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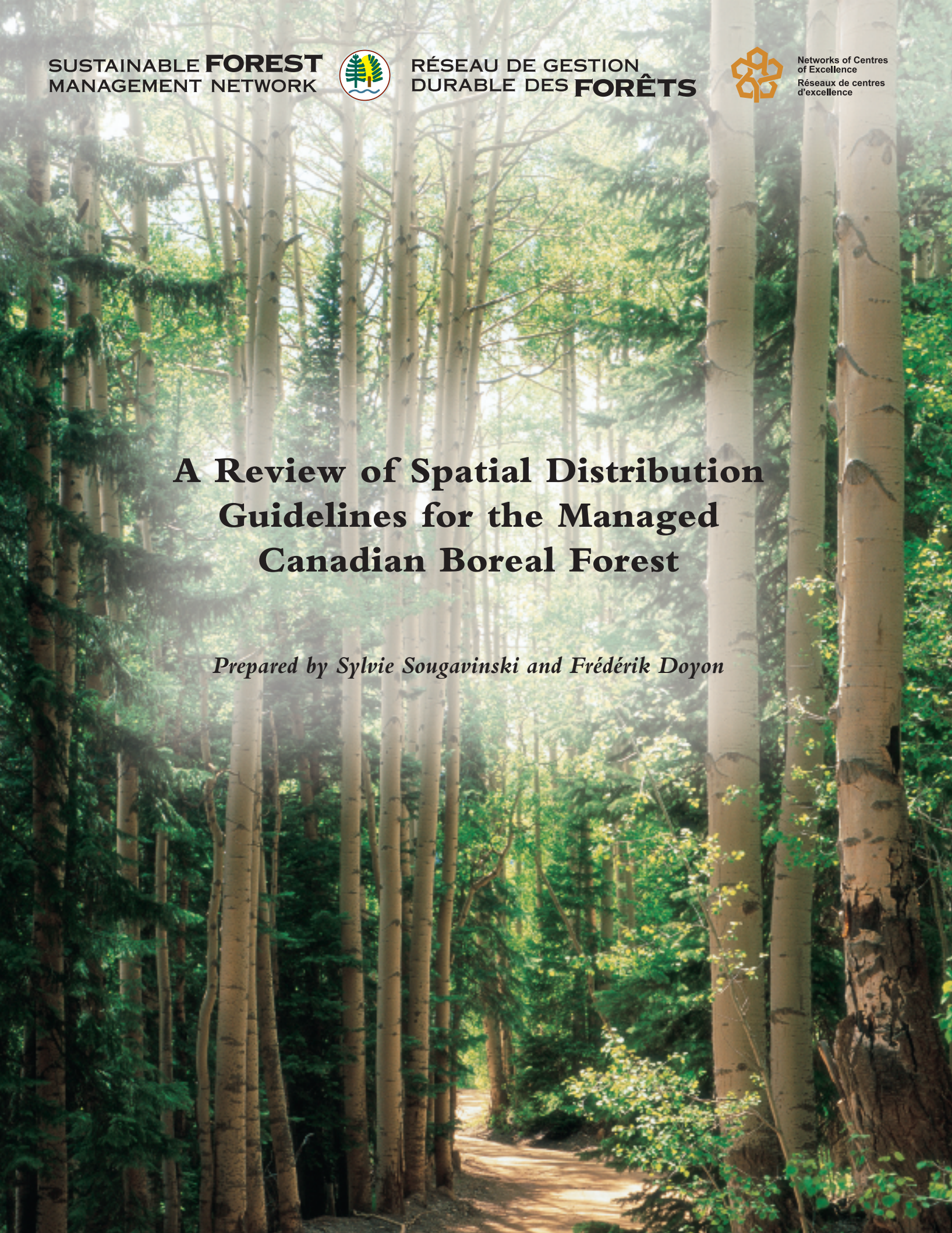

A Review of Spatial Distribution Guidelines for the Managed Canadian Boreal Forest

Prepared by Sylvie Sougavinski and Frédérik Doyon

THE SUSTAINABLE FOREST MANAGEMENT NETWORK

Established in 1995, the Sustainable Forest Management Network (SFM Network) is an incorporated, non-profit research organization based at the University of Alberta in Edmonton, Alberta, Canada.

The SFM Network's mission is to:
- Deliver an internationally-recognized, interdisciplinary program that undertakes relevant university-based research;
- Develop networks of researchers, industry, government, Aboriginal, and non-government organization partners;
- Offer innovative approaches to knowledge transfer; and
- Train scientists and advanced practitioners to meet the challenges of natural resource management.

The SFM Network receives about 60% of its $7 million annual budget from the Networks of Centres of Excellence (NCE) Program, a Canadian initiative sponsored by the NSERC, SSHRC, and CIHR research granting councils. Other funding partners include the University of Alberta, governments, forest industries, Aboriginal groups, non-governmental organizations, and the BIOCAP Canada Foundation (through the Sustainable Forest Management Network/BIOCAP Canada Foundation Joint Venture Agreement).

KNOWLEDGE EXCHANGE AND TECHNOLOGY EXTENSION PROGRAM

The SFM Network completed approximately 300 research projects from 1995 – 2004. These projects enhanced the knowledge and understanding of many aspects of the boreal forest ecosystem, provided unique training opportunities for both graduate and undergraduate students and established a network of partnerships across Canada between researchers, government, forest companies and Aboriginal communities.

The SFM Network's research program was designed to contribute to the transition of the forestry sector from sustained yield forestry to sustainable forest management. Two key elements in this transition include:
- Development of strategies and tools to promote ecological, economic and social sustainability, and
- Transfer of knowledge and technology to inform policy makers and affect forest management practices.

In order to accomplish this transfer of knowledge, the research completed by the Network must be provided to the Network Partners in a variety of forms. The KETE Program is developing a series of tools to facilitate knowledge transfer to their Partners. The Partners' needs are highly variable, ranging from differences in institutional arrangements or corporate philosophies to the capacity to interpret and implement highly technical information. An assortment of strategies and tools is required to facilitate the exchange of information across scales and to a variety of audiences.

The KETE documents represent one element of the knowledge transfer process, and attempt to synthesize research results, from research conducted by the Network and elsewhere in Canada, into a SFM systems approach to assist foresters, planners and biologists with the development of alternative approaches to forest management planning and operational practices.

Knowledge Exchange and Technology Extension Program (KETE)
Sustainable Forest Management Network

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Citation: Sougavinski, S. and F. Doyon. 2005. A Review of Spatial Distribution Guidelines for the Managed Canadian Boreal Forest. Translated from French, Original title: *Directives de répartition spatiale existantes pour la forêt boréale canadienne aménagée* (mars 2005). Sustainable Forest Management Network, Edmonton, Alberta. 100 pp.

ISBN # 1-55261-186-8
Printed in Canada
Cette publication est aussi disponible en francais
Published November 2005

EXECUTIVE SUMMARY

Timber harvesting modifies natural forest landscapes and, in the process, most likely alters ecosystem processes as well. Today, timber harvesting can no longer be carried out with the sole objective of maximizing profits. Pressures to protect social and ecological values are compelling the entire forest industry to manage forest landscapes using an approach more heavily based on natural forest dynamics. Such an approach seeks to reproduce, through forest harvesting , the patterns observed after natural disturbances. Planning the spatial distribution of cutblocks is therefore becoming increasingly important throughout Canada.

The objective of this study was to determine how various landscape elements are managed by various forest planning teams in Canada and why. The spatial elements considered were:

1. landscape management units;
2. landscape structure constraints, including size, shape and distribution of cutblocks, adjacency rules, connectivity, conservation areas and riparian areas; and
3. proportion constraints, including cover constraints, age class distribution and proportions of the silvicultural systems used.

1 — LANDSCAPE UNITS

How do Canadian organizations define the managed landscape: by administrative or ecological boundaries? The literature consulted indicates that boundaries are primarily administrative, and generally correspond to forest management areas or other licence areas granted by the province. Otherwise, most provinces and companies that have defined “ecological” planning units mainly use ecoregions or ecodistricts (topographical, climactic, pedological boundaries) primarily because this allows them to differentiate the various forest dynamics (succession, productivity, natural disturbance regime) occurring on the entire managed landbase. The landscapes generally range in size from 200 to 100,000 ha, but can be as large as 2.4 million ha in cases where their defining boundaries are strictly administrative.

2 — STRUCTURAL REQUIREMENTS

Size, shape and distribution of cutblocks

The configuration of cutblocks and their distribution across the landscape can significantly influence forest dynamics. For example, inappropriate management of these factors can result in the fragmentation of natural forests, which degrades wildlife habitats and makes the residual blocks more vulnerable to subsequent disturbances.

In Canada, cutblocks can range in size from 10 to 1,000 ha, but generally do not exceed 100 ha. Cutblock size distributions are governed mainly by the stand type, by the social constraints, by the natural stand boundaries, by the administrative as well as operational factors, and by the natural disturbance regime.

Cutblock shape is governed by similar factors, but more often by natural stand boundaries. Alternately, it follows the patterns of natural disturbances. Thus, wetlands and clumps of hardwoods are often left unharvested, for example in an attempt to emulate fire patterns. However, visual quality, worker safety, windthrow risk, silvicultural and operational constraints, and wildlife needs can also play a role.

The distance that wildlife must travel to find shelter, escape cover, or thermal cover can also limit the distance between two boundaries (and therefore size and shape). This distance, when required, ranges from 150 to 400 m. It can change depending on the needs of a particular wildlife species or the probability that an animal will be seen by humans.

Adjacency rules

Adjacency rules refer to the regulatory requirements related to cutblock distribution in the landscape over time. They determine whether a cutblock can be harvested based on the conditions of adjacent cutblocks. Generally, these regulations are governed by minimum tree height requirements in adjacent blocks. These rules are essentially the same throughout Canada, (typically 2 m or 3 m) varying mainly by stand type (2 m for softwood and 3 m for hardwood) and the number of passes carried out or planned in the block. A few provinces use the criterion of years elapsed (10 or 20 years) since the first pass. Buffer strips (~100 m) between the blocks are sometimes required in the event that the desired cutblock does not meet the prescribed rules.

The rationale for these rules is either silvicultural (in terms of the capacity to regenerate the sites), or social (in terms of the acceptability of the concentrations of cutblocks in the landscape). Some provinces, such as British Columbia, base their choice on principles related to the temporal and spatial distribution observed under a natural disturbance regime. Others, such as New Brunswick, base its rules on wildlife needs, and require that appropriate corridors be provided if the rules cannot be met.

Several groups establish wooded visual screens around specific sites (e.g., recreational, scenic, tourism) and along roadsides.

Connectivity rules

In many instances in Canada, a minimum degree of connectivity between stands and residual blocks is maintained. This is done by managing corridors composed of mature or overmature forests, established mainly to meet the needs of wide-ranging species. In general, in Canada, the boundaries of corridors are determined by structures present in the landscape (riparian areas or conservation areas, inoperable sites, old-growth forests, buffer strips). The aim is to incorporate connectivity into general forest planning (e.g. spatial distribution of cutblocks across the landscape). For example, researchers at the Fundy Model Forest use a set of information on wildlife needs to develop the spatial design of their network of corridors, resulting in strict procedures for establishing corridors.

Riparian areas

Buffer zones around lakes and streams are often maintained in order to preserve water quality and aquatic wildlife habitats. The width required may be fixed or variable, depending on the type of water body or its features. Generally, the wider the water body, the wider the buffer strip prescribed. Hence, buffer zones may be composed simply of lesser vegetation around ephemeral streams or stands, their prescribed width never exceeding 100 m. Only one province (British Columbia) requires the maintenance of both a protective buffer strip and a management area in which there are each distinct silvicultural requirements. Some groups argue that it would be preferable to determine the width of the buffer strips on the basis of local topographical features.

Conservation areas and habitats

The coarse-filter approach is widely used for the conservation of wildlife habitats. It is expected that by basing forest planning on natural disturbance regimes, most wildlife needs will be met. Otherwise, specific guidelines are instituted for certain species (or stands) for a variety of reasons. Protection of these zones is sometimes addressed by establishing a core area in which no intervention is permitted and a buffer zone in which forestry activities are restricted. Growing importance is being given to sensitive or unique environments at the stand level.

3 — PROPORTIONAL REQUIREMENTS

Cover constraints

Cover constraints are constraints which require that a proportion of a specified forest landbase be maintained in certain conditions deemed critical for a defined value. Hence, these are not static elements of the landscape.

When specified in provincial regulations, the proportion of forest cover that must be maintained in a landscape unit ranges from 5% to 35%. The objectives in this case are mainly related to maintaining wildlife habitats or stands and they are met by retaining old-growth forests, structure at the stand level and unique or sensitive environments. New Brunswick has designated the total area to be maintained by ecoregion and timber license for each preferential wildlife habitat identified at the outset, thereby ensuring that the variability of these habitats will be maintained at the provincial level. Alternately, the objectives set continue to be based on the concept of emulating the natural disturbance regime.

Age class distribution

Over the years, logging has greatly modified the age class distribution in landscapes. Several organizations have targeted an appropriate age class distribution based on the prevailing natural disturbance regime or the regime which would normally be observed under natural conditions.

Many organizations have devised strategies for maintaining or protecting old-growth forests (between 1-20%) rather than all seral stages, mainly after observing a decline of these forests on the landbase. The proportions maintained and the distribution adopted can reflect the representativeness of these forests under a natural disturbance regime, but are also sometimes influenced by timber supply

needs and ecological requirements (e.g. biodiversity). However, some groups have developed their targets by ecoregion for each stated forest cover type. New Brunswick goes further by specifying the exact area of old-growth forest to be preserved by forest cover type and by timber license.

Silvicultural systems used and distribution

The types of harvest systems used on a landbase have an enormous impact on the patterns in the landscape. All of the organizations surveyed appear to be trying to move away from conventional clearcuts towards alternative systems such as variable retention, shelterwood cutting, strip cutting and the use of multi-pass silvicultural systems. Once again, this trend reflects the objective of modelling human interventions in the landscape on the pattern of natural disturbances.

Conventional clearcuts continue to be used, however, for reasons of cost-effectiveness. The silvicultural systems used sometimes vary depending on the objective. Weyerhaeuser BC, for example, uses irregular shelterwood cutting solely in "old-growth" zones and selection cutting solely in "habitat" zones. It should be noted that such cutting regimes remain non-conventional for this type of forest.

ACKNOWLEDGMENTS

We would like to thank everyone who participated in the various stages of this study. This project would not have been possible without the participation of industry and government stakeholders who provided us with information by answering our questions, responding to our requests and sending us relevant documentation: Vern Bauman, Paul Boulianne, Joe Churcher, Francine Dorion, Simon Dyer, Glenn Dunsworth, John Gilbert, Donna Gracia, Alton Harestad, Brian Harvey, Vince Keenan, Luigi Morganitini, Frank Oberle, Greg Rowe, Eric Shroff and David Young.

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INTRODUCTION

Forestry activities have the potential to significantly alter landscapes and influence changes in forest dynamics. It is recognized that altering the spatial organization of ecosystems in landscapes or their component features influences ecological processes – the basic premise of landscape ecology (Forman and Godron 1986, Franklin and Forman 1987). The study of the effects of landscape pattern on ecological processes is relatively recent in the field of forestry. Interest in the subject is related to the worrisome decrease in the proportion of certain ecosystems, including the relative decline of old-growth forests in the landscape, and to commitments to maintain biodiversity. Forest managers and planners are now seeking to create more natural landscapes on the basis of an understanding of these landscapes and of the ecological processes associated with them. To this end, various organizations have developed guidelines for the spatial and temporal distribution of harvest cutblocks.

This report constitutes an overview of the landscape features taken into account by various Canadian organizations (government and industry) and of the reasoning (economic, ecological and social) behind these considerations.

The following aspects of spatial guidelines are considered:

1. *Definition of landscape unit*. This section intends to answer the following questions: How is the analysis of the landscape organized hierarchically? What are the management units to which these guidelines apply? What is the logic behind these choices?

2. *Structural requirements*.

    - *Size and shape*. This section addresses the spatial characteristics of cutblocks, i.e. size class distribution, shape guidelines.

    - *Adjacency rules*. This section addresses the rules which govern the spatial distribution of cutblocks.

    - *Connectivity rules*. Guidelines of this type are intended to ensure permanent travel corridors with few or no restrictions for spatially dynamic ecological processes.

    - *Riparian areas*. Riparian areas constitute vegetation strips of varying width left in place in order to reduce the risks associated with deterioration of the aquatic habitat.

    - *Conservation areas and habitats*. These elements are represented by the areas of the landscape for which there are explicit boundaries to protect certain values.

3. *Proportion requirements*

   - *Cover constraints*. Cover constraints are intended to maintain in perpetuity certain forest conditions in the landscape above a threshold deemed critical for the sustainable use of a resource. These constraints may be associated with maintaining certain habitats, viewsheds, water production functions, etc.

   - *Age class distribution*. Guidelines of this type are intended to maintain the age class distribution within a range deemed acceptable. This element applies, among other things, to the issue of old-growth forests.

   - *Silvicultural systems used and distribution*. Guidelines of this type stipulate a proportion of the landscape to be managed in accordance with a given silvicultural system in order to maintain the stand structure classes within a range deemed acceptable.

This document is divided into several sections, each related to the aspects of spatial guidelines outlined above. Each section is followed by a summary which provides an overview of the information gathered. This document also highlights the key components used and evaluated, and analyzes the relationship between the strategy adopted and the changes in forestry practices that these strategies entail. This analysis is intended to define an emerging common procedure which can be used as a planning tool.

Cautionary Note

It should be noted that the activities of the forest industry are sometimes severely restricted by provincial legislation. Hence, the following overview discusses the guidelines followed by the organizations only when these guidelines add a new element or concept to the subject discussed. It is therefore important not to interpret the absence of a company in a given section as an absence of guidelines on the subject discussed.

1. Definition of landscape unit

The first task in understanding the landscape as an ecological system is to define the term "landscape" itself. The most widely used definition is that of Forman and Godron (1986) who define it as "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout." A landscape is larger than a stand and smaller than a region. It represents a certain recurrence of conditions of spatial arrangement of landscape features. Its area therefore varies greatly depending on the elements deemed to determine its structure.

This first section endeavours to present, for each organization, how the structural hierarchy of the landscapes is understood and how the elements of each hierarchical level are delineated. This section also discusses how this understanding of the structural organization of the landscape is translated into functional management units on which the planning of forestry activities is based.

1.1 British Columbia

1.1.1 Government requirements

Landscape units in British Columbia are defined in *Higher Level Plans: Policy and Procedures* (British Columbia Ministry of Forests 1996). They are described as areas of land and water used for long-term planning of resource management activities from a perspective of conservation of biodiversity. In principle, landscape units should be delineated on the basis of topographic or geographic features. For instance, a watershed is one of the main criteria used to define them. It is also suggested that these boundaries be based on the various recognized natural disturbance regimes so as to homogenize the unit in question. However, existing administrative boundaries and road networks may also be used to delineate landscape units when the topography is less complex, unless this compromises ecological values.

A unit can be as large as 100,000 ha. The design of units (configuration and size) must take into account existing regional divisions to facilitate management, while avoiding excessively small areas which could have a negative impact on timber supply in the short term. Landscape units can include current or proposed protected areas as defined by the *Protected Area Strategy* (British Columbia Ministry of Forests 1996).

Once the landscape units of a subregional planning area have been delineated, one of three biodiversity emphasis options is assigned to them on the basis of various ecological, topographical, social or economic and administrative criteria. These various options are as follows:

- High: gives priority to the conservation of biodiversity
- Intermediate: Compromise between the conservation of biodiversity and timber production
- Low: gives priority to other social and economic values (e.g. timber production).

These biodiversity emphases are associated with various management requirements (conservation, connectivity, age classes) (Table 1). The evaluation, by the provincial government, of the economic and social impacts versus the risk to biodiversity incurred (provincial level) has led to the development of a framework for assigning these emphases.

Table 1. Comparison of various biodiversity emphasis options (BEO). Source: British Columbia Ministry of Forests (1995).

RANGE OF MANAGEMENT ALTERNATIVES FOREST PRACTICES CODE WITH BIODIVERSITY GUIDEBOOK OPTIONS			
BIODIVERSITY FACTORS AND RECOMMENDATIONS	**LOWER BIODIVERSITY EMPHASIS**	**INTERMEDIATE BIODIVERSITY EMPHASIS**	**HIGHER BIODIVERSITY EMPHASIS**
Risk to biodiversity	High	Intermediate	Low
Timber impact	Low	Intermediate	High
Distribution of BEO within a subregional planning area	45% (30-55%)	45% (35-60%)	10%

This distribution is expected to limit the short-term impact of the *Biodiversity Guidebook* on the timber supply to 4% above the amount specified in the provincial timber supply review.

It should be noted that the lower biodiversity emphasis option was based on the assumption that it would not be applied to more than approximately half of the area of any biogeoclimatic subzone of a subregional plan or of a forest district.

It is suggested that concentrating units of lower biodiversity emphasis on large contiguous areas be avoided in order to minimize the significant impact on biodiversity that such a distribution could represent. It should be noted, however, that a landscape unit may contain a few small areas or sectors of different biodiversity emphasis (Figure 1).

Once the landscape units have been delineated and the biodiversity emphasis options have been assigned, biodiversity conservation objectives can be established. The definition of these objectives falls into two major categories; biodiversity (priority and integral) and forest resources.

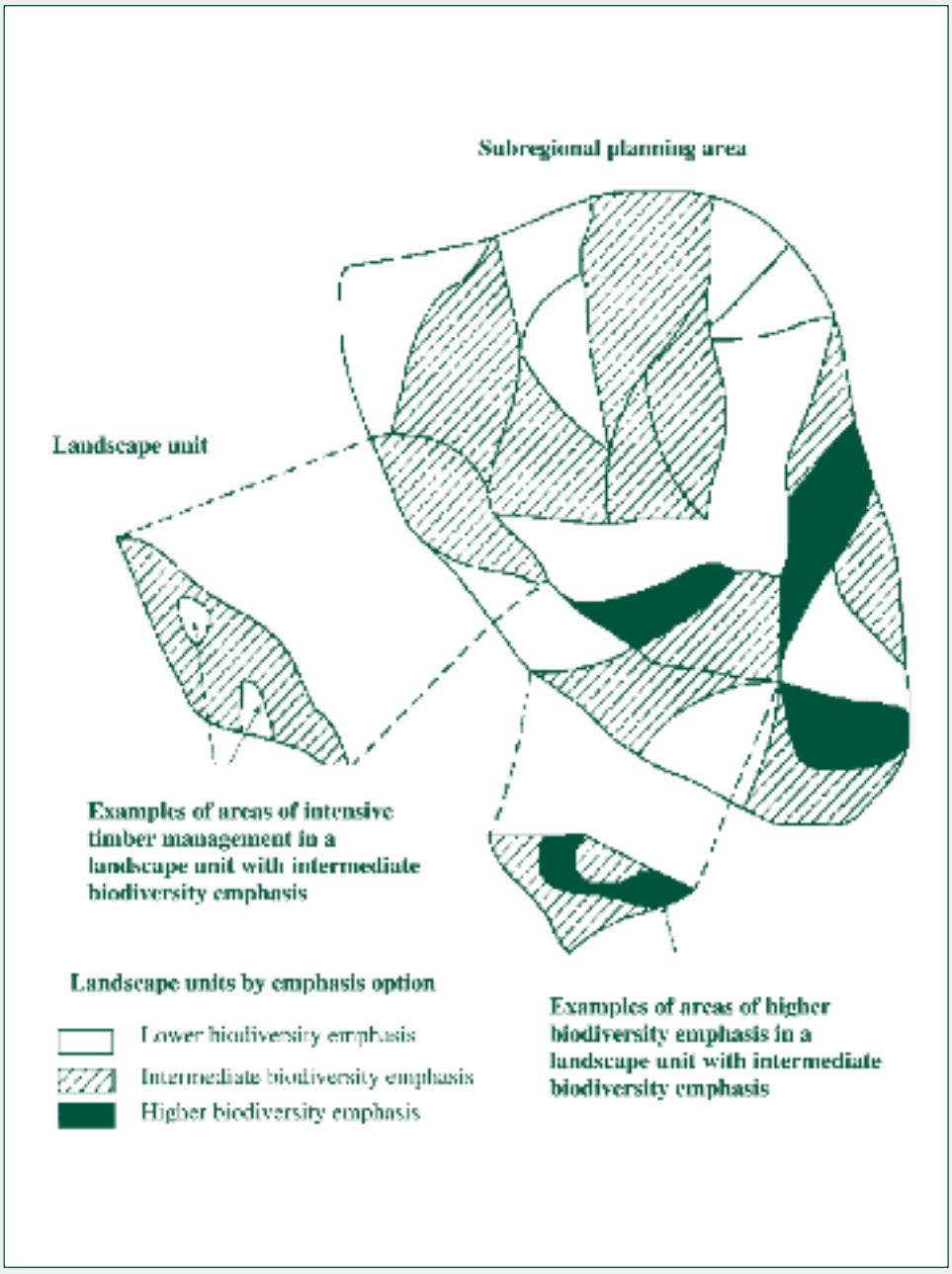


Figure 1. Example of the application and distribution of biodiversity emphasis options for landscape units within a subregional planning area. Source: British Columbia Ministry of Forests (1995).

Once again, these objectives can be determined using the *Biodiversity Guidebook* (British Columbia Ministry of Forests 1995). To this end, five natural disturbance types are recognized as occurring in British Columbia (Table 2).

The disturbance types that occur in biogeoclimatic zones, subzones and variants have been identified (Appendix 1). Once these disturbance types have been mapped, based on the biogeoclimatic subzones and variants present in the landscape unit, the appropriate recommendations are used to establish the biodiversity objectives for the unit.

Table 2. Natural disturbance types identified and recognized in British Columbia. Source: British Columbia Ministry of Forests (1995).

TYPE	DESCRIPTION
NDT1	Ecosystems with rare stand-initiating events
NDT2	Ecosystems with infrequent stand-initiating events
NDT3	Ecosystems with frequent stand-initiating events
NDT4	Ecosystems with frequent stand-maintaining fires
NDT5	Alpine Tundra and Subalpine Parkland ecosystems

1.1.2 Industry example: Clayoquot Sound

A group of experts recommended three levels of planning in Clayoquot Sound: subregional, watershed, and stand. The recommended planning is area-based rather than volume-based in the context of ensuring successful ecosystem-based management in the region (Clayoquot Sound Scientific Panel 1995).

The planning process identifies the area in the watershed available for timber production, specifies a rate (percentage of area per year) at which the watershed can be harvested, and identifies the locations where harvesting may occur. Forest reserves, based on credible biological and physical criteria, are designated at the watershed level before the delineation of harvestable areas and subsequent planning of specific forestry activities. The timber volume available for harvest each year from a watershed planning unit is determined by the planning process and depends on the characteristics of the area available for harvest.

1.1.3 Industry example: Weyerhaeuser Coastal BC

Weyerhaeuser's operating areas have been divided into three stewardship areas: timber (emphasis on commercial production), habitat (emphasis on the conservation of a wide range of wildlife habitats by maintaining a variety of structures) and old-growth (emphasis on the preservation of old-growth forests and their associated species in the landscapes) (Beese et al. 2003).

The landscape units used by Weyerhaeuser Coastal BC are delineated on the basis of watershed boundaries, and the size of each unit generally ranges from 10,000 to 50,000 ha (G. Dunsworth, pers. comm.).

1.1.4 Industry example: IISAAK Forest Resources

Iisaak is guided both by the *Forest Practices Code of British Columbia Act* and the recommendations of the Clayoquot Sound Scientific Panel (G.Rowe, pers. comm.).

The company uses two planning levels: watersheds of approximately 10,000-30,000 ha as well as individual drainages between 200 and 2,000 ha (G. Rowe, pers. comm.).

1.2 Alberta

1.2.1 Government requirements

The management unit boundary is purely administrative at the level of the Forest Management Unit (FMU) or the Forest Management Agreement (FMA) area.

1.2.2 Industry example: Daishowa Marubeni International Ltd.

This company owns three separate parcels of land of approximately 0.4, 0.2 and 2.4 million ha within the management area assigned to it. Within these parcels, there are no ecological subboundaries (apart from the fact that they are divided into hauling zones for purposes of modelling of harvesting costs) (F.Oberle, pers. comm.). For this type of property, a boundary based on the watershed is not considered to be a practical or useful unit. In the largest unit, which they are currently reworking, there may eventually be subdivisions, but strictly for administrative reasons.

1.2.3 Industry example: Alberta-Pacific Forest Industries Inc.

The area granted to this company under a Forest Management Agreement is divided into logical units primarily on the basis of administrative and operational criteria which facilitate forest management (Anonymous 2000*a*, Anonymous 2000*b*). Natural subregions, for the application of forest growth and research at the forest management agreement level, are also planned for implementation (Anonymous 2000*b*). Site-level information is used to determine the type of harvesting and the silvicultural system (Anonymous 2000*b*).

1.2.4 Industry example: Weyerhaeuser Alberta

The company operates in four FMA's of approximately 1 million ha each. The landscape unit in one FMA area is defined on the basis of the ecological classification of the territory or ecodistrict. In another FMA, landscape units are defined not only by ecological associations, but also by the many other activities or uses occurring on the area. These units range from 50,000 to 100,000 ha (L.Morgantini, pers. comm.).

1.2.5 Industry example: Millar Western Forest Products

Millar Western is responsible for managing a FMA of 300,000 ha. The Detailed Management Plan prepared for this area focuses on the integrated management of the forestry values related to timber harvesting, renewal and maintenance (Anonymous, no date a). The ground rules established by the company indicate that each FMA/FMU will be divided into compartments for which operational plans will be developed. However, forest operators are expected to maintain the biodiversity and ecological integrity of the landscapes that they manage (Anonymous 2002). The company relies on the definition of Forman (1996) to define the term "landscape" and adds that it may correspond to climactic, physiographic or ecological boundaries, but must also include the various human uses and the modification of the environment.

1.3 Saskatchewan

1.3.1 Government requirements

The administrative forest management unit constitutes the forest planning unit in the province of Saskatchewan.

1.3.2 Industry example: Weyerhaeuser Saskatchewan

Weyerhaeuser Saskatchewan is responsible for managing an area of 3.16 million ha under a Forest Management Licence Agreement (FMLA) (Anonymous 1999). Forest management activities are carried out on 10 forest management units specified in the agreement on the basis of soil type. These units have been grouped into three major forest management zones or landscape units: 1) mixed forest zone, 2) softwood forest zone and 3) northern Canadian shield zone. Table 3 outlines the management framework used by the company to develop target objectives.

Table 3. Types of ecosystem targets and corresponding planning scales determined by Weyerhaeuser Canada, Saskatchewan Division. Source: Anonymous (1999).

FOREST MANAGEMENT TARGET	MANAGEMENT UNIT (SCALE)
Annual timber supply	FMLA
Age class distribution	FMLA
Plant associations (maximum harvest volumes)	FMLA
Harvest blocks and residual blocks	FMLA
Mature and overmature seral stages (minimum retention rates)	Forest management units (10)
Retention of structures	Stand

1.4 Manitoba

1.4.1 Government requirements

According to the Timber *Harvesting Practices for Forestry Operations in Manitoba*, forest planning is to occur at the management unit level (Manitoba Natural Resources 1996).

1.4.2 Industry example: Louisiana-Pacific Canada Ltd.

The management area granted to the company is divided into three forest management units which constitute the planning level (D.Gracia, pers. comm.).

1.4.3 Industry example: TEMBEC-Pine Falls

The forest management unit constitutes the landscape unit for the company. However, Tembec uses watershed boundaries as the monitoring unit, a unit that may range from 10,000 to 50,000 ha (V. Keenan, pers. comm.).

1.5 Ontario

1.5.1 Government requirements

Most Ontario Crown forests are divided into forest management units. The responsibility for several aspects of the management of these units is delegated to companies through Sustainable Forest Licences (Ontario Ministry of Natural Resources 2001).

1.5.2 Industry example: Abitibi Consolidated

The management unit for the Crossroute Forest in Fort Frances, managed by Abitibi Consolidated (1,588,890 ha, of which 821,992 ha is productive forest), is divided into units which normally have similarities in terms of composition and development and are managed under the same silvicultural system (Anonymous, no date *b*).

1.6 Quebec

1.6.1 Government requirements

In Quebec, forests are managed under agreements in the form of Timber Supply and Forest Management Agreements or TSFMA's. These are contractual agreements, between the government and the holder of an operating permit for a wood processing plant. They govern the management of the forest area where the operator is authorized to harvest a certain volume of wood to supply its plant (Quebec Government 2002). Several holders of TSFMA's can harvest wood in the same area. This constitutes a "common area." Currently, all divisions in the common areas are under review, with the aim, among other things, of adjusting their often strictly administrative boundaries to ecological boundaries.

Forest management work must comply with the *Regulation respecting standards of forest management for forests in the public domain* (Province of Quebec 2001). To this end, TSFMA's are subdivided into territorial units called "territorial reference

units" (Quebec Government 2002). These are defined as "a common area or a subdivision thereof forming a single block and measuring less than 100 km^2 in the case of the hardwood forest zone, less than 300 km^2 in the case of the fir and mixed forest zone and less than 500 km^2 in the case of the spruce forest zone […]" (Province of Quebec 2001).

1.6.2 Industry example: Lake Duparquet Teaching and Research Forest (FERLD)

The Lake Duparquet forest is a 80 km^2 teaching and research forest (**Harvey et al. 2002**, *Forêt d'enseignement et de recherche du lac Duparquet 2002*) in which an ecosystem-based forest management approach is being developed. The forest is divided into two main parts: (1) a management area (75% of the area) in which a forest management plan based on the natural disturbance regime is implemented and (2) a conservation area (25%) used as a control.

The forest is divided into cohorts, each representing a different age class structure. These units have been delineated on the basis of an evaluation of the natural disturbance regime, the ecosystem classification and the characterization of forest dynamics (succession) at the stand level. The resulting multi-cohort arrangement makes it possible to maintain the landscape in a semi-natural age structure and composition.

1.6.3 Industry example: Montmorency Forest

The Montmorency Forest is used as a teaching and research forest by Laval University and managed using an integrated resource management approach. This is a boreal wet fir forest of 67 km^2 (6,664 ha). The landscape is divided into five subunits (landscape units) ranging in size from 3 to 10 km^2 each, delineated on a functional basis (e.g. intensive and extensive recreation, conservation), related to assigned objectives.

1.7 New Brunswick

1.7.1 Government requirements

The Crown forest of New Brunswick is subdivided into timber licenses, which are granted to the major forestry companies. A document prepared by the New Brunswick Department of Natural Resources and Energy serves as a guide for preparing forest management plans in the province (Province of New Brunswick 2000).

The objectives set out in the document *A Vision for New Brunswick Forests – Goals and Objectives for Crown Land Management* include maintaining the diversity of forest ecosystems and associated ecological values, on both a large and small scale, and were determined on the basis of the characteristics of each ecoregion (Province of New Brunswick 2000).

1.7.2 Industry example: Forest Management Guidelines to Protect Biodiversity in the Fundy Model Forest

The Greater Fundy Ecosystem Research Group believes that if one of the objectives of forest harvesting is to protect biodiversity, the harvesting method

selected must produce results similar to the disturbance regime characteristic of the area or of the forest type (Woodley and Forbes 1997). To attain this goal, a macro-scale (coarse filter) and micro-scale (fine filter) strategy is used.

The guidelines argue that to manage forests on the basis of historical disturbance regimes, it is important to adopt a stand-replacing or gap-based management approach. This distinction must be established first at the ecodistrict level (aggregations of forest communities based on climactic, geological and pedological characteristics) and then at the level of ecological units, which are characterized by differences reflected by the objectives associated with a given landscape as well as by the degree and type of harvesting practised.

Guidelines for the amount of tree removal within a watershed are being developed. It has been shown that the hydrology and nutrient regime of a watershed changes with disturbance, and the Greater Fundy Ecosystem Research Group hope to describe this relationship in the future.

1.7.3 Industry example: JD Irving Limited

The company manages its operations using an ecoregion-based system. Ecodistricts are used to establish yield curves adjusted to regional conditions (David Young, pers. comm.).

1.8 Nova Scotia

1.8.1 Government requirements

Management is carried out at the forest management unit level.

1.9 Newfoundland

1.9.1 Government requirements

Management is practised at the level of the forest management unit, called a "district." These districts range in size from 0.5 to 1.5 million ha.

1.10 Summary

In Canada, management units appear to be delineated primarily on an administrative basis, as defined by the history of allocation of management areas (Table 4). While some groups do indeed divide their managed areas into subunits, in most instances the spatial hierarchical structure of planning is dictated by operational considerations. This is probably due to a variety of provincial or internal administrative reasons. However, although these boundaries are not based on "ecological" objectives, they do not appear to prevent the integration of ecological elements or features, therefore demonstrating that the use of the "landscape" is recognized in forest planning. Alberta-Pacific, for example, plans to use natural subregions for growth and yield and research purposes, while Tembec monitors its lands on a watershed basis.

British Columbia is truly unique with respect to its hierarchical ecological classification system that is imbedded within the planning structure, an approach that resembles that of TRIAD. In British Columbia, defined landscape units are used to determine the main objectives, in this case protection of biodiversity. These objectives offer at the outset targets to be attained with respect to certain landscape elements (age class distribution, connectivity, etc.). Attaining these targets is then managed by biogeoclimatic zones, subzones and variants which in turn determine the natural disturbance regime type, an important determinant in forest planning.

Most other provinces and companies outside British Columbia, which have defined "ecological" planning units, use these landscape classification systems to manage certain aspects related to forestry activities. They then use ecoregions, ecosites or ecodistricts in which the natural disturbance regimes are sometimes described. However, this approach is somewhat difficult to apply in Canada and the trend is increasingly toward using more ecological definitions of managed landscapes with the aim of distinguishing among the various natural disturbance types.

Landscapes are also delineated on the basis of use, as observed in the two teaching and research forests in Quebec.

The landscapes delineated (ecoregions or other) range in size from 200 to 100,000 ha. However, the planning units are often significantly larger when they are delineated on the basis of administrative considerations, sometimes up to 2.4 million ha.

Table 4. Summary table of the various management units used for forest planning in Canada.

PROVINCE	DELINEATION CRITERIA	SIZE
1. BRITISH COLUMBIA		
Government requirements	ecological (topographical or geographical)	≤ to 100,000 ha
Clayoquot Sound Scientific Panel (1995)	ecological (watershed)	variable
Weyerhaeuser Coastal BC	ecological (watershed)	10,000 and 50,000 ha
Iisaak	ecological (watershed) ecological (drainage divide)	10,000-30,000 ha 200-2,000 ha
2. ALBERTA		
Government requirements	administrative	variable
Daishowa Marubeni . International Ltd	administrative and operational	0.4, 0.2 and 2.4 Mha
Alberta-Pacific Forest Industries Inc.	administrative and operational	not specified
Weyerhaeuser Alberta	ecological and social	50,000-100,000 ha
Millar Western Forest Products	administrative and operational	not specified

PROVINCE	DELINEATION CRITERIA	SIZE
3. SASKATCHEWAN		
Government requirements	administrative	not specified
Weyerhaeuser Saskatchewan	ecological (pedological)	variable
4. MANITOBA		
Government requirements	administrative	not specified
Louisiana-Pacific Canada Ltd.	administrative	not specified
TEMBEC-Pine Falls	administrative	not specified
5. ONTARIO		
Government requirements	administrative	variable
Abitibi Consolidated	ecological (composition, seral stage)	not specified
6. QUEBEC		
Government requirements	administrative	100 km^2, 300 km^2 or 500 km^2
Lake Duparquet Teaching and Research Forest	functional	– management area: 75% of the land area – conservation area: 25% of the land area
Montmorency Forest	functional	3-10 km^2
7. NEW BRUNSWICK		
Government requirements	ecological (ecoregions)	not specified
Fundy Model Forest	ecological (ecodistricts)	not specified
JD Irving Limited	ecological (ecoregions)	not specified
8. NOVA SCOTIA		
Government requirements	administrative	not specified
9. NEWFOUNDLAND		
Government requirements	administrative	0.5–1.5 Mha

2. Structural requirements

Structural requirements include any guideline concerning the arrangement or spatial organization of landscape elements. For the purposes of this review, we distinguish five components:

1. Size, shape and distribution of cutblocks

The size, shape and distribution of cutblocks might influence the dynamics of the landscape. For example, the impacts of the dispersal of small cutblocks in a given

landscape (checkerboard) and the uniformity of their boundaries are now being questioned. It is believed that this results in greater fragmentation of natural forests (Habin 1993), thereby degrading wildlife habitats and increasing the susceptibility of residual patches to disturbance (Franklin and Forman 1987).

2. Adjacency rules

Adjacency rules influence the distribution of cutblocks in the landscape over time. Should these rules favour a contiguous aggregation or rather a mosaic dispersed in the landscape? At what level does this aggregation occur? Is access to the territory subject to seasonal restrictions?

3. Connectivity rules

Landscape connectivity might be an important factor for a number of populations. Corridors are delineated areas intended to connect similar habitats in a landscape in order to facilitate species movement and dispersal. Connectivity can be provided by a riparian buffer strip that links mature forest habitats to a cutover, for instance. The effectiveness of a corridor in providing connectivity often depends on its width and how frequently it appears to be interrupted or discontinuous for the targeted species.

4. Riparian areas

Riparian areas are strips of vegetation maintained along watercourses and around lakes. The characteristics of these vegetation strips differ for the various planning teams depending on the importance accorded to watercourses and adjacent habitats.

5. Conservation areas and habitats

Areas delineated for specific production and conservation functions are discussed here. This includes any element of the landscape conserved permanently such as conservation areas, visual screens, protected habitats, sensitive environments, and any other delineated area in which special management practices are carried out.

It should be noted, however, that several provinces (e.g. Ontario, British Columbia) have developed specific guidelines for the conservation of various habitats or wildlife species. These guidelines are too numerous to describe here, but we indicate the general idea of what these guidelines are intended to accomplish, where they exist.

This section therefore examines and describes, for the various provinces and several major Canadian companies, the guidelines related to each of the types of structural requirements mentioned above.

2.1 British Columbia

2.1.1 Government requirements

2.1.1.1 Size, shape and distribution of cutblocks

The legal maximum size of a cutblock is 40 ha or 60 ha depending on which forest region the cutblock is in (Government of British Columbia 1995a, Government of British Columbia 1998). However, the *Operational Planning Regulation* (Government of British Columbia 1998) indicates that this limit can change if the cutblock in question is located within a sector covered by an approved higher level plan, which includes biodiversity conservation objectives (British Columbia Ministry of Forests 1995).

Cutblocks can also vary in size for hydrological, ecological, wildlife, recreational, silvicultural or other reasons, for example, but in such cases government approval must be obtained (Government of British Columbia 1998).

The *Biodiversity Guidebook* (British Columbia Ministry of Forests 1995) makes recommendations on forest patch size based on the type of natural disturbance regime. The Guidebook also provides suggestions on the distribution of cutblocks and leave areas. For example, the objective in an environment characterized by disturbance type NDT1 (rare stand-initiating events) is to maintain a range of small to large (up to 250 ha) similarly aged forest patches in the landscape. The forest patch size distribution applies to both harvest units and leave areas in the landscape units.

Following this same example, a combination of small dispersed clearcuts and some dispersed partial cuts could be used in this type of disturbance (Table 5). It is also suggested that large openings (larger than 40 or 60 ha) be created by using a few large aggregated harvest units along with mature and old seral stage forests maintained in a connected network. The size range of leave areas should be the same as that for openings.

Table 5. Example of a recommended distribution of patch sizes (harvest units and leave areas) for Natural Disturbance Type 1 within British Columbia's biodiversity guidelines. Source: British Columbia Ministry of Forests (1995).

PATCH SIZE IN HA (SINGLE CUTBLOCK OR AGGREGATION OF CUTBLOCKS)	% FOREST AREA WITHIN LANDSCAPE UNIT
<40	30-40
40-80	30-40
80-250	20-40

The shape of cutblocks is mainly governed by the *Visual Quality Objective Guidelines*. Visual inventories are conducted at the landscape level with the aim of delineating, classifying and recording the areas in the province considered visually sensitive (British Columbia Ministry of Forests 2001). This information is taken into account during planning and allows managers to identify scenic areas and to establish visual quality objectives. After analysing the effect of these decisions on timber supply, forestry practices are developed to attain these objectives. A monitoring program is then instituted in order to evaluate whether the chosen forestry practices are appropriate.

It is the responsibility of all licensees to address visual resource management when operating in scenic areas with or without visual quality objectives.

2.1.1.2 Adjacency rules

The *Timber Harvesting Practices Regulation* (Province of British Columbia 1998*b*) provides specifications concerning the distribution of cutblocks on the landscape. The regulation states that a licensee can harvest a cutblock adjacent to a previously harvested cutblock if 75% of its net area (or other percentage specified by the district manager) meets the greened-up requirements unless another sector (again specified by the district manager) adjacent to the one in question is sufficient in size to adequately manage and conserve the forest resources.

A cutblock is greened-up if it is adequately stocked (≥ 800 (on the Coast) or ≥ 1,000 trees per ha (in the Interior)) and the average height of the tallest trees of a representative sample of the commercially valuable species is at least 3 m.

Alternately, a cutblock is greened-up if it is not adequately stocked and the average height of the trees mentioned is at least 3.5 m, and either:

1. the cutblock is stocked with at least 500 trees per ha for the Coast or 700 trees per ha for the Interior, that are commercially valuable and at least 1.3 m in height, or

2. the district manager is satisfied that the cutblock is stocked with a sufficient number of trees per ha of a species that will result in adequate management and conservation of hydrological, wildlife, recreational and scenic values.

The district manager may vary the number of trees per ha at least 3 m in height required to meet the greened-up requirements, exclude a species from being counted for the purposes of these requirements or even vary the average height requirement for reasons of conservation or management of forest resources or of hydrological, wildlife, recreational and scenic values.

It should be noted that exceptions may apply.

2.1.1.3 Connectivity rules

It is suggested that connectivity in planning units be ensured by means of Forest Ecosystem Networks (FEN's) (British Columbia Ministry of Forests 1995). A FEN is a contiguous network of representative old-growth and mature forests delineated in a managed landscape. Connectivity can be provided in part by the mature forests of riparian areas and through other areas excluded from forest yield (e.g. retention areas, areas designated as high visual quality areas, sensitive, unstable or inoperable sites).

Provision can also be made for connectivity through the strategic location of Old Growth Management Areas (OGMA). Otherwise, connectivity may be enhanced by the application of partial cuts and by the appropriate distribution of cutblocks. The *Biodiversity Guidebook* (British Columbia Ministry of Forests 1995) provides guidelines on the importance of natural connectivity characteristics for each type of natural disturbance. Connectivity needs vary depending on the disturbance types (see Table 6).

Table 6. Example of guidelines on the frequency at which the connectivity characteristics of natural mature/old seral stage ecosystems should occur for Natural Disturbance Type 1. Source: British Columbia Ministry of Forests (1995).

NATURAL CONNECTIVITY CHARACTERISTICS	FREQUENCY OF OCCURRENCE
Upland to upland	High
Upland to stream	High
Upland to wetland	High
Cross-elevational	High
Wetland complex	Low – moderate
Riparian corridors	High
Island remnants	Low

Since the legally established landscape unit objectives focus on components such as OGMAs, the objectives defined for the unit may not necessarily delineate or define the FEN (British Columbia Ministry of Forests 1999). It is argued, however, that this concept may help in the preliminary stages of landscape unit planning.

2.1.1.4 Riparian areas

Riparian areas are located near watercourses, lakes and wetlands and include both the very wet environments and the adjacent vegetation that influences them. A riparian area consists of a management zone in which certain constraints apply, and sometimes a reserve zone (Government of British Columbia 1995b). The width of these zones is determined by the attributes of the watercourses, wetlands or lakes as well as of the adjacent terrestrial ecosystems.

There are six stream riparian classes (S1 to S6). Each is classified according to whether fish are present, whether it occurs in a community watershed and the average channel width. The minimum width of the reserve zone near watercourses ranges from 0 to 50 m, while the width of the management zone ranges from 20 to 100 m.

Five types of wetlands (W1 to W5) are classified by whether the wetland is a simple wetland or a complex wetland, by wetland size and by the biogeoclimatic unit in which the wetland occurs. The width of the reserve zone, when required, is 10 m, while the width of the management zone can be 20, 30 or 40 m.

Lakes are divided into four groups, based on lake size and the biogeoclimatic zone in which they occur. The width of the reserve zone can be 10 m, while the width of the management zone is 0, 20 or 30 m.

Recommended forestry practices have been developed taking into account their potential impact on the timber supply. For instance, for each site, a variable retention rate is prescribed. The following table (Table 7) summarizes the maximum overall retention rates in the management zones for each riparian class.

Table 7. Acceptable overall levels of basal area retention within the riparian management zone for each riparian class of stream, wetland and lake (overall average is calculated as the average for all the cutblocks in a forest management plan). Source: Government of British Columbia (1995b).

Riparian class	Maximum overall retention (%)
Stream	5% to 50% of the basal area
Wetland and lake	25% of the basal area

2.1.1.5 Conservation areas and habitats

Wildlife management areas are delineated, mapped and approved habitats for which there are mandatory management measures. A measure may partially (e.g. seasonally) or completely restrict activities. General wildlife measures prescribe a level of management appropriate to the conservation status of the identified wildlife species. In most cases, these management areas contain a core area, which is protected from all alteration, and a buffer zone. It should be noted that the measures taken for several of the identified species are applied at the stand level (Appendix 2).

2.1.2 Industry example: IISAAK

2.1.2.1 Size, shape and distribution of cutblocks

There do not appear to be any restrictions of this type, provided that at least 40% of the trees are retained and adequately distributed throughout the cutblock (Greg Rowe, pers. comm.). Otherwise, the harvest area must not exceed 40 ha.

2.2 Alberta

2.2.1 Government requirements

2.2.1.1 Size, shape and distribution of cutblocks

Cutblock size varies depending on the stand type (Province of Alberta 1994a). Cutblocks in deciduous stands or in stands where pine comprises 40% or more of the merchantable timber volume may reach 100 ha, but an average size of 60 ha is recommended. Cutblocks in spruce stands may be clearcut to a maximum of 24 ha in patches or 32 ha in strips where no part of the cutblock is farther than 150 m of a seed source. If a formal commitment is made to treat and plant the cutblock within 24 months of harvesting, the cutblock size may be increased. Proposed cutblocks larger than these standards may be approved for reasons that include layout design, reduction of road construction, reduction of environmental impacts and economic considerations (Province of Alberta 1994a).

The *Timber Harvest Planning and Operating Ground Rules* (Province of Alberta 1994a) state that cutblock boundaries should follow natural terrain features and timber type boundaries to minimize the impact of logging. However, the size and shape of cutblocks may be modified in cases where water-source areas or the water table may be significantly altered by logging, creating a risk of reforestation failure (Province of Alberta 1994a).

Finally, it is suggested that harvest design should minimize the risk of stand degradation and windfall that might provide a refuge for insect infestations or disease.

2.2.1.2 Adjacency rules

Subsequent pass cutblocks may be approved for harvest when adjacent previously harvested cutblocks are reforested to the standards set out in the *Timber Management Regulation* (Province of Alberta 1994b). These requirements stipulate that 80% of the 10 m^2 units contained in the blocks must be stocked and contain at least one established seedling which, in 60% of cases, must be a desired species. In addition, the blocks must not contain any area larger than 4 ha that does not meet these requirements under the *Timber Management Regulation* (Province of Alberta 1994b).

The *Timber Harvest Planning and Operating Ground Rules* also stipulate that the regeneration must have reached a height of 2 m in coniferous blocks where a three-pass harvest is planned, and 3 m where a two-pass harvest is planned (Province of Alberta 1994a). It is also important that the regeneration in deciduous blocks has reached 3 m in height and that 10 years have passed since the previous harvest pass (Province of Alberta 1994a).

Where an integrated harvest plan is proposed, the first pass coniferous and deciduous cutblocks should not share a common border. Where it is unavoidable, the maximum cutblock sizes and dimensions shall not exceed the dimensions for the deciduous cutblock. The boundary between the coniferous and deciduous cutblocks shall be clearly marked (Province of Alberta 1994a).

In cutblocks, the distance to hiding cover should not exceed 200 m if adequate measures are taken to improve cutblocks for wildlife (e.g. creating irregular edges, leaving residual stands, ensuring understories, leaving woody debris). Otherwise, this distance must not exceed 150 m.

In ungulate zones specified for elk, the distance to hiding cover should not exceed 300 m from any point in a cutblock.

2.2.1.3 Connectivity rules

Wildlife travel corridors are required in well-defined valleys or along permanent streams and rivers (Province of Alberta 1994a). These corridors should contain timbered stands on the floodplain of well-developed valleys, and forested areas at the top of well-developed valley breaks. These corridors should be at least two "sight distances" (distance at which 90% or more of a big game animal is hidden from human sight) in width to allow undisturbed movement of wildlife. When a stream buffer provides adequate sight distance, no additional consideration is needed. Harvest designs may include narrow cutblocks and other techniques designed to maintain or enhance travel corridors.

2.2.1.4 Riparian areas

Riparian protection areas must be identified and established where required. Water bodies are classified on the basis of physical description, type of water flow (permanent, intermittent, seasonal), channel development, fish and wildlife concerns and land use impact (Appendix 3). This results in 7 categories: 1) large permanent watercourses, 2) small permanent watercourses, 3) intermittent watercourses, 4) ephemeral watercourses, 5) lakes with recreational potential, 6) lakes without recreational potential, and 7) water-source areas and areas subject to normal seasonal flooding (Appendix 4).

Ephemeral watercourses are protected by buffers of lesser vegetation in wet gullies of indeterminate width, while intermittent watercourses are protected by brush and lesser vegetation. Width of buffers will vary according to soils, topography, water-source areas and fisheries value. Buffer zones of 30 to 60 m are maintained along permanent watercourses.

For lakes without recreational value exceeding 16 ha, no disturbance or removal of merchantable timber is permitted within 100 m of the high-water mark. The restriction is the same for lakes of recreational value exceeding 4 ha. Treed buffers of at least 20 m are required on all streams; in these buffers no harvesting of merchantable trees or disturbance of lesser vegetation is permitted.

2.2.1.5 Conservation areas and habitats

It is important that the visual impact of timber harvesting on the landscape be taken into consideration in all environments identified as unique (fragile or sensitive, tourism and recreational, and protected areas) (Province of Alberta 1994a).

Mineral licks and springs frequented by wildlife should be protected by a buffer zone of one sight distance. This distance may vary from one location to another.

A few provincial guidelines have been developed for certain wildlife species, groups of species and ecological regions with the aim of avoiding or reducing potential impacts on wildlife (Province of Alberta 1994a, Government of Alberta 2002) (see Appendix 5). These guidelines target primarily specific and previously designated wildlife sites that play an essential role in the survival of the species or groups of species identified. These guidelines are applied in a flexible manner, taking into account the physical and vegetative characteristics as well as the existing uses of the environment as a whole.

2.2.2 Industry example: Daishowa Marubeni International Ltd.

2.2.2.1 Size, shape and distribution of cutblocks

There do not appear to be any constraints of this type, apart from a minimum size requirement of 5 ha (Frank Oberle, pers. comm.). The distribution of cutblocks is determined solely by the current size of the stands. The aim is therefore to reproduce the existing pattern. Similarly, the shape of the cutblocks harvested by the company is governed entirely by the shape of the stands (Frank Oberle, pers. comm.).

2.2.3 Industry example: Alberta-Pacific Forest Industries Inc. (ALPAC)

2.2.3.1 Size, shape and distribution of cutblocks

Generally, stands are harvested by following their natural boundaries in order to maintain the existing landscape patterns (Anonymous 2000a, Anonymous 2000b). However, social concerns dictate a maximum cutblock size. To determine this maximum size, ALPAC proposes to limit the aggregate area of adjacent stands in which a cut is planned within the next 20 years to the size of the average five most productive stands of a forest management unit and of the 10 largest stands identified in the inventory of the management unit. This calculation has made it possible to increase the limit from a maximum of 60 ha to as much as 500 ha in some operational units.

The average area of the largest stands, by dominant species type, is identified on the basis of the forest inventory in order to obtain a higher limit for each operational unit. If necessary, the large stands are then restricted to the arbitrary social limit of 500 ha (Anonymous, no date *b*).

The shape of the cutblocks follows the natural features of the site and of the stands (Anonymous 2000*a*, Anonymous 2000*b*). The requirements related to road construction and windthrow risk are also taken into consideration. The layout design of cutblocks also takes into account the visual quality of visually sensitive environments.

ALPAC plans to disperse the cuts over the management unit in order to minimize the concentration of activities and facilitate dispersal of the retained stands of older age classes.

2.2.4 Industry example: Weyerhaeuser Alberta

2.2.4.1 Size, shape and distribution of cutblocks

The cutblocks used by Weyerhaeuser Alberta are variable in size and shape (Anonymous 1997) and modeled after natural disturbances, with the aim of better reflecting the characteristics of the ecological processes of natural subregions and ecodistricts. Maximum cutblock size is limited by watershed and social considerations (10-1,000 ha) (Luigi Morgantini, pers. comm.).

The shape of cutblocks follows natural stand boundaries (Luigi Morgantini, pers. comm.).

2.2.4.2 Adjacency rules

Weyerhaeuser Alberta is moving away from a two-pass system and is adopting a system of dispersed cuts (Luigi Morgantini, pers. comm.).

2.2.4.3 Connectivity rules

Weyerhaeuser Alberta follows the principle that forest connectivity will be ensured by the retention of various structures (e.g., trees and patches) at the stand level and by ensuring a minimum forest cover of 35% (12 m height) at the landscape level (Anonymous 1997) in order to facilitate species dispersal and maintain population distributions.

2.2.4.4 Riparian areas

The company also plans to create buffer zones around wetlands, marshes, swamps and riparian areas (Anonymous 1997). Elements and concerns relating to protection of the watershed will be addressed at the landscape level. Depending on the results of site-specific analyzes and the objectives set, proposals may be made to widen or reduce the current buffer zones and even to manage habitats in the riparian area through specific silvicultural practices such as selection cutting.

2.2.4.5 Conservation areas and habitats

Since the coarse filter approach may not be sufficient for the requirements of some species, the company plans to identify unique, rare or exceptional sites that may provide habitat for specific plant or animal communities and incorporate them in forest planning in order to protect them during harvesting (Anonymous 1997).

Certain practices such as multi-pass silvicultural systems, selection cutting, time-based restrictions (e.g. seasonal) and habitat protection could be proposed.

2.2.5 Industry example: Millar Western Forest Products (MWFP)

2.2.5.1 Size, shape and distribution of cutblocks

MWFP incorporates a wide variety of cutblock sizes, but does not impose any specific size limits (Anonymous 2002). Again from a standpoint of ecological integrity and conservation of biodiversity, the variability of natural disturbances must be taken into account in order to provide the necessary habitats for the wildlife dependent on it. It may also be useful to follow the boundaries of forest

inventory polygons, but they do not always reflect the boundaries of natural disturbances. It is preferable to use natural features as cutblock boundaries.

The following items are taken into account during the planning of cutblock shapes and sizes for a given compartment;

- current boundaries of forest inventory polygons,
- species and age of the trees and their silvicultural characteristics,
- habitat requirements of species of special concern and species at risk,
- quantity and distribution of immature and non-productive lands,
- area and location of watercourses and their respective buffer zones,
- location of roads, pipelines and power lines,
- topographical features,
- presence of a viable understory,
- retention of blocks of non-merchantable trees and shrubs,
- access to compartments and portions thereof,
- harvesting and road construction costs,
- potential windthrow of boundary or retained trees, and
- visual sensitivity.

The distribution of cutblocks should be representative of the natural variation of the landscape. MWFP proposes to incorporate irregular and/or natural boundaries and even to attempt to obliterate previous non-natural boundaries by not following them when possible (Anonymous 2002).

Cutblocks should also be designed to reduce the possibility of windthrow in adjacent areas and of the retained structures and also to promote the success of the regeneration. The risk of fire must also be taken into consideration.

2.2.5.2 Adjacency rules

The spatial patterns adopted by the company will reflect the assumptions derived from the timber supply analysis (TSA) and the sequencing of blocks in the detailed management plan or other higher level plan (Anonymous, no date *a*).

The company requires that sight distance, distance to shelter and distance to thermal cover be taken into account through the retention of structures, the maintenance of vegetation alongside roads, the establishment of wildlife corridors, and by taking advantage of the composition and topography of the landscape. This distance may vary from one site to another, but is generally 400 m. The objectives determined for this purpose are developed at the compartment level and applied

on cutblocks in a site-specific manner. The factors to take into account for the development of these objectives include: habitat types, ungulate density and land use, quality and density of roads.

2.2.5.3 Connectivity rules

MWFP plans to establish wildlife corridors. Any corridors identified during the evaluation of the compartment will have to be fully protected. It is important to take into account the classification, profile, pattern and proximity of watercourses and the definition of their associated valleys, types of cover, width of corridors, harvesting method, cutblock shape, continuity of cover or adjacency/forest patch size.

2.2.5.4 Riparian areas

For riparian strips, the objective of the guidelines is to:

- minimize the potential for soil erosion,
- prevent soil, cutting debris or other harmful substances from entering watercourses, and
- maintain healthy forest growth.

The various water bodies are classified on the basis of physical description, type of water flow and wildlife and other concerns (Appendix 6). This results in six types of watercourses, two categories of lakes, in addition to a category for water-source areas and floodplains. Management guidelines are provided for each defined type of water body (Table 8, Appendix 7).

Table 8. Typical buffer zones applied by Millar Western Forest Products alongside the various water bodies observed. Source: Anonymous (2002).

TYPE OF WATER BODY	CHARACTERISTICS OF RIPARIAN AREAS
Class "A" water bodies	– No disturbance or removal of timber within 100 m of the high-water mark. – No duff disturbance of intermittent (≥ 10 m vegetated buffer) and ephemeral (≥5 m vegetated buffer) streams within 2 km upstream of water body.
Class "B" water bodies	– No disturbance or removal of timber within 100 m of the high-water mark unless otherwise specified. – No duff disturbance of intermittent (≥ 10 m vegetated buffer) and ephemeral (≥ 5 m vegetated buffer) streams within 500 m upstream of water body
Large permanent watercourses	– No disturbance or removal of timber within 60 m of the high-water mark.
Small permanent watercourses	– No disturbance or removal of timber within 30 m of the high-water mark.

TYPE OF WATER BODY	CHARACTERISTICS OF RIPARIAN AREAS
Intermittent watercourses	– Buffer zone of shrubs and undisturbed lesser vegetation along channel of variable width depending on soil type, topography, water-source areas, fish habitat.
Ephemeral watercourses	– Buffer zone of undisturbed vegetation in the wet gullies.
Lakes (area > 16 ha)	– No disturbance or removal of timber within 100 m of the high-water mark unless otherwise specified.
Lakes (area > 4 ha, recreational potential)	– No disturbance or removal of timber within 100 m of the high-water mark unless otherwise specified.
Water-source areas, floodplains	– Retained wooded area of at least 20 m (width may vary depending on surface water production potential). No harvesting of merchantable trees or lesser vegetation unless otherwise specified.

2.2.5.5 Conservation areas and habitats

Fragile or sensitive environments are protected by the establishment of a protective buffer zone (or other management technique) based on the boundary of the opening associated with these sites or on the centre of the sites without openings (Table 9).

Table 9. Width generally applied around fragile or sensitive environments. Source: Anonymous (2002).

SENSITIVE SITES	WIDTH OF PROTECTIVE ZONES
Breeding and hibernation sites for salamanders, amphibians and reptiles at risk	100 m
Hibernation sites for bats	100 m
Nesting areas of colonial birds	100 m
Grizzly bear and wolverine dens	100 m
Mineral licks	100 m
Tree supporting a bird of prey nest	50 m
Tundra swan ponds	500 m
Natural springs	20 m

Logging and road planning in the caribou zone will be carried out in accordance with the *West-Central Alberta Standing Committee Guidelines for Forestry Operations.*

2.3 Saskatchewan

2.3.1 Industry example: Weyerhaeuser Saskatchewan

2.3.1.1 Size, shape and distribution of cutblocks

When selecting stands to be harvested, Weyerhaeuser plans to emulate, as much as possible, the range of natural variability (Anonymous 1999). Pending the availability of more detailed information, cutblocks may range in size from 10 to 500 ha. However, larger cutblocks may be created if necessary to control insect infestations or diseases such as mistletoe, to reduce windthrow risks, for salvage cutting after fire, or when it is deemed important to reduce the time that an area remains accessible to the public.

The company will endeavour to create a mosaic of stands of different sizes and shapes in order to reflect natural patterns as much as possible (Anonymous 1999).

2.3.1.2 Riparian areas

The proposed strategies aim to assign specific widths to riparian areas on the basis of local topographical features, particularly at the breakpoint between the valley of the watercourse or lake and the adjacent upland (Anonymous 1999).

2.4 Manitoba

2.4.1 Government requirements

2.4.1.1 Size, shape and distribution of cutblocks

Cutblock size can vary depending on site, species management guidelines and wildlife or other concerns. However, cutblocks are generally expected to average less than 100 ha (Manitoba Natural Resources 1996).

Cutblock design and configuration across an operating area must take into account a variety of factors such as site, stand type, logging system and renewal prescription, and give due consideration to other resources and resource users. Generally, cutblock boundaries should be located along natural wind-firm boundaries (e.g., ponds, hardwood stands and over ridges) (Manitoba Natural Resources 1996). At the conclusion of the harvesting season, the corners and ragged edges of the cutting face should be rounded and shaped to minimize the effect of wind on the exposed stand edge (Manitoba Natural Resources 1996). Conversely, a second document outlining wildlife management guidelines stipulates that cutblocks should have irregular edges in order to reduce the field of view and maximize the edge effect (Manitoba Natural Resources 1989).

2.4.1.2 Adjacency rules

These requirements are addressed in the wildlife management guidelines, which indicate that when less than 50% of forest cover is maintained in an operating area, cutblock size must not exceed 500 ha (5 km^2) and an adjacent area of equivalent size must be retained (Manitoba Natural Resources 1989).

The leave areas can be harvested when the stems in the adjacent harvest areas have reached a height of 2 m in softwood stands and 3 m in hardwood stands (Manitoba Natural Resources 1989).

The distance to shelter cover or escape cover must not exceed 200 m and the sight distance in the harvest area should not exceed 400 m. Visual barriers used to interrupt the sight distance can include regenerated sites, topographical features and non-merchantable or immature stands.

2.4.1.3 Connectivity rules

In areas where large populations of moose and other ungulates are present, wildlife travel corridors and buffers should be incorporated to enhance the use of cutovers by browsing ungulates (Manitoba Natural Resources 1996).

2.4.1.4 Riparian areas

A riparian management area with a minimum width of 100 m must be preserved around watercourses in which only selective cutting is permitted (Manitoba Natural Resources 1989).

2.4.1.5 Conservation areas and habitats

The *Forest Management Guidelines for Wildlife in Manitoba* outlines certain principles and considerations governing the use of buffer zones in forest planning. Where necessary and feasible, buffer strips must be left standing (Manitoba Natural Resources 1989) in order to:

- Serve as escape cover and travel corridors for wildlife populations,
- Serve as a visual barrier to prevent the harassment of wildlife by road networks and trails located in logging areas, and
- Serve as filter strips around lakes and watercourses in order to slow down runoff from adjacent harvesting areas, thereby reducing the risks of erosion and sedimentation.

The Manitoba guidelines stress, however, that additional guidelines are necessary for special, unique or sensitive environments (e.g., nesting sites of colonial birds, hibernation sites, mineral licks and birthing sites) identified in the management unit (Manitoba Natural Resources 1989).

2.4.2 Industry example: Louisiana-Pacific Canada Ltd.

2.4.2.1 Size, shape and distribution of cutblocks

The 2000-2001 annual report summarizes the forestry activities carried out between May 1, 2000 and April 30, 2001 by Louisiana-Pacific Canada Ltd. within Forest Management License Area (FLMA) #3 as well as part of Forest Management License Area #2 (Anonymous 2001*a*). According to the report, the average size of the 104 cutblocks for Forest Management License Area #3 is 27.0 ha, ranging from 1.0 to 81.5 ha, with a standard deviation of 20.3 ha (Figure 2).

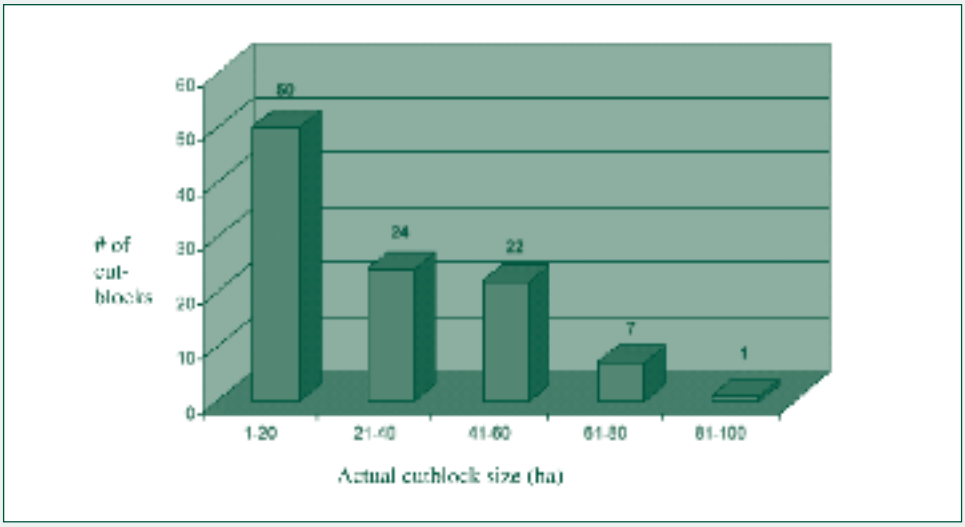


Figure 2. Distribution of cutblock sizes for 2000-2001 in Louisiana-Pacific Canada Ltd.'s FMLA #3. Source: Anonymous (2001a).

The shape and size of the cutblocks reflect the existing natural boundaries (topographical features or drainage), with the aim of promoting edge habitats (Donna Gracia, pers. comm.). The intention is to emulate, as much as possible, a mosaic of large and small openings in the landscape as created during the passage of fire (Anonymous 2001*a*).

2.4.3 Industry example: TEMBEC-Pine Falls

2.4.3.1 Size, shape and distribution of cutblocks

Cutblock size is influenced by the fact that 40% of the forest area is non-productive, while the productive stands are small (Vince Keenan, pers. comm.). Hence, most of the cutblocks are less than 20 ha in size. However, the total area of these cutblocks is slightly smaller than the area of the cutblocks ranging in size from 21 to 40 ha (Table 10).

Table 10. Distribution of cutblock sizes for 2000-2001 in Tembec Pine Falls Group's forest area. Source: Vince Keenan, pers. comm.

Cutblock size (ha)	Number of cuts	Total area
0-20	82	437.51
21-40	15	461.5
41-80	6	358.9
81-120	2	193.06
121-160	0	0
161-200	1	168.61
> 200	0	0
Total	106	1,619.58

The shape of the cutblocks reflects the irregular boundaries of the natural stands (Vince Keenan, pers. comm.).

2.5 Ontario

2.5.1 Government requirements

2.5.1.1 Size, shape and distribution of cutblocks

A management guide was recently developed for Ontario boreal and Great Lakes forests managed under a clearcutting silvicultural system (Ontario Ministry of Natural Resources 2001). It can also apply to certain areas managed under the shelterwood system.

This document provides guidance on clearcut size and how cuts should be distributed. It also addresses how forest managers can better simulate aspects of wildfire results and structural attributes. The recommendations are based on the natural disturbance regime prevailing in these areas, with the aim of obtaining more natural forest landscapes.

According to the guidelines, eighty percent (Boreal forest) or ninety percent (Great Lakes forest) of planned new clearcuts should be less than 260 ha. Also, a range of clearcut sizes should be created to ensure the size class distribution of clearcuts follows the same tendencies as fire disturbance size frequencies (Ontario Ministry of Natural Resources 2001). These restrictions reflect a balance between social concerns towards large clearcuts and natural disturbance pattern emulation.

The creation of clearcuts greater than 260 ha in size is, however, accepted if it can be demonstrated that it is consistent with moving towards more natural frequency and size class distributions, and where one or more of the following conditions are met:

- the clearcut is an attempt to “defragment” a previous group of smaller cuts;
- the clearcut is integrated as part of an overall strategy to provide wildlife habitat; and
- public and other user concerns have been adequately addressed.

The guide promotes an approach requiring that a clearcut follow natural landscape contours and forest stand boundaries as well as retaining individual trees and patches of trees (insular and peninsular) throughout the cut area and along the periphery (Ontario Ministry of Natural Resources 2001).

The guidelines suggest that 10% to 34% of the original stand or stands be permanently retained. This corresponds to insular residual patch retention ranging from 2% to 8% (≥ 25 ha), well distributed within the cutover on the basis of forest cover type. In addition, peninsular residual patches (8% to 28% of the cutover), again based on forest cover type, are to be retained and well distributed around the edge of cutovers. Fifty percent of the peninsular residual patch area is available for subsequent harvest once the regeneration in the adjacent clearcut has reached 3 m. Alternatively, a one-pass harvest may include the removal of 50% of the volume in 50% of the exterior edge of the peninsular area, leaving the core area unharvested (Figure 3).

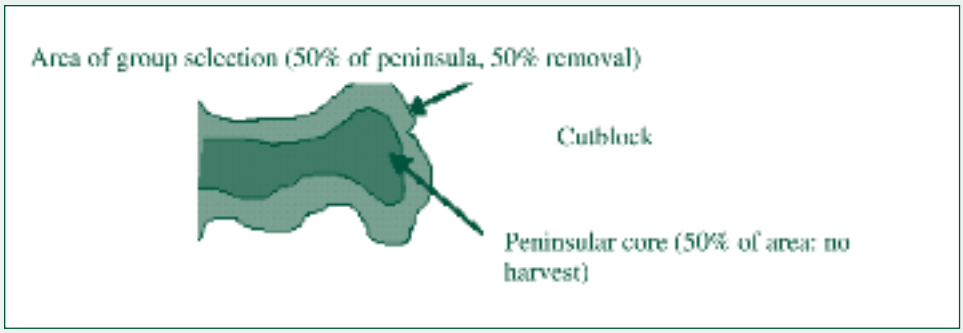


Figure 3. Harvesting technique within peninsular residual patches in the first pass. Source: Ontario Ministry of Natural Resources (2001).

2.5.1.2 Adjacency rules

New clearcuts must be separated in time from older clearcuts either long enough to allow regeneration in the old clearcut to reach 3 m in height or 20 years, whichever occurs first. The 3 m height restriction between cuts was imposed because it defines the break between the pre-sapling and sapling development stages used in the new wildlife habitat suitability models. The authors also cite the work of Imbeau *et al.* (1999), who found that forest bird assemblages were reestablished on cuts in Quebec once the cuts reached the sapling stage.

When these restrictions are not met, 10 to 260 ha clearcuts should be separated by an average distance of 200 m (minimum 100 m). For every 100 ha increase above the 260 ha limit, clearcuts of similar size must be separated by an additional 50 m. Dissimilar sized clearcuts must be separated by the distance indicated by the smallest clearcut.

The separation break must consist of stands at least 3 m in height and meet minimum stocking requirement of 30% of living trees per ha (distinguishing between forest land and non-forest land (Joe Churcher, pers. comm.)). However, for larger separation distances (≥ 600 m), at least 70% of the landbase must consist of stands at least 6 m in height and meet 30% stocking.

2.5.1.3 Connectivity rules

The guidelines simply noted that the residual habitats can serve as wildlife corridors (see section 2.5.1.5).

2.5.1.4 Riparian areas

A forest strip (~3 m wide) where the soil or vegetation (not necessarily trees) remains undisturbed must be left along water bodies. A degree of flexibility is permitted in the application of this rule, given the great variability of environments and conditions. The choice of operational practices must also take into account the availability of equipment, safety factors, economic factors and environmental concerns, whether or not the practices are related to water quality.

2.5.1.5 Conservation areas and habitats

It is expected that the coarse filter approach expressed in the recent Natural Disturbance Pattern Guide will capture the requirements of most wildlife species by maintaining a broad array of forest conditions. This approach is also expected to comply with most other provincial guidelines.

For instance, the province of Ontario has adopted a wide variety of guidelines concerning the preservation of other important resources, such as:

- *Timber Management Guidelines for the Protection of Tourism Values and*
- *Timber Management Guidelines for the Protection of Cultural Heritage Resources.*

Following a fine-filter approach in some cases, there are also guidelines for the protection of identified unique or sensitive sites and their surrounding environment:

- *Habitat Management Guidelines for Ontario's Forest Nesting Accipiters, Buteos and Eagles,*
- *Management Guidelines for the Protection of Heronries in Ontario, and*
- *Bald Eagle Habitat Management Guidelines.*

The province has also developed a *Conservation Strategy for Old-Growth Red and White Pine Forest Ecosystems* with the aim of protecting and restoring some of these forests, now absent from the landscape.

2.5.2 Industry example: Abitibi Consolidated

2.5.2.1 Size, shape and distribution of cutblocks

Efforts have been made to consolidate existing cutblocks in an attempt to reduce fragmentation and increase the quantity of large and medium-scale disturbances (Anonymous, no date *b*). Abitibi Consolidated expects to achieve this goal by concentrating harvesting in leave areas where the adjacent blocks contain adequately established regeneration.

Harvest blocks will be configured to emulate natural disturbance patterns, within the bounds of silvicultural requirements (Anonymous, no date *b*).

2.5.2.2 Conservation areas and habitats

The company plans to follow the provincial guidelines concerning rare, threatened and endangered species as well as identified unique or sensitive sites and their surrounding environment (Anonymous, no date *b*).

The company also plans to protect unique forest ecosystems containing species such as oak, elm, basswood, yellow birch as well as those containing rare plants.

2.6 Quebec

2.6.1 Government requirements

2.6.1.1 Size, shape and distribution of cutblocks

Two types of logging strategies are permitted by the Quebec provincial government (1) cuts separated by wooded breaks, and (2) block cutting without wooded corridors, also called mosaic harvesting. In the first type, the cuts are separated by forested corridors of variable width. Otherwise, the forested corridors are actually harvest areas that haven't yet been cut.

In both cases, the regulation stipulates, for each of the three Quebec forest zones, that the size of a single clearcut with regeneration and soil protection (CCRSP), or the size of a strip cutting with regeneration and soil protection (SCRSP) (total area of both the cut and leave strips) must never exceed 150 ha (Province of Quebec 2001). This is believed to promote harmonization of the various uses of the forest environment, limits the size of single-block cutting areas and encourages better spatial distribution of cutting areas (Quebec Department of Natural Resources 2000).

The dimensions and proportions of the CCRSP and SCRSP areas (Table 11) were determined with the aim of promoting the use of the forest landbase by the largest possible number of wildlife species and also by encouraging the creation of a mosaic of cutting areas of different sizes (Quebec Department of Natural Resources 2000).

Table 11. Size classes of a single-block cutting area and their extent (proportion of CCRSP or SCRSP areas) by Quebec forest zone. Source: Quebec Department of Natural Resources (2000).

Quebec forest zone	Proportion of CCRSP or SCRSP areas ≤ 25 ha	Proportion of CCRSP or SCRSP areas > 25 and ≤ 50 ha	Proportion of CCRSP or SCRSP areas > 50 and ≤ 100 ha	Proportion of CCRSP or SCRSP areas >100 and ≤ 150 ha
Hardwood forest zone	≥ 70%	≤ 20%	≤ 10%	–
Fir and mixed forest zone	–	≥ 70%	≤ 20%	≤ 10%
Spruce forest zone	–	≥ 20%	≤ 50%	≤ 30%

However, if a leave area between two cutting areas (block cutting) is equivalent in size to the largest cutting area and meets the regeneration requirements outlined above (establishment and height), then the size of a single-block area of clearcutting with regeneration and soil protection (CCRSP) or of the total area of the cut and residual strips of an area of strip cutting with regeneration and soil protection (SCRSP) must be less than 50 ha in the hardwood forest zone, 100 ha in the fir and mixed forest zone, and 150 ha in the spruce forest zone (Province of Quebec 2001).

The province, with the aim of shaping cutting areas favourable to wildlife as much as possible, and of limiting the width of large cutting areas, requires that the

length of a cutblock of a cutting area larger than 100 ha be equal to or greater than four times its average width (Province of Quebec 2001, Quebec Department of Natural Resources 2000).

2.6.1.2 Adjacency rules

Regeneration is established when the regeneration stocking is equal to the stocking that existed before the initial harvesting (Province of Quebec 2001).

When the adopted strategy is harvesting separated by wooded corridors, the regulation requires that until the regeneration is established and has reached an average height of 3 m, the holder of a management permit must preserve between any two such areas a buffer strip of trees, bushes or brushwood more than 3 m in height and at least:

- 100 m wide when one of the areas covers 100 to 150 ha; or
- 60 m wide when both areas are less than 100 ha.

The regulation also specifies that trees may be harvested in the buffer strip; however, that buffer strip must be at least:

- 125 m wide when one of the areas covers 100 to 150 ha; or
- 75 m wide when both areas are less than 100 ha.

These guidelines may be modified if another valuable resource is present. For example, in softwood and softwood-dominant mixed stands within a white-tailed deer yard, it is important to leave intact between two areas of clear cutting with regeneration and soil protection (CCRSP) a buffer strip at least 60 m wide until the dominant forest cover in those areas has reached an average height of 7 m.

Alternately, block cutting without wooded corridors requires that the area of the unharvested blocks (height ≥ 3 m) between two cutting areas be equivalent in size to the largest cutting area.

2.6.1.3 Connectivity rules

The buffer strip between cutblocks serves mainly as a visual screen and travel corridor for wildlife. However, it is important that this buffer strip not be composed of less than 1,500 standing, live trees per hectare of a commercial species having a dbh of 2 cm (Province of Quebec 2001).

2.6.1.4 Riparian areas

A buffer strip 20 m wide must be preserved along the banks of peat bogs with a pond, swamps, marshes, lakes or permanent watercourses, as measured from stands adjacent to the riparian ecotone. Trees may be harvested within this buffer strip, subject to certain conditions (Province of Quebec 2001).

2.6.1.5 Conservation areas and habitats

There are a number of sites (e.g., wildlife habitats, ecological reserves, recreation centres, accommodation centres, rest areas, beaches, experimental forests, education centres) within a management area in which timber harvesting cannot be carried out (Province of Quebec 2001) or which require special measures.

Furthermore, at a number of these sites, a buffer strip ranging from 30 m (mainly around highway corridors, access roads, and portage trails) to 60 m (mainly around resort areas, outdoor recreation areas, campgrounds, accommodation centres, rest areas or picnic areas, and scenic lookouts) is required.

Other types of restrictions may also be imposed. In an area frequented by caribou, the vegetation in areas used for calving, breeding or winter feeding must be left intact. Any harvest blocks in these areas must not be larger than 50 ha. In a white-tailed deer yard, a clearcut with regeneration and soil protection must not be larger than 25 ha in hardwood and hardwood-dominant mixed stands, or 10 ha in softwood and softwood-dominant mixed stands. Where strip cutting with regeneration and soil protection is used, the total area of the cut and residual strips may not exceed 10 ha of a single-block area.

Visual quality must also be preserved, mainly along scenic routes and around territorial units such as an historic or natural district, outdoor recreation centre, public beach, downhill skiing site, etc. This visual setting corresponds to the landscape visible according to the topography of the site up to a distance of 1.5 km from the limit of such sites.

It is also stipulated that a mossy black spruce stand having an area of 4 ha or more forming a single block must be preserved. Rare forest ecosystems are excluded from the productive forest area for conservation purposes.

2.6.2 Industry example: Lake Duparquet Teaching and Research Forest (FERLD)

2.6.2.1 Size, shape and distribution of cutblocks

The difficulty of emulating natural disturbance regimes is due to the fact that the average grain (spatial resolution) of disturbances is too large relative to the area of this forest (Harvey and Leduc 1999). Most of the forest cover in the FERLD originated from the fire of 1923. Hence, there is a need to develop guidelines concerning these elements of the landscape structure in a sustainable management context.

2.6.2.2 Adjacency rules

An effort is made to limit natural forest fragmentation as much as possible. From this standpoint, the designation of progressive cutblocks, in which new cutovers exist side by side with older ones, appears to be a much less intrusive practice in the forest.

Researchers are endeavouring to limit the number of cutting areas and to locate these cutting areas around the periphery of unharvested areas (Harvey and Leduc 1999).

Block cutting has been proposed to minimize the consequences of forest cover loss in a trapping area. It is expected that, at a regional level, this practice will result in: 1) a considerable increase in the degree of forest fragmentation caused by forest management; 2) a significant capital investment in the construction of a more extensive road network; and 3) a substantial increase in access to the uninhabited forest, as a consequence of the increased development of the road network.

2.6.2.3 Connectivity rules

Connectivity is mainly ensured by riparian strips, a conservation area, proposed protected areas and proposed harvesting methods (Brian Harvey, pers. comm.). A proposed protected area is intended to maintain the forest cover between a forest patch within the management area and the conservation area by means of an expanded riparian area associated with the Magusi River.

2.6.2.4 Riparian areas

The requirements and rules concerning the retention of riparian strips are governed mainly by provincial regulation (Brian Harvey, pers. comm.).

2.6.2.5 Conservation areas and habitats

Protected areas have been proposed for certain areas of the forest because they have attributes that may meet the criteria of the program (Harvey 2002). Four areas other than the conservation area are included in this proposal, which cover a total area of 2,973.06 ha (including 91.98 ha outside the teaching forest).

2.6.3 Industry example: Montmorency Forest

2.6.3.1 Size, shape and distribution of cutblocks

Silvicultural planning in the Montmorency Forest is based on the individual stand, thereby limiting the size of cutovers (Bélanger, no date). Over a period of ten years, nearly 70% of the blocks harvested were smaller than 30 ha. Approximately 30% of the harvested area consisted of cutblocks smaller than 10 ha, 30% was in 10-20 ha cutblocks, 15% in 20-40 ha cutblocks and 15% in 40-100 ha cutblocks. However, there is no fixed rule on the size of cutblocks.

The cutblocks are asymmetrical in shape. However, in sensitive areas, a greater effort is made to ensure that the shape of cutblocks follows the major natural landscape lines, especially along ridges.

2.6.3.2 Adjacency rules

Harvest blocks are well distributed across the landscape units. As a general rule, stands adjacent to recently harvested blocks are not harvested until the recently harvested stand is 20 years old (Paul Boulianne, pers. comm.).

2.6.3.3 Connectivity rules

Connectivity in the landscape is ensured by the stands retained between the cutblocks as well as the riparian strips (Paul Boulianne, pers. comm.).

2.6.3.4 Riparian areas

It is important not to disturb the soil or remove trees within a 15-20 m strip along watercourses (Bélanger, no date).

2.6.3.5 Conservation areas and habitats

Each type of ecosystem is preserved permanently. These protected ecosystems serve as control sites (Paul Boulianne, pers. comm.).

The strategy is expected to bring about a mix of habitats that will provide the diversity of habitats necessary to sustain the wildlife richness of the forest (coarse filter) (Bélanger, no date).

Moreover, the distribution of stands of different age classes is thought to minimize the need to preserve wildlife refuges.

The need to preserve visual screens is also reduced. Indeed, the aesthetic impact of small dispersed cuts is more limited.

It should be noted, however, that there is a recognized lack of data on the actual effect of such a strategy, apart from fragmentation, on biodiversity.

2.7 New Brunswick

2.7.1 Government requirements

2.7.2 Size, shape and distribution of cutblocks

The government limits the size of cutblocks in hardwood and softwood stands to 100 ha. However, larger cutblocks are possible if their purpose is to salvage mortality resulting from windthrow fire, or disease (Province of New Brunswick 2000).

No specifications are provided concerning shape.

2.7.1.2 Adjacency rules

The timing of harvesting in adjacent blocks must not be less than two planning periods (period = 5 years) when the combined area of blocks (current and adjacent) exceeds 100 ha (Province of New Brunswick 2000).

2.7.1.3 Riparian areas

The province has specified the width of watercourse buffer zones (discernable channel ≥ 0.5 m), as well as vehicle exclusion zones, to protect water quality and aquatic habitat for each license holder (Table 12) (Province of New Brunswick 2000). It is important to maintain zones ranging in width from 30 to 150 m depending on the characteristics of the watercourses. Timber harvesting is permitted in buffer zones as long as it does not compromise the function of the buffer.

Table 12. Width and specific characteristics of riparian buffer zones to be maintained by license in New Brunswick. Source: Province of New Brunswick (2000).

LICENSE	2002 BUFFER WIDTHS (METRES) BY FEATURE				
	Single-line streams[1]	Double-line streams[2]	Rivers	Lakes	Provincial highways
1	33	66	150	100	30
2	30	60	150	100	30
3	33	89	128	100	30
4 a[3]	55	117	139	150	30
4 b[4]	100	150	150	150	30
5	37	76	100	100	30
6	60	85	110	100	30
7	60	85	110	100	30
8	40	61	107	100	30
9	35	60	112	100	30
10	37	80	100	100	30

[1]**Single-line** Single-line water features on GIS cover type maps (streams). Also applies to 4-ha lakes/ponds.
[2]**Double-line** Double-line water features on GIS cover type maps (small rivers).
[3]Area of license not in Big South or Nepisiguit area.
[4]Big South and Nepisiguit area.

Also, aesthetic buffer zones 30 m wide will be maintained along highways (Table 12). It is also suggested that aesthetic buffer zones (> 60 m) be maintained along watercourses with high recreational use.

2.7.1.4 Conservation areas and habitats

Forest ecosystems or sites of unique ecological, historical, cultural or scenic value are protected. New Brunswick is currently conducting an inventory of these areas which will be incorporated into the *Protected Areas Strategy*, currently under development (Province of New Brunswick 2000).

2.7.2 Industry example: Forest Management Guidelines to Protect Biodiversity in the Fundy Model Forest

2.7.2.1 Size, shape and distribution of cutblocks

In forests managed under a stand-replacing disturbance regime, the size of cutblocks should range from 375 to 500 ha (Woodley and Forbes 1997). However, the guidelines emphasize the importance of not conducting cuts of that size every year. In order to obtain a more "natural" fragmentation, it is important instead to spread these cuts over a period of 10 to 15 years, which assumes cutovers of 25 to 50 ha.

No information is explicitly provided on the shape of cutblocks. However, the authors emphasize the importance of conducting harvesting operations on the basis of historical disturbance regimes, which implies that they intend to refer to these disturbance patterns for all cuts (Woodley and Forbes 1997).

2.7.2.2 Connectivity rules

The researchers recommend maintaining wildlife corridors at least 300 m wide and no more than 3 km long with a minimum canopy closure of 35% (height ≥ 12 m) in the Model Forest (Woodley and Forbes 1997). These rules were based on various information such as current research on flying squirrels, studies on wolves and martens in Banff National Park and on Bachman's Sparrow in wooded areas of Florida as well as the British Columbia guidelines.

2.7.2.3 Riparian areas

The research group considers that the steep river valley slopes of the Model Forest represent unique and sensitive conditions (Woodley and Forbes 1997). It therefore recommends maintaining the current provincial buffer setback of 60 m, but beginning at the top of the valley (instead of the shoreline), at a point where the slope is less than 20%. Also, no harvesting would be permitted in the areas along watercourses.

2.7.2.4 Conservation areas and habitats

The group also recommends that a network of protected areas be established and fully protected in the Model Forest to protect rare, unique and representative species and features. However, some activities (sustainable, non-motorized recreational hunting and fishing and some form of limited resource extraction) may be allowed.

2.7.3 Industry example: JD Irving

2.7.3.1 Size, shape and distribution of cutblocks

The standards adopted by the company limit the size of clearcuts to 60 ha (David Young, pers. comm.). The average size of cutting areas on company land is 26 ha. The average distribution of cutblock sizes proposed for the next 25 years is presented in Figure 4.

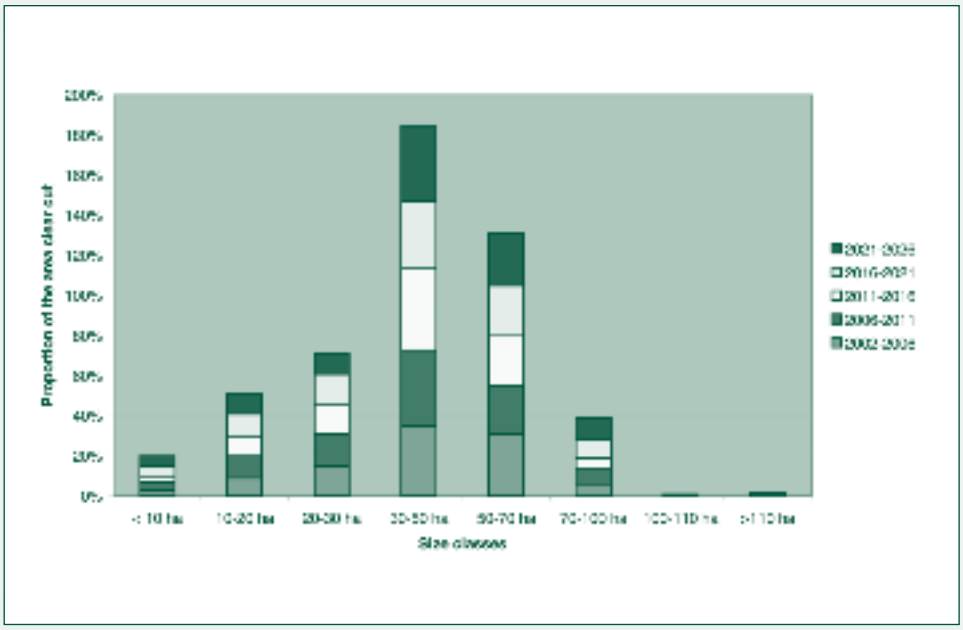


Figure 4. Average distribution of cutblock sizes proposed for 2002 to 2026 by JD Irving in New Brunswick.

The shape of the cutblocks is governed mainly by the shape of the natural stands (David Young, pers. comm.). However, other factors can influence their shape, such as:

- adjacent cutblocks,
- presence of watercourses,
- presence of a road, and
- mechanical operational constraints.

2.7.3.2 Riparian areas

A buffer zone 60 m wide is maintained on either side of any mapped watercourse with a width greater than 0.5 m (David Young, pers. comm.). Machinery is not permitted in areas adjacent to unmapped watercourses, which may be protected by a 15, 30, or 60 m buffer zone on both sides.

2.7.3.3 Conservation areas and habitats

When unique environments or threatened species are identified at the planning stage or during operations, an expert is called to the site to evaluate them and to recommend an appropriate management strategy (David Young, pers. comm.).

2.8 Nova Scotia

2.8.1 Government requirements

2.8.1.1 Size, shape and distribution of cutblocks

The Nova Scotia provincial regulations recommend that areas to be clearcut should not exceed 50 ha (Nova Scotia Department of Natural Resources 1989). However, it is argued that smaller cuts made more often provide a better distribution of the shrub-sapling seral stage.

Forest managers are encouraged to prescribe irregular borders (such as natural stand boundaries) in order to further enhance the edge effect, which is considered beneficial for wildlife (Nova Scotia Department of Natural Resources 1989).

2.8.1.2 Adjacency rules

The rules stipulate that, where the total area would exceed 50 ha, stands adjoining a clearcut area should not be clearcut until the regeneration in the original clearcut area is at least 2 m tall. If this is impossible, it is important to provide appropriate wildlife corridors (Nova Scotia Department of Natural Resources 1989).

2.8.1.3 Connectivity rules

Where an area planned for clearcutting exceeds the 50 ha size limit, it is suggested that one or more wildlife corridors be preserved in order to comply with this requirement. Wildlife corridors must have a minimum width of 50 m.

When possible, wildlife corridors that pass through clearcuts should be located in the middle of the clearcut (Nova Scotia Department of Natural Resources 1989). The best location for a corridor is along watercourses. Retained overmature stands or inoperable sites can also serve as cover.

2.8.1.4 Riparian areas

The new *Wildlife Habitat and Watercourses Protection Regulation*s (Province of Nova Scotia 2002) are based on the guidelines and standards developed in 1989 (Nova Scotia Department of Natural Resources 1989). These regulations call for retaining a special management zone of at least 20 m in width along all boundaries of the watercourse where the average width of the watercourse is equal to or greater than 50 cm.

However, where the land adjoining a watercourse (≥ 50 cm) has an average slope greater than 20%, the width of the special management zone must be increased by 1 m for each additional 2% of slope, to a maximum of 60 m in width. It is also important not to reduce the basal area of living trees to less than 20 m^2 per hectare or to create an opening larger than 15 m in the dominant tree canopy.

2.8.1.5 Conservation areas and habitats

Other guidelines exist at the stand level in order to conserve birds of prey and heron colonies (Nova Scotia Department of Natural Resources 1989). These guidelines mainly involve the retention of forest around nests.

The province has also developed additional guidelines for the protection of ecological reserves or unique sites (Nova Scotia Department of Natural Resources 1989). No timber harvesting is normally permitted within or near these areas.

2.9 Newfoundland

2.9.1 Government requirements

No official regulations were provided concerning this type of guideline.

2.10 Summary

2.10.1 Size, shape and distribution of cutblocks

The size of cutblocks harvested in Canada ranges from 10 to 1,000 ha, but generally does not exceed 100 ha (see Table 13). The size and distribution of these cutblocks appear to be governed mainly by the following factors:

- what is typically observed during a natural disturbance in a given region,
- the stand type,
- social constraints,
- natural stand boundaries, and
- administrative and operational considerations.

The shape of cutblocks appears to be governed mainly by natural stand boundaries. Alternately, their contours follow the boundaries of natural disturbances. For instance, wet environments (e.g. footslope) or hardwood groups are left unharvested and consequently affect the shape of cutblocks. However, these basic considerations are supplemented by other factors, such as:

- visual quality (e.g. British Columbia, Alberta-Pacific),
- worker safety (Weyerhaeuser Coastal BC),
- windthrow risks (of residual trees) (e.g. Alberta-Pacific, Manitoba),
- silvicultural and operational constraints (e.g. Alberta, JD Irving), and
- wildlife needs (e.g. Manitoba, Quebec).

Once again, the natural disturbance regime appears to be an important determinant of the boundaries, size, shape and distribution of cutblocks in the landscape.

Table 13. Summary table of cutblock size classes and their determining criteria.

PROVINCE	SIZE CLASS CONTROLS	SIZE CLASSES
1. BRITISH COLUMBIA		
Government requirements	– location (coast, interior) – natural disturbance patterns	40-60 ha variable
Weyerhaeuser Coastal BC	– location	20-40 ha
Iisaak		40 ha or no limit if retention ≥ 40%
2. ALBERTA		
Government requirements	stand type and silvicultural system	60-100 ha
Daishowa Marubeni . International Ltd	stand size	no limit
Alberta-Pacific Forest Industries Inc.	natural stand boundaries and requirements	500 ha
Weyerhaeuser Alberta	variability of natural disturbances, social requirements and watershed boundaries	0-1,000 ha
Millar Western	variability of natural disturbances, all ecological attributes, silvicultural, operational and other constraints	variable
3. SASKATCHEWAN		
Weyerhaeuser Saskatchewan	variability of natural disturbances	10-500 ha
4. MANITOBA		
Government requirements	wildlife or other resources	< 100 ha
Louisiana-Pacific Canada Ltd.	natural stand boundaries and variability of natural disturbances	1-81.5 ha (average of 27.0 ha)
TEMBEC-Pine Falls	stand size	1-200 ha (1-40 ha mainly)
5. ONTARIO		
Government requirements	variability of natural disturbances and social requirements	≤ 260 ha
Abitibi Consolidated	variability of natural disturbances	not specified
6. QUEBEC		
Government requirements	harmonization of the various uses of the forest environment, size limits and better spatial distribution of cutting areas	≤ 150 ha
Lake Duparquet Forest	stand size	to be determined
Montmorency Forest	stand size	1-100 ha (70% ≤ 30 ha)

PROVINCE	SIZE CLASS CONTROLS	SIZE CLASSES
7. NEW BRUNSWICK		
Government requirements	not specified	< 100 ha
Fundy Model Forest	variability of natural disturbances	375 and 500 ha (25-50 ha over 10 to 15 years)
JD Irving Limited	not specified	60 ha (average of 26 ha)
8. NOVA SCOTIA		
Government requirements	not specified	< 50 ha

2.10.2 Adjacency rules

In many cases, provincial regulations require that regeneration of the stands be completed before previously harvested blocks or adjacent blocks may be harvested (see Table 14) .

British Columbia's guidelines indicate that adjacency requirements may be waived if this is done for reasons related to the natural disturbance regime and the natural temporal and spatial distribution. New Brunswick requires that appropriate wildlife corridors be provided if its rules cannot be met. Adjacency rules therefore appear to be guided by wildlife needs.

Height requirements are similar in all provinces. In fact, the height of the stems, whether within the buffer strip or in cut or adjacent stands, must generally be 2 m or 3 m. Height limits vary according to:

- stand type (2 m for softwood and 3 m for hardwood), and
- number of passes carried out or planned.

In terms of time elapsed since the initial intervention (Alberta, Ontario, Montmorency Forest, New Brunswick), the figure is 10 to 20 years. This requirement is sometimes combined with a minimum stem height requirement (Alberta); in other cases it may be an alternative (Ontario) or it may be the only requirement (Montmorency Forest and New Brunswick).

Table 14. Summary table of the various adjacency requirements in Canada.

PROVINCE	ADJACENCY REQUIREMENTS
1. BRITISH COLUMBIA	
Provincial requirements	– 75% of the block area meets the regeneration requirements (≥ 800 or ≥ 1,000 trees/ha, a representative sample of which has an average height of 3 m
2. ALBERTA	
Provincial requirements	– Subsequent pass permitted when the blocks harvested meet the regeneration requirements and the regeneration has reached a height of 2 m or 3 m (depending on the number of passes) in softwood blocks and of 3 m in hardwood blocks and 10 years have elapsed

PROVINCE	ADJACENCY REQUIREMENTS
3. MANITOBA	
Provincial requirements	– An area equivalent to the harvested block must be retained if ≤ 50% of the cover disappears – Leave areas can be harvested when the height of the stems in the adjacent blocks has reached 2 m (softwood) or 3 m (hardwood)
4. ONTARIO	
Provincial requirements	– 20 years or 3 m before harvesting is permitted near previously harvested areas – Alternately, a separation strip ≥ 100 m must be maintained
5. QUEBEC	
Provincial requirements	– Strip cutting: separation strips ≥ 60 or ≥100 m must be maintained depending on the size of the cutting areas where the height of the stems ≥ 3 m – Harvesting is permitted if width of the strip is ≥ 125 m (one of the areas 100-150 ha) or ≥ 75 m (both areas ≤ 100 ha) – Block cutting: the unharvested blocks must be equivalent in size to the largest cutting area and height of the stems ≥ 3 m
Lake Duparquet Forest	– Limit the number of cutting areas and locate these cutting areas around the periphery of the unharvested areas, block cutting
Montmorency Forest	– 20 years must have elapsed before cutting a stand adjacent to a previously cut block
6. NEW BRUNSWICK	
Provincial requirements	– No cutting in adjacent blocks before 10 years if the combined area of the cut and adjacent blocks is > 100 ha
7. NOVA SCOTIA	
Provincial requirements	– Avoid cutting in adjacent blocks if the combined area of the two is ≥ 50 ha until the height of the stems has reached 2 m. Alternately, provide appropriate wildlife corridors.

The width of the buffer strips between cutblocks which allow two blocks to no longer be considered adjacent is sometimes specified (Ontario, Quebec). The width of these buffer strips depends on the width of the initial cut, but is usually around 100 m.

Several organizations establish wooded visual screens around specific sites (recreational, scenic, tourism, etc.) and also alongside roads.

The maximum distance that wildlife must travel to find shelter, escape or thermal cover, when required, ranges from 150 to 400 m. This distance may vary depending on the needs of a particular wildlife species or human visibility (proximity of a road).

2.10.3 Connectivity rules

Wildlife corridors (or maintenance of connectivity) between stands and cutblocks are provided, when indicated, by mature or overmature forests (British Columbia, Nova Scotia) (see Table 15).

These corridors are often provided to meet the needs of wide-ranging ungulate species (see conservation guidelines for caribou in Ontario, Alberta). Only the researchers of the Fundy Model Forest claim to take into account a set of information on wildlife needs by basing their reasoning on various studies. In all cases, this becomes a fairly calculated reasoning where strict guidelines are provided concerning the wildlife corridors to be maintained.

Other groups, such as Millar Western Forest Products, propose to identify travel corridors and when identified, to protect them.

Some organizations provide tools and factors to be taken into consideration when determining corridor boundaries. Several propose to use existing structures in the landscape to create corridors, mainly riparian areas, but also inoperable sites (flood plains, ends of valleys), wildlife conservation areas, old-growth forests, buffer strips maintained between cutblocks, etc. Hence, it is suggested that connectivity be incorporated into general forest planning through the layout design of cutblocks in the landscape, for example.

2.10.4 Riparian areas

Buffer zones around lakes and watercourses are usually maintained in order to preserve the quality of water and habitats for aquatic wildlife (see Table 16).

The required width of these riparian strips is sometimes the same regardless of the type of water body. In this case, the widths prescribed can vary significantly from province to province. For example, in Manitoba, the rules require maintaining a 100 m strip, while in Quebec it is 20 m.

Table 15. Summary table of the various landscape connectivity requirements in Canada.

PROVINCE	CONNECTIVITY REQUIREMENTS
1. BRITISH COLUMBIA	
Government requirements	– Network of ecosystems composed of contiguous mature and overmature forests, provided in part by riparian areas and forests not included in the forest yield – Connectivity needs vary depending on type of disturbance regime
2. ALBERTA	
Government requirements	– Required in defined valleys or along permanent watercourses – Width of at least two “sight distances”
Weyerhaeuser Alberta	– Ensured by the retention of trees and blocks at the stand level and by a minimum forest cover of 35% (height 12 m) at the landscape level
Millar Western	– Protection of identified corridors

PROVINCE	CONNECTIVITY REQUIREMENTS
3. MANITOBA	
Government requirements	– Incorporate corridors and protected areas in environments where large populations of moose and other ungulates are found
4. ONTARIO	
Government requirements	– Ensured by residual blocks
5. QUEBEC	
Government requirements	– Ensured by the buffer strip (must be composed of ≥ 1,500 living stems of commercial species ≥ 2 cm dbh/ha) between cutblocks
Lake Duparquet Forest	– Ensured by the riparian strips, the conservation area and the silvicultural technique put forth
Montmorency Forest	– Ensured by the stands retained between cutblocks as well as the riparian strips
6. NEW BRUNSWICK	
Fundy Model Forest	– ≥ 300 m wide, ≤ 3 km long, with minimum canopy closure of 35% (height ≥ 12 m)
7. NOVA SCOTIA	
	– Should cross clearcuts in the middle, along watercourses
	– Retained overmature stands or inoperable sites can also serve as cover

However, other provinces or companies use riparian strips of varying width, determined on the basis of the category of the water body or its attributes (British Columbia, Alberta, Millar Western Forest Products, New Brunswick).

Table 16. Summary table of the various requirements concerning the composition of riparian areas in Canada.

PROVINCE	COMPOSITION OF RIPARIAN AREAS	
	Type of water body	**Type of protection**
1. BRITISH COLUMBIA		
Provincial requirements	– watercourses	– reserve zone of 0-50 m – management zone of 20-100 m
	– wetlands	– reserve zone of 0-10 m – management zone of 20, 30 or 40 m
	– lakes	– reserve zone can be 10 m
	– lakes	– management zone of 0, 20 or 30 m

PROVINCE	COMPOSITION OF RIPARIAN AREAS	
	Type of water body	**Type of protection**
2. ALBERTA		
Provincial requirements	– ephemeral watercourses	– buffer of lesser vegetation in wet gullies (indeterminate width)
	– intermittent watercourses	– buffer of brush and lesser vegetation (variable width)
	– permanent watercourses	– conservation area of 30-60 m
	– lakes without recreational potential (> 16 ha in size)	– conservation area of 100 m
	– lakes with recreational potential (> 4 ha in size)	– conservation area of 100 m
	– water-source areas	– treed buffer of 20 m
Millar Western Forest Products	– watercourses (A)	– buffer strip of 100 m and 5 or 10 m vegetated buffer for intermittent and ephemeral drainages within 2 km upstream of watercourse
	– watercourses (B)	– buffer strip of 100 m and 5 or 10 m vegetated buffer for intermittent and ephemeral drainages within 500 m upstream of watercourse
	– large permanent	– conservation area of 60 m
	– small permanent	– conservation area of 30 m
	– intermittent	– buffer of brush and lesser vegetation along the channel
	– ephemeral	– vegetated buffer in wet gullies
	– lakes (> 16 ha)	– conservation area of 100 m
	– lakes (> 4 ha, recreational potential)	– conservation area of 100 m
	– water-source areas and flood plains	– treed buffer ≥ 20 m, no harvesting of merchantable trees or lesser vegetation
3. MANITOBA		
Provincial requirements	– any water body	– ≥ 100 m, selection cutting allowed

PROVINCE	COMPOSITION OF RIPARIAN AREAS	
	Type of water body	**Type of protection**
4. ONTARIO		
Provincial requirements	– source lakes, lakes > 10 ha, lakes of fisheries value, permanent and intermittent watercourses providing spawning grounds, or other types	– forest strip (~3 m) where the soil or vegetation remains undisturbed (not necessarily trees)
5. QUEBEC		
Provincial requirements	– peat bog with pond, marsh, swamp, lake or permanent watercourse	– 20 m buffer (harvesting subject to certain restrictions)
Lake Duparquet Forest	– any watercourse	– 20 m buffer
Montmorency Forest	– any watercourse	– buffer strip of 15-20 m
6. NEW BRUNSWICK		
Provincial requirements	– watercourse (discernable channel ≥ 0.5 m)	– vehicle exclusion zones and buffer zones 30-150 m (harvesting subject to certain restrictions)
Fundy Model Forest	– watercourse	– provincial requirement + no harvesting permitted within 5 m strip along watercourse
JD Irving	– mapped watercourses (width ≥ 0.5 m)	– 60 m buffer
	– unmapped watercourses	– possibility of a 15, 30, or 60 m buffer
7. NOVA SCOTIA		
Provincial requirements	– watercourses (width ≥ 50 cm)	– special management zone of 20 m
	– watercourses (≥ 50 cm) where the adjoining land has a slope of ≥ 20%	– 20 m + additional 1 m for each 2% of additional slope, to a maximum of 60 m

Generally, the wider the water body, the wider the riparian strip. Buffer zones may be comprised simply of lesser vegetation, around ephemeral watercourses for example, or stands, but their width never exceeds 100 m. British Columbia requires a protective strip (but not in all cases) and a buffer or management zone in which there are silvicultural constraints. However, the researchers of the Fundy Model Forest require that no harvesting be permitted within a 5 m strip along watercourses.

Some groups argue that it would be preferable to determine the width of riparian strips on the basis of local topographical features (unstable slopes) (Weyerhaeuser Saskatchewan, Fundy Model Forest).

2.10.5 Conservation areas and habitats

Conservation areas are sometimes protected by maintaining a core area in which no harvesting is permitted, surrounded by a buffer zone in which harvesting activities are restricted (British Columbia, Quebec). Alternately, they are simply controlled by cover constraints (% of area in certain conditions), or silvicultural constraints.

Increasing importance is being accorded to sensitive or unique environments or environments of importance to wildlife at the stand level. The organizations are requiring that these sites be identified in the field and preserved in accordance with the requirements specific to these various types of environments. Some of these organizations will even invite an expert to the site to provide specific guidelines appropriate to the sites identified (e.g., JD Irving).

3. Proportional requirements

Proportion requirements include the elements which must comprise or be included in the landscape. Hence, these are proportions of a managed area that must be maintained in specific forest conditions. Three subgroups of this type of constraint have been identified:

- cover constraints

Unlike conservation areas, the constraints discussed here represent cover retention requirements in specific habitats which are not static in the landscape.

It is important to stress here that the number of wildlife guidelines prescribing cover constraints for the protection of specific species makes it impossible to provide detailed descriptions of all of them. However, this section provides a general indication of what these guidelines, where they exist, are intended to accomplish.

- age class distribution

Over the years, logging has greatly modified the age class distribution in the landscapes. Indeed, the present age class distribution is often very different from the one in years passed, a difference that is strongly associated with changes to the disturbance regime (e.g., harvesting, fire suppression). In this section, we endeavour to determine the targeted age class distribution in the landscape and the criteria on which the choice of these targets is based. We also examine the strategies for retaining old-growth or mature seral stage forests. In fact, the literature surveyed shows a strong association between the two elements because studies of the current age class distribution frequently demonstrate an accelerating decline of these types of forests.

- silvicultural systems used and distribution

The type of logging conducted on the landbase will greatly influence landscape patterns. It is believed, for instance, that a forest landscape will become less fragmented by selection cutting than by other silvicultural systems. However, using only selection cutting would lead to a significant decrease in stand heterogeneity

(in terms of age and composition). This section examines and describes, for the various provinces and several large Canadian companies, the guidelines concerning each of the three types of proportion constraints mentioned above.

3.1 British Columbia

3.1.1 Government requirements

3.1.1.1 Cover constraints

3.1.1.2 Age class distribution

The retention of old-growth forests through the establishment of Old Growth Management Areas (OGMA) is one of the basic priority elements of the conservation of biodiversity in British Columbia (British Columbia Ministry of Forests 1999).

Recommendations on proportions of forest to be maintained in each seral stage vary depending on the biodiversity emphasis assigned at the subregion level (see Table 17). The procedures for determining the proportions of old-growth forests to be maintained (management areas) are based on the calculation of the representativeness of old-growth forests (solely at the variant level) and the ability to meet the targets set by using lands not contributing to the annual allowable cut.

Table 17. Comparison of various biodiversity emphasis options. Source: British Columbia Ministry of Forests (1995).

RANGE OF MANAGEMENT ALTERNATIVES FOREST PRACTICES CODE WITH BIODIVERSITY GUIDEBOOK OPTIONS			
BIODIVERSITY FACTORS AND RECOMMENDATIONS	**LOWER BIODIVERSITY EMPHASIS**	**INTERMEDIATE BIODIVERSITY EMPHASIS**	**HIGHER BIODIVERSITY EMPHASIS**
% old seral area	(natural % (proportion which already exists in non-harvestable environments) – 12%) x .5	(natural % – 12%) x .5	(natural % – 12%) x .75
% mature seral area	25% of natural	50% of natural	75% of natural
% early/young seral area	No limit	2 x natural	1.5 x natural

Natural seral stages can be determined on the basis of either stand characteristics or the recommendations set out in the *Biodiversity Guidebook* (British Columbia Ministry of Forests 1995). These guidelines, presented by disturbance type, were developed to allow a diversity of age classes to be maintained within the various biogeoclimatic zones, subzones and variants (see Table 18). To define them, the authors had to determine, on the basis of estimates of the long-term average return interval, the age class distribution (previously defined) which would naturally occur in biogeoclimatic zones.

To define these natural seral stages and their distribution (see Table 19), the following process was used:

1. Three seral stages were defined:

    A. Early/young:

    - forests less than 40 years old (20 years for deciduous stands)

    B. Mature:

    - forests 80 years or older for productive coastal forests (development of mature forest characteristics is faster in these forests)
    - forests 100-120 years or older for high elevation forests (development of mature forest characteristics is slower in these forests)

    C. Old:

    - forests 140 years or older for zones with more frequent disturbance
    - forests 250 years or older for less frequently disturbed zones

2. The approximate natural distribution of these seral stages has been calculated on the basis of the estimated long-term average interval between stand-destroying events (Appendix 1).

3. The targets set represent up to twice the estimated natural proportion of the early/young seral stage and at least half the natural proportion of mature and old seral stages. The proportion of old-growth forests found in protected areas was subtracted from the natural rate of old seral stage forest calculated.

Table 18. Seral stage definitions by biogeoclimatic zone in NDT1. Source: British Columbia Ministry of Forests (1995).

BIOGEOCLIMATIC UNIT	MEAN EVENT INTERVAL	EARLY/YOUNG SERAL STAGE	MATURE SERAL STAGE	OLD SERAL STAGE
CWH (Coastal Western Hemlock)	250 years	< 40 years	> 80 years	> 250 years
ICH (Interior Cedar Hemlock)	250 years	< 40 years	> 100 years	> 250 years
ESSF (Engelmann Spruce-Subalpine Fir)	350 years	< 40 years	> 120 years	> 250 years
MH (Mountain Hemlock)	350 years	< 40 years	> 120 years	> 250 years

Table 19. Recommended seral stage distribution for NDT1 (% of forest area within the landscape unit). Source: British Columbia Ministry of Forests (1995).

BIOGEOCLIMATIC UNIT	SERAL STAGE								
	EARLY/YOUNG			MATURE + OLD			OLD		
	1	2	3	1	2	3	1	2	3
CWH (Coastal Western Hemlock)	n/a	< 30	< 23	> 18	> 36	> 54	> 13	> 13	> 19
ICH (Interior Cedar Hemlock)	n/a	< 30	< 23	> 17	> 34	> 51	> 13	> 13	> 19
ESSF (Engelmann Spruce-Subalpine Fir)	n/a	< 22	< 17	> 19	> 36	> 54	> 19	> 19	> 28
MH (Mountain Hemlock)	n/a	< 22	< 17	> 19	> 36	> 54	> 19	> 19	> 28

1: Lower biodiversity emphasis
2: Intermediate biodiversity emphasis
3: Higher biodiversity emphasis

It is proposed that these forests be maintained in a variety of areas in the landscape. The minimum requirement for the old seral stage is included in the "mature+old" category.

It is also stressed that the objective of retaining old seral stage forests should include blocks designed so as to provide interior forest conditions. The proportion of old seral stage forests supporting interior forest conditions could range from 25% to 50% depending on the biodiversity emphasis assigned to the landscapes.

3.1.1.3 Silvicultural systems used and distribution

British Columbia requires that variable retention be applied in all cutblocks (British Columbia Ministry of Forests 1995). It is believed that retention requirements will have an impact at the stand level, but also contribute to maintaining the forest structure at the landscape level. The quantity of structure to be retained is based on the proportion that each biogeoclimatic zone occupies in the harvestable portion of the landscape unit and the extent of logging which has taken place in the past. The higher the proportion of harvestable area in a landscape or the greater the reduction in the abundance of trees for wildlife as a result of interventions, the higher the quantity of retention required.

When there are no established biodiversity objectives at the landscape level, the proportions are higher. In such cases, these recommendations are applied on an interim landscape unit or part of a forest development plan comprising a contiguous geographical unit.

3.1.2 Industry example: Clayoquot Sound Scientific Panel

3.1.2.1 Silvicultural systems used and distribution

The Clayoquot Sound Scientific Panel has recommended changes in timber harvesting practices (Clayoquot Sound Scientific Panel 1995). The trend is to move away from a strategy which concentrates on the trees to be removed and toward one which concentrates on the trees to be retained. This change is applied at the watershed level by delineating reserves in order to protect ecosystem integrity and forest values and is implemented at the stand (station) level by specifying trees to be retained in the individual cutting units.

It is their contention that all traditional silvicultural systems in Clayoquot Sound forests must be replaced by a variable retention silvicultural system.

3.1.3 Industry example: Weyerhaeuser Coastal BC

3.1.3.1 Cover constraints

The minimum retention rates applied by Weyerhaeuser within a framework of stewardship zones range from 5% to 20% at the stand level (see 3.1.3.3). At the landscape level, the legal requirements lead to forest retention rates of approximately 30% to 40%, approximately half of which comes from the productive forest (Beese et al. 2003).

3.1.3.2 Age class distribution

Weyerhaeuser in British Columbia has designated 10% of its license area as an "old-growth" stewardship zone within which old-growth forest attributes are to be maintained (see Table 20) (Beese et al. 2003).

3.1.3.3 Silvicultural systems used and distribution

A variable retention silvicultural system is the main system used by Weyerhaeuser Coastal BC (Beese et al. 2003).

The three zones delineated by the company (timber, habitat and old-growth – see Section 1.1.3) each have different landscape-level and stand-level retention objectives (see Table 20).

Table 20. Description of stewardship zones established by Weyerhaeuser Coastal BC. Source: Beese et al. (2003).

	STEWARDSHIP ZONE		
	TIMBER	HABITAT	OLD-GROWTH
Management emphasis	Commercial timber production	Habitat conservation	Maintain old-growth forest attributes
Proportion of the territory managed under this management emphasis	65%	25%	10%
Long-term retention in each cutblock (minimum)	Dispersed retention: 5% Group retention: 10%	Dispersed or group retention: 15%	Dispersed or group retention: 20%
Main silvicultural systems	– retention – shelterwood cutting	– retention – shelterwood cutting – selection cutting	– selection cutting – irregular shelterwood cutting

3.1.4 Industry example: Iisaak

3.1.4.1 Cover constraints

A maximum of 10% of the total watershed area (200-500 ha) may be cut over a 10-year period, and a maximum of 5% over a 5-year period for larger watersheds (Greg Rowe, pers. comm.).

3.1.4.2 Silvicultural systems used and distribution

Iisaak has undertaken to incorporate all recommendations of the Clayoquot Sound Scientific Panel in its forest-management approach (Greg Rowe, pers. comm.). Variable retention is therefore the main silvicultural system used. According to the company, this approach has allowed it to attain a 75% retention level on the 10,000 m3 harvested (Iisaak Forest Resources 2002).

3.2 Alberta

3.2.1 Government requirements

3.2.1.1 Cover constraints

Certain efforts will have to be made to protect the understory in order to develop shelter cover in hardwood stands where there are no appropriate softwoods to provide such cover (Province of Alberta 1994a).

3.2.1.2 Age class distribution

It is suggested that a minimum of 10% of the gross productive forest landbase of each forest management unit (FMU) should be maintained as mature/overmature forest that is representative of stand types in the area, with the objective of preserving wildlife habitats (Province of Alberta 1994a). Non-merchantable stands,

watercourse protection buffers and other areas not scheduled for harvest may contribute to the 10%. Stands managed as mature/overmature should be distributed throughout the disposition and be of a variety of sizes from 4 ha or larger.

3.2.1.3 Silvicultural systems used and distribution

The silvicultural system and harvest pattern must take into account the requirements of the tree species as well as the management and conservation objectives for timber and other resources (Province of Alberta 1994a). The usual silvicultural system (regeneration cutting) includes clearcutting in a pattern of alternating cut-and-leave blocks using a two-pass system. Where two-pass clearcutting is in significant conflict with other important forest values or resources and where timber age and condition permits, a three-pass system will be used.

Selection harvest or other silvicultural systems (e.g. shelterwood, seed tree) may be used where they are determined to be the most suitable to meet environmental, ecological or timber management objectives, or to protect other resource values.

Well-planned selective harvesting or small multi-pass cutblocks within larger stands should be considered in floodplains, but only where thermal and snow-interception cover and key habitat (e.g. snags, woody debris) are not jeopardized.

Logging techniques that will minimize the negative visual impact of logging should be used near recreation areas.

A variable retention system is applied in each cutblock with the objective of preserving wildlife habitats.

3.2.2 Industry example: Daishowa Marubeni International Ltd.

3.2.2.1 Age class distribution

The company aims for an inverse "J"-shaped age class distribution. However, due to the complexity of the model, objectives are set by seral class and not by age class (Frank Oberle, pers. comm.).

3.2.2.2 Silvicultural systems used and distribution

The company uses exclusively a one-pass variable retention silvicultural system (Frank Oberle, pers. comm.).

3.2.3 Industry example: Alberta-Pacific Forest Industries Inc.

3.2.3.1 Age class distribution

The strategy proposed is to maintain in productive stands percentages of old-growth forests similar to those that existed in the management area during the past 100 years. The analyzes indicate an average rate of 8% for these years, which becomes the target for the 200-year forest yield analysis. The distribution of these stands will not be managed directly and will vary over time. This age class (120 years) will include low-density stands (density "A"), buffer zones, hardwood stands with softwood understories, unplanned hardwood stands and softwood stands harvested at older ages.

3.2.3.2 Silvicultural systems used and distribution

Single-pass operations, in which variable quantities of structures are left in place, are normally used rather than traditional two-pass operations (Anonymous 2000*a, b*). This type of system results in blocks whose shape is more similar to the patterns left following a fire, which should contribute to lessen fragmentation and subsequent disturbance.

In the deciduous portion of the forest management area, an average of 5% of the merchantable hardwood volume will be retained for the maintenance of structure (variable retention) (Anonymous 2000a, b). In the coniferous portion, 1% of the merchantable softwood volume and 5% of the merchantable hardwood volume will be preserved for structure.

3.2.4 Industry example: Weyerhaeuser Alberta

3.2.4.1 Cover constraints

In order to facilitate species dispersal and maintain the distribution of populations, a minimum forest cover of 35% (height 12 m) at the landscape level will be retained (Anonymous 1997).

3.2.4.2 Age class distribution

Forest planning will endeavour to maintain the range of age structures, seral stages and relative abundance of the various types of cover based on the characteristics of the inherent ecological processes of each subregion present in the forest management area (Anonymous 1997).

The natural subregions found in the Drayton Valley Forest Management Area are: 1) Lower Foothills, 2) Upper Foothills and 3) Subalpine (Anonymous 2001*b*). These subregions exhibit climactic and vegetation differences which consequently influence their natural disturbance regime (see Table 21).

Table 21. General characteristics of the various natural subregions of the Foothills Model Forest. Source: Anonymous (2001*b*).

	LOWER FOOTHILLS	UPPER FOOTHILLS	SUBALPINE
Fire cycle (yrs)	65-75	80-90	130-190
% of area in patches > 2,000 ha	33	76	66
Lightning hits/ 1,000 ha	58	48	11
growing degree days	1,121	880	903
mm rain/yr	403	370	328
cm snow/yr	144	162	233

The company will also endeavour to maintain a natural distribution of the various seral stages. For instance, it plans to retain the mature seral stages at the locations where they are most likely to be found (i.e. on wet sites such as slopes facing northwest, north-northeast and east). South and southwest facing slopes and well-drained sites burn more frequently and are less likely to support these stands.

Weyerhaeuser plans to ensure that a certain proportion of old-growth forests (age exceeding the "rotation age") are maintained permanently in the forest management area. These mature seral stages are represented by:

- >110 years for coniferous forests
- >80 years for deciduous forests

Furthermore, a proportion of these will be in the overmature seral stage (> 140 years).

These seral stages will be maintained in each forest type of each natural subregion in order to accommodate the wildlife and plant species dependent on them.

The following proportions reflect the ecological requirements at the natural subregion level and are derived from an analysis of the current age class distribution and an approximate calculation of the historical trends and natural disturbances for each subregion. In the Lower Foothills, the minimum proportions for the mature seral stages are 5%, including 1% in the overmature stage (>140 years) (see Table 22). These proportions apply to all the plant associations apart from white spruce and lodgepole pine. This is explained by the fact that pure white spruce stands occur only in the older seral stages, while conversely, pine stands generally originate from fires and stands older than 100 years have little of chance of persisting in the landscape for long.

Table 22. Minimum proportions of stands maintained in the mature seral stage in the Lower Foothills of the Drayton Valley FMA by Weyerhaeuser Alberta. Source: Anonymous (2001*b*).

COVER TYPE	CURRENT PROPORTION OF MATURE FOREST (% OF FOREST COVER TYPE)	PROPORTION OF MATURE FOREST IN 1950 (% OF FOREST COVER	MINIMUM PROPORTION IN MATURE FOREST	MINIMUM PROPORTION IN OVERMATURE FOREST
Deciduous forest	3.1%	0%	5%	1%
Mixed forest	10.6%	0%	5%	1%
Pine-spruce forest	21.3%	0.6%	5%	1%
Lodgepole pine forest	9.5%	0%	1%	
White spruce forest	25.9%	0.3%	10%	2%

In the Upper Foothills, the proportions in mature seral stages are higher, reflecting the longer fire cycle and the greater probability that older stands will persist in the landscape longer (see Table 23).

Table 23. Minimum proportions of stands maintained in the mature seral stage in the Upper Foothills of the Drayton Valley FMA by Weyerhaeuser Alberta. Source: Anonymous (2001*b*).

COVER TYPE	CURRENT PROPORTION OF MATURE FOREST (% OF FOREST COVER TYPE)	PROPORTION OF MATURE FOREST IN 1950 (% OF FOREST COVER	MINIMUM PROPORTION IN MATURE FOREST	MINIMUM PROPORTION IN OVERMATURE FOREST
Deciduous forest	3.2%	0%	5%	2%
Mixed forest	9.7%	0%	5%	2%
Pine-spruce forest	47.5%	16%	10%	5%
Lodgepole pine forest	15.6%	0.3%	2%	1%
White spruce forest	69.9%	5.1%	20%	5%

The Subalpine Subregion is characterized by less frequent and more catastrophic fires (see Table 24). Here, the older stands usually persist longer in the landscape. This subregion has a longer fire cycle, reflecting a generally cooler and wetter climate with fewer lightning strikes.

Table 24. Minimum proportions of stands maintained in the mature seral stage in the Subalpine Subregion of the Drayton Valley FMA by Weyerhaeuser Alberta. Source: Anonymous (2001*b*).

COVER TYPE	CURRENT PROPORTION OF MATURE FOREST (% OF FOREST COVER TYPE)	PROPORTION OF MATURE FOREST IN 1950 (% OF FOREST COVER	MINIMUM PROPORTION IN MATURE FOREST	MINIMUM PROPORTION IN OVERMATURE FOREST
Mixed coniferous forest	60.3%	25.8%	10%	5%
Lodgepole pine forest	13.1%	1.7%	5%	2%
White spruce forest	90.4%	44.3%	20%	5%

3.2.4.3 Silvicultural systems used and distribution

Weyerhaeuser Alberta plans to adopt a range of modified silvicultural practices (e.g. mixed-wood management, multi-pass systems, selection cutting) combined with variable retention, which better reflect the ecological processes characteristic of the natural subregions and ecodistricts (Anonymous 1997).

3.2.5 Industry example: Millar Western Forest Products

3.2.5.1 Cover constraints

There appear to be no specific requirements of this type apart from the desire to determine measurable targets for each managed landscape, on the basis of an analysis of natural disturbances, natural succession processes, and current and historical conditions in the region, subregion and ecodistrict/ecoregion (Anonymous 2002).

Planning at the landscape level will ensure the availability of suitable habitats and conditions for grizzly bears. Timber harvesting and road planning will have to be carried out in a manner consistent with *Grizzly Bear Conservation in Alberta Yellowhead Ecosystem: A Strategic Framework*.

3.2.5.2 Age class distribution

There appear to be no specific requirements of this type apart from the desire to determine measurable targets for each managed landscape, on the basis of an analysis of natural disturbances, natural succession processes and current and historical conditions in the region, subregion and ecodistrict/ecoregion (Anonymous 2002).

3.2.5.3 Silvicultural systems used and distribution

Clearcutting combined with variable retention is the silvicultural system most frequently used in the FMA. The company has, however, undertaken to explore other alternatives, which include shelterwood cutting, strip cutting and other forms of harvesting involving variable retention and partial harvesting (Anonymous, no date)

3.3 Saskatchewan

3.3.1 Industry example: Weyerhaeuser Saskatchewan

3.3.1.1 Age class distribution

Because fire plays an important role in age class distribution, the aim is to maintain an age class distribution similar to that which results from periodic fires, while endeavouring to strike a balance between environmental, social and economic values (Anonymous 1999).

Forest management will aim for an age class distribution similar to what would occur under a 70-year fire cycle. This was chosen as a balance between social, economic and environmental values. As discussed above for Weyerhaeuser Alberta, this cycle makes it possible to avoid the undesirable extremes between the application of a cycle emulating the natural disturbance regime (30-50 years) and a current regime of 205 years.

Enough forests in the mature and overmature seral stages will be maintained for each type of forest in each unit (see Weyerhaeuser Alberta, Section 3.2.4.3). The minimum proportions are 5% of the mature seral stage and 1% of the overmature seral stage for all species associations, with the exception of white spruce (see Weyerhaeuser Alberta Section 3.2.4.3).

3.1.1.2 Silvicultural systems used and distribution

Weyerhaeuser Saskatchewan primarily uses a two-pass harvest system in which approximately half of an area is cut during the first pass (Anonymous 1999). A single-pass system can be used when it is considered desirable to limit access to the site.

The company uses mainly “modified” clearcutting with retention of structure in the stands. A few clearcuts are carried out in black spruce and black spruce/jack pine stands. Clearcuts can also be used to meet specific needs, such as salvaging diseased or infested stands and creating fire breaks.

3.4 Manitoba

3.4.1 Government requirements

3.4.1.1 Cover constraints

The *Forest Management Guidelines for Wildlife in Manitoba* stipulate that a minimum of 20% forest cover of indeterminate height should be maintained in any management unit for wildlife needs (Manitoba Natural Resources 1989).

There are various guidelines for wildlife environments identified in the management unit. For instance, there are guidelines for the protection of areas occupied by moose, elk, caribou, deer, birds of prey, nesting passerines and small game.

3.4.1.2 Silvicultural systems used and distribution

Clearcutting is generally the standard harvesting method in softwood stands, from which the entire merchantable volume is removed. However, this does not exclude the use of selection cutting or other harvesting methods (Manitoba Natural Resources 1996).

3.4.2 Industry example: Louisiana Pacific Ltd.

3.4.2.1 Silvicultural systems used and distribution

The various silvicultural systems used by Louisiana Pacific and their proportions are as follows:

- 20% modified clearcutting (variable retention harvesting),
- 75% modified clearcutting with understory protection, and
- 5% partial harvest (Anonymous 2001a).

3.4.3 Industry example: TEMBEC-Pine Falls

3.4.3.1 Silvicultural systems used and distribution

Clearcutting is the dominant silvicultural system. (see Table 25). However, the company is currently moving toward the adoption of a variable retention silvicultural system (Vince Keenan, pers. comm.).

Table 25. Distribution of cutting areas used by Tembec Pine Falls Group in Manitoba in 2000-2001. Source: Vince Keenan, pers. comm.

May 2000 to April 2001					
CUTBLOCK SIZE (HA)	NUMBER OF CUTS	CLEAR-CUTTING	SALVAGE CUTTING	SELECTION CUTTING	TOTAL AREA
0-20	82	401.1	30.69	5.72	437.51
21-40	15	364.82	96.68		461.5
41-80	6	358.9			358.9
81-120	2	193.06			193.06
121-160	0				0
161-200	1	168.61			168.61
> 200	0	-			0
Total	106	1,486.49	127.37	5.72	1,619.58

3.5 Ontario

3.5.1 Government requirements

3.5.1.1 Cover constraints

The province of Ontario has adopted a wide variety of guidelines for the protection of specific habitats. These include:

- *Timber Management Guidelines for the Provision of Moose Habitat*
- *Timber Management Guidelines for the Provision of White-Tailed Deer Habitat*
- *Timber Management Guidelines for the Provision of Pine Marten Habitat*
- *Timber Management Guidelines for the Provision of Pileated Woodpecker Habitat*
- *Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach*
- *Guidelines for Providing Furbearer Habitat in Timber Management*

3.5.1.2 Age class distribution

The age class structure for selected stand types must fall within or be moving toward the range of natural variability. The preferred management alternative will create the desired age class structure within acceptable natural bounds and within an acceptable time period. Acceptable bounds will reflect the following:

- the variability and uncertainty associated with natural disturbances and succession,
- social and economic constraints, and
- the relative rarity of older age classes in many FMU forests and their resultant values.

This objective will be met through the management of each forest management unit, but will take the ecoregional context into account. A benchmark reflecting natural forest conditions could be established for each FMU. The benchmark can also be used as a starting point to estimate the bounds of natural variation by modelling (e.g. Strategic Forest Management Model; OnFire II).

Ontario is currently attempting to develop a policy on old-growth forests. As part of this process, the province has produced a document defining the old-growth forests of the various forest communities found across the province. It provides an estimate of the age that marks the beginning of an old-growth forest and its duration, in the five main ecological zones of the ecoregions (Ontario Ministry of Natural Resources 2003). The definitions provided apply to all the recognized ecosites and the main tree species and include all the landscape types. These definitions should enable forest planners and managers to examine the current ecosystem databases and the forest inventory in order to adopt a localized strategy for conserving old-growth forests. These definitions should also make it possible to recognize current, historical and future old-growth forests.

In addition to protecting a portion of the current red pine and white pine old-growth forest ecosystems, other communities will be added to preserve the full range of age classes in the landscape.

3.5.1.3 Silvicultural systems used and distribution

The guide developed to promote forest management modelled on natural disturbances was developed for forests managed under a clearcutting silvicultural system and in certain cases for areas managed under the shelterwood cutting silvicultural system (Ontario Ministry of Natural Resources 2001). The use of silvicultural systems modelled on the natural disturbance regime typical of the area managed is advocated. Research demonstrates that, historically, individual stands in the boreal forest were shaped by the presence, absence and intensity of fire, and harvesting should reflect this pattern. Forest managers should also use harvesting techniques that more closely simulate moderate and low-intensity fires. Harvesting techniques should also be sensitive to the natural succession that

occurs in forest types that are not burned for long periods of time (e.g. application of the Careful Logging Around Advanced Growth (CLAAG) harvesting system in lowland black spruce stands).

In pure, but even more importantly in mixed stands, it is important to preserve a proportion of forest in the uneven-aged state. This proportion should be maintained within the bounds of natural variation. This objective can be achieved by the retention of old-growth and natural age class structures and the retention of older age classes within unique or sensitive sites.

3.5.2 Industry example: Abitibi Consolidated

3.5.2.1 Age class distribution

Abitibi Consolidated has set itself the objective of obtaining an age class structure representative of the forest condition under a natural disturbance regime, within the bounds of natural variation (Anonymous, no date *b*). For instance, for a fire cycle ranging from 40 to 70 years (according to the *Fire History Report*), this corresponds to a proportion of 5% to 12% of forest over 100 years.

It is also important to ensure that there is older age class representation of all forest units based on the age criteria in *Conserving Ontario's Old Growth Forest Ecosystems* (Ontario Ministry of Natural Resources 1994). The amount of representative area should reflect the bounds of natural variation.

It should be noted that various provincial parks and conservation reserves form an essential part of providing for older age class representation in the forest. Other non-regulated exclusions from the land base also contribute to older age class representation.

3.5.2.2 Silvicultural systems used and distribution

The company considers that most of their stands are even-aged and owe their origin to previous fires or other natural disturbances (Anonymous, no date *b*). Also, the species present (jack pine, poplar and white birch) are generally pioneer, shade-intolerant and fire-adapted species. Hence, clearcutting with patch retention (variable retention) is the main method used. However, in the units dominated by white pine, shelterwood seed cutting will be used.

3.6 Quebec

3.6.1 Government requirements

3.6.1.1 Cover constraints

The regulation states that the productive forest area of a management unit where harvesting is carried out shall always be composed of hardwood, mixed or softwood stands more than 7 m in height over at least 30% of that area (Province of Quebec 2001).

3.6.1.2 Silvicultural systems used and distribution

The regulation states only that any harvesting without regeneration and soil protection is prohibited (Quebec Department of Natural Resources 2000). The silvicultural systems used are adapted to the stand types and management objectives. No target is set in terms of proportion of silvicultural systems at the landscape level.

3.6.2 Industry example: Lake Duparquet Teaching and Research Forest (FERLD)

3.6.2.1 Cover constraints

The researchers endeavour to maintain the composition of the forest mosaic in a state which is similar to what it would be in the absence of silvicultural management. An effort is made to ensure that each dominant stand type is represented on the landscape. Using a model which predicts the composition of the boreal mixed forest when subject to dynamic change in the form of natural disturbances and objectives established for the cohorts in the management area, the proportion which should be occupied by each stand type according to the types of dominant environments present is determined.

However, these values are used to establish general objectives rather than target objectives, since the proportion of the area occupied by the various strata within a cohort is attributable to the historical disturbances and forest cover.

3.6.2.2 Age class distribution

An analysis of the succession patterns of forest stand types has made it possible to differentiate their three seral stages. These seral stages were then grouped into three different cohorts, each corresponding to a subset of normal forests which succeed one another in decreasing proportions as a function of the time elapsed since the last clearcut or last fire:

- Cohort 1: first seral stage of all the stand types identified
- Cohort 2: second seral stage of all the stand types identified
- Cohort 3: third seral stage of all the stand types identified

The main objective of this concept is to maintain these cohorts in conditions (composition and structure) similar to what would theoretically be observed under the influence of a natural disturbance regime.

To this end, the researchers have selected 140 years as the average age of the forest, taking into account the historical variability of the fire cycle and the fact that the current forest composition is the result of major changes in the climactic and disturbance regime.

However, it is recognized that setting as an objective an even-aged age structure with an average age of 140 years is not a realistic option where increasing timber production is an equally important goal. Rather, it is suggested that the average

age of the forest serve as a target fire cycle for a negative exponential age structure. The proportion of forest targeted for each of the three cohorts is thus based on the fire cycle and the maximum average age at time of harvesting.

This objective is considered a compromise between complete regulation of the forest and a negative exponential age structure. By using a fire cycle of 140 years as corresponding to the average age of the forest, and a harvestable age of 80 to 100 years, it is believed that approximately 45-55% of the management area should be composed of forest stands in the first seral stage (cohorts 1), 23-26% in the second seral stage (cohorts 2), and 20-30% in the third seral stage (cohorts 3+, where the + indicates that a minor portion of these stands should be treated by selection cutting or left untreated in order to generate fourth-cohort stands).

3.6.2.3 Silvicultural systems used and distribution

The silvicultural systems adopted are similar to the natural disturbance regime and the natural dynamics, consisting of successive rotations of hardwood-dominant, mixed and softwood-dominant stands (Figure 5). The silvicultural model developed also endeavours to maintain a certain proportion of each cohort (each representing a different seral stage, see Section 3.6.2.3) in the landscape (Figure 6).

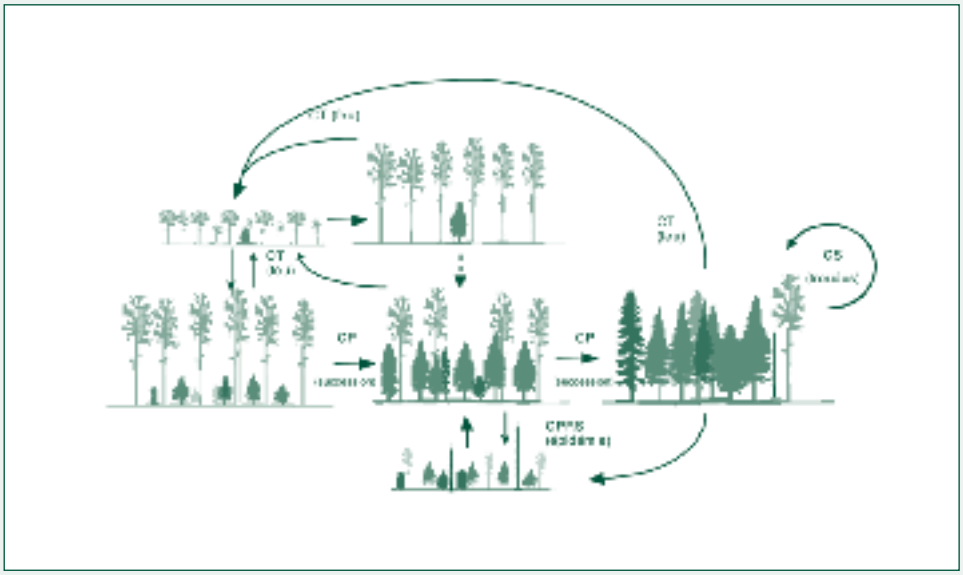
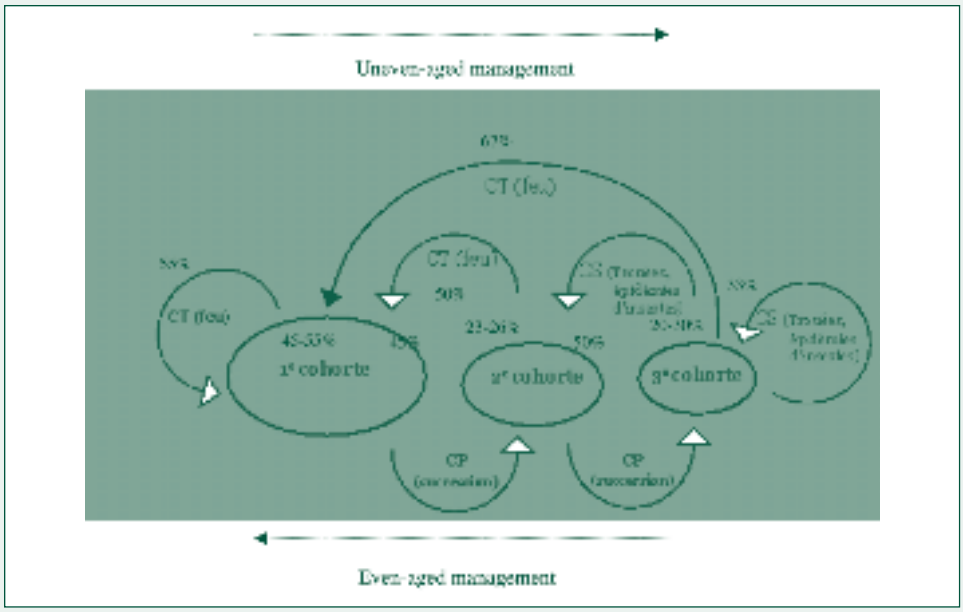


Figure 5. Diagram showing the natural dynamics and a silviculture adapted to the mixed sites of the FERLD (CC: clearcut; PH: partial harvest; SC: selection cutting).

Translation key: CT = CC; CP = PH; CS = SC; CPRS = CCRSP; feu = fire; trouées = gaps; épidémie = epidemic



CC= clearcut; PH= partial harvest; SC= selection cutting

Figure 6. Conceptual model of cohorts and flows in the FERLD, Quebec. Source: **Harvey et al. (2002).**

Translation key: CT = CC; CP = PH; CS = SC; feu = fire; cohorte = cohort; trouées, épidémies d'insectes = gaps, insect epidemics

3.6.3 Industry example: Montmorency Forest (Laval University teaching and research forest)

3.6.3.1 Age class distribution

At the landscape unit level (3-10 km^2), an objective of mixing stands at the regeneration, young and mature stages has been set (Bélanger, no date). Generally, an attempt is made to distribute the cuts in such a way that each unit contains:

- one-third of the area in regeneration stands (0-20 years),
- one-third of the area in young stands (20-40 years), and
- one-third of the area in mature and overmature stands (40-60 and 60-80 years).

It is believed that this distribution makes it possible to recreate a natural landscape similar to that which existed at the turn of the 20th century, at which time one-third of the area consisted of gaps and two-thirds of mature forest.

3.6.3.2 Silvicultural systems used and distribution

The silvicultural system applied is strictly an even-aged system of patch cutting with regeneration protection. This is the system best suited to the ecology and dynamics of the boreal fir forest (Bélanger, no date). Irregular shelterwood cutting is also practised on a small scale on recreational sites, for example, where protecting the landscape is an important objective (Paul Boulianne, pers. comm.).

3.7 New Brunswick

3.7.1 Government requirements

3.7.1.1 Cover constraints

All forest-dwelling vertebrate wildlife species (birds, mammals, reptiles, amphibians) have been characterized with respect to habitat associations that occur at the scale of forest stands. Five distinct upland habitat types were described as a result of that process: Hardwood, Tolerant Hardwood, Spruce-fir, Pine and Mixedwood. At the stand level, habitats are defined in terms of vegetation communities, successional stages, and peak volume (Table 26).

Table 26. Stand-level habitat composition criteria recommended by the New Brunswick Department of Natural Resources. Source: Province of New Brunswick (2000).

	COMPOSITION CRITERIA		
Habitat type	**Vegetation communities[1]**	**Seral stages[2]**	**Volume**
Old Hardwood Habitat (OHWH)	IHSW, THP, THSW	Old or large	Peak total volume ≥ 70 m^3/ha
Old Tolerant Hardwood Habitat (OTHH)	THP, THSW	Old	
Old Spruce-Fir Habitat3 (OSFH)	SP, BF, BS, CE	Old or large	
Old Pine Habitat (OPIH)	Any community; softwood content ≥ 25% and < 75%	Old	
Old Mixedwood Habitat (OMWH)		Old or large	
Large Mixedwood Habitat (LMWH)		Large	

[1] See Table 29

[2] See Table 30

The objectives were compiled for each ecoregion and then prorated to timber license, thereby ensuring the maintenance of viable populations of all species across the areas of Crown land to which the species are indigenous.

Table 27. Management objectives for habitat types by license and ecoregion in New Brunswick. Source: Province of New Brunswick (2000).

ECO-REGION	HABITAT TYPE	OBJECTIVE BY CROWN LICENSE FOR OLD AND/OR LARGE SERAL STAGE (HA)									
		1	2	3	4	5	6	7	8	9	10
1	OHWH	170	180								520
	OTHH	330	500								4130
	OSFH	1760	4150		12260						13570
	OMWH	1710	1570		2320						9040
	LMWH	170	220		200						430
2	OHWH	3720	730								750
	OTHH	3260	1650								2020
	OSFH	20530	6150								2700
	OMWH	17690	3230								3150
	LMWH	1870	440								370
3	OHWH	190	60	80	200		200	340		950	720

Eco-region	Habitat type	Objective by Crown License for OLD and/or LARGE seral stage (ha)									
		1	2	3	4	5	6	7	8	9	10
	OTHH	390	290	640	1890		1650	3720		9400	8840
	OSFH	1610	1090	4110	6740		1760	2350		3060	6490
	OMWH	1650	620	1780	3610		860	920		2380	6250
	LMWH	220	100	110	290		100	180		530	510
4	OHWH						180	250			
	OTHH						130	380			
	OSFH						1330	2220			
	OPIH						80				
	OMWH						680	480			
	LMWH						120	90			
5	OHWH				220		1830	850	1420	580	
	OTHH				1700		5710	2900	4470	3550	
	OSFH				1820		13790	5820	6420	2070	
	OPIH						1080		430		
	OMWH				1650		6020	2010	6180	1330	
	LMWH				190		980	390	1150	270	
6	OHWH		340	840	220	610	920				
	OTHH		410	3000	1070		1790	1400			
	OSFH		4960	13060	5770	3950	9980	6960			
	OPIH						2030				
	OMWH		1840	5940	2030	2560	3430	2290			
	LMWH		300	650	190	490	540	460			
7	OHWH						280	690	130		
	OTHH						430	1410			
	OSFH						1810	3040	420		
	OPIH						190	160			
	OMWH						990	1280	490		
	LMWH						160	250	100		

This document also contains tables in an appendix which integrate the timber license requirements with respect to vegetation communities and wildlife habitat objectives (see Table 28).

Table 28. Example of integration of vegetation communities and wildlife habitat objectives for timber license 1 in New Brunswick. Source: Province of New Brunswick (2000).

VEGETATION COMMUNITY	CONSTRAINING OBJECTIVE BY ECOREGION (HA)		
	1	2	3
THP	320	5,330	310
THSW	470	6,090	460
SP	630	6,750	500
BF	1,340	14,180	1,140
PINE	0	890	0
EC	0	0	220
OHWH1	*170*	*3,720*	*190*
OSFH2	*1,760*	*20,530*	*1,610*
OMWH3	*1,710*	*17,690*	*1,650*
LMWH3	*170*	*1,870*	*220*

All habitat types have spatial criteria. Minimum patch sizes are 375 ha for Old Spruce-fir Habitat (OSFH), and range from 10 to 60 ha for other types. A minimum of 75% of the area of each block must meet the prescribed criteria, and block widths must normally exceed 1000 m and always exceed 500 m.

Provision of spatially adequate old spruce fir habitats beyond the spatial planning horizon requires that the area of non-spatially referenced habitat (gross habitat) exceed that of the spatially referenced objective (net habitat). To that end, an objective exists for gross old spruce fir habitats for all planning periods beyond those spatially referenced.

White-tailed deer wintering areas (DWA's) are also defined for each license. These areas are managed so as to maximize the sustainable supply of deer winter habitats. For the purpose of deer habitat management, the province was subdivided into northern and southern regions. All DWA's have been assigned to either the northern or southern region. Timber harvesting activities must not reduce habitat levels by more than 15% over a given five-year period.

3.7.1.2 Age class distribution

Conserving the diversity of forest ecosystems and their associated ecological values is one of the province's objectives (Province of New Brunswick 2000). One method for attaining this objective is to direct forest management activities so as to ensure that the full range of naturally occurring forest types and seral stages are maintained. Stands are defined on the basis of the vegetation community present and its seral stage. The various vegetation communities are defined by the overstory tree species composition (see Table 29).

Table 29. Species composition criteria of vegetation communities in New Brunswick. Source: Province of New Brunswick (2000).

VEGETATION COMMUNITY	COMPOSITION CRITERIA[1]	
Tolerant Hardwood Pure (THP)	SW[2] < 50%;	TH[3] ≥ 20%; TH+RM4 ≥ 75%
Tolerant Hardwood – Softwood (THSW)	SW < 50%;	TH ≥ 20%; TH+RM ≥ 35% and <75%
Intolerant Hardwood – Softwood (IHSW)	SW < 50%;	TH < 20% or TH+RM < 35
Pine (PI)	SW ≥ 50%;	PI[5] ≥ 35%
Jack pine (JP)	SW ≥ 50%;	JP[6] ≥ 35%
Cedar (CE)	SW ≥ 50%;	CE[7] ≥ 35%
Black spruce (BS)	SW ≥ 50%;	BS[8] ≥ 35%
Spruce (SP)[11]	SW ≥ 50%;	SP[9] ≥ 35%
Balsam fir (BF)[12]	SW ≥ 50%;	BF[10] ≥ 35%
Tolerant Hardwood-Softwood (THSW)	SW ≥ 50%;	TH ≥ 20%; TH+RM ≥ 35% and <75%

[1] Criteria are not mutually exclusive. The stands that meet more than one set of criteria are assigned on the basis of the priority indicated in the table.
[2] All softwood species
[3] Tolerant hardwood: primarily sugar maple, yellow birch and American beech
[4] Red maple
[5] Pine: white and red pine
[6] Jack pine
[7] Eastern cedar
[8] Black spruce
[9] Spruce: white and red spruce
[10] Balsam fir
[11] Includes those stands with greater than 75% spruce+fir and greater than 35% spruce (SPP)
[12] Includes those stands with greater than 75% spruce+fir and greater than 35% fir (BFP)

Older seral stages are characterized as follows:

- Old: crown closure declines due to mortality in the overstory
- Large: there are stems of 45 cm in diameter or greater in the stand; stand must provide habitat for certain vertebrate species

The approximate ages at which these two seral stage types begin have been estimated for each vegetation community on the basis of the most abundant species present (see Table 30).

Table 30. Approximate minimum ages of the old and large seral stages. Source: Province of New Brunswick (2000).

VEGETATION COMMUNITY	APPROXIMATE MINIMUM AGE	
	OLD	LARGE[2]
Tolerant Hardwood Pure (THP)	90 / 120[1]	90 / 120
Tolerant Hardwood – Softwood (THSW)	90 / 120	90 / 120
Intolerant Hardwood – Softwood (IHSW)	70	90
Pine (PI)	90	90
Jack pine (JP)	70	—[3]
Cedar (CE)	80	—
Black spruce (BS)	80	—
Spruce (SP)	90	110
Balsam fir (BF)	60	—

[1] Currently existing uneven-aged stands with a vegetation community of THP or THSW are assigned a start age of 90 for OLD; current and future clearcut stands are assigned the age of 120.

[2] Habitat requirement only.

[3] Stands with vegetation communities of JP, CE, BS or BF do not regularly produce trees of 45 cm or greater in diameter; hence they do not achieve a seral stage of LARGE.

Objectives concerning the area of the vegetation communities to be maintained in the old and/or large seral stages were determined for ecoregions and prorated to Crown licenses (see Table 31). These areas are equivalent to 12% of the total area in each community as defined in the 1982 provincial inventory and adjusted for human disturbance.

Table 31. Management objectives for vegetation communities by license and ecoregion.[1] Source: Province of New Brunswick (2000).

ECO-REGION	VEGETATION COMMUNITY	OBJECTIVE BY CROWN LICENSE FOR MATURE OR OVERMATURE SERAL STAGES (HA)									
		1	2	3	4	5	6	7	8	9	10
1	THP	320									1520
	THSW	470	480								2640
	PINE		110								
	JP		700								
	SP	630	1670								4840
	BF	1340	2210								12710
	BS		1170								
2	THP	5330	940								530
	THSW	6090	1730								1370
	PINE	890									
	CE		610								
	SP	6760	3140								2090
	BF	14180	3890								1250
	BS		690								

Eco-region	Vegetation Community	Objective by Crown License for mature or overmature seral stages (ha)									
		1	2	3	4	5	6	7	8	9	10
3	THP	310		330	820		700	1940		3680	3690
	THSW	460	130	530	980		560	1110		1770	3050
	PINE				50						
	JP		90								
	CE	220	70	390	750						
	SP	500	540	2680	5260		1710	2380		2720	2780
	BF	1140	330	760	1970		310			770	3170
	BS		90	1330							
4	THSW						280	450			
	CE						240				
	SP						1570	2800			
5	THP				920		3340	820	1970	1130	
	THSW				660		4260	1830	2930	950	
	PINE				50		1000	240	200		
	CE				430		1680		1540	530	
	SP				1280		11100	6000	6200	1670	
	BF				310					500	
	BS				390		3980	1540			
6	THSW		720	2530	800	1080	2610	1740			
	PINE		60	720	130	150	1330	230			
	JP		430	2510		350	2620	1130			
	CE		320	1100		440					
	SP		2060	4900	1990	1340	3470	3110			
	BF		670								
	BS		4460	9020	4520	2580	8000	5590			
7	THSW						610	1350	320		
	PINE						180	180			
	JP						180				
	CE								80		
	SP						950	2160	300		
	BS						1280	1660	130		

[1] There are no objectives where the area of overlap between an ecoregion and a license is less than 5% of the total license area. If a license contains over 30% of an ecoregion, there will be objectives for that ecoregion. This applies to ecoregion 4 in licenses 6 and 7. There is no objective for a vegetation community (other than PINE) when it comprises less than 5% of the overlap area between an ecoregion and a license. There is an objective for the pine community for all overlap areas, except if the area is less than 1% or less than 10 ha.

3.7.1.3 Silvicultural systems used and distribution

The New Brunswick regulations stipulate that uneven-aged management techniques must be used in tolerant hardwood stands that have potential for sawlog production (Province of New Brunswick 2000).

The full range of harvest prescriptions (partial harvest, multi-pass, clearcut) will be investigated. The methods selected will be biologically and economically viable and compatible with achieving the stated forest objectives.

3.7.2 Industry example: Forest Management Guidelines to Protect Biodiversity in the Fundy Model Forest

3.7.2.1 Age class distribution

The authors of the guidelines believe that the mature and overmature age classes of all forest types should be better represented in the Model Forest. To this end, it is recommended that at least 12% of the area (except regenerating or non-forest communities) should be maintained in a mature-overmature age class and 4% should be in the overmature age class. These minimums represent one-third of the estimated proportions based on 100-year stand-replacing disturbance regimes and take into account timber supply needs and biodiversity requirements. On an ecodistrict level, the mature or overmature component should always exceed the minimum patch size of 375-500 ha. Old forests under uneven-age management should have a minimum canopy crown closure of 60%.

3.7.2.2 Silvicultural systems used and distribution

The authors argue that the forests should be managed according to the prevailing disturbance regime, i.e. by gap or stand-replacing disturbance regimes (Woodley and Forbes 1997). The corresponding silvicultural practices are selection cutting and clearcutting respectively. In forests dominated by a gap disturbance regime, it is recommended that a closed canopy population of uneven-aged trees and a sufficient number of young trees to regenerate the forest be maintained.

In order to meet various wildlife needs, the guidelines recommend using a variable retention system in each cutblock.

3.7.3 Industry example: JD Irving

3.7.3.1 Silvicultural systems used and distribution

The company uses mainly a variable retention silvicultural system. The following table describes the silvicultural activities on the harvested areas of the lands managed by the company (see Table 32).

Table 32. Summary of harvested areas on lands managed by JD Irving Limited in New Brunwick. Source: David Young, pers. comm.

Total cuts		Natural stands						Managed stands	
All prescriptions		Variable retention	Overstory removal	Shelterwood cutting	Two-pass method (2/3 residual removed over 5-15 years)	Single tree or group selection method	Three-pass method (2 additional passes planned (1/10 years)	Variable retention	Commercial thinning
Period	%	%	%	%	%	%	%	%	%
1	100	60	3	10	6	7	10	0	4
2	100	53	2	5	6	5	11	0	18
3	100	30	2	10	13	4	20	1	20
4	100	41	0	4	5	3	2	14	31
5	100	10	0	1	0	7	21	25	36
Total	100	39	2	6	7	5	13	7	21

3.8 Nova Scotia

3.8.1 Government requirements

3.8.1.1 Cover constraints

Approximately 50% of deer wintering areas designated by the province must be maintained in softwood stands of sufficient height and density to reduce snow accumulation (Nova Scotia Department of Natural Resources 1989). These wintering areas, composed of a mixture of age classes and species, should be no smaller than 10 ha. Timber harvesting (preferably selection cutting), if performed, must be carried out in the fall or early winter. The individual openings should not exceed 10 ha, separated by uncut areas at least equal in size to the cut areas. Uncut areas should be left attached to adjacent shelter areas by travel corridors with a minimum width of 50 m.

3.8.1.2 Age class distribution

It is important to maintain 3% to 8% forest cover in the managed area, mainly in the form of old-growth forest (Nova Scotia Department of Natural Resources 1989).

3.8.1.3 Silvicultural systems used and distribution

Under the new *Wildlife Habitat and Watercourse Protection Regulations*, a variable retention silvicultural system must be used, which means that on any harvest site comprising an area greater than 3 ha, 10 living or partially living trees must be left standing for one full rotation for each hectare of forest land cut.

3.9 Summary

3.9.1 Cover constraints

When specified, the proportion of forest cover that must be maintained in a managed landscape ranges from 5% to 35%. The objectives of these types of constraints are mainly related to preserving wildlife habitats or stands and are met by retaining old-growth forests, stand-level structures and unique or sensitive environments (see Table 33).

Where no cover proportion is specified, the objectives set are vague, but continue to be based on the concept of emulating the natural disturbance regime and therefore of preserving proportions of cover similar to what would be naturally observed. Where wildlife habitats are concerned, the trend is increasingly to use a coarse-filter approach based on what can be learned from the natural disturbance regimes in order to ensure that wildlife needs, structures and habitats at the landscape level will be preserved (see British Columbia, Ontario, Alberta-Pacific, Montmorency Forest, Fundy Model Forest). The resulting landscape is then examined and the necessary adjustments made to meet more specific wildlife needs. For instance, practices have been developed for specific wildlife species (or specific stands) because they have a certain value (e.g. game, cost-effectiveness) or because they are threatened or endangered (see Ontario, Quebec, New Brunswick).

The system used in New Brunswick is particularly interesting. The province first identified preferential habitats used by wildlife, then determined adequate areas to be maintained for each wildlife species, by ecoregion for each timber license, thereby ensuring that the variability of these habitats will be maintained at the provincial level. However, these habitat types are not all required, with the exception of a single habitat type for which it is required that provisions be made for future planning periods.

Table 33. Summary table of the various cover constraints required and/or met by the organizations surveyed.

PROVINCE	CONSTRAINT
1. BRITISH COLUMBIA	
Weyerhaeuser Coastal BC	– 30-40% of structures retained at the landscape level
Iisaak	– 10% of the total watershed area of 200-500 ha may be cut over a ten-year period – 5% of the total watershed area > 500 ha may be cut over a five-year period
2. ALBERTA	
Provincial requirements	– efforts focused on understory protection
Weyerhaeuser Alberta	– retention of forest cover ≥ 35% (height 12 m)
Millar Western	– proposes to determine measurable targets/managed landscape – planning will ensure the availability of suitable habitats and conditions for grizzly bears

PROVINCE	CONSTRAINT
3. MANITOBA	
Provincial requirements	–≥ 20% of forest cover maintained in any management unit – guidelines for maintaining appropriate habitats for moose, elk, caribou, deer, birds of prey, nesting passerines and small game
4. ONTARIO	
Provincial requirements	– preserve a proportion of uneven-aged forest in pure stands and especially in mixed stands – wide variety of guidelines for the protection of specific habitats
5. QUEBEC	
Provincial requirements	–≥ 30% of the productive forest area must be composed of hardwood, mixed or softwood stands ≥ 7 m
Lake Duparquet Forest	– ensure a still undetermined proportion of each dominant stand type on the territory
6. NEW BRUNSWICK	
Provincial requirements	– habitat type maintenance objectives were compiled for each ecoregion and then determined for each timber license (10 and 60 ha depending on the habitat and the license) – spatial criteria required only for old-spruce fir type habitats (≥ 375 ha) – white-tailed deer wintering areas are determined/timber license and forestry activities must not reduce habitat levels by more than 15% over a period of 5 years
Fundy Model Forest	– maintain closed canopy, a population of uneven-aged trees and a sufficient number of young trees to regenerate the forest
7. NOVA SCOTIA	
Provincial requirements	– maintain 3-8% forest cover in the managed area, mainly in the form of old-growth forest

3.9.2 Age class distribution

The age class distributions targeted by the organizations that have adopted such objectives are determined by the natural disturbance regime prevailing in the area or at least by what should normally be observed under natural conditions (see Table 34). It should be noted that most groups are moving away from homogeneous landscapes.

Many organizations have also established strategies for maintaining or protecting old-growth forests rather than all seral stages or age classes. Some have indicated that they have adopted this approach because after analysis, it was evident that it is mainly these types of forests that are in decline. The proportions of old-growth forests maintained in the landscapes range from 1% to 20%.

The amount of old-growth forest to be maintained by the organizations surveyed is also based on the representativeness of old-growth forests under a natural disturbance regime, but is also influenced by:

- timber supply needs (Fundy Model Forest),
- concerns about the reduction of old-growth forests in the landscape (New Brunswick), and
- ecological requirements (Weyerhaeuser Alberta, Saskatchewan).

Several groups propose to use what already exists in lands not contributing to the annual allowable cut (buffer zones, protected areas). Alberta-Pacific suggests maintaining these forests in locations where they are most likely to be found (in many cases environments spared by fire). In this way, the proportion and distribution of these forests should emulate the patterns left by natural disturbances.

British Columbia, Weyerhaeuser in Alberta and in Saskatchewan, and New Brunswick have developed their targets by ecoregion for each defined cover type. New Brunswick has gone even further by indicating in hectares the exact area of old-growth forest to be preserved by cover type and by timber license.

Maintaining old-growth forests in the landscape certainly appears to constitute an important element of current forest planning in Canada.

Table 34. Summary table of the various targets set for age class distribution in the landscape and/or for proportions of old-growth forests maintained by the organizations surveyed.

PROVINCE	AGE CLASS OR SERAL STAGE TARGETS
1. BRITISH COLUMBIA	
Government requirements	– up to twice the estimated natural proportion of the young stage and at least half of the natural proportion for the mature and old stages
Weyerhaeuser	– 10% of the territory is managed under old-growth stewardship zones
2. ALBERTA	
Government requirements	– 10% of the productive portion/forest management unit managed as mature/overmature forest representative of the stand types
Daishowa Marubeni International Ltd.	– inverse "J"-shaped age class distributions
Alberta-Pacific Forest Industries Inc.	– 8% old-growth forests in productive stands for the 200-year timber supply analysis (120-year age class)
Weyerhaeuser Alberta	– 5% and 20% in the mature seral stage (> 110 years: softwood, > 80 years: hardwood) including 1-5% in the overmature seral stage (> 140 years)

ENTITY	AGE CLASS OR SERAL STAGE TARGETS
3. SASKATCHEWAN	
Weyerhaeuser Saskatchewan	– 5% and 20% in the mature seral stage (> 110 years: softwood, > 80 years: hardwood) including 1-5% in the overmature seral stage (> 140 years)
4. ONTARIO	
Government requirements	– the age class structure must be moving toward the range of natural variability and may reflect the variability associated with natural disturbances and succession, social and economic constraints, the relative rarity of the older age classes and their associated values
Abitibi Consolidated	– 5% to 12% forest over 100 years – ensure that older age classes are represented in all forest units; the proportion should reflect the bounds of natural variation
5. QUEBEC	
Lake Duparquet Forest	– age structure in three cohorts corresponding approximately to the three seral stages (cohort 1: 45-55%, cohort 2: 23-26% and cohort 3: 20-30% of the management area)
Montmorency Forest	– 1/3,1/3, 1/3 rule whereby each landscape unit is composed of one-third regenerating stands (0-20 years), one-third young stands (20-40 years) and one-third mature and overmature stands (40-60 and 60-80 years)
6. NEW BRUNSWICK	
Government requirements	– 50-14,000 ha in old (60-120 years) or large stage (90-120 years) depending on the ecoregion, the vegetation community in question and the timber license
Fundy Model Forest	– 12% of the area maintained as mature-overmature forest – 4% of the area maintained as overmature forest
7. NOVA SCOTIA	
Government requirements	– 3-8% of the managed landbase maintained as old-growth forest

3.9.3 Silvicultural systems used and distribution

All of the organizations surveyed appear to be moving away from conventional clearcuts and to integrate more variable retention systems, as well as other systems (Table 35). This trend reflects an objective aimed at intervening in the landscape in a way that emulates natural disturbances and which therefore endeavours to respect natural ecological processes and protect wildlife habitats. Indeed, many organizations are moving toward the use of alternate silvicultural systems for most timber harvesting (e.g. Lake Duparquet Forest). Nonetheless, conventional logging continues to be widely used for reasons of cost-effectiveness.

Table 35. Silvicultural systems used by the organizations surveyed and proportion of landscape where used.

PROVINCE	SILVICULTURAL SYSTEMS USED	PROPORTION OF USE ON THE LANDBASE
1. BRITISH COLUMBIA		
Provincial requirements	– variable retention	– all cutblocks
Clayoquot Sound	– variable retention	– all cutblocks
Weyerhaeuser Coastal BC	– variable retention	– undetermined portion of "timber" and "habitat" zones
	– shelterwood cutting	– undetermined portion of "timber" and "habitat" zones
	– selection cutting	– undetermined portion of "habitat" and "old-growth" zones
	– irregular shelterwood cutting	– undetermined portion of "old-growth" zone
Iisaak	– variable retention	– all cutblocks
2. ALBERTA		
Provincial requirements	– clearcutting (block cutting) using a two-pass system	– standard system
	– three– pass system	– used if conflict with other forest values or resources
	– selection cutting, shelterwood cutting or seed cutting	– if deemed more appropriate
	– selection cutting or smaller multi-pass cutblocks	– in large stands in the floodplain zone if thermal cover is not jeopardized by the operation
	– variable retention system	– all cutblocks
Daishowa Marubeni International Ltd.	– variable retention (single-pass)	– all cutblocks
Alberta– Pacific Forest Industries Inc.	– variable retention system (mainly single-pass)	– all cutblocks
Weyerhaeuser Alberta	– **mixed-wood management**, multi– pass, selection cutting systems, combined with a variable retention system	– indeterminate proportions
Millar Western	– clearcutting with variable retention	– all cutblocks

PROVINCE	SILVICULTURAL SYSTEMS USED	PROPORTION OF USE ON THE LANDBASE
3. SASKATCHEWAN		
Weyerhaeuser Saskatchewan	– modified two-pass clearcutting with variable retention	– standard system
	– a single-pass system may be used	– when considered desirable to limit access to the site
	– clearcutting	– sometimes in black spruce/jack pine stand – sometimes in order to meet specific needs
4. MANITOBA		
Provincial requirements	– clearcutting	– standard system in softwood stands
	– selection cutting or other permitted harvesting methods	
Louisiana– Pacific Canada Ltd.	– modified clearcutting (variable retention)	– 20% of all cutblocks
	– modified clearcutting with understory protection	– 75% of all cutblocks
	– selection cutting	– 5% of all cutblocks
TEMBEC– Pine Falls	– clearcutting	– standard system
	– trend toward variable retention	– all cutblocks
5. ONTARIO		
	– silvicultural systems modelled on the natural disturbance regime typical for the area	– all cutblocks
	– techniques sensitive to natural succession (e.g. CLAAG in lowland black spruce stands)	– all cutblocks
	– variable retention system	– all cutblocks
Abitibi Consolidated	– clearcutting	– all cutblocks
	– shelterwood cutting	– used in blocks dominated by white pine
6. QUEBEC		
Provincial requirements	– cutting without regeneration and soil protection is prohibited	– all cutblocks
Lake Duparquet Forest	– clearcutting	– 55% of cohorts 1 – 50% of cohorts 2 – 67% of cohorts 3

PROVINCE	SILVICULTURAL SYSTEMS USED	PROPORTION OF USE ON THE LANDBASE
6. QUEBEC		
	– partial harvest	– 45% of cohorts 1 – 50% of cohorts 2
	– selection cutting	– ≥ 33% of cohorts 3
Montmorency Forest	– patch cutting with regeneration protection	– standard system
	– irregular shelterwood cutting	– recreational or other environments requiring landscape protection
7. NEW BRUNSWICK		
Provincial requirements	– uneven-aged harvest methods	– in tolerant hardwood stands that have potential for sawlog production
Fundy Model Forest	– clearcutting and selection cutting	– indeterminate
	– variable retention	– all cutblocks
JD Irving Limited	– variable retention	– 39% of cutblocks in natural stands/ 25 years
	– overstory removal	– 2% of cutblocks in natural stands/ 25 years
	– shelterwood cutting	– 6% of cutblocks in natural stands/ 25 years
	– two-pass method (2/3 of the residual stand is removed between 5-15 years))	– 7% of cutblocks in natural stands/ 25 years
	– single tree or group selection method	– 5% of cutblocks in natural stands/ 25 years
	– three-pass method (2 additional passes planned (1/10 years)	– 13% of cutblocks in natural stands/ 25 years
	– variable retention	– 7% of cutblocks in managed stands/ 25 years
	– commercial thinning	– 21% of cutblocks in managed stands/ 25 years
8. NOVA SCOTIA		
Provincial requirements	– variable retention	– all cutblocks

Silvicultural systems can also vary depending on the initial objective. For instance, the types of cuts used by Weyerhaeuser BC change depending on the objective assigned to the landscape. Irregular shelterwood cutting is used only in the "old-growth" zone and selection cutting only in the "habitat" zone. These advanced harvesting methods remain non-conventional.

CONCLUSIONS

This summary provides an overview of the spatial distribution guidelines used in forest planning in Canada. Landscape management is certainly an evolving concept in Canada and efforts driven by this trend are focused mainly on the following five aspects:

- Harvest blocks whose size and shape are based on natural stand boundaries and patterns left by the prevailing natural disturbance regime,
- protection of watercourses through the development of very detailed guidelines for each type of watercourse, in order to better protect aquatic environments and ensure connectivity between habitats,
- an age class distribution which is tending to move gradually away from traditional homogeneous forest landscapes (normal forest) and instead toward obtaining a more heterogeneous distribution emulating the natural disturbance regime,
- preservation of old-growth forests because their loss and the loss of biodiversity associated with them constitute a growing concern, and
- modified silvicultural systems (partial harvest and variable retention) modelled more on natural disturbances, which provide for the retention of structures in order to meet wildlife needs, conserve biodiversity and safeguard social values.

It is clear that the approaches presented in this summary are very diverse, reflecting the variety of ecological, social and political conditions in each province of Canada. The level of integration of the spatial dimension in forest planning also varies greatly depending on the province. Some provinces use an array of guidelines and tools which facilitate the application of the concept of landscape design, while others are still absorbing this concept. In a large country such as Canada, where the forestry sector is under provincial jurisdiction, it is sometimes difficult to get a complete picture of the innovations developed by each province. This is particularly true when a sector of economic activity undergoes a paradigm shift, as is currently the case for forestry. This inventory of approaches therefore offers an opportunity for the provinces that are less advanced in this regard to take advantage of the imaginative solutions already developed.

Nonetheless, research in this field is still at a very early stage. A number of tools and validation methods have yet to be developed. Predicting the effect of various spatial distribution strategies on biodiversity and other values important to society is a very complex process and requires developing and interfacing a range of highly technical digital models (**Doyon and Duinker 2003**). An initial line of models must be capable of spatially representing future forest conditions in a realistic way, while a second will assess the various values of interest (biodiversity, economic profitability, landscape aesthetics, etc.) under these new conditions.

The empirical assessment of such guidelines is even more difficult because of the difficulty of conducting experiments at the landscape level. Despite the empirical evidence of several ecological processes sensitive to spatial conditions, some critics have questioned the usefulness of applying these arduous new methods if their usefulness cannot be empirically validated. For example, a document prepared by Tembec Inc. and Wildlands League (2001) raises several concerns about Ontario's *Forest Management Guideline for Natural Disturbance Pattern Emulation*. The authors believe that this document does not adequately address the important ecological and management issues currently facing Ontario forests and that it anticipates benefits that do not resolve these issues.

Furthermore, in most cases, the patterns observed under the natural disturbance regime can only be partially emulated. In their comparison, Andison and Marshall (1999) show that although British Columbia's biodiversity guidelines for landscapes in the interior of the province can recreate a more natural landscape by comparison with the previous forest management system, the fact remains that this system does not recreate the conditions observed under the natural disturbance regime for several essential parameters. The authors conclude that the concept of endeavouring to emulate the natural disturbance regime incorporates many more elements than commonly believed and that there are limits in terms of reproducing disturbances as a paradigm for landscape management based on our current knowledge and capabilities. This is particularly true in systems whose disturbances have more stochastic dynamics, such as those under a fire regime (**Armstrong 1999**). An effective monitoring method has therefore yet to be proposed to validate through empirical data the hypothesis of emulation of the natural disturbance regime.

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APPENDIX 1: Natural disturbance types by biogeoclimatic zones and subzones, variants and regions of British Columbia

Source: British Columbia Ministry of Forests (1995)

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
AT – Alpine Tundra			NDT5	All
BG – Bunchgrass				
	BGxh – Very Dry Hot BG			
		BGxh1 – Okanagan BGxh	NDT4	K
		BGxh2 – Thompson BGxh	NDT4	K
		BGxh3 – Fraser BGxh	NDT4	C
	BGxw – Very Dry Warm BG			
		BGxw1 – Nicola BGxw	NDT4	K
		BGxw2 – Alkali BGxw	NDT4	C
BWBS – Boreal White and Black Spruce				
	BWBEdk – Dry Cool BWBS			
		BWBEdk1 – Stikine BWBSdk	NDT3	G, R
		BWBEdk2 – Liard BWBSdk	NDT3	G, R
	BWBEmw – Moist Warm BWBS			
		BWBEmw1 – Peace BWBSmw	NDT3	G
		BWBEmw2 – Fort Nelson BWBSmw	NDT3	G
	BWBEwk – Wet Cool BWBS			
		BWBEwk1 – Murray BWBEwk	NDT3	G
		BWBEwk2 – Graham BWBEwk	NDT3	G
		BWBEwk3 – Kledo BWBSwk	NDT3	G
	BWBEvk – Very Wet Cool BWBS		NDT3	R
CDF – Coastal Douglas-fir				
	CDFmm – Moist Maritime CDF		NDT2	V
CWH – Coastal Western Hemlock				
	CWHxm – Very Dry Maritime CWH			
		CWHxm1 – Eastern CWHxm	NDT2	V
		CWHxm2 – Western CWHxm	NDT2	V
	CWHdm – Dry Maritime CWH		NDT2	V
	CWHds – Dry Submaritime			
		CWHds1 – Southern CWHds	NDT2	V
		CWHds2 – Central CWHds	NDT2	V
	CWHmm – Moist Maritime CWH			
		CWHmm1 – Submontane CWHmm	NDT2	V
		CWHmm2 –Montane CWHmm	NDT2	V
	CWHms – Moist Submaritime CWH			
		CWHms1 – Southern CWHms	NDT2	V
		CWHms2 Central CWHms	NDT2	V

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
CWW – Coastal Western Hemlock				
	CWHwh – Wet Hypermaritime			
		CWHwh1 – Submontane CWHwh	NDT1	V
		CWHwh2 – Montane CWHwh	NDT1	V
	CWHwm – Wet Maritime		NDT1	R
	CWHws – Wet Submaritime			
		CWHws1 – Submontane CWHws	NDT2	R
		CWHws2 – Montane CWHws	NDT2	R, V
	CWHvh – Very Wet Hypermaritime			
		CWHvh1 – Southern CWHvh	NDT1, NDT3	V
		CWHvh2 – Central CWHvh	NDT1, NDT3	R
	CWHvm – Very Wet Maritime			
		CWHvm1 – Submontane CWHvm	NDT1, NDT3	R, V
		CWHvm2 – Montane CWHvm	NDT1, NDT2	R, V
		CWHvm3 – Central CWHvm	NDT1	R, V
ESSF – Engelmann Spruce Subalpine Fir				
	ESSFxc – Very Dry Cold ESSF		NDT3	K
	ESSFxcp – Very Dry Cold Parkland ESSF		NDT5	K
	ESSFxv – Very Dry Very Cold ESSF		NDT2	C
	ESSFxvp – Very Dry Very Cold Parkland ESSF		NDT5	C
	ESSFdc – Dry Cold ESSF			
		ESSFdc1 – Okanagan ESSFdc	NDT3	K, N
		ESSFdc2 – Thompson ESSFdc	NDT3	K
	ESSFdcp – Dry Cold Parkland ESSF			
		ESSFdcp1 – Okanagan ESSFdcp	NDT5	K, N
		ESSFdcp2 – Thompson ESSFdcp	NDT5	K
	ESSFdk – Dry Cool ESSF		NDT3	N
	ESSFdkp – Dry Cool Parkland ESSF		NDT5	N
	ESSFdv – Dry Very Cold ESSF		NDT3	K
	ESSFdvp – Dry Very Cold Parkland ESSF		NDT5	K
	ESSFmc – Moist Cold ESSF		NDT2	R
	ESSFmcp – Moist Cold Parkland ESSF		NDT5	G, R
	ESSFmk – Moist Cool ESSF		NDT2	R
	ESSFmkp – Moist Cool Parkland ESSF		NDT5	R

Zone	Subzone	Variant (if applicable)	NDT	Region(s)
ESSF – Engelmann Spruce – Subalpine Fir				
	ESSFmm – Moist Mild ESSF			
		ESSFmm1 – Raush ESSFmm	NDT2	G
		ESSFmm2 – Robson ESSFmm	NDT2	G
	ESSFmmp – Moist Mild Parkland ESSF			
		ESSFmmp1 – Raush ESSFmmp	NDT5	G
		ESSFmmp2 – Robson ESSFmmp	NDT5	G
	ESSFmv – Moist Very Cold ESSF			
		ESSFmv1 – Nechako ESSFmv	NDT2	G
		ESSFmv2 – Bullmoose ESSFmv	NDT2	G
		ESSFmv3 – Omineca ESSFmv	NDT2	G, R
		ESSFmv4 – Graham ESSFmv	NDT2	G
	ESSFmvp – Moist Very Cold Parkland ESSF			
		ESSFmvp1 – Nechako ESSFmvp	NDT5	G
		ESSFmvp2 – Bullmoose ESSFmvp	NDT5	G
		ESSFmvp3 – Omineca ESSFmvp	NDT5	G, R
		ESSFmvp4 – Graham ESSFmvp	NDT5	G
	ESSFmw – Moist Warm ESSF		NDT2	K, V
	ESSFmwp – Moist Warm Parkland ESSF		NDT5	K, V
	ESSFwc – Wet Cold ESSF			
		ESSFwc1 – Columbia ESSFwc	NDT1, NDT2	K, N
		ESSFwc2 – North Monashee ESSFwc	NDT1	G, K, N
		ESSFwc3 – Cariboo ESSFwc	NDT1	C, G
		ESSFwc4 – Selkirk ESSFwc	NDT1, NDT2	K, N
	ESSFwcp – Wet Cold Parkland ESSF			
		ESSFwcp2 – North Monashee ESSFwcp	NDT5	G, K, N
		ESSFwcp3 – Cariboo ESSFwcp	NDT5	C, G
		ESSFwcp4 – Selkirk ESSFwcp	NDT5	K, N
	ESSFwk – Wet Cool ESSF			
		ESSFwk1 – Cariboo ESSFwk	NDT1	C, G
		ESSFwk2 – Misinchinka ESSFwk	NDT1	G
	ESSFwm – Wet Mild ESSF		NDT1, NDT2	N
	ESSFwmp – Wet Mild Parkland ESSF		NDT5	N
	ESSFwv – Wet Very Cold ESSF		NDT1	R
	ESSFwvp – Wet Very Cold Parkland ESSF		NDT5	R
	ESSFvc – Very Wet Cold ESSF		NDT1	K, N
	ESSFvcp – Very Wet Cold Parkland ESSF		NDT5	K, N
	ESSFvv – Very Wet Very Cold ESSF		NDT1	K

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
ICH – Interior Cedar-Hemlock				
	ICHdw – Very Dry Warm ICH		NDT4	N
	ICHdk – Dry Cool ICH		NDT3	C
	ICHdw – Dry Warm ICH		NDT3	N
	ICHmc – Moist Cool ICH			
		ICHmc1 – Nass ICHmc	NDT2	R
		ICHmc1a – Amabilis Fir Phase, ICHmc1	NDT2	R
		ICHmc2 – Hazelton ICHmc	NDT2	R
	ICHmk – Moist Cool ICH			
		ICHmk1 – Kootenay ICHmk	NDT3	K, N
		ICHmk2 – Thompson ICHmk	NDT3	K
		ICHmk3 – Horsefly ICHmk	NDT2	C
	ICHmm – Moist Mild ICH		NDT2	G
	ICHmw – Moist Warm ICH			
		ICHmw1 – Golden ICHmw	NDT2	N
		ICHmw2 – Columbia-Shuswap ICHmw	NDT2	K, N
		ICHmw3 – Thompson ICHmw	NDT3	K, N
	ICHvc – Wet Cold ICH		NDT2	R
	ICHvk – Wet Cool ICH			
		ICHvk1 – Wells Gray ICHvk	NDT1	C, K, N
		ICHvk2 – Quesnel ICHvk	NDT1	C
		ICHvk3 – Coast ICHvk	NDT1	C
		ICHvk4 – Cariboo ICHvk	NDT1	C, G
	ICHvc – Very Wet Cold ICH		NDT1	R
	ICHvk – Very Wet Cool			
		ICH ICHvk1 – Moist ICHvk	NDT1	K, N
		ICHvk2 – Slim ICHvk	NDT1	G
IDF – Interior Douglas-fir				
	IDFxh – Very Dry Hot IDF			
	IDFxh1 – Okanagan IDFxh		NDT4	K, N
	IDFxh1a – Grassland Phase, IDFxh1		NDT4	K
	IDFxh2 – Thompson IDFxh		NDT4	K
	IDFxh2a – Grassland Phase, IDFxh2		NDT4	K

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
IDF – Interior Douglas – fir				
	IDFxm – Very Dry Mild IDF		NDT4	C
	IDFxw – Very Dry Warm IDF		NDT4	C
	IDFdk – Dry Cool IDF			
		IDFdk1 – Thompson IDFdk	NDT4	K
		IDFdk1a – Grassland Phase IDFdk1	NDT4	K
		IDFdk2 – Cascade IDFdk	NDT4	K
		IDFdk3 – Fraser IDFdk	NDT4	C
		IDFdk4 – Chilcotin IDFdk	NDT4	C
	IDFdm – Dry Mild IDF			
		IDFdm1 – Kettle IDFdm	NDT4	K, N
		IDFdm2 – Kootenay IDFdm	NDT4	N
	IDFmw – Moist Warm IDF			
		IDFmw1 – Okanagan IDFmw	NDT4	K
		IDFmw2 – Thompson IDFmw	NDT4	K
	IDFww – Wet Warm IDF		NDT4	V
MH – Mountain Hemlock				
	MHmm – Moist Maritime			
		MHMHmm1 – Windward MHmm	NDT1	R, V
		MHmm2 – Leeward MHmm	NDT1	R, V
	MHmmp – Moist Maritime Parkland			
		MHMHmmp1 – Windward MHmmp	NDT5	R, V
		MHmmp2 – Leeward MHmmp	NDT5	V
	MHwh – Wet Hypermaritime MH			
		MHwh1 – Windward MHwh	NDT1	V
		MHwh2 – Leeward MHwh	NDT1	R, V
	MHwhp – Wet Hypermaritime Parkland MH			
		MHwhp1 – Windward MHwhp	NDT5	V
		MHwhp2 – Leeward MHwhp	NDT5	R, V
MS – Montane Spruce				
	MSxk – Very Dry Cool MS		NDT3	C, K
	MSxv – Very Dry Very Cold MS		NDT3	C
	MScc – Dry Cold MS		NDT3	K
	MSck – Dry Cool MS		NDT3	N
	MSdm – Dry Mild MS			
		MSdm1 – Okanagan MSdm	NDT3	K, N
		MSdm2 – Thompson MSdm	NDT3	K

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
PP – Ponderosa Pine				
	PPxh – Very Dry Hot PP			
		PPxh1 – Okanagan PPxh	NDT4	K
		PPxh2 – Thompson PPxh	NDT4	K
	PPdh – Dry Hot PP			
		PPdh1 – Kettle PPdh	NDT4	N
		PPdh2 – Kootenay PPdh	NDT4	N
SBPS – Sub-Boreal Pine–Spruce				
	SBPSxc – Very Dry Cold SBPS		NDT3	C
	SBPSdc – Dry Cold SBPS		NDT3	C
	SBPSmc – Moist Cold SBPS		NDT3	C, R
	SBPSmk – Moist Cool SBPS		NDT3	C
SBS – Sub-Boreal Spruce				
	SBSdh – Dry Hot SBS			
		SBSdh1 – McLennan SBSdh	NDT3	C
		SBSdh2 – Robson SBSdh	NDT3	C
	SBSdk – Dry Cool SBS		NDT3	C, R
	SBSdw – Dry Warm SBS			
		SBSdw1 – Horsefly SBSdw	NDT 3	C, B
		SBSdw2 – Blackwater SBSdw	NDT3	C, B
		SBSdw3 – Stuart SBSdw	NDT3	C
	SBSmc – Moist Cold SBS			
		SBSmc1 – Moffat SBSmc	NDT3	C
		SBSmc2 – Sebine SBSmc	NDT3	C, B, R
		SBSmc3 – Muskus SBSmc	NDT3	C
	SBSmh – Moist Hot SBS		NDT3	C, B
	SBSmk – Moist Cool			
		SBS SBSmk1 – Muskwa SBSmk	NDT3	C
		SBSmk2 – Williston SBSmk	NDT3	C
	SBSmm – Moist Mild SBS		NDT3	K
	SBSmw – Moist Warm SBS		NDT3	C, B
	SBSvc – Wet Cool SBS			
		SBSvk1 – Willow SBSwk	NDT3, NDT3	C, B
		SBSvk2 – Finlay-Peace SBSwk	NDT2	B
		SBSvk3 – Tsaba SBSwk	NDT3	B
	SBSvk – Very Wet Cool SBS		NDT2	B
SWB – Spruce-Willow-Birch				
	SWBdk – Dry Cool SWB		NDT2	C, R
	SWBdks – Dry Cool Scrub SWB		NDT2	C, R
	SWBmk – Moist Cool SWB		NDT2	C, R

APPENDIX 2: List of species for which there are delineated wildlife habitat areas and associated management measures in British Columbia

Fish
Bull trout *(Salvelinus confluentus)*
Higher level plan recommendations *(RMZ objectives)*
Amphibians
Tailed frog *(Ascaphus truei)*
Reptiles
Gopher snake *(Pituophis catenifer deserticola)*
Night snake *(Hypsiglena torquata)*
Racer *(Coluber constrictor)*
Rubber boa *(Charina bottae)*
Birds
American white pelican *(Pelecanus erythrorhynchos)*
American bittern *(Botaurus lentiginosus)*
Sandhill crane *(Grus canadensis)*
Western grebe *(Aechmophorus occidentalis)*
Trumpeter swan *(Cygnus buccinator)*
Long-billed curlew *(Numenius americanus)*
Ferruginous hawk *(Buteo regalis)*
Prairie falcon *(Falco mexicanus)*
Turkey vulture *(Cathartes aura)*
Northern goshawk *(Accipiter gentilis atricapillus)*
Queen Charlotte goshawk *(Accipiter gentilis laingi)*
Ancient murrelet *(Synthliboramphus antiquus)*
Cassin's auklet *(Ptychoramphus aleuticus)*
Marbled murrelet *(Brachyramphus marmoratus)*
Lewis's woodpecker *(Melanerpes lewis)*
White-headed woodpecker *(Picoides albolarvatus)*
Bobolink *(Dolichonyx oryzivorus)*
Grasshopper sparrow *(Ammodramus savannarum)*
Brewer's sparrow *(Spizella breweri breweri)*
Sage thrasher *(Oreoscoptes montanus)*
Yellow-breasted chat *(Icteria virens)*
Mammals
Pacific water shrew *(Sorex bendirii)*
Keen's long-eared myotis *(Myotis keenii)*
Mountain beaver *(Aplodontia rufa rufa and Aplodontia rufa rainieri)*
Vancouver Island marmot *(Marmota vancouverensis)*
Fisher *(Martes pennanti)*
Higher level plan recommendations (RMZ objectives)
Grizzly bear *(Ursus arctos)*
Higher level plan recommendations (RMZ objectives)
Mountain goat *(Oreamnos americanus)*
Bighorn sheep *(Ovis canadensis californiana, Ovis canadensis canadensis)*

Vegetation communities

Douglas-fir/Garry oak–oniongrass *(Pseudotsuga menziesii/Quercus garryana–Melica subulata)*

Ponderosa pine–black cottonwood–snowberry *(Pinus ponderosa–Populus balsamifera ssp. trichocarpa–Symphoricarpos albus)*

Ponderosa pine–black cottonwood–Nootka rose–poison ivy *(Pinus ponderosa–Populus balsamifera ssp. trichocarpa–Rhus radicans)*

Water birch–red-osier dogwood *(Betula occidentalis–Cornus stolonifera)*

APPENDIX 3: Watercourse classification table for the province of Alberta

Water-course Classifica-tion	Mapping Designation	Physical Description	Portion of Year Water Flows	Channel Development	Fish and Wildlife Concerns	Land Use Impact
Large Permanent	Solid heavy line or double line.	Major streams or rivers. Well-defined flood plains. Valley usually exceeds 400 m in width.	All year.	Unvegetated channel width greater than 5m.	Resident fish populations. Important over-wintering habitat. Important feeding and rearing habitat.	Water quality often reflects all upstream land use impacts and natural processes. Primarily sedimentation of stream channels.
Small Permanent	Usually solid although some are heavy broken lines.	Permanent streams. Often small valleys. Bench (floodplain) development.	All year but may freeze completely in the winter.	Banks and channel well- defined. Channel width 0.5 m to 5 m.	Significant insect populations. Important spawning and rearing habitat. Resident fish populations. Overwintering for non-migratory species.	Primarily sedimentation of stream channels. Water quality. Fish populations sensitive to siltation. Loss of streambank fish habitat.
Intermittent	Usually broken light line. Should be identified on the ground.	Small stream channels. Small springs are main source outside periods of spring runoff and heavy rainfall.	During wet season or storms. Dries up during drought.	Distinct channel development. Usually channel is unvegetated. Channel width to 0.5 m Some bank development.	Food production areas. Potential spawning for spring spawning species. Drift invertebrate populations in pools and riffles.	Sedimentation from bank and streambed damage will damage fish habitat downstream.
Ephemeral	Not normally mapped.	Often a vegetated draw.	Flows only during or immediately after rainfall and snowmelt.	Little or no channel development. Channel is usually vegetated.	Siltation may impact fish habitat.	Sedimentation downstream due to ground disturbance.
Water-source Areas (except muskegs)	N/A	Areas with saturated soils or surface flow. Seepages.	All year. May or may not freeze in the winter.	N/A	Potential high value to fall spawners. Potential high-use areas for terrestrial wildlife.	Disturbance may cause stream sedimentation. Interruption of winter flow may disrupt fish egg incubation.
Lakes	Solid line outline a water body. Reserved areas will be noted on referral map.	Large water collection areas permanently filled with water.	Normally frozen in winter.	N/A	Important fish-bearing habitat.	Aesthetic values may be disrupted. Protential for wildlife disturbance. Local sedimentation.

APPENDIX 4 Standards and guidelines for operating beside watercourses for the province of Alberta

Watercourse Classification	Roads, Landings and Bared Areas	Watercourse Protective Buffers	Operating Conditions Within Buffers and Water-Source Areas Where Operations are Approved	
			Tree Felling	Equipment Operation
Large Permanent	Not permitted with 60 m of the high-water mark or from water-source areas within that buffer. May be permitted within 60 – 100 m of the high-water mark with written approval of a Forest Officer.	No disturbance or removal of merchantable timber within 60m of the high-water mark except where specifically approved in the Annual Operating Plan.	Trees will normally be felled so they do not enter the watercourse. The objective is that no slash or debris is to enter the watercourse. Should slash or debris enter the watercourse, immediate removal is required without a machine entering the watercourse.	Where removal of timber within 60 m is approved, no machinery is to operate within 20 m of the high-water mark. Timber within 20 m shall be removed by winching or other means such that the machine stays outside of the 20 m strip. Where possible, topographical breaks should be used as protection strip boundaries.
Small Permanent	Not permitted within 30 m of the high-water mark or from water-source areas within that buffer. May be permitted within 30- 100 m of the high-water mark with written approval of a Forest Officer.	No disturbance or removal of merchantable timber within 30 m of the high-water mark except where specifically approved in the Annual Operating Plan.	Trees will normally be felled so they do not enter the watercourse. The objective is that no slash or debris enter the watercourse. Should slash or debris enter the watercourse, immediate removal is required without a machine entering the watercourse.	Where removal of timber within 30 m is approved, no machinery shall operate within 20 m of the high-water mark. Timber within 20 m shall be removed by winching or other means such that the machine will remain outside the 20 m strip. Where, possible, topographical breaks should be used as protection boundaries.
Intermittent	Not permitted within 30 m of the high-water mark or water-source areas within that buffer.	Buffer of brush and lesser vegetation to be left undisturbed along the channel. Width of buffer will vary according to soils, topography, water-source areas and fisheries values. Treed buffer is not required unless specifically requested by a Forest Officer.	Trees will be felled so they do not enter the watercourse unless otherwise approved. Should slash or debris enter the watercourse, immediate removal is required without the machine entering the watercourse.	Heavy equipment may operate within 20 m only during frozen or dry periods. No random, skidding through watercourse channels. Crossings must be planned with adequate crossing structures. Crossings are to be removed on completion of operations. Where fish and spawning movements have been identified, Special crossings that will not obstruct upstream fish pass or cause stream siltation may be required.
Ephemeral	Construction not permitted within a watercourse or a water-source area.	Buffer of lesser vegetation in wet gullies to be left undisturbed.	Large accumulations of slash or debris accumulations be removed progressively.	Random skidding through watercourse permitted only during frozen or dry ground periods. Temporary crossings are to be removed on completion of operations.
Lakes (little or no recreation, waterfowl or sport fishing potential)	Not permitted within 100m of the high-water mark without written approval of a Forest Officer.	On lakes exceeding 16 ha in area, there will be no disturbance of timber within 100 m of the high-water mark except where specifically approved in the Annual Operating Plan.	Trees within these areas shall be felled away from the water body. No slash or debris shall enter the water body.	If timber removal is approved, no machinery is to operate within 20 m of the high-water mark.
Lakes (with recreational, waterfowl or sport fishing potential)	For shorelines not located within reserved areas, no disturbances will be permitted within 200 m of the high-water mark without the written approval of the Forest Superintendent.	On lakes exceeding 4 ha in area, there will be no disturbance or removal of timber within 100 m of the high-water mark except where specifically approved in the Annual Operating Plan.	Trees will be felled so they do not enter the water body. No slash or debris shall enter the water body.	If timber removal is approved, no machinery is to operate within 20 m of the high-water mark. Consideration must be given to aesthetics when harvesting adjacent to lakes with recreational potential. Any timber harvesting within reserved areas shall be conducted subject to specific operating conditions.
Water-source Areas and Areas Subject to Normal Seasonal Flooding.	Construction not permitted unless approved in the Annual Operating Plan. No log decks permitted. The number of stream crossings must be minimized. No disturbance of organic duff layers or removal of lesser vegetation.	Treed buffers of at least 20 m on all streams. No harvest of merchantable trees or disturbance of lesser vegetation unless approved in the Annual Operating Plan. Buffer width may be altered according to its potential to produce surface water, provided it is approved in the Operating Plan.	Heavy machinery not permitted in the water-source areas during unfrozen soil conditions. Minimal disturbance or removal of duff or lesser vegetation. Timber may be harvested if stream sedimentation is the only resource concern, provided there is no disturbance of the organic soils and lesser vegetation when harvesting the trees. On unstable areas subject to blowdown, merchantable trees should be carefully harvested from water- source areas to minimize root disturbances of duff layers and watercourse damming.	Road construction, timber harvest, reforestation and reclamation shall be done with equipment capable of operating without causing excessive disturbance to the organic soil layers. Heavy equipment is not permitted during moist or wet soil conditions. May be operated during frozen periods according to specific conditions in the approved Annual Operating Plan. No dirt caps or depositing of soil will be permitted on roads in water-source areas, unless a separation layer is incorporated or the road is designed to provide adequate surface and subsurface drainage away from the road-bed. Where a separation layer is used, the soil cap shall be removed as operations are completed.

APPENDIX 5: Recommended guidelines for wildlife or other designated areas in Alberta

- Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta (July 26, 2001)
- Key Ungulate Areas (Sept. 29, 2000)
- Trumpeter Swan (October 30, 2001)
- Mountain Goat and Bighorn Sheep Ranges (May 23, 2001)
- Operating Guidelines for Industrial Activity — Caribou Range — Northwest Alberta (EUB Informational Letter IT 94-22)
- Strategic Plan and Industrial Guidelines for Boreal Caribou Ranges in Northern Alberta

APPENDIX 6: Watercourse classification table used by Millar Western Forest Products

Watercourse Classification					Fisheries/ Wildlife Concerns	Potential Impact
	Mapping Designation	Physical Description	Portion of Year Water Flows	Channel Development		
Class "A" Waterbodies	Solid red on Watercourse Crossing Code of Practice maps (Water Act)	Not applicable	All year	Not applicable	Known habitats critical to the continued viability of locally or regionally important fish species Habitat areas are sensitive enough to be damaged by any type of in-stream activity or changes to water quality and regime	Fish and fish habitat affected by sediment load, turbidity, deposition of sediment, chemical contamination or alteration of stream flow
Class "B" Waterbodies	Solid (variable colour) lines overlain by small circles on Watercourse Crossing Code of Practice maps (Water Act)	Not applicable	All year	Not applicable	Key broadly distributed habitat areas important to the continued viability of a population of locally or regionally important fish species Habitat areas are sensitive enough to be potentially damaged by in-stream activities Potential short- and long-term effects of in-stream activities considered to have detrimental effects on, and are a high risk to the survival of, resident fish populations	Fish and fish habitat affected by sediment load, turbidity, deposition of sediment, chemical contamination or alteration of stream flow
Large Permanent	Solid heavy line or double line	Major streams or rivers Well-defined flood plains Often wide valley bottoms	All year	Non-vegetated channel width exceeds 5 m	Resident fish populations Important overwintering, feeding and rearing habitat Important wildlife feeding/travel corridors	Water quality often reflects all upstream land use impacts and natural processes Primarily sedimentation of stream channels Loss of wildlife habitat; restriction of movement
Small Permanent	Usually solid although some are broken heavy lines	Permanent streams Often small valley bottoms Bench (floodplain) development	All year but may freeze complete-ly in the winter	Banks and channel well-defined Channel width from 0.5 to 5 m	Significant insect populations Important spawning and rearing habitat Resident fish populations Overwintering for non-migratory species Important wildlife feeding/travel corridors	Primarily sedimentation of stream channels Water quality Fish populations sensitive to siltation Loss of streambank fish habitat Loss of wildlife habitat; restriction of movement

APPENDIX 7: Standards and guidelines for operating beside watercourses used by Millar Western Forest Products

Watercourse Classification	Roads, Landings and Bared Areas	Riparian Management Zones	Operating Conditions Within Riparian Management Zones and Water-Source Areas Where Operations Are Approved	
			Tree Felling	Equipment Operation
Class "A" Waterbodies	Nothing new permitted within 100 m of high-water mark. Any existing roads may be maintained at present classification standards. Any proposed watercourse crossings within 2 km upstream must be specifically approved in CD.	No disturbance or removal of timber within 100 m of the high-water mark. No duff disturbance of intermittent (min 10 m vegetated buffer) or ephemeral drainages (minimum 5 m vegetated buffer) within 2 km upstream of Class A water body.	Not allowed without specific Department approval.	Not allowed without specific Department approval.
Class "B" Waterbodies	Nothing new permitted within 60 m of high-water mark unless specifically approved in CD. Any watercourse crossings within 500 m upstream must be specifically approved in CD.	No disturbance or removal of timber within the appropriate riparian management zone unless specifically approved in CD. No duff disturbance of intermittent (minimum 10m vegetated buffer) or ephemeral drainages (minimum 5 m vegetated *buffer*) within 500 m upstream of Class B water body.	Trees will normally be felled so that they do not enter watercourse. Should slash or debris enter the watercourse immediate removal is required without a machine entering the watercourse.	Where removal of timber within 60 m is approved, no machinery is permitted within 30 m of the high-water mark.
Large Permanent	Not permitted within 100 m of the high-water mark or water-source areas within the riparian management zone, unless specifically approved in the CD.	No disturbance or removal of timber within 60 m of high-water mark unless specifically approved in CD.	Trees will normally be felled so that they do not enter watercourse. Should slash or debris enter the watercourse, immediate removal is required without a machine entering the watercourse.	Where removal of timber within 30 m is approved, no machinery is permitted within 20 m of the high-water mark. Where possible, topographical breaks should be used as riparian management zone boundaries.
Small Permanent	Not permitted within 30 m of the high-water mark or water-source areas within the riparian management zone, unless specifically approved in the CD.	No disturbance or removal of timber within 30 m of high-water mark unless specifically approved in CD.	Trees will normally be felled so that they do not enter watercourse. Should slash or debris enter the watercourse, immediate removal is required without a machine entering the watercourse.	Where removal of timber within 30 m is approved, no machinery is permitted within 20m of the high-water mark. Where possible, topographical breaks should be used as riparian management zone boundaries.

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SPECIAL FUNDING AGREEMENTS

- Sustainable Forest Management Network/BIOCAP Canada Foundation Joint Venture Agreement

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- University of Victoria
- University of Waterloo
- University of Western Ontario
- University of Winnipeg
- Wilfrid Laurier University

AFFILIATES

- Canadian Institute of Forestry
- Forest Ecosystem Science Cooperative
- Forest Engineering Research Institute of Canada
- Lake Abitibi Model Forest
- Manitoba Model Forest
- National Aboriginal Forestry Association

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