Floor Oxbridge Plaza
9820-106 St
Edmonton, Alberta
T5K 2J6
Telephone (780) 427-2700
E-mail env.infocent@gov.ab.ca
http://environment.gov.ab.ca/info/home.asp

Ducks Unlimited Canada, Corporate Headquarters
P.O. Box 1160
Stonewall, Manitoba, Canada
R0C 2Z0
E-mail: communications@ducks.ca

North American Waterfowl Management Plan
c/o Canadian Wildlife Service
Environment Canada
Ottawa, Ontario K1A 0H3
E-mail: nawmp@ec.gc.ca

Tree Species

Contents

Introduction

This section of the guide describes a number of tree species common to Alberta. The descriptions include sections on growth, uses, management of the species, damaging agents, and its value to wildlife. This section also includes brief descriptions of trees and shrubs that are particularly suitable for wildlife plantings.

Tree Species Common to Alberta

WHITE SPRUCE *(Picea glauca)*

White Spruce ***(Picea glauca)***

Other common names: Western white spruce, Porsild spruce, silver spruce.

Needles – four-sided; about 2 cm long; bluish-green; aromatic when crushed; easy to roll between thumb and forefinger.

Cones – slender, cylindrical when open; hanging; about 5 cm long; scales are flexible and smooth-edged.

Bark – gray-brown, scaly; inner bark silvery-white

Growth

White spruce is a medium to large sized tree, usually 12 to 21 m high and 15 to 45 cm in trunk diameter. In good sites it may reach more than 30 m in height and more than a metre in diameter. It grows best on well drained, moist, silty soils, but occurs on many soil types. It has a medium tolerance to drought and can tolerate some flooding during the growing season. The seedlings will tolerate acid soils of pH 4.5 but have a very low tolerance to soil salinity. The root system grows fairly flat, but on deep soils will form a 'heart' root system.

White spruce is a widespread tree in the boreal forest, but is rarely found in pure stands. It is more commonly found with balsam fir, aspen and white birch. Because it tolerates shade, it maintains its lower limbs and needles more than pines, making it an excellent choice for shelterbelts and windbreaks in moist areas.

Uses

White spruce is one of the most valued wood species in Canada. It is used for lumber, plywood and pulpwood. The wood is light coloured, has low weight when dried, is straight grained and has good machining properties. It is used in all forms of building construction and in general millwork. The long fibres and low resin content make it excellent for pulp, paper and newsprint manufacturing. White spruce can also be used for log houses, musical instruments, paddles and various boxes and containers.

Other Characteristics

Occasionally, stands of white spruce may be found with smooth, grey bark. Cone sizes can vary from one to five cm in length and may be found halfway down the tree. Branches of white spruce generally sweep upwards. It has a tan or reddish brown coloured cambium.

Management

Regeneration

Seed crops occur about every one in four years but do not follow cycles, so planting is generally the fastest and most accepted method of regeneration. Planting rates may vary from 1,200 to 2,500 trees per hectare. A 70% survival rate 5 years after planting, or 800 well-spaced stems per hectare, is usually considered stocked. At harvest, target densities for managed stands are usually between 800 and 1,000 stems per hectare. Actual densities may be less than 400 stems per hectare in mature, naturally occurring stands.

Culture

White spruce grows slowly while the roots become established. Thinning at regular intervals will help maintain good diameter growth, but should only occur when the tree crowns are intermeshed. Thinning too early may create conditions that encourage spruce weevil and sawfly infestations.

Harvest

White spruce may be clearcut, shelterwood cut or selection cut. Clearcutting removes all the trees at once, while shelterwood cutting removes all the trees over two or more stages. These methods are used on even aged stands. Selection cutting should involve removing larger trees from the overstory while maintaining a healthy population of younger trees, in uneven aged stands.

White spruce reach maturity between 80 and 120 years. In a mixed wood stand with balsam fir and aspen, harvest may occur earlier, when the other species mature. Due to a heavy crown and shallow roots, heavy winds can blow down large spruce that are in a heavily thinned or poorly stocked stand.

Damaging Agents

Insect pests include the yellow headed spruce sawfly, spruce budworm and terminal shoot weevil. The sawfly affects scattered trees up to 5 m tall. The spruce budworm feeds on balsam fir as well as white spruce. Both the yellow headed sawfly and the spruce budworm can cause severe growth and volume reduction of individual trees and stands, and cause mortality after 5 or more years of defoliation. The terminal shoot weevil slows height growth and affects stem straightness. It will cause trees to grow multiple stems when it attacks repeatedly.

Moderate winds can windthrow white spruce, particularly if management practices excessively thin the stand or create openings. On deep, well-drained soils, windthrow is less of a problem. Shallow roots, thin bark and flammable needles make spruce forests susceptible to fire.

Snowshoe hares can girdle and kill young spruce trees. Red squirrels and spruce grouse eat various parts of the trees.

Wildlife

White spruce stands provide a source of thermal cover and food for various birds and animals. Martens, wolverines, bobcats, coyotes and lynx hunt birds and mammals that live in the stands. Moose, white-tailed deer and elk use spruce stands for shelter. A wide variety of birds may be attracted, depending on the age of the stand and diversity of other plant species available.

Management for Wildlife

Conversion of old fields, brushy areas and other timber types to pure stands of white spruce is not recommended if wildlife habitat is a goal.

Some wildlife species, such as sharp-tailed grouse and short-eared owls, require large open areas and converting these areas to conifer forest is detrimental. Other wildlife species, such as spruce grouse and red squirrels, prefer conifers. In a large hardwood blocks, conversion of several 4 to 8 hectare areas to spruce can provide some habitat diversification and thermal cover for ungulates.

Planting spruce for wildlife habitat involves using a lower population rate of 1000 trees per hectare and an irregular spacing, to provide a better diversity of plant species. Snags should be left, if possible. White spruce will tolerate woody competition that wildlife requires. Hand thinning or spot herbicide treatments are preferred over broadcast herbicide applications.

Trees that die from frost, browsing or other factors, and are not replanted, will provide small openings for wildlife. Existing stands may be thinned to let light reach the ground, stimulating the understorey and attracting wildlife. Selective harvesting of natural stands will change the habitat and therefore the array of wildlife species using the area will also change.

BLACK SPRUCE *(Picea mariana)*

Black Spruce ***(Picea mariana)***

Other common names: Bog spruce, swamp spruce

Needles – four-sided; 0.5 to 1.5 cm long; bluish green; easy to roll between thumb and forefinger.

Cones – egg-shaped; spherical when open; hanging; 2 to 3 cm long; remain on tree for years.

Twigs – covered with rust-coloured hairs.

Bark – grayish-brown; inner bark olive-green.

Growth

Under good conditions, black spruce averages 12 to 20 m in height and 20 to 25 cm in diameter at maturity, although it may reach 30 m and 45 cm in exceptional cases. It is usually found on wet organic soils, but will grow on a wide range of sites and conditions. Black spruce does not compete well with white spruce on optimal sites, but is able to tolerate anaerobic conditions, while white spruce cannot.

Black spruce is commonly found in pure stands on organic soil, or mixed with balsam fir, white spruce, tamarack, jack pine, trembling aspen and various other trees. It is a significant component mixed with lodgepole pine in the Alberta foothills. Many black spruce stands have a nearly continuous ground cover of feather mosses, peat moss and/or lichens.

Uses

Because of its long fibres, black spruce is most commonly used for pulpwood, especially for high quality papers. It can also be used for lumber, rails and firewood.

Other Characteristics

Cones are clustered at the top of the tree. Drooping branches sweep up at the ends. Black spruce have fine hairs on their twigs and an olive green cambium under the bark. They may have a distinctive tuft at the crown on wet sites.

Management

Regeneration

Black spruce stands are often even aged due to their origin by fire. Stands can be clearcut, then direct seeded, planted or allowed to naturally regenerate, to produce new, even aged trees. A good seedbed is important to ensure full stocking on wetland sites.

Black spruce cones remain on the tree for years, providing a relatively regular supply of seed. Wind will carry the seeds up to 3 times the height of the tree, so trees 15 m high will distribute seeds up to 45 m in openings or clearcuts.

Natural seeding is hard to control and may result in too much or not enough seed. Direct seeding may be done by hand or with a snowmobile. Planting is usually recommended on sites with well drained peat or mineral soils.

Culture

Black spruce thins itself naturally, so additional thinning is usually not necessary. Growth can be extremely slow on poor sites. Drainage may improve growth rates on waterlogged areas.

Harvest

Clearcutting or strip cutting (for better seeding) is recommended for harvesting black spruce. Maturity ranges from 60 years on high land to 90 to 140 years in wetland areas. Changes in the water table may make an area unproductive for timber after harvesting. This risk should be assessed prior to logging.

Damaging Agents

Black spruce has few serious enemies. Spruce budworm and the yellow headed spruce sawfly may defoliate some trees, but seldom cause serious damage. The snowshoe hare may girdle and kill seedlings and saplings.

Trees on the edge of openings are subject to windthrow and stem breakage, especially if the trees have butt-rot. Black spruce is easily killed by ground and crown fires, and rates high in fire hazard. Changes in the water table, whether from beaver dams or road construction, can also cause problems in black spruce.

Wildlife

Few species use natural black spruce stands exclusively – mixed stands provide a better habitat. The black spruce upland edge is usually the most important part of the stand for game species.

Red squirrels and spruce grouse use black spruce stands for food and cover, as do a variety of small mammals and birds. These species attract predators such as lynx, coyotes, bobcats, and weasels, especially during high population cycles.

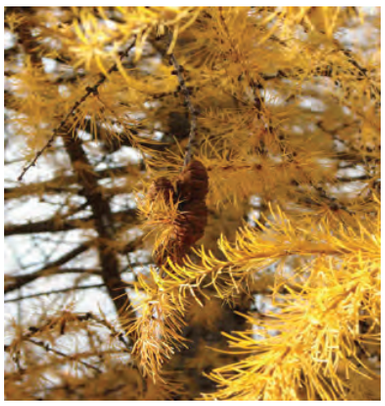
Deer and moose may use black spruce for cover, especially when it occurs in a mixed stand. Bears often select den sites in black spruce stands, and moose occasionally do so too.

Management for wildlife

Clearcutting portions of black spruce stands at different times provides habitat for a wider variety of species than simply maintaining an even aged stand.

In large clearcuts, dead standing "snag" trees will attract birds for nesting, insects for food and perches for hunting. Snag trees are best used in areas that do not require burning for regeneration.

TAMARACK *(Larix laricina)*



Tamarack ***(Larix laricina)***

Other common names: Larch

Needles – soft, flat and slender; clusters of 10 to 20; about 2.5 cm long; light green, turning yellow in autumn before falling off.

Cones – round, light brown when mature; less than 2 cm long.

Bark – thin, reddish-brown to gray; scaly; inner bark is dark reddish purple.

Growth

Tamarack is a small to medium sized conifer that, like other members of the larch family but unlike other conifers, sheds its needles every year. Average height of mature trees is 15 to 23 m, with a diameter of 35 to 50 cm. Tamarack is usually found on moist, organic soils but will grow on a wide range of soil types and moisture conditions. It grows best on moist, light, well-drained soils.

Stands may be pure and even-aged, or mixed with black spruce, balsam fir, white spruce and/or trembling aspen. Western larch looks similar to tamarack, but has very different ecological characteristics. Subalpine larch may be found in high elevation locations along the BC-Alberta border.

Uses

Tamarack is a moderately hard, heavy wood, somewhat oily and sometimes having a spiral grain, which may make it less desirable for some lumber uses. It is very durable in wet ground and is often used for posts, poles, floor planking, skids and pilings. It can also be used for pulp.

Other Characteristics

Tamarack grown on high moisture sites are sometimes referred to as red tamarack. These trees are more resistant to rot than those grown on dry sites. This may have to do with the ratio of sapwood to heartwood. The heartwood ranges in colour from medium brown, to pinkish-red, to greenish-purple.

Management

Regeneration

Tamarack is extremely shade intolerant and seldom reproduces itself without disturbance. It is often succeeded by more shade tolerant spruce. Natural regeneration after harvest is best in a good seed year (every three to six years) on completely cleared sites. Brush severely inhibits regeneration.

Seedlings need abundant light and a constant water table for best growth. While tamarack grows rapidly, black spruce is sometimes used to regenerate tamarack sites.

Culture

Growth can range from very slow in water-logged areas, to a good rate on better sites. Thinning can be performed if a market exists, but is not recommended in organic soils, because the trees may be subject to windthrow.

Harvest

Maturity varies from 70 years on the best sites to 120 years on poor sites. Clearcutting in a good seed year is recommended. An alternative might be to leave 25 to 40 trees per hectare to provide seed for regeneration.

Damaging Agents

Several insects attack tamarack. The most important is the larch sawfly, which can defoliate large areas, causing growth loss and death. Weakened trees are prone to attack by the larch beetle. Spruce budworm and other defoliators may sometimes cause injury.

Changes in the water table, often caused by beaver dams or road construction, can also kill tamarack. Strong winds can uproot tamarack in wet or swampy sites, but compared to black spruce it is fairly windfirm.

Snowshoe hare will kill seedlings, while moose and white-tailed deer browse them to a small extent. Porcupines will feed on the inner bark and deform or kill larger trees.

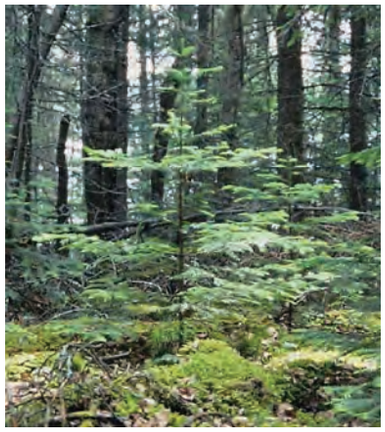
Wildlife

Some non-game wildlife species use large tamarack swamps heavily. Others prefer small stands or the edges of large stands. The area between a tamarack swamp and the upland forest is most productive for game species because it tends to contain a greater plant diversity. Small mammals such as voles and shrews are found in tamarack and can attract various predators. The edge of tamarack stands sometimes support browse shrubs for deer. A range of birds are found in mixed stands.

Management for wildlife

When managing for wildlife diversity, tamarack should be harvested on a rotation scheme to maintain 60 to 80 percent of the stand in large sapling-pole timber size or larger. Seed tree or shelterwood harvesting systems are preferred for tamarack stands. If clearcutting is used, it should be done in small blocks to encourage birds to use the cutover.

BALSAM FIR *(Abies balsamea)*



Balsam Fir ***(Abies balsamea)***

Other common names: Balsam, eastern fir

Note: Subalpine fir *(A. lasiocarpa)*, found on the eastern slopes of the Rockies, the Clear Hills and a few other locations, is very similar.

Needles – flat with rounded points; two rows, arranged on either side of the twig; 1.5 to 4 cm long; dark, shiny green on top, rows of white bands underneath; resinous and fragrant.

Cones – oblong; stand erect on the branch; 5 to 10 cm long; scales and seeds fall when ripe, leaving a central spike on the tree.

Bark – smooth, grayish, dotted with aromatic, resin-filled blisters when young; old trees have rich, brown bark.

Growth

Balsam fir is a medium sized, short lived tree. It normally grows from 12 to 18 m tall, 30 to 45 cm in diameter and matures in about 65 years.

The tree can grow in pure stands or in combination with spruce, aspen, and birch. It is found on a wide range of organic and inorganic soils and can tolerate acidic conditions. Balsam fir is very shade tolerant and will grow very rapidly when the overstory is removed. It can sit for more than ten years in a suppressed condition and still respond well to releasing. It requires a good supply of moisture to thrive.

Uses

Balsam fir is similar to spruce in most characteristics, but is less resilient and not as strong. While not a preferred lumber species, it is used for light frame construction, paneling and crates. Because it is less dense than other major species, balsam fir provides a lower pulp yield. Prolonged needle retention and a pleasant fragrance make balsam fir a favourite for Christmas trees and wreath-making. High resin content may gum up saws, but essential oils can be extracted from the resin for fragrances.

Other Characteristics

Resin blisters are often found on its smooth, gray bark. It is the most symmetrical of the conifers and has a very pointed crown.

Management

Regeneration

Stands can regenerate naturally or be replanted with up to 2,500 trees per hectare. Having established balsam seedlings in the stand at harvest will lead to more successful natural regeneration. Otherwise, raspberries and hardwoods may take over. In some cases, winter damage may occur after the overstory is removed.

Where low numbers of seedlings are present before harvest, patch and strip clearcuts or shelterwood cuts should be used to promote seedling development. Slash accumulation should be minimized to improve seedling chances. Seed trees are not recommended due to possible windthrow.

Culture

Shade tolerance and natural regeneration often results in dense stands of small diameter balsam fir. Thinning dense stands 2 to 4 m tall can result in earlier harvest, increased diameter growth and a better resistance to budworm infestations. Spacings of 2.3 by 2.3 m or 2.6 by 2.6 m are recommended. Early rot is often a problem. By the time balsam fir reaches merchantable size, root and stem rot is often quite advanced.

Harvest

Balsam fir reaches maturity at about 65 years. It can be clearcut and managed as an even aged stand or selectively cut at the age of 40 to 50. When selectively harvesting, the overstory trees should be removed as they mature, or in 10 to 20 year cutting cycles.

When there are no young seedlings in the stand, patch clearcuts of less than one hectare or strip clearcuts 30 to 45 m wide can be made. The rest of the stand should be patch or strip cut when adequate regeneration is established.

Damaging Agents

Many agents act against the healthy growth of balsam fir. Spruce budworm is the most important insect pest of balsam fir. The insect prefers mature and overmature fir trees, causing extensive mortality after five or more years of defoliation. Balsam fir may be more vulnerable to spruce budworm than white spruce.

Shallow roots, thin bark and very flammable needles make balsam fir susceptible to fire. Wind easily topples exposed trees, so thin strips or large single trees should not be left after harvest. Flooding will kill the trees rapidly. Black bears will girdle balsam fir.

Butt and stem rot can be a serious problem in mature and overmature trees, often reducing the usable volume of merchantable sized trees to the point where it is uneconomic to harvest them. Butt and stem rot may be minimized by harvesting at 45 to 50 years. Other root and heartwood rots can also damage balsam fir.

Wildlife

Pure stands of balsam fir have sparse ground vegetation and provide habitat for few wildlife species. In mixed stands however, balsam fir provides good habitat for many wildlife species. Moose use balsam for food and cover; bears use uprooted balsams as dens; deer, rodents and other small animals all find a place in mixed balsam stands.

Many bird species, including those that favour upland conifers, are found in balsam fir stands. Lowland balsam, together with black spruce, supports numerous bird species. Some species of reptiles and amphibians may be present, especially if temporary ponds are present and forest litter is abundant.

Management for Wildlife

A patchwork harvesting scheme which leads to different aged hardwood and balsam stands will provide habitat diversity for most forest wildlife species.

Balsam can provide important winter shelter for deer in low-lying coniferous areas. Selective cutting maintains shade in the stand and prevents aspen and birch from establishing. In large balsam areas, clearcuts of 2 to 8 hectares permit fast growing, shade intolerant species to become established, providing food and habitat diversity.

In large, mixed stand clearcuts, leave scattered dense clumps in one or two hectare patches for wildlife cover. Dead hardwood snags provide food and shelter for many species.

Balsam fir is short-lived, but the rotation may be extended to 60 years or more by incorporating white spruce into the stand, to meet some of the needs of wildlife which require older trees.

DOUGLAS-FIR *(Pseudotsuga menziesii)*

Douglas-fir ***(Pseudotsuga menziesii)***

Other common names: One species of Douglas-fir exists in Canada, but two forms are recognized. Coastal Douglas-fir grows on the islands and mainland of the west coast. Douglas-fir found in Alberta are the Interior form. It may also be called Blue Douglas-fir

Needles – flat with rounded points; two rows, arranged on either side of the twig; 1.5 to 4 cm long; dark, shiny green on top, rows of white bands underneath; resinous and fragrant.

Cones – oblong; stand erect on the branch; 5 to 10 cm long; scales and seeds fall when ripe, leaving a central spike on the tree.

Bark – smooth, grayish, dotted with aromatic, resin-filled blisters when young; old trees have rich, brown bark.

Growth

On the prairies, Douglas-fir is restricted to the western part of Alberta. It may grow to 30 m in height and more than 90 cm in diameter in Alberta. The species has a tapering trunk, with a limby crown and bluish-green foliage. As the tree gets older, the trunk gradually reduces the number of branches over most of its length. The root system is strong and wide-spreading, making it quite windfirm.

Douglas-fir is a characteristic species of the Montane Region which includes a small portion of south-western Alberta. It grows on a variety of soils, doing best on well aerated, deep, acidic sites. Poorly drained or compacted soils will reduce tree vigor. Douglas-fir grows in pure stands, or in combination with various pine, spruce and fir species.

Uses

Douglas-fir is one of the most important timber species in North America. In Alberta, it is used for flooring, plywood, structural timber and telephone poles.

Management

Regeneration

Douglas-fir can be planted, but usually regenerates better naturally because of the severe site conditions where it is found. Erratic spacing and a lack of reliable seed fall has resulted in attempts to regenerate Douglas-fir by planting. However, moisture is usually a limiting factor where Douglas-fir occurs normally in Alberta and plantations on dry sites may not be successful. Aerial seeding has been used on some sites. Cones mature in July and August, dispersing seed into September. First year seedlings grow best under light shade, but older seedlings prefer full sunlight.

Culture

Seedlings and saplings respond well to release from brush and overstory trees. Poles and small sawlog sized trees respond well to thinning. However, close growing stands should not be heavily thinned, as the trees become susceptible to sunscald, snowbreak and windthrow. Natural pruning is very slow. Artificial pruning will reduce the time to produce clear lumber.

Harvest

Clearcut areas should be small, in a lee side, to encourage snow accumulation and natural regeneration. Shelterwood systems are preferred because Douglas-fir is shade tolerate in the seedling stage. Selective cuts, with approximately 30% overstory removal, can be used to manage Douglas-fir on dry sites.

Damaging Agents

Douglas-fir is susceptible to a wide range of insects and diseases. Root rots may make trees susceptible to windthrow and heart rots can cause a serious loss of wood. Dwarf mistletoe is the most damaging stem disease. Younger trees are also

susceptible to needle cast. The Douglas-fir tussock moth and the western spruce budworm are the most important insect enemies defoliating trees of all ages. The Douglas-fir beetle can cause extensive mortality during outbreaks in its population.

Small animals consume a large quantity of Douglas-fir seeds, reducing the chance of effective natural regeneration. Wildlife browse and clip seedlings and saplings. Domestic livestock may trample and graze seedlings. High winds, snow and ice may break the tops off trees or cause blowdowns. Crown fires destroy trees of all ages, but thick bark makes older trees fairly resistant to ground fires.

Wildlife

Many species of birds and mammals consume the seeds of Douglas-fir. Deer browse the twigs and black bears sometimes strip the bark to consume the inner growing layer.

JACK PINE *(Pinus banksiana)*

Jack Pine ***(Pinus banksiana)***

Other common names: Scrub pine, Hudson Bay pine

Needles – short, flat and slightly twisted; two per cluster; stiff and spread apart; 2 to 4 cm long.

Cones – oblong to conical shaped; curved in towards the branch and directed away from the trunk of the tree; 2.5 to 7 cm long; may be green or purplish, turning yellow-brown when ripe; remain on the tree for years.

Bark – thin, reddish-brown on young trees, becoming dark brown and flaky on older trees.

Growth

Jack pine is a fast growing, small to medium sized tree, normally 20 to 25 m tall and 25 to 40 cm in diameter on good sites. It usually grows in pure even-aged stands, but can be found with other shade intolerant species like aspen and birch. It is very common from Edmonton east throughout the Prairie Provinces.

Jack pine grows on a wide range of soils, from dry, sandy sites to clay loams. It prefers moist soils that are well drained and can tolerate acidic conditions.

Uses

Jack pine wood has medium strength and hardness. It machines and finishes well. The wood is yellowish white when no heart stain is present, but red heart stain is common on old growth. The sapwood may be tan, while the heartwood is more red-coloured. The species is used for pulpwood, lumber, railway ties, power poles, fence posts and firewood. The vascular system allows chemical preservative to penetrate the wood easily, making jack pine a wood that treats very well.

Other Characteristics

Jack pine has a tap root and needles are found in pairs. When jack pine and lodgepole pine grow in close association, they will interbreed; there is a large zone of jack pine and lodgepole pine hybrids in Alberta. Parboiling the male flower clusters to remove excess resin makes them suitable for eating.

Management

Regeneration

Seed cones of jack pine are tightly closed by waxy materials. When the waxes are melted, the cones open and the seeds are released. Cones near the ground may be opened by the heat of the sun, which is critical when managing pine for natural regeneration. Fire may also release seeds. Areas burned or logged may regenerate naturally, although logged areas usually require scarification. Jack pine can also be regenerated by planting.

Culture

Jack pine is one of the most shade intolerant conifer trees and direct sunlight is required to establish seedlings. The trees will have better form if the stand thins itself naturally. They may be thinned after the stand begins to show dominance, which normally occurs when the stand is approximately 10 years of age.

Harvest

Jack pine stands mature after 70-90 years. Clearcutting is the most accepted method for jack pine harvest.

Damaging Agents

Jack pine is susceptible to a variety of pests capable of causing damage or death. Dwarf mistletoe is the most obvious damaging agent seen by the public. Many root and stem borers, leaf feeders, needle miners, root feeders and sucking insects affect the tree. The jack pine budworm, bark beetles and terminal weevils are some examples.

Diseases and fungi, such as western gall rust and Armillaria root rot, can damage or destroy jack pine. Early harvesting will help avoid heart rot and root rot problems.

Windthrow is not a serious problem, except on shallow soils or in heavily thinned stands. Spring fires, drought and flooding may kill seedlings.

White-tailed deer may kill trees up to 2 m in height, while snowshoe hares and elk may severely damage seedlings. Porcupines may cause extensive damage in older stands. Red squirrels damage the bark and will occasionally girdle trees.

Wildlife

Natural stands of jack pine are valuable to many non-game wildlife species. Plants such as blueberry, wintergreen, bearberry, and bog cranberry are associated with jack pine stands and provide food for birds and animals. Planted stands provide fewer benefits because these plants are often shaded out.

Deer use jack pine stands for food and thermal protection. Woodland caribou get much of their winter food from lichens in old growth jack pine stands. They use very open growing stands that are often not suited to timber production. Hares benefit from the dense cover of young stands. Other animals benefit as well, though deer mice and meadow voles sometimes damage young seedlings.

Jack pine is a better browse species than most other conifers, providing a medium quality deer food. Red squirrels feed on the seeds from the cones as well as the cambium. Both pine marten and fisher inhabit upland coniferous forest types.

Spruce grouse and various songbirds use jack pine stands for habitat. Jack pine also provides the main habitat for three-toed woodpeckers. Owls use stands for day roosts and hunting, and many other birds use the trees for winter food and cover.

Management for Wildlife

To maintain wildlife value, jack pine should be regenerated after harvest. Conversion to spruce will exclude many wildlife species as the trees mature.

Most wildlife species in jack pine forests prefer natural clumps of trees rather than an even canopy. Natural regeneration, aided by burning, seeding and site preparation, produces the best stands for wildlife. A broken canopy provides more edge and transitional areas, while allowing better sunlight penetration to the forest floor.

Maximum benefits for game wildlife occur when jack pine is harvested as soon as it can produce a usable product. Snags (dead trees) provide cavity nest sites, perch sites and food for insect eating birds. Small openings should be left to provide forage for various species.

Jack pine generally grows rapidly and outgrows competing vegetation. A jack pine stand containing other trees and shrubs attracts and supports more wildlife species.

Shrubs, hardwoods and other plants provide food close to the protective cover of the pines. Hardwood strips, planted for insect control, provide excellent habitat within plantations.

LODGEPOLE PINE *(Pinus contorta)*

Lodgepole Pine ***(Pinus contorta)***

Other common names: Black pine, Rocky Mountain lodgepole pine

Needles – 2 needles per cluster; often spirally twisted, needle-shaped, stiff and sharp pointed; dark green to yellowish green; 2.5 to 7.5 cm long.

Cones – cylindrical to egg-shaped; thin scales tipped with slender prickles; tan coloured; 2.5 to 5 cm long; cones are directed towards the trunk of the tree; mature cones may remain on a tree for many years; require heat to soften the resin that holds the scales together.

Bark – orange brown, somewhat scaly.

Growth

Lodgepole pine is a two needled pine found in the Cypress Hills of Saskatchewan and in large tracts of Alberta, particularly in the foothills. Tree sizes vary greatly depending on the site and stocking rate, but normally range from 18 to 24 m in height and 18 to 33 cm in diameter.

Lodgepole pine is found on a wide range of soil types and moisture conditions, but grows best on well drained loams. It is drought tolerant, but does not prefer salinity or calcium-rich soils. It can be found in pure stands, especially in the upper foothills, or mixed with spruce, aspen and white birch.

Uses

Lodgepole pine can be used for pulp and paper, lumber and firewood, or treated and used for railway ties, posts and poles. The wood is almost white, soft and straight grained, with a fine uniform texture. It is an important cover tree in shelterbelts, scenic sites and recreation areas.

Other Characteristics

Lodgepole pine is a very straight stemmed and majestic tree. The cones have sharp barbs on the seed scales. When lodgepole pine and jack pine grow in close association, they will interbreed. The wood is very resinous and will burn even when green.

Management

Regeneration

Lodgepole pine is somewhat tolerant of shade and competition. Occasionally, seedlings become established under a forest canopy, but these trees rarely do well. It may be naturally regenerated by seed or by planting.

Lodgepole pine is a 'fire species'. Its cones may remain on the trees without opening for years. Following fires that do not destroy the cones, massive seed releases result in dense stands of young trees. These stands thin themselves through competition, however, significant growth loss may occur if density is not managed.

Culture

There are many possible management scenarios and techniques for lodgepole pine. Lodgepole pine limbs are generally small in diameter and lumber yields are high. Self-thinning and natural pruning are variable; open growing stands are more limby and dense stands are more likely to self prune. Individual tree size is greatly affected by stand density. On poor sites, dense young stands may stagnate if not thinned at an early age.

Harvest

Stands generally mature at about 100 years of age, but maturity can occur in as little as 60 years. Vigorous, productive lodgepole pine forests are best maintained by regenerating even–aged stands. Clearcutting with either natural regeneration or planting is recommended.

Damaging Agents

Lodgepole pine has similar pests as jack pine. Common insect pests include the mountain pine beetle, lodgepole terminal weevil and Warren root collar weevil. Common diseases include dwarf mistletoe, western gall rust, pine stem rusts and Armillaria root rot. Young trees may be girdled by snowshoe hares.

Wildlife

Lodgepole pine provides both food and shelter for wildlife. Twigs are browsed by deer and elk, while seeds are eaten by squirrels, chipmunks and grosbeaks.

MANITOBA MAPLE *(Acer negundo)*

Manitoba Maple ***(Acer negundo)***

Other common names: Boxelder, ash-leaved maple, western boxelder

Leaves – usually 3 to 7 leaflets; coarsely serrated; bright green with lighter green below; 5 to 12 cm long, each with a short stalk.

Twigs – light green to purplish, with a polished look; buds blunt, with one or two scales, coated with fine white hairs.

Flowers – male and female flowers are on separate trees.

Fruit – a two-winged seed that may stay on the tree most of the winter.

Bark – rough, grayish.

Growth

Manitoba maple is a medium sized tree, reaching heights of 15 m or more and diameters of greater than 60 cm on the prairies. It is a fast-growing, relatively short lived tree, with a shallow, fibrous root system. The species can withstand drought and extremely cold, harsh climates.

It is the most widely distributed maple in North America and is found on virtually all soil types, along streams, in ravines and in wooded valleys. On the prairies, Manitoba maple is commonly found with green ash, bur oak, plains cottonwood and willow.

Uses

Because of its drought and cold tolerance, Manitoba maple is commonly used for shelterbelts. The fibrous root system is a good soil stabilizer for reducing erosion. It is also used as an ornamental. Seeds are an important food source for wildlife. Wood may be used for boxes, rough construction, furniture or other uses, but is relatively weak.

Other Characteristics

Sap from Manitoba maple may be used to make maple syrup.

Management

Regeneration

Manitoba maple has male and female flowers on separate trees. Trees begin to produce seeds at around 10 years of age, with prolific seed production each year. Seeds ripen through the late summer and fall, and are spread by the wind. This prolonged period allows for a variety of moisture, site and temperature combinations. One and two year old seedlings are often abundant from natural seeding, but will generally die off unless openings are provided.

Reproduction from root and stump sprouts is common. Manitoba maple readily regenerates in open areas near seed trees.

Damaging Agents

Various fungi affect Manitoba maple, causing root and other rots, along with certain stem cankers. Verticillium wilt will kill Manitoba maple. It is also susceptible to large leaf spot and powdery mildew. Another fungal disease produces a red stain in the wood of living trees, but does not damage the wood.

Insects that attack the tree include leaf-feeders, borers and scale insects, but they do relatively little damage. Box-elder bugs do not greatly damage trees, but will invade nearby houses when cold weather comes. Manitoba maple attracts aphids, which drip honeydew. Canker worms are a common defoliator in shelterbelts and urban situations.

Ice and wind damage are common in older trees. The tree has thin bark and is susceptible to fire and mechanical damage. Manitoba maple is also highly sensitive to 2, 4-D.

Wildlife

Seeds and other parts of Manitoba maple are used for food by many species of wildlife. The delayed seeding habit allows some seeds to remain on the tree throughout the winter.

TREMBLING ASPEN *(Populus tremuloides)*

Trembling Aspen ***(Populus tremuloides)***

Other common names: Quaking aspen, poplar, trembling poplar, white poplar, popple

Leaves – nearly circular, with a short point at the end; 4 to 6 cm long; fine, irregular teeth on the margin; slender, flattened stalk; trembles in the breeze.

Twigs – slender, smooth, shiny; gray-brown.

Fruit – male and female flowers found on separate trees; narrow, conical catkins split into cottony mass containing tiny, brown seeds; ripens in spring, before full leaf expansion.

Bark – thin and smooth; pale green to white; becomes gray and furrowed with age.

Growth

Trembling aspen is the most widely distributed tree in North America. It grows on almost every soil type and in a wide range of moisture conditions, but grows best on moist, well-drained, sandy or gravelly loam soils. It has fairly high nutrient requirements, particularly for calcium, and prefers a pH above 6.0. It does not tolerate flooding well and is rarely found on less than imperfectly drained sites.

Trembling aspen is a fast-growing, moderately short-lived tree. Mature trees on good sites normally range from 20 to 25 m tall and 18 to 30 cm in diameter. It often occurs in pure stands after fires, where it can act as a "nurse tree" to various softwoods. Pure stands are gradually replaced by shade tolerant slower-growing species, resulting in the mixed-wood and mature softwood stands common in the boreal forest.

While aspen may form "pure" stands, these stands usually consist of a number of clones. Clones are genetically identical, but variability between clones in such factors as stem form, rate of growth and decay, volume, and size and shape of the leaves may be significant.

Recognizing and manipulating clones may enable the manager to choose "superior" genetic material. Inventory techniques may need to be altered (for example, establishing more plots to cover a range of clones). Most clones on the prairies occupy less than one hectare, but in areas with less recent glaciation, individual clones may cover more than 40 ha.

Aspen are highly intolerant of shade and do not respond well to fire, soil compaction, or mechanical damage to roots.

Uses

The wood is white to grayish white in colour and comparable in strength to spruce. It has a wide variety of uses, including waferboard, oriented-strand board, paperboard, pulp and paper, plywood, lumber, pellets, boxes, furniture stock, flooring, fuelwood and other products. Aspen makes particularly good sauna benches and playground structures because the wood surface does not splinter.

Management

The key to aspen management may revolve around clonal types. However, aspen management is still in its relatively early stages and many important knowledge gaps currently exist.

Regeneration

Aspen is often a pioneer species and is usually the first tree to appear on unoccupied land. In the aspen parkland, where conifer trees are scarce, it is also the climax species. After harvest, fire or windthrow, thousands of suckers per hectare sprout from the old root systems. At age 2, stocking should exceed 20,000 plants per hectare.

By removing as much overstory as possible, more heat and light reach the forest floor and stimulate suckering. Even a small residual overstory will hinder suckers, making them smaller, less vigorous and produce a much lower stocking rate. A thick duff layer may also hinder suckering. Suckering is not significant at northern latitudes where the temperature remains cold, or in undisturbed forests, but is very vigorous on disturbed sites.

Culture

Natural pruning is excellent and aspen thins itself through competition, insects and diseases. No additional thinnings are needed for pulpwood production, while one or two treatments may increase the yield and hasten harvest for sawlog and veneer production.

Good sucker densities will only happen where sufficient root mat exists. The presence of heavy shrub cover would suggest an insufficient root mat. Weeding may be necessary to remove shrubs and encourage better suckering.

Harvest

Clearcutting is the recommended method of harvest, followed by full-tree or tree-length skidding, which helps eliminate competing vegetation for the regeneration. Light to moderate slash left on the ground will not discourage suckering, but decays quickly and provides nutrients for the next stand.

Site preparation should be avoided, as it reduces the vigour of suckers and damages the root mat. This damage may show up years later, in the form of premature stand mortality and an increase in wood stain, from fungal pathogens that infect the damaged roots.

When stands reach maturity they begin to "break up". This may occur as early as 50 years of age on marginal sites or past 70 or 80 years of age on better growing areas. Harvesting when the stand is just reaching maturity will encourage prolific suckering. After maturity, trees begin to die, stand volume and quality declines and shade tolerant species start to take over.

If there is a lack of shade tolerant species, stands may revert to species from earlier successional stages, like willows or alder. Overmature stands may be successfully underplanted to shade tolerant species, like spruce.

Aspen cut from late fall to early spring tend to sucker more vigorously. Possible reasons for increased suckering may be high levels of food stored in the roots, plus the lack of soil compaction and root abrasion when harvesting on frozen ground.

After harvest

Properly managing trails and landings can enhance wildlife, aesthetics and recreation opportunities. Logs and limbs in the landing can be used for firewood or burned. A native seed mix can be broadcast on trails and the landing, to attract wildlife and reduce erosion. For enhanced timber production, all remaining trees should be cut or killed, however snag trees are desirable for wildlife and should not seriously reduce suckering.

Damaging Agents

Trembling aspen are susceptible to a variety of damaging agents. More than 300 insect species use aspen as a host, but only a few are serious pests. Insect pests are grouped into defoliators, borers and sucking insects.

Forest tent caterpillar and large aspen tortrix are defoliators and may severely reduce growth rates over large areas of infested aspen. Few trees die, unless under other stresses such as drought, but it may take 3 or 4 years for total growth recovery.

Leaf miners and leaf beetles feed on the foliage as well. Aspen bark contains some chlorophyll, which can account for up to two per cent of the tree's energy requirements. This may be a survival mechanism against defoliators. Stem borer insects weaken trees, provide entry points for various diseases and disrupt nutrient and water movement. Aphids and leafhoppers are the most common sucking insects.

The most common diseases include the fungal stem pathogen Hypoxylon canker, various root and stem decays and staining fungi. Hypoxylon canker infects trees of all ages. Young and medium aged trees that are suppressed or under stress, mature trees and overmature trees are all susceptible.

False tinder conk produces decay in the heartwood of trees nearing maturity, so harvesting before maturity may be an option. External indicators, such as conks or weeping, need not be present for rot to be extensive. If they are present, rot likely will be extensive. The degree of rot is related to site, stand history and genetics. Each site should be assessed individually.

Beavers, porcupine, mice and hares all feed regularly on aspen, injuring young and more mature stands. Deer, elk and moose browse young plants. Older trees may be used as antler rubs, or have their bark opened to infection by moose and elk "toothing" the trunks.

Overgrazing by cattle, sheep or big-game animals disturbs roots, compacts soil and can greatly reduce the number of aspen trees by reducing growth and promoting decay. Cattle heavily grazing young stands for three years in a row may destroy them.

Wildlife

Aspen is an extensive and valuable species that is easily managed for wildlife. Shrubs and other plants associated with it provide excellent food and shelter for many wildlife species. Wildlife shows an immediate response after harvest.

White-tailed deer are attracted to slash twigs, then return to feed on the newly sprouting sun loving plants and hide in the thicket of aspen suckers. Moose, elk, deer, hare and beaver prefer this high quality browse species when available. Ruffed grouse find food and shelter in young aspen stands. Young stands, used for food, are especially valuable if they are under 4 hectares in size and if medium and mature stands, which are used for shelter and nesting, are found nearby.

Management for Wildlife

Managing aspen for timber production benefits most wildlife species. Wildlife abundance depends on the age of the stand. By managing the stand to keep 25% of the aspen in each of four age classes; 1-15; 15-30; 31-45 and 45+ years, more wildlife species will be suited for the area.

Ruffed grouse benefits most when clearcuts are in blocks of one to four hectares, creating maximum age diversity in small areas. Deer benefit from cuts less than 8 ha, while clearcuts for moose may be greater than 18 ha.

If there are recent clearcuts nearby, cutting may be delayed until the adjacent sites reach the 15-30 year age class. On cuts larger than 8 ha, retaining clumps of mature male aspen (distinguished in late winter by large buds) provides a winter food supply for grouse. To enhance wildlife habitat, walk the stand and mark any special interest trees before harvest. These could include: trees with cavities for nesting or denning; any dead tree, if still sound; large trees near water, for eagle nest trees; clumps of nut or fruit shrubs; an especially aesthetic tree.

It should be noted that each tree saved may reduce aspen production, through reduced sucker numbers and vigour, because of the shade the tree produces. Ten to fifteen snag trees per hectare, of varying sizes, should be left for non-game birds. The best snags are alive but have rotten centers. Slash piles provide habitat needs for birds, snakes and salamanders.

Some wildlife species, like the pileated woodpecker, require older, overmature aspen stands for habitat.

WHITE BIRCH *(Betula papyrifera)*

White Birch ***(Betula papyrifera)***

Other common names: Paper birch, canoe birch, silver birch

Leaves – oval or heart-shaped; double-toothed; 5 to 10 cm long, 2.5 to 5 cm wide, dull on top, pale and downy underneath.

Fruit – 'cone'-type hanging cylinder; 4 to 5 cm long.

Twigs – dark, reddish-brown; slender; no wintergreen taste.

Bark – thin, smooth and papery; reddish-brown, turning white with age; peels easily.

Growth

Birch is a medium sized, fast growing tree, normally reaching heights of 6 to 20 m and diameters of 10 to 45 cm. It grows on most soil types and in most moisture conditions, from sand dunes to heavy organic and acidic 'bog' sites.

It is not drought tolerant and grows best on moist, well-drained sandy or silty-loam soils.

Birch is found in pure stands as a pioneer species, or mixed with aspen and other hardwoods. Pure stands may gradually be replaced with conifer stands. As the conifers age and openings appear, birch may become re-established.

The roots of birch trees are sensitive to changes in soil temperature and rapid increases can kill the roots, causing death of the tree. A high tolerance to acid soils makes birch a good choice for revegetating certain mine spoils.

Uses

Birch can be used for lumber, veneer, furniture and firewood. It is an important wildlife browse species and its appearance makes it a valuable ornamental. The quality of the bark lends itself to use for craft purposes. Birch may be tapped for syrup production.

Management

Regeneration

Birch is a shade intolerant tree and requires full sunlight for best growth. It often only lasts one generation and is then replaced by more shade tolerant species. Regeneration occurs through natural seeding and stump sprouts. Clearcutting encourages dense regeneration in pure stands. Unlike aspen and poplar, white birch is not clonal.

Culture

Once established, a birch stand needs no intermediate treatments. Individual trees express early dominance and the suppressed trees soon die, which provides a type of natural thinning. Birch trees are short lived and decay very rapidly when dead.

Harvest

On poor sites, birch should be harvested after 60 years or less, then restocked with species more suited to the site conditions. Good sites may be held up to 80 years. Stands should not be held too long, as growth will decrease and the stand will deteriorate rapidly.

Clearcutting is recommended on pure stands. The dense regrowth helps to keep the soil temperature down. Shelterwood harvesting is also recommended, as the residual trees shade the ground and keep soil temperatures down. In mixed stands, species composition is the deciding factor. If birch is mixed with low quality species, it should be favoured. If mixed with high quality and high value species, it may be best to remove birch from the stand.

Damaging Agents

Birch is susceptible to a variety of root and stem diseases. Birch leaf miner species cause early leaf fall and weaken the tree. Trees under drought stress may develop top dieback and become susceptible to bronze birch borer. This insect may increase the injury and eventually kill the tree. The bark of birch contains volatile oils which are flammable. Even moderately hot fires can kill large trees.

Moose and deer browse birch seedlings and this may reduce the quality of younger stands by reducing the stocking rate. Mice and hares may damage seedlings, while porcupines damage larger trees by feeding on the inner bark. Sapsucker holes also damage trees and provide access for disease and decay.

Wildlife

White birch stands, including the understorey, are similar to aspen and are often excellent wildlife habitat. Birch is a preferred browse for moose. Deer and hares also browse birch, along with other shrubs in the understorey. Various songbirds are found in birch stands, depending on the age of the stand. In winter, catkins of mature birch provide food for sharp-tailed grouse and grosbeaks.

Management for Wildlife

Small clearcuts of one quarter to four hectares ensure age diversity within the stand and provide abundant browse. Scattered, uncut snag trees rot quickly, providing habitat for insect-eating birds.

Scattered birch stands found within large conifer stands are important browse areas for moose and deer. These types of stands may be encouraged by clearcutting and allowing natural regeneration to occur.

EASTERN COTTONWOOD *(Populus deltoides* ssp. *deltoides)*
PLAINS COTTONWOOD *(Populus deltoides* ssp. *monilifera)*
POPLAR HYBRIDS *(Populus* ssp.*)*

Eastern and Plains Cottonwood ***(Populus deltoides)***

Other common names: Various regional names. Hybrids may be produced under specific names; i.e. Brooks #6, Griffin, Northwest.

Leaves – 5 to 10 cm long; bright, shiny green above, paler below; eastern – almost equilateral triangle shaped; plains – more broad than long, smaller and more coarsely toothed; have long, smooth, flattened stalks.

Fruit – oval, tapering pods on flexible stems.

Twigs – stout; yellow-green; buds are resinous and stick out from the twigs.

Bark – smooth, yellow-gray on young trees; gray and deeply furrowed on mature trees.

Growth

Eastern cottonwood is a large, fast-growing, but short-lived tree. It may reach heights of 20 to 30 m and diameters of 60 to 120 cm. It is generally found east of the prairies. Plains cottonwood is classified as a separate species by some and as a subspecies of eastern cottonwood by others. It is found across the southern prairies, especially near rivers and streams.

Plains cottonwoods grow best on deep, rich, well-drained loams. Sufficient moisture is necessary for optimum growth. It may occur in pure stands, or in association with various hardwoods.

Poplar hybrids are the result of natural or manmade crosses among poplar species. Different crosses provide different growth characteristics, and some hybrids have tremendous growth rates. They generally grow best on deep, medium-textured soils with good moisture holding capabilities. Hybrid poplars may be less tolerant of harsh winters than local poplar species.

Uses

Plains cottonwoods are used as fast-growing shelterbelts and windbreaks. The wood may be used for pallets, rough construction, interior parts of furniture, boxes and wood pulp. Other possible uses include roughage for animal feed and stock for biomass operations.

Hybrid poplars are planted for pulpwood, energy uses, erosion control and in areas where fast-growing trees are needed.

Other Characteristics

The protein-rich leaves of cottonwood have a greater amino-acid content than wheat, corn, rice or barley.

Management

Regeneration

Plains cottonwood is a prolific seed producer. Seeds have a cotton-like tuft of hair and are dispersed by wind and water. Full sunlight, freedom from competition and abundant moisture are necessary to ensure establishment. They establish easily from stem and root cuttings.

Culture

Plains cottonwood and poplar hybrids are very intolerant of both shade and root competition and require full sunlight for maximum growth. Plains cottonwood is usually a pioneer species, which is gradually replaced by other broadleaf tree species. It does not normally regenerate until the overstory breaks up. For hybrid popular, weed, grass and shrub competition must be controlled for the first two years, to aid in establishment.

Damaging Agents

Leaf rusts and stem cankers are the most damaging diseases. Defoliators like the forest tent caterpillar, gall mites and boring insects damage the wood and cause loss of vigor.

Wildlife

Moose and deer often browse poplar species. Buds and catkins are important food sources for several songbirds and game birds.

BALSAM POPLAR *(Populus balsamifera)*

Balsam Poplar ***(Populus balsamifera)***

Other common names: Poplar, black poplar

Leaves – egg-shaped, tapers to a sharp tip; 6 to 15 cm long; fine toothed margin; shiny dark green above; whitish-green below; bottom may be stained with resin; fragrant.

Fruit – egg-shaped pods 6 to 8 mm long; split into cottony mass containing tiny seeds.

Twigs – smooth; reddish-brown; resinous and fragrant; lateral buds pressed against the twig.

Bark – smooth, greenish-brown on young trees; dark gray and furrowed on older trees, with flat-topped ridges.

Growth

Balsam poplar is a fast growing medium-sized deciduous tree, usually 9 to 25 m tall and 30 to 70 cm in diameter. It is adapted to a range of soil textures and moisture conditions, from well drained to poorly drained or waterlogged. It does best on rich, moist, low-lying ground, preferring moister ground than aspen. It does not grow well on organic bog sites. Balsam poplar can be found in pure even-aged stands, or mixed with various hardwood and softwood species.

Balsam poplar has low shade tolerance, rapid juvenile growth, good self-pruning, and a relatively short life span. It is a common early successional species and is later replaced by more shade tolerant species such as white spruce.

Uses

The wood from balsam poplar is similar to that of trembling aspen, except for a coarser texture and a higher incidence of wet pockets. It is well know for its dark brown heartwood. The widespread availability of aspen means that balsam poplar is less often used for fibre, lumber products and pallets. Balsam poplar generally has straighter stems than aspen. It may be used for rails, though balsam poplar rails are not as good as pine rails. It is a common natural shelterbelt tree on the prairies and is a useful browse and cover species for game.

Hybrids of balsam poplar are being tested in short rotation, intensive culture plantations, for pulpwood and other products. Under proper management, some hybrids may yield 3-4 times the output of native aspen while providing pulpwood of acceptable quality. However, winter hardiness has been a significant problem with hybrid poplar.

Management

Regeneration

Balsam poplar reproduces naturally from seed and has prolific root suckering abilities. It may be artificially regenerated from seedling transplants, root cuttings and stem cuttings.

Culture

Identical to aspen.

Harvest

Similar to aspen. Clearcutting is the preferred harvest method.

Damaging Agents

Several defoliator insects, including the forest tent caterpillar and some wood boring and gall forming insects, are the most common insect pests. Leaf spot, rust and various stem and root rots are the main diseases.

Animals browse on poplar stem material, but eat little foliage. Beavers frequently cut balsam poplar growing near watercourses, but given a choice, prefer aspen. As balsam poplar grows older, the bark thickens and it can tolerate moderately intense fires.

Wildlife

Balsam poplar is used extensively by beavers. Moose, deer, elk and other animals will browse stem material, but eat little foliage. Ruffed grouse may feed on the buds in the winter.

Trees and Shrubs for Wildlife Habitat Plantings

Blueberries *(Vaccinium spp.)*

Blueberries are found throughout the boreal forest (commonly with jack pine) on dry muskegs and sandy soils. On wet sites, blueberries may indicate acidic soil conditions. The berries usually ripen by mid-August. Blueberries grow in dense patches as a low, branching shrub, up to 40 cm tall. They are an important food source for many species of wildlife.

Thorny Buffaloberry *(Shepherdia argentea)*

Thorny buffaloberry is native to the southern parts of the prairies. It prefers moist areas, such as river valleys and wetland margins and will tolerate salinity, drought and some spring flooding. It produces a bushy shrub up to 5 m tall. Clusters of fruit, which vary from scarlet to orange, ripen in July and August. Thorny buffaloberry is an important winter food source for game birds and other species. It provides escape cover and is a minor browse species.

Choke Cherry *(Prunus virginiana)*

Choke cherry is native to the prairies and is commonly found on bluff borders, along fence lines and on riverbanks. It does best in moist, well-drained areas, but is moderately drought tolerant. It reaches heights of 7 m in 20 to 25 years. Fruit matures from late July to early September.

Figure 12: Grouse and songbirds relish the choke cherry fruit. Twigs are browsed by white-tailed and mule deer. Foliage can be toxic to cattle.

Cranberries *(Vaccinium vitis-idaea* (bog), *Viburnum opulus* (high-bush), *Viburnum edule* (low-bush))

Three species are present on the prairies; high-bush, low-bush and bog (dry ground) cranberry. Bog cranberry has the widest distribution. Low- and high-bush cranberries prefer moist hardwood or mixedwood sites, while bog cranberry is most commonly found in association with jack pine. Cranberries are important food sources for a variety of wildlife species.

Red-osier Dogwood *(Cornus stolonifera)*

Red-osier dogwood is a native shrub, commonly found in woodlands, coulees and by water courses. It is adapted to most areas of the prairies and will grow up to 3 m in height. Bright reddish branches make it conspicuous in winter as do white berries in the summer. Dogwood is a preferred browse species of deer, moose and hares. It provides dense cover as its main value to wildlife. The fruit provides food for robins, waxwings and game birds.

Red Elder *(Sambucus racemosa)*

Figure 13: Red elder flowering

Native stands of red elder are found in abundance in moist areas of the prairies. This fast-growing species can reach a height of 4 m. It will tolerate saturated soils, but is not drought resistant. It reproduces from seed, suckers and layering branches. The berries of red elder are bright red and conspicuous. They provide food for songbirds, game birds and squirrels. It is of moderate importance as a browse species to moose and deer.

Hawthorn *(Crataegus spp.)*

Hawthorn is a wide spreading, bushy shrub or tree, bearing stout thorns on its branches and stems. It will grow nearly anywhere and is often found on coulee slopes, in river valleys and in open woods. Plants can range from 1.5 to 7.5 m tall, with fruit resembling small apples. The fruit often remains on the plant throughout the winter. It is consumed by song and game birds, while leaves and shoots provide forage for deer and hares. The thorny branches deter nest predators, making hawthorn an important species for loggerhead shrike, ruffed grouse, brown thrashers, robins and mourning doves.

Hedge Rose *(Rosa gallica)*

The hedge rose was introduced to Canada from Asia. It may reach a height of 2 m and produces an oblong hip up to 2.5 cm long, brick red in colour. Hedge rose provides excellent nesting, loafing and winter cover for many thicket-dwelling birds. The hip is a favoured food of sharp-tailed grouse and pheasants, while the shrub is browsed by white-tailed and mule deer.

Russian Olive *(Elaeagnus angustifolia)*

Russian olive is a drought hardy, alkaline soil tolerant shrub or small tree introduced from Eurasia. It will reach a height of 7 m on the prairies, but seldom lives longer than 20 years. The silver coloured fruit is drupe-like and contains a large seed. The fruit provides fall and winter food plus excellent cover and protection for songbirds, pheasants, waxwings and sharp-tailed grouse, but has little value as a browse species. It grows rapidly, providing early protection for new plantings.

Saskatoon *(Amelanchier alnifolia)*

Saskatoon is a native shrub common throughout the prairies. It grows well on a variety of soils and has a moderate tolerance of salinity. It thrives in both sunny and shaded areas and is drought tolerant once established. The species may be difficult to establish and grows fairly slowly. It reaches a height of 3-5 m at maturity. The purple berries usually ripen in July. Saskatoon provides cover, nesting and roosting opportunities for several bird species. The berries provide food for numerous song and game birds, along with white-tailed and mule deer. Hares browse the twigs.

Sea buckthorn *(Hippophae rhamnoides)*

This small, drought resistant shrub is well adapted for growth on sandy soil and steep slopes. It will reach a height of up to 5 m. Male and female flowers are produced on separate plants and both are required for fruit production. The yellowish-orange berries may remain on the tree through the winter. The berries are an important food for pheasant and other game birds. Deer browse the foliage and twigs.

Siberian Crabapple *(Malus baccata)*

Siberian crabapple is a vigorous, cold and drought hardy tree introduced into Canada and well adapted to most areas of the prairies. The tree may reach a height of 9 m on good sites. The dense growth provides high quality cover for roosting, loafing and nesting birds. The small, red or yellow berry-like fruit remains on the tree well into the winter, providing food for songbirds, game birds and squirrels.

Western Snowberry **(Symphoricarpos occidentalis)**

Snowberry is a medium sized shrub that grows up to 1 m in height and produces clusters of white berries by late August. It grows on well- to moderately well-drained sites in the open or under aspen or mixed aspen and white spruce. The fruit and foliage provide an important food source for a variety of wildlife species.

Selected Readings

A Field Guide to Western Trees. George Petridges.

Identification Guide to the Trees of Canada. Jean Lauriault. National Museum of Natural Sciences.

Manual of Plant Species Suitability for Reclamation in Alberta. Alberta Land Conservation and Reclamation Council.

Plants of the Western Boreal Forest and Aspen Parkland. J. D. Johnson et al.

Shelterbelt Varieties for Alberta. Alberta Agriculture; Agdex 277/33-1

Silvics of North America: Volume 1 – Conifers; Volume 2 – Hardwoods. USDA Forest Service.

Trees in Canada. John Laird Farrar

Trees and Shrubs of Alberta. Kathleen Wilkinson

Woodlot Management Planning

Contents

Criteria and Indicators of Sustainable Forest Management for Woodlot Management Planning

The activity of management planning does not in itself contribute to sustainable forest management, however the contents of the plan may have considerable impact. The process of developing and implementing the plan may also influence the sustainability of the woodlot. Following is a brief description of the Criteria for Sustainable Forest Management and some Indicators of accomplishment related to woodlot management planning.

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes found throughout the woodlot and surrounding landscapes. Indicators of accomplishment include:***

- The community, including the aboriginal community, is consulted about cultural, historic, or geological sites of special interest to these groups. The groups' concerns are identified in the management plan.

Criteria 2: ***Ecosystem condition and productivity. The management plan is focused on maintaining the health, vitality, and biological production of the woodlot. Indicators of accomplishment include:***

- The plan identifies or anticipates hazards and describes strategies to reduce the risk of loss to fire, insects and disease.

Criteria 3: ***Soil and water. Soil and water resources are conserved by maintaining their quality and quantity within the forest ecosystem. Indicators of accomplishment include:***

- The management plan includes detailed maps and photos showing permanent and intermittent water bodies, watercourses, and their riparian buffer zones and identifies these as areas requiring special treatment.
- Operational plans include consideration for conservation and protection of soils and water on the woodlot and on adjoining properties.

Criteria 4: ***Role in global ecological cycles. The plan specifies management activities that contribute to the health of global ecological cycles. Indicators of accomplishment include:***

- The management plan maintains a woodlot as a productive forest that contributes to carbon sequestration.

Criteria 5: ***Economic and social benefits. The community at large benefits from market and non-market goods produced by a woodlot. The management plan includes multiple benefits to present and future society. Indicators of accomplishment include:***

- The management plan includes provisions to manage for both timber and non-timber products and market and non-market goods.

Criteria 6: ***Society's responsibility. The woodlot owner recognizes society's responsibility for sustainable forest management. The community's interests are given full consideration during the development and implementation of the management plan. Indicators of accomplishment include:***

- The community is made aware of the management plan and is given the opportunity to comment on the plan's contents.
- The plan adopts best management practices with sustainable forest management as a primary goal.

Introduction

People own and use woodlots for many varied reasons. Some reasons are economic, such as harvesting timber or firewood, or collecting non-timber forest products such as wild fruit or mushrooms. Other reasons for ownership are related to the environment, such as developing and maintaining wildlife habitat, enjoying the aesthetics of forested land, or using the land for recreation. Most owners have multiple reasons for owning woodlots, and at times, some of these reasons may appear to be in conflict. Regardless of why woodlot owners choose to invest in forested land, the reasons for ownership form the objectives for the woodlot. A plan that clearly articulates these objectives and outlines how to achieve them will help to ensure the owner's reasons for owning the woodlot are satisfied. In addition, once objectives are clearly articulated, a plan can be developed to outline how these objectives will be met, conflicting issues can be resolved, costs of achieving the objectives can be determined, and priorities can be established. This sequence forms the basis for the woodlot management plan.

Steps to Woodlot Management Planning

Creating an effective woodlot management plan requires technical knowledge and time commitment to develop the plan and resources to implement it. The following five steps summarize the management planning process:

Step 1: Setting Goals and Objectives

An objective is something to strive for while a goal is something to achieve. Articulating the goals and objectives will help the woodlot owner better understand how the different objectives can be met and what goals can be realistically set and achieved. These goals and objectives should be clearly established before the management plan is developed.

The objectives defined in the management plan must reflect the woodlot owner's needs and desires and the goals must contribute to meeting those needs. The exercise of setting goals and objectives will give the landowner insights into the interaction of goals and objectives, identify and possibly resolve conflicting objectives and related goals, and help to prioritize different activities.

The woodlot owner's needs will include economic, social and environmental aspects of owning the woodlot. Economic goals relate to income flows and/or returns on investment. Is the income desired immediately, or later, in one payment, or as an income stream over a period of time? Environmental goals focus on maintaining or enhancing the non-consumptive uses of the land. Such objectives as protecting and conserving riparian zones, planting fruit trees for winter food for wildlife, or identifying and protecting special sites that support endangered plant species are examples of goals that are focused on the environment. Social objectives recognize that woodlot owners are stewards of the land and have a responsibility to society to manage that land for a wide range of benefits.

The goals and objectives may be numerous and some may not seem compatible, however, all should be defined in the management plan. Examples of common woodlot owners' goals are:

- Wildlife habitat creation, protection or enhancement
- Recreation and eco-tourism
- Soil and water conservation and protection
- A complement to agricultural crop production
- Timber production
- Special forest products (berries, mushrooms, willows for wreaths, etc.)
- Source of income
- Investment
- Forage production
- Aesthetics

Step 2: Identifying Resources

The resources needed to achieve the stated goals and objectives must be assessed. This assessment might include a woodlot inventory, an evaluation of financial resources, equipment and labour requirements, and technical assistance.

Obtaining an inventory of the woodlot resources is a key step in the planning process. A detailed discussion of the woodlot inventory is provided elsewhere in this Guide. The woodlot inventory can be used to collect a wide range of information such as timber and vegetation characteristics, soil types, abundance and type of wildlife, topography, roads, locations of water bodies and other features of the landscape. The woodlot owner's objectives and the type of inventory that is needed to meet those objectives will determine the information that will be collected and how detailed the inventory will be. Regardless of the type of inventory that is undertaken, maps are essential tools in the development of the management plan.

Maps: Much of the information needed to conduct a forest inventory or to represent information collected from an inventory can be presented on maps. Forest management plans should include several maps, the number and type again depending on the objectives of the inventory. The basic map should clearly identify the boundaries of the property and show Section, Township and Range. The woodlot owner must know the location of the boundaries of the property, the legal description and any other legal agreements before beginning the inventory or management plan. If boundary locations are not known, a Land Surveyor may be required. Aerial photographs at a scale of 1:20,000 are helpful and, if current, may at times be more useful than maps to locate features. Figure 14 illustrates an aerial photograph of a property containing some forestland. Other maps that might be needed are forest cover maps, topography maps and soil maps. Maps are useful tools in understanding the variety of features and resources present on the woodlot.

Figure 14. Aerial photograph of a section of land.

Source: Ag-Canada – Prairie Farm Rehabilitation Center

Ecological information: Information that could be pertinent to an inventory could include soil types, drainage and topography, climate, and eco-regions. Additional information on ecological topics is available on the Internet at the following sites:

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6303 - Soils and ecoregions in Alberta

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6903 - Alberta Soil Information Centre

http://www.waterforlife.alberta.ca/02645.html - Watershed Support Material and
http://esrd.alberta.ca/fish-wildlife/species-at-risk/default.aspx - Publications Alberta Species at Risk

Woodlot inventory data: The woodlot owner may require data from an inventory to meet a variety of objectives for the woodlot. Some woodlot owners may only need a walk through the property to formulate the objectives and develop a simple management plan. Others may need a detailed forest inventory where information is collected on timber growth and yield with the intention of harvesting trees and reforesting cutovers. Still others might need a detailed description of the plant species, their locations and abundance. An inventory of sufficient detail to satisfy the goals and objectives for the woodlot is an essential component of the management plan.

Financial resources: The revenues and expenses must be estimated for the woodlot operations. If the objectives include income from the woodlot, either lump sum or periodic payments, the amounts must be estimated to determine if financial support is required and the cost of that support. Examples of cost items in a woodlot operation where harvesting timber is the objective are labour and equipment to conduct the harvest and to reforest the logged site. Carrying charges for financing operations must also be included in cost estimates. Financial aspects of operating the woodlot should be discussed with financial institutions or financial advisers to determine the economic viability of operating the woodlot.

Labour, equipment and time: The availability of labour and equipment should be given full consideration during the planning process. This item can be critical if the woodlot owner will schedule several activities on the woodlot, or the activities are season dependent. Locally available equipment and labour may be in high demand due to seasonal work and may not be available to the woodlot owner without prior planning.

The availability and need for these resources must be given consideration when developing the management plan. Once the resources are identified, actions to assess how these resources will be obtained can be determined.

Step 3. Developing the Plan

A management plan could be formal or informal. An informal plan is usually the result of a walk through the woodlot with an Extension Specialist or forestry consultant and may consist of general observations about the woodlot and notes on objectives and planned activities. Such a plan is a valid tool in woodlot management provided it is formalized to the written stage, can adequately guide the woodlot owner to achieve his/her objectives, and is readily accessible to the woodlot owner for reference from time to time. A formal plan may be more complex and contain considerable detail on the goals and objectives, resource characteristics, planned activities, numerous maps and other information of interest.

In general, a management plan will include information on the following items:

- A description of the goals and objectives.
- A description of the woodlot resources including information collected during the inventory. Examples of this information could be timber volumes for different forest stands in the woodlot and expected growth rate for those stands.
- A description and related schedules for long and short term activities that achieve the goals and objectives for the woodlot. Examples of goals and related activities may be a harvest schedule for different stands identified in the inventory to address the goal of income flows.
- A records section showing revenues, expenses, costs of harvesting and reforestation, volumes harvested, and other information.
- Maps. A variety of maps could be included depending on the level of detail in the management plan.

The management plan can be simple and as short as two or three pages or it can be longer and more complex. The plan may be developed to achieve a specific goal such as timber production but should still be consistent with the overall objectives for the woodlot. In many cases, the woodlot owner plans for a variety of activities to address a range of objectives. The result is an Integrated Resource Management Plan (IRM), that is, a plan that addresses a number of resources on the woodlot simultaneously or in an integrated way, rather than in isolation from one another. An IRM approach to woodlot management will help to identify and possibly mitigate conflicting objectives and related activities. More complex plans, where a number of interrelated activities and resources are involved, may require the assistance of forestry practitioners such as professional foresters or woodlot extension specialists.

Step 4. Implementation and Monitoring

The management plan should be developed with the intention that it be implemented. Unless the plan is consulted regularly, it will not serve its purpose. A potential consequence of not following the schedules and activities described in the plan is that objectives will not be met. Even the best management plan is worthless if it is not implemented. Another aspect of the plan is to monitor adherence and determine if the plan is still relevant in view of current objectives (which may change over time) and woodlot conditions, particularly conditions that affect the feasibility of certain activities. For example, harvest plans based on a forest stand that has been destroyed by wildfire are no longer relevant. The plan may need modifications to accommodate changes to the current condition.

Step 5. Plan Adaptation

The management plan allows the woodlot owner to establish an efficient process and avoid unnecessary costs, delays and mistakes. However, a management plan should also be flexible. Changes in some of the woodlot's resources, management techniques, markets, weather, or other factors may mean parts of the plan must be adjusted to accommodate the changes. New developments must be incorporated into the plan from time to time to reflect the current status. The plan's flexibility facilitates its adaptation to current conditions and allows it to evolve as the woodlot evolves.

Woodlot owners vary in their management practices. Some take a passive approach and prefer to leave their woodlot as it is and assume an evolving woodlot will continue to meet their objectives. Others (such as shown in the example of a management plan in British Columbia) conduct active forestry work such as thinning, reforestation, or timber harvesting. Whichever approach the woodlot owner chooses to adopt, a management plan will help to identify what needs to be done now to achieve desired goals and objectives in the future – either a few days or many years from today. A plan that is practical, realistic and leads to actions is a plan that will meet the needs of the woodlot owner.

Beneficial Management Practices

- Establish clear goals and objectives for the woodlot to meet the owner's needs.
- When formulating goals and objectives, those that appear to be in conflict with one another should also be included.
- Ensure all legal boundaries have been established and any legal agreements that might affect the land are clearly understood before starting the planning exercise.
- Identify the resources needed to develop a plan relevant to the owner's needs. Resources include woodlot resources, financial resources, equipment and labour requirements, and technical assistance needed.
- Include a woodlot inventory that has a sufficient level of detail to meet the woodlot objectives.
- Utilize current maps and aerial photographs to represent resources and physical features of the woodlot. Update maps and photos as required.
- Formalize the plan as a written document that is easily understood and easily accessible.
- Develop a management plan that is flexible to accommodate changing woodlot resources, evolving objectives, and other changes.
- Use an integrated resource management approach to planning to accommodate the management of multiple resources and resolve conflicting objectives.
- Monitor the level of adherence to the plan and record activities that demonstrate adherence.
- Maintain records of all activities on the woodlot and include these records as part of the management plan.
- Consult or utilize the services of forestry professionals, extension specialists, financial advisors, and others trained in management planning.

Selected Readings and Internet Sites

Internet Sites

http://www.agric.gov.ab.ca/ - Agriculture and Forestry

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6303 - Soils and ecoregions in Alberta

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6903 - Alberta Soil Information Centre

http://www.waterforlife.alberta.ca/02645.html - Watershed Support Material and
http://esrd.alberta.ca/fish-wildlife/species-at-risk/default.aspx - Publications Alberta Species at Risk

Publications

Managing your Woodland: A non-forester's guide to small-scale forestry in British Columbia. This publication provides a sample of a woodlot management plan for a family owned property in British Columbia. That plan is only about 4 pages in length yet clearly describes the owner's objectives, the property's resources, and the planned activities. The book is available on the Internet as a PDF file at: http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/20291.pdf.

The Woodlot Inventory

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to the Woodlot Inventory are:

Criteria 1: ***Biological diversity. Conservation, maintenance, and enhancement of biological diversity by recognizing the range of sites and their contribution to maintaining the integrity of the ecosystem both within and adjacent to the woodlot. Indicators of accomplishment include:***

- Forest inventory includes area of the forest by type and age class and wetlands in each ecozone. Additional land features such as soil type, geomorphologic highlights or endangered plant or animal species are identified, in order to enhance the forest inventory as a biological diversity planning tool.
- Contact with local authorities and aboriginal groups to gather information on special sites within the woodlot.
- Identification of special sites specific to any endangered species or sites of special significance to the local community including the aboriginal community.

Criteria 2: ***Ecosystem condition and productivity. Conservation of the forest ecosystem condition and productivity by monitoring, through an inventory program, the health, vitality and rates of biological production. Indicators of accomplishment include:***

- Total growing stock of both merchantable and non-merchantable tree species is inventoried.
- Changes in forest area and the cause of such changes are recorded.
- Permanent sample plots are re-measured periodically to provide an indication of forest growth rates including forest regeneration, mortality trends, incidence and extent of new species and declining numbers of existing species.

Criteria 3: ***Soil and water. Conservation of soil and water resources by maintaining current records such as maps and aerial photographs of watercourses, water bodies and soil types. Indicators of accomplishment include:***

- Forest inventory maps showing location of water bodies, watercourses, and soil types within forested and unforested areas.
- Riparian zones identified in the forest inventory and classified as sensitive areas.
- Erosion prone areas identified.

Criteria 6. ***Society's responsibility. The woodlot owner accepts society's responsibility for sustainable development. The forest inventory can contribute to this criterion by providing information that will lead to fair, equitable and effective forest management decisions. Indicators of accomplishment include:***

- Consultation with the community including the aboriginal community when the forest management plan is developed, and resulting satisfaction by participating groups.
- Coverage, attributes, frequency and statistical reliability of forest inventories.
- Availability of forest inventory information to the public.

Introduction

Knowledge and understanding of the woodlot's resources are essential to develop a realistic and practical plan for the woodlot. The inventory is an important tool to collect and assemble woodlot resource information needed to develop this plan. Information on trees, land, and any other characteristics that could affect management and long-term use decisions is collected during the inventory.

Conducting an inventory is the first step to develop a management strategy for the woodlot. An inventory is usually concerned with more than just the timber resources. A wide range of information may be collected, including soil characteristics, topography, wildlife habitat, water, roads and other features. Information on vegetation may include tree species, size and volumes as well as understorey species and any unique or rare vegetation.

The level of information collected can range from broad to very detailed, depending on the resource concerned and its planned final use. A highly detailed inventory may not be needed for many small woodlots. A quick walk-through may provide enough information to set goals, while a more detailed inventory may be necessary to determine the timing of harvest or other management activities. The more information that is assembled, the more useful the inventory will be when developing management options for the woodlot.

Steps to Conducting an Inventory

The woodlot has both timber and non-timber resources that can be inventoried. Non-timber resources could include products such as mushrooms, wild fruit, recreation or wildlife. This section will focus on inventory methods for timber resources, although many other resources could also be included during this inventory phase. The following is an outline of steps to follow to conduct a forest inventory.

Determine the inventory goals. Establish the goals and objectives for managing the woodlot. Determine the woodlot characteristics likely to impact those objectives and the information required to inventory the relevant characteristics. The original goals may change with improved knowledge of the resources present.

Assemble available information about the woodlot. Obtain existing information for the woodlot area from municipal and provincial government agencies or possibly from local forest industry firms. These agencies or firms may have information such as soil, topographical or timber type maps and aerial photographs or related data such as volume tables by timber type.

Prepare maps for the area. Use the available aerial photos and maps and personal experience of the area to divide or stratify the woodlot into homogeneous areas based on features like tree species composition, height, age, and density. Foresters call such homogeneous areas stands. The stands are delineated on maps or photos and form the basis for "counting" the woodlot resources. Two ha. (5 acres) is the smallest stand area recognized in the Alberta provincial inventory, however, individual woodlot owners may adopt smaller minimum size stands. Stands with similar characteristics are grouped into strata and treated as a group. These strata will be used to sample the forest and subsequently estimate timber volumes. Stratification reduces the variability within sample units and reduces costs of obtaining timber volume estimates. The final map product is also a useful reference for management planning and navigation.

Prepare for fieldwork. The stands or group of stands, if stratified, will be sampled in the field. Design a sampling pattern (plot locations and route of travel) that adequately covers each stand or strata. Assemble the equipment and record sheets that will be used for the fieldwork.

Conduct the inventory. Walk through the woodlot. Make field measurements and record information according to the predetermined sampling pattern.

Analyze and summarize field data. Assess and summarize the data collected. If information on timber quantity and quality was one of the objectives, verify stand labels (descriptors of the timber within the stand) or locations of different vegetation, and then calculate timber volumes. Summarize the data in simple tables and maps. Revise maps and site information based on the fieldwork.

Update the inventory. Conditions within a woodlot are not static. Both the resources contained and a landowner's objectives will change with time. Periodically, inventories must be updated to reflect these changes.

Maps

Maps are an important part of an inventory. Maps provide a link between woodlot information and management planning. A sequence of maps made to similar standards over a period of time will provide an historical reference of how the woodlot changed over the years.

Map folios are an effective way to manage a variety of resource characteristics without providing too much clutter on any one map. A map folio starts with a base map showing

land information and permanent features such as roads, trails, creeks, pipelines and buildings. An aerial photo may serve as a base map if the photo reflects current conditions in the woodlot. A map based on aerial photography may provide a more useful reference than the air photo itself. Overlays made of writeable transparent material such as acetate can be used to indicate different features or management activities. Features such as timber stands, wildlife habitat, proposed management activities or other items of interest may be drawn on separate overlays. As a woodlot changes, features marked on the base map or overlays may be revised to reflect current conditions.

Sampling Timber and Designing a Timber Survey

Sampling timber is often called "Timber Cruising" and is the basis for estimating timber volumes. The first step in sampling timber is to assemble all available information from government agencies or other sources on the targeted survey area. This information should be in the form of forest cover maps, aerial photographs, contour maps and any other data that could assist in managing the woodlot's resources. The woodlot's physical boundaries, land characteristics, and current growing stock should be determined regardless of the size of the woodlot.

A sampling plan is prepared after stand boundaries have been defined and the desired level of inventory information has been established. Timber resource assessment could require measuring every tree. This is sometimes done in small very high value stands but is not practical for Alberta conditions. Instead, a sample of trees is measured to provide the basis for estimating the timber volume for the whole woodlot. This kind of sampling uses the same statistical theory as opinion polls. By collecting information from a variety of sample plots, statements can be made about the volume, the rate of growth, the potential quality and the health of trees for the total area.

There are two methods commonly used to sample timber - the variable-radius plot method and the fixed-area plot method. Both are based on sampling a 'population', or grouping of trees. The variable-radius plot method is complex, prone to error, and difficult to check, therefore is not recommended for the woodlot owner.

The fixed-area plot method is appropriate for sampling the forest at all stages of its development, from regeneration to mature timber. Either temporary (TSP) or permanent sample plots (PSP) can be used. PSPs are permanently marked and re-measured periodically such as every ten or more years, and provide the best means to determine tree growth and mortality. Such plots require extra work to establish and maintain.

Sample plots must accurately represent the woodlot because the management and future sustainability of the forest area is based on information collected from these plots. Sampling procedures are only valid if the plots are randomly located and represent a true sample of the extent and condition of the trees present in the woodlot.

The sample design has two components – the number of plots that must be established, and their location. A sampling program usually begins by stratifying a woodlot into relatively homogeneous areas called stands (also called strata or types) based on certain selected criteria related to the planned future use of the area. For example, characteristics such as species composition, tree height and density could be the basis for stratification if trees will be grown for pulpwood or sawlogs. Once stratification has been completed the number of plots required in each strata must be determined. If the woodlot area is not stratified more plots will be required to achieve the same level of accuracy of the final volume estimates.

Plots must provide a truly representative and unbiased sample of the timber before an acceptably accurate estimate of the timber volumes can be prepared. This requires plots be established randomly.

One of two options is normally used to select the plot locations. Both procedures usually begin with a grid laid over the map of the area to be sampled. Grid lines should cross contour lines (lines joining points of equal elevation) so that any correlations between elevation and plot placement can be avoided. Plots can be established on a grid across the woodlot area. Since the grid locations are independent of the location of the trees the grid points are considered to be randomly located. The grid must be dense enough to ensure several plots are placed in each stand so that accurate volume estimates

can be produced. Figure 15 demonstrates how a grid could be placed over an inventory map. The irregular lines represent stand boundaries i.e. each polygon, or defined area, represents a group of trees that share similar characteristics (e.g. species, height, age) that are noticeably different from those in each of the neighboring polygons. The first option utilizes points determined by the grid to represent plot locations. The second but more difficult option is to use a denser grid, and then randomly select grid points for plot locations. Usually a table of random numbers is used to select unbiased locations for the grid points. Biased sampling will result in biased timber survey results and yield incorrect timber volume estimates.

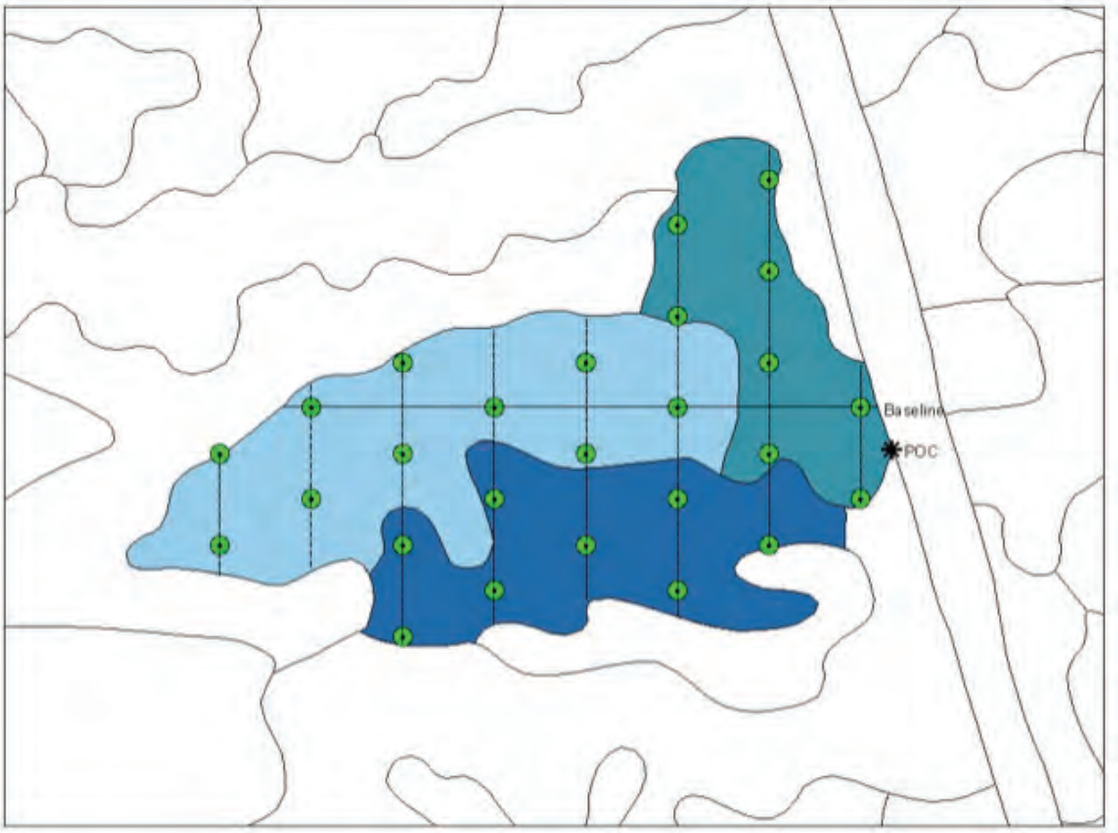


Figure 15. Stand map showing stand boundaries (polygons) and grid of sample plot locations.

The number of plots required for volume sampling varies according to the purpose of the sample, the desired accuracy of estimate, and the variability of the trees (e.g. tree size, density, species) within the woodlot. More plots are required where topography and/or soil conditions are variable because timber volumes and rates of tree growth are likely to vary greatly across such an area. The objective is to portray the diverse character of the woodlot as accurately as is required to meet the objectives of the plan.

The number of plots placed in each stratum or stand type may be the same or vary based upon stratum size, importance of the stratum, or variability. Large strata are generally assigned more plots, although a ceiling in the number may be set. More plots may be established in a stratum that contains the best timber because a more precise estimate of that timber may be considered important. Areas with a variety of growing conditions will require more plots than areas where growing conditions are more uniform if the same level of accuracy of estimate is required.

When the variability of the stands in an area is not known, professional foresters will often conduct a reconnaissance survey to obtain information to calculate the number of sample plots required to achieve a given level of accuracy of estimation. However for woodlot inventories, a minimum of 3 plots per stand and 30 plots per stratum or stand type is considered acceptable. One plot per ha, distributed proportionately among the strata, may be used for areas larger than 30 ha. Such a sample will provide information that is detailed enough for most woodlot planning purposes. In practice, the budget often limits the number of plots established rather than the level of accuracy required. A more intensive sample may be considered before timber is advertised for sale or before harvesting begins to ensure estimated volumes are correct to an acceptable level of accuracy.

Establishing and Measuring Sample Plots

Two-person crews are most efficient for plot establishment and for personal safety. The first person maintains direction with a compass and measures pre-determined distances between plots. The second person assists with distance measurements and records data. Distances are measured with a tape, chain, or topofil (a device utilizing string to measure distance). The survey line, or cruise line, begins at an easily identified starting point marked on the timber stand map and continues along a specified compass bearing for a predetermined distance to the plot location. The survey line is flagged (marked with colourful tape) at the starting point and at regular intervals along the way and at direction changes. Each flag is marked with distance and compass bearing to facilitate relocating the line if checking becomes necessary. Distances and directions are also recorded on the map. Features of interest such as stream crossings or stand boundaries are noted and used to update maps.

Plot centers are marked with flagging tape. Plots may be square, rectangular or circular. Square plots are the most common because they are the easiest to layout. Circular plots are preferred for stands where trees are very short. Usually, plots are spaced equal distances apart.

Plot size varies from 50 m2 for dense, immature stands, to 200 m2 for open, old growth stands. 100 m2 square plots (10 X 10 m or 32.8 X 32.8 ft) is the most common size. The same plot size should be kept throughout the woodlot to avoid confusion and to simplify data compilation. Sometimes a combination of plots of different sizes having the same centre point is used. If, for example, a woodlot contains a stand of aspen with an understorey of small spruce trees, a 100 m2 plot could be used for the aspen and a 50 m2 plot for the spruce. Both plots would have the same centre point. In general, 100 m2 should be considered the default size. Table 5 presents various plot dimensions and factors to convert per plot to per hectare values.

Table 5. Plot dimensions, plot areas and conversion factors for fixed area sample plot sizes.

Circular plots			Rectangular plots		
Plot area	**Plot radius (m)**	**Plot factor***	**Plot area**	**Plot dimension (m)**	**Plot factor**
.002 ha (20m^2)	2.52	500	.005 ha (50m^2)	10 x 5	200
.005 ha (50m^2)	3.99	200	.01 ha (100m^2)	10 x 10	100
.01 ha (100m^2)	5.64	100	.02 ha (200m^2)	20 x 10	50
.02 ha (200m^2)	7.98	50	.03 ha (300m^2)	30 x 30	33.3

*The plot factor is used to convert a plot total to a per hectare basis. For example, if there are six spruce trees in a 2.52 m plot, those 6 trees represent 6 x 500 or 3,000 spruce trees per hectare

Usually, the trees within sample plots are only measured to a predefined minimum DBH (diameter at breast height measured 1.3m or 4.5 ft above average ground level). This minimum size varies depending on the purpose of the inventory. For example, timber in Alberta is usually sold as sawlogs or pulp logs. A common standard for minimum sawlog size for lumber production is 15 cm inside bark stump diameter and 10 cm top diameter. Comparable diameters for pulp logs are 13 and 7 cm for stump and top respectively. Stump diameter is determined at 0.3 m above average ground level. The smallest tree measured is usually below the utilization standard so that an estimate of the trees that will soon reach merchantable size is obtained. The most practical approach is to measure all trees 7.0 cm DBH or larger as is done on crown land in Alberta.

The following is recorded for every tree that meets the minimum size within the plot:

- Tree species
- Tree diameter (DBH)
- Height of each tree or the general stand height based on 2 or 3 measured tree heights per plot. If general stand height is used, heights are estimated for trees measured only for diameter.

Additional detailed information may be recorded including:

- Height of every tree
- Tree ages (usually based on the ages of 3 representative trees per plot)
- Information on tree decay or insect presence/damage
- Growth rates for the last 10 or 20 years (based on the increment core samples)
- Other resource information (e.g. soils, presence of mushrooms, wildlife)

Measuring Tree Diameter

The most simple and accurate way to measure tree diameter is to use a diameter tape. This is a metal tape, similar to a carpenter's tape, with a hook on the end that can be fixed in the tree bark to assist in the measurement of large trees. The scale on the diameter tape translates the tree's circumference directly into a diameter. The tape is wrapped around the circumference of the tree at breast height or 1.3 m above the ground level. Caution must be exercised because diameter tapes also have a regular distance scale that can be used by mistake. If a regular tape measure is used, the tree diameter is calculated by dividing the circumference as read on the regular tape by 3.1416.

Figure 16. Measuring DBH
Source: http://www.mytreetracker.org/

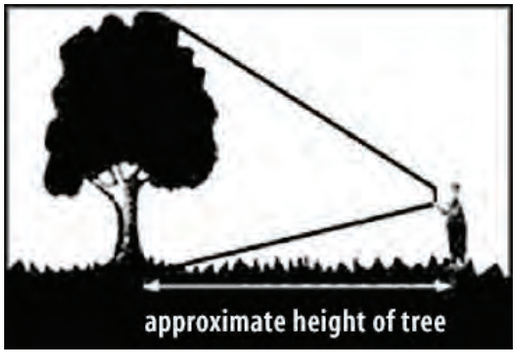


Figure 17. Tree height using stick method.
Source: http://www.gfc.state.ga.us/forest-management/champion-tree-program/how-to-measure-a-tree/index.cfm

Measuring tree height can be done without using expensive instruments, however accuracy usually suffers. One method is to hold a stick at arm's length so the stick, when pivoted to touch the user's face, is just long enough to reach the eye on the same side of the face as the hand holding the stick. He must choose a location to clearly see the base and the top of the tree. He positions himself facing the tree with his arm at full arm's reach and held horizontal toward the tree to be measured. The stick must be in a vertical position. The user then moves away from or towards the tree until, without moving his head, until the top of the tree and the top of the stick are aligned, and the bottom of the tree and the top of the hand holding the stick are aligned. The distance to the tree approximates the height of the tree providing the method is used only on level ground. While not practiced in commercial forestry, tree heights can be estimated effectively with this method.

Table 6. Formulae to calculate tree heights from clinometer readings

Formula 1

Tree height = (TT + TB) x HD x .01

Use this formula when TB reading is negative.

Formula 2

Tree height = (TT – TB) x HD x .01

Use this formula when TB reading is positive.

Where:

TT =	Angle to tree top (%)*
TB =	Angle to base of tree (%)*
HD =	Horizontal distance from the tree
SD =	Slope distance from tree **
% =	per cent of slope on clinometer scale
*	Angle to top of tree should be kept below 100% or the accuracy of the measurement will drop.
**	Use a slope correction table to calculate horizontal distance.

Note: Angle to the base of the tree will be negative when the base is below eye level and positive when the base is above eye level.

Determining Tree Age

Ages provide an indication of growth rate and stand condition but are not required to calculate timber volume. Stand age can be estimated by determining the age of five or six trees in each stand. The age of a tree is usually defined by counting annual growth rings on a core extracted at breast height (1.3 m) with an increment borer - a type of hollow auger. Care must be taken to hit the centre or pith of the tree stem to obtain age accurately. Tree branches point to the pith and provide guidance on where to aim the increment borer.

An annual growth ring is comprised of light coloured springwood and darker summer-wood. The rings in deciduous species like aspen and poplar are not always well defined and can be difficult to see except in a strong light. Rot is often present in older trees and obscures the rings, making it difficult to determine the age of such trees. The rings are counted beginning at the cambium layer below the bark, and finishing at the pith. The cambium is the white coloured layer below the bark and is the source of both wood and bark cells. Usually the core is taken at 1.3 m and the number of years the tree required to reach that height must be added to arrive at total tree age. Alternatively, stand age can be determined by cutting several trees and counting the growth rings on the stump. A correction factor is still required to account for the years from seed germination to stump height.

The ring width for the last 5 or 10 years (those next to the cambium) is recorded to obtain an indication of the current rate of tree growth.

Figure 18: Tree core

Figure 19: Using increment borer to determine the age

Processing the Cruise Data

In order to obtain useful information, the sample plot data must be compiled into a summary. This summary should state the age and the current merchantable volume and timber quality present in individual stands, in individual strata or timber types, and for the woodlot as a whole. Measurements of the last 5 or 10 years of growth can be used to forecast future volumes, assuming that the current rate of growth will continue. This information provides the basis for developing a woodlot management plan and a schedule for developing the area.

The plot data are compiled according to the harvesting or merchantability specifications and the planned management activities. For example, if the area is to be selectively logged, a minimum cutting diameter limit may be set for each species. The sample plot data compilation determines the volume of each species within the prescribed minimum measurements. In this way the effects of different cutting systems on the volume to be logged each period can be explored.

The sample plot data are compiled by forest type or by strata. The plots within each stratum are compiled as a group to produce a volume per hectare for each species. These volumes are multiplied by the area of the stratum to obtain a total volume for the stratum. The basic steps of this compilation include calculating:

- Individual tree volumes (Tables 7 and 8);
- Per hectare species volumes for all plots;
- Total volume by species for each stratum;
- Total volume by species or species group (e.g. conifer vs. hardwood) for the whole area.

The height and diameter measurements for all trees in the same plots are used to calculate plot volumes. The heights of at least one-third of the trees on the sample plots should be measured. The heights of the remaining two-thirds of the trees in the plots can be estimated using the measured trees as a reference.

Once the heights and diameters of each tree are available, the volume of each tree and each species in each plot can be calculated. This is done by consulting volume tables that are compiled by species and region. Volume tables are based on past detailed measurements of a large number of trees spanning the complete range of diameter and height for each species. The tables give the volume of the standing tree for each height and diameter measurement to some utilization standard e.g. gross volume for trees with a 15 cm stump and an 11 cm top (small sawlog standard). Deductions for tree defects like decay and sweep or crook must be made to obtain a net volume estimate.

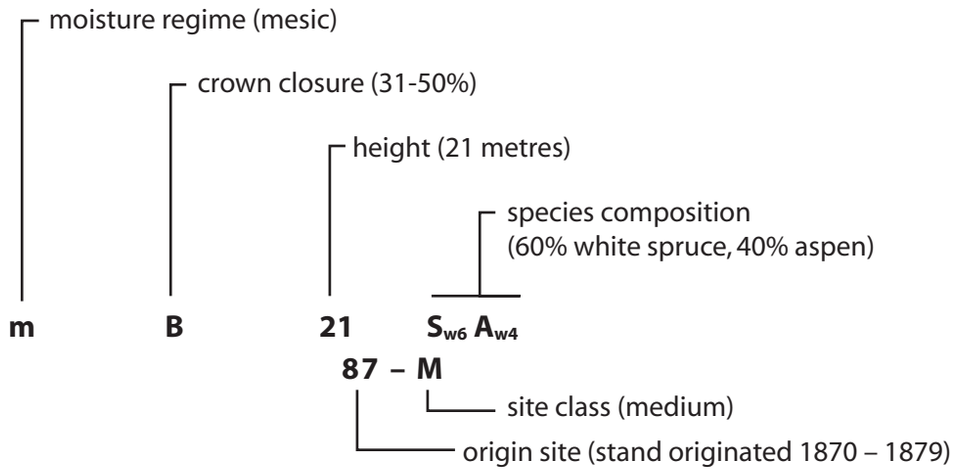
The plot information is compiled to create a species and volume summary. Net per hectare volumes for each species are listed by stand, timber type or stratum, and then multiplied by the correct areas to obtain a net volume for that species. The areas for all the strata are summed to arrive at the total volume of wood.

An updated forest cover map is created from the sample plot information. The map usually shows the location of the plots, the stand boundaries and any other information that will help in laying out roads and landings. The map may record other information such as environmentally sensitive areas, wildlife habitat ranges or potential recreation sites that may need protection, or stands that would benefit from silvicultural treatments like thinning. This map and its associated information form the basis for planning the protection, management and timber harvesting activities for the woodlot.

Stand Classification

Many different systems are used to classify stands; however all try to identify important characteristics of individual stands of trees. Following is an example of one of the simplest versions of a stand label used in the Alberta Vegetation Inventory. Many other factors could also have been included in this label, but these vary according to application and perhaps region (province). Local authorities or specific map keys should be consulted to obtain further information on local classification systems.

Figure 20. Example of a stand label used in the Alberta Vegetation Inventory.



Sample Compilation

The following example illustrates the process to compile the data from sample plots in a particular woodlot. The objective in this example is to gain a more accurate estimation of volume. The woodlot has been divided into four strata.

Strata	Area	Cover Type
1	4.0 ha	(CD) White spruce/Aspen
2	4.8 ha	(D) Aspen
3	3.2 ha	(C) Black spruce/Tamarack
4	5.8 ha	(C) Jack pine

The woodlot owner is considering harvesting the jack pine stand (strata 4). Before making a final decision, a timber sampling program is designed to estimate the timber volumes in the stand.

Six plots are established within the pine stand, one per hectare, placed at pre-determined intervals along sample lines. A plot size of 200 m2 is used with a plot per hectare factor of 50 (one ha contains 10,000 m2). Plot information is recorded. Trees are tallied by species, height and diameter class, and the information is recorded on the cruise tally cards, one card for each plot. Figure 20 illustrates a cruise tally card with hypothetical tree measurements.

Figure 21. Example of a cruise tally card

CRUISE TALLY CARD

	HEIGHT (m)							
DBH	12.5-13.9	14.0-16.5	16.6-19.5	19.6-22.5	22.6-25.5	25.6-28.5	28.6-31.5	31.6-34.5
14	0							
16								
18		xx	x					
20			xxxx					
22				xxxx				
24			**	0				
26								
28								
30								
32								
34								
36								
38								
40								
42								
44								
46								
48								
50								
52								
54								
56								

Jack Pine = x White Spruce = 0 Aspen = *

Calculations

Tables 7 and 8 present volumes by tree diameter and height classes for conifers and aspen respectively. These tables are entered for each tree size recorded on the cruise tally card (Figure 20). Number of trees (per size class) x single tree volume (from Tables 7 and 8) x plot per hectare factor = volume per hectare. Below is a summary of calculations based on the cruise tally card shown in Figure 20.

Species	Trees per plot	Volume per tree (m^3)	Conversion factor	Volume per ha(m^3)
Spruce	1	0.049	50	2.5
	1	0.367	50	18.4
	Sub total			20.9
Jack pine	2	0.131	50	13.1
	1	0.159	50	8.0
	4	0.207	50	41.4
	4	0.304	50	60.8
	Sub total			123.3
	Total Conifers			144.2
Aspen	2	0.306	50	30.6
	Total deciduous			30.6

Data from the remaining five plots are compiled in the same manner. An average volume per hectare based on the six plots tallied is used to determine total stand volume.

Plot	Total Coniferous	Total Deciduous
1	144.2	30.6
2	190.0	Nil
3	72.0	65.0
4	212.0	26.0
5	160.4	40.2
6	101.3	80.4
Average	**146.7 m^3/ha**	**40.4 m^3/ha**

Total stand volume is derived by multiplying the average volume per hectare by the total stand area:

Total stand coniferous volume = 146.6 x 5.8 = 850.3 m^3

Total stand deciduous volume = 40.4 x 5.8 = 234.3 m^3

A summary of the area and volume figures, along with timber quality, age, insect and disease evidence and any other pertinent data, may then be transferred to map overlays to provide a picture of the quality and quantity of products in the woodlot.

Table 7. Single tree volumes (m^3) for conifers (utilization 15/11).

	Height (m)							
DBH (cm)	13	15	18	21	24	27	30	33
14	0.049	0.057	0.069	0.082	0.094	0.106	0.119	0.131
16	0.080	0.093	0.113	0.133	0.153	0.173	0.193	0.213
18	0.113	0.131	0.159	0.187	0.215	0.243	0.272	0.300
20	0.147	0.171	0.207	0.244	0.280	0.317	0.354	0.390
22	0.183	0.213	0.258	0.304	0.349	0.395	0.440	0.486
24	0.221	0.257	0.312	0.367	0.422	0.477	0.532	0.587
26	0.261	0.304	0.369	0.434	0.499	0.564	0.629	0.695
28	0.304	0.354	0.430	0.505	0.581	0.657	0.732	0.808
30	0.349	0.407	0.494	0.580	0.667	0.754	0.841	0.929
32	0.397	0.463	0.561	0.660	0.758	0.857	0.956	1.056
34	0.448	0.521	0.632	0.743	0.854	0.966	1.077	1.189
36	0.501	0.583	0.707	0.831	0.955	1.080	1.205	1.330
38	0.556	0.648	0.785	0.923	1.061	1.200	1.338	1.477
40	0.614	0.715	0.867	1.019	1.172	1.325	1.478	1.631
42	0.675	0.786	0.953	1.120	1.288	1.456	1.624	1.792
44	0.738	0.859	1.042	1.225	1.409	1.592	1.776	1.960
46	0.804	0.936	1.135	1.334	1.534	1.734	1.935	2.135
48	0.872	1.016	1.232	1.448	1.665	1.882	2.099	2.317
50	0.943	1.099	1.332	1.566	1.800	2.035	2.270	2.506
52	1.017	1.184	1.436	1.688	1.941	2.194	2.448	2.701
54	1.093	1.273	1.544	1.815	2.086	2.358	2.631	2.904
56	1.172	1.365	1.655	1.945	2.237	2.528	2.820	3.113
58	1.253	1.459	1.770	2.080	2.392	2.704	3.016	3.329
60	1.337	1.557	1.888	2.220	2.552	2.885	3.218	3.552
62	1.424	1.658	2.010	2.363	2.717	3.071	3.426	3.781
64	1.512	1.761	2.136	2.511	2.887	3.263	3.640	4.018

Source: Alberta Forest Service

Table 8. Single tree volumes (m^3) for Aspen (utilization 15/11).

Height (m)								
DBH (cm)	13	15	18	21	24	27	30	33
14	0.046	0.054	0.065	0.076	0.087	0.099	0.110	0.121
16	0.077	0.090	0.108	0.127	0.145	0.164	0.182	0.201
18	0.110	0.127	0.154	0.180	0.206	0.233	0.259	0.285
20	0.144	0.167	0.202	0.236	0.271	0.305	0.339	0.373
22	0.180	0.209	0.253	0.296	0.339	0.382	0.424	0.467
24	0.219	0.254	0.306	0.359	0.411	0.463	0.515	0.567
26	0.260	0.302	0.364	0.426	0.488	0.550	0.611	0.673
28	0.304	0.352	0.425	0.497	0.569	0.642	0.714	0.785
30	0.350	0.406	0.489	0.573	0.656	0.739	0.822	0.905
32	0.399	0.462	0.558	0.653	0.748	0.842	0.937	1.031
34	0.450	0.522	0.630	0.737	0.845	0.951	1.058	1.165
36	0.505	0.585	0.706	0.826	0.946	1.066	1.186	1.305
38	0.562	0.652	0.786	0.920	1.054	1.187	1.320	1.453
40	0.622	0.721	0.870	1.018	1.166	1.314	1.461	1.608
42	0.684	0.794	0.958	1.121	1.284	1.446	1.608	1.770
44	0.750	0.870	1.049	1.228	1.407	1.585	1.762	1.940
46	0.818	0.949	1.145	1.340	1.535	1.729	1.923	2.116
48	0.890	1.032	1.245	1.457	1.668	1.879	2.090	2.300
50	0.964	1.118	1.348	1.578	1.807	2.036	2.264	2.492
52	1.040	1.207	1.455	1.704	1.951	2.198	2.444	2.690
54	1.120	1.299	1.567	1.834	2.100	2.366	2.631	2.896
56	1.202	1.395	1.682	1.969	2.255	2.540	2.825	3.109
58	1.288	1.493	1.801	2.108	2.415	2.720	3.025	3.329
60	1.376	1.595	1.924	2.252	2.580	2.906	3.232	3.557
62	1.466	1.701	2.051	2.401	2.750	3.098	3.445	3.792
64	1.560	1.809	2.182	2.554	2.925	3.295	3.665	4.034

Source: Alberta Forest Service

Beneficial Management Practices

- Develop a well-defined plan that includes clear objectives for the woodlot. Objectives may be adjusted after information becomes available from the inventory.
- Ensure all legal boundaries are clearly marked on the ground and on maps or aerial photographs.
- Conduct a preliminary walk-through and note special land features of interest such as wet areas, occurrence of rare or unusual species, etc. and verify that maps are correct.
- Follow established sampling methodology when designing the inventory to obtain reliable timber volume estimates.
- Monitor the woodlot's productivity and forest changes by regularly updating the inventory.
- Maintain records showing stand boundaries, plot locations, timber volumes and other land features of interest, particularly to track and understand changes over time.
- Consider including non-timber values such as wildlife habitat, wild fruit, or recreation potential as part of the inventory to broaden future opportunities.
- Utilize expertise and information available from government agencies, forest industries and forestry consultants.

Woodlot Health: Pest Management

Contents

Figure 22: Wood boring beetle damage & fire scaring

Criteria and Indicators of Sustainable Forest Management for Forest Health

Criteria 1: ***Biological diversity. Conservation of biological diversity by maintaining integrity, function, and diversity of living organisms and their environments. Indicators of accomplishment include:***

- Diverse forest cover types including tree species, age classes and genetic variability to mitigate widespread pest infestation and provide a variety of wildlife habitat.
- Diverse insect species to provide natural population control.
- Occurrence and protection of endangered species.
- Control of invasive exotic species.

Criteria 2: ***Ecosystem condition and productivity. Maintenance and enhancement of forest ecosystem condition and productivity. Indicators of accomplishment include:***

- Area of forest disturbed by insects, diseases and other pests and subsequent control measures.
- Prudent use of control measures consistent with local regulations.

Introduction

Long-term woodlot management must consider the continuous cycle of change that occurs over time on any forested land. Mammals, birds, insects, diseases, weather, and fire are natural agents of change within the forest. A healthy forest can support a variety of plants and animals, is able to recover after natural events like fire or insect infestations and

can resist extreme changes like weather. When the forest is in imbalance, tree health is weakened and the forest is vulnerable to negative impacts from pests.

Maintaining a healthy and vigorous forest is important to the woodlot owner. Pests threaten the overall health of trees and compete with human uses of the forest. Some pests cause only minor physical damage, while others limit growth or kill the trees. Many factors have negative effects on the health of a forest. Some are biotic or living, such as insects, disease-causing organisms or mammals. Others are abiotic or non-living, such as non-contagious disorders like drought and severe weather events like hail and ice storms.

Careful planning by woodlot owners will reduce the risk of pest damage. Early detection of pest activity and appropriate control within natural systems can reduce losses from damage and promote a "balanced" ecosystem.

Figure 23: Porcupine girdled lodgepole pine near Drayton Valley

Steps to Sustaining a Healthy Woodlot

A management program that emphasizes early detection and control will help reduce losses during pest outbreaks. A pest management program consists of the following steps:

- Plan ahead
- Conduct frequent inspections
- Learn to recognize local pests
- Decide if control is necessary
- Integrated pest management options

1. Plan ahead

The best control is prevention. Careful planning will reduce the potential for outbreaks. Consider the following:

- Select tree species or varieties resistant to local pests.
- Select tree species compatible with the site and area.
- Prepare the site before planting to reduce the stress of competition from weeds and shrubs.
- Do not introduce pests. Inspect seedlings for insects or diseases before planting.
- Plant your seedlings properly to ensure a good start.
- Maintain a variety of species of different ages, i.e. trees that are not all the same species and age.
- Do not transport material from an infected area. Avoid transporting logs or firewood, especially wood with bark attached, from infested areas or from out of province.
- Plan according to the life expectancy of each species.

2. Conduct frequent inspections

Establish an annual routine to survey the different species and age classes to determine the incidence of insects and diseases. During these surveys, examine the root collar base, stems, foliage, buds and upper branches for external signs of injury caused by insects, diseases or other damage agents. Maintain annual records of pests and their resultant injury. Record tree injury to establish tolerance levels for control action or other management options.

3. Learn to recognize local pests

Positive identification is essential before any control measures are taken. Become familiar with the common tree pests likely to occur in the area. Diagnose the signs and symptoms by referring to guides, such as "A Field Guide to Forest Insects and Disease of the Prairie Provinces" by Y. Hiratsuka, D.W. Langor and P.E. Crane; and "Tree and Shrub Insects of the Prairie Provinces" by Ives and Wong.

Additional information on forest pests is available at the following Internet sites:

Internet sites provided by government agencies are available to assist with pest diagnosis.

The Alberta government's "Forest Pest Damage Diagnostic System" is available on the Internet at: http://esrd.alberta.ca/lands-forests/forest-health/forest-pests/forest-pest-damage-diagnostics.aspx. This site facilitates searches for a known pest or tree and includes image galleries to assist with identification. Alternatively, the local agriculture fieldman may assist with diagnosis.

Additional advice and information is also available on the Internet from an Alberta Sustainable Resource Development Forest Health Officer at: http://esrd.alberta.ca/lands-forests/forest-health/default.aspx or e-mail at Fh.Info@gov.ab.ca

Finally, a sample can be sent for identification or diagnosis to agencies of municipal, provincial or federal governments, to woodlot organizations, or to forestry and agriculture departments in universities. Care must be exercised collecting, preparing, and shipping a sample to ensure the pest can be identified when it is received.

Tips for collecting and preserving samples:

- Preserve the sample in a 70% alcohol solution if an expert will not examine the specimen within two days. More fragile specimens such as moths should be kept frozen.
- Place the sample in a sturdy container such as a pill bottle or margarine container.
- Label the sample. Use pencil if possible and mark the location, date, collector's name and the tree species. Include a sample of the tree or plant if the species is not known. Below is an example of labels.

Canada, Alberta, 5km west of Barrhead off HWY 33 June 17, 2005 Coll. J. Doe	Beetle was collected from under bark of White Spruce. There was evidence of a gallery underneath.

4. Decide if control is necessary

Consider the following questions to decide if control is necessary:

- How widespread is the pest?
- Has it caused problems in the past?
- What is the potential for further damage?
- What effect will the damage have on the woodlot?
- What is the cost of control, compared to the value of the potential loss?
- What are the natural control agents?
- Is the suspected pest(s) a major pest?
- Can the pest spread to other areas?
- What is the extent and severity of the damage?
- How important is the type of tree affected?
- What is the overall impact on the woodlot?
- Can the pest be controlled safely, effectively and economically?
- Can the forest be changed over time to reduce the impact of the pest? (e.g. remove highly susceptible tree types, and/or diversify species and age classes appropriate for climate and soil type)?
- What conditions could be making the woodlot unhealthy? (e.g. drought, over crowding)
- Can the forest conditions be changed to improve the health of the woodlot? (e.g. fertilizing, thinning or irrigation)

The local agriculture field man can provide advice on pesticide treatment options.

5. Integrated pest management options

Integrated pest management (IPM) is a management strategy to provide a more complete control system. IPM combines prevention with cultural, biological, chemical and other control methods. Developing an IPM program that combines parts of available techniques can reduce the risk of serious loss from pests.

IPM techniques may include:

- species selection
- biological control (introduced viruses, bacteria or insects)
- cultural control (slash disposal, thinning, pruning)
- chemical control
- genetic engineering (breeding more resistant plants)

Keeping good records of pest levels and control methods employed is essential to integrated pest management. Good records help to assess changes in pest levels and the effectiveness of control techniques. Survey results and follow-up information should also be recorded.

Insect and Mite Pests

Forests and woodlots contain thousands of insect and mite species and most cause no serious damage to trees. Many insects are beneficial and act as pollinators, decomposers or predators of pests. Examples include aphid-eating ladybugs, predaceous ground beetles and parasitoid wasps. Some insects can be destructive and are considered pests.

Insect pests are categorized into groups including chewing, sucking, or gall forming insects depending on the insect's method of activity and the location and type of tree damage they cause. The major insect types are:

- defoliators
- sucking insects and mites;
- gall formers
- stem and wood borers;
- bark beetles
- cone and seed feeders.
- root-feeders

The stage of growth influences the susceptibility of trees to insects and other pests. Some pests attack mature and over-mature trees, while others target young stands. Many pests affect trees throughout the life of the stand.

Exotic Pests

Exotic pests are organisms that are introduced into an area beyond their natural range of occurrence and become pests in their new environment. They are also referred to as alien, non-native, or introduced pests. Having evolved in a different ecosystem these non-native species may have few natural enemies and can often lead to outbreak populations that can decimate native species. For example, the western white pine population was decimated by the white pine blister rust introduced to British Columbia in the early 1900's.

Alberta Sustainable Resource Development, in conjunction with the Canadian Forest Service and Canadian Food Inspection Agency, detects and monitors exotic forest pest species within Alberta. Critical Pest Infestation Response Plans have been established for invasive exotic species, such as Asian long horned beetle, to eliminate the pest as soon as it is detected in Alberta.

Many species of plants are also considered exotic pests, although they are often referred to as invasive plants or weeds. Alberta Sustainable Resource Development detects, monitors and controls these plants within the Green Area, as defined under the Timber Management Regulation 60/73, of the Province. This is done in conjunction with other landowners and municipal, provincial and federal agencies. Unlike other exotic pests, many invasive exotic plants have established in Alberta and the current management practices of these have been geared to limit their spread. Continuous vigilance is necessary; many invasive exotic plants continue to pose a threat of establishing in Alberta and other parts of Canada.

The Canadian Food Inspection Agency is responsible for monitoring and regulating exotic pests in Canada, and the administration and enforcement of the regulations for quarantine pests under the Plant Protection Act.

Additional information on exotic pests is available on the Internet at the following site:
http://esrd.alberta.ca/lands-forests/forest-health/forest-pests/default.aspx.

Other Animal Damage

Other common animal pests are snowshoe hares, red squirrels, voles, mice, deer, moose and elk. These animals damage the tree by girdling the stem or eating new growth, shoots, buds or bark.

Wildlife activity can affect tree survival, growth rate, form and reproductive capability, as well as weaken trees, making them more susceptible to insects and diseases. Damage is more severe in young stands where new trees are accessible, succulent, and nutrient-rich. As trees increase in diameter, height, and root mass, they are better able to survive wildlife damage. Newly introduced or exotic tree species may provide a popular new food source for certain animal species.

Animal damage may not always have a negative impact on trees and shrubs. For example, jack pine growing in partial shade may be made sturdier by pine grosbeaks or chickadees eating their buds. Before using expensive control measures, observe and question.

Animal damage to trees occurs in several forms. These include:

- Barking – the outer protective layers of a tree are gnawed or stripped away.
- Browsing – eating buds, foliage and shoots.
- Budding – feeding on buds and emerging foliage.
- Clipping – severing shoots, stems and roots.
- Pulling – extracting seedlings from the ground, partially or completely.
- Rubbing – damaging the branches or main stem of a tree.
- Trampling – bruising or crushing seedlings.

Invasive Plants

Restricted, noxious and nuisance weeds are aggressive, difficult to manage, and invasive plant species. These weeds may displace or significantly alter native plant communities and can also cause economic damage to private and public lands. Alberta's Weed Control Act provides legislation to keep these weeds from being introduced or from spreading in the province. Each class of weeds is treated differently.

What is the difference between restricted, noxious, and nuisance weeds?

Restricted weeds are usually found in very few regions of Alberta and usually low populations are present at any one location. They are designated Restricted to prevent their establishment. Where found, "Destruction" of the restricted weeds is required. Noxious weeds are already established in many regions of the province. "Control" of noxious weeds is required where they are identified as problematic. "Destruction" and "Control" are defined in the Weed Control Act. Nuisance weeds are common species that can be found throughout the Province, and as such are very difficult to eliminate. They can cause significant economic losses, but are so biologically suited to Alberta that they cannot be eradicated.

Municipalities have the legislative power to upgrade the status of a weed from noxious to restricted but cannot lower the status. This also applies to nuisance weeds upgraded to noxious or restricted status by the municipalities.

Detailed lists and information on these weeds are available on the Internet at: http://www.agric.gov.ab.ca/app21/infopage?cat1=Diseases%2FInsects%2F%20Pests

Weed Management

To comply with the Weed Control Act, problem weeds can be managed by mechanical, chemical, and biological control measures but chemical and mechanical control are most common. Restricted weeds are difficult to control and often the only effective means of destruction is handpicking. Agricultural or industrial herbicides are available to control most nuisance weeds and many noxious weeds. Biological control by insect or bacteria may be an option in some situations, but effective control agents have only been developed for a limited number of problem weeds. The local agriculture field man can provide advice on weed management strategies. Regional contact information is available on the Internet at: http://www.aaaf.ab.ca/aaaf-directory.html or from the local municipal office or Agriculture Service Board Program at (780) 427-4213.

Biotic Diseases (Infectious)

Biotic diseases are caused by living organisms such as bacteria, fungi, viruses, nematodes or parasitic plants. Detailed information is presented in Appendices to this chapter. Appendix 1 includes details on these pests and Appendix 2 lists tree hosts.

Abiotic Injury (Non-Infectious)

Abiotic injuries are caused by climate (temperature extremes and fluctuations, and water stress), mechanical injury, nutrient deficiency and pollution. Appendix 1 to this chapter includes details on abiotic injuries and Appendix 2 lists tree species' susceptibility.

Common Pests of Alberta Woodlots

Some of Alberta's common woodlot pests are described below. Similar information is presented in Appendix 1 to this chapter by type of damage produced, and in Appendix 2 by host tree species. A more complete list including colour photographs is found in the publications cited and the Internet sites referenced.

Pests of Deciduous Trees

Bruce spanworm – feeds principally on aspen, but will feed on other deciduous trees. Outbreaks seldom last more than 2 or 3 years. The larvae are green or olive with longitudinal white bands. They leave large amounts of silk webbing hanging from defoliated trees. Severe defoliation may occur, but tree mortality is rare and natural control is effective.

False tinder conk – is the most economically important decay organism found on aspen in the prairies. It produces a white trunk rot with black zone lines around each area of decay. On the exterior of the tree, a perennial, cracked, hoof-shaped conk up to 12 cm wide, with a black upper surface, is formed. No economical control other than harvest is recommended.

Forest tent caterpillar – is the most serious defoliator of aspen in Western Canada. It also attacks most other deciduous trees. Outbreaks typically last 6 to 10 years, but may persist longer. Young larvae hatch in the spring about the same time as aspen leaves flush. Mature larvae are blue with black and yellow markings in a 'keyhole' pattern along the back.

Figure 24: Forest Tent Caterpillar on aspen at Deadwood

Light defoliation has little effect on tree growth. However, two or more years of moderate to severe defoliation greatly reduces tree growth and may cause branch and twig mortality. Trees seldom die, because new leaves are grown in the same year, however, trees under stress may be killed. Natural control is effective but takes time.

Hypoxylon canker – is one of the most important aspen diseases on the Prairies. The fungus produces large cankers that eventually girdle the stem. It is most common in poorly stocked aspen stands, trees on the stand edge and in trees that are under stress or injured by hail, animals or other damaging agents. Hypoxylon canker weakens the stem, which is subsequently often broken by the wind at the infection site. Trees infected on the lower main stem usually die within 5 years. Heavily infected sites should be harvested and the site regenerated.

Large aspen tortrix – feeds primarily on the foliage of trembling aspen, but will also attack willow and balsam poplar. Young larvae mine the leaves, while older larvae pull the leaves together with silken threads and feed within the leaves. Mature larvae are dark green with a black head and spots along their backs. Defoliation can be distinguished from tent caterpillar damage by the large amounts of silk left behind, and from Bruce spanworm damage by the presence of flat discs of eggs on the leaves and empty pupal skins among the leaves. Defoliation reduces diameter growth and may cause top kill (dieback), but rarely causes tree mortality. Outbreaks are often extensive and tend to precede the forest tent caterpillar. They generally last 2 or 3 years, ending when forest tent caterpillar populations become high.

Figure 25: Crysomedae beetle mating on aspen tree near Deadwood and larvae .

Leaf beetles – larvae or adults feed on foliage, however outbreaks tend to be short-lived. Feeding damage leaves a scorched appearance, but seldom causes branch or tree death. Some beetles will only feed on aspen or willow, while others will feed on a variety of species.

Poplar borer – is an important pest of trembling aspen, particularly in the aspen parkland. Adults lay eggs in notches cut into the bark. Larvae feed on the inner bark and sapwood for 3 years, spending each winter in a pupal cell deeper in the heartwood. The third winter is spent as a pupa and the adult finally emerges in late spring of its fourth year. Trees infested with the poplar borer often ooze a varnish-like sap, which stains the bark surface. While trees are not usually killed, the weakened stems may break during windstorms. Woodpeckers will damage the trees while searching for larvae, and the openings they create in the trees provide access for various diseases. Infected wood has low timber value.

Satin moth "exotic" – a European introduction that arrived in Canada in the 1920s and has recently taken up residence in some parts of Alberta. It prefers poplar and willow, especially ornamental varieties. The larvae are extensive defoliators and damage is most evident in June. This species is of particular concern in hybrid poplar plantations, though no outbreaks have been recorded in woodlots yet.

Pests of Coniferous Trees

Dwarf mistletoe – is a parasitic flowering plant that attacks pine and occasionally spruce. Seeds stick to the twigs and germinate, eventually growing into the tree, usually through young twigs. Heavily infected trees will not reach merchantable size. Infected trees form a "witches broom", which makes them unsightly and weakens their branches (and can become a safety hazard). This plant can be diagnosed by the presence of spindly yellow-brown plant stems at the base of the brooms. Removing infected trees, clear-cutting and maintaining strip barriers provide acceptable control.

Jack pine budworm – jack pine is the primary host. Other pines, tamarack and white spruce are secondary hosts. Outbreaks usually last 2-3 years. Young larvae feed in flower clusters or along the sides of new shoots. Larvae are about 22 mm long, olive-green with a dark head and paired pale yellow spots along the back. The jack pine budworm is a wasteful eater, cutting needles off at the base and feeding only on the basal portions. Severely defoliated trees have thinned crowns and there is often top kill. Tree mortality is low, unless the trees are stressed from drought.

Larch sawfly – attacks tamarack and other larches. Adult females are about 10 mm long and predominantly black, with orange markings on the abdomen. Young larvae are pale green with a black head. Mature larvae are about 16 mm long and gray-green with a black head. The larvae eat the needles and cause defoliation. Prolonged defoliation will eventually kill the tree. A parasite introduced in Manitoba in 1961 can control the insect in areas where the parasite has been released.

Mountain pine beetle – can be one of the most destructive pests in Western Canada. Lodgepole pine is the main host, but it will attack other pines. Eggs are laid in long j-shaped galleries cut in the inner bark. Young larvae feed on the inner bark and over-winter, pupate and develop into adults, and begin their new attacks in mid to late summer.

Mountain pine beetles attack mature and over mature trees, killing by the girdling effect of the galleries and by fungi they carry, including blue stain fungus. Needles become discoloured the spring after infestation. Infestation may be identified by the presence of pitch tubes and/or sawdust around the base of the tree.

The Mountain Pine Beetle is considered a serious risk in Alberta. Suspected occurrences of this pest should be reported to an Alberta Forest Health Officer. Contact information is available on the Internet at: http://alberta.ca/albertaFiles/includes/DirectorySearch/search.cfm or e-mail Fh.Info@gov.ab.ca .

Additional information on the Mountain Pine Beetle is available on the Internet at: http://mpb.alberta.ca/

Figure 26: Pitch tube on Lodgepole Pine and MPB from Wilmore Wilderness Park.

Pine stem rusts – usually affect jack pine, Scots pine and lodgepole pine on the Prairies. Stalactiform blister rust and comandra blister rust are two of the most common. Both produce orange-yellow spores. They will infect mature trees but cause the most mortality in young seedlings and nursery plants by girdling the stems.

Spruce beetle – outbreaks usually originate in areas with large supplies of slash and blow down, or damaged standing timber. After populations build, the beetles often move into adjacent trees. These outbreaks can cause high mortality in standing green timber. Prairie spruce beetles usually have a two-year life cycle. Adults construct egg galleries in the phloem that engrave the sapwood. The galleries tend to follow the grain of the wood. Larvae feed and over-winter under the bark and emerge as adults from late spring to late summer. Individual beetles reproduce in one to three years. This species attacks only mature and over mature trees.

Spruce budworm (eastern) – is the most common budworm in the region and feeds on a variety of trees, including balsam fir, white spruce and occasionally black spruce. The young larvae mine needles, buds and unopened shoots, feeding within the expanding shoots. The larvae are about 20 mm long, olive green with black heads and pairs of dots along the back. They are wasteful eaters, eating needles at the base of the bud and leaving the rest in a tangled silk mass. The foliage dries out, turns red and is eventually washed away with rain. Short periods of feeding seriously reduce tree growth. Longer outbreaks produce branch and tree death. Balsam fir is more susceptible than white or black spruce.

Spruce cone rust – attacks only the cones of spruce, causing them to open prematurely. Orange-yellow spores are produced on the cones. Most of the infected cones do not produce viable seeds.

Spruce needle rusts – Eight species of needle rust diseases affect spruces on the prairies. Coloured spores may be found on infected needles, buds and cones, but do not affect twigs or branches. Infections may be heavy, causing most or all of the current year needles to drop prematurely. Trees do not seem to be damaged significantly from heavy infections, although infected Christmas trees will lose value. Stem rusts are considered a more significant problem than needle rusts.

Spruce spider mite – will attack spruce, larch, balsam fir and other coniferous trees. It is mainly a concern in shelterbelts, ornamental trees, and plantations on dry sites. The microscopic mites pierce needles and suck the sap causing needles to dry, turn yellow or brown and fall off. They also spin silk-like webbing around needles and twigs and tend to affect the inner portion of branches in the lower part of the tree. Several years of severe infestations may result in reduced tree vigour, branch dieback or the premature death of the tree. Heavy precipitation, wind and high humidity provide the main forms of natural control.

Terminal weevils – attack most species of pine and spruce on the Prairies. Adults emerge in the spring, feed on the bark at the base of the terminal leader and lay eggs in the wounds. Larvae feed in the cambium, then either congregate in a feeding ring, or mine the pith, killing the leader. White pine weevils, which attack spruce, move downward from leader tip, while lodgepole pine weevils move upward from the leader base. Attacks kill the leaders of young pine and spruce, especially in open-growing stands. Repeated attacks cause crooked or bushy trees of low value. Attacks on young trees often result in multiple stems and reduced height growth and timber value. Christmas tree stands can be seriously damaged.

Warren root-collar weevil – feeds on white spruce, jack pine, lodgepole pine and other conifers. The larvae feed on the bark and the cambium at or below the duff level, causing resin to flow from the tree. This feeding will girdle and sometimes kill the tree and create a significant entry point for various root rots and other diseases.

Western gall rust – infects 2-needle pines (lodgepole, Scots, jack) across North America. This fungus causes round woody galls (up to 10 cm in diameter) to form on branches and occasionally on main stems. Powdery, orange-yellow spores are produced on the surface of galls. Gall development on the main stem can result in tree deformity and mortality. Trees break easily at the galls. Branch galls do not seem to affect the vigor of the trees.

White-spotted sawyer beetle – attacks most conifer species in the Prairie Provinces but activities are restricted to dead and dying trees, or cut logs. The large, black adults have bodies up to 3 cm long, with extremely long antennae. They lay eggs in the bark of logs throughout the summer. Larvae feed in the inner bark and sapwood, forming irregular shaped galleries before boring into the wood. The oval-shaped holes may penetrate up to 15 cm into the wood then turn back towards the log surface. Larvae usually spend two years in the log before maturing.

In the Prairie Provinces, most woodborer damage in harvested logs is caused by the white-spotted sawyer beetle. The large wormholes can degrade lumber and may prevent pine logs from being sold as power poles. They also provide entry points for fungi that can stain and decay the wood.

Yellow-headed spruce sawfly – attacks most spruce species of the Prairies. Larvae winter in the soil and emerge in late spring as adults. Eggs are deposited at the base of new needles. New needles are eaten before advancing to older leaves. Heavy attacks may completely defoliate the tree while repeated attacks may reduce height and diameter growth or even kill the tree. These sawflies prefer young open-grown trees particularly in shelterbelts and tend to concentrate on previously defoliated trees.

Figure 27: Yellow-headed Spruce Sawfly feeding on White Spruce at woodlot near Valleyview.

Pests of Coniferous and Deciduous Trees

Armillaria root disease – is one of the most important diseases of young trees in the Prairies. Most coniferous and deciduous trees may be hosts. Small, infected trees are killed quickly, while larger trees may continue to grow for several years. Typical symptoms are discolouration of foliage on the entire tree, white fungal fans between the bark and the wood, a thinned crown on mature trees and /or the presence of clusters of yellow-brown mushrooms at the base of trees.

Porcupine – is a serious pest of pine trees though it also feeds on willow. Porcupines climb trees to feed on the bark along the stem or branches. Damage is by girdling and may lead to death of the affected stem or branch or the entire tree. Porcupines prefer trees aged from seven to maturity and can be destructive to plantations, shelterbelts and woodlots in a short time. They are nocturnal and cause the most damage during the winter.

Woolly aphids – may infest a variety of hosts, including pine, spruce, ash, Manitoba maple, elm, apple, hawthorn, cottonwood, and Saskatoon trees. The insects feed on sap from the tree leaves, causing leaf deformation. Some species produce a powdery white wax and large amounts of honeydew. None of the species cause serious damage to trees, but they may create unsightly appearances and the honeydew they produce is often objectionable.

Yellow-bellied sapsucker – drills small holes on the trunks of various tree species. It can form elaborate galleries or may only create a few holes. In extreme cases, it will cause girdling above the galleries. Damaged areas create entry points for many other pests, however, the galleries are beneficial to some wildlife species such as humming birds that rely on sap in early spring before flowers emerge. The yellow-bellied sapsucker is protected under the "Migratory Birds Convention Act" therefore it cannot be controlled. Applying burlap wrap or pruning paint over wounds may repair damaged areas. Hardened sap should be removed before applying pruning paint.

Appendix 1. Common pests of Alberta woodlots by damage categories, symptoms, impact, and control options.

Damage category	General description	Pest examples	Age of trees affected	Location of damage	Key signs and symptoms	Impact	Control options
Defoliators	Caterpillar, larvae, beetle	Spruce budworm, Jack Pine budworm, Forest tent caterpillar, Bruce spanworm, Larch sawfly, Yellow-headed spruce sawfly, Large aspen tortrix, Leaf beetles, Satin moth	All ages	Leaves and buds	- Frass (insect excrement) and silken webbing on buds, foliage, and branch tips. - Partial or complete loss of foliage caused by feeding. - Discolouration of foliage. - Pupal cases and/or larvae found on branches.	Reduced vigour, stress, dieback.	Natural predators, biological and chemical insecticides.
Sucking insects and mites	Tiny bugs, woolly specks	Spruce spider mite, woolly aphids, aphids	All ages	Leaves, buds	- Sticky honeydew on foliage and sooty mold giving black appearance to foliage and twigs (some species). - Premature foliage drop and wilting. - Discoloured foliage. - Large groups of feeding insects.	Damaged foliage and stems and reduced tree growth and vigour.	Natural predators, biological and chemical insecticides.
Gall formers	Gall containing tiny insects	Cooley spruce gall adelgid, poplar bud gall mite	All ages	Shoots & buds	- Round to cone shaped galls on new shoots or leaves. - White cottony specks on infested trees (some species).	Parts of the tree swell or form galls that can reduce tree vigour.	Natural predators, removal of all infected trees in the area.
Stem and wood borers	Grub, beetle	Poplar borer, terminal weevils, white spotted sawyer beetle	All ages	Stem & shoots	- Wood chips and/or boring dust at the base of trees or logs (some species). - Dead terminal shoot (some species). - Tunnels with entrance/exit holes. - Wood stains with resin oozing from puncture wounds in tree.	- Wormholes - Stain that downgrades wood quality. - Dead terminal leaders. - Damage to decked wood.	Tree removal, cut and burn.

Appendix 1. Continued

Damage category	General description	Pest examples	Age of trees affected	Location of damage	Key signs and symptoms	Impact	Control options
Bark beetles	Small dark beetle, grub or larvae, galleries under bark	Elm bark beetle, Spruce beetle, Mountain pine beetle	Usually mature trees	Stem and shoots	- Sawdust around entrance holes. - Fading yellow, green, or red crowns. - Characteristic galleries (tunnels) in the inner bark. - Grayish-blue staining of sapwood (some bark beetle species). - Woodpecker feeding damage causing reddish trunks and piles of bark fragments.	The tree is killed by girdling or by an introduced harmful fungus like blue stain.	Natural predators, tree removal, cut and burn, bark peeling.
Root-feeders	Larvae, grub, beetle	Warren root-collar weevil	Usually young trees	Roots and root collar	- Girdling of roots and root collar. - Encrusted pupal cases near girdled area. - Whitish encrusted layer over feeding sites on root collar.	Tunneling in the bark, girdling the roots and lower stem and causing entry points for root and stem decay organisms.	Natural predators, removal of surrounding duff, removal of tree root material.
Cone and seed feeders	Larvae	Spruce cone worm	Mature trees	Cones & foliage	- Evidence of chewed cones and/or seeds. - Galleries and tunnels within cones (some species). - Webbing and/or frass on the outside of cones (some species). - Entrance holes on cones (some species).	Seeds and cones are damaged or destroyed mostly by chewing injury.	Natural predators, biological and chemical insecticides.
Stem and root decays and stains	Blue or white wood, discolouration, dead branches or wilting	False tinder conk	All ages	Stem, roots, trunks and butts	- Stem discolouration. - Blue or white wood, discolouration. - Dead or wilting branches.	Reduced wood volumes without affecting tree growth or mortality. Stem decay provides habitat for cavity dwelling and nesting wildlife.	- Removal of infected material and tree. - Sanitation cutting and burning.

Appendix 1. Continued

Damage category	General description	Pest examples	Age of trees affected	Location of damage	Key signs and symptoms	Impact	Control options
Dwarf mistletoe	"Witch's broom," yellow growth at base of "broom"	Dwarf mistletoe	Young stands	Stems and branches	- Abnormal branch growth. - "Witches' brooms." - Fruiting bodies at the base of the "brooms."	- Stunted growth, 1/3 growth loss. - Reduced vigour. - Tree mortality. - Chronic.	- Remove infected trees and/or stand. - Clear strips as barriers to spreading.
Root diseases	Mushrooms at tree base, fungi in roots	Armillaria root rot	Young trees	Roots	- Fruiting bodies (mushrooms) at tree base - Wilting, die back, roots discolouration with obvious fungal growths.	- Growth loss and tree mortality may occur. - Infected trees become less wind firm.	- Natural and biological control. - Stump removal before planting. - Plant resistant species.
Stem cankers/ rusts	- Discoloured stem (yellow or orange) - Branch or stem breakage - Orange powder galls	Hypoxylon canker, Western gall rust, Pine stem rust, Spruce cone rust.	All ages	Stems and branches	- Discoloured stem (yellow or orange) - Globose galls on stems - Orange powder on gall	- Trunk breakage. - Tree mortality.	- Harvest heavily infected stands. - Keep stand healthy, reduce tree stress through thinning. - Plant resistant aspen clones.
Foliage and cone diseases	Damaged or discoloured leaves or cones	Needle cast, needle rust, cone rust and leaf spot diseases	All ages	Leaves and cones	- Discoloured leaves. - Orange rust on leaves or cones. - Leaf spotting.	Minimal damage, slight growth loss.	None

Appendix 1. Continued

Damage category	General description	Pest examples	Age of trees affected	Location of damage	Key signs and symptoms	Impact	Control options
Abiotic: Climate High Temperatures	Dead leaves and/or branches, discolouration, wilting	Heat defoliation, Sunscald, heat canker, birch dieback, shoot droop.	All ages	Leaves, branches, and other areas	- Discoloured leaves. - Dead branches. - Foliage wilting.	Stunted/reduced growth,. Mortality.	None
Abiotic: Climate Low Temperatures	Dead leaves and/or branches, discolouration, wilting	Frozen unprotected roots, frost damage to stem, branches and/or leaves	All ages	Leaves, roots and branches	- Discoloured leaves. - Dead branches. - Wilted foliage.	Stunted/reduced growth. Mortality.	None
Abiotic: Climate Temperature Fluctuations	Cracking in trunk, separated rings, breakage	Frost cracks, frost shake, midwinter thaw	All ages	Leaves, roots and branches	- Discoloured leaves. - Dead branches. - Wilted foliage.	Stunted/reduced growth. Mortality.	None
Abiotic: Climate Water Stresses	Dead leaves and/or branches, discolouration, wilting	Drought, winter drying (red Belt), leaf scorch, flooding, leaf wilt	All ages	Entire tree	- Discoloured leaves. - Dead branches. - Wilted foliage.	Stunted/reduced growth. Mortality.	None
Abiotic: Mechanical Injuries	Bruising, breakage, defoliation, scaring, cracks, white trunk or branches.	Ice, snow, wind, hail, root compaction, transplanting, wildlife (scraping, girdling, browsing), windfall	All ages	Leaves, branches, roots and trunk	- Discoloured leaves. - Dead branches. - Wilted foliage.	Stunted/reduced growth. Mortality.	None
Abiotic: Nutrient Deficiency	Yellow foliage, dead foliage and / or branches	Low nutrient levels, salt toxicity	All ages	Branches, roots and foliage	- Discoloured leaves. - Dead branches.	Discoloured leaves. Dead branches.	None
Abiotic: Pollution	Yellow foliage, dead foliage and / or branches	Herbicide damage, Industrial pollution, acid rain, animal urine, industrial fumes	All ages	Foliage, and roots	- Discoloured leaves. - Dead branches.	Discoloured leaves. Dead branches.	None

Appendix 2. Damaging agents of the most common Alberta tree species.

Tree Species	Animals	Diseases	Environmental Stress
White spruce	Spruce beetle Spruce budworm White pine weevil White-spotted sawyer beetle Wooly aphid Yellow-headed spruce sawfly Spruce spider mites	Armillaria root rot Spruce cone rust Spruce needle rust	Wind throw Drought
Jack pine and Lodgepole pine	Jack pine budworm Lodgepole pine terminal weevil Mountain pine beetle Pitch blister moth Warrens root-collar weevil Woodborers Porcupine Yellow-bellied sapsucker Snowshoe hare	Needle cast Dwarf mistletoe Pine stem rust Western gall rust	Road salt Flooding
Tamarack	Bark beetle Larch sawfly Woodborers Porcupine		Low herbicide tolerance
Black Spruce	White-spotted sawyer beetle	Armillaria root rot Root and stem decays	Flooding
Balsam fir	Spruce budworm Woodborers	Armillaria root rot Root and stem decays	
Trembling aspen	Bruce spanworm Poplar borers Poplar leaf miner Forest tent caterpillar Large aspen tortix Leaf beetles Gypsy moth Beaver	Armillaria root rot Hypoxylon canker False tinder cook Various Stem decays/stains	Shade Drought Herbicides
Balsam poplar and hybrid poplars	Poplar leaf miners Wooly aphids Poplar borer Voles Deer/moose/elk Beaver	Armillaria root rot Hypoxylon canker Various Stem decays /stains	Shade Drought Herbicides
White Birch	Birch leaf miners Bronze birch borer Yellow-bellied sapsucker Beaver	Fungal conks Silver leaf Root and stem decays	Drought Herbicides Soil temperature fluctuations

Beneficial Management Practices for Maintenance and Improvement of Forest Health

- Maintain biological diversity as a pest control strategy.
- Learn to recognize pests and their activities.
- Routinely monitor the incidence of insects and diseases on the woodlot and adjacent areas and maintain maps and records.
- Use natural control measures whenever possible.
- Make prudent use of chemicals consistent with all regulations.
- Follow environmental guidelines for chemical containers and applicators.
- Ask for advice and guidance from qualified pest control practitioners.
- Involve/inform neighbours of pest management activities.
- Develop and follow a pest management plan or strategy.

Selected Readings, Internet Sites, and Information Sources

Internet sites

http://esrd.alberta.ca/lands-forests/forest-health/default.aspx - Forest Health, ESRD

http://esrd.alberta.ca/lands-forests/forest-health/forest-pests/default.aspx - Forest Pests, ESRD

http://esrd.alberta.ca/lands-forests/forest-health/forest-pests/forest-pest-damage-diagnostics.aspx
- Forest Pest Damage Diagnostics

http://www.agric.gov.ab.ca/app21/infopage?cat1=Diseases%2FInsects%2F%20Pests
- Diseases/Insects/Pests, Agriculture and Rural Development

http://mpb.alberta.ca/Default.aspx - Mountain Pine Beetle in Alberta

Books and Publications

Annual report. Alberta Sustainable Resource Development.

A field guide to forest insect and diseases of the Prairie Provinces. Hiratsuka, Y.; Langor, D.W.; Crane, P.E. 1995. Natural Resources Canada, Canadian Forest Service, Edmonton, Alberta. Special Report 3.

Forest health in Alberta. Alberta Sustainable Resource Development, Forest Management Branch. 1987 to present.

Forest landowner. Washington State University.

Forest stewardship – a handbook for Washington forest landowners. Washington State University.

Managing your woodlot – A non-forester's guide to small-scale forestry in British Columbia. B.C. Ministry of Forests and Land.

The woodlot steward. James Fazio. University of Idaho.

The woodlot workbook. Oregon State University.

Tree and shrub insects of the Prairie Provinces. Ives, W.G.H.; Wong, H.R. 1988. Canadian Forest Service, Edmonton, Alberta. Information report NOR-X-292.

Woodlot management home study courses. Nova Scotia Department of Lands and Forests.

Woodlot stewardship plan. Minnesota Division of Forestry.

Information Sources

Alberta Environment and Sustainable Resource Development (ESRD) – Alberta Information Centre
Main Floor, Great West Life Building
9920 108 Street
Edmonton Alberta Canada T5K 2M4
Call Toll Free Alberta: 310-ESRD (3773)
Toll Free: 1 877 944-0313
Fax: 780 427-4407
Email: ESRD.Info-Centre@gov.ab.ca

Canadian Forest Service Northern Forestry Centre
Natural Resources Canada
5320 122 Street
Edmonton, AB T6H 3S5
Phone: 780-435-7210
Fax: 780-435-7359

Silviculture

Contents

Criteria and Indicators of Sustainable Forest Management for Silviculture

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes found throughout the woodlot and surrounding landscapes. Indicators of accomplishment include:***

- Forest renewal can influence plant and animal communities. Efforts are made to maintain, enhance or protect a diverse population of plants and animals during reforestation operations and subsequent tending of the new forest. Due diligence is exercised to identify and if necessary protect species at risk or critical habitat.
- Sites of historical, geological, archeological, or cultural importance are identified in the management plan for the woodlot. Strategies are developed to give full consideration to these sites during the implementation of the silviculture plan.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. A primary focus of silviculture work is to maintain or enhance the forest productivity of the woodlot. Indictors of accomplishment include:***

- Activities to protect against fire, insect, and disease will contribute to a sustainable woodlot. Operations are conducted in ways to minimize the risk of fire and protective measures consistent with provincial and municipal regulations are implemented. Insect or disease outbreaks are reported to the appropriate authorities to protect the woodlot and surrounding properties.
- Integrated pest management strategies are adopted as a first approach to controlling pests or competing vegetation. Chemical or biological pesticides are used prudently in accordance with manufacturers' instructions and in compliance with provincial and federal regulations.
- Woodlots are regenerated with species best suited to the site.
- The emerging forest or advanced regeneration is protected from damage during silviculture and harvest operations and from domestic animals.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Many silviculture activities have the potential to influence quality and quantity of water and protect and conserve soil. Indictors of accomplishment include:***

- Soil productivity is maintained by conducting silvicultural operations such that rutting, erosion and soil compaction is minimized. Land taken out of production for uses such as landings, roads, trails and slash piles is kept to a minimum.
- Water quantity and quality is maintained by protecting or minimizing operations in riparian zones and water bodies or courses.
- Compliance with regulations established to protect soil and water including operating ground rules and disposal of hazardous materials.

Criteria 4: ***Role in global ecological cycles. Implement forest management practices to contribute to the health of global ecological cycles by utilizing the carbon sequestration capacity of forests. The combined action of woodlot owners who manage healthy vigorously growing forests will influence global ecosystem function. Indicators of accomplishment include:***

- The woodlot is managed as a productive forestland to maintain its role in carbon sequestration.

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest plan to benefit present and future society. Indicators of accomplishment include:***

- Silvicultural activities are planned and implemented to maximize both timber and non-timber values.
- The woodlot owner maintains a healthy and safe work environment.

Criteria 6: ***Society's responsibility. The woodlot owner accepts society's responsibility for sustainable development. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- The community is informed of the woodlot management plan including silviculture operations and is given the opportunity to comment on planned activities.
- Silvicultural activities are planned with consideration given to locations in the woodlot of special interest to the community, including aboriginal groups.

Introduction

Silviculture is the science of establishing, growing, tending, and harvesting trees. A silviculture system is a planned program of treatments scheduled throughout the life of the forest stand. These scheduled events range from harvesting the forest to regenerating and subsequently tending the new stand.

The woodlot owner has many options to consider when choosing silviculture activities. Whether planting trees, thinning juvenile stands, or harvesting mature timber, there are numerous systems and strategies available that can be adapted to suit local conditions and meet specific objectives. In addition, responses to silvicultural systems differ among species and the system chosen could influence the forest for many years into the future. A thorough knowledge of the silvics of the species will help to select an appropriate silvicultural activity. The silvics of a wide variety of North American tree species are described in detail on the following Internet site: http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Many factors must be considered before choosing a silviculture system. These factors include:

- Objectives: The objectives must be clearly stated in the woodlot management plan. The silviculture activity selected must contribute toward these objectives. For example, the objectives will articulate the importance of aesthetics, wildlife diversity, rate of growth of the next stand, or income flow versus one lump-sum payment. Objectives need not be mutually exclusive since silviculture systems can accommodate multiple objectives.
- Economics: Current and anticipated market conditions will influence the choice of silviculture system. The harvest method and timing of the harvest will be determined by the markets for the resulting forest products. The harvest system selected may influence regeneration costs, and the regeneration system selected will in turn be influenced by current cost and availability of equipment, materials, and labour.
- Regeneration: Regeneration can be performed by artificial methods where trees are planted or seeds are sown, or by natural methods where seeds originate from logging debris or are dispersed by nearby mature trees. Choices must be made on the method most appropriate for the site.
- Climate: Local climate can affect, and in some circumstances dictate, the silviculture system. For example, regions subjected to consistently high winds are appropriate for harvest systems that do not leave stands vulnerable to blow-down. Length of the growing season will affect species choice or vegetation management approaches.
- Current stand: The harvest system selected will be influenced by the current stand. Tree size and stand size, for example, will determine harvest equipment and methods. The growth rate and maturity of the current stand will influence the timing of treatments such as thinning, pruning, or fertilizing.
- Species suitability: Some species are more suited to a particular site or region than other species, and some silvicultural systems are more appropriate for some species than are others. For example, green ash, which is resistant to drought, may be more appropriate for an afforestation project located in a dry agriculture zone. A clearcut harvest system will favour regeneration of intolerant species like pine or aspen, while a selective logging system is more favourable for regeneration of shade tolerant species like spruce.
- Wildlife: Wildlife habitat is sensitive to disturbance from silviculture treatments. The woodlot owner's objectives regarding wildlife can be met if silviculture treatments are selected to create or enhance habitat. Small irregular shaped cut-blocks, for example, will create more habitat and more diverse habitat than will large rectangular blocks.
- Pests: Silviculture treatments can be selected to reduce the impact of pests already established in the woodlot, or discourage migration of pests from other properties. Forest harvests could be scheduled to give higher priority to areas of severe pest infestation. Selective logging could be planned to remove individual trees affected by insects such as Mountain Pine Beetle – an effective control measure – and reduce the chance of spreading to other parts of the woodlot or to other properties.
- Time: Availability of time and labour is often a limiting factor in choosing a silviculture treatment. Reliable, competent contractors must be available to implement any silviculture treatment selected.

The choices must be consistent with the objectives for the woodlot and should be based on knowledge of the outcomes of different silvicultural activities. Once the choices are made, the planning process can begin.

Pre-Harvest Silviculture Planning

Long-term management including harvest, reforestation of the logged area, and future products from the new stand should be considered before starting a harvest operation. The plan cannot account for all potential problems, therefore planning management strategies to overcome anticipated difficulties will improve results and/or reduce costs. For example, reforestation difficulties can be expected for sites prone to heavy brush competition after logging. This potential problem can be mitigated by ordering large planting stock before the area is harvested to allow for prompt reforestation before the brush becomes established.

The following issues should be considered before logging operations begin:

1. Standing timber

- What products are expected from the harvest.
- Which silviculture system will be selected.
- When the harvest will take place, how it will be conducted, and what equipment will be used.
- Who will be involved in the various management activities.
- Where the products will be marketed.
- What the market conditions are.
- At what stage the timber in the woodlot is – juvenile, mature, or over-mature.
- Any areas or situations that require special attention.
- What the impact on wildlife habitat will be.
- What tree species are desirable for the next stand.

2. After the harvest

- What form of regeneration will be required.
- Whether site preparation will be required.
- Who will do the site preparation, and when and how it will be done.
- Whether regeneration will be natural or artificial.
- If planting is required, where the seedlings will come from.
- How far in advance the seedlings should be ordered.
- Who will do the planting, what methods will be used, and when it will be done.

3. After regeneration

- What survival surveys are necessary and when they will be done.
- What vegetation control method will be required.
- Whether follow-up plantings will be necessary.
- What stand protection is necessary.
- Whether the stand will require thinning/releasing.

The method of harvest can now be considered in view of these issues.

Harvest Methods

Harvest methods are selected to suit the landowner's goals, adapt to the stand conditions, and to accommodate markets for the products. The harvest system will affect how the new stand will be regenerated and the structure of the new stand. Harvesting the timber in one pass will result in an even-aged stand while removing portions of the stand over a period of time will yield an uneven-aged stand. When the youngest and oldest trees in a stand differ by less than 20 years, the stand is considered to be even-aged, while ages of trees in an uneven-aged stand differ by more than 20 years. Harvest methods must be adapted to the characteristics that are unique to each woodlot and must meet the objectives of the woodlot owner.

The three most common forest harvest methods are clearcut with various modifications, selective cut, and shelterwood cut. These harvest methods mimic natural occurring disturbances such as fire, other natural destructive agents, or aging, and allow the landowner to benefit from products in the woodlot. Other harvest methods such as seed tree harvest, coppice cuts, and sanitation cuts are less common although applied in specific circumstances. Each harvest method has advantages and disadvantages depending on the site, tree species, management objectives and other factors.

Clearcutting Method

Clearcutting removes all merchantable trees from the specified area in one pass. The new stand that results after clearcutting will depend on the original stand conditions and on the surrounding forest type. Usually this new stand is composed of even-aged, fast growing, short lived species.

Clearcutting is especially suited to even-aged stands of shade intolerant (sun loving) species such as aspen, balsam poplar and pines. Clearcutting is often criticized because it results in unnatural conditions. However a stand regenerated after clearcutting is similar in many respects to a stand resulting after a natural disturbance such as wildfire, high wind, or widespread severe insect or disease damage.

Clearcuts can vary in size and shape depending on the objectives of the harvest. Generally, large blocks are more cost effective to harvest than smaller blocks, but large blocks also require greater expertise to manage in terms of operational logistics during both the harvest and reforestation stages. If the objective is to establish a large even-aged stand after the harvest, then a large size cut is appropriate. If the objective is to create a mosaic of stand ages after harvest, then a series of smaller dispersed clearcut blocks harvested over a number of years should be considered. Large cut blocks provide a lump sum cash payment while smaller blocks harvested over a period of years will provide an income stream over the duration of the harvests. Objectives such as wildlife habitat and diversity of stand ages can be addressed by selecting the appropriate cut block size.

After clearcutting, the new stand can originate from natural regeneration where seeds occur in the logging slash and/or are dispersed from the surrounding forest, or artificial regeneration where seeds are broadcast or tree seedlings are planted. Stands like aspen or balsam poplar often regenerate from root suckers and may not require artificial seeding or planting. Clearcut pine stands often regenerate naturally if sufficient well-distributed cones are in the logging slash, and ground conditions favour seed germination. Naturally regenerated stands may vary in density and very high densities are not uncommon under some conditions. Very dense stands will need further tending to optimize tree growth.

If natural regeneration is not successful, the area should be artificially regenerated. Artificial regeneration includes seeding and tree planting. Seeding is usually done by manual broadcasting, but planting trees is the more common method to regenerate clearcuts. Tree planting is usually done manually, although mechanical planters applicable to some woodlot situations are available. The main advantages of tree planting over other regeneration methods is that large seedlings can be planted to compete with other vegetation, and that density or inter-tree spacing can be controlled.

Clearcutting is generally the most cost-effective harvest method. Logging is facilitated because there is no need to avoid residual trees, and supervision can be minimized because all merchantable sized trees are removed. In addition, clearcut blocks are more easily accessible and economical for site preparation and subsequent tree planting.

Clearcutting also presents disadvantages. The large volume of material removed per unit area requires more trips by the skidder and causes greater disturbance to the forest litter and underlying forest soil. The risk of soil erosion and rapid runoff, particularly as slopes and cut block size increase, is greater for clearcuts than for other harvest methods. Clearcut blocks are more prone to invasion by dense shade intolerant shrubs and grasses, making regeneration to commercial tree species potentially difficult and costly. Finally, large open cut blocks have an unattractive visual effect and although some wildlife species thrive in these conditions, others cannot tolerate large open areas.

The negative factors of clearcutting can be mitigated by considering the effect of the harvest on the surrounding forest and on wildlife habitat. Blow-down of shallow rooted species like black and white spruce can be avoided by designing cut blocks that minimize exposed faces of the surrounding forest stands to prevailing winds. Blow-down could also be avoided by integrating topography into the design to lessen wind exposure. Laying out the cut block so that the shape and orientation follow natural contours can help to minimize erosion from runoff. Cut block size and shape can also be altered to accommodate the needs of wildlife.

Figure 28: Clearcutting

Clearcutting in patches or strips can be beneficial to some wildlife. The increased sunlight promotes growth and establishment of vegetation while still providing cover close to the food source. Irregular shaped cut blocks will increase the amount of edge, provide food, and reduce the exposure of wildlife to long sightlines. These changes can often be made at no additional cost, but require efforts during the initial planning stages and knowledge of the outcomes of harvesting.

Selective Cutting Method

Selective harvesting removes individual trees or small groups of trees according to predetermined criteria. Trees are harvested using a selective system to generate periodic income, to create small openings for regeneration and to improve the growth of the residual stand. This harvest method is best suited to uneven-aged stands of shade tolerant species such as spruce or fir, or to mixedwood stands of spruce and aspen. Selective harvest methods are also used to convert even-aged stands to uneven-aged stands if the managed species is shade tolerant.

Generally, selective harvests target the older trees and leave the younger fast growing trees to continue growing until they reach a desired size. However, not all merchantable size or high value trees are cut. Some are left for seed source and for future income and some are left to maintain a desired stocking level. Unhealthy or deformed trees or unwanted species can also be removed during these periodic harvests so that a vigorously growing stand remains. Sustainability can be achieved by balancing the volumes removed with the additional growth of the residual stand. Table 9 summarizes basic characteristics of trees to cut and trees to keep in a selection harvest operation.

Table 9. Basic characteristics of trees to cut ands trees to keep in selection harvesting.

Trees to cut	Trees to keep
Low vigour, slow growing trees	Rapidly growing, valuable species
Trees with a crooked stem or leaning	Well-formed, vigorous trees of desired species
Severely exposed, tall, thin, shallow rooted trees	Trees important for their value to wildlife
Trees that interfere with crop trees	
Diseased trees	

Selection harvesting should be considered only for wind firm stands to minimize wind damage to the exposed residual trees. Damage from the harvest activity also needs consideration and can be reduced if skidding and other travel is restricted to designated trails. This will help to protect seedlings, larger residual trees, and soils. The trails can also be used to access the stand for other silviculture treatments, fire protection and recreation.

Forest regeneration is usually left to natural processes, although artificial reforestation methods are also used. Planting is an option particularly when the landowner wishes to increase the stocking of a specific species.

Figure 29: Selective harvesting

Selective harvesting provides several benefits. It has a lower visual impact than clearcutting and is therefore preferred where recreation or scenic values are important. Sensitive areas such as steep slopes or buffer strips, where ground disturbance must be minimal and the forest canopy must be kept intact, can be harvested by selective logging methods. Wildlife habitat is usually not severely affected, although the introduction of access trails may disrupt some wildlife activity. Finally, since the harvests are done periodically, they create a potential income stream lasting as long as the stand is maintained.

Selection harvest also has disadvantages. Since this harvest method will increase the risk of wind damage to the residual stand, trees that will be vulnerable to wind damage should be either harvested or protected from exposure. In addition, the remaining vegetation, including the residual trees, can be damaged if special care is not exercised during the logging operation. This means work will progress slowly and costs will be higher. Only experienced operators should be used to harvest trees selectively.

Selective harvesting can be a useful method of managing a woodlot for profit while maintaining the values inherent in a closed canopy forest. It is likely the most difficult system to apply and requires special efforts in planning and executing the operation.

Attention must be given to the resulting stand to ensure a high quality stand of well-spaced vigorous trees remains. The public is more accepting of this harvest method if the residual stand appears healthy and visually appealing because it produces the least amount of visible logging activity. The goal of selective harvesting is to improve the forest, not degrade it.

Shelterwood Cutting Method

The shelterwood method is a combination of selective cutting, clearcutting and seed tree cutting methods. The shelterwood cutting method removes trees in a series of two or more partial cuts. Unlike the selection cutting method, the shelterwood method will not provide a continuous cover of mature trees. These cuts stimulate the germination and rapid growth of a new forest in the shelter and the shade of mature trees. The mature trees usually provide seed for regenerating the site. Once young trees are well established on the cutover, the remaining larger trees are removed, leaving only the even-aged regeneration.

The first cut - the preparatory cut – removes about 25% of the trees and is similar to a selection cut or thinning. The lower stand density gives the remaining trees more space to grow and to become wind firm. A preparatory cut may not be necessary in stands previously thinned. In stands where density continues to be high, additional preparatory cuts may be beneficial.

The **seed cut** may be used to encourage natural regeneration from seeding. This cut removes about half the trees including all trees in the intermediate and co-dominant crown classes and any undesirable species. The remaining trees are not fully exposed to wind and the partial canopy provides shade for new seedlings. Only the best trees are left for a seed source.

The **final cut** is the removal cut and all remaining trees are harvested. This cut is made when the new crop is well established and can benefit from additional growing space. The preparatory and the seed tree cuts have prepared the site for the new stand in terms of creating a receptive seedbed, providing a seed source from the healthy fast growing trees remaining after the cuts, and maintaining a partial canopy to protect the newly established seedlings.

Wind throw is a serious concern in shelterwood methods. Uprooted trees create unsightly and unproductive areas in the woodlot. Salvage operations in a partially cut stand are often more costly than clearcutting. Planning a shelterwood harvest to minimize windthrow requires considerable expertise. The risk of windthrow is related to soil texture, soil moisture, wind speed and the species, age, rooting habit, size and crown development of the residual trees. Selection cutting that removes very little of the mature stand in the initial harvest will greatly reduce the risk of wind damage.

Other Cutting Methods

Other cutting methods such as the seed tree cutting method and the sanitation cutting method are variations of clearcutting and selective cutting. The seed tree method is similar to the seed cut conducted under a shelterwood cutting system. Unlike the seed cut in the shelterwood system, the seed tree cut leaves only 10 to 25 seed trees per hectare as a seed source and is similar to a clearcut where there is virtually no canopy remaining to protect the new forest. Healthy fast growing trees with good form should be selected for seed trees. Species susceptible to wind throw because of shallow rooting characteristics should be left in clumps rather than lone-standing, to protect them from wind damage. After the new stand is well established, seed trees may be harvested but care must be exercised to avoid damage to the new forest.

Another harvest method is the sanitation cutting method. This method is used to remove trees killed or infected by insects or disease. The goal of a sanitation cut is to prevent the pests from spreading to healthy trees or stands. Trees removed in a sanitation cut are usually used for firewood.

The clearcut, selection cut, shelterwood cut, and seed tree cut systems are summarized in the appendix to this chapter.

Not all forest must be harvested. The woodlot owner may value the uncut forest more than the income that could be derived from harvesting the timber. However the forest is not static; rather it is continuously changing. As the forest evolves from one state to another, it may cease to meet the objectives of the woodlot owner. An even-aged forest containing only one or two tree species, or an over mature forest containing many decadent trees is susceptible to damage from fire, insects or disease, and the probability of change is high. Forest management activities such as harvesting may help to maintain a healthy diverse forest and contribute towards meeting the objectives of the woodlot owner.

The harvest systems discussed have been presented within the context of establishing or regenerating a new forest after the harvest. For this reason, pre-harvest planning is essential to ensure the harvest system will facilitate the establishment of the new forest. As different options are available to harvest the forest, so too are options for regeneration and establishment.

Forest Regeneration Systems

Forest regeneration is the process of renewing a forest by natural or artificial means. Natural regeneration is by natural seeding or root sprouting, while artificial regeneration is by direct seeding or planting. Prompt renewal of a harvested forest is important to ensure the sustainability of the woodlot. Therefore, a plan to renew the disturbed forest should be developed before harvest operations begin. The plan should be appropriate to the site and the species being managed, as well as the chosen harvesting method. Regeneration is an essential component of sustainable woodlot management and should be an integral part of the overall woodlot management plan.

The regeneration method selected will influence the cost of establishing the new forest and may also affect subsequent tending requirements. Natural regeneration is usually the lowest cost method of forest renewal. Often, a naturally regenerated forest is best suited to the site because it originates from trees already growing on or near the logged-over area. Artificial regeneration usually requires a higher initial cost, but allows better control of species composition and stocking levels.

The naturally regenerated forest will originate from seed or from root suckers. Hardwood species like aspen and balsam poplar produce seed every year, but most reproduction occurs from root and stump suckers. Softwood species like pine and spruce reproduce almost exclusively from seed, although layering – a process where branches in contact with moist organic soil will root – does occur in partially cut black spruce stands.

Harvested hardwood or mixedwood stands left to natural regeneration processes will usually revert to hardwood species. This is because of the prolific root suckering characteristic of the hardwoods, particularly aspen and balsam poplar, and because of the preference of these species to grow in open sunlight; i.e. they are shade intolerant. The harvest operation in these stands will create openings in the canopy and cause soil disturbance, particularly if logged during frost-free seasons. These actions cause warming of the soil and in turn stimulate root suckering. The softwood component – usually white spruce - in mixedwood stands is often immature and is left to continue growing. Natural softwood regeneration is minimal.

Softwood stands will regenerate naturally from seed if an adequate seed supply is present, and if the site conditions are favourable for seed germination and seedling growth. Seed supply varies for softwood species by year. White spruce, for example, usually produces a good seed crop every 2 to 5 years, black spruce every 3 years, and tamarack every 3 to 6 years. Seed supply can be assured if harvest operations coincide with years of high seed production.

Seeds are more likely to germinate when in contact with exposed mineral soil. Harvest operations or subsequent site preparation will create disturbances to expose mineral soil and temporarily reduce the ground vegetation cover. The activity will also flatten branches so cones and seeds are closer to the ground. Some species like pine produce serotinous cones that require high temperatures to open and disperse their seeds. Fire creates these high temperatures; however, sufficiently high temperatures to open the cones can also be reached in clearcuts. The emerging seedlings require light, nutrients, and moisture to become established and compete with other vegetation. These factors combine to increase the risk of failure of regeneration from natural seeding.

Figure 30. Natural regeneration of white spruce.

Artificial regeneration methods are used when natural methods have failed, or the risk of failure by natural methods is high. Artificial regeneration also allow greater control of species composition and inter-tree spacing of the new forest. It is accomplished either by direct seeding or by planting seedlings. Direct seeding is done by manually or mechanically broadcasting seed. This method has risks similar to natural seeding. However seed availability is assured regardless of the natural seed crop, and there is some control over where the seeds are broadcast.

Planting is the most common and successful method of regenerating a forest but may also be the most costly. Since seedlings are planted only in desired spots, this method provides control of spacing between trees of the desired species. It also allows flexibility to determine species composition, and gives planted seedlings an initial size advantage over competing ground vegetation. Planting is usually done manually although mechanical planters are suitable for some woodlot situations. Follow-up thinning treatments to reduce stand density to maximize growth are not usually necessary in planted cutovers.

The chance of success of forest renewal by natural or artificial reforestation methods can be improved by preparing the site to facilitate reforestation and by managing vegetative competition after the new forest becomes established. Both activities add to the cost of forest renewal but these costs must be weighed against the benefits, as well as the objectives of the woodlot owner.

Site Preparation

Site preparation is a silvicultural activity that modifies a site to provide favourable conditions for natural or artificial regeneration. Some logging operations leave slash or logging debris scattered throughout the site, while others accumulate slash at landings or other locations. Logging during winter months causes minimal soil disturbance but the freezing temperatures facilitate shearing of woody plants that could potentially compete with the regenerated stand. Summer logging has a smaller effect on woody plants but creates greater soil disturbance. The risk of reforestation failures can be reduced by appropriate site preparation techniques. These silvicultural activities use mechanical or manual techniques to disturb the soil, break-up and/or scatter logging debris, or reduce vegetation.

Site preparation should be part of the reforestation plan. The method and level of site preparation required will be determined by the harvest method and resulting site conditions. The goal is to improve the chance of successfully reforesting a site, and the results will vary depending on the technique used. Some expected results are:

- Creation of suitable microsites (or spots) for seed germination or for planting seedlings;
- Soil disturbance without causing excessive damage;
- Reduced vegetation to compete with emerging or planted seedlings;
- Higher soil temperature to stimulate root suckering and seed germination;
- Crushed, broken, and scattered logging debris or slash;
- Disruption of compacted soils and dense root masses.

Generally, site preparation is accomplished by mechanical or manual scarification, by fire, or by applying herbicides.

Scarification

Scarification is the most common site preparation practice. As with any site preparation technique, the objective is to create a suitable environment for seeds to germinate or planted seedlings to become established. Generally, scarification methods are intended to disturb soil, slash and vegetation to varying degrees. The disturbance could be in continuous strips or in patches. Continuous strips are created by special implements such as disk trenchers that leave furrows and berms, plows that clear vegetation and upper organic layers of the forest floor, or other implements that are dragged or pushed across the site to disturb the soil and vegetation.

Patch scarification prepares "patches" of disturbance. An example of a mechanical patch scarifier is the Bracke, which scrapes or scalps pieces of sod approximately 0.5 m2 to expose mineral soil and create suitable planting spots. These scarification methods require specialized implements and heavy equipment and are best suited to large cutovers.

Other methods are intended mainly to disturb the slash. Heavy chains with large spikes dragged behind a skidder will break up logging debris and push cone-bearing slash close to the ground. "Shark Finned Barrels" are sometimes included with the chains to further disturb the slash and mix the soil. Drum Choppers (large water-filled drums equipped with

blades) dragged behind a tractor or skidders are also used to break and flatten slash. Although the main function of these techniques is to manage slash cover, mineral soil is also exposed to create environments suitable for seed germination and seedling establishment. These methods also require specialized equipment and are best suited for larger cutovers.

Manual scarification methods may be more appropriate for woodlots where smaller areas are treated. Scarification can be done manually or with motorized hand tools to scrape away the organic layer and remove vegetation around a spot to be planted or seeded. Patches about 0.5 m2 are cleared of vegetation and forest litter to prepare a suitable planting or seeding spot. Spacing of the scarified patches can be selected to meet the woodlot owner's objectives. This low cost method creates minimal disturbance and does not require specialized and costly equipment.

Fire as a Site Preparation Tool

Wildfire, a common natural occurrence in forested areas, is nature's way of preparing a site for a new forest. Fire creates many characteristics that other site preparation methods attempt to mimic. However, many factors must be considered before intentional burning, known as prescribed burning, is used to prepare a site for regeneration.

A prescribed burn may not always produce the results intended. For example, the fire can be hot enough to physically and chemically damage thin or sensitive soils; it may damage or destroy valuable wildlife habitat including standing and fallen dead trees or nesting sites; it may remove the protective vegetation cover from areas sensitive to wind or water erosion; and it may eliminate existing seed sources. Finally, the effect of fire on neighbouring properties must always be considered.

Prescribed burning in or near forested areas requires careful planning and expertise. Precautions such as fireguards or other measures must be taken to control the extent of the fire. Fire permits are usually required and significant liability may occur if the fire escapes. Small scale burning of slash piles is acceptable among woodlot owners, although the objective may be for aesthetic purposes rather than to prepare the site for reforestation. Woodlot owners do not often use fire as a site preparation tool because of its unpredictable and dangerous nature.

Site Preparation Using Herbicides

Herbicides are used to prepare a site for reforestation by controlling shrubs, grasses and other weeds. Herbicides are most commonly used as a stand tending technique where vegetation is controlled after seedlings are established. Tests and limited operational trials across the Prairie Provinces have shown some herbicides can control vegetation without damaging coniferous seedlings. Regulations govern the use of herbicides in forestry, therefore woodlot owners must consult local authorities before planning an herbicide application in their woodlot.

Tree Planting

Site preparation costs could be a major component of the investment in the new forest. Reforesting an area with high quality seedlings using good planting techniques and hardy stock will reduce the risk of losing that initial investment.

The decision to plant trees rather than to rely on other regeneration methods is most often made because other methods have failed or the risk of failure by other methods is too high. The decision to plant may also be made because the regeneration effort is focused on controlling the species composition or the stocking levels, or because of the lack of a natural seed source.

Once the decision to plant has been made, the choice of species and stock type must be considered. The choice of species largely depends on the woodlot owner's objectives and on the planting site. Although softwoods are the most common trees planted, hardwood species are also considered to meet specific objectives. If the objective is to grow commercially valuable timber, then appropriate hardwood or softwood species would be selected in anticipation of future markets. For example, widely spaced white spruce would be a likely species choice if softwood sawlogs or veneer logs were the intended end products. If softwood pulp logs was intended, then closer spaced conifers would be more appropriate. Faster growing hardwood species may be planted when the objective is to create or enhance wildlife habitat, stabilize erosion prone areas, or perhaps grow trees for their carbon sequestration potential.

Figure 31: A 10-year-old white spruce plantation.

Stock types are available in various forms and sizes. Some are bare root, some are plugs grown in containers, and some are rooted or unrooted cuttings.

Generally, bare root stock is the largest and is preferred in areas of high vegetation competition. Bare root stock is reared in fields but sometimes is started in the greenhouse and later transplanted to a field. A two-digit code describes the history and age of bare root seedlings and is an indication of size. The first digit is the number of years in a seedbed, and the second is the number of years in a transplant bed. For example a 2-1 seedling was in a seedbed for the first two years and in a transplant bed for the last year making it three years old. Reforestation with bare root seedlings is usually costlier than with other stock types because their purchase price is usually higher, they are more difficult to store, and they are laborious to plant because of the larger roots.

Container grown seedlings, or plugs, are the most common stock type used in reforestation. These seedlings are grown in containers packed with nutrient enriched peat moss or other growing medium. When ready for shipping or planting, the seedling is extracted from the container with the roots and growing medium, or plug, intact. Container grown seedlings are available in a variety of sizes based on the volume of the container expressed in cubic centimetres. For example, a 411 container seedling was grown in a 411 cc container. Age is sometimes also described using the same coding as bare root stock. A 2-0 plug means the seedling was grown in the container for two growing seasons but was not moved to a transplant bed. Container seedlings are preferred because of their low purchase cost, relatively short rearing time requirements, and ease of planting. Most species used for reforestation can be reared in containers, however conifers are the most common.

Cuttings, either rooted or unrooted, are uncommon in reforestation projects. However, their use is increasing, particularly where fast growing hybrid poplar is the desired species. They may be used in a woodlot for specialized objectives such as planting for carbon sequestration or wildlife, or when special contractual arrangements are made with a hardwood using industry. Their use is also becoming more common among forest industries based on hardwood feedstock. Advantages of using cuttings are their low purchase price and low planting cost. Rooted and unrooted cuttings are easily produced but availability is sometimes an issue.

Regardless of the stock type selected, all stock should originate from areas with similar environmental conditions as those of the planting site. Stock from similar nearby areas is preferable to stock from similar distant areas. Ideally, stock should originate from the same ecoregion as the planting site.

Time of Planting

Spring is the preferred time to plant because abundant moisture is available for the trees and because the seedling can become established within the first growing season. Planting should begin after frost has left the ground and soil temperature exceeds 4 C, but before shoot growth begins. Planting can be done in the fall but spring planting will improve winter survival because of the better root development during the first growing season. Fall-planted trees are also more susceptible than spring-planted trees to frost damage and to damage from rodents and other wildlife.

Seedling Spacing

Spacing between planted seedlings depends on the tree species and on the objectives of the planting. Wider spacing will result in fewer but larger trees than narrower spacing, however, trees growing in open conditions will have more branches and poorer form than trees growing in denser conditions. Tree mortality from a number of natural causes will always occur throughout the life of a forest stand, therefore future stand development must be considered when selecting spacing at the time of planting.

Trees are usually planted in equally spaced rows. The goal is to plant enough trees to fully utilize the site, while providing adequate space to maintain fast growth. Optimal spacing will maximize tree growth without the need for a noncommercial thinning to maintain plantation vigor. A typical spacing for white spruce is 2 x 2 m, about 2,500 trees per ha. At maturity, that stand will likely have 700 to 800 trees per ha or less, therefore considerable mortality is assumed. Table 10 provides conversions from inter-tree spacing to number of trees per ha.

Table 10. Number of trees per hectare at different spacing.

Inter-tree spacing (metres)	Number of trees per hectare
2 X 2	2500
2.5 X 2.5	1600
3 X 3	1111
3.5 X 3.5	816
4 X 4	625

Handling Seedlings

Methods used to handle seedlings from the time the seedlings are purchased to the time they are planted will greatly influence their survival after planting. The greatest threats to seedlings during these handling stages are moisture and temperatures beyond acceptable ranges. Roots, especially fine root tips, are the most vulnerable and are susceptible to drying after prolonged exposure to air. The seedling tops or shoots can also be damaged from drying, particularly when left in direct sunlight and wind. Tops and roots of container grown stock are less susceptible to damage than are bare root seedlings because the peat plug of the container stock protects the roots and contains a short-term supply of moisture. Extra efforts must be made to protect the exposed roots of bare root seedlings. Precautions must be taken to ensure seedlings are protected at all times.

Several aspects must be considered during the handling stages. The first stage in handling is transportation from the nursery to the planting site. During transport, seedlings must be kept cool, well ventilated and out of the direct sun and wind. Refrigerated trucks should be used for long trips but covered ventilated vans or trailers can be used for short hauls.

Seedlings are kept in cold storage before shipping. They are usually delivered to the planting site in boxes and may still be frozen on arrival. When the seedlings are received they should be checked immediately to ensure they are still moist and if necessary, watered. Stock should be kept at 2 to 4 °C until planting. However, these cool moist conditions may encourage the growth of mould that consumes the seedlings' nutrient reserves. At 5 °C, seedlings break dormancy, begin to generate heat and rapidly deplete their nutrient reserves. The accumulating heat can raise the temperature enough to damage or even kill the seedlings. Seedlings should be planted quickly to avoid damage from excessive heat or from growth of mould.

Seedlings may arrive frozen. Frozen stock should be thawed slowly to prevent cell damage but must be completely thawed before planting to allow the movement of water and nutrients in the seedling, and to eliminate damage from breakage of frozen roots. Frozen stock must be planted within two days of thawing.

At the planting site

At the planting site, stock should be stored in the shade and protected from the wind. Locations with air circulation near streams, patches of snow, tall trees, or north facing slopes are good storage sites. Boxes can be piled but must allow air movement around them to maintain cooling effects. If cool shaded storage locations are not available, reflective tarpaulins can be used to protect the seedlings from wind and sun. Torn boxes and bags should be repaired to reduce the risk of seedlings drying.

Trees should be planted as soon as possible after they arrive at the planting site. They may be stored for one or two days in a cool cellar or in the shade if necessary but this waiting time should be kept to a minimum. During storage, seedlings should be kept in their packaging and on their side and stood upright only for watering. Active seedlings – those not frozen – must not be kept in total darkness for more than 48 hours. Boxes should be opened to allow watering when necessary, and to expose the seedlings to light.

The number of seedlings on site should be kept to a minimum – perhaps one day's supply – because planting delays could prolong the storage time at the site where storage conditions may not be ideal. If delays do occur, bare root stock should be 'heeled in'. A trench is dug deep enough to entirely bury the roots and the stock is temporarily planted, or 'heeled in' in this trench. These seedlings should be watered regularly until planting time. Container stock can simply be placed on the ground and watered regularly to keep the plugs moist. A tarpaulin can be used for shade but air circulation must be maintained. Planting should be done as soon as possible.

The planter has the last contact with the seedlings. During planting, bare root stock should be kept in pails or planting bags with wet peat or wet sawdust or mud in the bottom to maintain dampness. Planting bags and pails should be in good repair to prevent moisture loss. Container stock generally has enough moisture in the plug and additional dampness is not required.

The planter should only carry one or two hours supply of seedlings. He/she should handle individual seedlings rather than groups to avoid exposing seedlings longer than necessary. During rest breaks, the planting bag full of seedlings should be protected from wind and sun or even freezing temperatures. Planting should cease during hot dry weather until conditions improve.

The handling methods and issues outlined above relate to maintaining the health and early survival of seedlings, but these precautions are easily translated into operational logistics and efficiencies. The key message to remember for any planting operation is that exposing the seedlings to the weather elements is detrimental to their survival, and protection from these elements before and during planting will improve the probability of survival.

Tree Planting Techniques

Tree planting in most woodlots is done manually, although planting machines suitable for woodlots are available. In general, manual planting is preferred and most efficient for small irregular shaped blocks and blocks containing forest debris. These conditions are typical of woodlot blocks that have been harvested. Mechanical planting is suitable when trees are planted in long continuous rows and the ground is clean of any forest vegetation or debris. These conditions are typical of shelterbelt or afforestation plantings. Both planting methods will yield good results if the techniques and tools used and suitable for the site conditions.

Manual Tree Planting

Several methods are used to hand-plant trees depending on the type of planting stock, the site conditions, and the planting tool to be used. Container seedlings are usually planted using a dibble, planting bar, or shovel. Other specialized tools such as the pottiputki are also used. These tools are less common among woodlot owners, partly because of their higher purchase cost and partly because they only are used to plant container seedlings. These tools create a small hole or slit for the seedling plug and allow the planter to maintain high production levels – up to 2000 seedlings per day for experienced workers - depending on site conditions. Bare root stock is planted with a shovel, mattock or other similar tool. These tools will create larger slits or holes to accommodate the larger seedling roots and do not permit as high a production rate as do container stock. Regardless of the planting tool, correct planting techniques will improve the likelihood of survival. Remember:

- Plant only one seedling per planting hole.
- Bare root seedling roots must be spread out in the planting hole and not rolled into a ball or 'J' shape.
- Seedlings must be planted as vertical as possible. On slopes, the tree should be no more than 10 degrees from vertical.

The planting spot or micro-site should be selected where mineral and organic soil are mixed. On scarified sites, this occurs where the duff layer and the mineral soil meet. When mixed soil is not evident, the seedling should be planted in mineral soil. Seedlings planted in the duff layer may not survive because the duff layer dries regularly. A suitable planting spot should be selected away from rocks, stumps or water holes. On sites scarified with discs or plows, the seedlings should be planted on the edge of furrows.

Seedlings should be planted to the same depth they grew at the nursery. The collar of bare root seedlings should be at ground level, while the top of the soil plug of container grown stock should be 1 to 2 cm below ground level. In the fall, white spruce can be planted deeper in mineral soil to reduce the chance of frost heaving. Pine, however, is susceptible to damping off when planted deeper than the root collar.

The roots should not be exposed nor any branches buried. Air pockets in the planting hole can kill the roots. The soil should be packed gently but firmly around the seedling to eliminate air pockets without damaging the roots. Appropriate spacing should be maintained between seedlings, and they should not be planted near to existing natural seedlings.

Mechanical Tree Planting

Mechanical planting is done with the planting machine towed behind a tractor. These systems have high production rates but in general, their efficient operation is restricted to planting in long continuous rows on level ground free of stones, brush and other forest debris. Mechanical planters are rarely used in woodlot applications because cut blocks are usually small and irregular shaped and likely contain logging debris. Mechanical planters are however often used to establish shelterbelts or for afforestation. Shelterbelts are usually planted in long continuous rows on agricultural fields that are clear of forest debris and are relatively stone free. Afforestation is usually done on abandoned farm fields that are clear of forest debris, although stones may be present. Both applications could be efficiently planted with mechanical planters at alower cost than manual methods.

A variety of planting machines are available but those most applicable to woodlots operate much the same way. The machine opens a furrow, the seedling is dropped into the furrow, and packing wheels close the furrow. The depth of the furrow and the interval between seedlings can be adjusted as required. This planting method is usually a two-person operation with one driving the tractor and the other sitting on the planting machine placing individual seedlings either in the ground or in the planting device, depending on the type of planting machine. While the mechanical planting method can plant thousands of trees per hour under some site conditions, planting quality may be lower than hand planting. This could be compensated either by planting more trees or by following behind the planting machine to manually correct any planting deficiencies.

Direct Seeding

Natural seeding can originate from cone-bearing branches left scattered throughout the harvested area after logging or from nearby trees. When seed of the desired species is not available from these sources, artificial direct seeding is required. Aerial seeding is sometimes done for large-scale industrial applications, but for most woodlots, seed can be effectively broadcast manually.

Manual seeding is done either by broadcasting seed throughout the area or by spreading small amounts of seeds on specific spots that are suitable seedbeds. Widespread broadcasting may result in fewer established seedlings than seeding specific seedbeds because seeds must land on exposed mineral soil to germinate and become established. Hand seeding, however, allows seeds to be placed on suitable seedbeds in appropriate locations such as away from existing natural seedlings or spaced at desired intervals. Either method is relatively low cost compared to tree planting. However, potentially aggressive scarification needs, expensive seed, and high risk of failure could result in higher costs that other regeneration methods. Regardless of the seeding method, seed used to regenerate a site should originate from the general area where it will be sown.

Maintenance and Monitoring

Follow-up activities will be needed for a few years after planting to ensure the reforested site are fully stocked with healthy vigorous trees of the desired species. Following the first growing season, a preliminary survey may be conducted to monitor the survival rate of a planted area. Not all planted seedlings can be expected to survive but the cause of any excessive mortality should be determined to avoid similar results after replanting. Sites left to natural regeneration or seeded directly should be assessed after one or two years to determine if additional action is required to reforest the site. Closer examination may be required to determine if sufficient seed have germinated to adequately restock these areas.

The need for maintenance work can also be determined during the field assessments. Competing vegetation can significantly reduce the survival rate of reforested sites. During the assessments, the amount and type of vegetation can be determined and its current and future impact on the new forest can be gauged. Follow-up treatments such as mechanical or chemical methods to control the vegetation can be planned if necessary, and implemented at an appropriate time.

The occurrence of insects and diseases can be monitored and remedial action taken before the pests become widespread. Excessive browsing or other feeding habits of wildlife species should also be observed to determine if action is required. For example plastic translucent tubes placed over the seedlings will protect the seedling from browsing until it grows taller, is more able to withstand the damage, or becomes less palatable to the wildlife. Livestock should generally be kept away from newly reforested areas to reduce damage from trampling, although sheep are used to control vegetation in some industrial forestry operations.

Monitoring and survey methods vary from casual walks through the area to systematic statistically valid sampling schemes. In most woodlot situations, a walk-through to assess the success and health of the reforested area should be sufficient. In larger areas, the woodlot owner should consult with forestry practitioners for advice on how to proceed with more sophisticated survey methods.

Afforestation

Afforestation is the establishment of trees on land that is traditionally non-forested. Marginal farmland, sensitive soil types, or other areas that would benefit from the stability and long-term management objectives met by trees are candidates for afforestation.

Preparing land for afforestation is similar to preparing land for shelterbelt plantings and is important for tree establishment and survival. Areas to be planted may be cultivated using conventional farm implements prior to planting to reduce weed competition, conserve moisture, and increase soil temperature and fertility. A six to eight week settling period after cultivation will help to eliminate air pockets on heavy soils. Alternatively, the cultivated land could be left fallow for a year or more. Additional cultivation may be required if weeds continue to emerge. Low growing green manure crops or cover crops may be used where nutrient levels are low and the risk of erosion is high. Cover crops and chemical fallow provide the benefits of good ground cover in the summer and snow trapping in the winter. A low growing cover crop may also help to reduce competition from unwanted vegetation.

Once the seedlings are established, additional tending is required to maintain vigorous growth and high survival rates. Manual or mechanical weeding or judicious use of herbicides are options to control vegetative competition during the first few years. Planted seedlings tend to be more succulent and palatable than natural seedlings, thus increased browsing or other feeding damage from deer, hare or porcupines may occur. Plantations should be monitored or protected until they become well established and the seedlings are able to withstand competition and browsing.

After the new forest is established following reforestation or afforestation operations, the emerging seedlings are vulnerable to inter-tree competition or competition from other vegetation. Various activities are undertaken to reduce this competition to improve the seedling's chance of survival and maximize tree growth.

Stand Tending

Stand tending is a management activity that modifies forest vegetation to meet the woodlot owner's objectives. Forest stands are tended to improve the growth rate, quality, and value of crop trees – the trees targeted. Crop trees are usually managed for timber production, although the tending activity may also target other management goals such as improving access or modifying wildlife habitat. Vegetation management, thinning, and pruning are examples of stand tending activities.

Stand tending has several general objectives. These include:

- Control competing vegetation and species composition of the stand.
- Control stand density.
- Reduce losses to insects, disease and fire.
- Reduce volume losses from natural tree mortality.
- Encourage production of forage or browse.
- Improve access to the woodlot.
- Improve aesthetic appeal or value of the woodlot.

The type of tending activity undertaken is largely dependent on the stage of development of the stand. During younger stages, when the stand is comprised of seedlings, tending is focused on releasing the seedlings from competing vegetation. As the seedlings become established, attention might shift to controlling species composition. Undesirable shrubs or hardwood species, for example, could be removed at this stage. At the sapling stage a thinning might be considered if the trees are too dense.

For example, naturally regenerated pine stands can be too dense after a wildfire or after certain kinds of scarification. As the stand continues to develop, the influence of lesser vegetation or unwanted species will decline, but overcrowding among the desirable species becomes problematic. Tending activities at this stage will include additional thinnings and perhaps pruning, and are intended to improve the quality of the crop trees. During later stages of stand development, trees approach merchantable size and the timber removed during tending activities may produce revenue.

Stand tending not only improves the value of the woodlot, but encourages a better understanding of the forest and stand dynamics. For some woodlot owners, stand tending provides the opportunity for a family activity that promotes a healthy well-maintained woodlot. Understanding how forest stands grow and develop will improve understanding of the rationale for stand tending activities.

Forest Stand Dynamics

Trees vary widely in growth, longevity and branching habits. As trees grow older, the crowns overlap, sometimes reducing available sunlight and moisture and depleting nutrient levels. Lower branches die from lack of sunlight and the reduced crown surface area causes a decline in growth rates. This inter-tree competition is dependent on the density of the stand and the size of the trees. Thinning may be necessary at this stage to reduce density and allow sunlight to enter the stand in order to maintain full crowns. Full crowns are needed to utilize the rapid growth potential inherent in young stands.

Natural thinning occurs in dense stands through the interaction of trees with one another to compete for sunlight and nutrients. The tree's position in the crown canopy generally determines that tree's chances of out-competing its neighbours. A tree can be classified by the role its crown plays in the forest canopy, and each tree will fall into one of the following six categories:

- Dominant – trees with crowns above the general level of the canopy. Dominant trees have well developed crowns and receive full sunlight from above and full or partial light from the sides.
- Co-dominant – trees with crowns that form the general level of the canopy. Co-dominants receive full sunlight from above, but only partial light from the sides. The crowns are medium sized and well developed, but more crowded than dominants.
- Intermediate – trees that are shorter than co-dominants. They receive little light from above and none from the sides. The crowns extend into the general canopy but are small and crowded.
- Suppressed or overtopped – trees that do not extend into the general canopy level and receive no direct light from above or the sides.
- Wolf trees - wolf trees develop in the open. The crowns are free growing or exposed on two or more sides and receive full light from above and from the sides. Wolf trees have branches well below the general canopy of the stand.
- Standing dead – standing dead trees that have succumbed to competition, insect, disease or other causes.

Natural processes in the forest can be modified by stand tending techniques to achieve the woodlot goals. For example, competition among trees can be managed by controlling the number of trees competing with one another. Similarly, competition between trees and other vegetation can be managed by controlling the vegetation that is affecting the growth of the seedlings.

Vegetation Management

Vegetation management is the first stand tending activity to consider after regeneration. Grass, brush or undesirable tree species can be detrimental to regenerated stands due to competition for light, moisture and nutrients. A vegetation management strategy should be a component of the pre-harvest silvicultural assessment that includes an evaluation of the effect of harvest methods on subsequent vegetation. The strategy may include initial brushing activities and plans for other stand tending operations during later stand development stages.

Brushing

Brushing is the removal or suppression of undesirable vegetation to allow seedlings to become established and maintain vigorous growth. Brushing is typically applied within the first five years after regeneration. It is done manually or mechanically and may include chemical treatments.

Manual brushing techniques include hoeing and pulling unwanted vegetation by hand. Vegetation can also be controlled with brush saws or other motorized tools to cut the unwanted woody plants. These methods can target specific vegetation species and can be adapted to a wide range of sites. Manual brushing is labour intensive but the use of motorized tools such as brush saws can be effective even in heavy brush conditions. Costs can be reduced if the brushing activity is focused around the target seedling but vegetation in the surrounding area is left uncut to minimize the amount of area treated. A disadvantage of manual brushing in heavy vegetation such as hardwood saplings is the slash cover that results after treatment. These slash conditions may pose a fire threat for the first few years until the cut vegetation flattens and begins to decompose.

Mechanical techniques include cultivating and mowing the competing vegetation. This method is faster than manual treatments, but is less selective and limited to flat terrain that is relatively free of rocks and heavy forest debris such as logs and large branches. Mechanical techniques work best when seedlings are visible or in straight rows so the machinery can avoid crop trees. Tending a newly established shelterbelt where seedlings are planted in rows and consistently spaced is an ideal application for mechanical techniques. But even in ideal conditions, mechanical brushing requires costly machinery. If the appropriate equipment is not available for other uses on the property, the cost of purchase or rental specifically for stand tending may be too high.

Chemicals to control grass and shrubs may be a viable stand tending method under some circumstances. Control can be selective or non-selective, depending on application method and chemicals used. Application methods include backpack or machine mounted sprayers, stem injection, brush-on techniques, or soil applications. Chemical treatment may be cost effective, but requires current knowledge of registered herbicides, local regulations, and skill in safe handling and application procedures.

Grazing by sheep or cattle may also be used to control unwanted vegetation. Several forest industries in Western Canada have conducted operational trials using sheep to graze grass and shrubs on logged areas. Those trials have shown generally acceptable results although the availability of sheep and experienced handlers may be a barrier in some areas. Timing and intensity of grazing must be considered to maximize the efficacy of the treatment. Livestock can damage seedlings and herding and fencing costs may be substantial.

Brush control as a stand tending technique is conducted at an early age and directly addresses seedling survival. Selecting the optimum timing for brush control may mean delaying treatment until crop trees are larger and more visible. Treatments must be at an age early enough to prevent mortality or severe growth loss of crop trees due to competition from surrounding vegetation. Season is also important when scheduling brush control operations. Vegetation cut in mid-summer will sprout less vigorously than vegetation cut early in the year or during the dormant season. Seasonal timing of chemical application will affect the efficacy of the treatment and the effect of the chemical on crop trees.

As the new stand grows and becomes established, the influence of competition from grass and shrubs declines but inter-tree competition increases. Brush control treatments that focused on seedling survival are replaced by thinning treatments to improve growth and value of the crop trees.

Thinning

Trees in dense stands grow slowly as they compete with one another. Some trees may gain dominance, overtop and suppress smaller trees, and eventually cause mortality of trees in the lower canopy. This process is slow and volumes in the dead and dying trees have no value for timber production. Natural mortality processes can be simulated and hastened by deliberately removing trees to reduce stand density and increase the space available to the residual trees. This is a stand tending process called thinning.

Thinning is the practice of removing some trees in the forest stand to increase the growth of the remaining trees. The availability of nutrients, water and sunlight limit the total volume of wood that a stand can produce, while stand density influences the size of individual trees. Thinning does not change the availability of these elements but concentrates them on fewer stems, resulting in larger trees than in an untreated stand.

Thinning provides a number of benefits. Some are directly related to enhanced tree growth, some are focused on economics, while others are non-timber related. These benefits are:

- Crop trees grow faster and reach marketable size earlier.
- Thinning captures timber volumes that would otherwise be lost through natural mortality.
- Thinning concentrates growth on fewer and eventually larger and more uniform sized stems. In general, and depending on stand density, the final harvest from a thinned stand will yield higher merchantable volumes than an untreated stand.
- Thinning may reduce insect and disease outbreaks by removing defective trees and improving stand vigour. Thinning, however, may also increase the incidence of insect and disease activity in some circumstances. For example the increase in air currents in open stands may facilitate the spread of harmful fungal spores.
- Periodic thinning during the life of the stand will provide an income stream when markets exist for the removed material.
- Tree species and stem form can be controlled during the thinning process through selection of trees to cut and trees to retain resulting in higher valued end products.
- Wildlife habitat will be affected by thinning. Habitat for some wildlife species may be improved while for others it will be reduced. Lower stand density increases light to the forest floor, resulting in an increase in forage and browse production. Lower stand density however, may also reduce thermal and escape cover.
- Reducing stand density improves access to the stand for livestock, wildlife, recreation, fire control, and future management activities.
- Thinning may improve the aesthetics of the woodlot.

Thinning treatments can be done at many stages of stand development and is usually conducted in even-aged stands. At younger ages, trees removed in the thinning are too small to have commercial timber value. This treatment is called pre-commercial thinning. At later ages, timber removed may be marketable. Then, the treatment is called a commercial thinning. These classifications are generalizations because markets determine commercial tree size. As an example, very small trees may not be marketable as conventional products, such as posts or lumber, but could be marketed as biomass fuel for an energy producing facility.

Figure 32: Pre-commercial thinning

Pre-commercial thinning, also called juvenile spacing, is intended to control density, species composition, and quality of the crop trees. It is not intended to produce revenue from the removed material. Some pre-commercial thinning activities focus less on spacing and more on improving the quality of the crop trees. For example, sanitation spacing or improvement cuts remove defective stems or unwanted species and may not provide revenue. Consideration should also be given to maintaining the species diversity of the woodlot. Species diversity provides a degree of protection to the crop trees from severe insect and disease infestation and may also reduce the rate of spread of wildfires. Diversity also has a variety of benefits for wildlife.

Various hand and motorized tools and mechanical implements are used for pre-commercial thinning. Selective pre-commercial thinning methods can be applied using simple hand tools such as axes, or motorized tools such as brush saws or chainsaws. Selective methods allow the operator to choose the crop trees that best meet the objectives of the thinning, such as desired species and inter-tree spacing. Mechanical implements such as drum choppers or mechanized brushing machines are non-selective and remove or destroy trees in swaths or clumps. Non-selective mechanized systems are best suited to large areas of very dense regeneration, such as occurs in pine stands after a wildfire. Selective thinning methods using hand or motorized tools are more applicable to woodlot scale operations, although this method is also commonly used in the forest industry.

The common term "commercial thinning" is a partial harvest method conducted in a stand that has commercial timber value. This stand tending technique is done later in the development of the stand when stems cut can be marketed for lumber, posts, firewood or other commercial products. Selective harvest techniques are utilized during commercial thinnings because trees are selected for felling or retention based on predetermined criteria. For example, the criteria may be to regulate inter-tree spacing to maximize growth of the residual stand. Revenue from the harvested material might be a secondary objective. Another example is to thin to maximize revenue from the trees removed. Then, larger trees would be harvested for their revenue while retaining smaller trees at a prescribed spacing to continue to grow until the next thinning or the final harvest.

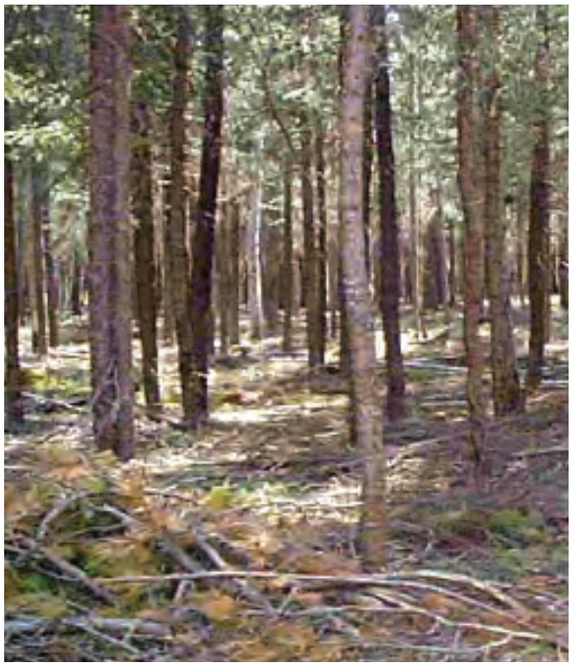


Figure 33: Commercial thinning

Variations of conventional harvest practices are similar in operation and objectives to commercial thinning. The hardwood component of a mixedwood spruce-aspen stand might be logged to obtain revenue from the aspen while retaining the spruce understorey for harvest in future years when the rapidly growing released spruce reach commercial size. Similarly, salvage cuts or sanitation cuts are partial harvests and can also be termed commercial thinning when the cut trees have commercial value.

Commercial thinning practices may differ in their objectives but all have growth of the residual stand as a common goal. All commercial thinning techniques harvest trees individually and therefore require special precautions to ensure the residual stand is not damaged during the logging operation. Key to the success of the thinning is the use of experienced loggers who understand and are committed to the goals of the selective harvest operation.

Timing and Intensity of Thinning Treatments

Thinning intensity is the degree of alteration to the original stand - the greater the number of trees removed, or the wider the spacing relative to the uncut stand, the more intense the treatment. Timing of the treatment is the age of the stand when the treatment is applied.

A forest stand will benefit from thinning when tree crowns overlap, indicating the site is fully occupied. At this stage of stand development, treetops differentiate into crown classes and trees in the dominant or co-dominant crown classes begin to suppress trees lower in the crown canopy. The resulting competition slows growth and eventually leads to mortality among trees in the intermediate and suppressed crown classes. Ideally, density is controlled as soon as the stand becomes fully occupied, but before inter-tree competition reduces growth rates. Repeated thinnings or entries can be scheduled to manage the stand toward a fully occupied state while spacing crop trees to maintain rapid growth and good form. In practical terms however, intensity and timing of treatments may be determined more by financial constraints than by the biological optimum.

Several factors affect the intensity and timing of treatment. Pre-treatment conditions such as target tree species, stand density, unwanted tree species or other vegetation, and health of the stand are examples of factors that affect the intensity and timing of the treatment. The site quality is also a factor because it is an important determinant of tree growth and will affect how trees respond to thinning treatments. Productive sites can support a wider range of stand densities or treatment intensities than poorer sites. Woodlot management goals such as desired timber products from the thinnings and final harvests also influence intensity and timing of treatments. Table 11 summarizes factors affecting timing and intensity of treatment and outlines issues to consider for those factors.

Table 11. Factors affecting the timing and intensity of thinning treatments.

Factors affecting timing and intensity of thinning	Considerations
Size, quality and uniformity of the end product	Thinning intensity should target the desired end products at the final harvest. Density at final harvest can be as low as 250 stems per hectare for large diameter peeler logs or as high as 1000 stems per hectare for smaller diameter round wood.
Characteristics of the existing stand	Species characteristics will affect the type and intensity of treatment. Early treatment before the overstorey develops is needed for intolerant species. Additional entries may be needed in such stands. Treatment for shade tolerant species can be delayed, although growth losses may be incurred due to competition from other plants or trees for nutrients and water. Species sensitive to root damage or soil compaction may be damaged by repeated entries.
Site quality	Productive sites can support a wider range of densities without significant growth losses. These sites represent the best investment and will provide the shortest payback period. Poorer sites are at risk of stagnating if not treated, but tending may make the difference between a merchantable crop and no crop.
Markets	Materials salvaged from the thinning may have markets. Treatments can be scheduled to provide these materials when markets exist. Timing the treatments to coincide with markets could make the difference between a pre-commercial and a commercial thinning.
Availability of time, equipment, and cash	Frequent low intensity thinnings are an option when resources are available to invest. If only one or two treatments will be conducted, timing can be delayed and intensity of each treatment increased.

Selecting and Spacing Crop Trees

Selecting the trees to retain is the most important decision made in juvenile spacing or commercial thinning operations. These crop trees will be the target of subsequent management strategies including interim and final products harvested. Crop tree selection depends on the age, size, condition, and past management history of the trees, and the objective of the thinning. The best trees should be selected for crop trees consistent with the objectives of the thinning even if the prescribed spacing is varied. For example, if the prescribed spacing is 3 m or 1,100 trees per hectare, spacing could vary from 2 to 4 m if necessary to allow the selection of better quality crop tree. As long as the average stand density is near 1,100 stems/ha the prescribed spacing has been met. Characteristics of crop trees and trees to remove in a thinning are listed below.

Characteristics of trees to keep (crop trees):

- Preferred species – the most valuable species adapted to the site.
- Dominant or co-dominant.
- Good form including straight single stems, small diameter branches and complete tops.
- Full crowns at least two thirds live and of good colour.
- Free of insects and diseases.
- Vigorous leader growth.
- Wind-firm and able to grow vigorously throughout the planned rotation.

Characteristics of trees to cut:

- Undesirable species.
- Diseased.
- Damaged.
- Undesirable form.
- Suppressed, or a small tree crowding a crop tree.
- Merchantable tree overtopping healthy understorey.
- Good crop tree too close to another crop tree.

Spacing

Inter-tree spacing is a key factor in maximizing timber value and yield from the woodlot. Spacing too wide may yield larger diameter trees but of poor form. Merchantable volumes per hectare may be too low if the crop trees do not fully utilize the site. Spacing too narrow will yield many small diameter stems of limited commercial value. Many factors affect how the stand will respond to various thinning intensities or spacings, and these factors vary for different stages of stand development. Recommendations to guide the woodlot owner with choosing the treatment intensity are presented in Table 12 for different stages of stand development.

The need to thin a stand can also be determined by estimating the rate of diameter growth of a few sample co-dominant trees. The growth rate can be determined by measuring the growth rings on a core extracted at breast height with an increment borer. Declining diameter growth rates indicate that the stand could benefit from spacing. Opinions of experienced local foresters should also be pursued for additional support in the decision making process.

Table 12. Thinning recommendations for various stages of stand development for conifers in the Prairie Provinces.

Development stage	Stand density (stems per ha)	Recommendations and comments [1]
Seedling: Up to 1.3 m in height	<2,000	May be under stocked and require fill-in planting.
	2,000 – 5,000	Acceptable but could be fewer if well spaced.
	5,000 – 30,000	Overstocked and should be scheduled for spacing at 10 to 20 years of age or sooner.
	+30,000	Overstocked. Mechanical strip thinning followed by manual spacing within 5 years.
Sapling: Up to 10 cm DBH	<1,000	May be under stocked.
	1,000 – 4,000	Acceptable but could be fewer if well spaced.
	4,000 – 30,000	Overstocked – juvenile spacing required.
	+30,000	Overstocked. Mechanical strip thinning or spacing should be considered.
Pole size: 10 – 20 cm DBH	<400	Under stocked.
	400 – 1,500	Acceptable without treatment.
	+1,500	Commercial thinning if residuals are healthy and wind firm.
Sawlogs: +20cm DBH	<250	Under stocked. Harvest and regenerate.
	250 – 1,000	Acceptable.
	+1,000	Commercial thin if residuals are healthy and wind firm.

1 Comments are based on broad density classes. Exact target densities will vary with site, species and intended product.

Thinning Methods and Tools

A variety of methods are used for selective or non-selective thinning treatments. Cutting with brush saws or chain saws is the most common method for selective thinning and is generally applicable to Western Canadian woodlots. Manually pulling trees is a possibility for thinning a small area in a young stand. Herbicides are also options in some circumstances. Girdling is a less common but effective method of thinning or killing unwanted trees. An axe, chain saw or specialized girdling tool is used to remove the bark and cambium in a ring around the stem to block nutrients from reaching the roots. A girdled tree may take two or three years to die so release of crop trees occurs gradually. The girdled trees eventually break, usually at the girdled part of the stem, and could create a hazard. Fallen trees may also damage crop trees. This method is sometimes used to release conifers from a hardwood overstory.

Commercial thinning methods or overstory removal are similar to other kinds of selective harvests. A variety of special equipment is available for these small-scale harvest operations. The equipment is light and manoeuvrable to allow minimum damage to crop trees and to the soil. Small-scale selective harvest equipment ranges from modified farm tractors to specialized yarding machines such as radio-controlled winches. Lightweight tree harvesters or feller-bunchers are also applicable to selective thinning operations. The high cost of this equipment can be avoided by using specialized logging contractors experienced in selective logging techniques.

Non-selective thinning generally refers to strip thinning where trees are destroyed in swaths leaving uncut strips. This is a pre-commercial mechanized thinning method applicable in large stands of high-density, usually fire origin, conifers. A mechanical strip thinning technique uses a tractor or skidder to pull a drum-chopper – a large water filled drum equipped

with several blades along the drum's width - that crushes trees in 3 m wide swaths. The uncut strip width varies but is usually from 2 to 5 m. Trees along the edges of the residual strip can benefit from the opening created by the cut swath. Additional benefit can be achieved by subsequent selection thinning within the residual strip to release the best crop trees. Various tools have been tested in place of the drum chopper to cut or chip the trees in the swaths rather than crush them, however the drum chopper is most commonly used. Most strip thinning applications have been in industrial operations.

A summary of the advantages and disadvantages of various thinning tools and methods is presented in Table 13.

Table 13. Advantages and disadvantages of various thinning tools.

Thinning tool	Application	Advantages	Disadvantages
Chain saw	Trees to cut are > 4 cm diameter	Easy to identify crop trees and maintain spacing.	Difficult work, labour intensive, machinery repairs frequent.
Brush saw	Trees to cut are < 10 cm diameter	Easy to identify crop trees and control spacing; high productivity; safer than chain saw; fewer but more expensive repairs.	Best in terrain < 40%; limited to trees < 10cm in diameter; operator training required.
Girdling	Trees to kill are > 6 cm diameter	No slash produced; slow release may benefit some species; equipment is inexpensive and easy to maintain.	Difficult to see crop trees and maintain spacing; snags create a hazard; physically demanding; low productivity; may require follow-up clean-up; release and response are slower than when trees are removed; snags create fire ladder; direction of falling snags cannot be controlled.
Hand pulling	Trees < 3cm diameter and must be easily pulled.	Crop trees easy to see and spacing easily maintained; no training or equipment required; safe operation.	Constant bending leads to fatigue for workers; limited to small trees when dominance is not established; in-growth likely.
Chemical	Trees > 6 cm diameter	Possibly lowest cost; no slash produced; low equipment maintenance; slow release may benefit some species; less re-growth.	Chemicals may affect wildlife, or water bodies; operator training and certification required; release and response slower than when trees are cut; dead trees and shrubs provide fuel ladder into crops trees.
Mechanical (strip thinning)	No crop tree selection; trees killed in clumps or swaths; best in dense even-aged stands on slopes < 65% and stumps < 30 cm	High productivity; slash is compacted and broken; fire hazard reduced after several years.	High machine costs; no crop tree selection; trees in leave strips could be damaged; trees in cut strip may be badly damaged but not killed; requires operator training.

Adapted from: "Managing Your Woodlot: A Non-Forester's Guide to small Scale Forestry in British Columbia", BC Ministry of Forests and Lands. Available online at: http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/20291.pdf

Other Stand Tending Activities

Pruning and fertilization are also tending activities that may apply to Western Canadian woodlots, but in general these operations are not as common as vegetation management and thinning. Pruning is conducted to improve log quality and value while fertilization is applied to enhance tree growth.

Pruning

Pruning is the removal of the lower tree branches either by natural processes or by artificial techniques. During the natural pruning process, lower branches die from the shade created by the upper branches and by the crowns of neighbouring trees. This is a slow process and is affected by the tree species' shade tolerance characteristics and by stand density. Shade tolerant species such as spruce retain their lower branches longer than do shade intolerant species like pine or aspen. For a given species, natural pruning occurs earlier in denser stands than in open stands because of the increased shading to the lower branches. Artificial pruning can advance and control the natural pruning process.

Figure 34: Pruned white spruce

Pruning is a long-term investment conducted to create knot-free logs suitable for high value timber products such as peeler logs or specialized clear lumber products. However, unless used to manage fire hazard, pruning every tree in a stand is rarely cost effective. Therefore, those trees selected for pruning should be healthy with good form and likely to be retained for at least twenty years. Trees along the stand's outer perimeter should not be selected for pruning. Maintaining full crowns, including living and dead lower branches on these perimeter trees will reduce the effect of drying winds within the stand and provide better escape cover for wildlife.

The first pruning should be done when the trees are 8 to 10 cm DBH. At this juvenile stage the branches are still small, leaving small knots, and the pruning wounds heal quickly because of the rapid growth rate of the young trees. The first pruning or 'lift' should be done to a height of 2.5 m, or the length of one peeler log. The second pruning may occur when the trees reach 20 cm in diameter or the branches to be pruned are 3 to 4 cm in diameter at their base. A third pruning could be done if necessary to produce a clear trunk of at least 5.25 m (16 foot log plus stump) at maturity.

The best time to prune is just before the growing season when the trees are still dormant and before the buds begin to swell. As a guideline, two-thirds to one-half of the total height of the tree should be retained as live crown and no more than one-third of the live crown should be removed at any one time. Some landowners disregard the live crown rule and simply prune dead branches or small suppressed branches that show little annual growth. Knots in timber products represent both living and dead branches on the tree. Dead branches result in loose knots while live slow growing branches represent tight knots. Both living and dead branches should be cut in the pruning process.

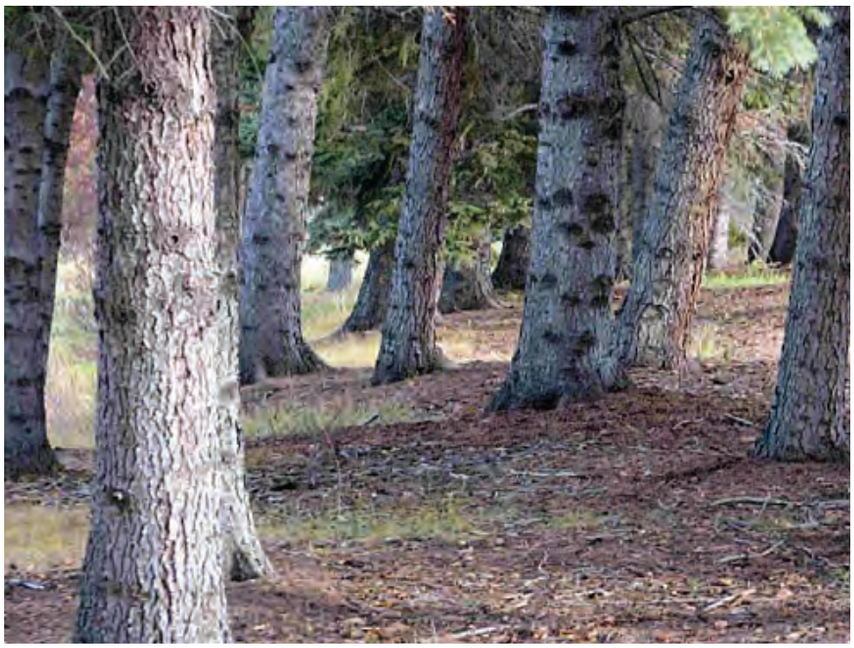


Figure 35: Pruned stand

Numerous hand tools can be adapted to pruning trees although a pruning saw, bow saw or pruning shears are recommended for best results. Cuts should be made without cutting into the branch collar. Part of the tree's natural defense system is found in this swollen area where the branch joins the trunk. Heavy branches should be undercut to prevent damage to the bark when the branch falls. Pruning work can be physically demanding, particularly if the branches being pruned are some distance from the ground.

Some of the advantages and disadvantages of pruning are summarized as follows:

Advantages of pruning

- Produces clear lumber that may yield high value.
- Produces lumber with fewer and smaller knots.
- Provides some control of pests such as mistletoe.
- Reduces the risk of crown fires by removing lower branches that act as fire ladders.
- Produces aesthetically pleasing or park-like forests.
- Reduces limbing effort at final harvest.

Disadvantages of pruning

- Pruned stands have less thermal and escape cover for wildlife and result in increased line of sight.
- Removal of lower branches eliminates lichen as a food source for some wildlife species.
- Thick lower branches provide some physical barrier to damage to the stem by girdling pests such as porcupine.
- Pruning is labour intensive.

Pruning presents an opportunity for the woodlot owner to improve the economic and aesthetic value of the property. The economic returns on the long-term investment, however, may be limited due to markets and competing products. The woodlot owner must carefully consider the objectives for the property before embarking on any substantial effort to prune a forest stand.

Fertilizing

Site productivity in terms of availability of soil nutrients is an important determinant of tree growth. Although trees may be well spaced and have adequate moisture, their maximum capacity is limited by the availability of nutrients. In such cases, site productivity may be improved by adding fertilizer to increase the amount of nutrients available to the tree. Trees will often respond to nutrient applications but this is not a common forest management activity in the Prairie Provinces. There are few specific recommendations to guide the woodlot owner in fertilizer applications for forests, however there may be some potential in certain circumstances. Local information applicable to the woodlot may be available from forest management agencies, agriculture departments of provincial or municipal governments or from forest industry in the area.

Planning Stand Tending Operations

Stand tending operations will proceed more efficiently if efforts are made to plan. Below is a checklist to help with the planning process:

- Prepare a map of the area to indicate roads, trails, landmarks, buffer strips and treatment areas. Larger areas can be divided into smaller blocks.
- When using power saws or other equipment, plan travel lanes to facilitate refueling stops at central locations.
- Work with the terrain rather than against it. Work across slopes rather than downhill. On steep slopes, work uphill then return downhill to refuel before working uphill again. Plan the work to avoid crossing streams or other obstacles.
- When debris will be left in the forest, the material should be cut so it falls into the area already cleared so the operator can avoid walking on the felled stems or branches. Use the wind to advantage when felling stems.
- Felled trees should not interfere with crop trees. If this occurs, the crop tree should be freed of any felled stems or branches.
- Commercial thinning requires planning similar to a harvest operation. The extraction method, skid trails, landings and access roads must be planned not only for an efficient harvest but also to minimize damage to the residual trees. Skid trails should be marked before logging begins.
- Either trees to keep or trees to cut should be clearly marked for a selective thinning operation. Alternatively, a well-trained crew willing to follow the landowner's specifications can choose the cut and leave trees during the harvest operation.

Planning for fire hazard reduction must also be considered in a stand tending operation. Many stand tending activities create slash that results in a fire hazard. Bucking or crushing the slash to lay it closer to the ground will increase its decomposition rate and reduce the fire hazard. Existing fuel breaks such as untreated buffer strips, trails, blocks of deciduous trees or wet areas should be considered when planning for fire hazard reduction.

A stand tending activity represents a long-term investment in the forest. The investment will increase the value of the timber and non-timber products and services from the woodlot – in some cases immediately, in others spread over a period of time, and in still others, returns may not be realized for many years. The stand tending operation should therefore include planning related to operational considerations as well as to investment protection strategies.

Beneficial Management Practices for Silviculture

- Develop a detailed plan to describe the silviculture activities to be undertaken. The plan should include the silviculture prescriptions, harvest method, site preparation method, reforestation strategies, and operational details. Ensure the plan is consistent with the overall objectives for the property.
- Learn the silvics of the tree species that will be managed and select silvicultural systems that are complimentary to those species.
- Choose a harvest system to facilitate the establishment of the kind of new forest desired – even-aged or uneven-aged, mixedwood or single species.
- Integrate clearcut block design with land contours to minimize soil erosion.
- Consider the effects of increased wind exposure from clearcut blocks on the surrounding forest.
- Use irregular shaped cut blocks to improve wildlife habitat.
- Use selective harvest systems to manage mixedwoods for shade tolerant species in wind-firm stands.
- Leave high quality vigorous trees after selective logging. Do not degrade the stand by harvesting only the best trees.
- During selective logging, use designated skid trails to avoid damage to the residual trees.
- Develop forest regeneration plans before harvesting begins.
- Natural regeneration of coniferous stands depends on seed availability. Schedule harvests to coincide with years of high seed production.
- Soil disturbances from logging will stimulate root suckering in aspen stands.
- Disturbances from logging also expose mineral soil and create seedbeds or micro-sites suitable for seed germination.
- Consider manual patch scarifying to create good seedbeds or planting spots. Larger and heavier scarifying equipment is more costly and may be less efficient in small cutovers.
- Prescribed burning is a valuable site preparation tool, however, the fire's effects are not always predictable and special measures must be taken to protect the surrounding area.
- Know and understand the regulations governing herbicides for use in forestry applications.
- Select planting stock or seed that originates near the area to be reforested.
- Protect seedlings from the weather elements at all times prior to planting.
- When seedlings are delivered, ensure they are thawed before planting but do not allow seedlings to exceed 5 °C and break dormancy. Seedlings should be planted as soon as possible after delivery.
- Select planting spots that have a mixture of organic and mineral soil or mineral soil alone. The duff layer dries regularly and can lead to seedling mortality.
- When planting seedlings, ensure roots or root plugs are not clumped but are vertical in the planting hole.
- Gently but firmly pack soil around planted seedlings to eliminate air pockets around the roots.
- Spacing between planted trees should be based on the final product desired. Wider spacing will result in larger trees than narrower spacing.
- Consider future natural mortality when determining the spacing between planted trees.
- Survey planted areas within one or two years to assess survival rates. Causes of excess mortality should be determined before replanting. Seeded areas should also be assessed to determine if additional action is required.
- During thinning operations, consider maintaining species diversity to reduce widespread insect or disease infestation, reduce rate of spread of wildfires and to improve wildlife habitat.
- Manual or motor-manual thinning methods allow selection and spacing of crop trees. Mechanical methods such as strip thinning are nonselective and do not provide for inter-tree spacing.
- Overlapping tree crowns indicate that the site is fully utilized and trees may benefit from thinning.

- Monitor the growth rates of crop trees by measuring growth rings on an increment core taken at breast height. A decline in diameter growth indicates that the stand could benefit from thinning.
- Consider stand development trends over the long term when making spacing decisions. Natural mortality will reduce stand density throughout the life of the stand and affect timber products at the final harvest.
- Prune only trees that are expected to grow vigorously for at least 20 years. Do not prune trees on the periphery of a stand.
- Do not prune more than one third of the live crown.
- Plan a stand tending operation to facilitate foot and machine travel.

APPENDIX

Summary of harvest methods

Silviculture System	Situations	Advantages	Disadvantages
Clear-cut	1. Stands with a high volume of dead, dying, diseased or windfall trees. 2. Mature of over mature stands. 3. Regeneration of shade intolerant species is desired. 4. An even-aged stand is desired. 5. A change of species is desired. 6. Most effective with pure stands of shade intolerant species such as aspen and pine.	1. Economical to log. 2. More accessible and economical for site preparation and planting. 3. Best for converting to new tree species. 4. Best for regenerating shade intolerant species. 5. Damage to 'leave' trees from logging, windfall, etc., is not an issue. 6. Easy to plan and supervise. 7. Good for many wildlife and bird species.	1. May increase the potential for erosion and rapid runoff for a few years. 2. Appearance is undesirable until regrowth well established. 3. No timber products available for a long time. 4. Unwanted grasses, shrubs or trees may establish. 5. May increase impact of wind and temperature changes. 6. Debris may create a fire, insect or disease problem. 7. Natural regeneration may be inadequate and require further treatment.
Selection	1. Mixed wood and uneven-aged stands. 2. Trees that can reproduce and grow in considerable shade. 3. Parts of riparian areas. 4. Near roadsides, urban areas or high traffic recreation sites. 5. Works well with white spruce, Douglas fir, balsam fir, green ash and Manitoba maple.	1. Visually pleasing. 2. Provides a more regular income. 3. May reduce the chance of insect and disease outbreaks. 4. Excellent protection from wind and water erosion. 5. Provides good habitat for many bird and wildlife species. 6. Improves genetic quality of future stand through superior parent seed trees. 7. Allows opportunities to salvage damaged trees.	1. Harvest costs higher. 2. Income lower vs. large cuts. 3. Complex method. Requires good knowledge of trees to avoid high grading and balance growth with harvest. 4. High damage potential for seedlings and other trees. 5. Frequent entries may cause soil compaction and damage to residual stems. 6. Trees may have too much space, developing a large taper and too many limbs. 7. Not well suited for shade intolerant species. 8. Need permanent trails. 9. May spread Armillaria.

Silviculture System	Situations	Advantages	Disadvantages
Shelterwood	1. Softwood and mixed wood stands of shade tolerant species, including Douglas-fir. 2. Sheltered stands on well drained soils. 3. Works well with birch stands. Controls soil temperature to reduce the chance of temperature fluctuations killing the roots.	1. Partial shade means seedlings less subject to drying out and frost damage. 2. Reduces competition, as many weed species are shade intolerant. 3. More pleasant visually, beneficial to wildlife. 4. Preparatory cut acts like a thinning, remaining trees can add significant wood volume. 5. In mixed wood stands, younger maturing species may be removed before they die. 6. Less slash, so fire risk is low. 7. Income more evenly distributed over the years. 8. Low erosion potential.	1. Logging and repeated entries may damage regenerating plants and crop trees. Final harvest requires good timing and care. 2. Logging and management costs are higher. 3. Marking stands for prep and seed cuts requires knowledge and skill. 4. Windfall losses may be high. 5. Markets may be limited for small and low-quality products from early cuts. 6. Roads and extraction trails must be efficient.
Seed Tree	1. Similar to clear-cut situations, but leaves sufficient seed source to encourage natural regeneration. 2. Where artificial regeneration is difficult or uneconomical. 3. Usually with shade intolerant species. 4. Works best with white spruce, occasionally black spruce and possibly tamarack and white birch. 5. Where adequate numbers of wind firm trees of a desirable species and age are well dispersed through the block.	1. Similar to clear-cutting. 2. Superior parent trees selected. 3. Seed more uniformly spread than clear-cutting. 4. Should not require tree planting. 5. Should reduce cost of regeneration.	1. Lightning may strike seed trees, destroying them and starting fires. 2. Wind may damage seed trees. 3. Species need light seeds that will carry in the wind, germinate and grow in the open. 4. Cost of harvest increases if you return later for seed trees. 5. Spot planting may be needed if seed is unevenly spread. 6. May have to wait for a seed-producing year.

Selected Readings and Internet Sites

Internet Sites

http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm - Silvics of North America, USDA Forest Service

http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/20291.pdf - Managing Your Woodlot: A Non-forester's Guide to Small Scale Forestry in British Columbia

Books and Publications

Clearing for the future. Jonsered bulletin.

Essentials of forestry practice – 4th Edition; Charles Stoddard and Glenn Stoddard. John Wiley and Sons. 1987.

Forest stewardship: A handbook for Washington forest landowners. Washington State University.

Guide to the silvicultural management of trembling aspen in the Prairie Provinces. G.A. Steneker. Canadian Forest Service Information Report NOR-X-164. Northern Forest Research Centre, Edmonton AB.

Growth of lodgepole pine after mechanical strip thinning in Alberta: 15-year results. 1982. Bella, I.E.; DeFranceschi, J.P. The Forestry Chronicle 58(3): 131-135.

Introduction to Forest Science – second edition. Young R. and Ronald Giese, editors. John Wiley and Sons 1990.

Labor Productivity for Pre-commercial Selection Thinning in Young Coniferous Stands in Manitoba. 1988. De Franceschi, J.P.; Steele, T. Canadian Forestry Service.

Labor productivity and costs of motor-manual release of spruce from hardwoods in Manitoba. 1990. DeFranceschi, J.P.; Bell, F.W. Forestry Canada, Northwest Region. Information Report NOR-X-312. 14 p.

Merchantable Thinning Manual – Softwoods. Nova Scotia. Dept. of Lands and Forests.

Managing Your Woodland - A Non-Forester's Guide to Small Scale Forestry in British Columbia. B.C.Ministry of Forests and Lands.

Organized Thinning. Husqvarna forestry technique bulletin.

Practical Guide to Private Forest Management – Plantation Maintenance. Canadian Forestry Service.

Silvicultural systems. John D. Matthews; Clarendon Press, Oxford 1989.

Spacing effects 15 years after planting three conifers in Manitoba. 1980. Bella, I.E.; DeFranceschi, J.P. Environment Canada, Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta. Information Report NOR-X-223.

Swedish forestry techniques with possible applications in the third world. The Forest Operations Institute Box 1184, S-163 13 Spanga, Sweden.

The woodland workbook. Oregon State University.

Woodland Stewardship Plan. Minnesota Division of Forestry.

The woodland steward. James Fazio, University of Idaho.

Woodlot management home study courses. Nova Scotia Department of Lands and Forests.

Woodlot Access: Roads, Trails, Culverts and Bridges

Contents

Criteria and Indicators of Sustainable Development Applicable to Constructing Access in a Woodlot.

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes. Indicators of accomplishment include:***

- Stream crossings are constructed and maintained to protect fish habitat and avoid obstructions to the passage of fish.
- Roads and trails constructed in wetlands or riparian areas are planned for winter access only.

Criteria 3: ***Soil and water. Conserve soil and water resources by maintaining their quantity and quality in the forest ecosystem. Road, trails and waterway crossings can be constructed and maintained to minimize or negate impacts on water resources. Indictors of accomplishment include:***

- Access is planned to minimize the area of land withdrawn from production by roads and trails.
- Water siltation is avoided through control of erosion, planned drainage systems to divert runoff away from watercourses, carefully installed water crossings, and timing of construction activities.

Construction of roads, trails and waterway crossings in a woodlot are potentially ecologically disruptive activities. Roads and trails leave a permanent mark on the landscape and waterways may be directly affected. However, work can be planned and conducted to minimize these impacts and contribute to a sustainably managed woodlot.

Introduction

Access to the woodlot may be needed to conduct a variety of activities to meet the woodlot objectives. Forest management operations such as timber harvests, reforestation, or stand tending may need access roads for workers and equipment to reach the operation site. Large woodlots may need foot and/or vehicular access to remote parts of the property for fire protection. The woodlot owner may want to create access routes for recreational purposes. In general, access is developed to accommodate a number of uses, although the road or trail is usually built to accommodate its primary purpose.

Road and trail construction will create a visual and, at times, an environmental impact on the woodlot and surrounding landscape. New roads and right-of-ways may be visually unattractive because of the contrast they create with the forest. Well-integrated roads and trail systems increase the landscape's appeal and facilitate access to the resources that the woodlot can offer. Aquatic ecosystems are particularly vulnerable to road construction work because of the increased amounts of sediments that can potentially be introduced into the waterways. Woodlot owners must be aware of these elements and take appropriate action to limit erosion and sedimentation and its effects. Visual and environmental impacts can be reduced or eliminated by giving appropriate consideration to the location of the road or trail, and the construction methods and materials used.

Woodlot Access Roads and Trails

Construction of woodlot access roads and trails should begin with the development of a plan that identifies the purpose and uses of the access, the location, and the construction methods and materials. The first step in road construction is to identify the type of road needed and the best layout for the road. Criteria to take into account include:

- Dimensions of the woodlot and constraints in topography;
- Protection of streams, rivers, lakes and wetlands;
- Protection of exceptional forest ecosystems such as old growth forests;
- Locations and protective measures for threatened or vulnerable species, unique habitat conditions for species at risk, and riparian areas;
- The frequency and period of use - permanent, temporary, seasonal or winter road;
- Location in relation to forest stands, site quality (soil and drainage) and terrain;
- The range of uses for the access including timber or firewood production and/or harvesting, fire protection access, and recreational activities;
- Type of equipment needed and available budget.

Tips to consider when planning woodlot roads and trails:

Consult forestry practitioners during the planning stage of road construction: Woodlot extension specialists or forestry consultants can provide assistance with the planning and layout of construction projects, provide advice on cost effectiveness of construction options, and identify legal aspects of access development. Local forest industries experienced in locating and constructing forest roads may also be willing to provide advice to woodlot owners.

Check existing access roads: Investigate using existing roads and trails before planning new routes. Roads on adjoining properties may also be possible alternatives to constructing new roads if the neighbour will permit access.

Develop strategies to mitigate environmental issues related to watercourses on the woodlot: Many environmental issues related to road construction can be resolved by carefully planning road locations to avoid water bodies or courses. An analysis of the lakes, streams and rivers allows landowners to choose locations to reduce erosion and reduce construction costs.

Consult and understand legislation pertaining to the protection of streams and water bodies: Alberta has legislated strict policies and regulations pertaining to water and watershed management. The Water Act, Provincial Regulations, and a Code of Practice for Watercourse Crossings are in effect to manage headwaters, maintain recharge capabilities, manage watersheds for water supply stability, and protect critical fisheries habitat. The new Alberta Water Act enacted in 1999 stipulates the obligations and exemptions with regards to road building and stream crossings. Federal legislation is included in the Navigable Waters Protection Act, The Fisheries Act and the Canadian Environmental Assessment Act. Permanent stream crossings are highly regulated. Temporary stream crossings are regulated according to class of water

body, and where and when they can be constructed or installed. There are restricted activity periods for mapped Class B and Class C water bodies.

Avoid stream or river crossings: Constructing stream or river crossings is costly and has multiple effects on the aquatic environment. Roads should not be built within 60 m of a permanent stream (watercourse that flows at all times) or within 30 m of an intermittent stream (watercourse in which the stream bed is completely dry during certain seasons).

Locate access roads in the least sensitive forest stands: Sensitive environments such as areas with thin soil, unique forest ecosystems, wetlands and special wildlife habitat such as heronries should be avoided.

Plan gentle rather than sharp turns in the road: Soil erosion will increase from fast water moving around a sharp turn. Gentle turns will have less of a scouring effect and therefore reduce erosion effects.

Plan winter roads to access wet areas: Travel over wet soils can lead to severe rutting and soil compaction and result in reduced forest productivity and eroded or damaged soils. Only winter roads should be planned for wet areas. Visits to the site during different seasons will demonstrate the actual conditions at different times of the year.

Avoid building roads on steep slopes: Plan to minimize traffic on rugged terrain. Aim to maintain an average slope of 1– 2%. Gentle slopes are particularly important for a watercourse approach.

Building the Woodlot Access Road

Large areas of mineral soil are moved and exposed during the road construction process. The potential for soil erosion from road surfaces and from cleared right-of-ways is significant. This is a characteristic of road construction work that must be carefully monitored and remedial action taken to safeguard against the loss of valuable soil or the sedimentation of streams and water bodies.

Tips to consider when building woodlot access roads:

Do not conduct construction work during wet seasons or periods: Clearing of the right-of-way should be done in the dry season, during late fall or winter. Excavation, road form, and compacting work should be done the same day.

Limit the width of the right-of-way to twice the width of the roadway: The limited right-of-way width facilitates drying of the road but limits the size of the cleared area. Culvert lengths and subsequent costs are also kept to a minimum. Wider right-of-ways unnecessarily remove forests from the productive land base and expose wildlife to predators. Overly wide right-of-ways often create a negative visual effect.

Ensure proper drainage of the road surface: Drainage ditches and culverts are needed to ensure the regular discharge of runoff.

Use adequate drainage techniques during construction work: Minimize sediment runoff during and after construction. Divert water from roadside ditches to vegetated areas that are more than 20 m from watercourses.

Harvest trees in right-of-ways before constructing roads: Harvesting the timber from the right-of-way before road construction begins will utilize the timber values and in particular, improve the appearance of the road.

Refrain from leaving logging debris, stumps and piles of dirt along the road: Push non-merchantable timber, debris and stumps into depressions and bury them or place them behind the line of trees and out of sight.

Leave stumps that cannot be buried in an upright position: Standing stumps have a more natural appearance than do stumps that have been pushed over.

Design the road to accommodate the intended traffic: The road width should be sufficient for logging trucks to travel easily. Turnarounds located at strategic locations will reduce trucking costs.

Seed right-of-ways with herbaceous plants and grasses to prevent erosion: Re-vegetated right-of-ways will be resistant to soil erosion and will reduce the risk of road subsidence. Grasses and herbaceous plants will provide food and cover for wildlife and will help to integrate the right-of-way into the landscape.

Constructing and using roads during winter months when soils are frozen and not subject to compaction or erosion can resolve many road-building issues. In wet areas, or in sensitive areas such as riparian zones, winter harvest is a practical solution that addresses environmental concerns and maintains the productivity of the forest. Suggestions for successfully building roads in these winter operating areas are:

- Use winter roads in areas with soft ground and refrain from excavating or removing material from the site.
- Make winter roads short and do not cross watercourses.
- Do not begin construction until the soil has frozen to a depth of at least 35 cm.
- Use snow to backfill winter roads.

Figure 36: Woodlot Trail

Bridges and Culverts

Building a stream crossing requires careful planning. Proper construction is required to limit changes to the aquatic environment. In addition, since construction often requires working in the streambed, sediment loading in the water may occur despite all the precautions taken.

Planning stream crossings

The solidity, durability, and stability of the crossing will depend on how well the crossing is planned. The more detailed and refined the design, the less will be the risk to the aquatic environment. Selecting the appropriate location to establish the crossing will greatly influence the success of the installation.

Tips to help determine a stream-crossing site:

- Select a narrow and straight part of the stream for the crossing;
- Choose a dry site over a marshy or swampy area to ensure stability.
- Avoid areas with steep slopes.
- Avoid deep ditches. The amount of fill required to cover the culvert in a deep ditch will result in a steep slope.
- Locate the bridge or culvert downstream from a spawning bed. If this is not possible, install the crossing at least 50 m upstream from the bed.

How to recognize a spawning bed

Spawning beds are areas where species of fish reproduce. For example, in Alberta, rainbow trout spawn in tributaries with clear running water and fine gravel and little or no aquatic vegetation. If the stream seems like it may harbour spawning trout, consult a wildlife specialist for assistance in identifying spawning beds.

Planning the structure

Several different types of crossings can be used. The choice of the appropriate structure depends on several factors. These include:

- The type of soil on the banks and bed of the watercourse;
- The season – winter or summer - the crossing is to be installed;
- The width of the crossing;
- The speed of the water at the crossing;
- The budget for the project; and
- How the crossing will be used

Culverts

A culvert is a circular pipe installed on the bed of a watercourse and then covered with fill. There are several different types of culverts.

For watercourses less than 1 m wide:

Wooden culverts are made from logs. Logs form the basic shape of the culvert and the deck. The log deck can be covered with fill.

For watercourses less than 3 m wide:

Plastic culverts require careful installation.

Galvanized steel culverts are very resistant to buckling and deformation.

Arch culverts allow the natural stream bottom to be retained. They are useful in sensitive areas (spawning beds) or to protect wildlife habitat.

For watercourses 3–10 m wide:

Parallel culverts: Two or three culverts are installed next to each other. This reduces the risk of erosion. When possible, limit the number of culverts to two and leave one metre between them. A bridge should be considered when more than two culverts are required.

For watercourses over 10 m wide (or 3–10 m wide with a high flow rate):

Bridges: A wooden bridge consisting of two cribs, wood or steel beams and a wood deck should be used. The structure requires the services of an engineer to design the bridge.

Installing the structure

Precautions must be taken during construction to limit erosion and sediment transport in the watercourse. Construction work should be scheduled for late spring or late summer when water levels are the lowest and risks of erosion during construction are reduced. Crossings for watercourses supporting fish populations or emptying into fish habitat should not be installed during spawning seasons.

Tips to consider when installing culverts:

- Ensure the culvert is firmly footed on stable, well-drained soil: A sand or gravel foundation will increase the lifespan of the culvert.
- Place the culvert along the same axis as the watercourse: The pipe must be installed in a straight line perpendicular to the roadbed.
- Follow the natural gradient of the watercourse.
- Bury the culvert to the correct depth: The culvert should be buried to a depth equivalent to 10% of its diameter. This will allow the streambed to build up to its natural level and prevent the creation of a waterfall effect at the outlet.
- Prepare the inlet and outlet to minimize turbulence and subsequent erosion.
- Lay riprap over an impermeable membrane.
- Place rock 20 cm in diameter or more around the inlet and outlet of the culvert, burying it up to 85% of its height.
- Maintain at least a 30 cm thick layer of fill above the culvert.

Bank Stabilization

Areas disturbed by the road building or crossing installation should be restored and stabilized to prevent erosion. The fill on top of the crossing and the road surface may be sowed with grasses or other herbaceous plants. Roots from plants hold the soil particles and prevent or reduce erosion. Placing rocks where erosion is a risk may also stabilize the watercourse banks. These areas can also be sown to grass and herbaceous plants to help hold the soil in place.

The vegetation cover, stumps, and other forest debris should be preserved within 10 to 20 m on either side of the road at watercourse crossings. This can be accomplished during the construction phase by selecting the trees to protect and limiting the number of trees that are cut. The ground cover and stumps in the right-of-way should be preserved to maintain the stability of the area. Materials in the watercourse or its shoreline contribute to its permanence and should not be removed. During construction, efforts should be made to minimize disturbance to shorelines and structures. Where streambeds or banks have been disturbed, remedial actions must be taken so the watercourse will maintain its function.

Recreational Trails (ATVs, Snowmobiles or Hiking)

Constructing recreational trails provides access to the woodlot for harvesting and other forest management work and also allows for leisure activities. To maximize the benefits from the woodlot's features, certain guidelines should be followed to ensure that recreational use does not damage the woodlot. Repeated use by ATVs or snowmobiles may damage the soil and vegetation, disturb wildlife, and modify habitat used by threatened or vulnerable species. Restricting traffic to a network of roads and trails developed for recreation use will minimize overuse and control access to areas intended for this purpose.

Tips to consider when planning a recreational trail:

- Utilize bridges and culverts to cross watercourses. Avoid using fords or other locations where no crossing has been installed.
- Avoid areas that are very sensitive ecologically, such as exceptional forest ecosystems and the habitats of threatened or vulnerable species.
- Keep traffic away from poorly drained areas and areas with steep slopes. Designated recreational trails will help to limit access in these areas.
- Locate the trail network through a variety of forest stands and include sites of special interest.
- Winding roads are more appealing than straight ones for recreational activities.

Figure 37: Recreational trail

Constructing a recreational trail

Constructing a recreational trail requires some activities similar to construction of other access types. For example, culverts must be installed at stream crossings and the effects of the trail on waterways must be given full consideration. Runoff should be channelled to a vegetated area at least 20 m from a watercourse. Although the trail may be intended for lightweight use only, provisions may be made to accommodate other use such as heavier ATVs that might be used to haul firewood or timber. This may be a particularly important consideration when constructing watercourse crossings.

Tips to consider when constructing recreational trails

- Cut branches that obstruct the trail as close as possible to the trunk.
- Pile logging debris on the side of trails to provide shelter for small wildlife.
- Snowmobile and ATV trails should be 3 m wide (one-lane trails).
- Trails intended for foot travel such as hiking or skiing should be 2 m wide.

Maintaining the Road and Trail Network

Regular maintenance of logging roads, recreational trails and stream crossings ensures a longer life for the road network and protects the investment. Stream crossings, roads and trails must be inspected regularly to determine if all elements of the network are operating as intended. The cause of any failures must be determined and appropriate remedial actions taken.

The key to maintenance is regular inspections. All elements of the road network, particularly watercourse crossings, should be inspected and maintained annually. Regular inspections will identify such items as downed trees or branches that block the trail or road, or signs of erosion. Blocked roads can be easily cleared during inspection times and signs of erosion may indicate that runoff diversion channels will need to be constructed before the next rainfall. Crossings may need special or immediate attention. Culvert inlets and outlets should be kept clear of any plant debris or soil that may have accumulated. Erosion of the road or bank fill should be corrected as soon as possible. If beavers are causing damage, install riprap to permanently prevent similar damage in the future. Finally, the recreational road and trail network should not be used during wet weather to avoid soil rutting and compaction.

Beneficial Management Practices

- Develop a plan to identify the purpose and uses of the access, the location, and the construction methods and materials to be used.
- Consult with forestry practitioners including woodlot extension specialists on regulations governing access routes and waterway crossings and to gain current knowledge on locating and constructing access routes.
- When planning an access route, consider its range of uses and develop protective measures for sensitive or special sites.
- Utilize existing roadways, including routes on neigbouring properties instead of building new ones.
- Avoid waterway crossings whenever possible.
- Plan gentle curves and slopes. Avoid sharp turns and steep slopes.
- Plan winter roads for wet areas.
- Limit the width of the right-of-way to twice the width of the roadway.
- Harvest trees in right-of-ways before road construction begins.
- Dispose of logging debris from right-of-ways.
- Seed right-of-ways to grasses and herbaceous plants.
- Begin winter road construction after the ground has at least 35 cm of frost.
- Make winter roads short and avoid crossing waterways even when soil is frozen.
- Backfill winter roads with snow.
- Construct crossings at the straightest and most narrow segment of the stream.
- Locate a bridge or culvert downstream from fish spawning beds.
- Consider installing a bridge if more than two culverts are needed for a crossing.
- Schedule crossing construction work in late spring or late summer when stream flow is lowest. Do not schedule construction during fish spawning season.
- Install culverts perpendicular to the roadbed and parallel to the stream flow.
- Prepare the culvert's inlet and outlet to minimize water turbulence.
- Restore vegetative cover on disturbed areas around the crossing site including waterway banks.
- Limit the number of trees cut during the construction phase. Retain forest debris to maintain soil stability and firmness.
- Do not remove material from the waterway or the shoreline.
- Restore disturbed streambeds or banks.
- Design recreational trails to limit access to specific areas.
- Plan recreational trails to traverse a variety of forest stands and sites of special interest.
- Recreational trails should be 3 m wide for ATV or snowmobiles (1 lane) and 2 m wide for foot traffic.
- All elements of a road and trail network should be inspected annually to identify maintenance and/or repair requirements.
- Blocked culverts must be cleared immediately.

Selected Readings

Best management practices for water quality. BMP Field Guide. New York State Forestry.

Sound forestry practices for private woodlots. Fondation de la faune du Quebec.

Harvesting Timber in a Working Woodlot: Profit and Sustainability

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Harvesting Timber in a Woodlot

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes. The woodlot owner recognizes the potential impact of timber harvests on plant and animal populations and their diversity. Indicators of accomplishment include:***

- Logging methods are planned to maintain or enhance the ecosystem, species, and genetic diversity of the woodlot.
- Sites of special significance to the immediate community and the community at large, including the aboriginal community, are identified and protected during timber harvest operations.
- Strategies to identify and protect locations supporting species at risk are included in the harvest plans.
- Wetlands are protected from harvest. Uncut buffer strips are planned for each watercourse in the planned harvest area.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Harvest systems complimentary to prompt forest renewal are adopted.
- Damage to residual timber or advanced regeneration is minimized during harvest operations.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Forest cover, particularly forest cover near water bodies, can protect soils and influence water supplies both locally and at the watershed level. Indictors of accomplishment include:***

- Harvests are conducted during the winter months when soils are frozen, or during dry periods to minimize damage to soils.
- Logging operations are planned to make efficient use of harvest machinery to reduce machine movements.
- Water bodies and courses are protected from harvest machinery. Only partial cuts are planned in riparian zones.
- Hazardous materials are disposed of according to regulations.

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest plan to benefit present and future society. Indicators of accomplishment include:***

- Harvested timber is fully utilized based on current market conditions.
- Logging operations are conducted in accordance with accepted health and safety standards.
- Non-timber products are identified for possible market opportunities.
- Fuel, lubricants, and other supplies and their containers are handled according to regulations.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- The community, including the aboriginal community, is apprised of planned timber harvest operations.
- Sites such as archaeological, geological, historical, or aboriginal traditional areas, which have special significance to the community, are protected from disturbance during harvest operations.
- All regulations governing timber harvests are respected.

Introduction

Harvesting timber is a costly but important woodlot activity. Although realizing a financial return is a major reason to harvest timber, changing species composition, removing damaged or diseased trees, or improving the quality and future value of the stand are also legitimate reasons to harvest timber from the woodlot. Whatever the reason to harvest, the operation should be planned carefully to optimize the yield and to accommodate numerous economic, social, and environmental concerns. The harvest plan must always be based on the objectives for the woodlot and must be complementary to other components of the woodlot management plan.

Several harvest methods are available to the woodlot owner. Some of these methods and their silvicultural implications are described in the Silviculture section of this guide. This section will focus on the operational aspects of harvesting timber from the woodlot.

Harvesting Timber

Timber harvesting is usually conducted based on a plan that specifies logging at predetermined time intervals – perhaps annually, or every five or ten years. At times however, harvests are conducted to meet a woodlot owner's immediate needs or the stands are too small to spread the operation over a period of time. However, even small logging operations require careful consideration.

Once the decision to harvest is made, a number of factors should be considered before implementing the operation. Markets will determine the profitability of the harvest. Markets for timber fluctuate, therefore harvest should be timed to accommodate demand for the products. Markets for labour and equipment also fluctuate and attention must be given to these factors of production to ensure costs are minimized and the quality of the operation will meet the woodlot owner's objectives for the harvested land.

The timing of the harvest not only means timing to accommodate economic conditions but also timing the operation to minimize costs of subsequent management activities such as establishing a new forest. The method and season of the harvest may influence or even determine the strategy for establishing the new forest. Reforesting the land using natural regeneration or artificial reforestation techniques must be considered prior to commencing logging. The woodlot owner must also understand how various logging methods or seasons of logging will affect subsequent regeneration efforts.

Harvesting can have significant impact on other resources in the woodlot. Threatened or vulnerable species, crucial wildlife habitat, or unique forest ecosystem may need special attention to minimize or eliminate disturbance from the harvest operation. The landscape quality and resource sustainability should be preserved and not be compromised by a logging operation. These are all factors that should be considered when planning or implementing a logging operation.

There are four general steps to a logging operation. These are:

- Planning the harvest
- Logging (felling trees)
- Skidding and forwarding logs or trees
- Processing (delimbing, slashing, sorting the timber, etc.)

Planning the Harvest

Harvests can be conducted while preserving other resources and minimizing costs. Logging techniques must be selected to suit the site and terrain conditions and the operation must be done during the appropriate season. For example, small equipment may be appropriate in a selection harvest system where a vigorous understorey of valuable conifers must be protected, and choosing to log during winter months when the ground is frozen will create less ground disturbance than if operating in late spring when the moist soil is subject to rutting and compaction.

A forest management plan or silvicultural prescription prepared by trained forestry practitioners, such as woodlot extension specialists, is very helpful when undertaking a harvest operation. These documents contain information on the stand to be harvested, the type of operation planned, harvesting method, and provisions for accessing the site and protecting regeneration. The plan will guide the woodlot owner to ensure logging activities are consistent with the stated objectives for the woodlot.

Tips to consider before the logging operation begins:

An important first step is to consult local regulations: Consult the local municipality, county, or municipal district to verify by-laws and regulations pertaining to woodlot harvesting, water and stream protection and other land use regulations. Many municipalities and local governments have by-laws that affect timber-harvesting activities.

Decide on the type of harvest: The harvest method must be selected. A choice must be made among selection cutting, shelterwood cutting or methods that favour the protection of regeneration and soil. The harvest method selected and the size of the trees to harvest will determine the kind of machinery to use (tractor, ATV, etc.). The harvesting technique must be adapted to the characteristics of the woodlot. For example, light equipment may be most appropriate in poorly drained areas.

Hire skilled, recognized, or certified logging contractors: Many woodlot owners in Alberta hire logging contractors to harvest timber. A woodlot owner association or the local woodlot extension specialist may provide assistance in selecting reputable logging contractors.

Mark the trees to be logged: Selection logging means some trees are harvested while others are left. Best results will be obtained when trees to be harvested (or left) are clearly identified perhaps even marked with flagging tape or tree paint, before logging begins. Tree marking is particularly important when the logging contractor does not fully understand the selection logging process or its objectives.

Schedule logging to accommodate local markets, according to seasons and weather conditions: Logging should be done during the driest periods of the year to minimize damage to soil and regeneration. Winter logging will leave a minimal logging imprint. Some markets however may require delivery during specific times of the year.

Opt for small cutovers and respect the natural stand contours: Using a variety of cuts and irregularly shaped cutovers promotes forest biodiversity and helps integrate cutovers into the landscape.

Promote biodiversity: Consult with a woodlot extension specialist to determine if the area to be harvested will affect particular elements of the woodlot, such as threatened or at risk species or exceptional forest ecosystems such as old growth forests, before proceeding with the harvest operation.

Identify sensitive areas in the cutting block: Plan protective measures in advance for sensitive areas such as water-courses, buffer strips, steep slopes, thin soil and wetlands.

Plan skid trails, landings, processing sites and other heavy traffic areas: Landings and processing areas should be located on stable, well-drained soil. Roadside logging activities visible to the public should be kept dry and clean and show minimal disturbance to portray an appearance of a well-managed and planned forestry operation. The quality of the operation may be judged by the appearance of these areas.

The Logging Process

Logging, particularly selective logging, on Alberta woodlots is often done using chainsaws to fell, limb and buck the logs, and small equipment to skid or forward the timber to the roadside. Mechanized operations that utilize feller-bunchers, delimbers and slashers are more common among larger operations based on tree-length or full tree harvest systems. Log dimensions required by timber buyers and the primary forest products industry may vary depending on local and regional market conditions, and the logging process should be designed to accommodate these market requirements. Regeneration and residual stems left for future harvests must be adequately protected during the logging process. It is very difficult to adequately protect regeneration, saplings, and residual trees, particularly if they are over 80 cm high.

Logging tips:

Opt for directional felling: Fell trees diagonal to the skid road to facilitate and minimize machinery traffic during skidding and forwarding operations. Operate machinery carefully and efficiently to reduce movements. Feller operators should take precautions to protect young shoots and saplings.

Harvest wet areas when the ground is frozen: Winter harvesting when soils are frozen will support heavy machinery without damaging the soil. Snow cover will offer some protection to regeneration. Horses or light machinery such as ATVs and snowmobiles can be used successfully in these areas.

Deposit logging debris on skid trails: Machinery can easily travel over logging debris deposited on skid trails without damaging the underlying soil. The deposited logging debris creates a protective matt that distributes the machines' weight, thus minimizing soil compaction and rutting.

Manage logging to create and/or enhance wildlife habitat: When practical, enhance wildlife habitat by leaving small islands of standing mature trees (5 to 10 stems) and snags that do not pose a risk to workers' safety in cutovers. A few dead trees and logging debris can also be left on the ground to provide nesting sites and cover. Tree species without commercial value and fruit-bearing trees should be left standing in cutovers to provide food for terrestrial wildlife and birds.

Respect municipal and county by-laws and regulations on watercourses: Ensure all regulations governing logging activities near watercourses are understood and followed. When in doubt, consult local regulatory agencies or discuss issues with a woodlot extension specialist.

Logging near watercourses and crossing streams with machinery requires extra precautions to ensure waterways are protected: Permanent or intermittent watercourses play an important role in the forest ecosystem. Key elements in protecting these areas include:

- Riparian zone buffer strips;
- Reduction and prevention of sedimentation in water courses;
- Protection of spawning areas;
- Allowing for the free passage of fish in streams.

Maintain a 10 or 15 m wide forested buffer strip around water courses and bodies. Wider protective strips are preferred on steep slopes. Harvesting up to 50% of the stems (10 cm and more in diameter) within the strip will yield adequate timber volumes and still leave a protective forest cover.

Prevent erosion in the buffer zones: Do not expose the soil in the buffer strip. Disturbance within the buffer strips can be minimized by using light machinery or restricting operations to winter months.

Adopt special precautions to protect the environment when logging on slopes greater than 30%: Steep slopes are vulnerable to erosion. Disturbance to the vegetation should be minimized to protect the soil and rocks from erosion. Avoid clear cuts and limit movements of machinery to minimize ground disturbance on these sites. Partial cuts that leave uniformly distributed stems will contribute to stabilizing the slope. If the stand is to be harvested, felling should start at the top of the slope and proceed downhill.

Avoid harvesting timber on wetlands: Wetlands are characterized by wet or poorly drained soils. They include black spruce, larch and alder swamps, peatlands, and other swampy areas. These sensitive ecological sites are highly productive and essential to wildlife and the health of watercourses. Motorized vehicles should be avoided in these areas to protect the fragile environment. Timber harvests may cause a rise in the water table and should be avoided if possible.

Consider the effect of logging on the landscape: A landscape is a portion of the territory that can be viewed by the observer. Logging can have a major visual effect on the landscape by creating areas that are seen as unsightly. Some elements that should be considered to preserve the landscape include:

- **Avoid creating straight-edged cutovers:** Harmonize the contours of cutovers with the natural contours dominating the landscape by imitating the shape of natural gaps as much as possible. Promote the rapid re-establishment of vegetation in the cutover.
- **Protect summits:** Ridgelines (summits) are visible and provide a focal point for the landscape. Clearcutting should be avoided on hilltops.
- **Create a visual screen along roads:** Abide by regulations governing roadside cutting.
- **Dispose of logging debris:** Deposit or process logging debris so that it is not visible from the roadside. Slash piles can provide benefits to some wildlife species. However, accumulating slash in visible locations should be avoided whenever practical.

Skidding and Forwarding

Skidding and forwarding are primary hauling processes that move timber from the stump to the roadside. Skidding is done with a skidder to drag the stems to a central location for additional processing. Forwarding involves hauling the logs or short wood without dragging the timber on the ground, but carrying it with a forwarder or trailer. Other types of equipment applicable to woodlot scale operations include ATVs, snowmobiles, farm tractors, and off-road wheeled and tracked logging machines. Such equipment can have a significant impact on the soil, regeneration, and other components of the ecosystem. Erosion problems after logging operations often occur on skid trails. Primary hauling activities can result in the exposure of mineral soil and the formation of water-filled ruts due to the repeated passage of machinery or the stems being dragged on the ground as they are skidded.

Figure 38: Skidding

Tips for skidding and forwarding:

The following is a list of issue to consider to improve the quality of primary hauling operations and to reduce soil erosion:

Opt for winter logging: Restrict logging activities to periods when the soil is frozen to a significant depth. Winter logging is preferred in the most fragile areas.

Delimb trees on the skid trails: Branches and logging debris can be scattered over the trail to reduce soil compaction and to increase the bearing capacity of the trail.

Select a logging contractor who practices careful logging techniques: The contractor selected to log the woodlot should be knowledgeable in logging techniques, including felling and primary hauling, based on the quality and abundance of regeneration and the presence of wet areas, thin soils, etc. The logger will utilize regularly spaced trails to reduce ground disturbance on the site.

Avoid mineral soil exposure caused by machinery movements and skidding logs: The duff, or organic layer of the soil, should be preserved whenever possible. This can be accomplished through careful logging practices.

Divert water from ruts in skid roads: Water should be diverted from rutted areas to areas with a vegetative cover. Diversions should be done regularly to minimize loss of soil from erosion.

The following suggestions can help to protect watercourses:

- Never use watercourses as access roads, skid roads, or trails;
- Cross streams at planned crossings rather than fording the stream;
- Block run-off in ruts and divert it to an area at least 20 m from the nearest watercourse;
- Refrain from driving machinery in the 20 m buffer strip along a watercourse except at planned crossings.

Maintain a clean work environment during forestry operations: Logging operations require the use of various fluids and other supplies. Absorbent materials such as sawdust should always be available in the event of a spill. Machinery should be maintained to minimize fluid leaks. All garbage such as oil containers, tires or cables should be collected regularly to maintain a clean and safe work environment.

The basics of tree processing

Tree processing includes felling the tree and subsequent processing activities such as delimbing, slashing, sorting, chipping, piling the logs, etc. Initial processing is done either at the stump, i.e. at the site where the tree was felled, or the felled tree can be skidded to a central collection point for processing.

Figure 39: Tree harvesting

Tips for effective processing:

Check standards and procedures: Consult a woodlot extension specialist for information on the current standards and procedures for wood processing in the area. Wood processing facilities may have requirements unique to their operation, therefore the local wood buyer should also be consulted to ensure products will meet the buyer's standards.

Opt for delimbing at the stump: Delimbing trees at the site they are felled, i.e. at the stump, leaves logging slash scattered throughout the cutover rather than accumulated at central locations. Branches left scattered throughout the cutover protect regeneration, conserve soil moisture, provide food for wildlife and minimize visual impacts at the landing or piling area.

Do not locate the landing or piling area in a highly visible spot: The movement of forest machinery to haul and process logs at central locations can disturb soils excessively because of the concentrated activity in a small area. During forestry operations, these areas should be located away from public roads or isolated from publicly accessible areas by vegetated and/or treed buffers.

Keep timber processing activities away from watercourses: Locate landings at least 10 to 15 m from shorelines of water bodies or courses to avoid affecting the quantity and quality of their water. Landings should be located on soils with a bearing capacity sufficient to support machinery and their movements.

Avoid power lines during all harvest and processing operations: The presence of power lines in a harvesting or processing area creates a serious health and safety risk to workers. Power lines should always be avoided, particularly when creating or loading log piles or other activities that require the operation of machinery with a high reaching boom.

Create adequate space for piles: The landing should be at least 6 m (20 ft.) wide to allow easy access to the wood by the loader and truck. A 30 m passageway should be left at the end of the road where wood is piled to allow trucks to manoeuvre when entering or leaving the landing. Woodpiles should be spaced about 0.5 metres apart to slow the aging process and to facilitate loading operations.

Sort wood into piles by species: Different species mixed within the same pile could create additional work during loading or unloading and therefore increase costs. Efforts made during the initial piling operation to sort by species may facilitate loading and unloading wood to the buyer's specifications.

Protect piles from wind and dirt: Woodpiles should be located in a dry, shady area out of the wind to ensure that the appearance of the wood does not change rapidly. Weathered wood will have a deteriorated appearance and may not seem attractive to prospective buyers.

Clean up after the harvested wood is removed: After the harvest operation is completed and the timber has been hauled, the landing sites should be cleared of logging debris such as branches, chips, and bark. Breaking the compacted soil and restoring a vegetative cover of grasses, shrubs and/or tree seedlings will rehabilitate landings. The goal should be to return the landings to the productive land base of the woodlot.

Figure 40: Tree delimber

Beneficial Management Practices

Planning the harvest

- Develop a harvest plan that specifies all operational aspects of the logging. The plan must be complimentary to other components of the woodlot management plan.
- Develop a pre-harvest silvicultural prescription to ensure logging techniques used are consistent with the objectives for the woodlot.
- Consult local regulations pertaining to timber harvesting, water and stream protection, and other land uses.
- Choose the type of harvest (e.g. selection or clear-cut) then select the appropriate harvest equipment.
- Hire skilled, recognized, or certified logging contractors.
- Mark trees that will be cut (or trees that will be retained) for efficient and effective selection logging operations.
- Conduct logging operation during dry weather or during winter months to reduce the logging imprint.
- Schedule logging operations to satisfy demands for timber products.
- Opt for small and irregularly shaped cutovers and respect natural contours to minimize visual impacts of harvests.
- Plan skid trails, landings, processing sites, and other heavy traffic areas.
- Plan protective measures in advance for ecologically sensitive areas.
- Investigate markets for timber products, and markets for labour and harvest machinery before initiating a logging operation.

The logging process

- Opt for directional felling.
- Harvest wet areas when the ground is frozen.
- Deposit logging debris on skid trails to cushion underlying soils.
- Leave small islands of standing trees for wildlife in clear-cut areas.
- Avoid crossing streams with harvest machinery.
- Leave 10-15 m wide strips as buffer zones around wet areas.
- Maintain a tree cover in riparian buffers by selectively logging up to 50% of the stems.
- Use light machinery when logging in buffer strips to avoid exposing soil. Winter logging is preferred in these areas.
- Avoid clear cuts on slopes greater than 30%.
- Begin harvesting at the top of the slope and proceed downhill.
- Consider the visual effect of logging on the landscape. Avoid straight-edged cutovers, protect summits, create a visual screen along roadways, and dispose of logging debris.

Skidding and forwarding

- Opt for winter logging.
- Delimb trees on skid trails.
- Select an experienced logging contractor who understands the harvest objectives.
- Avoid exposing mineral soil by machines' movements.
- Divert water from the ruts in skid roads. Divert water away from watercourses.
- Do not use watercourses as access roads.
- Cross streams at planned crossings.
- Maintain a clean work site. Dispose of all containers and discarded supplies and keep machinery well maintained.

Tree processing

- Check standards and procedures to satisfy the timber buyers' requirements.
- Opt for delimbing at the stump so logging slash will be distributed throughout the cutover.
- Locate landing and piling areas away from public view.
- Keep timber processing activities away from watercourses.
- Avoid power lines during harvesting and processing operations.
- Sort timber by species.
- Protect woodpiles from wind and dirt.
- Clear processing sites of logging debris and break compacted soils after the harvest operation is completed.

Forest Grazing

Contents

Criteria and Indicators of Sustainable Forest Management for Forest Grazing

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the woodlot. Indictors of accomplishment include:***

- Designated grazing areas are monitored regularly to ensure the plant community and its diversity is not altered.
- Areas supporting special ecological features or species at risk are identified and protected from grazing damage.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Blocks scheduled for harvest are assessed for their ability to support grazing and regenerate to productive forests.
- Grazing is postponed after logging until the regeneration is established and is hardy. Advanced and emerging regeneration is protected from livestock damage.
- The grazing management plan includes provisions for livestock rotation to ensure recovery of grazed areas.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Indicators of accomplishment include:***

- Access control techniques are utilized to manage animal movement, particularly in sensitive riparian zones or where damage to soils or water bodies and courses could result.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- Sites of special value to the community, including the aboriginal community, are identified and protected from grazing activities. Sites of special interest could include archaeological, geological, historical or traditional use areas.

Introduction

Many woodlot owners combine conventional agriculture with woodlot management activities. For example, some woodlot owners may manage the forested portions of the property for timber production while maintaining agricultural crops and livestock in other parts. The integration of livestock into woodlot management is a natural progression. Concern exists that cattle grazing in areas managed for forest production may damage established trees or emerging seedlings. However, research suggests that growing trees and raising cattle together are compatible when appropriate silvicultural and grazing management practices are employed.

Forest Grazing Management

Working forest systems have the potential to provide valuable cattle forage. Cattle grazing on forested land can occur successfully when appropriate management techniques to protect the forest system are utilized. Woodlot forests often have multi-use purposes including timber production, wildlife habitat, and/or recreation. However, some grazing practices, particularly over-grazing, can cause long-term damage to the forest and negatively affect these other uses. Introducing cattle grazing into the array of uses means grazing must be managed to integrate the activity with the other objectives for the property. Grazing management techniques to minimize effects of cattle on forestland include:

- Match stocking rate to carrying capacity
- Maintain an even distribution of livestock
- Minimize grazing during fragile periods
- Provide adequate rest to the land after grazing

Figure 41: Forest grazing

Match Stocking Rate to Carrying Capacity

Carrying capacity on forested land differs from that of tame pastureland. Forestland supports various grasses but also includes shrubs, forbs and grass-like plants. Common forest plants such as peavine and vetch are very palatable and nutritious and have a good to fair forage value. Over-grazing forest land, particularly where new forests are being established after logging, can lead to a high incidence of damage to established and planted trees and emerging seedlings. It can potentially cause soil compaction and damage tree roots. A recent study recommended that grazing should not exceed 30% of forage on cutover land to protect regeneration.

Controlling grazing rates to match carrying capacity also improves the long-term ability of the forest to produce forage. Heavy grazing may result in an increase in less productive plant species and a decrease in carrying capacity over a period of time. Frequent monitoring during grazing is needed to determine when livestock should be moved and will help to identify changes in the range conditions that could lead to long-term damage.

Maintain an Even Distribution of Livestock

Numerous strategies can achieve an even spatial distribution of livestock over the grazing area. Herding the animals can effectively improve their distribution, although this method is time consuming. Animal dispersal may also be managed by placing water and salt in strategic locations to encourage a desired distribution pattern. This strategy can also be used to encourage animals to move into treed portions of the range. Some data indicate that cattle will not travel more than two miles to water on flat terrain, and not more than one mile to water on rough terrain. As a result, valuable forage may be under-utilized solely because of the distance from water, while areas close to water will get excessive grazing pressure. Portable water systems can also be used to manage livestock distribution. This method provides the flexibility of regularly relocating the water to ungrazed areas, although this can also be time consuming. Water and salt should be in different locations to further encourage dispersal throughout the area. Distribution may also be regulated by managing access. Fences will ensure livestock utilize designated areas while cut lines or trails through forested areas will encourage movement into the treed grazing sites and improve overall forage utilization.

Minimize Grazing During Fragile Periods

The most fragile periods for a logged forest area is during the first year after harvesting, and particularly in the first year until new growth has hardened off. Cattle grazing on these sites should be deferred until late summer of the first year after timber harvest. Some data indicate forage is improved when grazing is deferred until the second year after timber harvest. Regular monitoring of grazed areas to assess the regeneration is also important. A recent Alberta study recommended monitoring during the critical regeneration period should be done for up to 5 years post harvest on coniferous cutovers and 2 years post harvest on deciduous or mixedwood cut blocks. In general, grazing forested areas should be postponed until June or even later depending on the forage carryover from the previous year. A general rule of thumb for any grazing system is that for each day grazing is postponed in the spring, the grazing season will be extended three days in the fall.

Provide Adequate Rest to the Land After Grazing

Any grazing system should allow the land to rest following a grazing period. This rest time allows plants to rebuild their energy reserves and maintain their vigour and ability to continue to grow and reproduce. Continuous overgrazing where plants are grazed a second time prior to recovering will cause a change in the plant community and an increase in invasive non-desirable plant species such as wild strawberry and Kentucky bluegrass. The change in plant community can lead to a decrease in the quality of forage and a decline in the carrying capacity of the site. Developing multiple pastures or grazing sites will facilitate the rotation of cattle to provide adequate rest periods for each site and decrease the likelihood of overgrazing.

Grazing and Timber Integration

Integrating timber management objectives with livestock grazing can be accomplished successfully. Grazing can be used as a vegetation management tool to promote the establishment of a new forest while simultaneously providing valuable forage for livestock. Deciduous and mixedwood forests are likely to be most adaptable to integrating timber and livestock production, although coniferous forests also provide valuable grazing land.

Figure 42: A woodlot protecting a feedlot from wind

The woodlot owner planning to integrate grazing with timber management objectives should ensure the woodlot management plan includes a grazing management component and that all grazing activities are considered within the context of the timber management objectives. In addition to the management strategies discussed in the previous section, the following recommendations will contribute to integrating timber and livestock production on the woodlot:

- Effective communication and planning between the forest operator and grazing operator prior to harvesting timber.
- Perform rangeland health assessments prior to harvesting timber to identify potential problems in regeneration responses. Problem areas may include locations where the forest is already unhealthy (possibly due to overgrazing). Such problem areas may require additional planning or management to promote regeneration and stand development.
- Assess grazing patterns in proposed cut block areas prior to logging. If livestock use is high in the proposed harvest location, special considerations and management techniques may be necessary to ensure successful regeneration.
- Conduct winter timber harvesting when possible to minimize damage to the soil through rutting and compaction.
- Following harvest, graze at a light to moderate level with stocking rates based on the pre-harvest mature forest community. Aim for a forage utilization rate in deciduous cut blocks of less than 30% and a light "hoof-print".
- Continually monitor grazing and rangeland health to assess regeneration success and grazing impact.

(Recommendations adapted from Lane & Willoughby. "Timber Harvesting and Livestock Grazing Effects on Deciduous Communities of the Lower Foothills Subregion." 2004)

Additional information on grazing and timber integration can be found on the Alberta Sustainable Resource Development website at http://esrd.alberta.ca/lands-forests/grazing-range-management/grazing-timber-integration.aspx

Beneficial Management Practices

- Include a grazing component or separate grazing plan in the woodlot management plan.
- Match stocking rate to carrying capacity.
- Do not graze more than 30% of forage on cutover land to protect forest regeneration.
- Conduct frequent inspections to identify changes in range conditions that could lead to long-term damage to the carrying capacity.
- Maintain an even distribution of livestock throughout the grazing area.
- Herd animals into desired locations.
- Apply livestock distribution tools such as strategic water and salt locations and temporary fencing to manage the intensity of grazing.
- Utilize portable watering systems to manage animal movements.
- Install fences to manage access.
- Construct or maintain forest roads and trails to encourage animal movements into treed areas.
- Minimize grazing on cutovers during fragile regeneration periods.
- Defer grazing on cutovers until at least the end of the first year after harvest and preferably until the second.
- Monitor grazed cutovers regularly to assess the forest regeneration. Conifer cutovers should be monitored for at least 5 years after harvest and deciduous or mixedwood cuts for at least 2 years.
- Postpone grazing until June or later depending on the forage carryover from the previous year. Delaying grazing one day in the spring will extend the grazing season 3 days in the fall.
- Provide adequate rest to the land after grazing to allow forage to recover.
- Develop multiple pasture or grazing sites to allow rotation of cattle and avoid overgrazing.
- Assess potential forested rangeland prior to timber harvest to determine if special measures will be required to regenerate the stand. Grazing should not be planned on sites where regeneration difficulties are anticipated.
- Conduct winter timber harvests to minimize soil damage and other disturbances.
- Following timber harvest, graze at a light to moderate level with stocking rates based on the pre-harvest mature forest community. Aim for a forage utilization rate in deciduous cut blocks of less than 30% and a light "hoof-print".
- Consider grazing as a thinning tool. Light to moderate levels of grazing may increase growth of young aspen suckers while heavy grazing will retard growth.
- Monitor grazing and rangeland health continuously to assess regeneration success and grazing impact.

Selected Readings and Internet Sites

Internet Sites

http://esrd.alberta.ca/lands-forests/grazing-range-management/grazing-timber-integration.aspx - Grazing & Timber Integration, ESRD.

http://esrd.alberta.ca/lands-forests/grazing-range-management/documents/GrazingandTimberIntegrationManual-May18-2011.pdf - Grazing & Timber Integration Manual, Government of Alberta.

Books and publications

Timber harvesting and livestock grazing effects on deciduous communities of the Lower Foothills Subregion. Lane, C.T.P, Willoughby, M.G. 2004. Alberta Sustainable Resource Development.

Integration of cattle into a working forest systems. Sage Ecological Research, Invermere, British Columbia. 2004.

Literature review and industry information: Timber grazing integration. Timberline Forest Industry Consultants. Alberta Sustainable Resource Development.

Agroforestry

Contents

Criteria and Indicators of Sustainable Forest Management for Agroforestry

All six criteria for sustainable forest management are addressed by agroforestry activities on private land. These criteria are:

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes.***

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem.***

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water.***

Criteria 4: ***Role in global ecological cycles. Implement forest management practices to contribute to the health of global ecological cycles by utilizing the carbon sequestration capacity of forests.***

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest management plan to benefit present and future society.***

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property.***

Indicators to measure accomplishment include the health, quantity and productivity of natural or planted forests, forest belts, and buffers. The extent these forests are contributing to water quantity and quality, to mitigating global warming, and to providing benefits not only to the landowner but also to the surrounding and global community are strong indicators of addressing these criteria. Finally, the extent the interests of neighbours, the community at large, and interested groups such as aboriginal people are considered in the planning and implementation of activities on the woodlot is a measure of sustainable forest management.

Introduction

Agroforestry is a land management approach that deliberately combines the production of trees with the production of agricultural crops and/or livestock. Agroforestry brings together the science of producing farm products with the science of growing trees. Blending agriculture and forestry with accepted conservation practices can optimize economic, environmental and social benefits. The optimization of these benefits is commonly known as sustainable development.

Agroforestry is an established activity in many parts of the world, although the science and its application continue to emerge. Developing countries, particularly where land is scarce, have accepted agroforestry as a viable alternative to their traditional methods. In Western Canada trees have been grown on farmland for many years, however the concept of combining the production of trees and crops and/or livestock is relatively new.

This section will describe some of the benefits of agroforestry and some of the methods currently in use. Shelterbelts are given special focus because they have been proven to provide many benefits and have been accepted by agriculture and forestry practitioners.

Where Does Agroforestry Apply

The most common application for agroforestry is at the individual operation or farm level. However, agroforestry is also practical and can work very well at the community level. The community based approach is applicable where there is an interest in promoting the adoption of conservation practices and alternative land uses, and where there is support for a collaborative watershed approach to management of landscapes containing mixed ownerships, a variety of vegetation types and multiple land uses.

Agroforestry systems are implemented to achieve economical, environmental and/or social goals. In general most lands are candidates for agroforestry activities; however some lands are identified for special consideration. These include lands requiring protection due to highly erodible soils, flood-prone locations, economically marginal production potential, and environmentally sensitive sites. Often the goal on these lands is to restore essential processes needed for ecosystem health and sustainability.

Benefits of Agroforestry

Typically, agroforestry systems require the addition of trees or the tending of existing trees to create planned desired benefits. Planned benefits include:

- Reduced cropping and reduced environmental risk
- Lower inputs
- Cropping diversification and positive impacts of increased biodiversity
- Higher overall yields
- Income diversity
- Improved soil structure
- Source water protection
- Animal comfort
- Greenhouse gas reduction
- Ecological diversity

An additional benefit that could accrue to the landowner in the near future is from the sale of carbon, or more specifically, the sale of carbon credits resulting from the carbon sequestered by trees grown for that purpose. All trees sequester carbon from the atmosphere. Individual fast-growing hybrid poplars can remove as much as to 45 kg of carbon dioxide per year from the atmosphere. In a plantation setting however, the amount of sequestered carbon dioxide would be more conservative and likely range from 12 to 26 kg per year per tree. On an area basis, planting in a 3m x 3m grid yields 1100 trees per ha and results in approximately 13 to 28 tonnes of carbon sequestration per ha per year. Currently there is no market for carbon trading in Canada. Expectations are that future market systems will develop to allow producers to capture financial value from the carbon sequestered by trees they grow.

Key Traits of Agroforestry

Agroforestry practices are intentional combinations of trees with crops and/or livestock where the interaction between the components is intensively managed as an integrated agroecosystem. These key characteristics are the essence of agroforestry and distinguish it from other farming or forestry practices.

To be called agroforestry, a land-use practice must satisfy all of these criteria:

- Intentional: Combinations of trees, crops and/or animals are intentionally designed and managed as a whole unit, rather than as individual elements that may occur in close proximity but are controlled separately.
- Intensive: Agroforestry practices are intensively managed to maintain their productive and protective functions. These practices often involve annual operations such as cultivation and fertilization.
- Interactive: Agroforestry management actively manipulates the biological and physical interactions between the tree, crop and animal components. The goal is to simultaneously enhance the production of more than one harvestable component, while providing conservation benefits such as non-point source water pollution control or wildlife habitat.
- Integrated: The tree, crop and/or animal components are structurally and functionally combined into a single integrated management unit. Integration may be horizontal or vertical and above or below ground. Such integration utilizes more of the productive capacity of the land and helps balance economic production with resource conservation.

Agroforestry Systems

Agroforestry systems can be categorized into five areas of activity:

- Alley cropping
- Forest farming
- Riparian forest buffers
- Silvopasture
- Windbreak shelterbelts

Alley cropping: Alley cropping, also called intercropping, is the management of agriculture crops grown between rows of long-term tree crops to provide annual income while the tree crop matures. Benefits can include increased crop yield and quality, increased biodiversity and a reduction of negative environmental impacts such as soil erosion. Figure 43 illustrates a recently established agroforestry system where 3 rows of poplar are planted in conjunction with a forage mix. The system provides an annual harvest of hay and at age 20 or 25 when the tree crop matures, a harvest of timber or wood fibre with a potential market value. In other applications, poplar, which has the capacity to absorb large amounts of nutrients and water, could be incorporated into a farm manure disposal system. For example, multiple rows of poplars could be used to remove animal waste in slurry form, such as hog manure. The University of Missouri Internet website provides information on alley cropping at: http://www.centerforagroforestry.org/practices/ac.asp

Figure 43: Alley cropping in northeastern Alberta.

Forest farming: Forest farming is the intentional cultivation of edible, medicinal, or decorative specialty crops beneath a canopy of native or planted trees. The tree canopy is modified to provide correct shade levels for the high value under-planted crop.

Figure 44: An idealized forest farming system.
Figure courtesy of USDA Agroforestry centre

Riparian forest buffers: Riparian forest buffers are natural or re-established streamside forests. The ideal buffer system is made up of three components. The first component, located next to the cropped area, is a grass and shrub strip. Beside this is a managed forest strip where a variety of fast growing trees can be planted and managed for eventual harvest for wood products. Finally there is a strip of mostly native trees. The natural tree strip is not generally harvested, although it can potentially be harvested on a selective cutting basis. The system protects water quality by reducing non-point source pollution from adjacent land, reduces bank erosion, protects aquatic environments, enhances wildlife, and increases biodiversity.

Naturally occurring riparian forest buffer strips provide an immediate and low cost solution to environmental issues such as stream bank stabilization, sediment and nutrient filtration, and water temperature regulation. Forest buffer strips may benefit from enhancements to provide more economic opportunities and improved function. Riparian zones and associated forest buffers occupy a small portion of the total area, but make a valuable contribution to a healthy and biologically diverse landscape. Additional information is available on the Internet from The Association for Temperate Agroforestry at http://www.aftaweb.org/riparian_buffers.php and from the University of Missouri at http://www.center-foragroforestry.org/practices/rb.asp.

Silvopasture: Silvopasture systems deliberately combine trees with forage and livestock production. In some parts of the world trees are managed for high-value sawlogs as well as shade and shelter for livestock and forage. Managed grazing in Christmas tree or timber plantations can result in annual income from forage and livestock production and high value wood products when trees are harvested at maturity in future years. Tree growth rates are often reported to be considerably higher when animals are introduced into what would otherwise be a tree only system. Figures 45 and 46 illustrate silvopastoral systems.

Agroforestry opportunities may exist on the Prairies to improve livestock and forage production if they are managed in conjunction with trees such as poplar, pine and larch. However, little research has been conducted in western Canada to fully quantify the feasibility.

Forest grazing is commonly practiced on the prairies and is similar to silvopasture. However, forest grazing lacks the intentional systems approach that obtains the best interactions among animals, forage and trees. Forest grazing must be managed to consider the impacts of livestock on tree root damage and on the loss of understorey diversity. Carefully managed use of livestock can provide weed control and help to prepare a seedbed for natural regeneration. Grazing will also prune lower tree branches and reduce fire hazard that can result from heavy fine fuel loading. More information on silvopasture can be found in Chapter 4 of "A Guide to Agroforestry in BC" and is also available on the Internet at: http://www.woodlot.bc.ca/swp/Downloads/files/AgroforestryGuide.pdf.

Figure 46: Horse grazing in an established tree plantation

Windbreak shelterbelts: Windbreaks in the Prairie Provinces are a familiar form of agroforestry and can be either new plantings of trees and shrubs or existing trees maintained as windbreaks. Windbreak shelterbelts can be designed and managed to enhance crop production, protect people and livestock, and enhance soil and water conservation. Figure 47 illustrates shelterbelts positioned to protect the farmstead, surrounding fields and a riparian forest buffer.

Figure 47: An example of windbreaks to protect the field and farmstead and a riparian forest buffer.

Five windbreak shelterbelt types based on their functions are:

- Shelterbelts to protect farmsteads
- Shelterbelts to protect soils
- Shelterbelts to protect wind sensitive crops
- Shelterbelts to protect livestock
- Shelterbelts to manage snow cover

Shelterbelts to protect farmsteads: Shelterbelts can be managed to protect farmsteads from winter winds. Farmstead shelterbelts will trap blowing snow to prevent snow build-up in the yard or driveways. In addition, reduced wind exposure can reduce heating costs for buildings and homes.

Farmstead shelterbelts should be five rows deep and located on the prevailing wind side of the yard. The inside row should be no closer than 30 m from the main buildings and driveways to prevent snow build-up. If space is limited, the number of tree rows should be reduced rather than decreasing row spacing or planting closer to buildings. The outside row of the shelterbelt should be planted with shrubs to act as a snow trap and the inside row planted with tall, dense, long-lived trees. In areas of high snow accumulation a shrub row can be planted to trap snow 30 to 100 m ahead of the main shelterbelt. Figure 48 illustrates how an additional shrub row can be planted as a snow trap outside of the other functional shelterbelt tree rows to prevent snow from accumulating around buildings or along access roads.

Figure 48:. Typical snow trapping with shelterbelts and use of shrub row to enhance snow trapping.
Figure courtesy of PFRA

The decrease in wind speed resulting from appropriate shelterbelt placement will decrease heating costs for homes and buildings. Tests conducted by PFRA in the Prairie Provinces indicated dense four-row shelterbelts (two rows of conifers plus two rows of deciduous trees) reduced home heating losses by up to 25%. Older homes that allow for more air filtration will receive greater benefits from protection resulting form shelterbelts. In general, energy saving is proportional to the decrease in wind speed.

Shelterbelts to protect soils: Shelterbelts provide a zone of protection that can extend from 10 to 20 times the height of the shelterbelt. Reduced wind speed within the zone of protection lowers the risk of soil erosion and generally increases soil moisture.

The main factors that influence the erodibility of soils are moisture and texture, the amount of soil aggregation, the crop residue level or vegetative cover, and the field width. Generally, lighter or sandier soils are more erodible than heavier soils. As soil dries and aggregation decreases, the soil becomes more prone to wind erosion. Single row shelterbelts of trees such as Green Ash may not provide enough wind protection for highly erodible soils, particularly when crop residue levels are low in the spring. These erodibility factors, along with farm equipment size, will determine the shelterbelt spacing.

Zero and minimum tillage systems significantly increase the amount of crop residues and therefore reduce the risk of wind erosion. Shelterbelts on these fields can still provide significant benefits in the form of increased soil moisture and heat levels for improved crop growth. Also in the event of crop failure when crop residues are minimal, the shelterbelt will be available to reduce erosion levels.

Shelterbelts to protect wind-sensitive crops: Shelterbelts protect a variety of wind-sensitive row, cereal, vegetable, orchard and vine crops. Fruit crops including their pollination are most sensitive to wind and therefore yield greater benefits from shelterbelt protection. Leafy crops such as vegetables and forage are less sensitive and root or grain crops are the least sensitive. Warm weather crops such as corn, peppers, and tomatoes mature earlier because of higher heat units and reduced wind damage to leaves. Wind damaged leaves force the plant to waste its resources to repair the damage. Quality of the crop may also be affected. When subjected to effects of strong winds and soil movement, some crops develop more fibres, and fruits can be bruised. In addition, wind protection increases pollination success and pesticide effectiveness.

Shelterbelts to protect livestock: A managed windbreak will protect livestock in winter and summer and will provide economic benefits over the long term. Reducing wind speed can:

- Lower animal stress
- Improve animal health
- Increase feeding efficiency
- Protect the working environment in and around the livestock area
- Screen noise and reduce odours associated with livestock operations
- Provide significant amounts of wildlife habitat

Shelterbelts can provide a very effective winter shelter for livestock. Shelterbelts designed specifically for this purpose should have no more than 40% porosity. The belt should be composed of three to five rows of shrubs and one or two rows of dense conifers and should extend at least 30 m beyond the protected area. Figure 49 illustrates a livestock wintering area protected by a windbreak.

The specific needs of animals dictate that special attention be given to access, snow storage, and drainage when planning a livestock windbreak. Proper drainage for melting snow must be provided to reduce the level of mud in feedlot or wintering areas. Likewise, runoff from the feedlot should be directed away from the trees, since its high nitrate levels may damage the windbreak. The time spent on layout, site preparation, weed control, and replanting is paid back many times throughout the life of a windbreak.

Figure 49: A shelterbelt protects livestock from prevailing winter winds.

Shelterbelts to manage snow: Shelterbelts can help to manage and control snow movement and accumulation. Optimum snow management allows easy access to animals, buildings, and forage and grain storage facilities during the winter months. A well designed shelterbelt system will:

- Collect snow in low-use areas and keep it out of high-use areas
- Save on fuel expenses
- Reduce equipment wear
- Save on labour for snow removal and livestock feeding

The distribution of snow can be managed through shelterbelt design. Porous shelterbelt designs lead to a longer and shallower down-wind distribution of snow. Less porous shelterbelt designs result in deeper and shorter snowdrifts. Porosity can be managed by varying tree species and spacing or by pruning lower branches.

Shelterbelt height, density and bottom gap affect snow distribution. A more porous barrier (about 50%) will distribute snow up to 35 times the height of the shelterbelt. By comparison, a solid fence or a very dense shelterbelt would result in the majority of the snow accumulating within 15 times the height of the shelterbelt.

Shelterbelts can be established to protect roads from snow accumulation. A dense shelterbelt should be placed about 15 times (or slightly more) its mature height away from the roadway to capture the majority of the snow. Alternatively, the shelterbelt can be planted closer to the roadway and the branches from the bottom 2 m of the trees removed. The gap allows wind to move through the lower part of the canopy and carry snow beyond the road.

Planting rows of closely spaced conifer trees perpendicular to the prevailing winds creates a "wind shadow" on the downwind side of the shelterbelt and causes blowing snow to be deposited in deep drifts. Shelterbelts established 35 to 70 m away from a road, building or farmstead are an ideal living snow fence. Conifers not only provide good wind protection, but also add winter colour to the farmstead.

Shelterbelt Establishment

Shelterbelt establishment requires the following activities:

- Tree species selection
- Site preparation
- Shelterbelt tree planting
- Tree maintenance

Tree species selection: Choosing the right tree species requires balancing objectives with the climate, soil and physical characteristics of the site and the growth characteristics of the tree species. The desired characteristics of an ideal tree species will depend on its expected function. The selection should be based on climatic suitability, irrigation requirements, if the tree will provide shelter for crops, livestock or buildings, if it will provide wildlife habitat, or if its timber value will provide an economic return. Characteristics considered desirable are:

- High value or multiple values
- Fast growing
- Creates minimal shade
- Deep-rooted with few large lateral roots near the soil surface
- Does not produce chemicals toxic to other plants or animals
- Tolerant of a variety of site conditions
- Tolerant or resistant to disease and insects

Site preparation: Site preparation is one of the most important steps in the successful establishment of shelterbelts. Good site preparation techniques will facilitate tree planting and will reduce weed competition and seedling stress caused from lack of moisture, light and nutrients. Site preparation techniques include mechanical methods such as discing, cultivation, harrowing and perhaps mowing, and herbicide application such as band spraying, spot spraying and incorporation of granular herbicides. The best time to prepare the planting site is in the late summer and fall before planting. Site preparation is more difficult in the spring just before the area is planted.

Shelterbelt tree planting: Planting can begin as soon as the ground has thawed and before leaves emerge. The long-term success of the shelterbelt is, in part, dependent on how well the trees are planted. Steps to a successful shelterbelt planting are:

- Consult the plan and ensure proper setbacks from buildings, utilities, and roadways.
- Plant only as many trees as can be adequately maintained.
- Plant trees at the same depth they were grown at the nursery (or up to 3 cm deeper). Planting depth is indicated by a change in colour on the bark at the former soil line.
- When planting by hand insert the spade into prepared soil and create a wedge shaped hole by forcing the shovel forward. Place the tree in the space ensuring roots are evenly spread. Remove the spade and replace the soil and tamp firmly (with foot) over the root system.
- Water trees immediately after planting if soil moisture conditions are poor.
- Fence off planting areas to protect newly planted trees from being eaten or trampled by livestock.

Shelterbelt Maintenance: A shelterbelt is successfully established when it can perform its desired function(s). Shelterbelts will require maintenance after planting and before they are established and periodically over its life.

Weed control and replacing dead seedlings will be the focus of maintenance activity during the first three years. During this period, dead seedlings should be replaced promptly to ensure inter-tree spacing is consistent with the planned shelterbelt design. Weed control is particularly important during the first three years to ensure healthy fast growing seedlings become well established. Weeding can be performed by combinations of hand weeding, mechanical tillage and chemical sprays. Cultivation to control weeds should not extend beyond three years to protect expanding root systems. After the third year when seedling are well established, Mowing will adequately control weeds.

Mulching with organic or plastic material is an effective alternative to cultivation and herbicide weed control. Organic mulches are loose materials such as wood chips, straw, flax shives, or bark and are applied manually. Plastic mulches are sheets of plastic laid on the ground around the seedlings to provide a barrier to weed seed germination. Plastic mulches are usually easier to apply than organic mulches and while organic mulches reduce soil temperature, plastic mulches will maintain or increase soil temperature. In general, mulching is more expensive than using herbicides, however it provides several years of low input weed control.

Additional maintenance will include irrigation during dry periods, branch pruning, and regular inspections to monitor incidence of disease or insect activity. Irrigation, however, may not always be feasible. Newly established seedlings are most susceptible to dry periods, therefore some tree mortality and subsequent replanting may be required. In later years, lower branches should be pruned and dead branches removed to create the desired snow distribution effects. Removing lower branches in some conifers can create a more even distribution of snow cover. These activities may extend throughout the life of the shelterbelt.

Biodiversity Opportunities

Agroforestry systems including single row shelterbelts, multi-row belts, riparian buffer strips and silvopasture systems create biodiversity benefits. Some of these benefits include:

- Corridors are created where animals can easily move between forested areas that provide the majority of their habitat requirements.
- Important food sources are provided for some animals.
- Animals are attracted for viewing. Shrubs such as high bush cranberry, elderberry and wild apples can attract songbirds, game birds, deer, and rabbits.
- Multiple rows can offer thermal cover, food, and bedding areas for some animals.

A range of values and benefits can be realized at the landscape level when multiple landowners adopt shelterbelt systems. For example, a number of producers creating buffer strips to reduce agricultural impacts on water quality are more likely to have a greater impact than one producer implementing such a practice in isolation. Similarly, positive cumulative effects will result when managing agroforestry systems to provide wildlife habitat.

Setting Objectives and Planning for Agroforestry

Agroforestry activity and related objectives is only one component of the overall plan for the farm operation or area. The objectives of the agroforestry plan must be realistic and appropriate for the property and must not contradict other objectives set in the overall plan. Agroforestry should therefore be planned to complement other activities and contribute to the overall plan for the operation or landscape.

Planning helps to turn intentions into realty. Planning focuses attention on establishing and achieving objectives and helps to:

- Organize and document ideas
- Avoid costly mistakes
- Ensure resources are well managed
- Maximize potential returns, and
- Monitor progress toward achieving goals

Management objectives are targets that list planned achievements over the short and long term. Short-term objectives are usually specific and occur over a short time frame. An example of a short-term objective might be "Over the next three years, determine market opportunities for hybrid poplar timber, and research the impact of these poplars on forage production in an alley cropping system". Long-term objectives are more broadly worded and have a longer time frame for implementation. An example of a long-term objective might be "Over the next ten years, supplement annual income with revenue from selective harvest of mature trees in grazing areas and plant trees to connect natural wooded areas and multi-row shelterbelts to create wildlife habitat corridors".

Both a farm and a landscape approach to planning are preferred. A farm plan approach will be specific to the operation. A landscape approach will consider the benefits of designing a system to recognize neighbours' landscape features and other adjacent areas. For example, the plan could include connecting wildlife habitat on the property with existing habitat in adjacent areas or protecting common water bodies. This broader approach to planning could enhance objectives of the property and contribute to the objectives of adjacent areas.

Linking Objectives to Landscape Planning

After the objectives for the property are developed, the bigger picture - the landscape level - is considered. Issues to recognize in this phase are how the property fits into the broader landscape, opportunities to enhance ecological features, and impacts on adjoining properties. Full consideration must be given to the effects of planned activities on the objectives of the neighbouring properties and efforts made to complement those objectives whenever possible.

Beneficial Management Practices for Agroforestry

- Develop a well-defined plan that includes clear objectives for agroforestry activities and are complementary to the goals and objectives for the entire farm property.
- Aim for multiple benefits such as timber values and crop protection values from shelterbelts.
- Design shelterbelts or other forested areas to maximize and optimize benefits to the landowner and the surrounding landscape. Consider the broader landscape when implementing agroforestry activities.
- Use natural or planted forest areas or belts to protect or enhance the quality of water bodies and to protect soil from wind erosion.
- Choose tree species best suited to the local growing conditions and to their desired function.
- Concentrate efforts to control weeds during the first three years after planting tree seedlings. Avoid cultivating for weed control after the first three years to minimize damage to seedling roots.
- Consider impacts of activities on the neighbours' property.

Selected readings and Internet sites and additional information

Books

A Guide to Agroforestry in BC. Forest renewal B.C. and Small Woodlands program of BC.

Internet sites

http://www.centerforagroforestry.org/practices/ac.php - Alley Cropping, Center for Agroforestry

http://www.woodlot.bc.ca/swp/Downloads/files/AgroforestryGuide.pdf - A Guide to Agroforestry in BC

http://www.usda.gov/wps/portal/usda/usdahome?navid=agroforestry - Agroforestry, USDA

http://www.aftaweb.org/riparian_buffers.php - Riparian Forest Buffers, AFTA

http://www.centerforagroforestry.org/practices/rb.php - Riparian Forest Buffers, Center for Agroforestry

http://www.agr.gc.ca/eng/about-us/offices-and-locations/agroforestry-development-centre/publications/?id=1367963053819 – Shelterbelt Publications, Agriculture and Agri-Food Canada

http://www4.agr.gc.ca/resources/prod/doc/pfra/shelterbelt/design/shelterbelt.swf - Shelterbelt Planning Tool

http://www.aftaweb.org/ - Association for Temperate Agroforestry

http://www.saskforestcentre.ca/ - Sask Forest Centre

http://nac.unl.edu/ - USDA National Agroforestry Center

Establishing a Short Rotation Intensive Culture Poplar Crop

Contents

Criteria and Indicators of Sustainable Forest Management Related to the Intensive Culture of Short Rotation Poplar Crops

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes. Indictors of accomplishment include:***

- Poplar plantations are installed in unforested areas and provide habitat for a diversity of wildlife species.
- The woodlot management plan includes provisions to manage weeds in the plantation, with efforts directed towards controlling invasive species.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Insect and disease conditions are monitored regularly. Outbreaks are reported to local authorities and actions taken to minimize spreading to other parts of the woodlot or to other properties.
- Integrated pest management strategies are implemented as a first approach. Chemicals are used prudently and in accordance with manufacturer specifications.

Criteria 4: ***Role in global ecological cycles. Implement forest management practices to contribute to the health of global ecological cycles by utilizing the carbon sequestration capacity of forests. Indicators of accomplishment include:***

- Poplar plantations are installed and managed for their carbon sequestration value.

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest plan to benefit present and future society. Short rotation poplar crops may diversify woodlot owners' income by providing marketable timber. Indicators of accomplishment include:***

- Marketable poplar timber provides economic opportunity and diversification to the woodlot owner and to community members.
- Operations are conducted in accordance with workplace health and safety standards.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- Efforts are made to abide by all local and provincial regulations that control land use and land easements.

Introduction

Short rotation intensive culture (SRIC) refers to growing a tree to maturity in less than 20 years using traditional agricultural practices. Planting and maintaining a poplar crop is similar to planting and maintaining a traditional agricultural crop - at least during the first four or five years until the poplar crop becomes well established. Research and operational trials on SRIC have been ongoing for many years in various parts of Canada. The original purpose may have been to test various poplar species to select fast growing and hardy clones able to withstand Prairie conditions. The current interest, however, seems to focus on providing short rotation crops to supply feedstock to forest industry, creating carbon sequestration opportunities, and diversifying economic circumstances in the agriculture sector.

Hybrid poplar is widely used for SRIC because of its ability to propagate from dormant stem cuttings. This ease of propagation has facilitated breeding programs with the result that numerous well-tested clones are available for operational planting. A variety of hybrid poplar clones have been developed to address the wide range of soils, weather extremes, and moisture conditions found throughout the Prairie Provinces.

Hybrid aspen has also been tested and will soon be a viable cropping option. Breeding programs are currently underway to test fast-growing aspen hybrids. Aspen does not propagate from dormant stem cuttings, but a process has been developed to propagate aspen and hybrid aspen clones from juvenile root cuttings. Hybrid aspen and hybrid poplar clones do not necessarily prefer the same sites. However, the option to plant hybrid aspen provides greater opportunity to select the best suited clone for each site.

As with more traditional crops, poplar yields are a function of soil quality, tree spacing, tree variety selection (planting stock), and management inputs such as site preparation, fertilization, cultivation, and pesticide application (usually herbicide). Great care must be taken in establishing and maintaining a crop to ensure maximum yields at the end of the 18 to 20 year rotation.

Planting Site Selection

Soil properties should be carefully considered when deciding where to plant hybrid poplars. Research conducted by the Prairie Farm Rehabilitation Administration (PFRA) has shown hybrid poplars grow best in fertile, productive soils. Soil characteristics such as moisture and drainage, pH, texture, and aeration must be considered. Some guidelines to consider for suitable site characteristics are:

- Medium textured soils are preferred. Loams, sandy loams, and clay loams are preferred for poplars.
- Relatively fertile soils are best. In agricultural soils, nutrient availability is seldom a problem. However, fertility management can significantly increase growth rates.
- Avoid sites with very sandy soils unless the crop will be irrigated.
- Avoid areas prone to summer flooding or areas that remain wet until mid-summer. Poplars can tolerate standing water for short periods of time but not for prolonged periods. As with any agriculture crop in flooded soil, the roots lack oxygen and die.
- Poplar does not do well in saline soils. Conductivity greater than 2.0 ms/cm is likely to be limiting and values in excess of 4.0 ms/cm will result in reduced growth and severe dieback. Hybrid poplars prefer a pH of 5.5 to 8.0.
- The best sites have annual precipitation over 400 mm, or access to groundwater within 1 to 5 m of the soil surface. Site with lower precipitation levels will need irrigation.
- Avoid slopes greater than 8%. Steep slopes affect access and drainage, and are susceptible to erosion.
- Poplar is a shade intolerant species. Planting sites should be exposed to direct sunlight.

Additional factors that will influence the selection of a planting site are:

- Field access – Access to fields is necessary for site preparation, planting, maintenance, and harvesting. An all season access road that requires minimum upkeep would be ideal.
- Field shape or configuration – Field shape is usually determined by existing physical features. Rectangular or square fields are the most desirable shape to minimize the headlands area. An 8-metre headland is required around the entire field to allow maintenance equipment to maneuver.

- Proximity to markets – Wood processing facilities are located along the forest fringe areas of the province. Plantations providing feedstock to these firms must be within an economic hauling distance – currently up to 200 km (one-way). Wood supply beyond the economic hauling distance may not be economically feasible.
- Easements – Easements for overhead power lines and underground utilities may restrict the locations and limit the acreage available to plant trees. Registered caveats to support easements along with specified boundaries will be filed with the Lands and Titles offices of the provincial government. Easements may prohibit growing trees within the easement boundaries.

Site Preparation

Site preparation is essential for the successful establishment and early survival of poplar plantings. The degree of preparation varies depending on soil type, present crop or vegetation cover, and climate of the region. Intensive site preparation to control perennial plants is appropriate for land in pasture or forage crops, while less intensive preparation is suitable for land used to grow cereal grains or oilseeds. Preparation methods and agricultural equipment are similar to those used for traditional agricultural crops. A properly prepared site will enhance root development and tree growth, and will improve the effectiveness of subsequent weed control activities. The appropriate level of preparation will also facilitate future operations on the site.

Site preparation usually begins in the fall prior to planting, and is completed the next spring before planting. The operations include the following sequence of steps:

1. Determine if the vegetation is comprised of annuals (cereal, oilseed crops, or annual weeds) or perennials (forage crops, pasture, perennial weeds).

2. Apply herbicides to control perennial plants. Usually a mix of glyphosate and 2-4-D is applied in late summer.

Figure 50: Spraying

3. Cultivate the site by discing to prepare the soil for planting. Discing may be done in the fall but must be at least 10 days after applying herbicide. Use a breaking disc to a depth of at least 20 cm (8 inches) followed by two passes with a finishing disc. The finishing disk will break apart sod clods existing from the forage crop or pasture. Sod will break apart easier if finish discing is done in the spring because of the freeze-thaw cycles of winter. If discing in the spring, an application of non-selective herbicide should be considered to control annuals that may have emerged.

Figure 51: Deep Discing

5. Mark the planting grid based on the desired inter-tree spacing (discussed below). This should be done in the spring just prior to planting, as grid lines may become obscure to the planters if eroded by wind, rain or melting snow.

Figure 52: Markings on field

Tree Spacing

Tree spacing affects the growth and health of a stand, and may determine the end use of the timber. The configuration of the spacing, i.e. square or rectangular spacing, will affect maintenance operations.

Hybrid poplar is shade intolerant, meaning it does not grow well in the shade but prefers direct sunlight. Competition for sunlight, soil moisture and nutrients will affect tree growth. Close spacing patterns restrict sunlight to individual trees, increase inter-tree competition, and reduce tree growth. In addition, closely spaced stands have reduced air circulation and higher humidity and are therefore more prone to disease than wider spaced stands. However, dense stands achieve crown closure sooner than wider spaced stands. Crown closure occurs when branches of neighbouring trees begin to interlock. Full crown closure creates shade, which reduces the need for weed control. Choosing an appropriate spacing is generally a compromise depending on the requirements of the hybrid poplar to achieve optimum growth. The range of recommended spacing is:

3.0 x 3.0 m (10 x 10 ft) = 1111 trees / ha (435 trees / ac)

3.6 x 2.4 m (12 x 8 ft) = 1157 trees / ha (454 trees / ac)

3.6 x 3.6 m (12 x 12 ft) = 772 trees / ha (303 trees / ac)

The 3.0 x 3.0 m spacing is best for narrow crowned varieties. This spacing permits two-way cultivation. The 3.6 x 2.4 m spacing works well with narrow to medium crowned varieties but limits cultivation to one direction only; this may seriously impact the ability to control weeds. Yields for these two spacings are similar and they are mainly used for the production of pulpwood or other wood products that are not based on larger log diameters. The 3.6 x 3.6 m spacing is suited for medium to wide crowned varieties. Yield per hectare at this spacing is less in terms of number of trees, but it allows two-way cultivation. Wider spacing is usually used for the production of sawlogs suitable for lumber, plywood or veneers.

Although the number of trees declines as spacing increases, the increased growth rate at wider spacing may compensate for the decrease in the number of trees. The goal is to choose a spacing that will maximize stand growth rather than tree growth, but still yield the desired product – pulpwood logs or sawlogs.

Planting Stock

Hybrid poplar crops are usually established from one of three types of planting stock – dormant stem segments, over-winter dormant rooted plugs, and bare root stock. Dormant stem segments or "cuttings" are usually 22 to 25 cm (9 to 10 inches) long and 9 to 19 mm (3/8 to 3/4 inches) in diameter. Cuttings should have at least two viable buds on the upper 10 cm, with one of these occurring on the upper 2cm, and should be free of disease and bark defects. Cuttings will produce a stand of genetically identical trees that originated from a single selected tree variety, sometimes called a "clone". Cuttings are collected in the winter from 1-year-old tree stems and stored over winter at –3 °C to keep them dormant.

Figure 53: Planting stock

Over-Winter Dormant (OWD) rooted plugs are established using 7.5 cm (3 inch) long cuttings planted in Styrofoam blocks. Cuttings are planted in a greenhouse in June and grown for a period of 4 months. The rooted plugs are pulled from the Styrofoam blocks in October and stored over winter at –3 °C.

Figure 54: Rooted plugs

Rooted bare root stock differ from the rooted plugs in that the roots are not contained in soil at the time of outplanting, hence the term "bare" root. Bare root stock is established using 15 cm (6 inch) cuttings planted in a field or nursery bed. The cuttings are grown in the nursery bed from June through to October then lifted. The lifting operation removes most of the soil from the roots and results in a bare root plant. The bare root plants are then kept in storage at –3 °C until outplanting.

Hybrid Poplar Clones

Hybrid poplars are produced by selectively cross-pollinating different poplar species. The resulting hybrid can then be propagated vegetatively by rooting cuttings taken from the selected seedlings. Cuttings and the resulting trees have characteristics identical to the hybrid parent plant.

Many hybrid poplar clones have been tested for their hardiness and adaptability to the extreme climate and short growing season of the Canadian Prairies. These tests have shown that certain clones are adapted to the unique growing conditions of the region. Most clones used in other locations of North America have been found to be unsuitable for the Prairies.

Only clones proven hardy to the region should be considered for hybrid poplar plantations. New clones, however, are being developed that may be suitable for agroforestry applications. Clones currently recommended for the north central part of Alberta are Walker (also known as Melville 2393), Brooks #1 (Griffen), Northwest, Green Giant (Brooks #6), and P38. Other clones such as Assiniboine, Manitou, and Hill can be grown successfully in other regions of the Prairie Provinces.

Planting

Prior to planting, all fields should be treated with herbicide to control any annuals that may have emerged after the site preparation of the previous fall. A pre-emergent herbicide can then be applied to help control spring annuals.

Figure 55: Tree planting

Over-Winter Dormant rooted plugs (OWD) and bare root stock types are recommended for hybrid poplar crops in the Prairies. Planting usually occurs in early spring within 3 to 4 weeks of ground thaw and before the shoots break bud and start new growth. Soils should be moist but not wet or submerged in standing water. Both OWD and bare root stock can be machine or hand planted. Hand planting a grid-marked field is both fast and effective. Trees should be planted deeper than the depth to which they were grown in the nursery (2.5 cm or 1 inch). The upper portion of the root plug or root collar must not be exposed after the soil settles.

Field Maintenance

Good weed control is essential. Most weeds have a vigorous root system and grow faster than the newly planted trees. They can also out-compete the trees for moisture, nutrients and sunlight. Effective weed control is important until the poplars are tall enough to shade out the weeds, usually 4 to 5 years after establishment. Once the crowns have closed, the shade effect is enough to suppress most weeds and grasses.

The method of weed control used will depend on weeds present, soil type and equipment available. The most common methods are mechanical cultivation, herbicide application, or a combination of both.

Mechanical Cultivation

Tillage is an effective means of controlling weeds. Usually, the total number of cultivations required in a particular year is dependent upon tree age and types of weeds present. During the field establishment year, two cultivations in both directions of the field are required. During years 2, 3, and 4, four cultivations could be required annually to adequately control weeds. Tillage must be shallow (5 to 7 cm) to avoid damaging the root systems. Also, care must be taken to ensure the trees are not physically damaged. Commonly, a 40 to 60 hp tractor with hydraulic lift and a 2 m (6 foot) wide cultivation disk are used for mechanical operations. Tillage could be done in both directions if the spacing pattern can accommodate the tractor.

Figure 56: Weed control

Herbicides

The choice of herbicide depends on site conditions, weed species, soil type and climate. Post-emergent herbicides are applied as a directed spray to the foliage of weeds when they are small seedlings and growing actively. Only those herbicides registered for use on poplars should be applied. Always follow label instructions closely to ensure safe application and good results.

Figure 57: Weed control – Spraying

Pests

Numerous insects and diseases can damage hybrid poplar crops and reduce growth or cause tree mortality. Using tested clones or varieties that are well-adapted to the region, and are resistant or tolerant to multiple pests, is the best way to avoid serious pest impact or injury to trees. The clones recommended in this document have historically shown resistance to a variety of pests and have been proven to withstand the climate of the Prairies. Deer and other wildlife species will browse and rub trees or cause other mechanical damage during the early stages of the trees' development. Practices that stimulate early rapid growth (good site preparation and maintenance operations) will help trees to grow above the "browse line" or to recover from damage.

References to products in this publication are for your convenience and are not an endorsement of one product over other similar products. The user is responsible for using chemicals according to the manufacturer's current label directions. Follow directions exactly to protect the environment and people from chemical exposure.

Beneficial Management Practices

- Select plantation sites with suitable characteristics. Hybrid poplars prefer fertile medium textured soils and 400 mm of precipitation or irrigation. Sites should be easily accessible to facilitate maintenance and be exposed to direct sunlight.
- Choose rectangular shapes for the plantation site to minimize area lost to headlands (area for machinery to turn around).
- Consider overhead power lines, underground utilities, and other easements before selecting a plantation site.
- Begin site preparation by discing in the fall and again in the spring. Use a finishing disc to smooth the land and facilitate grid layout. Apply herbicides in late summer to control perennials. Apply pre-emergent herbicides prior to planting in the spring.
- Select tree spacing consistent with the crown characteristics of the tree. Tree varieties with wide crowns should be spaced wider than varieties with narrow crowns.
- Consider the width of maintenance machinery when selecting tree spacing.
- Choose a spacing that will provide the product type required and will maximize stand growth rather than tree growth.
- Select planting stock from clones known to be hardy to the region.
- Over-Winter Dormant rooted plugs (OWD) and bare root stock types are recommended for hybrid poplar crops in the Prairies.
- Plant trees deeper than they were grown in the nursery (2.5 cm or 1 inch). The upper portion of the root plug or root collar must not be exposed after the soil settles.
- Maintain shallow tillage (5 to 7 cm) to control weeds without damaging tree roots.
- Use only herbicides that are registered for poplars and follow all manufacturers' instructions.

Selected Readings and Internet Sites

Internet Sites

http://www.poplar.ca/upload/documents/cropman.pdf - Hybrid Poplar Crop Manual for the Prairie Provinces, Saskatchewan Forest Centre

http://www.agr.gc.ca/eng/about-us/offices-and-locations/agroforestry-development-centre/publications/?id=1367963053819 – Publications, Agroforestry and Agri-Food Canada

Publications

A Grower's Guide to Hybrid Poplar. Ministry of Natural Resources, Ontario, Canada.

Considerations for Hybrid Poplar Production. Prairie Farm Rehabilitation Administration, Indian Head, Saskatchewan, Canada.

Establishing a Short Rotation Intensive Culture (SRIC) Poplar Plantation. Univ. of Wisconsin, USA. Publication FCDU002, July 1998.

Guidelines for Establishing Poplar Plantations in the North-Central U.S. 1993. Hansen, Edward; Daniel Netzer; and David Tolsted. USDA Forest Service, North Central Forest Experimental Station. NC – 363.

Growing Hybrid Poplars as a Crop. Prairie Farm Rehabilitation Administration, Indian Head, Saskatchewan, Canada.

Fire Protection in the Woodlot

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Fire in the Woodlot

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes and recognize of the role of fire in an evolving ecosystem. Indicators of accomplishment include:***

- Fire management plan that protects against widespread and intense fire.
- Identification of sites, habitats and/or species that require extra protection from fire.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Use of fire as a management tool to regenerate new forests and maintain forest health.
- Woodlot activities are conducted in ways to minimize risk of fire.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Wildfire on woodlots can affect the quantity and quality of water sources. Intense fires can damage the soil. Fire can spread to adjoining properties and potentially affect watersheds. Indicators of accomplishment include:***

- Fire occurrence and size is minimized and special attention is given to areas near water bodies.

Criteria 5: ***Economic and social benefits. Woodlot resources provide numerous benefits to society as well as to the landowner. Multiple benefits are included as a goal in the woodlot plan to benefit present and future society. Indicators of accomplishment include:***

- The woodlot has a fire management plan to protect resources from damage.
- The non-timber values are protected from fire damage.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- Participation in planning activities to prevent, detect and suppress forest fires in the community.
- Communication with neighbours and regulatory agencies regarding planned burning events.
- Fire regulations are adhered to in order to minimize threat to the woodlot and to adjacent properties.

Introduction

Fire is a natural component of the forest ecosystem. The destructive or beneficial effects of a fire depend upon the nature of the fire and on the kind of disturbance or damage it causes. As a destructive agent, a fire will damage timber, wildlife, range, aesthetic, and recreation resources. Intense fires can cause immediate and long-term damage to soils and watersheds. Buildings, historical features, and other man-made improvements also may be damaged or destroyed. At times, these features become part of the fuel and contribute directly and/or indirectly to the difficulty and cost of controlling the event.

Fire also plays a beneficial role in many forest and range ecosystems. For example, fires create seedbeds, open cones to release seeds, recycle nutrients locked in the vegetation, control insects and diseases, reduce competition to seedlings from heavy grass and shrub cover, and rejuvenate wildlife habitats. However these same fires can also be very destructive, often burning more forested area in a province than is harvested each year. Although fire is an important component of forest health, large fires can cause economic loss and alter an ecosystem for many years into the future.

In some circumstances, fire is used as a forest management tool. Fires set intentionally to achieve a management objective are termed "prescribed burns". Prescribed burns are conducted to mimic a wildfire and create the conditions that result in nature after a wildfire. Such "burns" are sometimes used to achieve certain forest management objectives under controlled conditions. A prescribed burn can be used to reduce the fire hazard created by logging debris, to prepare a site for planting or seeding, to eliminate undesirable tree or shrub species, or to control insects and diseases. Fire is sometimes used in cutover pine and aspen stands because these species are particularly well adapted to regenerate naturally after fire. The "Silviculture" section presented elsewhere in this guide further describes the regeneration characteristics of some species and their adaptability to fire.

Fires require three elements: fuel, oxygen and heat. Forests are perfect sites for fires because the first two elements are abundant. Fuel is present in the form of needles, twigs, bark and wood; and oxygen is readily available in the atmosphere. All that is needed is a source of heat to start the fire. Removing one or more of these elements will extinguish the fire and this is the basis of fire fighting strategies. The "Fire Triangle" illustrates the interdependency of the three elements of fire.

The Fire Triangle

Figure 58: Fire Triangle
Figure: Toso Bozic

The interaction of the three equal sides of the fire triangle, heat, fuel and oxygen, are required for the creation and maintenance of any fire. When not enough heat is generated to sustain the process, when the fuel is exhausted, removed, or isolated, or when oxygen supply is limited, a side of the triangle is broken and the fire is suppressed.

Prescribed burning in any forest environment, including woodlots, is a risky practice because some conditions change constantly and cannot be controlled. Wind speed and direction, air humidity, and moisture content of fuel influence the risk of fires. If prescribed burns are planned, or the risk of unintentional fire is high, close attention should be paid to all three factors.

Wind, especially over 30 km/h, can be extremely dangerous. Wind direction can quickly change putting unprotected areas in jeopardy. At relative humidity below 30 per cent, forest litter and other fuels dry rapidly and fire control becomes more difficult. Dry fuel is a product of wind and low humidity, as well as the length of time since the last rainfall. When specific weather conditions are present, extreme caution should be taken to reduce the chance of fire.

How a Fire Works

When dry fuel and oxygen are available and a source of heat is presented, conditions are favourable for a fire to ignite. As the fire consumes the fuel and oxygen, more heat is produced, preheating fuel in the immediate area. The fire also heats the air, which rises, allowing new air to blow in to take its place. This self-generated wind and the already existing wind provides additional oxygen to further feed the fire, preheats more fuel, and carries embers away to start new fires.

Wind reacts in different ways depending on the time of day and the topography of the land. During the day, air warmed by the sun moves up the slopes as the lighter warm air rises. At night, as the air cools, the colder and heavier air sinks and winds tend to move down slopes. Winds associated with fires tend to follow the daytime trend. Heated air moves up slopes, preheating the fuel and encouraging the fire. Fires generally tend to spread uphill faster than downhill and the steeper the slope, the faster the rate of spread. South and west facing slopes exposed to direct sunlight dry faster and may be potential 'hot spots' during dry weather.

Not all fires react the same way or have the same destructive potential. Dense fuels, like standing trees or deadfall, ignite and burn slowly but provide intense heat. Light fuels such as slash, brush, cuttings, and other residues ignite and burn rapidly but usually produce less heat. A combination of the two provides the most dangerous situation.

Fire Protection

Damage to the forest caused by uncontrolled fire creates a challenge to woodlot management. Loss of resource values caused by fire will be minimized through organized prevention, detection, and suppression methods. Communicating with neighbours about planned or existing burning activities will contribute to a fire aware and prepared community. Like all other woodlot management activities, a plan is the key to effective and efficient fire prevention, preparation, detection, and suppression.

Figure 59: Burnt house and forest area

Prevention

Most fires on private land can be prevented. Two main area of focus are: monitoring all activities in the woodlot; and modifying forest fuels to reduce the risk of fire. Woodlot activities such as stand tending, timber harvest and recreation may be restricted during periods of high fire risk. Campfires must be monitored carefully at all times. Woodlot owners may adopt a no smoking policy as do forest industry on their woodlands, particularly during periods of high fire risk. Discarded bottles or other glass should be collected to reduce their chance of creating an ignition source. In general, access to the woodlot should be limited during times of high or extreme fire danger.

Most fires begin within 40 m of a road. Access roads should be mowed regularly and cleared of roadside debris. Parking area should be dirt, gravel or mowed to eliminate fires caused by vehicles or their occupants.

Managing fuel is another aspect of fire prevention. Maintaining a healthy forest of vigorously growing trees will reduce the risk of fire. Pruning trees up to 3 m from the ground reduces the chance of ground fires spreading to the crowns. Slash should be scattered to hasten its decomposition, or piled and burned during damp weather. Areas of standing timber, particularly deciduous species, may be used as firebreaks.

High-risk areas may require special preventive measures such as fireguards. Guards can be prepared by plowing or discing strips 3 to 6 metres wide. These strips should be reworked each spring and during mid-summer to minimize the grass cover.

Components of the woodlot management plan should include fire prevention strategies. For example, plans for new plantations could include firebreaks. Alternatively, access roads could be planned with fire control as the objective. Water sources may require upgrading or new sources created for emergency fire fighting. Water tanks can be placed in strategic locations during the fire season. Adequate preparation may mean the difference between losing some revenue and losing the woodlot.

Preparation

A quick response improves the chances of early control and keeps losses to a minimum. A plan of attack should be prepared and reviewed regularly before a fire starts.

Woodlot owners and employees should always have access to fire fighting equipment when in the woodlot. Necessary equipment should be easily accessible and if possible, strategically located in caches throughout the woodlot. Equipment could include a water pump, shovels, fire extinguisher, mattock, pulaski, axe, fire rake and swatter. The local fire control agency should be contacted for recommended items and legislative requirements.

Detection

Developing an observation routine can help in early detection and control of woodlot fires. Areas should be checked regularly, especially during dry, high-risk periods, after lightning storms, or when forestry work is under way in the area.

Suppression

When a forest fire is first detected, the woodlot owner should immediately call for help. Even a small fire can quickly spread beyond the point where one individual can stop it. The following steps outline a line of action:

- Assess the fire and develop a plan of action. Note the fire's speed, intensity and current weather conditions. Note the fire's direction and any natural or man-made barriers in the area.
- If possible, stop the spread of the fire at its head by digging or raking a firebreak. If the fire is small enough, fight it directly with dirt and/or water, then work on the flanks and the rear. Circle it with a fire-line dug to mineral soil. A direct attack can be very dangerous. If the fire is too hot or dangerous to attack the head, start at the flanks and work rapidly towards the head. Extinguish spot fires away from the main fire.
- When the fire is surrounded or contained, widen and improve the line at critical points. Extinguish or cut down burning snags.
- Mop up. After the fire is under control, walk through the burned area putting out smoldering stumps, roots and logs. Do not allow ashes to blow across or roots to burn under the fire-line.
- Patrol the fire until it is completely out.

Note: when using water pumps or fire extinguishers, direct the spray to the base of the flames.

Fire Damage

The most obvious result of a major fire is the loss of timber. Less severe fires cause a variety of other losses through damage and injuries to woodlot resources. These include:

- Weakened and damaged trees
- Reduced wood quality from fire scarring
- Damaged soil from intense heat
- Soil erosion from loss of vegetative cover
- Destroyed aesthetic value
- Reduced or eliminated wildlife populations
- Temporary loss of wildlife habitat
- Loss of forage
- Impaired air and water quality

Woodlots, Fire and the Urban Development

In recent years there has been a growing trend for urban residents to move to small rural acreages, often within forested areas. The increased populations in forested areas means an increased risk of fire in those areas. The woodlot owner must be aware of this increased risk and take appropriate measures to protect the woodlot and surrounding forests. The acreage owner must also be aware of the increased risk from fire in forested areas and ensure property is adequately insured against fire loss. Measures to protect property by reducing the risk of fires starting and spreading are available through the "Fire Smart" program developed by Partners in Protection. The Fire Smart Manual is available on the Internet at: http://esrd.alberta.ca/wildfire/fire-smart/documents/Firesmart-HomeownersManual-ProtectYourHomeFromWildfire.pdf.

Denser populations mean communities must collectively develop fire prevention strategies and have plans in place in case of a forest fire. These precautions do not eliminate fire but do reduce the risk.

Best Management Practices

- Include fire management in the woodlot management plan.
- Communicate with neighbours about planned or existing burning activities. Take precautions even when burning is done on nearby properties.
- Monitor all activities on the woodlot. Activities that utilize machinery always have the potential to provide an ignition source for a fire.
- Restrict activity such as stand tending or forest harvesting during period of high or extreme fire danger. Access should also be limited during these periods.
- Consider a no smoking policy on the woodlot.
- Collect refuse such as bottles that might provide an ignition source during hot weather.
- Dispose of all fuel and lubricant containers according to provincial or municipal regulations.
- Keep access roads mowed to reduce the grass cover and collect woody debris from the roadsides.
- Manage fuel loads. Scatter slash to facilitate quick decomposition or pile and burn it during damp weather; prune trees up to 3 m to restrict ground fires from spreading to the crowns.
- Construct fireguards by plowing swaths 3 to 6 m wide and reworking the swaths in the spring and mid-summer to minimize vegetative cover.
- Utilize strips of standing timber, particularly deciduous trees, as fireguards.
- Install fireguards around new plantations.
- Include fire control as an objective when planning access roads.
- Upgrade water sources or develop new ones to fight fire during an emergency.
- Locate water tanks in strategic locations during the fire season.
- Locate firefighting equipment in strategic locations and ensure anyone working on the woodlot can easily access the equipment.
- Consult with local fire control agencies about recommended equipment and legislated requirements.
- Consider training opportunities for yourself and for others.
- Develop an observation routine, especially during periods of high fire danger, after lighting storms, or while forestry work is underway, to detect and control fire in its early stages.
- Ask for assistance as soon as a fire is spotted. Do not wait until the fire is out of control.
- Follow established fire suppression, mop up, and post fire patrol techniques to ensure the fire is attacked effectively, is kept under control, and does not restart.
- Participate in community fire protection plans.

Selected Readings and Internet sites

Internet Sites

http://esrd.alberta.ca/wildfire/fire-smart/documents/Firesmart-HomeownersManual-ProtectYourHomeFromWildfire.pdf - Fire Smart Manual

Books and Publications

Forest Stewardship: A Handbook for Washington Forest Landowners. Washington State University.

Managing Your Woodland: A Non-Forester's Guide to Small Scale Forestry in British Columbia B.C. Ministry of Forests and Lands.

Woodlot Management Home Study Courses - Nova Scotia Department of Lands and Forests.

The Woodland Steward - by James Fazio, University of Idaho Woodland Stewardship Plan - Minnesota Division of Forestry.

The Woodland Workbook - Oregon State University.

Business Plan Basics

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Business Planning for a Woodlot

The process of business planning will not affect sustainable forest management. However, some of the elements in the plan could have an impact on sustainability.

Criteria 5: ***Economic and social benefits. The community at large benefits from market and non-market goods produced by a woodlot. Woodlot resources provide economic benefits to society and to the woodlot owner. Indicators of accomplishment include:***

- The woodlot business plan includes marketing strategies for a variety of products to provide multiple benefits to society.
- Woodlot operations are conducted in accordance with requirements of organizations such as the Workers' Compensation Board.

Introduction

The business of managing a forest should be no different than the business of managing any other enterprise. For both, the owners or managers must establish business goals and objectives and outline the strategies and actions that will contribute to meeting those goals and objectives. Forest management differs from other businesses in the length of time required before returns on investment are realized. The long-term nature of forest management investments means expenditures that may not yield a return for many years must be carefully planned. But not all woodlot business decisions are based on long-term investments. At times, the woodlot owner must make short-term decisions in response to market conditions or to meet immediate needs. The woodlot owner must be prepared to respond to such situations within the context of a business plan that is financially realistic in that it outlines attainable goals, and flexible to accommodate market fluctuations and changing personal circumstances.

Business Plan Basics

A business plan is an important component of the woodlot management plan. All components of the woodlot management plan, including the business component, should complement each other and contribute to the overall objectives for the woodlot. Together with the goals and objectives, a business plan will outline financial aspects of the woodlot.

A business plan can be prepared by financial experts, professional foresters, or by the woodlot owner. The complexity of the plan will depend on the range of activities that are planned and the financial implications of the actions. Regardless of how complex or simple, a business plan should have the following basic elements:

- Marketing
- Financial management
- Contracts
- Regulations and legal protection

Marketing Basics

Markets are driven by demand. Consumers of products place demands on the materials used to manufacture those products. Similarly, the demand for timber is driven by consumer demand for wood products. The kind of wood products demanded, such as lumber to build houses, or pulp to manufacture paper, will influence the types of timber demanded. Woodlot owners planning to sell timber should consider the following:

- Timber Markets
- Value Added Opportunities
- Options to Sell Timber
- Timber Measurement Units
- Market Surveys
- Marketing
- Hiring a professional forester

Timber Markets

The Alberta timber market consists of the deciduous market and the coniferous market. These markets have their own unique supply and demand factors and their own price cycles. Products from both species groups are sold in domestic and export markets.

In the deciduous market, hardwood species (poplar, aspen, birch) are sold to mills/processors to produce pulp, oriented strand board (OSB) and lumber. The demand for deciduous timber is driven by the demand for paper products, sheeting products, and miscellaneous dimension lumber products.

In the coniferous or softwood market, spruce, pine and fir (S-P-F) logs are used to produce construction lumber, plywood, veneer, pulp and other solid wood and panel products. Softwood timber is used for a variety of wood products for residential and commercial construction. Woodlot owners should understand the products manufactured by different mills in their area and the raw materials, i.e. the timber species and specifications, required to create those products. Knowledge of these markets and their requirements is an important tool for assessing the timber value of different forest stands in the woodlot and maximizing returns from the property.

The value of tree species will depend on the products produced from timber of that species. In general, markets for coniferous species are more lucrative than markets for deciduous species. In Alberta, woodlot owners rely to a large extent on the S-P-F lumber market. Forest companies that produce plywood or veneer purchase peeler logs. Peeler logs are large diameter timber, usually white spruce and Douglas fir, and occasionally some hardwood logs. Peeler logs command a premium price over logs used for lumber. A high quality peeler log must be straight and have low taper, have a minimum stump diameter of 30 cm (12 inches), a minimum length of 4.9 m (16 feet), and little or no outside scars. Small quantities of deciduous species are processed into dimension lumber and specialty furniture and panel products.

Many Alberta mills use coniferous and deciduous wood to produce various grades of pulp. The main source of coniferous wood fiber is wood chips acquired from sawmills or lower quality or smaller sized coniferous logs. Aspen is the most common deciduous species used by pulp producers. OSB plants also use aspen as their main species although certain amounts of balsam poplar and white birch are also utilized.

Other potential markets for timber products from private woodlots include:

- Firms that produce fence posts utilize small diameter lodgepole pine, tamarack and jack pine timber. These firms require logs that range from 2 m (6 feet) in length with a 5 cm (2 inch) top, up to 3 m (10 feet) in length with a 20 cm (7 inch) top. Larger trees can be used for poles and rails.
- Log homebuilders require larger diameter spruce or pine logs with specified top diameters, low taper and straight grain.
- Firewood dealers buy logs or stove length blocks either split or unsplit. These dealers buy dry (dead) and green conifer, birch, balsam polar, and aspen. Birch has the highest value for firewood.
- Non-timber markets for special forest products may offer another opportunity for private woodlot owners. Twigs, mosses and lichens can be harvested and used in the production of floral arrangements, craft supplies, furniture, foods and pharmaceutical products. Berries, herbs and mushrooms can be harvested and sold directly to consumers or to distributors with access to consumer markets.

Value Added Opportunities

Value added is defined as the value of the output minus the value of the input. The value of an output can be increased by adding more input. When a woodlot owner adds labour to a product, that product's value, the output, is increased; the woodlot owner has added value to the product. Standing timber has a certain value based on the market or based on the value of the timber to the woodlot owner. When standing timber is sold, the buyer will further process that timber, i.e. will add value by harvesting, milling, etc., then will sell it at a higher price.

Figure 60: Flooring

The woodlot owner can capture some of that added value by assuming some or all of the additional costs of adding to the timber's value. The woodlot owner may harvest the standing timber and sell it on the landing. The harvest operation has added value to the timber. The woodlot owner may also choose to saw the decked timber into lumber adding further value to the standing timber. The more labour the woodlot owner is willing to put into the product, the higher its value will be.

Adding value to timber requires financial resources, time commitment and expertise. Financial resources are required to purchase equipment or hire workers. Value added activities are often labour intensive and time consuming, and require various levels of skill and knowledge. Factors to consider before pursuing a value-added opportunity should include:

- Additional income and additional costs associated with processing and marketing the product.
- Skills and attitude required to realize the market opportunity.
- Size, stability and accessibility of the value-added market.

Options to Sell Timber

Timber can be sold in various forms depending on the amount of input the woodlot owner is willing to provide. The following are examples of marketing options for varying levels of input:

- **Delivered wood:** The landowner takes responsibility for logging and hauling the logs to the mill. Payment is by a "Delivered Wood Price" and should cover the logging, loading, and hauling costs, and provide a return for the trees (stumpage). This option gives woodlot owners the flexibility to sort logs according to different buyers' specifications to gain a better price.
- **Decked Wood:** The landowner logs the timber and piles it at the roadside. The mill is responsible for loading and hauling the logs. The landowner is paid a "Decked Wood Price" which should cover logging costs and provide a return for the trees. The landowner has the flexibility to sort logs and deal with more than one buyer.
- **On the stump:** The mill takes responsibility for logging and hauling the timber. The forest owner is paid a price for the standing timber, "on the stump" (stumpage). The woodlot owner is not required to do any of the work involved in harvesting and hauling the logs. However, the landowner should supervise the harvesting operations to ensure environmental concerns are met and there are no discrepancies concerning wood volumes harvested.
- **Sawn timber:** Woodlot owners may harvest their own timber or purchase logs to manufacture lumber with a portable mill. The lumber is sold (by the thousand board feet) to lumber yards or directly to consumers.
- **Bidding:** Landowners sell their products to highest bidder. Landowners may sell their standing timber or already decked timber. Some necessary information for this type of sale includes tree species, size of area for harvesting, size of trees, location of sales, sales type, and dates.

Timber Measurement Units

Different forest companies may quote prices in different units. Woodlot owners must be able to convert these prices to a common unit such as dollars per cubic metre to make comparisons. Units include:

- By the metric tonne.
- By the cubic metre.
- Using a foot board measure (fbm). One board foot is the equivalent of a board measuring 1" x 12" x 12".

The factors used to convert weight to volume will vary by area and according to the species and quality of the timber. Density varies among species; consequently weight per cubic metre will also vary. Moisture content of wood will affect its weight – green logs weigh more than dry logs - although logs can dry and lose weight without reducing their volume. The woodlot owner selling wood should know the conversion factors used by the buyer to make valid comparisons. The following lists the more common conversion factors:

Convert From	Convert To	Multiply By
Cubic metre (m^3) of green coniferous	metric tonne	.82 to .87
Cubic metre (m^3) of green deciduous	metric tonne	.90 to 1.1
Thousand board feet (Mfbm)	Cubic metre (m^3)	0.4292
Cubic metre (m^3)	Thousand board feet	233

Landowners should be familiar with timber market trends. Timing of timber sales is very important and a landowner has to be prepared and have a plan to take advantages of markets.

Market Survey

Like any business, the success of a woodlot operation depends on markets and the distance to them. Transportation is often the greatest expense. Information regarding customers, competitors, and the competitors' products are necessary to make informed business decisions. A market survey, whether complex or simple, can help gather the information needed to support decisions. The survey can gather information on the demand for the product in terms of the annual volumes needed, the potential number of customers, and the available industrial and commercial markets. To determine the supply of the product, the survey could gather information on the available sources of supply and the volumes and types of products available, current prices, and the suppliers or competitors.

Marketing

A marketing plan should be developed using information from the survey for its basis. An important first step is to promote the product or service. Advertising in local newspapers, website development and "word-of-mouth" are a few ways to promote a woodlot business. Fairs, farmers' markets and community events may provide additional outlets.

Repeat customers are very important as markets and as sources for 'word-of-mouth' advertising. Once a business is established, the key to satisfied customers is:

- reliable delivery
- competitive prices
- product satisfaction
- high quality

Maintaining detailed files on customers is a good marketing strategy and will be a valuable resource for business planning. A customer file may contain information about the client, purchase dates, product specifics, price, special instructions and other facts. Knowing traditional customer habits allows a woodlot owner to plan for busy seasons and try some innovative marketing ideas during slow periods.

The critical marketing issues for woodlot owners are:

- Volume of merchantable timber to sell
- Quality of timber
- Best time to sell timber
- Best market for the timber
- Contract negotiations
- Monitoring the logging operations
- Market surveys and follow up with customers after the sale

Hiring a Professional Forester

Hiring a professional forester may help the woodlot owner to maximize value from the woodlot in terms of forest production and in terms of marketing products from the woodlot. In general, professional foresters can provide the following services:

- Expertise in forest management – The forester can determine the best management options for the woodlot consistent with the woodlot owners' objectives.
- Market knowledge – Many professional foresters are knowledgeable about timber sales, local markets, current pricing, and demand and supply needs. They may also advise on log scaling and log evaluation.
- Experience with loggers and ability to monitor or work with loggers. They may also advise on selecting harvest contractors that are appropriate for the woodlot operation.
- Contract oversight – Experienced foresters will monitor harvesting operations and ensure contract compliance including Beneficial Management Practices. The forester can act on the woodlot owner's behalf to address problems with the logger or contractor.

Financial Management Basics

Many landowners ignore the financial aspect of their woodlots. Consideration of financial management provides woodlot owners with an opportunity to evaluate the financial viability of the woodlot. A comparison of income generated with expenses and labour invested can provide an indication of the productivity of the operation. Some woodlot owners only want their forest to pay enough to cover land taxes, or avoid losing money. Financial records are also important for these woodlots for tax reporting requirements and to monitor overall costs of owning the property.

Record keeping does not have to be elaborate to be useful. Computer based spreadsheets simplify record management and provide flexibility to create numerous reports. Small operations may only need a three-columns income/asset/expense ledger. Larger, commercial operations may require more elaborate systems and may benefit from professional advice.

Figure 61: White spruce logs

Keeping even simple records allows a landowner to monitor the financial aspects of the operation, learn its strengths and weaknesses, make plans for future activities, and prepare financial statements for tax or loan purposes. Every year, a statement of income and expenses should be prepared, to understand where money came from and went to, and to allow for year-to-year comparisons. Examples of the kind of information that could be collected include:

- An income column that might contain entries for wood sales, other woodlot product sales, land sales, leases, income from incentive programs and grants, and other sources of income.
- An asset column listing the values of timber, land, building, equipment, tools etc.
- An expense column showing expenditures on stand improvement (thinning, pruning, tree planting etc.), equipment, trails and roads, employee wages, professional fees, office and general expenses, interests on loans, materials and supplies, etc.

Tax benefits may arise from depreciation, capital gains, business losses or other aspects of operating a woodlot. Accountants and other professionals can help with complex taxation questions.

Contracts

Conducting business with a handshake is a common practice among woodlot owners. This arrangement may be appropriate if the buyer and seller know exactly what is expected from each other. As sales volumes increase however, the consequences of disagreements or misunderstandings also increase and the wisdom of the handshake method of doing business becomes questionable. Contracts or written agreements specify the expectations of each party and play an important role in protecting woodlot owners and their operations.

According to law, a contract is not intended to create an advantage or disadvantage for either party but should be for the benefit of both. Woodlot owners must be aware of the contents of a contract to ensure their objectives are adequately met by the terms of the agreement. Signing a contract or agreement implies the woodlot owner has a good understanding of the terms and conditions as well as the effects that may result from the contracted activity. A contract should never be signed if the terms and conditions are not fully understood.

Contracts are commonly prepared for a variety of situations. Christmas tree growers may have contracts with wholesalers, landowners may have permits for 'cut-your-own' firewood operations, and mills may have contracts for delivery of various grades of timber. Owners may contract the services of individuals or companies to plant trees, do release work or conduct a harvest.

Sample contracts are often available, with 'fill in the blanks' options for landowners. They may cover most of the terms and conditions required, but landowners should not rely on them completely. A sample contract should only be used as a guideline to aid with developing a document that addresses the needs of all parties concerned.

Every contract is different and requires specific provisions, depending on the situation. Contracts generally identify the individuals involved, the terms of the agreement, the responsibilities of each individual, costs and values of products and activities, special requirements, time periods, legal requirements and signatures.

Written or oral contracts establish the responsibilities of the landowner and the purchaser when selling timber to loggers or forest companies. Written contracts, however, minimize the risk of misunderstandings between a landowner and the timber buyer. Some key issues to specify and clarify in a timber sale contract include:

- The parties involved (e.g. seller, buyer and contractor names)
- Land location
- The trees or stands of timber to be harvested
- An estimate of the amount of timber to be harvested and the basis for final payment
- When logging is to begin and when it must be completed
- Environmental restrictions to protect the condition of the land
- Specific follow-up work to be performed by the logger such as removal of damaged trees, repairs to fences, reclamation and reforestation
- The unit price to be paid for the timber and the schedule of payments
- Liability insurance requirements, Workman's Compensation Board compliance and other regulations that require permits

Common contract provisions may include:

- Contracting parties: names and addresses
- Location: legal description, maps and work areas
- Products sold: type and amount for sale, identification of products (diameters, marking systems, species, prices, lump sum, unit sale, price per unit, preferred unit of measure, location of measuring, type of payment, and taxes)
- Responsibilities: guarantee of performance, performance bond, cash deposit, lump sum, amount per unit
- Time: starting date, completion date, provisions for changing dates, termination clause
- Legal requirements and responsibilities: local laws, regulations and statutes, fire protection, permits, protection from legal claims and liens, liability insurance, occupational health and safety
- Logging responsibilities: cutting methods, merchantability, penalties (material left in woods, damage to stand, unauthorized removal) access, water and soil conditions, logging equipment, costs of property damage
- Special requirements: subcontracting, improvement costs, use of property by third parties, arbitrators in case of disagreement
- Signature: buyer, seller, witnesses, and date

Types of Contracts

The following types of contracts are used by landowners and forest companies:

- **Lump sum contract:** The landowner agrees to a lump sum payment to be received at the start of the contract which covers the trees harvested and the impact on the land. The contract specifies the condition of the land at the end of logging.
- **Cutting contract:** The landowner agrees to offer a minimum volume of timber for sale each year. The price may be predetermined or based on a formula.
- **Land lease with timber purchase:** The land is leased annually and payment for the timber is by a lump sum either at the beginning of the contract or at the time of harvest.
- Lease land and timber: Both land and timber are leased.
- **Increment contract:** An annual payment is made to the landowner based on the expected annual growth for trees on the land.
- Management services agreement: The forest company provides management services in exchange for the right to purchase the timber. Services include developing a management plan. The landowner agrees to give the company a predetermined amount of timber at a predetermined price each year or the right of first refusal on any timber sold.

Regulations and Legal Protection

Federal and provincial legislation may affect how woodlot owners operate their businesses. Farm employees are generally exempt from the Workers' Compensation Board; however, when working in a woodlot they may be considered forestry workers and treated as such by the board. The woodlot owner should know and understand the legal obligations of using contractors or hired labour. Financial liabilities may arise in the event of a contractor dispute, accident, injury or other incident. Before using hired labour, woodlot owners should check their legal responsibilities with Occupational Health and Safety and the Workers' Compensation Board.

There are no specific laws in Alberta that determine the actions of woodlot owners when managing trees. However, there are regulations pertaining to the environment, fisheries, soil protection, fire prevention and transportation that will influence the activities of individual woodlot operators. The owners of private forestland must recognize their responsibility to comply with all regulations even though they may not be involved in the actual logging.

Acts and regulations that landowners must be aware of include:

- The Soil Conservation Act requires all landowners to take steps to prevent soil loss or deterioration and to stop existing soil loss or deterioration.
- The Forest Prairie and Protection Act requires landowners to reduce or eliminate any fire hazards such as those created by logging operations. Landowners will be penalized for failure to comply and could be charged with the fire fighting costs in cases where a fire escapes and requires provincial or municipal action to extinguish it.
- The Alberta Environmental Protection and Enhancement Act is intended to protect air and water quality. This legislation assures that proper conservation and reclamation practices are used on land affected by activities such as logging. Assistance in establishing proper practices is available through the area offices of Alberta Environmental Protection and Sustainable Resource Development.
- The Water Act is intended to regulate activities that alter the flow of water, alter the direction of water flow or alter the level of water. Water is defined as all water on or under the surface of the ground.
- The Federal Fisheries Act prevents landowners from any undertaking that either disrupts, alters or destroys fish habitat.
- The Forests Act and Motor Transport Act require individuals hauling logs on public roads to comply with weight restrictions, emergency precautions and transportation records requirements. A permit (Private Land Haul Permit) must be purchased from Sustainable Resource Development to haul coniferous trees or logs exceeding 2.2 meters in length on any public road.

- The Municipal Government Act gives local municipalities the power to enact by-laws that can influence or even limit logging activities on private land. Some municipal districts have made a development permit a requirement for logging private land. Increased municipal control can be expected as a result of public concern over all forestland.
- Landowners are responsible for compliance under the Workers Compensation and Occupational Health and Safety Acts when contract loggers are working on their property.
- The Income Tax Act does not have specific provisions for woodlot enterprises. As a result, woodlot operators tend to be treated as part-time farmers rather than full time farmers. In addition, the Income Tax Act treats the revenue from a one-time harvest differently than revenue that is sustainable long-term income.
- At the provincial level, woodlot operators don't receive the same fuel tax reductions that farmers receive for primary agricultural production.
- Municipal tax assessments (under the Municipal Government Act) allow farmland to be assessed on its productive value while woodlots (that aren't farmed) may be assessed on fair market value. This assessment is likely to be much higher and result in higher property taxes.
- Burning of any kind on privately owned forest land during the period April 1 to October 1 will require a burning permit from the local municipality.

No matter how good the plan or idea, the woodlot goals and objectives will not be met if it is not financially viable. Business plans have to address the market, contracts, regulations, legalities, financial aspects and other business related issues. Business plans, similar to woodlot plans, must be adaptable and able to change in response to the current situation.

Best Management Practices

- Develop a business plan that is financially attainable and flexible enough to adapt to changing markets or other conditions. Business plans should address the market, contracts, regulations, legalities, financial aspects and other business related issues.
- Ensure the business plan goals and objectives are complimentary to the woodlot management plan.
- Understand the products manufactured by local mills and the raw materials, i.e. the timber species and specifications, required to create those products. Utilize this knowledge to assess the timber value of different forest stands in the woodlot and to maximize returns from the property.
- Sort logs to meet buyers' specifications and gain higher prices.
- The value to standing trees can be increased by additional processing – logging, piling, hauling, milling, etc. Increase revenues from timber by assuming some of the responsibility (and cost) for adding value.
- Before pursuing value added opportunities, consider the additional cost of processing and marketing, skill requirements, and the size, accessibility, and stability of the market.
- Consider the pros and cons of various timber selling options such as on the stump, at the landing, delivered to the mill gate, etc. before deciding how to market the timber.
- Convert prices to common units such as $ per cubic metre before comparing prices from different buyers.
- Timber markets fluctuate. Study timber market trends to determine the best time to sell woodlot products.
- Conduct market surveys to gather information and use the information to develop a marketing plan and to support business decisions.
- Understand the supply and demand for woodlot products that will be marketed. Know who is supplying and who is demanding the products and associated prices before entering the market.
- Once a business relationship is established, maintain good customer relations by ensuring reliability of supply, competitive prices, product satisfaction and high quality.
- Maintain detailed customer files as a marketing strategy.
- Consider the services of a professional forester with expertise and experience in forest management, marketing timber products, and dealing with forestry contractors.
- At a minimum, maintain simple financial records of income, assets, and expenses to monitor the financial status of the woodlot operation.
- Consult with financial experts about taxation or other financial issues.
- Always transfer verbal arrangements into written contracts to ensure both parties understand the terms and conditions of the agreement. A contract should never be signed until the terms and conditions are fully understood.
- Use sample contracts as a guide only. Do not adopt a sample contract as a final document.
- Know and understand the legal obligations of using contractors or hired labour.
- Be aware of regulations pertaining to the environment, fisheries, soils protection, fire prevention and transportation that will influence the activities of individual woodlot operators.

Wildlife and Woodlots

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Wildlife Management in the Woodlot

Criteria 1: ***Biological diversity. Conservation, maintenance, and enhancement of biological diversity by recognizing that wildlife species are vulnerable and forest management practices can be adapted to meet the needs of many wildlife species. Indicators of accomplishment include:***

- Activities that increase the diversity of forest cover and other vegetation, and create transition zones to accommodate the habitat needs of wildlife species.
- Harvest systems such as selective logging that reduce extended open areas and maintain continuous forest cover.
- Wildlife travel corridors within the woodlot and connecting to adjoining properties.
- Recorded data on the species present on, and in the vicinity of the woodlot to gain an understanding of local wildlife populations and population changes.

Criteria 2: ***Ecosystem condition and productivity. Maintaining the stability, resilience, and rates of biological production in the forest ecosystem of the woodlot for the benefit of wildlife species. Indicators of accomplishment include:***

- Changes in forest area, in the vegetation species, and in the wildlife species and the cause of such changes.
- Identification of endangered species or species of special significance to the local community including the aboriginal community.

Criteria 5: ***Multiple benefits to society. Sustaining the flow of benefits to society by maintaining a diverse wildlife population. The woodlot supports a wildlife population that migrates among adjoining properties and provides benefits beyond the landowner. Indicators of accomplishment include:***

- The abundance and variety of wildlife in the region beyond the property boundaries.
- Wildlife travel corridors that permit wildlife movements beyond the woodlot owner's property.
- Collaboration among property owners and the community at large in wildlife management issues.

Introduction

Wildlife and woodlots go hand in hand. One of the purest pleasures for woodlot owners is watching the daily activities of the various birds and animals associated with stands of trees. Interests in wildlife may include hunting and trapping, or more unhurried pursuits such as photography, bird watching and other leisure activities. Pest control by beneficial wildlife like predacious insects and small birds can help maintain a healthy, productive and diverse forest without adding costs for woodlot owners.

Figure 62: Ruby-throated hummingbird in elm near Barrhead

To improve wildlife habitat, woodlot owners must actively manage their land. The results depend on existing habitats, how they may be modified or enhanced and the goals of the landowner. Managing a woodlot for wildlife involves developing a plan and following it through.

The woodlot owner must make choices before developing the wildlife plan. What animals use the area? Will habitat be managed for a variety of wildlife species, a specific group, or a single species? Each choice will require a different approach, and each approach has advantages and disadvantages.

Managing for wildlife does not preclude managing for timber. In some cases, timber harvesting is important to maintaining or improving wildlife habitat. Management can keep the woodlot healthy and productive, and provide diverse habitat for wildlife.

What is wildlife?

Wildlife is defined as wild animals and includes amphibians, birds, fish, insects, mammals and reptiles. All animals are discussed in this chapter except pest species. Pest species are discussed in detail in the "Woodlot Health" section of this guide.

Wildlife Habitat

Food, water, cover and space are the major elements of wildlife habitat. These four major elements combine to meet the habitat needs of wildlife and are described as follows:

Food – Trees, combined with the understorey layer of shrubs, forbs and grasses, provide a valuable source of food and cover in woodlots. Plant eaters utilize all plant materials including fruits, nuts, twigs, leaves, grasses, bark and roots. Meat eaters consume insects, carrion and other animals. Food requirements differ among wildlife species, and often change as animals grow older. The availability of food and consequently the diet of wildlife changes with the seasons. Details on wildlife use of selected woody plants are presented in Appendix 1.

Water – Wildlife species have different water requirements. Some species meet their water needs from succulent plant material or dew with no need for open water. Others use open water to escape from insects in the summer. For certain species, water is the most important part of their habitat. The lack of a suitable water source may be the limiting factor for many wildlife species in prairie woodlots. Riparian areas surrounding water are important transition areas and provide habitat for a wide variety of wildlife.

Cover – Wildlife require cover for protection from weather elements and from predators. Thermal cover provides protection from extreme heat or cold. Escape and protective cover is used to evade predators, hide nests, and raise young. Cover may include brush or rock piles, thickets, dense stands of saplings, standing or fallen logs with cavities, or evergreen stands. Cover needs vary among wildlife species. Travel corridors that allow wildlife to travel between suitable areas without excess exposure to predators or weather are important parts of wildlife habitats and should be considered when developing a management plan.

Space - Space, as a concept of wildlife habitat, implies the individual habitat components – food, water, cover, and territory – are contained within an appropriate size area.

The landowner must provide these elements to achieve wildlife management goals established for the woodlot.

Plant Components of Wildlife Habitat

Trees – Conifers or evergreen trees, and deciduous or hardwood trees are important components of wildlife habitats. Trees provide escape, cover, shelter, and nesting sites. Tree parts such as leaves, twigs, buds, seeds, bark, and sap are food for wildlife. Both conifer and deciduous trees provide thermal cover during periods of extreme or sudden changes in temperature. Young hardwood trees and shrubs less than 1 m in height provide ideal habitat for many wildlife species.

Grasses and Legumes – Grasses and legumes provide cover for ground-nesting birds and forage for many animals. Grassy habitats occur in forest openings and can be composed of naturally seeded plant species or sown with commercial mixtures.

Flowering plants – Flowering native plants are an import food source for nectar feeding species such as hummingbirds and butterflies. The woodlot, yard, and homestead are ideal locations to promote these favoured plants. In the yard and homestead sites, plants such as lilac, honeysuckles and larkspurs attract a wide range of these animal species. In the woodlot, some wildlife species seek the nectar produced by flowering herbs and wild shrubs. Openings created by beaver or by selective logging promote the establishment of shade intolerant plants such as bluebells, wild roses and tiger lilies and create favourable habitats for a number of animal species.

Figure 63: Hummingbird moth nectaring at a dandelion near Peace River

Insect species feed on plant parts such as leaves and on nectar. For example, insects in the caterpillar or larvae stage feed on leaves, while in the butterfly or adult stage they feed on nectar. Plants that flower early are especially important for bees. Many of the best bee plants are herbs, so an herb area may benefit many insects and as well as the kitchen. Moths are attracted to flowers and night-flowering plants. On a warm night in June lilac bushes are often alive with various moths. Lists of flowers, shrubs and trees suited for various species are available in horticultural books.

Summer fruit and cover plants – Trees, shrubs, water plants and vines provide nesting cover and protection from weather elements. Many of these plants produce root suckers and create dense thickets ideal for nesting sites and winter protection. Fruit such as Saskatoons and raspberries provide food throughout the summer. These fruit and cover plants attract a variety of birds and animals.

Fall Fruit and Grain – Shrubs and grain plants that provide fall food are especially important for wildlife. Migratory birds feed on these plants to build up fat reserves before flying south. Resident birds and mammals depend on fall food to build up fat reserves to help them survive the winter. Field crops not covered with snow are used throughout the winter by many birds and animals.

Figure 64: Bohemian waxwing in a chokecherry tree by Barrhead

Winter Fruit – The best winter wildlife foods remain on the trees through the winter and often have a low appeal when they first mature. Some fruits are bitter in early winter but become more palatable later in the season after freeze thaw cycles. Hazelnuts and bur oak acorns, also called mast, provide food for several wildlife species during fall and winter.

Plant components of wildlife habitat function individually for specific purposes such as food or shelter, and combined to form systems to provide a biologically diverse plant and wildlife community.

Structural Components of Wildlife Habitat

Many natural features of the landscape contribute to wildlife habitat. Some features such as cut-banks or water bodies are easy to identify as useful for wildlife. The occurrence of dead standing or downed trees, or rock and brush piles is also important structures, although it may not be so obvious that they are used by wildlife. Other characteristics such as dust, grit, and salt are not as apparent but do contribute to quality habitat. Recognition and understanding of these components will enhance the diversity and health of wildlife species.

Cut-banks – Burrowing birds such as swallows and kingfishers, and animals such as badgers and foxes, use soil and gravel exposed along creeks, rivers and gravel pits. Gravel pits cut below the water table can provide a water source for wildlife.

Water – Water is an integral part of wildlife habitat and originates from springs, marshes, creeks, ponds, lakes, rivers or man-made sources. Generally, dripping or flowing water is more attractive to wildlife than still water.

Dust and Grit – Birds use dust and grit to control external parasites by wallowing in dust beds. Fine and coarse grit is needed in the gizzard to grind up seeds and other foods. Dust and grit are usually easily available but woodlot owners could create specific areas for this habitat component.

Salt – Some wildlife species, such as moose, deer, and grosbeaks, will actively seek salt deposits. Salt availability can be improved by leaving salt blocks in areas frequented by wildlife. Alternatively, a burlap bag full of salt can be hung from a tree and so that rainwater can wash the salt into the soil.

Nest boxes and feeders– Nest boxes and feeders are supplements to natural cavities and nesting structures. Nest boxes can range from simple birdhouses to more elaborate purple martin houses. Platforms can be built to create nesting sites for particular species such as Alberta's Eastern phoebe. Other platforms, such as round flax bales in open water provide nesting sites for geese and may encourage wildlife to move into the area.

Feeders supplement the food naturally available to wildlife. Feeders can be purchased at specialty pet stores or at local hardware stores. Diversifying the kind of seed will attract a variety of bird species. For best results, feeders should be filled daily and be placed in different locations throughout the woodlot

Brush and rock piles – Brush and rock piles provide escape cover, nesting, and den sites for many animals. If brush and/or rock piles do not occur naturally they can be constructed to enhance the habitat quality. Location of the piles is important. They should be placed in edge zones within 50 – 75 m of feeding and watering areas or along travel lanes. Piles on the edge of a small pond will provide reptile and amphibian habitat.

Snags – A 'snag' is a dead or dying tree. Hard snags contain sound wood and retain some branches. Soft snag are in advanced stages of decomposition and have few limbs. Snag trees can be used as nesting sites, perches, for establishing territory, or as a food source for birds and animals. Large snags – taller than 2 m - are more useful than small ones. Fallen snags and logs on the ground also provide food and cover for birds and animals.

Snags may be created to enhance the habitat quality and attract a wider range of wildlife species. Living trees that appear diseased or deformed and have cavities can be selected for retention as snag trees. One to six hard snags and additional soft snags per hectare should be preserved. Each type of snag has a specific role as wildlife habitat.

Figure 65: Snag tree

Edge – Edge is the area of transition from one cover type to another. An edge may occur between a cut and uncut forest, where a forest meets a field, where different plant communities meet, or where plant succession stages come together.

Naturally occurring edge may be caused by changes in soil type or landforms. Edge may be induced by fire, flooding, erosion, grazing, planting, seeding or timber harvest. Harvesting timber in large, uniform blocks creates much less edge than cutting in irregular blocks.

Edge features include length, width, configuration, contrast and habitat size. The size and layout of the edge features affect the diversity of the wildlife community. Planting trees and shrubs that are of particular value to wildlife species can enhance the attractiveness of an edge to wildlife. For example, planting fruit and nut trees on the edge where sunlight is greater will increase the fruit production and hence increase the wildlife food supply.

Edges can be created by clearing a band of woody growth around the perimeter of an area. The cleared band should be a constant width of 6 to 9 m with a feathered or saw-toothed edge. The cleared band can be seeded with a grass-legume mix or left to regenerate naturally.

Edges are usually richer in wildlife than adjoining areas. They provide simultaneous access to more than one type of area and a larger variety of vegetation. A narrow band of unharvested crop along the perimeter of a woodlot offers escape cover for rabbits and upland game birds, feeding sites for upland birds, deer and woodland birds, and good hunting conditions for hawks, owls and foxes.

Travel Corridors – Wildlife need continuous wooded areas to survive. Wooded strips connecting larger wooded areas provide travel corridors that wildlife use to move between wooded areas. The woodlot has limited value for wildlife if it is isolated from other wooded areas or is too small in size. When wooded areas become fragmented, with large open spaces between areas of cover, wildlife will use the woodlots and wooded areas less. Travel corridors of vegetative cover that join wooded areas and reduce exposure to predators or weather, increase the use and value of woodlots for many wildlife species.

Riparian Zones

The riparian zone is the area of vegetation next to a water body, watercourse, or intermittent watercourse. This area is a rich source of food and cover for fish and wildlife and a productive area for recreation, timber, and forage. Diversifying the zone by retaining or creating standing and fallen snags will increase the diversity of wildlife species.

Figure 66: Riparian Forest

Riparian zones support many plant and animal species and provide diversity to the woodlot. These zones intercept overland drainage, reduce soil erosion, stabilize stream banks and help trap sediments and nutrients. The shape of many riparian zones maximizes the development of edge and therefore increases the variety of vegetation and food choices.

Many wildlife species prefer riparian zones to other habitat types. Higher humidity, greater shade, and other features create microclimates important to many animals. Wildlife will often use riparian areas for travel corridors.

Riparian zones are sensitive to disturbance and operations such as logging should be limited. Buffer strips left around wetlands can provide some protection to these zones. A minimum undisturbed strip width of 60 m is acceptable around water bodies larger than 0.5 ha, and 30 m wide strips are acceptable around smaller ones. Trail or road cutting should be minimized in these areas. Trails crossing streams at right angles will reduce the impact of the trail on the stream. Campsites in riparian zones may improve chances of wildlife contact, but will disturb habitat through trampling, soil erosion, compaction and loss of vegetation. Similarly, excessive grazing will have the same effect. Precautions to protect the riparian environment and activities to enhance habitat elements will maintain and improve the quantity and diversity of wildlife species.

Vegetation Management for Wildlife

Vegetation can be managed to improve wildlife habitat. Removing patches of larger trees will increase sunlight to the forest floor and promote the establishment and growth of ground vegetation and shade intolerant tree species such as pine or aspen.

Thinning and/or clearing should be directed at mature trees with diameters greater than 20 cm. Thinning is more appropriate to increasing browse production in woodlots smaller than 8 ha, while clearing is more important for larger woodlots. Each clearing should be 0.5 to 2 ha in size, with only the mature trees removed. Up to 10% of the woodlot may be devoted to clearings, landings or other open areas.

Effects of Timber Harvest Methods on Habitat

Stand management and timber harvests can be planned to provide timber age classes and arrangements that are preferred by many wildlife species. Different methods have different effects on wildlife habitat and how the animals use the land. In general, cut blocks should be spread through the stand rather than cutting adjacent areas in successive years. This leaves a better mix of cover for wildlife and will help guard against blow-down in the residual stand.

Clearcutting

Clearcuts remove all trees on a site. The opening from clearcutting stimulates shade intolerant species such as birch and aspen to become quickly established. This new growth provides food and cover for many wildlife species including deer and grouse. The cuts should follow the topography and have irregular boundaries to increase the amount of edge. Snags and clumps of standing trees should be left for cover, food, and shelter. Treetops and limbs may be piled to form brush piles for cover. Trails and landings may be seeded with grasses or legumes after logging is complete to improve food and nesting cover and to protect the soil from potential erosion.

Shelterwood Cutting and Selection Cutting

Shelterwood and selection cutting remove a portion of the trees depending on the purpose of the cut. In shelterwood cuts, 40-60% of the trees are harvested to leave a more open but well distributed stand to promote regeneration. In selection cutting, trees within a specified diameter range are targeted for removal. Both harvest systems reduce the tree density and therefore increase the amount of light reaching the forest floor. The increased light will stimulate establishment of shade intolerant species such as aspen, birch and pine, and provide a food source for wildlife. Both harvest methods can provide revenue to the woodlot owner.

Other Management Practices

In addition to harvesting, other forest management practices affect wildlife habitat. These activities range from simply erecting fences to keep livestock out of wildlife areas, to promoting establishment of tree seedlings, shrubs and grasses used for feed and cover. Exposing the forest floor to sunlight will increase ground vegetation. Shearing trees and shrubs at ground level under frozen winter conditions simulates clearcutting and results in an abundance of new vegetation. Controlled burning reduces the litter cover and stimulates new growth of ground vegetation and seed germination. These practices are deliberate activities to provide food and cover for wildlife and unlike harvest activities, do not produce revenue for the woodlot owner.

Wildlife Habitat Planting Designs

Trees and shrubs can be planted to create or improve wildlife habitat. Several different planting designs are used, including various configurations of shelterbelt plantings, block plantings, extending bluffs of trees, planting abandoned fields and farmyards, and food plots. An effective wildlife planting will have a pyramid or dome shape when viewed from the end. This shape is achieved by planting taller species in the centre of the strip or block and shorter shrubs at the edge. Soil, topography, drainage, climate, and existing vegetation must be considered before making planting decisions. Choosing the species to plant is also important. Trees and shrubs that provide food seasonally and year-round are generally preferred.

Shelterbelts and Forestbelts

Single or multi-row shelterbelts are recognized for their application in protecting soil and crops, and managing snow. Forestbelts are multi-row shelterbelts designed to duplicate a natural forest and generally provide the same benefits to agricultural crops as shelterbelts. However, while many species planted in shelterbelts and forestbelts provide cover for wildlife, they provide little food, particularly as the trees mature. Shrubs that retain their fruit over winter such as sea-buckthorn, Siberian crab, chokecherry, highbush cranberry and buffalo berry can complement a new or existing belt and provide food for wildlife throughout the winter months.

The width of forestbelts and the variety of tree and shrub species are particularly desirable features of this planting design. Belts provide even better habitat if not planted in straight rows. A curved belt provides more edge and reduces sightlines that expose wildlife. Although both types of plantings can produce merchantable timber, forestbelts are more commonly intended to provide future revenue from timber harvests. Shelterbelt and forestbelt planting is presented in detail in the "Agroforestry" section of this guide.

Figure 67: Developed windbreak

Bluff Extensions

Trees and shrubs planted on the edge of small bluffs of trees can provide improved food sources and cover. Planting several rows to connect bluffs will create travel corridors for wildlife.

Figure 68: Tree planting along the river

Block Plantings

Block plantings could be located in corners or along edges of farmland or woodlots. Plantings located near food plots, feeding areas, or nearby wetlands will increase wildlife use. An irregular shaped block that increases the amount of edge is preferred. The planting configuration should place taller conifers in the centre of the block to provide thermal cover for wildlife, and shorter, denser shrubs along the edge to provide food and cover. After seedlings become established, undergrowth should be allowed to grow. A block as small as 10 rows wide and 60 m long can benefit wildlife; however, larger blocks are more beneficial.

Planting Abandoned Farmyards

Shelterbelts on abandoned farmyards can be modified to provide ideal wildlife habitat. Planting a variety of trees will create diversity and increase food productivity. The yard may be left open as a feeding area, with trees and shrubs planted in clumps or rows to provide a large edge area.

Wildlife Food Plots

Wildlife food from insects and plant materials are usually abundant and readily available through spring, summer and autumn. Winter creates a higher demand for food, however less food is available at this time. Late winter storms can be especially stressful. Plantings to provide year-round food, particularly shrubs that retain their fruit over winter months, is an option.

Artificial feeding is a subject of debate. It can concentrate animals and make them more vulnerable to predators and dependant on the feeders for food. However, in severe weather, it may mean the different between survival and starvation.

Controlling Wildlife

Wildlife is a source of enjoyment in the woodlot, however overpopulation, easy access to food, or lack of fear may make some species a nuisance. For example, hares can significantly damage young conifer plantations by eating tender young seedlings or girdling the stems of established plants. The best approach to eliminating wildlife problems is through prevention.

Small mammals such as mice, voles and hares can be partially controlled by reducing ground cover, thus making the animals susceptible to predators. Bait stations away from planted areas, or chemical repellents are other options.

Fencing may control large game such as deer and elk. Planting unpalatable species on the outer rows of a plantation or using repellents may deter animals from entering the plantation. Food plots may lure animals away to feed in different areas.

Physical barriers may be used to protect all or parts of tree seedlings. Wire screens or flexible sleeves protect against girdling by rabbits or mice. Rigid polypropylene mesh tubes are placed over individual trees to prevent browse damage from deer. The tubes break down in the sunlight after a few years, but protect the seedling until it becomes established. Nets or paper caps placed on the terminal buds may provide effective protection.

No one method will guarantee success. Combinations of fencing, physical barriers, repellents, habitat manipulation, stand management and the use of licensed hunters are options available to reduce wildlife damage.

A Summary of Guidelines for Managing a Woodlot for Wildlife

General guidelines for managing a woodlot for wildlife include: protect the woodlot from uncontrolled fire, protect the woodlot from intensive grazing, practice selective logging, preserve den and food trees, and develop woodlot borders.

The following points should be considered.

- Build a firebreak around and through the woodlot. Use fire with caution.
- Restrict grazing and fence woodlots where practical.
- Harvest trees selectively or in select groups.
- Develop border transition areas by cutting trees and encouraging shrubs, grasses and legumes.
- Establish wildlife travel corridors between wooded patches or woodlots and to watering areas.
- Leave 60 m buffer zones when harvesting timber near water bodies.
- Plant food and fruit producing trees where needed.
- Maintain sufficient openings.
- When harvesting trees, leave food producing trees, den trees, standing dead trees and roost trees.
- When planting new stands, diversify the tree species and include trees that produce food and cover.
- Use waste materials to build brush piles near woodlot edge.
- Leave a few rows of unharvested field crops near woodlots for winter food.
- Encourage variety in the woodlot. Diverse vegetation means diverse wildlife.
- Have a good plan before starting and update the plan regularly.

Wildlife Species – Game Species

Hundreds of animal species are native to the Prairie Provinces. A wide variety of animals, large and small, are an integral part of Prairie woodlots. Volumes of information are available elsewhere describing the various activities, characteristics, habitat requirements and management objectives for many species found in Western Canada. This section describes the ecology, food, habitat requirements and management suggestions for some game species found in the Prairies. Habitat and management information for selected fur bearing species is presented in Appendix 2. Additional information can be obtained from the sources listed in the "Selected Readings" at the end of this section.

Moose

Ecology – Moose occupy much of the central and northern Prairie Provinces. They are timid, solitary animals, preferring secluded areas away from humans.

Food – Moose feed extensively on the foliage and twigs of most deciduous shrubs and trees. They also eat evergreen species, but these are a less important food source. Succulent land and water plants, like yellow pond lily, pondweeds and bur reeds are used in the spring and early summer.

Habitat and Shelter – The best moose habitat is a mixedwood forest in its early succession stages. The first 15 or 20 years after a fire or clear-cut are ideal. Areas near lakes, rivers, deltas, or organic land provide diverse vegetation and are important components of moose habitat. Dense, mature, mixedwood and evergreen stands offer cover during severe winters when deep or crusted snow limits movement. Snow depths up to 90 cm usually do not hamper mobility for moose.

Moose in the northern prairies often winter on farmlands out of the forest where there is ample food and more protection from predators. Retaining suitable habitat, especially mixedwood stands, is particularly important in the northern agricultural zone.

Figure 69: Moose

Management Suggestions

- Retain streams and lakes for moose to escape from insects in the summer.
- Encourage willow shrub lands for year-round forage.
- Open foraging areas should be irregularly shaped and 2 to 5 ha in size.
- Provide dense forest blocks at least 1 ha in size and interspersed with conifers to provide thermal cover.
- Provide salt licks as a source of sodium.

Moose respond well to regenerated logged areas. Moose habitat will also attract small plant eating animals, upland game birds, songbirds, snowshoe hare and beaver.

Whitetail Deer

Ecology – The whitetail deer is the most adaptable and abundant big game animal on the Prairies. Populations flourished as habitat created by the agriculture industry expanded. Continued survival of whitetail deer populations is now closely linked to agricultural crops.

Food and cover requirements vary among the prairie, parkland, forest fringe and forested zones. Wooded areas diverse in height and species composition that have extensive edge and are near farmland provide ideal seasonal food and cover. Whitetail deer frequent river flats, coulees, aspen groves and mixed wood forests.

Food – Whitetail deer primarily browse shrubs and trees, but also eat cereal grains, tame grasses and legumes. Deep snow may restrict movement and food availability in the winter.

Choice and availability of food varies with the season. Winter foods include twigs, buds and fruits of many deciduous shrubs and trees. Whitetails browsing pine shoots and buds can be a severe pest to plantations. Cereal grain, alfalfa and fall rye shoots are winter favourites but farm shelterbelts and haystacks are also commonly used for food and shelter in winter. Spring feed shifts to forbs, native grasses and leaves, and tame pasture grasses, legumes and fall rye sprouts. Summer food includes woody browse and herbs as new shoots and leaves appear. Later in the summer, second-growth grasses become part of the diet. The fall diet includes ripened fruit, especially snowberry, rose, silverberry and chokecherry, and grain and shoots from fall-seeded crops.

Habitat and shelter – Dense aspen stands, shrub, and marsh vegetation provide excellent cover. Rugged, sloping terrain provides shelter from wind and minimizes detection by predators. The south facing slopes provide exposure to the warm sun. Snow depths up to 40 cm usually do not restrict movement for deer.

In winter, whitetails concentrate in blocks of native aspen parkland, major wooded valleys and wooded escarpments. Summer habitat includes wooded draws, aspen groves and wooded wetland areas. Their range is much larger in the spring, summer and fall, so cover for fawning and resting is more important during these periods. Small rivers, streams and continuous native tree cover are important travel corridors.

Figure 70: Whitetail deer

Management Suggestions

- Maintain part of the woodlot in a 1-15 year age class.
- Plan checkerboard harvest patterns to provide the maximum amount of edge. Whitetails respond best to clearcuts less than 8 ha.
- Manage the edges of winter cover for browse production (15 m wide area with trees and brush less than 5 m tall) to minimize travel to winter feed.
- Leave 5-15 snag and den trees per hectare in clear cuts for other birds and animals.
- Create grassy openings in or near timber leaving at least 1 ha of openings for every 20 ha of woodlot. Seed "log landings" with clover and grasses.
- Keep open areas less than 200 m wide.
- Maintain dense shrub and forest growth, at least 1.5 m high and greater than 75% crown closure for thermal and escape cover. In the winter, whitetail deer may require blocks of thermal cover larger than 16 ha. In the most severe winters, blocks of up to 64 ha may be needed.
- Develop salt licks to encourage use of the area.
- Protect riparian areas for travel corridors and cover.

Healthy populations depend on balancing deer numbers with the supply of winter food. Starving deer will over-graze and damage their winter range. Forest harvesting favours deer by opening the forest canopy, allowing new growth to start on the forest floor.

Mule Deer

Ecology – Mule deer usually prefer uncultivated areas and are consistently found in rugged terrain. Native grass-shrub land is the most common mule deer habitat. However in northwestern Alberta, it inhabits an agricultural area comprised of a patch-work of river coulees and farmland.

Figure 71: Mule deer in canola field near Peace River

Food – Browse followed by forbs dominate the mule deer diet. Seasonally, forbs are most important in spring and summer and deciduous browse is most common in late summer and fall. Summer food species include thorny buffalo berry, snowberry, rose, red-osier dogwood, chokecherry and skunk bush. Evergreens are usually browsed during winter. Rabbit brush, creeping juniper and sagebrush are common winter feed. Grasses are an important food source only in the spring when vegetation is first turning green. Damage to Christmas tree plantations or orchards may be seasonally important. In northwest Alberta, mule deer are often observed feeding in alfalfa and canola fields. While they are often found in the same area as cattle, there is little competition between the two for food.

Habitat and Shelter – South-facing slopes with grasslands, shrubs, open and closed forests, mixed forests, and dense stands are considered key mule deer habitat. These areas provide sunlight, higher temperatures and shallow snow cover. Snow depths under 40 cm usually do not pose problems for this species.

Elk

Ecology – Elk generally prefer heavily wooded and hilly wilderness areas. However elk often live near farm areas and can cause considerable damage to crops and haystacks.

Food – The ability to use a variety of habitats and foods make elk a good competitor with other big game animals. Woody browse, including aspen, willow, rose, wild red raspberry and high-bush cranberry, are preferred in all seasons but spring. Sedges and grasses make up half the diet in the spring, but less than ten per cent the rest of the year. Fall food includes forbs but cultivated crops may account for a quarter of the diet.

Habitat and Shelter – Elk are able to adapt to a variety of habitat areas. Preferred habitats include drainages and river floodplains, forest fringes and recently disturbed areas that provide a wide variety of food species. Mixed-wood and hardwood forests with grassland openings are used more than softwood forests and bogs.

Management Suggestions

- Establish open, sparsely treed grasslands as foraging habitat.
- Develop 60-75% of the area as open foraging habitat, with the rest as forest cover.
- Maintain forested escape and thermal cover of coniferous or mixedwood blocks at least 12 hectares in size located within 100 to 250 m of foraging areas.
- Establish artificial salt licks.

Figure 72: Elk

Black Bear

Ecology – Black bears occur in low population densities. Until recently, it was shot or poisoned indiscriminately, but now it is managed as a big game animal. The black bear is highly evolved and is considered intelligent. Food sources associated with human activities, such as garbage dumps, campgrounds, roadsides and bee yards can pose hazards to humans.

Food – The diet of black bears varies depending on the habitat, but vegetation such as berries, nuts, buds, catkins, tubers and digestible herbs are common foods. Spring foods include horsetail, grasses, sedges and some forbs. In the summer and early autumn, berries and hazelnuts are eaten. Rodents, colonies of insects and carrion are also part of the diet. Bears in agriculture-forest fringe areas eat farm crops such as oats.

Most bear foods are scattered and only available for short periods at a time. When food is scarce, bears may move closer to settlements or farm areas, threatening crops, beehives and livestock.

Figure 73: Black bear

Habitat and Shelter – Black bears inhabit forested areas, swamps and berry patches. Dense cover and rough terrain is used for escape cover and bedding sites. Dens are dug under upturned root masses or trunks of fallen trees, on hillsides, or on level ground, and lined with grass or other litter. The bears enter their dens in autumn and usually emerge in early April.

Management Suggestions

- Maintain riparian areas for travel lanes and food sources.
- Berry producing shrubs and food crops, particularly oats, will attract bears and provide a food source.

Many woodlot managers may not want to manage for black bear because bears are generally considered a threat to humans. Black bears, however, are a naturally occurring wildlife species and do contribute to the biological diversity of the woodlot.

Spruce Grouse

Ecology – The spruce grouse earned the name 'fool hen' because it has never learned to fear people. Its range corresponds to the boreal forest.

Food – The most important food for spruce grouse are conifer needles, such as from spruce, pine and tamarack trees. Spring and summer foods include leaves, flowers and fruit from various deciduous plants. The autumn diet includes berries and seeds along with conifer needles.

Habitat and Shelter – Spruce grouse habitat is in coniferous and mixedwood forests. They usually inhabit well-concealed sites, often under low branches in brush or deep moss, in or near spruce thickets. In fall, spruce grouse may be attracted to grit sources such as gravel roads, lakeshores, stream banks and uprooted trees.

Figure 74: grouse

Management Suggestions

Spruce grouse is considered an upland game bird. It requires continuous areas of coniferous forest. Management activities to maintain those forests will help to maintain spruce grouse populations.

Sharptail Grouse

Ecology – The sharptail grouse is a common upland game bird usually associated with grassland and aspen parkland habitats. Native grasses and shrubs are important to maintain populations. While it may be seen in fallow fields in the spring or in shelterbelts in the fall, the sharp-tail needs native vegetation year-round to survive.

Food – The sharptail diet includes berries, green leaves, buds and insects. Young birds feed heavily on grasshoppers and beetles. The summer diet for the adult includes flower heads from weeds like goat's beard and sow thistle, among other plants. Fruit from rose, snowberry, silverberry, bearberry, choke cherry and pin cherry, along with small grains, make up the fall diet. Through the winter, they eat buds from aspen, birch, chokecherry and willow, and dried berries. Spring favourites include aspen catkins and the succulent leaves from forbs such as dandelion. Sharptails do not need drinking water in their natural habitat. Moisture requirements apparently come from succulent foods.

Food Plots – One half to one hectare of wheat, oats, flax, barley, clover, corn or sunflowers may be left as a food plot. The plot should be located at least 100 m from trees taller than 6 m. Food plots near evergreens or other tall trees make sharptails vulnerable to hawks and owls.

Habitat and Shelter – In general, a mosaic of grass, shrubs and trees provides the best habitat for sharptails, especially in the winter. Shelter from weather extremes and predators is important for survival. In spring, the males roost in snowberry, rose and silverberry shrubs near their dancing grounds. This habitat, often in the early successional stage of forested areas, provides protection from hawks, owls, coyotes and foxes. Females usually nest within a 1 km radius of the dancing grounds. A mix of grass, sedges and low shrubs for are essential for nesting cover.

Areas with grasses and forbs, and short woody areas are used for brood rearing. Adults use tall shrubs and trees for shade and protection during the hot part of the summer. In autumn when food is plentiful, the birds may be found away from normal nesting and breeding grounds. In winter, sharptails burrow into soft snow on the leeward side of aspen bluffs in clumps of shrubs, sedges or cattails to escape the cold and wind.

Breeding Habitat – The sharptail dancing ground, or lek, is usually found on a slight rise or open flat area that provides a wide field of vision for the birds. The males gather on the lek, the females come to breed then disperse for nesting. These specialized reproductive habitats are sensitive to disturbance including grazing. Suitable dancing grounds are common on or near native grasslands, however nesting and brood-rearing habitat may be lacking or jeopardized by cultivation, drought, and overgrazing. When trees or shrubs invade a dancing ground, it is usually abandoned.

Management Suggestions

- Do not plant evergreens within 1 km of dancing grounds.
- Maintain existing marshes, grassland and brush areas.
- Delay mowing roadsides and hayfields until mid-July after the nesting period is completed.
- Consider controlled burning of brushland in spring or fall every five or ten years.
- Light to moderate livestock grazing controls natural succession and maintains openings.
- Leave or plant small food plots for winter.
- Remove tall trees near leks and food plots.
- Sharptails respond to management practices that reverse natural forest succession. Brush land that is burned, mowed or sheared every five to ten years provides the best habitat. Woodlots managed for sharptails will also benefit deer, many small mammals and other birds.

Ruffed Grouse

Ecology – The ruffed grouse is the most widely distributed resident game bird in North America and may be found wherever there is sufficient woody cover. Populations fluctuate widely on roughly a 10-year cycle.

Food – Spring and summer food is mostly tree and shrub blossoms, insects and foliage. Spiders and insects are protein sources for young chicks. In fall, ripening fruits of rose, bearberry, chokecherry, hawthorn and snowberry, plus the catkins and buds of aspen, willow and other trees and shrubs are important foods for the ruffed grouse. Aspen and willow buds are major winter foods.

Habitat and Shelter – Ruffed grouse are closely associated with the early successional stages of forests, such as after clear-cutting or burning. Ruffed grouse are most common in deciduous and mixed wood forests, and in wooded bluffs, drainages and coulees in agricultural areas.

Aspen is considered a primary component of ruffed grouse habitat. A diversity of tree age classes and understorey plants is important to provide habitat for all seasons. Three age classes of aspen should be accessible in each territory of 2 to 4 ha: the first are sapling stands from 4 to 15 years old for brood cover; the second are sapling and small pole stands from 6 to 25 years old for fall and spring cover; and the third are older stands for nesting, winter cover and food.

The optimum cover for spring breeding and drumming includes dense tall shrubs and tree saplings. 10 to 20 year old pole size aspen allows ruffed grouse to watch for ground predators and protects them from birds of prey. Drumming males usually avoid spruce areas.

Nesting cover is almost always in thick woods, often at the base of a tree. The best brood cover includes dense herbs and moderately high shrubs and is often found in very young forests, forest fringes and open glades. Overgrazing removes optimum habitat, but light grazing can create trails to help young grouse move around. Ruffed grouse will nest in alfalfa fields and can suffer losses from first cut haying operations.

Preferred fall and winter habitat depends on the availability of food. Dense closed canopy stands of aspen are often the best areas. Deep fluffy snow is important for roosting in cold temperatures.

Aspen Management Options – Aspen cover is the most important component of ruffed grouse habitat and can be managed to improve its quality. Four examples of aspen management options are:

- In a 16 ha woodlot, harvest four 1 ha blocks every 12-15 years.
- In a 16 ha woodlot, harvest one 4 ha block every 12-15 years.
- If the stand is mature, harvest in 4 to 8 ha blocks. Allow at least 5 years between each harvest and reserve islands of mature male aspen to provide a winter food supply.
- If the stand is over-mature and must be cleared completely, leave 0.25 ha islands or 30 m wide strips of male aspen for every 4 ha cut. These larger cuts will not produce as high a grouse density, but will provide more than unmanaged cuts.

Management Suggestions

- Maintain 3 age classes of aspen in close proximity within 16 ha blocks.
- Harvest trees in blocks less than 4 ha.
- If aspen stand age and condition prevent small cuts, leave 0.25 ha islands or 30 m wide strips of aspen standing for every 4 ha harvested.
- Leave strips of mature aspen along bog or marsh edges, or other brushy areas.
- Do not plant large blocks of conifers in forest stands managed for ruffed grouse.

How to Make a Drumming Log

Drumming lots may be built to enhance ruffed grouse habitat. A log should be located near the centre of each 4 ha drumming territory. Choose a hardwood tree larger than 25 cm in diameter and fell it near a tall protective guard tree. Leave a 1 to 2 m high stump. The stump should be 2.5 to 3 m from the guard tree and the drumming log should end up no more than 30 cm from the guard tree. The fallen log should have thick brush or young aspen saplings surrounding it, to protect the drumming male from predators. Mature male aspen should also be within sight of the log. The drumming site will be within 0.5 m of the butt end of the log, or within 0.5 m of the guard tree, and 20 to 25 cm above the surrounding area.

Gray (Hungarian) Partridge

Ecology – The gray partridge is an introduced species on the prairies. It requires less natural vegetation and tolerates more cultivation than sharptail grouse and often lives in or near farm shelterbelts throughout the year. Hungarian partridge are primarily a bird of the grasslands and farmlands, although mild winters allow them to spread into parkland habitats.

Food – Seeds and insects are the main food source. Green plant material is eaten in late winter and spring. Cultivated grains, including wheat, oats and barley, and weed seeds, make up most of their diet. Adult partridges eat varying amounts of grasshoppers, crickets and other insects, but chicks are dependent on insects during their first 10 weeks.

Hungarian partridges obtain moisture from dew and food items and do not require open water. They do require a ready supply of grit. In winter, they're often found near gravel roads when snow covers the ground.

Habitat and Shelter – Hungarian partridges prefer a combination of croplands, grasslands and some woody cover. Annual weeds and grasses dominate nesting and brooding areas. Ditches, grassy edges of shelterbelts, and farmyards all provide good nesting and brood rearing habitat.

The quantity and quality of protective cover in spring, and the severity of winter, are the most limiting factors. Cultivation, grazing and burning of habitat will all reduce Hungarian partridge populations.

Management Suggestions

- Row plantings such as shelterbelts in crop fields in agricultural areas is the preferred habitat and will support populations of gray or Hungarian partridge.

Wildlife Species - Insect Eaters

Canadian Toad

The Canadian toad inhabits riparian areas of the aspen Parkland and the Boreal Forest of Alberta. It is an insectivore and feeds on grasshoppers, caterpillars and many other insect pests. It hunts mostly at night or on cooler days and seeks shelter in animal burrows during the day.

Figure 75: Canadian Toad beside the Peace River

Saddle-backed shrew

The saddle-backed shrew is found in boreal coniferous forests in Alberta near forest edges and moist shrubs. Its diet is almost exclusively insects, including caterpillars, beetles and sawfly cocoons. This shrew is able to climb trees and will feed heavily on sawflies. When saddle-backed shrew densities are high, they can have a major impact on sawfly populations.

Evening grosbeak

The evening grosbeak prefers thick coniferous forests, but will also adapt to mixed deciduous habitats. It is primarily a seedeater, consuming spruce, fir, and pine seeds. The evening grosbeak will also eat large numbers of larvae and pupae of the spruce budworm, making it a valuable gleaning bird in infested areas.

Figure 76: Female evening grosbeak near Dunvegan

Black-capped Chickadee

The chickadee is a common bird of woodlots in the Prairie Provinces. It eats a variety of berries and seeds, and is an important gleaning bird, searching trees and bark for insect eggs, larvae and pupae. It feeds in large quantities, making it one of the most important pest exterminators in the forest.

Little brown bat

The little brown bat is found in a wide variety of habitats in the summer and hibernates in the winter. It consumes a wide variety of mosquitoes, moths and other insects. Little brown bats may live for up to 30 years.

Other Common Animals

Snowshoe hare

Snowshoe hare requires habitat with dense shrub understories. Summer diet is largely tender herbs. Winter food includes twigs of trees and shrubs. Many predators such as lynx, foxes and coyotes rely on hares as one of their main food sources.

Northern flying squirrel

The northern flying squirrel is a nocturnal animal seldom seen during the day. Its nest may be an abandoned woodpecker hole, a hollow tree, or a round mass of twigs and leaves in the branches of a tree. It feeds on seeds, nuts, fruits, berries, bark, leaves, insects, eggs, and young birds, and is found throughout Canada in heavily wooded areas, especially evergreen forests.

Porcupine

The porcupine is found in most deciduous and coniferous forests but prefers pine habitats. It is primarily vegetarian, eating leaves, shrubs, and trees. Bark, sapwood, and tree buds make up the bulk of its winter food. Porcupines can devastate woodlots by girdling a large number of trees. They crave salt and will gnaw anything with even a trace of salt in it. Fishers are the most common and successful porcupine predators, while great horned owls and other animals will occasionally attack them.

Red-backed vole

Voles are the dominant small mammals of the northern Prairie Provinces and are an important food source for bird and mammal predators. Population cycles can fluctuate and when they peak, predators may feed exclusively on them.

The red-backed vole is found in coniferous and mixedwood forests. Nests are usually built under stumps or fallen logs, although some are found in tree hollows. Its diet varies widely, including seeds, bark, stems, berries and roots, along with insects, young mice, snails and fungal material.

Red-backed voles are indicators of environmental disturbances and events like clearcut logging or land developments will eliminate populations from the area. This may be a result of the loss of mushrooms and lichens, both important food sources that are lost when the trees are removed.

Great horned owl

The great horned own is widely distributed and well adapted to most habitats on the Prairies. Its prey ranges from geese or skunks to shrews or songbirds, though medium sized mammals and birds like hares, ducks and upland game birds, are the most important food sources. Adult horned owls have few natural predators.

Beneficial Management Practices

- Develop a well-defined wildlife management plan that includes clear objectives for the species that will be managed.
- Use timber harvest systems that create or enhance wildlife habitat. Selective logging will reduce the size of openings in the forest and maintain the continuity in the forest canopy. Clearcut logging will disrupt the forest cover but will encourage natural regeneration of shade intolerant trees and shrubs.
- Plan forest harvests so that logged areas are scattered throughout the woodlot rather than in contiguous blocks. Cut blocks should be irregular shaped.
- Leave at least 6 dead standing, diseased, or deformed trees for nesting and feeding sites on cut blocks.
- Leave some logging slash on the ground for wildlife use.
- Plant fruit producing plants for wildlife feed. Include plant species like choke cherry that retain fruit over winter months to provide year round feed.
- Develop transition zones of shrubs and grasses along edges of farm fields or logged blocks.
- Plant multi-row shelterbelts or forest belts. Curved rows are better than straight rows to increase the amount of edge and to reduce wildlife exposure down long sight lines.
- Wildlife plantings should have taller trees species in the centre and shorter species along the edges. Viewed from the end, ideal plantings will have a dome shape.
- Plant or retain conifer trees for their thermal cover function. Include thermal cover trees near potential wildlife use areas.
- Develop or maintain wooded corridors that connect forested areas both within and beyond the property.
- Create wildlife nesting or cover sites by building nesting boxes or brush and rock piles.
- Leave 60 m buffer zones around wetlands larger than 0.5 ha and 30 m around smaller areas.
- Conserve riparian zones by not logging, or by limiting logging activities to selective logging and only during winter months. Erect fences to protect these zones from livestock overgrazing or compacting moist soils.
- Adopt natural methods to control wildlife. Examples of natural controls are planting species undesirable to wildlife around areas to be protected, removing habitat such as ground cover for rodents, or attracting natural predators to control populations.
- Become familiar with the wildlife species present and their food and habitat requirements.

Appendices

Appendix 1. Wildlife use of selected woody plants

Common name *(Scientific name)*	Part of plant eaten							Plant used by		Wildlife value *
	Buds	Twigs	Bark	Foliage	Fruit	Catkins	Canes	Birds	Mammals	
Alder *Alnus* spp.	●	●		●	●	●		●	●	M
Apple *Malus* spp.		●	●	●	●			●	●	H
Ash, Mountain *Sorbus Americana*	●	●		●	●			●	●	H
Aspen, Trembling *Populus tremuloides*	●	●	●	●		●		●	●	H
Aspen, Cottonwood *Populus deltoids*	●	●	●	●		●		●	●	M
Birch (Water, White) *Betula* spp.	●	●	●	●	●	●		●	●	M
Blueberry *Vaccinium myrtilloides*	●	●		●	●			●	●	M
Bunchberry *Cornus Canadensis*	●				●			●		L
Cherry, Choke *Prunus virginiana*		●			●			●	●	H
Cherry, Pin *Prunus pennsylvanica*		●		●			●	●		H
Cherry, Crabapple *Malus* spp.					●			●		
Cherry, Highbush *Viburnum trilobum*		●		●	●			●	●	M
Dogwood, Red-osier *Cornus stolonifera*		●	●		●			●	●	H
Elderberry *Sambucus* spp.	●	●	●	●	●			●	●	M-H
Elm, American *Ulmus americana*	●	●		●	●			●	●	M
Fir, Balsam *Abies balsamea*		●	●	●	●			●	●	M

H=High; **M**=Medium; **L**=Low

Values derived from American wildlife and plants: A guide to wildlife food habits, by A.C. Martin, H.S. Zim and A.L. Nelson.

Appendix 1. continued

Common name *(Scientific name)*	Part of plant eaten							Plant used by		Wildlife value *
	Buds	Twigs	Bark	Foliage	Fruit	Catkins	Canes	Birds	Mammals	
Hawthorn *Crataegus* spp.	●	●		●	●			●	●	M
Hazelnut *Corylus Americana*	●	●		●	●	●		●	●	M
Honeysuckle, Tartarian *Lonicera tatarica*					●			●		M
Larch *Laris* spp.	●	●	●	●	●	●		●	●	L
Maple, Box elder *Acer negundo*						●		●		H
Nannyberry *Viburnum lentago*	●	●	●		●			●	●	M
Olive, Russan *Elaeagnus angustifolia*		●		●	●			●	●	M
Pine, Red *Pinus resinosa*	●				●			●	●	M
Pine, Scots *Pinus sylvestris*	●				●			●	●	M-H
Poison-Ivy *Rhus toxicodendron*		●		●	●			●	●	H
Raspberry *Rubus* spp.	●			●	●		●	●	●	H
Rhodondendron *Rhododendron* spp.	●	●		●				●	●	L
Rose *Rosa* spp.	●	●		●	●			●	●	H
Saskatoon *Amelanchier alnifolia*	●	●	●	●	●			●	●	H
Spruce, White *Picea glauca*			●	●	●			●	●	M
Willow *Salix* spp.	●	●	●	●	●			●	●	M
Wintergreen *Gaultheria procumbens*	●	●	●	●	●			●	●	L

H=High; **M**=Medium; **L**=Low

Values derived from American wildlife and plants: A guide to wildlife food habits, by A.C. Martin, H.S. Zim and A.L. Nelson.

Appendix 2. Habitat components and management activities for furbearers in the Prairie Provinces.

Species	Key components of habitat	Management activities to maintain or enhance habitat quality
Badger	Non-forested habitats with soils suitable for burrowing and able to support burrowing prey.	Maintain grassland communities of sufficient size, or interspersed with agricultural land to support prey base.
Black Bear	Mosaic of forested and non-forested covertypes; mixed forest with a variety of tree and shrub species; refuge provided by relatively inaccessible terrain.	Provide a variety of successional stages; maintain or encourage covertype mosaic through cutting and burning; provide units of suitable habitat and area for refuge and travel corridors; maintain units of forest cover in association with cliffs, rock outcrops and riparian areas; enhance production and diversity of hard- and soft-mast-producing vegetation.
Beaver	Availability of suitable foods, particularly deciduous woody vegetation within suitable foraging distance (<100 m from water).	Manage vegetation (i.e. cutting, burning) to provide early successional stages of vegetation in suitable size classes.
Coyote	Expansion of range chiefly a result of clearing of forests and agricultural development that has directly and indirectly increased food availability.	Elimination of competing large predators, urbanization and agricultural expansion have all enhanced habitat conditions and contributed to range expansion of the species. Specific procedures to enhance habitat quality for the species are unnecessary.
Fisher	Closed canopy mature to old-growth forests. Coniferous to deciduous forest; mosaic of forest and successional habitats; suitable den sites (i.e. snags, downfall, rock crevices) in association with forest cover.	Maintain high degree of interspersion between intensively managed stands and stands managed with sufficiently long rotations to provide structural and vegetative diversity similar to old growth; ensure snag availability; maintain vegetation in riparian areas and ridgelines for dispersal; maintain large debris and downfall.
Red Fox	High degree of edge habitat from a mosaic of woodland, shrub land, cropland, and grassland.	Maintain woodlots in agricultural areas with minimal grazing or disturbance to ensure diversity of understory vegetation and foods; maintain shelterbelts and fencerows for cover and travel corridors; encourage establishment of fruit producing shrubs and trees.
Lynx	Mixture of mature forest and other successional stages; irregular distribution of forest cover types; successional stages provide food and cover for prey species.	Maintain mature coniferous cover interspersed with early to mid-successional stages, and relatively small clearcut areas of irregular shape; maintain debris and understory suitable for prey cover.

Appendix 2. (continued)

Species	Key components of habitat	Management activities to maintain or enhance habitat quality
Marten	Relatively dense mature to old-growth coniferous or mixed-wood forest; interspersion of forest and successional habitats; suitable den sites, downfall, snags to provide access from beneath the snow.	Maintain high degree of interspersion between intensively managed stands and stands managed with sufficiently long rotations to provide structural and vegetative diversity similar to old-growth; ensure snag availability; maintain vegetation in riparian areas and downfall such as brush piles.
Mink	Permanent surface water; vegetative cover within and adjacent to wetlands; structural cover (i.e. logjams, downfall, boulders) provide den sites.	Maintain vegetative cover within and adjacent to wetlands; maintain or increase structural/ physical diversity associated with wetland areas (i.e. downfall, logjams, backwaters) to provide cover and foraging; increase pool-riffle ratio; increase water permanence.
Muskrat	Permanent water of sufficient depth or velocity to prevent freezing of entire water column; presence of herbaceous aquatic vegetation and herbaceous vegetation in riparian areas.	Manage vegetative succession (i.e. burning, water level manipulation) to provide preferred food species; control water levels to provide suitable habitat year round.
River Otter	Water quality, permanent surface water, vegetative cover within and adjacent to wetlands; structural cover (i.e. log jams, downfall, boulders) to provide cover and foraging sites; den sites.	Maintain vegetative cover within and adjacent to wetlands, increase pool-riffle ratio; increase water permanence; encourage, establish or maintain beaver populations.
Raccoon	Wetlands, riparian habitats, suitable den sites and winter food availability.	Preserve wetlands; maintain riparian vegetation; eliminate grazing, intense fire or cutting in woodlots; maintain snags or diseased trees for den sites; encourage fruit and mast trees/shrubs; construct wetlands adjacent to woodlands; maintain or establish fencerows and shelterbelts.

Selected Readings, Internet Sites and Contact Information

Internet Sites and Contact Information

General Wildlife:

Canadian Wildlife Service
Prairie and Northern Region
Twin Atria Building, Room 200, 4999–98 Avenue
Edmonton AB T6B 2X3
1-800-668-6767
E-mail: cws-scf@ec.gc.ca
http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=5F569149-1

Alberta Conservation Association
1-877-969-9091
E-mail: info@ab-conservation.com
http://www.ab-conservation.com

Mammals:

Alberta Fish and Wildlife
http://www.programs.alberta.ca/Living/Dynamic.aspx?N=770+563+569

Birds:

Ellis Bird Farm Ltd
Box 5090, Lacombe, AB T4L 1W7
403-346-2211 (OFFICE)
403-885-4477 (SITE, SUMMER ONLY)
http://www.ellisbirdfarm.ca/

Bird Studies Canada
P.O. Box 160,
Port Rowan, Ontario N0E 1M0
1-888-448-2473
Email: generalinfo@bsc-eoc.org
http://www.bsc-eoc.org/bscmain.html

50 Birds
http://www.50birds.com/

Amphibians & Reptiles:

Alberta Fish and Wildlife
http://www.programs.alberta.ca/Living/Dynamic.aspx?N=770+563+569

Insects:

Alberta Lepidopterists Guild
http://www.biology.ualberta.ca/old_site/uasm/alg/

Insects of Alberta
http://www.insectsofalberta.com

Books and Publications

A Guide to Wildlife Food Habits. A.C. Martin, H.S. Zim and A.L. Nelson.

Alberta Butterflies. C. D. Bird, G. J. Hilchie, N. G. Kondla, E. M. Pike and F. A. H. Sperling; The Provincial Museum of Alberta. 1995.

The Amphibians and Reptiles of Alberta. A field guide and primer of boreal herpetology. Second Edition. Anthony P. Russell and Aaron M. Bauer; University of Alberta Press; 2000.

A Prairie Guide to Feeding Winter Birds. Bob Waldon, Western Producer Prairie Books.

Aquatic Invertebrates of Alberta. Hugh Clifford. University of Alberta Press. 1991.

The Audubon Society Guide to Attracting Birds. Stephen Kress.

The Birds of Alberta. Ray Salt and Bert Wilk. The Queens Printer. 1958.

Butterflies of Alberta. John Acorn. Lone Pine Publishing. 1993.

The Butterflies of Canada. RA. Layberry, P.W. Hall and J. D. Lafontaine; University of Toronto Press; 1998.

Canadian Mammals. Austin Cameron, National Museum of Canada.

Compact Guide to Alberta Birds. Chris Fisher, John Acorn and others. Lone Pine Publishing. 2005.

Damselflies of Alberta, Flying Neon Toothpicks in the Grass. John Acorn. University of Alberta Press. 2004.

Designing Tree Plantings for Wildlife. Prairie Farm Rehabilitation Administration. Agriculture Agrifood Canada.

Discovering Moths, Nighttime Jewels in Your Backyard. Down East Books. 2002.

Dragonflies Through Binoculars. Sidney Dunkle. Oxford University Press. 2000.

Feeding the Fish in Your Dugout or Pond. Alberta Agriculture Food and Rural Development. 2003.

The Fishes of Alberta. Martin Paetz. The Queen's Printer 1970.

Fish of Alberta. Michael Sullivan. Lone Pine Publishing. 2003.

Forest Landowners. Washington State University.

Forest Stewardship: A handbook for Washington forest landowners. Washington State University. WSU Extension and the Washington Department of Natural Resources. 1998.

The General Status of Alberta wild Species. Alberta Sustainable Resource Development. 2000.

Guidelines For Increasing Wildlife on Farms and Ranches. Edited by Robert Henderson, Great Plains Agricultural Council Wildlife Resources Committee and Cooperative Extension Service, Kansas State University.

Handbook for Timber and Mule Deer Management Coordination on Winter Ranges in the Caribou Forest Region. Land Management Handbook Number 13, B.C. Ministry of Forests.

Hinterland Who's Who – four page publications on various wildlife species in Canada.

Landscaping For Wildlife, Non game Wildlife Program – Section of Wildlife. Carrol L. Henderson, Minnesota Department of Human Resources.

Managing Your Woodland: A Non-Forester's Guide to Small Scale Forestry in British Columbia. BC Ministry of Forests and Lands.

Methods for Reclamation of Wildlife Habitat in the Canadian Prairie Provinces. Jeffrey Green and Richard Salter, for Environment Canada and the Alberta Recreation, Parks and Wildlife Foundation.

The Mammals of Alberta. Dewey Soper. Edmonton: Hamly Press, 1964.

The Mammals of Canada. A.W.F. Banfield, U of Toronto Press, 1974.

Mammals of the Canadian Wild. Adrian Forsyth, Camden House, 1985

Mammals of Alberta. Don Pattie and Chris Fisher. Lone Pine Publishing. 1999.

A Nature Guide to Alberta. A Handbook of Birds, Mammals, Reptiles, Insects, Fishes, Flowers, Trees, Grasses, Rocks, etc. David Spalding (ed.). Hurtig 1980.

NatureScape Alberta. Myrna Pearman, Ted Pike; NatureScape Alberta; 2000.

Planting Trees for Wildlife. PFRA Shelterbelt Centre, Indian Head, Saskatchewan.

The Relationship Between Habitat and Furbearers. In Arthur Allan, pg 164-179, Wild Furbearer Management and Conservation in North America, OMNR 1987.

Resource Reader, wildlife – two page publications on various wildlife species in Saskatchewan.

Songbirds in Your Garden. John Terres, Harper and Row Publishers, New York.

Terrestrial Wildlife Habitat Inventories. various regions of Saskatchewan, Saskatchewan Parks and Renewable Resources.

Tiger Beetles of Alberta. John Acorn. University of Alberta Press. 2001.

Tree and shrubs for wildlife habitat plantings. Prairie Farm Rehabilitation Administration. Agriculture Agrifood Canada.

Wild Furbearers of Saskatchewan. Wayne Runge and David Henry, Saskatchewan Parks, Recreation and Culture, 82 pg.

Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, 1987.

Wildlife Habitats in Managed Forests – the Blue Mountains of Oregon and Washington. USDA Forest Service, Ag Handbook No. 553.

Wildlife Habitat, A Handbook for Canada's Prairies and Parklands. Canadian Wildlife Service, Environment Canada.

Wildlife Habitat Improvement Guide. NEBRASKAland Magazine, Lincoln, Nebraska.

Wildlife habitat plantings on pivot corner. Prairie Farm Rehabilitation Administration. Agriculture Agrifood Canada.

Wild Mammals of Western Canada. Arthur and Candace Savage, Western Producer Prairie Books, 1981.

Winter Bird Feeding : An Alberta Guide. Myrna Pearman. Ellis Bird Farm. 1991.

Woodland Stewardship Plan. Minnesota Division of Forestry.

The Woodland Workbook. Oregon State University.

The Woodland Steward. James Fazio, University of Idaho.

Woodlot Management Home Study Courses. Nova Scotia Department of Lands and Forests.

Woody Cover Plantings for Wildlife. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Woodlot Recreation

Contents

Criteria and Indicators of Sustainable Forest Management Applicable to Recreation in the Woodlot

Recreational use of the woodlot, either for private or public use, can potentially make the property a showroom of nature and its processes.

Criteria 1: ***Biological diversity. Conserve and maintain the integrity, function, and diversity of living organisms and complexes encompassing the property and surrounding landscapes. Indicators of accomplishment include:***

- The recreation management plan identifies ecologically sensitive features of the woodlot or other special sites and describes strategies to conserve and protect them.
- Planned recreation activities and developments do not impact the diversity of plant and animal species.
- Non-consumptive activities are identified as recreation opportunities.

Criteria 2: ***Ecosystem condition and productivity. Maintain the health and biological productivity of the forest ecosystem. Indicators of accomplishment include:***

- Fire protection and prevention strategies are included in the recreation management plan, particularly near camping and picnic sites.
- Recreation sites are designed and supplied to minimize damage to the surrounding forest.

Criteria 3: ***Soil and water. Maintain the forest quantity and quality to conserve soil and water. Indicators of accomplishment include:***

- Road and trails are designed for multiple purposes to reduce their frequency and minimize the area of land withdrawn from the productive forestland base.
- Recreation utilization schedules are planned during weather and seasons when road and trail use will not damage soils or waterways.
- Bridges traverse waterways that must be crossed.

Criteria 5: ***Economic and social benefits. Include multiple benefits as a goal in the forest plan to benefit present and future society. Indicators of accomplishment include:***

- Recreation, forest management and other woodlot activities are integrated to maximize multiple benefits from the woodlot.
- All operations are carried out within applicable workplace health and safety regulations.

Criteria 6: ***Society's responsibility. The community and its interests are given full consideration before initiating actions on the property. Indicators of accomplishment include:***

- The interests and values of the community at large, including the aboriginal community, are considered in the recreation component of the management plan.

Introduction

Many outdoor activities take place in a woodlot. Some are for fun, others for profit. Traditional outdoor recreation takes many forms and could include consumptive uses of the woodlot such as harvesting wildlife, wild fruit, or mushrooms, or using the outdoor features of the property for non-consumptive uses such as cross-country skiing, horseback riding, hiking, or communing with nature. While these activities are for fun, they also have the potential to be for profit.

Recreation Opportunities in the Woodlot

Recreation Sites

Woodlots can be developed as campgrounds or picnic areas. Existing clearings or forest openings are possible locations for this activity. Camping and picnic sites can range from primitive to fully developed facilities with shelters, tables and bathrooms. Firewood can be provided for campers to reduce damage to nearby trees or deterioration of the natural vegetation. Well-placed fire rings or grills will help to contain fires and encourage campers to use the same spots for their fires. Portable water tanks or other water sources should be available at the site at all times. Fire prevention and protection are important considerations whenever open fires are permitted.

Historical and Local Heritage Sites

Alberta is rich with history and culture ranging from archaeologically significant areas to artifacts of the life and times of early settlers and aboriginal people. Interpretive signs or designated trails can offer educational opportunities to visitors of the woodlot. Protection and preservation of these sites is crucial and must be identified in the management plan.

Nature Sites

Wildlife watching, fishing, boating, nature walks, viewpoints and plant identification are other options for woodlot owners. Pamphlets are useful to describe these sites and could be used for self-guided tours. The pamphlet might contain lists of wildlife that frequent the area, descriptions and identification keys of plants that occur along a nature walk, or photos showing the views from certain points along the walk. Pamphlets can be good marketing tools, especially if rare or unusual species are highlighted.

Figure 77: Hunting blind

Woodlot Recreation as an Income Source

Recreation opportunities in privately owned woodlots have potential to diversify or improve income from the property. Diversifying farm income by providing recreation opportunities on the land is well established in the agriculture community. Farm vacations are common in European countries. Commercial tour operators include stops or overnight stays at farms to provide a unique experience on a working farm or ranch. Woodlots have the resources to supply these services but have the added advantage of providing forested areas, and to some extent wilderness areas, that may appeal to urban consumers. Woodlots provide ideal settings for many forms of recreation. Fruit and berry picking, horseback riding, sleigh rides and cross-country skiing are a few examples. Providing overnight facilities such as camping or bed and breakfast are other possibilities. These experiences are available in many parks and commercial venues, although often they are heavily used, or are located long distances from the urban consumer. Woodlots are well positioned to capitalize on these opportunities.

Many factors will determine the level of recreational use and the potential for commercial applications of a woodlot property. Tracts of land in close proximity to high population centers, unique woodlot features, and diverse ecosystems are in high demand. Areas far from cities could be very attractive to people seeking a wilderness experience. The woodlot owner must also be willing to invest in amenities to accommodate visitors and be willing to allow public access to the property.

Woodlot owners planning to provide recreation experiences as an income source should consider the following steps:

- Develop a recreation component to the woodlot management plan.
- Include resources suitable for recreation purposes in the woodlot inventory.
- Develop a trail network to all parts of the woodlot that will be made available to visitors.
- Determine the services that will be provided.
- Market the experiences and services.
- Give full consideration to safety and liability issues.

Develop a Management Plan:

The importance of a woodlot management plan that addresses all activities planned for the property has been emphasized elsewhere in this Guide. If recreation is an objective for the woodlot, the woodlot plan should include a component to describe the recreation activities that are expected. Recreation may be intended for the sole use of the woodlot owner, or for commercial purposes. In both cases, the activities should be described and integrated with other planned activities for the property to avoid potential conflicts, particularly for activities that have visual impacts.

The decision to include recreation as an objective for the woodlot does not preclude other uses including consumptive uses such as timber harvesting. The woodlot owner must prioritize the activities so that the recreation objective is ranked according to his or her preference. Recreational use may have to be restricted on portions of the property being harvested for timber. Alternatively, the harvest operation may be modified to accommodate recreational uses. For example, a clearcut could be replaced with a selection cut if appropriate for that forest stand, or a cutover block could be used as a wildlife viewing area. The diversity of the forest, including cut and uncut blocks and blocks in varying stages of regeneration, will result in diversity of plant and wildlife species. These strategies could be integrated into the recreation component of the management plan and facilitate multiple uses of the woodlot. Details on forest management activities that can enhance wildlife are presented in the "Wildlife" and "Silviculture" sections of this guide.

Include Recreation Resources in the Woodlot Inventory:

The woodlot management planning process includes an inventory of the woodlot resources. An inventory describes the quantity and quality of the resources on the woodlot at a level of detail that will meet the woodlot owner's objectives. Inventory information allows the assessment of resources to help the woodlot owner determine how those resources will contribute to the objectives for the property. It may also identify additional or new opportunities. The "Inventory" section of this guide details inventory procedures for timber resources. However, when recreation is an objective, the woodlot inventory should include resources that are pertinent to recreation activities. This aspect of the inventory can be conducted in conjunction with the timber inventory or as a separate task. An inventory of recreation resources could collect the following information about the woodlot:

- Slope characteristics
- Vegetation types
- Water bodies and their condition
- Line of sight or vistas
- Wildlife and fish populations
- Existing land use including agriculture
- Cultural and historical sites
- Access to population centers
- Types of access roads, and trails

The combination of these factors will help determine the level of recreational that could be considered for the woodlot.

Develop a trail network:

A developed trail system is an important aspect of woodlot recreation. Trails are the most common improvements made to facilitate woodlot recreation for both personal and commercial use. A forest trail is used either as part of the recreation experience in itself, as with a nature trail, or as a means to reach a recreation area such as a scenic view, a picnic spot, or a camping site.

Road and trail systems are necessary for woodlot operations such as harvesting, tree planting, and fire protection. These access systems can also be used for recreational purposes providing there is no conflict with the road's primary use. The location of the road or trail will depend on its primary use and on landscape considerations. Roads intended to accommodate timber harvest equipment can accommodate recreational use, but trails planned for recreation will not likely be suitable for heavy machinery. Factors that must be determined before road and trail construction begins include:

- The purpose of the trails (the primary and other uses)
- Frequency and season of use
- Construction and maintenance costs
- Impact of the trails on the ecosystem (will this affect the recreation experience?)
- Users of the trail (e.g. ATVs, hikers, etc.)
- Tourist needs (e.g. does the trail offer what the visitor desires?)

General guidelines for trail characteristics include the following (adapted from: The Woodlot Stewardship Plan, Minnesota DNR):

Snowmobile trails:

- Minimum width on a one-way trail – 3 m
- Minimum width on a two-way trail – 4 m
- An additional 1 m should be cleared outside the trail surface
- Minimum turning radius – 30 m
- Branches and obstacles cleared to 3 m above the trail
- Reflector signs placed on the right side of the trail at certain intervals

Ski trails:

One-way

- Intensive use – 3 to 4 m – one or two tracks set.
- Moderate use – 3 to 3 m – one or two tracks set.
- Low use – 2 m – one or no tracks set.

Two-way

- 3 to 4 m
- Downhill section should widen at the bottom as the slope increases
- Uphill slopes, for herringbone or sidestepping – 4 to 5 m

General

- 1 m of horizontal clearance on either side of the track
- 3 m of vertical clearance above expected snow depth
- Minimum 15 m turning radius, 30 m preferred
- Avoid curves on downhill slopes and at the bottom of hills. If necessary, provide a runout, widen the trail or increase turn radius. As slope increases, lengthen the runout – if needed, widen the trail or increase the turn radius.

All trails

- Vertical and horizontal sight distance from trail should be 15 m
- Cut back snow banks at road crossings
- Install warning signs at crossings
- Cross contours at right angles – avoid routing trails along side slopes
- The approach to a slope should be as long as the slope itself
- Trails should not be routed over streams, lakes or other water bodies
- Provide bridges 2 m wide over water courses
- Route trails away from areas of potential conflicts
- Place various signs along the trail
- Avoid hazards such as cliffs, ditches, steep hills, sharp curves, and fences

Determine the Services that will be Provided:

The woodlot owner may provide services in addition to the experiences offered by the natural setting of the woodlot. Services provided could include guided interpretive tours for individuals or groups, rental of skis, ATVs or other equipment, bed and breakfast, or sleigh rides. Services can be adapted to the season. During hunting season, hunters may be interested in bed and breakfast services or ATV rentals. In the spring and fall, observing migratory birds may be of interest, and during winter, sleigh rides are a popular activity. The woodlot owner must be sensitive to the clients' needs and be able to respond to those needs with a variety of services.

Market the Experiences and Services:

Marketing is an important step in the commercial development of the woodlot's recreation resources. Marketing is the moving of goods from the producer to the consumer. This is usually accomplished through advertising either formally or informally. Formal advertising is done in newspapers, pamphlets or other printed media. Participation at fairs, trade shows or other public events is a good way to promote the woodlot and services available and provides the opportunity for personal contact with prospective clients. Once a reputation is established, the informal advertising method becomes effective. Satisfied customers want to talk about their positive experience on the woodlot and will willingly promote it to others. In many ways, word-of-mouth advertising is the most effective marketing form because of the personal and seemingly unbiased opinions about the quality of resources the woodlot offers.

The final decision to proceed with this aspect of woodlot management requires consideration of the following questions:

- Are you willing to have visitors, many of which will be strangers, in your woodlot?
- What services can you offer?
- What is unique about the woodlot that would attract clients?
- Do you have resources (money, infrastructure equipment and time) for this business?
- How much knowledge do you have about woodlot recreation?
- How much are you willing to learn about woodlot recreation and management, including the financial aspects?
- What do you know about marketing and your potential clients?

Safety and liability

Woodlot owners who allow access to their woodlot for recreation are burdened with numerous issues such as unacceptable levels of trespass, littering, fence and property damage, livestock damage, and wildlife law violations. Some landowners try to stop unauthorized recreational use of their property. Others have found ways to manage recreational use to minimize disruptions and create needed income. Hunters and other outdoor recreationists are generally aware of landowner rights and concerns, although various problems do occur. Often, landowners who work positively with responsible users gain greater security, new friends, additional income, and the personal satisfaction that comes from helping and working with others.

Public access to the woodlot for recreation creates a liability for the woodlot owner. Regardless of the safety measures in place, accidents can happen, people can be injured and property can be damaged. The landowner can make users responsible for their own safety and liable for damages, however this does not necessarily guarantee the landowner will not be held responsible. Insurance is available to protect the woodlot owner in these situations. The prudent woodlot owner will investigate legislated insurance requirements and recommended protection levels before allowing access to the property.

Beneficial Management Practices

- Include a recreation component to the woodlot management plan.
- Conduct an inventory of recreation resources or collect recreation resource data in conjunction with the woodlot forest inventory.
- Consider the recreation value of forest management activities. For example cut blocks can provide wildlife viewing areas and regenerated cut blocks may demonstrate stages of forest succession, etc.
- Develop a trail and road network to all parts of the woodlot that will be accessed by visitors. Design the access to accommodate the primary purpose (hiking, skiing, logging equipment) but plan to accommodate other woodlot management activities.
- Locate firefighting equipment near areas of public use.
- Install fire rings or pits to encourage users to build fires in the same spot and prevent accidental ignitions.
- Provide firewood to discourage campers from damaging trees or other vegetation.
- Protect and preserve sites of cultural value.
- Consider providing services such as guiding or equipment rentals in addition to providing recreation experiences. Be flexible to accommodate changing seasons and resulting changing demands for services.
- Develop a strong client base by actively promoting the recreation resources and services available.
- Consider safety and liability issues before allowing access to the woodlot. Purchase adequate insurance for protection against damage, injury and associated financial losses.

Selected Readings

Ecotourism in Canada. Canadian Environmental Advisory Council; Environment Canada. Hull, Quebec.

Sherwood Park Natural Area Management Plan. Natural Areas Program brochures; Alberta Forestry, Lands and Wildlife.

Ecotourism Comparables Study. Alberta Tourism.

Facility Development Options For Wildlife Viewing Sites. Alberta Watchable Wildlife Program.

The Woodlot Stewardship Plan, Minnesota DNR.

Section IV : Section IV: Glossary of Terms

-A-

Access
Means of gaining entry to a tract of timber.

Aerobic
1. Having molecular oxygen as a part of the environment.
2. Growing only in the presence of molecular oxygen, such as aerobic organisms.
3. Occurring only in the presence of molecular oxygen, as applied to certain chemical or biochemical processes such as aerobic decomposition.

Afforestation
The establishment of a tree crop on an area from which it has always or for very long been absent. Where such establishment fails and is repeated, the latter may properly be termed "reafforestation."

Age
Age of the trees comprising a forest, crop, or stand. In forests, the mean age of dominant (and sometimes co-dominant) trees is taken. The plantation age is generally taken from the year the plantation was begun, without adding the age of the nursery stock.

Age-of a tree
The time elapsed since the germination of the seed or the budding of the sprout or cutting from which the tree developed.

Age Class
A distinct group of trees or portion of growing stock recognized on the basis of age.

Anaerobic
1. Having no molecular oxygen in the environment.
2. Growing in the absence of molecular oxygen, such as anaerobic bacteria.
3. Occurring in the absence of molecular oxygen, as in a biochemical process.

Annual Growth
Average annual increase in the biomass of growing-stock trees of a specified area.

Artificial Regeneration
Establishing a new forest by planting seedlings or by direct seeding (as opposed to natural regeneration).

Available Nutrients
The amount of soil nutrient in chemical forms accessible to plant roots or compounds likely to be convertible to such forms during the growing season.

Available Water
The portion of water held in a soil that can be readily absorbed by plant roots, corresponding to a pressure of approximately 15 bars. See also field capacity moisture tension, soil.

-B-

Biodiversity (biological diversity)
Refers to the variety of life on three different levels: the variety of ecosystems (ecosystem diversity); the variety of species (species diversity); and the variety within species (genetic diversity).

Boreal Forest
One of three main forest zones in the world; it is located in northern regions and is characterized by the predominance of conifer trees.

Browse
Buds, shoots, and leaves of woody plants that can be eaten by livestock or wild animals.

Brush
Growth of small trees and shrubs.

Buffer
A protected strip of vegetated land beside roads, watercourses, mineral licks or other important features.

-C-

Canopy
The more-or-less continuous cover of branches and foliage formed by the crown of adjacent trees.

Clay
As a particle-size term: a size fraction less than 0.002 mm in equivalent diameter.

Clay (textural class)
Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

Clay loam
Soil material that contains 27 to 40% clay and 20 to 45% sand.

Clearcutting
A forest management method that involves the complete felling and removal of a stand of trees. Clearcutting may be done in blocks, strips or patches.

Climate
The average weather conditions experienced at a particular place over a long period, usually more than 70 years.

Clone
A group of plants that reproduced from, and are genetically identical to a common ancestor.

Coarse Sand
25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.

Coarse Sandy Loam
25% or more very coarse and coarse sand and less than 50% any other one grade of sand.

Coarse Texture
The texture exhibited by sands, loamy sands, and sandy loams except very fine sandy loam. A soil containing large quantities of these textural classes.

Commercial Forest
Forestland that is able to grow commercial timber within an acceptable time frame; forest areas where resource use is the prime focus for management.

Coniferous
Refers to a forest stand or category of trees or bush that is popularly called "evergreen." The wood of conifers is commercially known as "softwood."

Conservation
The sustainable use of forest resources in a manner that does not degrade the collective resource values of a region over the long term.

Cover Type
This term is used to describe the general tree species composition of the forest stand to which it is applied.

Cropland
Agricultural land cultivated for the production of crops. It may also include fallow land, feedlots, orchards, vineyards and nurseries.

Crown Class
The relative position of the tree or shrub crown with respect to the competing vegetation surrounding the tree or shrub. The crown class for each tree or shrub is judged in the context of its immediate environment, that is, those trees or shrubs that are competing for sunlight with the subject tree. Crown class is essentially a classification of competition for light and is aimed at separating trees that are growing freely from those that are not. It designates trees or shrubs with crowns of similar development and occupying similar positions in the crown canopy. Five crown classes are commonly recognized: dominant, co-dominant, intermediate, overtopped (suppressed) and open grown trees.

Dominant trees – Trees or shrubs with crowns receiving full light from above and partly from the side; usually larger than the average trees or shrubs in the stand, with crowns that extend above the general level of the canopy and that are well developed but possibly somewhat crowded on the sides. A dominant tree is one that generally stands head and shoulders above all other trees in its vicinity.

Co-dominant trees – Trees with crowns forming the general level of the main canopy in even-aged groups of trees and receiving full light from above and partial light from the sides.

Intermediate trees – Tree with crowns extending into the lower portion of the main canopy of even-aged groups of trees, but shorter in height then the co-dominants; receiving little direct light from above and none from the sides, usually with small crowns that are crowded on the sides.

Suppressed trees – Trees with crowns entirely below the general level of the canopy of even-aged groups of trees, receiving no direct light either from above or from sides.

Open grown trees – Trees with crowns receiving full light from all sides due to the openness of the canopy.

Crown Closure
The percentage of the ground covered by shade from the natural spread of the foliage of plants. This is usually expressed as percentage.

Crown Land
Public land that is managed by the federal or provincial/territorial government.

Cutblock
A specified area of merchantable timber with defined boundaries designated for harvest.

-D-

Defoliation
The loss of leaves or needles on a plant or tree.

Defoliator
An insect or other agent that consumes foliage.

Diameter at Breast Height (DBH)
The stem diameter of a tree measured at breast height above ground level, or 1.3 m.

-E-

Early Forest Succession
The biotic (or life) community that develops immediately following the removal or destruction of vegetation in an area. For instance, grasses may be the first plants to grow in an area that was burned.

Ecodistrict
A part of an ecoregion characterized by distinctive geology, soil, water, fauna and land use.

Ecological Land Classification
A process of delineating and classifying ecologically distinctive areas based on geologic, landform, soil, vegetative, climatic, wildlife, water, and human factors. This holistic approach to land classification can be applied incrementally, from site-specific ecosystems to very broad ecosystems. This system provides for seven levels of generalization: ecozones, ecoprovinces, ecoregions, ecodistricts, ecosections, ecosites and ecoelements.

Ecology
The science that deals with the interaction of plants, animals, and their environment.

Ecoregion
A part of a province characterized by distinctive regional ecological factors, including climate, physical geography, vegetation, soil, water, fauna and land use.

Ecosite
Ecological units that develop under similar environmental influences (climate, moisture, and nutrient regime).

Ecosite Phase
A subdivision of the ecosite based on the dominant tree species in the canopy.

Ecosystem
A dynamic system of plants, animals and other organisms, together with the non-living components of the environment, functioning as an interdependent unit.

Ecosystem Management
An ecological approach to natural resource management to assure productive, healthy ecosystems by blending social, economic, physical, and biological needs and values.

Ecozone
An area of the Earth's surface that is representative of a broad-scale ecological unit characterized by particular abiotic (non-living) and biotic (living) factors.

Edge
The boundary between open land and woodland or two other ecological areas.

Edge Effect
Where two habitats adjoin, there is more species diversity than in either one alone. Used most often to describe ecological effects caused by the environment of the forest edge where forest meets open land.

Endangered Species
Species that are threatened with imminent extinction; includes species whose numbers or habitats have been reduced to critical levels.

Erosion
The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Erosion can also involve the detachment and movement of soil or rock by water, wind, ice, or gravity.

Even-aged Forest
A forest stand or type in which relatively small age differences (10-20 years) exist between individual trees.

Extirpated Species / Extirpation
Refers to the local extinction of a species that is no longer found in a locality or country, but exists elsewhere in the world.

-F-

Forbs
Broad-leaved, non-woody plants that die back to ground level after each growing season (perennial). Ferns and fern allies are considered forbs.

Forest Management Plan (FMP)
A plan prepared for a forest management unit that describes how the timber or other resources will be managed.

Forest Soil
A soil developed under forest vegetation.

Forest Type
A group of forest areas or stands whose similar composition (i.e., species, age, height and density) differentiates it from other such groups.

Fragmentation
The splitting or isolating of patches of similar habitat, typically forest or prairie plant communities, but including other types of habitat. Habitat can be fragmented naturally or from land management activities, such as clearcut logging or cultivation.

-G-

Geographic Information System (GIS)
An organized collection of computer hardware, software, geographic data, and personal data designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

A computer system capable of holding and using data describing places on the earth's surface.

Grassland
Ground covered by vegetation that is dominated by grasses. Grassland constitutes a major world vegetation type and occurs where there is sufficient moisture for grass growth, but where the environmental conditions prevent tree growth. The extensive mid-latitude grassland is known as steppe or prairie, whereas the corresponding tropical vegetation is called savannah.

Ground Cover
A ground cover is any low-growing plant that shades an area in the landscape.

-H-

Habitat
The area that provides an organism with adequate food, water, shelter, and living space, and/or the conditions of that environment including the soil, vegetation, water, and food.

Hardwood(s)
Trees that lose their leaves in autumn, also refers to the wood produced by these trees. Hardwoods belong to the botanical group angiospermae and are the dominant type of tree in deciduous forests.

Humus
1. The fraction of the soil organic matter that remains after most of the added plant and animal residues have decomposed. It is usually dark coloured.
2. Humus is also used in a broader sense to designate the humus forms referred to as forest humus. They principally include mor, moder, and mull type humus forms. (Also see organic matter, soil, mor, moder, mull, and horizon, soil.)
3. All the dead organic material on and in the soil that undergoes continuous breakdown, change, and synthesis.

-I-

Inventory (Forest)
A survey of a forest area to collect data about the area. It usually includes specific data about the resources of the area (timber, wildlife, water, etc,) the types, condition and distribution of ecosystems on the landbase, specific species, etc. for a specific purpose, such as planning, purchasing, evaluating, managing or harvesting.

-L-

Landscape
A large land area composed of interacting ecosystems that are repeated due to factors such as geology, soils, climate, and human impacts. Landscapes are often used for coarse grain analysis.

L-F-H Layers
The duff or "O" horizon is comprised of three zones that blend into each other with degrees of decomposition distinguishing layers from one another, the LFH soil layer. Organic layers developed primarily from leaves, twigs, and woody materials, with a minor component of mosses.

- **L**: The original structures of the organic material are easily recognized.
- **F**: The accumulated organic material is partly decomposed.
- **H:** The original structures of the organic material are unrecognizable

-M-

Mean Annual Increment
Total incremental growth up to a given age divided by that age. Average growth per year.

Management Plan
A detailed long-term plan for managing a landbase area. It usually includes data about the landbase and prescribes management activities designed to provide an optimum sustainable supply of resources according to the landowner's/steward's goals.

Mature/overmature Stands
Stands that have reached rotation age or have a reduced growth rate due to advanced age. Such stands normally have large mature or overmature trees, an abundance of large live trees with heart rot, numerous snags, stubs and high stumps and an abundance of large downed woody debris.

Microclimate
The climate of a small area resulting from the modification of the general climate by local differences in elevation or exposure. The sequence of atmospheric changes within a very small region.

Microsite
The specific spot occupied by an individual organism. Also, the more or less specialized relationships existing between an organism and its environment.

Mitigation
A process of minimizing or compensating for damages to natural habitats. To decrease the degree of damage to an ecosystem. It may include restoration, enhancement, or creation. According to the Clean Water Act, mitigation is a sequential process that includes avoiding impacts, then minimizing impacts, and lastly, compensating for impacts.

Mixedwood Stands
Stands containing both deciduous and coniferous species.

Moisture Regime
Represents the available moisture supply for plant growth on a relative scale. It is assessed through an integration of species composition and soil and site characteristics. Moisture regime ranges from very xeric to hydric.

-N-

Natural Regeneration
Renewal of a tree crop by natural seeding, sprouting, suckering or layering.

Nutrient
Elements or compounds essential as raw materials for organism growth and development.

-O-

Old Growth
A forest of mature or overmature timber that is beyond its peak growing period.

Open Grown
Trees with crowns receiving full light from all sides due to the openness of the canopy.

Organic
An order of soils that have developed dominantly from organic deposits. The majority of organic soils are saturated for most of the year, unless artificially drained, but some of them are not usually saturated for more than a few days. They contain 17% or more organic carbon.

Overmature
Trees or stands past the mature stage, where growth rates or value are declining.

-P-

Pest
An organism capable of causing material damage. Forest pests include insects, tree diseases and noxious fungi.

Pioneer
A plant capable of invading newly exposed surface soil and persisting there until supplanted by successor species; a species that can serve as a nurse crop because it will tolerate being planted on a bare site, which it can prepare for successor species.

Protected Area
An area protected by legislation, regulation or land-use policy to control the level of human occupancy or activities. Categories of protected areas include protected landscapes, national parks, multiple-use management areas, and nature (wildlife) reserves.

Pulp
Wood chips that have been ground mechanically into fibres and are used for the production of inexpensive paper, such as newsprint, or that have been chemically treated to remove the lignin and are used to manufacture higher quality papers.

-R-

Reforestation
The reestablishment of trees on denuded forestland by natural or artificial means, such as planting and seeding.

Regeneration
The continuous renewal of forests. Natural regeneration occurs gradually with seeds from adjacent stands or with seeds brought in by wind, birds or animals. Artificial regeneration involves direct seeding or planting.

Release
Freeing a tree or group of trees from more immediate competition by cutting or otherwise eliminating growth that is overtopping or closely surrounding them.

Relief
Elevations or inequalities of a land surface, considered collectively. Land having no unevenness or differences of elevation is called level, gentle relief is called undulating, strong relief, rolling, and very strong relief, hilly.

Riparian Area
An area of streamside vegetation including the stream bank and adjoining floodplain, which is distinguishable from upland areas in terms of vegetation, soils, and topography.

Rotation
Period of years between establishment of a stand of timber and the time when it is considered ready for final harvest and regeneration; planned number of years between the regeneration of a timber stand and its final cutting.

Runoff
The portion of the total precipitation on an area that flows away through stream channels. Surface runoff does not enter the soil. Groundwater runoff or seepage flow from groundwater enters the soil before reaching the stream.

-S-

Seeding
The sowing of seeds over an area on which a forest stand is to be raised.

Seedling
A small tree grown from seed. Usually the term is restricted to trees less than 2 cm DBH.

Selection Cutting
Annual or periodic cutting of trees in a stand in which the trees vary markedly in age. The objective is to recover the yield and maintain an uneven-aged stand structure, while creating the conditions necessary for tree growth and seedling establishment.

Selection Harvest
An uneven-aged silvicultural system in which selected trees are harvested individually or in small groups at periodic intervals throughout a rotation; the objective is to improve the timber condition, composition, structure and value.

Selective Cutting
A harvest practice in which only trees of a certain species with a specified diameter and/or value are harvested.

Seral Stage
The series of changes occurring in the ecological succession of plants. (e.g. - pioneer stage, or climax stage).

Shelterwood Systems
A method of harvesting that involves two cuts: the first cut leaves trees at intervals to provide the canopy and species required for natural regeneration; the second cut harvests the resulting new crop of trees (which are fairly even-aged).

Silvicultural Systems
Systems that follow accepted silvicultural principles, whereby the tree crops are tended, harvested and replaced to produce a crop of a desired form. This includes even-aged (i.e., clearcutting, shelterwood or seed tree cutting) or uneven-aged (i.e., selection cutting) systems.

Silviculture
The theory and practice of controlling the establishment, composition, growth and quality of forest stands. Can include basic silviculture (e.g., planting and seeding) and intensive silviculture (e.g., site rehabilitation, spacing and fertilization).

Site
A land area based on climatic, physical, biological and other factors that determine its suitability and productivity for particular species and silvicultural alternatives.

Site Class
Classification based on ecological factors and the potential production capacity of an area; a measure of the relative production capacity of a site.

Site Index
Measure of forest productivity generally expressed as the height in meters of dominant and co-dominant tree species at a specific index age such as 25,50, or 100 years. Site indexes are normally grouped by site classes.

Site Preparation
A mechanical, fire, chemical, or hand treatment that modifies the site to provide favourable conditions for artificial regeneration.

Slash
The residue left on the ground after timber cutting, or left after a storm, fire, or other disturbance event. Slash includes unused logs, uprooted stumps, broken or uprooted stems, branches, bark, etc.

Snag Tree
A dead standing tree at least 6 m in height that may provide roosting or cavity nesting/denning opportunities for wildlife.

Soil
The naturally occurring unconsolidated material on the surface of the earth that has been influenced by parent material, climate (including the effects of moisture and temperature), macro and micro-organisms, and relief, all acting over a period of time to produce soil that may differ from the material from which it was derived in many physical, chemical, mineralogical, biological, and morphological properties.

Soil Class
A group of soils having a definite range in a particular property such as acidity, degree of slope, texture, structure, land-use capability, degree of erosion, or drainage.

Soil Classification
The systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties.

Soil Horizon
A layer of soil or soil material approximately parallel to the land surface; it differs from adjacent genetically related layers in properties such as colour, structure, texture, consistence, and chemical, biological, and mineralogical composition.

Soil Order
A category in the Canadian system of soil classification. All the soils of Canada have been divided into nine orders: Chernozemic, Cryosolic, Solonetzic, Luvisolic, Podzolic, Brunisolic, Regosolic, Gleysolic, and Organic. All the soils within an order have one or more characteristics in common.

Soil Productivity
The capacity of a soil, in its normal environment, to produce a specified plant or sequence of plants under a specified system of management. The "specified" limitations are needed because no soil can produce all crops with equal success and a single system of management cannot produce the same effect on all soils. Productivity means the capacity of soil to produce crops and is expressed in terms of yields.

Soil Texture
The relative proportions of various sized soil particles separated from soil.

Softwood(s)
Cone-bearing trees with needles or scale-like leaves; also refers to the wood produced by these trees. Softwoods belong to the botanical group gymnospermae and are the predominant tree type in coniferous forests.

Stand
A community of trees sufficiently uniform in species, age, arrangement or condition so as to be distinguishable as a group in the forest or other growth in the area.

Stand Density
A quantitative measurement of a forest stand often expressed as number of stems, volume or basal area per unit area.

Succession
The replacement of one plant community by another in progressive development toward climax vegetation.

Sucker
A sprout from the lower portion of a stem, especially from the root.

-T-

Thinning
A partial cutting or spacing operation made in an immature forest stand to accelerate the growth of the remaining trees.

Threatened Species
A species that is likely to become endangered if certain pressures are not reversed.

Timber Operations
Includes all activities related to timber harvesting including site assessments, planning, road construction, harvesting, reclamation and reforestation.

Timber Stand Improvement
Intermediate thinning of a forest stand, prior to it reaching mature rotation age, generally for the purpose of improving growing conditions or controlling stand composition.

-U-

Understorey
The trees and other vegetative species growing under the canopies of larger adjacent trees and other woody growth.

Uneven-aged
The term uneven-aged is used to describe stand of trees in which ages of the trees generally differ by more than 20 years. These forest stands are made up of tree species which have evolved a regeneration pattern which is tolerant of lower light conditions and competition from other species.

-V-

Volume Table
A table showing gross volume of trees, based on given tree measurements.

Vulnerable Species
A species that is considered at risk because it exists in low numbers or in restricted ranges, due to loss of habitat or other factors.

-W-

Water Table
The upper surface of groundwater or the level in the ground where the water is at atmospheric pressure.

Watershed
An area of land that is drained by underground or surface streams into another stream or waterway.

Weeding
A release treatment in stands during the seedling stage that eliminates or suppresses undesirable vegetation regardless of crown position.

Wetlands
Those areas that are inundated by surface or ground water with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetation or aquatic life that requires saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Wildlife Habitat Diversity
The distribution and abundance of different plant and animal communities and species within a specific area.

-X-

Xeric Moisture Regime
A xeric habitat is characterized by soils that are well to rapidly drained and low or deficient in moisture that is available for the support of plant life.


Alberta
Government