FOREST PRACTICES

CODE

of

BRITISH COLUMBIA

Biodiversity Guidebook

September 1995

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Preface

This guidebook has been prepared to help forest resource managers plan, prescribe and implement sound forest practices that comply with the Forest Practices Code.

Guidebooks are one of the four components of the Forest Practices Code. The others are the ***Forest Practices Code of British Columbia Act***, the regulations and the standards. The *Forest Practices Code of British Columbia Act* is the legislative umbrella authorizing the Code's other components. It enables the Code, establishes mandatory requirements for planning and forest practices, sets enforcement and penalty provisions, and specifies administrative arrangements. The **regulations** lay out the forest practices that apply province-wide. **Standards** may be established by the chief forester, where required, to expand on a regulation. Both regulations and standards, where required and established under the Code, must be followed.

Forest Practices Code guidebooks have been developed to support the regulations, but are not part of the legislation. The recommendations in the guidebooks are not mandatory requirements, but once a recommended practice is included in a plan, prescription or contract, it becomes legally enforceable. Guidebooks are not intended to provide a legal interpretation of the *Act* or regulations. In general, they describe procedures, practices and results that are consistent with the legislated requirements of the Code.

The information provided in each guidebook is to help users exercise their professional judgment in developing site-specific management strategies and prescriptions to accommodate resource management objectives. Some guidebook recommendations provide a range of options or outcomes considered acceptable under varying circumstances.

Where ranges are not specified, flexibility in the application of guidebook recommendations may be required, to adequately achieve land use and resource management objectives specified in higher-level plans. A recommended practice may also be modified when an alternative could provide better results for forest resource stewardship. The examples provided in many guidebooks are not intended to be definitive and should not be interpreted as the only acceptable options.

Acronyms used in this guidebook

NDT – natural disturbance type
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

AT – Alpine Tundra
BG – Bunchgrass
BSBW – Boreal White and Black Spruce
CDF – Coastal Douglas-fir
CWH – Coastal Western Hemlock
ESSF – Engelmann Spruce–Subalpine Fir
ICH – Interior Cedar Hemlock
IDF – Interior Douglas-fir
MH – Mountain Hemlock
MS – Montane Spruce
PP – Ponderosa Pine
SBPS – Sub-Boreal Pine-Spruce
SBS – Sub-Boreal Spruce
SWB – Spruce–Willow–Birch

FEN – forest ecosystem network
OGMA – old-growth management area
OPR – operational planning regulation
PNC – potential natural community
RMA – riparian management area
WHA – wildlife habitat areas
WTP – wildlife tree patches

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Introduction

The intent of this guidebook is to provide managers, planners and field staff with a recommended process for meeting biodiversity objectives—both landscape unit and stand level—as required in the *Forest Practices Code of British Columbia Act and Regulations*. The practices presented here are designed to reduce the impacts of forest management on biodiversity, within targeted social and economic constraints. The recommendations presented apply to the provincial forest.

Like most guidelines used in natural resource management, these have been developed from a combination of scientific evidence and informed professional judgment. They represent an attempt to integrate society's desire both to generate commercial forest products and to ensure the conservation of biological diversity in managed forests. A companion document, summarizing the scientific literature that supports the ecological concepts in this guidebook, is currently in preparation.

We recognize that this guide has its limitations, but nevertheless believe it marks a significant step towards responsible stewardship of all the resources in the forest. As scientific understanding and social values change over time, so the scientific and value-based choices presented here will be revisited.

In summary, the guidebook provides direction on:

- applying biodiversity emphasis options at various levels
- establishing biodiversity objectives for the landscape unit
- designing a landscape unit—one that involves delineating forest ecosystem networks—to achieve biodiversity objectives for the landscape unit
- addressing stand attributes to maintain biodiversity both in landscape unit plans and, where biodiversity objectives for the landscape unit are absent, in forest development plans.

This guidebook is based on, and replaces, the following joint publications of the B.C. Ministry of Forests and the Ministry of Environment, Lands and Parks:

- the *Coastal Biodiversity Guidelines*
- the *Interior Fish/ Forestry/Wildlife Guidelines*
- the *Wildlife Tree Harvesting Guidelines.*

Biodiversity management

Biological diversity (or biodiversity) is the diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.

Developing a biodiversity conservation strategy that is based on a variety of management strategies for individual species is neither feasible nor effective. The impact of forest management practices on many species is unknown and certain practices that benefit some species are often detrimental to others. Recommended instead is the development of an ecosystem management approach that provides suitable habitat conditions for all native species. In this way, habitat diversity is used as a surrogate to maintain biodiversity. Key biodiversity concepts are described in Appendix 1.

At the same time, however, special efforts may be needed to protect the habitat of species known to be at risk, such as threatened, endangered, or regionally important species. Specific strategies for addressing these species are outlined in the *Managing Identified Wildlife Guidebook.*

Planning to maintain biodiversity should occur at a variety of levels all of which are linked hierarchically (Figure 1): provincial (such as the provincial biodiversity strategy), regional (such as the planning being carried out by the Commission on Resources and the Environment), subregional (such as the planning being carried out through Land and Resource Management Planning), landscape, and stand. This guidebook applies to two of those levels: landscape and stand.

The biodiversity management approach described here is based on ecological principles and will be refined over time as new knowledge is obtained and management practices evolve. The underlying assumption of this approach is that all native species and ecological processes are more likely to be maintained if managed forests are made to resemble those forests created by the activities of natural disturbance agents such as fire, wind, insects, and disease. It has been these natural ecological processes, along with burning by aboriginal peoples, that have determined the composition, size, age, and distribution of forest types on the landscape, as well as the structural characteristics of forest stands.

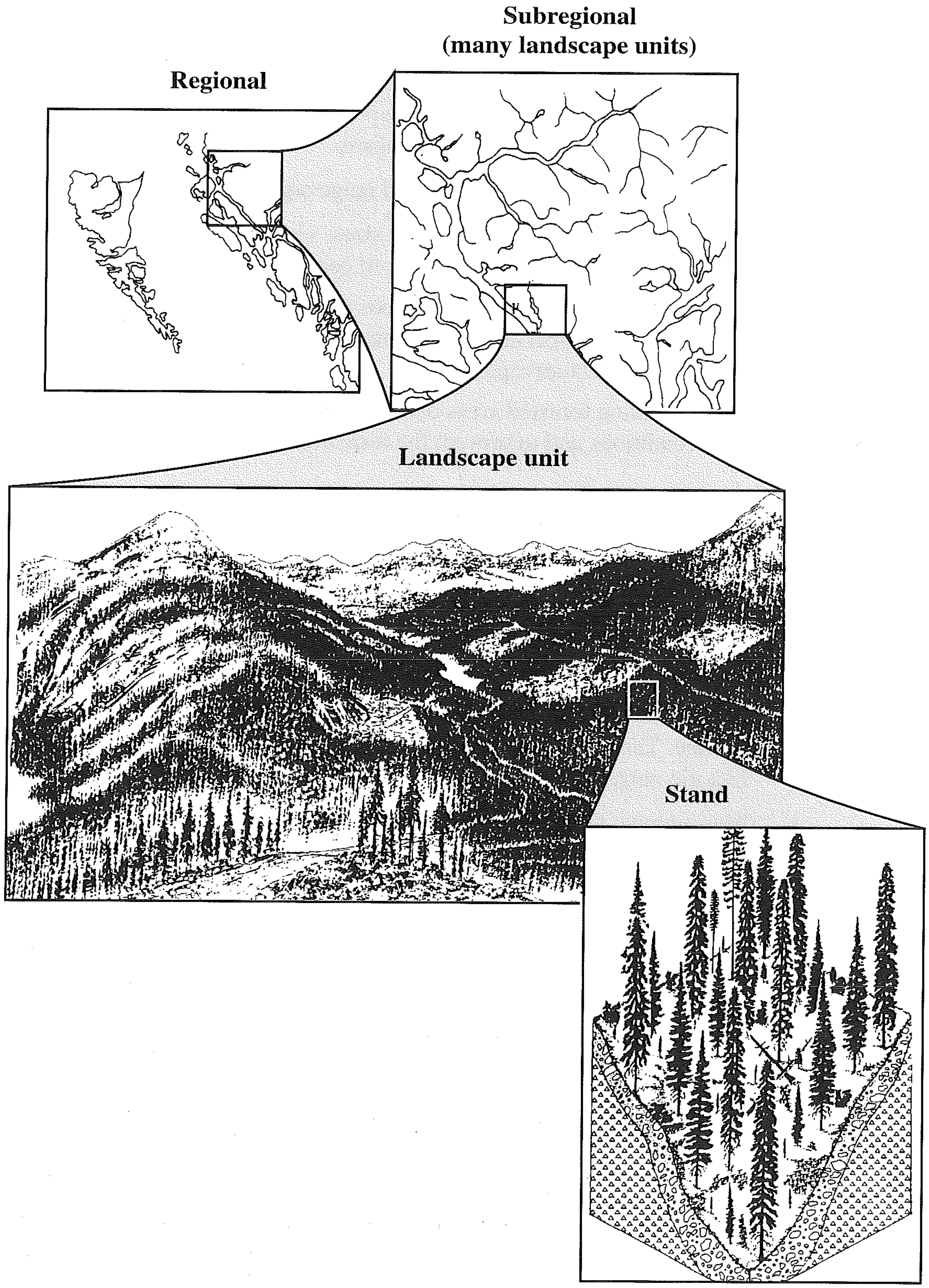


Figure 1. Levels at which the maintenance of biodiversity can be considered (provincial level not shown).

Principles and assumptions on which this guidebook is based:

- The more that managed forests resemble the forests that were established from natural disturbances, the greater the probability that all native species and ecological processes will be maintained.
- The habitat needs of most forest and range organisms can be provided for by:
  - maintaining a variety of patch sizes, seral stages, and forest stand attributes and structures across a variety of ecosystems and landscapes
  - maintaining connectivity of ecosystems in such a manner as to ensure the continued dispersal and movement of forest- and range-dwelling organisms across the landscape
  - providing forested areas of sufficient size to maintain forest interior habitat conditions and to prevent the formation of excessive edge habitat.
- To sustain genetic and functional diversity, a broad geographic distribution of ecosystems and species must be maintained within forest and range lands.
- Management for biodiversity must be flexible and adaptive. This guidebook provides recommendations rather than specific prescriptions for managing biodiversity. Success in meeting the intent of these recommendations depends on the innovativeness and creativity of land managers.
- Not all elements of biodiversity can be—or need to be—maintained on every hectare. The intent is to maintain in perpetuity all native species across their historic ranges.
- Management for biodiversity should be applied within landscapes regardless of administrative boundaries. Where natural landscapes have been administratively divided, management agencies and licensees should develop a biodiversity plan together. Landscape units are the basis on which the success of biodiversity management will be evaluated.
- The conservation of biodiversity depends on a coordinated strategy that includes:
  - a system of protected areas at the regional scale
  - provision for a variety of habitats at the landscape scale
  - management practices that provide important ecosystem attributes at the stand scale.
- Intensive forestry and other resource development within managed landscapes can be compatible with the maintenance of biological diversity.
- Where past forest management practices have resulted in forest conditions that prevent biodiversity objectives from being achieved, biodiversity can be restored over time by managing the forest to create—or recover—the required ecosystem elements.

Relationships to other guidebooks

This guidebook describes future desired conditions for forests and grasslands at the landscape and stand levels. Other guidebooks that also provide direction on maintaining biological diversity at the landscape level are the *Riparian Management Area Guidebook*, the *Managing Identified Wildlife Guidebook*, and the *Regional Lakeshore Guidebook*. Riparian management areas (RMAs) and wildlife habitat areas (WHAs) can contribute to meeting the old-growth and connectivity objectives within a landscape unit. It is also likely that RMAs and WHAs will be the main building blocks for the design of Forest Ecosystem Networks (see the section "Designing forest ecosystem networks"). Figure 2 shows how the *Biodiversity Guidebook* works together with the *Riparian Management Area* and *Managing Identified Wildlife* guidebooks. All of the guidebooks referred to above should be used together to build the basic landscape unit management strategy.

As well as these, several other guidebooks—notably those that address terrain stability, watershed assessment procedures, community watershed management, and visual landscape management—involve land zoning and recommend certain constraints to harvesting and grazing activities. Collectively these guidebooks provide planners with further direction on how land might be zoned into the long-term leave areas needed to minimize the effects on biodiversity of habitat fragmentation and old-growth conversion.

The administrative process for establishing, varying or canceling landscape units and landscape unit objectives is described in the *Higher Level Plans Guidebook.*

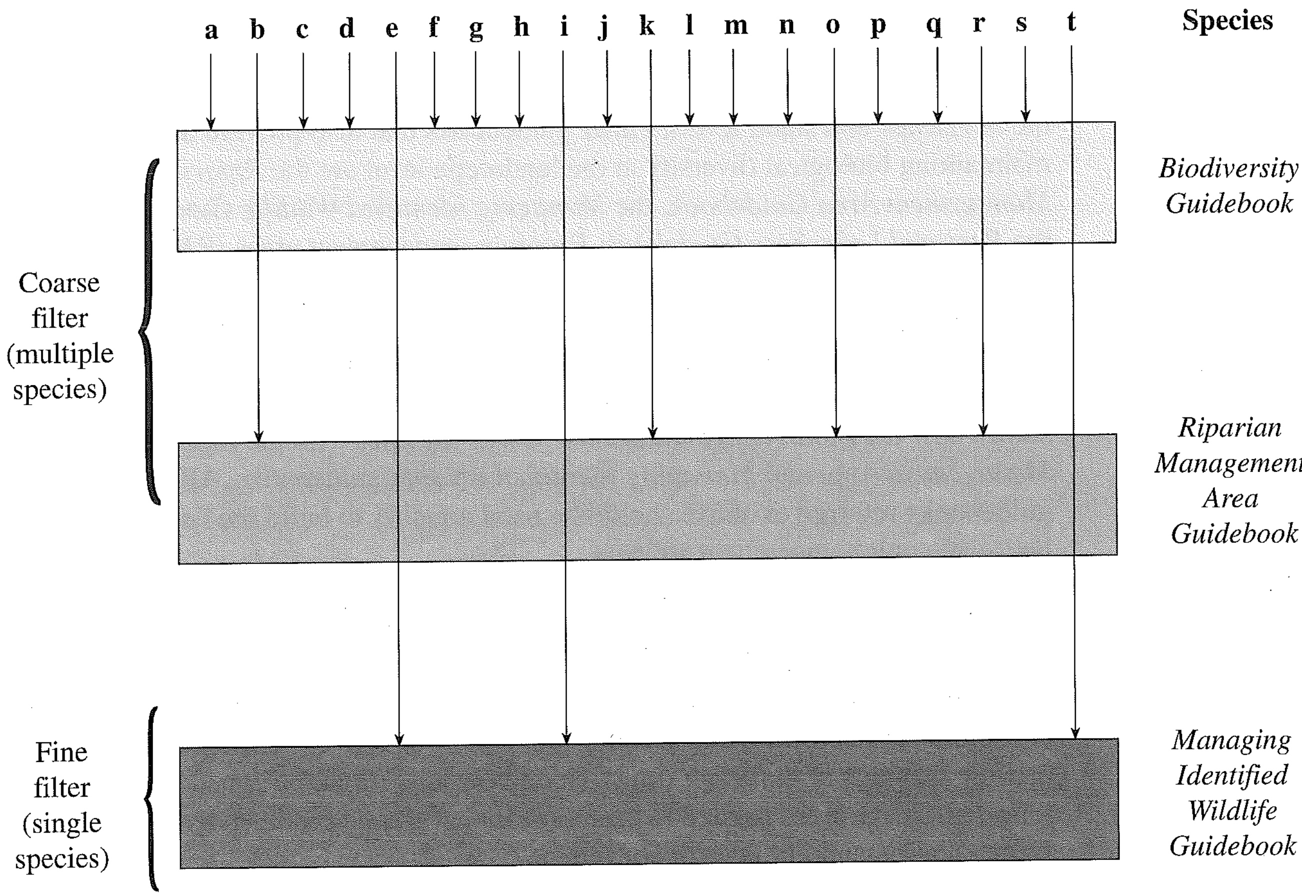


Figure 2. The relationship between the *Biodiversity Guidebook* and the *Riparian Management Area* and *Managing Identified Wildlife* guidebooks. This conceptual diagram illustrates how the recommended practices in the different guidebooks are designed to ensure that the critical requirements of all species are protected. The practices in the *Biodiversity* and *Riparian Management Area* guidebooks act as the coarse filter, protecting most species; the practices in the *Managing Identified Wildlife Guidebook* act as the fine filter, protecting those species whose habitat requirements are not adequately covered by the coarse filter guidelines.

Biodiversity emphasis options

As natural ecosystems become increasingly modified by human activities, natural patterns of biodiversity become increasingly altered and the risk of losing native species increases (Figure 3). The greatest degree of disruption occurs from extreme habitat modifications such as urbanization and agriculture. Parks and protected areas, on the other hand, if appropriately managed, maintain close to natural levels of biodiversity. Managed forest lands fall between those two extremes, and can support varying levels of natural biodiversity, depending on the management practices. More natural levels of biodiversity will be maintained in managed forests if those forests are managed to mimic important characteristics of natural forest conditions.

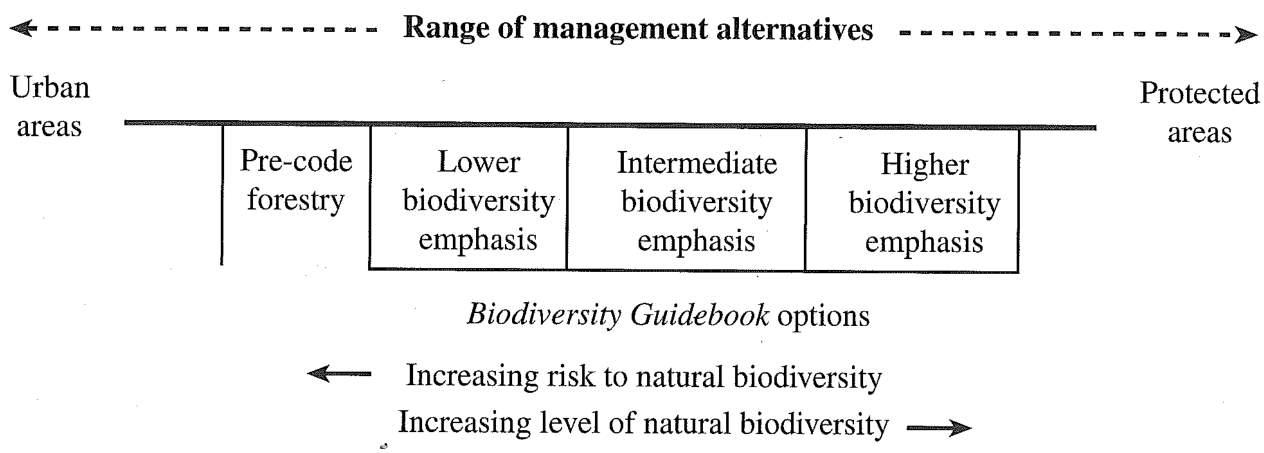


Figure 3. The range of management options for maintaining biodiversity.

This guidebook outlines a range of three options for emphasizing biodiversity at the landscape level. Each option is designed to provide a different level of natural biodiversity and a different risk of losing elements of natural biodiversity (Appendix 2):

- The lower biodiversity emphasis option may be appropriate for areas where other social and economic demands, such as timber supply, are the primary management objectives. This option will provide habitat for a wide range of native species, but the pattern of natural biodiversity will be significantly altered, and the risk of some native species being unable to survive in the area will be relatively high.
- The intermediate biodiversity emphasis option is a trade-off between biodiversity conservation and timber production. Compared to the lower biodiversity emphasis option, this one will provide more natural levels of biodiversity and a reduced risk of eliminating native species from the area.

- The higher biodiversity emphasis option gives a higher priority to biodiversity conservation but would have the greatest impact on timber harvest. This option is recommended for those areas where biodiversity conservation is a high management priority.

In reality, these options are points on a continuum, and in between lie a range of options that may be selected depending on the relative priority allocated to biodiversity conservation and timber production in an area.

Applying biodiversity emphasis options to landscape units

Applying biodiversity emphasis options to landscape units across a subregional planning area is a key part of a biodiversity management strategy.

Biodiversity emphasis options can be assigned to landscape units in the following ways:

- Direct assignment of a biodiversity emphasis option to a landscape unit by a regional or subregional land use planning process.
- Indirect assignment of biodiversity emphasis options to landscape units by a regional or subregional land use planning process that develops broad-scale land use zonation. In such instances agency representatives will assign a specific landscape unit an emphasis option consistent with the zonation.
- In the absence of regional or subregional plans, interim biodiversity emphasis options can be assigned to a landscape unit by joint agreement of the district manager and the designated environmental official.

If no landscape unit has been designated for an area, or an emphasis option has not been assigned for a landscape unit, the default is that the area is managed using the lower biodiversity emphasis option.

To assist with the process of assigning biodiversity emphasis options to landscape units, each unit can be evaluated according to several criteria: topographic and ecosystem complexity, wildlife and fisheries species diversity, significance of key management species and social and economic considerations.

Government has evaluated social and economic impacts against risk to biodiversity on a provincial basis and provided the following policy direction concerning landscape unit biodiversity emphasis assignments within subregional areas. Table 1 illustrates the proportion of the area of a subregional planning unit that should fall under higher, intermediate, or lower biodiversity emphasis. These percentages apply to the provincial forest within the subregional planning unit. For example, approximately 45% (from 30% up to 55%) of the area should fall into the lower biodiversity emphasis category.

Table 1. The distribution of biodiversity emphasis options within a subregional planning area

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

Lower biodiversity emphasis	Intermediate biodiversity emphasis	Higher biodiversity emphasis
45% (30–55%)	45% (35–60%)	10% (no range)

The intent of this guidance is to limit the impacts of this guidebook, on short-term timber supply, to no more than 4% over the amount specified in the timber supply review, on a province wide basis. Subregional planning that results in percentages outside of the ranges specified in Table 1 will have to be evaluated to determine if resultant impacts on short-term timber supply are consistent with government policy direction.

In some cases, large portions of a landscape unit may require a different biodiversity emphasis than the rest of the landscape unit. For example, a low elevation subzone may have a different biodiversity emphasis option assigned than a high elevation subzone. Within a landscape unit, minor areas (up to thousands of hectares in size), may be managed differently from the rest of the unit. For example, a landscape unit assigned a lower biodiversity emphasis option could contain some small protected areas that would contribute to the seral stage and patch size requirements for the landscape unit. Alternatively, stands managed for intensive timber production may be part of any landscape unit, regardless of the biodiversity emphasis option assigned the major portion. (Figure 4).

Concentration of the lower biodiversity emphasis option over extensive, contiguous areas of a subzone or subregional planning area (over several adjacent landscape units, for example) should be avoided as it will greatly impact natural levels of biodiversity in that area. Instead, landscape units with the lower biodiversity emphasis should be distributed across the subregional planning area.

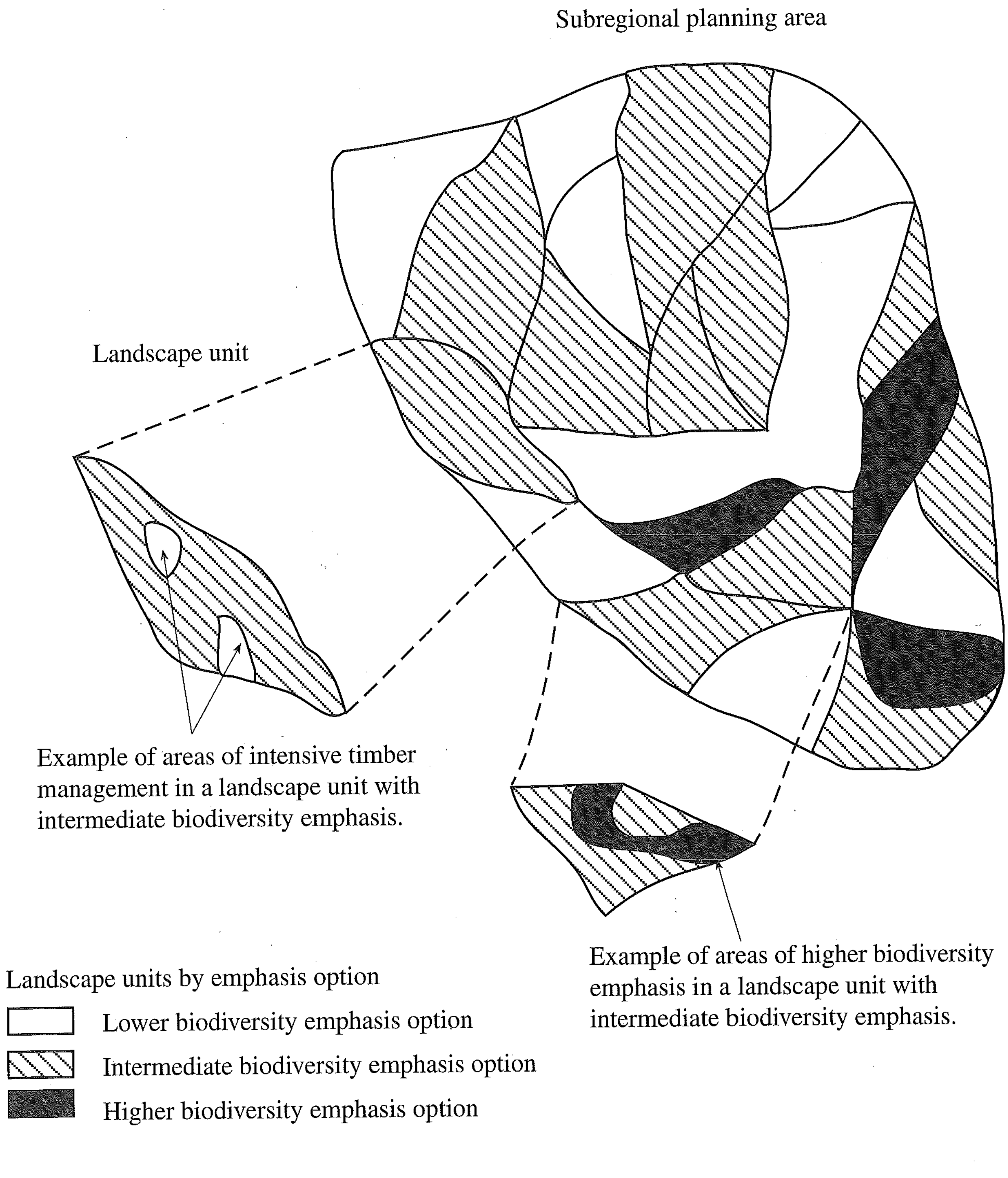


Figure 4. Example of the application and distribution of biodiversity emphasis options for landscape units within a subregional planning area.

Establishing landscape unit biodiversity objectives

Once landscape units have been delineated and the biodiversity emphasis option determined, objectives for maintaining biodiversity within the units may be set for the following characteristics:

- seral stage distribution
- temporal and spatial distribution of the cut and leave areas "patch size distribution"
- old seral retention and representativeness
- landscape connectivity
- stand structure
- species composition.

British Columbia has tremendous ecological variation. Although some general forest and range management practices can broadly accommodate the needs of all ecosystems, more often a variety of practices is needed to respond to the different natural disturbance regimes under which ecosystems have evolved.

For the purpose of setting biodiversity objectives, five natural disturbance types (NDTs) are recognized as occurring in British Columbia. They are:

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

These disturbance types characterize areas with different natural disturbance regimes. Stand-initiating disturbances are those processes that largely terminate the existing forest stand and initiate secondary succession in order to produce a new stand. The disturbance agents are mostly wildfires, windstorms and, to a lesser extent, insects and landslides. The stand-maintaining disturbances—such as the understorey surface fires that occur in the Interior Douglas-fir and Ponderosa Pine biogeoclimatic zones—serve to keep successional processes stable.

The following descriptions of the five NDTs include the biogeoclimatic zones, subzones, and variants that fall under each disturbance regime. As additional information becomes available, the number of NDTs and the biogeoclimatic units within them may be revised and refined. Appendix 3 provides an alphabetically listed cross reference of biogeoclimatic units to NDTs and forest region.

The geographic distribution of NDTs is presented in Figure 5.

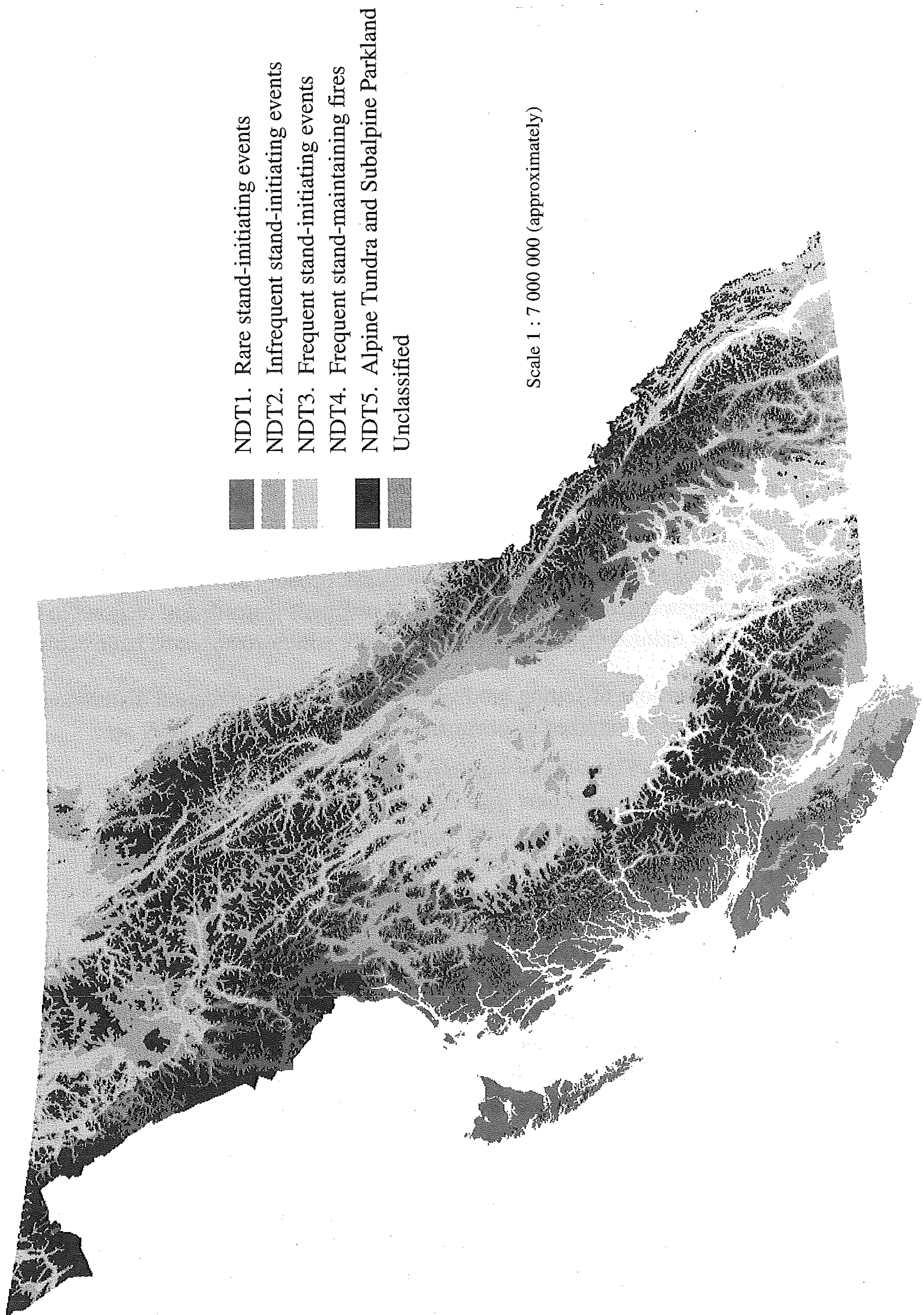


Figure 5. The distribution of NDTs across British Columbia. (Prepared by Research Branch, Ministry of Forests. Based on Provincial Biogeoclimatic Subzone/Variant Mapping (Version 1.0).

Recommended procedure for establishing landscape unit biodiversity objectives

- Confirm the biodiversity emphasis option for the landscape unit.
- Map the NDTs within the landscape unit, based on the biogeoclimatic subzones and variants present in the unit.
- Use the NDT recommendations to establish the biodiversity objectives for the landscape unit.
- Where a landscape unit consists entirely of one NDT, the biodiversity objectives for the landscape unit should be those of the NDT. However, where a landscape unit consists of more than one disturbance type, biodiversity objectives for the landscape unit should be developed for each of the NDTs present. In areas that are transitional between two NDTs, the management practices should be modified to reflect that transition.
- Where a disturbance type accounts for only a small, isolated part of a landscape unit, meeting the landscape level objectives for the small area may not be possible. In such cases include the small area in an adjacent disturbance type.

Establishing seral stage objectives for natural disturbance types

The composition of plant and animal communities changes as forest stands develop through time after a disturbance. Various organisms find their habitat needs during different stages of forest development (known as seral stages, or forest ages) and most specialist species are associated with either the early herb/shrub stage or the mature to old seral stages.

Different natural disturbance regimes have created forests with greatly differing seral stage distributions. Portions of the province with less frequent stand-initiating disturbance have more older forest, and a greater abundance of species adapted to landscapes of older forests, than do areas with more frequent disturbance.

Forest harvesting generally increases the amount of young forest and decreases the amount of older forest, because commercial forest rotations are generally shorter than natural disturbance return periods. This effect is most pronounced in forest types that have the lowest frequency of natural stand-initiating disturbance. Therefore, the more that managed forests diverge from natural disturbance regimes, the greater the risk of loss of biodiversity.

The seral stage guidelines provided by NDT are intended to help foresters maintain the diversity of seral stages and disturbance regimes found within various biogeoclimatic zones, subzones and variants. The method used for establishing seral stage definitions and distributions is described in Appendix 4.

It is unclear to what extent management can deviate from natural seral stage distributions without losing elements of biodiversity. Even at the scale of landscape units, natural patterns often vary from the average. This guidebook, while acknowledging the uncertainties, presents the minimum requirements considered to have a good probability of maintaining biodiversity within the landscape unit. It assumes that greater change from natural seral stage distributions would increase the risk to biodiversity, and less change would decrease the risk.

Cutblock size and biodiversity objectives

Section 21 (1) of the Operational Planning Regulations (OPR) states that cutblock design, including size, shape, and pattern, must be consistent with the objectives established under a higher-level plan, including objectives for the maintenance of biodiversity. Recommendations in this guidebook for cutblock maximum size, and pattern are provided in the section on "Temporal and spatial distribution of cut and leave areas." Also included there are recommendations for patch size distribution for cutblocks and leave areas.

The maximum cutblock size that may be proposed is either 40 or 60 ha, depending on which forest region the plan is in (OPR 21 (2)). However, smaller (OPR 21 (3) (a)) or larger (OPR 21 (3) (b)) maximum cutblock sizes may be allowed by the district manager for specific reasons. Where larger cutblocks are specified, the cutblock design must be consistent with the structural characteristics and the temporal and spatial distribution of natural openings (see recommendations in the section on "Stand management to maintain biodiversity").

Linked to the importance of maintaining the temporal and spatial distribution of cutblocks and natural openings is the importance of maintaining landscape level connectivity. Connectivity recommendations in general are provided in Chapter 3; and forest ecosystem networks (FENs), one way to achieve landscape connectivity, are described in detail in the section "Designing forest ecosystem networks." Where locations of FENs are known, they must be identified and described on forest development plans (OPR 15 (2) (g)).

Natural disturbance type 1: ecosystems with rare stand-initiating events

Historically, these forest ecosystems were usually uneven-aged or multi-storied even-aged, with regeneration occurring in gaps created by the death of individual trees or small patches of trees. When disturbances such as wind, fire, and landslides occurred, they were generally small and resulted in irregular edge configurations and landscape patterns.

The mean return interval for these disturbances is generally 250 years for the CWH and ICH, and 350 years for the ESSF and MH biogeoclimatic zones.

Occasionally, major windthrow events have occurred as a result of hurricane-force winds on certain exposed parts of coastal British Columbia. The average return interval for these has been approximately 100 years. Those portions of the CWHvm1, CWHvm2, CWHvh1 and CWHvh2 variants where these wind events occurred should therefore be considered to fall within NDT3, ecosystems with frequent stand-initiating events.

Biogeoclimatic units in NDT1

The following biogeoclimatic subzones and variants make up this disturbance type:

CWHvh1	ESSFvc	ICHvc
CWHvh2	ESSFvv	ICHvk1
CWHvm1	ESSFwc1 (north of the west arm of Kootenay Lake)	ICHvk2
CWHvm2	ESSFwc2	ICHwk1
CWHvm3	ESSFwc3	ICHwk2
CWHwh1	ESSFwc4 (north of the west arm of Kootenay Lake)	ICHwk3
CWHwh2	ESSFwk1	ICHwk4
CWHwm	ESSFwk2	
	ESSFwk3	MHmm1
	ESSFwm (north of Crawford Creek)	MHmm2
	ESSFwv	MHwh1
		MHwh2

While stand-initiating fire disturbances also occur—though rarely—in the Interior Douglas-fir and Ponderosa Pine biogeoclimatic zones, these zones are not included in NDT1 because the stand-maintaining surface fires are the dominant ecological influence.

Seral stage distribution (NDT1)

To maintain important landscape characteristics in this disturbance type, a relatively high proportion of forests with mature and old seral stage forest attributes is required. In managed stands this requirement can be met through the use of a combination of silvicultural systems.

Table 2 defines seral stages for each biogeoclimatic zone within this disturbance type; Table 3 recommends targets for seral stage distribution in the type.

Table 2. Seral stage definitions by biogeoclimatic zones in NDT1

Note: The mid-seral stage, between early and mature, is not designated.

Biogeoclimatic unit	Mean event interval[b]	Seral stage[a]		
		Early	Mature	Old
CWH[c]	250 yr	<40 yr	>80 yr	>250 yr
ICH	250 yr	<40 yr	>100 yr	>250 yr
ESSF	350 yr	<40 yr	>120 yr	>250 yr
MH	350 yr	<40 yr	>120 yr	>250 yr

[a] Seral stages can be defined by the ages presented in this table or by stand-level attributes.

- The early seral column should be used for partially cut stands with less than 30% of natural stand volume.
- Younger stands or partially cut stands can be considered mature if they provide the important habitat attributes of a mature-aged stand (see Appendix 5).
- Older mature stands or partially cut stands can be considered old if they provide the important attributes of an old-aged stand (see Appendix 5).
- Silvicultural treatments may be used to accelerate the development of these attributes.
- Stand-level attributes and partial cutting prescriptions to meet mature and old seral stage objectives should be developed for each biogeoclimatic subzone or variant, based on natural stand characteristics, and approved by the resource agencies. Silvicultural systems should then be developed to create these attributes in young stands. Until these attributes and silvicultural systems are developed, managers can use the following approximation for partial cutting: A stand can meet the mature seral criteria if, after partial cutting, the residual stand volume and stand attributes (see Appendix 5) are greater than 70% of the natural stand (all original diameter classes are represented in proportion to the average stand profile for the subzone and variant).

[b] This represents an average value over large geographic areas for each NDT. Consequently, forests can be found that are older than the mean event interval, as the age definition of old seral sometimes specifies.

[c] Some portions of the CWH have a much more frequent disturbance history due to extensive windthrow. For those areas see the tables in NDT3.

Table 3. Recommended seral stage distribution for NDT1 (% of forest area within the landscape unit)

Biogeoclimatic unit	Seral stage								
	Early			Mature + old[a]			Old		
	L[b]	I[b]	H[b]	L	I	H	L	I	H
CWH	n/a	<30	<23	>18	>36	>54	>13	>13	>19
ICH	n/a	<30	<23	>17	>34	>51	>13	>13	>19
ESSF	n/a	<22	<17	>19	>36	>54	>19	>19	>28
MH	n/a	<22	<17	>19	>36	>54	>19	>19	>28

[a] The minimum requirement for the old seral stage is included in the "Mature + old" category.

[b] L designates the lower biodiversity emphasis option; I designates the intermediate biodiversity emphasis option; H designates the higher biodiversity emphasis option.

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

Recommendation:

- Seral stages should occur in a variety of patch sizes within the landscape unit.

Temporal and spatial distribution of the cut and leave areas (NDT1)

The pattern and timing of forest harvesting are the dominant factors that determine the size and spatial distribution of similarly aged forest patches in managed landscapes. The objective in this disturbance type is to maintain a range of small to large (up to 250 ha) similarly aged forest patches on the landscape. The forest patch size distribution applies to both harvest units and the leave areas in the landscape units.

Partial cutting and some small clearcuts could be used in this NDT. Complete reliance on small, dispersed clearcuts and small leave areas, however, would lead to excessive forest fragmentation. Therefore, some larger patches should be cut to form larger openings; others should be identified as leave areas.

Harvest units and the remaining mature forest stands within the operable forest should be distributed in the landscape unit as shown in Table 4.

Table 4. Recommended distribution of patch sizes (harvest units and leave areas)[a] for NDT1

Note: These values represent a vision of desired future conditions and will not necessarily be initially achievable in a watershed where forest operations are just beginning.

Patch size (ha)	% Forest area within landscape unit
<40	30–40
40–80	30–40
80–250	20–40

a Patch size refers to a single cutblock or an aggregation of cutblocks.

Recommendations:

- To approximate the historic pattern of this landscape type, a combination of smaller dispersed clearcuts, some dispersed partial cuts, and a few large aggregated harvest units should be used, along with mature and old seral stage forests maintained in a connected network.
- Patch sizes greater than 40 or 60 ha can be created by harvesting the entire larger patch at one time or by aggregating small cutblocks over time. In either case, structural attributes (i.e., live and dead trees) consistent with the natural disturbance type are to be retained within the patch. If smaller cutblocks are aggregated over time, the district manager may waive or reduce green-up requirements to accomplish this. When approved cutblocks exceeding 40 or 60 ha are advertised, and appear in the *Gazette*, the fact that they meet biodiversity retention objectives should be indicated.
- The size range of leave areas should be the same as that for openings.

Old seral stage retention and representativeness (NDT1)

The target for old seral stage retention in this disturbance type is described in the recommendations below.

Recommendations:

- The total area that should be retained within the landscape unit in old seral stage condition is shown in Table 3. Rare site series should be retained in greater proportion than they occur in the landscape unit; other site series should generally be retained in proportion to their occurrence in the landscape unit. Where site series mapping is not available, a combination of forest cover and site productivity or site index information should be used to determine representativeness.

- The old seral stage retention objective should include patches designed to provide some forest interior conditions across a landscape unit. Where a lower biodiversity emphasis option is chosen, the target for forest interior conditions may be as low as 25% of the old seral area indicated in Table 3. If an intermediate or higher biodiversity emphasis option is chosen, the target should be 50% of the area indicated in Table 3. Objectives for obtaining forest interior conditions can sometimes be accomplished most efficiently by increasing old seral stage retention around wildlife habitat areas, riparian management areas, or other suitable areas. (For a description of forest interior, see Appendix 1.)
- Old seral retention objectives set in Table 3 sometimes cannot be met because of previous harvesting or natural disturbance history.
  - For a higher or intermediate biodiversity emphasis area, all the existing old seral forest should be retained, and additional areas designated to be left to become old seral forest and make up the shortfall in the future.
  - For a lower biodiversity emphasis area, the economic and social consequences of halting the timber harvest of old seral forest may be politically unacceptable. If so, some additional harvesting of old seral stands may proceed, and the area equivalent to the shortfall in old seral area must be recruited over time, according to an approved long-term recruitment plan. The old seral retention objective must be in place by the end of three rotations. In this situation a much higher risk to biodiversity exists until the old seral requirements in Table 3 are in place.

Landscape connectivity (NDT1)

Historically, these forests existed as contiguous tracts of old seral stage forest in which stand structure was complex because major stand-initiating events were rare. Current forest practices greatly alter these forests compared to historical conditions.

Connectivity can be maintained through the delineation of forest ecosystem networks. It can also be achieved at a broader scale within landscape units, according to the recommendations under "Temporal and spatial distribution of the cut and leave areas," above. The methods selected should depend on the connectivity objectives of the landscape unit.

Management to reduce fragmentation and maintain connectivity in managed forest landscapes should be guided by the type and degree of connectivity found in each disturbance type. Connectivity can be maintained by a combination of the following methods:

- Maintain late successional forest linkages as part of forest ecosystem networks (see the section "Designing forest ecosystem networks"). These linkages should mimic the type and degree of connectivity found in each disturbance type.
- Manage the forest matrix (the forest between the defined linkages) to maintain additional connectivity through the use of:
  - seral stage and patch size guidelines
  - stand remnants left during harvesting operations (such as small unharvested patches or advanced regeneration)
  - stand management to maintain some of the structural attributes of older forests.

Recommendations:

- Connectivity should be maintained or provided for—especially in those areas identified as "high" in Table 5—using variable width linkages as part of forest ecosystem networks.
- Tailor the application of seral stage, patch size, and stand structure recommendations to manage the area outside of defined linkages to meet the specific connectivity objectives of the landscape unit.

Table 5. The frequency with which connectivity characteristics of natural mature/old seral stage ecosystems occur for all biogeoclimatic subzones of NDT1

Natural connectivity characteristics[a]	Frequency of occurrence
upland to upland	high
upland to stream	high
upland to wetland	high
cross-elevational	high
wetland complex	low – moderate
stream riparian	high
island remnants	low

[a] See glossary definition of "connectivity."

If an intermediate or higher biodiversity emphasis is chosen, the areas that are identified as old seral linkages may be incremental to the areas indicated in Table 3. If a lower biodiversity emphasis is chosen, linkages should not result in the areas of old seral stage exceeding the distribution objectives in Table 3.

Stand structure (NDT1)

Maintaining a variety of canopy layers (vertical structure) and spatial patchiness (horizontal structure) is important for maintaining biodiversity in this NDT.

Recommendations:

- Stand management activities should maintain the natural variety of canopy layers and gaps among and within stands across the landscape.
- Even-aged or partial cutting silvicultural systems may be appropriate, but retention of mature forest attributes is especially important in this NDT. These attributes can be retained throughout the stand and / or concentrated within wildlife tree patches (see the section on "Wildlife trees"). Note, however, that these wildlife tree patches should not be additive to those recommended in "Stand management to maintain biodiversity."
- Practices for maintaining stand structure should be considered for all stands and applied as outlined in "Stand management to maintain biodiversity."

Species composition (NDT1)

The section on "Stand management to maintain biodiversity" recommends stand level practices for maintaining species composition.

Recommendations:

- A significant component of the landscape unit should be maintained in communities with plant species composition similar to that in communities that have developed through natural succession.
- Extensive conversion from climax to young seral species, or from young seral to climax or non-native species, should be avoided.
- Rare forest stand types (that is, those accounting for less than 2% of the area, such as birch, cottonwood, aspen, alder and maple) within the landscape unit should be maintained over the rotation.
- The proportion and distribution of the deciduous broadleaf components of stands should be maintained within the range found in unmanaged stands within the landscape unit.

Natural disturbance type 2: ecosystems with infrequent stand-initiating events

Historically, these forest ecosystems were usually even-aged, but extended post-fire regeneration periods produced stands with uneven-aged tendencies, notably in the ESSF and SWB biogeoclimatic zones where multi-storied forest canopies result.

Wildfires were often of moderate size (20 to 1000 ha), with unburned areas resulting from sheltering terrain features, higher site moisture or chance. Many larger fires occurred after periods of extended drought, but the landscape was dominated by extensive areas of mature forest surrounding patches of younger forest.

The mean return interval for these disturbances is about 200 years for the CDF, CWH, ICH, SBS, ESSF and SWB biogeoclimatic zones.

Biogeoclimatic units in NDT2

The following biogeoclimatic subzones and variants make up this disturbance type:

CDFmm

CWHdm
CWHds1
CWHds2
CWHmm1
CWHmm2
CWHms1
CWHms2
CWHws1
CWHws2
CWHxm1
CWHxm2

ESSFmc
ESSFmk
ESSFmm1
ESSFmm2
ESSFmv1
ESSFmv2
ESSFmv3
ESSFmv4
ESSFmw
ESSFwc1 (south of the west arm of Kootenay Lake)
ESSFwc4 (south of the west arm of Kootenay Lake)
ESSFwm (south of Crawford Creek)
ESSFxv

ICHmc1
ICHmc1a
ICHmc2
ICHmk3
ICHmm
ICHmw1
ICHmw2
ICHwc

SBSvk
SBSwk1 (mountain)
SBSwk2

SWBdk
SWBdks
SWBmk
SWBmks
SWBvks

Seral stage distribution (NDT2)

As a result of the major fires that occurred in this disturbance type, the landscape would have consisted of extensive areas of even-aged stands with snags and veteran trees that had survived previous fires. Small areas were missed by the burns. Table 6 defines seral stages for each biogeoclimatic zone within this disturbance type; Table 7 recommends targets for seral stage distribution in the type.

Table 6. Seral stage definitions by biogeoclimatic zones in NDT2

Note: The mid-seral stage, between early and mature, is not designated.

Biogeoclimatic unit	Mean event interval[b]	Seral stage[a]		
		Early	Mature	Old
CWH	200 yr	<40 yr	>80 yr	>250 yr
CDF	200 yr	<40 yr	>80 yr	>250 yr
ICH	200 yr	<40 yr	>100 yr	>250 yr
SBS	200 yr	<40 yr	>100 yr	>250 yr
ESSF	200 yr	<40 yr	>120 yr	>250 yr
SWB	200 yr	<40 yr	>120 yr	>250 yr

[a] Seral stages can be defined by the ages presented in this table or by stand-level attributes.

- The early seral column should be used for partially cut stands with less than 30% of natural stand volume.
- Younger stands or partially cut stands can be considered mature if they provide the important habitat attributes of a mature-aged stand (see Appendix 5).
- Older mature stands or partially cut stands can be considered old if they provide the important attributes of an old-aged stand (see Appendix 5).
- Silvicultural treatments may be used to accelerate the development of these attributes.
- Stand-level attributes and partial cutting prescriptions to meet mature and old seral stage objectives should be developed for each biogeoclimatic subzone or variant, based on natural stand characteristics, and approved by the resource agencies. Silvicultural systems should then be developed to create these attributes in young stands. Until these attributes and silvicultural systems are developed, managers can use the following approximation for partial cutting: A stand can meet the mature seral criteria if, after partial cutting, the residual stand volume and stand attributes (see Appendix 5) are greater than 70% of the natural stand (all original diameter classes are represented in proportion to the average stand profile for the subzone and variant).

[b] This represents an average value over large geographic areas for each NDT. Consequently, forests can be found that are older than the mean event interval, as the age definition of old seral sometimes specifies.

Table 7. Recommended seral stage distribution for NDT2 (% of forest area within the landscape unit)

Biogeoclimatic unit	Seral stage: Early			Mature + old[a]			Old		
	L[b]	I[b]	H[b]	L	I	H	L	I	H
CWH	n/a	<36	<27	>17	>34	>51	>9	>9	>13
CDF	n/a	<36	<27	>17	>34	>51	>9	>9	>13
ICH	n/a	<36	<27	>15	>31	>46	>9	>9	>13
SBS	n/a	<36	<27	>15	>31	>46	>9	>9	>13
ESSF	n/a	<36	<27	>14	>28	>42	>9	>9	>13
SWB	n/a	<36	<27	>14	>28	>42	>9	>9	>13

a The minimum requirement for the old seral stage is included in the "Mature + old" category.

b L designates the lower biodiversity emphasis option; I designates the intermediate biodiversity emphasis option; H designates the higher biodiversity emphasis option.

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

Recommendation:

- Seral stages should occur in a variety of patch sizes within the landscape unit.

Temporal and spatial distribution of the cut and leave areas (NDT2)

The pattern and timing of forest harvesting are the dominant factors that determine the size and spatial distribution of similarly aged forest patches in managed landscapes. The objective in this disturbance type is to maintain a range of small to medium-sized (up to 250 ha) similarly aged forest patches on the landscape. The forest patch size distribution applies to both harvest unit and the leave area between harvest units.

Clearcutting with wildlife tree patches and some small clearcuts can be used to simulate the small-scale disturbances that naturally occurred in this disturbance type. However, complete reliance on small, dispersed clearcuts and small leave areas would lead to excessive forest fragmentation. Therefore, some larger patches should be cut to form larger openings; others should be identified as leave areas.

Harvest units and the remaining mature forest stands of various sizes within the operable forest should be distributed in the landscape unit as shown in Table 8.

Table 8. Recommended distribution of patch sizes (harvest units and leave areas)[a] for NDT2

Note: These values represent a vision of desired future conditions and will not necessarily be achievable in a watershed.

Patch size (ha)	% Forest area within landscape unit
<40	30–40
40–80	30–40
80–250	20–40

[a] Patch size refers to a single cutblock or an aggregation of cutblocks.

Recommendations:

- Patch sizes greater than 40 or 60 ha can be created by harvesting the entire larger patch at one time or by aggregating small cutblocks over time. In either case, structural attributes (i.e., live and dead trees) consistent with the natural disturbance type are to be retained within the patch. If smaller cutblocks are aggregated over time, the district manager may waive or reduce green-up requirements to accomplish this. When approved cutblocks exceeding 40 or 60 ha are advertised, and appear in the *Gazette*, the fact that they meet biodiversity retention objectives should be indicated.
- The size range of leave areas should be the same as that for openings.

Old seral stage retention and representativeness (NDT2)

The target for old seral stage retention in this disturbance type is described in the recommendations below.

Recommendations:

- The total area that should be retained within the landscape unit in old seral stage condition is shown in Table 7. Rare site series should be retained in this condition in greater proportion than is their occurrence in the landscape unit; other site series should generally be retained in proportion to their occurrence in the landscape unit. Where site series mapping is not available, a combination of forest cover and site productivity or site index information should be used to determine representativeness.
- The old seral stage retention objective should include patches designed to provide some forest interior conditions across a landscape unit. Where a lower biodiversity emphasis option is chosen, the target for forest interior conditions may be as low as 10% of the old seral area indicated in Table 7. If an intermediate or higher biodiversity emphasis option is chosen, the target should be 25% of the area indicated in Table 7. Objectives for obtaining forest interior conditions can sometimes be accomplished most efficiently by increasing old seral stage retention around wildlife habitat

areas, riparian management areas, or other suitable areas. (For a description of forest interior, see Appendix 1.)

- Old seral retention objectives set in Table 7 sometimes cannot be met because of previous harvesting or natural disturbance history.
  - For a higher or intermediate biodiversity emphasis area, all the existing old seral forest should be retained, and additional areas designated to be left to become old seral forest and make up the shortfall in the future.
  - For a lower biodiversity emphasis area, the economic and social consequences of halting the timber harvest of old seral forest may be politically unacceptable. If so, some additional harvesting of old seral stands may proceed, and the area equivalent to the shortfall in old seral area must be recruited over time, according to an approved long-term recruitment plan. The old seral retention objective must be in place by the end of three rotations. In this situation a much higher risk to biodiversity exists until the old seral requirements in Table 7 are in place.

Landscape connectivity (NDT2)

Historically, these forests existed as contiguous tracts of old seral stage forest in which stand structure was complex because major stand-initiating events were rare. Current forest practices greatly alter these forests compared to historical conditions.

Connectivity can be maintained through the delineation of forest ecosystem networks (see the section "Designing forest ecosystem networks"). It can also be achieved at a broader scale within landscape units, according to the recommendations under "Temporal and spatial distribution of the cut and leave areas," above. The methods selected should depend on the connectivity objectives of the landscape unit.

A combination of smaller dispersed clearcuts, some dispersed partial cuts, a few large aggregated harvest units, and some mature and old seral stage forests, maintained in a connected network, should more closely approximate the historic pattern of this landscape type.

Management to reduce fragmentation and maintain connectivity in managed forest landscapes should be guided by the type and degree of connectivity found in each disturbance type. Connectivity can be maintained by a combination of the following methods:

- Maintain late successional forest linkages as part of forest ecosystem networks (see "Designing forest ecosystem networks"). These linkages should mimic the type and degree of connectivity found in each disturbance type.

- Manage the forest matrix (the forest between the defined linkages) to maintain additional connectivity through the use of:
  - seral stage and patch size guidelines
  - stand remnants left during harvesting operations (such as small unharvested patches or advanced regeneration)
  - stand management to maintain some of the structural attributes of older forests.

Recommendations:

- Connectivity should be maintained or provided for—especially in those areas identified as "high" in Table 9—using variable width linkages as part of forest ecosystem networks.
- Tailor the application of seral stage, patch size, and stand structure recommendations to manage the area outside of defined linkages to meet the specific connectivity objectives of the landscape unit.

Table 9. The frequency with which connectivity characteristics of natural mature/old seral stage ecosystems occur for all biogeoclimatic subzones of NDT2

Natural connectivity characteristics[a]	Frequency of occurrence
upland to upland	high
upland to stream	moderate
upland to wetland	moderate
cross-elevational	high
wetland complex	low
stream riparian	high
island remnants	low

[a] See glossary definition of "connectivity."

If an intermediate or higher biodiversity emphasis is chosen, the areas that are identified as old seral linkages may be incremental to the areas indicated in Table 7. If a lower biodiversity emphasis is chosen, linkages should not result in the areas of old seral stage exceeding the objectives in Table 7.

Stand structure (NDT2)

Maintaining snags, veteran trees, and coarse woody debris within predominantly even-aged stands is important for biodiversity in this NDT. Reserving a component of the old seral stages that historically have not burned is also important.

Recommendations:

- Even-aged silvicultural systems with wildlife tree patches are appropriate to mimic the natural stand-initiating events. Note, however, that these wildlife tree patches should not be additive to those recommended in "Stand management to maintain biodiversity."
- Partial cutting, including commercial thinning, can be used to maintain a number of mature forest characteristics in some stands.
- Where possible, existing veteran trees should be maintained when second-growth stands are harvested.
- Practices for maintaining stand structure should be considered for all stands and applied as outlined in "Stand management to maintain biodiversity."

Species composition (NDT2)

Natural forest succession in this NDT created a mosaic of different successional stages. Species composition within these successional stages varies from early seral communities to climax communities. Maintaining that variety of species composition within seral stages is an important component of maintaining biodiversity in this NDT.

Rare ecosystems within the landscape unit also contribute significantly to the richness of species composition and to the maintenance of diversity.

The section "Stand management to maintain biodiversity" recommends stand level practices for maintaining species composition.

Recommendations:

- A significant component of the landscape unit should be maintained in communities with plant species composition similar to that in communities that have developed through natural succession.
- Extensive conversion from climax to young seral species, or from young seral to climax or non-native species, should be avoided.
- Rare forest stand types within the landscape unit (that is, those accounting for less than 2% of the area, such as birch, cottonwood, aspen, alder, and maple) should be maintained over the rotation.
- The proportion and distribution of the deciduous broadleaf components of stands should be maintained within the range found in unmanaged stands within the landscape unit.

Natural disturbance type 3: ecosystems with frequent stand-initiating events

Historically, these forest ecosystems experienced frequent wildfires that ranged in size from small spot fires to conflagrations covering tens of thousands of hectares. Average fire size was likely 300 ha in some parts of the BWBS biogeoclimatic zone, but went as high as 6000 ha in other parts of the zone where topographic features did not limit fire spread. The largest fires in the province occur in this NDT, often exceeding 100 000 ha and sometimes even 200 000 ha.

Natural burns usually contained unburned patches of mature forest that were missed by fire. Consequently, these forests produced a landscape mosaic of even-aged regenerating stands ranging in size from a few to thousands of hectares and usually containing mature forest remnants.

There were also frequent outbreaks of defoliating insects and an extensive presence of root diseases caused by *Armillaria* and *Phellinus* (especially in the ICH biogeoclimatic subzones). The impact of these infections on tree survival and stand structure ranged from low to severe. Tree mortality within mature forest remnants and regenerating stands resulted in dead trees, decaying logs, and canopy gaps. Riparian areas within the forest landscape provided special habitat characteristics not found in the upland areas.

Mean return interval for disturbances is about 100 years for the wind-dominated CWH and the fire-dominated SBPS and BWBS with deciduous species prominent. For the SBS and BWBS with coniferous species prominent, the mean fire return interval is about 125 years. The ESSF, ICH and MS units in this NDT experience a mean disturbance return interval of about 150 years.

The presence or absence of Douglas-fir does not influence the disturbance frequency, but determines the number and size of mature remnant stands that survive extensive crown fires to provide structural diversity. Douglas-fir is the most fire-resistant tree species in this NDT.

Biogeoclimatic units in NDT3

The following biogeoclimatic subzones and variants make up this disturbance type:

Douglas-fir restricted or absent		Douglas-fir throughout	
BWBSdk1	MSdc	ICHdk	SBSdh1
BWBSdk2	MSxk	ICHdw	
SBSdh2			
BWBSmw1	MSxv	ICHmk1	SBSdw1
BWBSmw2		ICHmk2	SBSdw2
BWBSvk	SBPSdc		SBSdw3
BWBSwk1	SBPSmc	ICHmw3	SBSmh
BWBSwk2	SBPSmk		SBSmw
BWBSwk3	SBPSxc	MSdk	
		MSdm1	
	SBSdk	MSdm2	
	SBSmc1		
	SBSmc2		
	SBSmc3		
	SBSmk1		
	SBSmk2		
ESSFdc	SBSmm		
ESSFdk	SBSwk1 (plateau)		
ESSFdv	SBSwk3		
ESSFxc			

Seral stage distribution (NDT3)

As a result of the frequent stand-initiating wildfires that occurred in these dry forests, the landscape is characterized by a mosaic of even-aged stands of different ages. Table 10 defines seral stages for each biogeoclimatic zone within this disturbance type; Table 11 recommends targets for seral stage distribution in the type.

Table 10. Seral stage definition for biogeoclimatic zones in NDT3

Note: The mid-seral stage, between early and mature, is not designated.

Biogeoclimatic unit	Mean event interval[b]	Seral stage[a]		
		Early	Mature	Old
BWBS[c]	100 yr	<20 yr	>80 yr	>100 yr
SBPS	100 yr	<40 yr	>100 yr	>140 yr
BWBS[d]	125 yr	<40 yr	>100 yr	>140 yr
SBS	125 yr	<40 yr	>100 yr	>140 yr
MS	150 yr	<40 yr	>100 yr	>140 yr
ESSF	150 yr	<40 yr	>120 yr	>140 yr
ICH	150 yr	<40 yr	>100 yr	>140 yr
CWH[e]	100 yr	<40 yr	>80 yr	>140 yr

[a] Seral stages can be defined by the ages presented in this table or by stand-level attributes.

- The early seral column should be used for partially cut stands with less than 30% of natural stand volume.
- Younger stands or partially cut stands can be considered mature if they provide the important habitat attributes of a mature-aged stand (see Appendix 5).
- Older mature stands or partially cut stands can be considered old if they provide the important attributes of an old-aged stand (see Appendix 5).
- Silvicultural treatments may be used to accelerate the development of these attributes.
- Stand-level attributes and partial cutting prescriptions to meet mature and old seral stage objectives should be developed for each biogeoclimatic subzone or variant, based on natural stand characteristics, and approved by the resource agencies. Silvicultural systems should then be developed to create these attributes in young stands. Until these attributes and silvicultural systems are developed, managers can use the following approximation for partial cutting: A stand can meet the mature seral criteria if, after partial cutting, the residual stand volume and stand attributes (see Appendix 5) are greater than 70% of the natural stand (all original diameter classes are represented in proportion to the average stand profile for the subzone and variant).

[b] This represents an average value over large geographic areas for each NDT. Consequently, forests can be found that are older than the mean event interval, as the age definition of old seral sometimes specifies.

[c] BWBS with deciduous prominent.

[d] BWBS with coniferous prominent.

[e] Those portions of CWH subject to regular extensive windthrow disturbance.

Table 11. Recommended seral stage distribution for NDT3 (% of forest area within the landscape unit)

Biogeoclimatic unit	Seral stage								
	Early			Mature + old[a]			Old		
	L[b]	I[b]	H[b]	L	I	H	L	I	H
BWBS[c]	n/a	<36	<27	>13	>23	>34	>13	>13	>19
SBPS	n/a	<66	<50	>8	>17	>25	>7	>7	>10
BWBS[d]	n/a	<54	<40	>11	>23	>34	>11	>11	>16
SBS	n/a	<54	<40	>11	>23	>34	>11	>11	>16
MS	n/a	<46	<35	>14	>26	>39	>14	>14	>21
ESSF	n/a	<46	<35	>14	>23	>34	>14	>14	>21
ICH	n/a	<46	<35	>14	>23	>34	>14	>14	>21
CWH[e]	n/a	<66	<50	>11	>23	>34	>11	>11	>16

a The minimum requirement for the old seral stage is included in the "Mature + old" category.

b L designates the lower biodiversity emphasis option, I designates the intermediate biodiversity emphasis option; H designates the higher biodiversity emphasis option. Note: The lower biodiversity emphasis option was established based on the assumption that it would not be applied to more than approximately half of the area of any biogeoclimatic subzone within a subregional plan or forest district.

c BWBS with deciduous prominent.

d BWBS with coniferous prominent. Note: In much of the BWBS, commercial species are found largely or entirely on alluvial sites. In such cases, seral stage objectives should be applied to those commercial species stands separately from the adjacent upland forest.

e Those portions of CWH subject to regular extensive windthrow disturbance.

Recommendation:

- Seral stages should occur in a variety of patch sizes within the landscape unit.

Temporal and spatial distribution of the cut and leave areas (NDT3)

Past forest harvesting practices in these areas have produced a landscape pattern that is notably different from the natural pattern. Dispersed medium-sized cutblocks and leave areas have resulted in a fragmented forest with few areas of extensive, contiguous forest. In contrast, beetle-salvage logging has resulted in large-scale disturbances, but without retaining many mature forest remnants within those harvested areas.

A clustered harvest pattern, using large aggregated harvest units, most closely simulates the natural pattern of large fires and large unburned areas or, in certain coastal variants of the CWH, simulates windthrow disturbance. It also results in less fragmentation of the landscape. Retention of patches of forest or single trees within aggregated harvest units simulates the island remnants left within areas of large burns. These remnants are vital to maintain biological diversity, especially when large cuts are used.

A harvest strategy such as this provides numerous ecological benefits. Concentrating harvesting activity in one area allows other large areas of older forest to be left intact and unfragmented for extended periods. As well, the combination of seral stage distribution and harvest unit size recommendations are designed to ensure that some large, unfragmented mature forests are always present on the landscape.

Harvest units and the remaining mature forest stands within the operable forest should be distributed in the landscape unit as shown in Tables 12 to 14.

Table 12. Recommended distribution of patch sizes (harvest units and leave areas)[a] for biogeoclimatic subzones with Douglas-fir throughout stands in NDT3

Note: These values represent a vision of desired future conditions and will not necessarily be initially achievable in a watershed where forest operations are just beginning.

Patch size (ha)	% Forest area within landscape unit
<40	20–30
40–80	25–40
80–250	30–50

[a] Patch size refers to a single cutblock or an aggregate of cutblocks.

Table 13. Recommended distribution of patch sizes (harvest units and leave areas)[a] for biogeoclimatic subzones with Douglas-fir restricted or absent in NDT3

Note: These values represent a vision of desired future conditions and will not necessarily be initially achievable in a watershed where forest operations are just beginning.

Patch size (ha)	% Forest area within landscape unit
<40	10–20
40–250	10–20
250–1000	60–80

[a] Patch size refers to a single cutblock or an aggregate of cutblocks.

Table 14. Recommended distribution of patch sizes (harvest units and leave areas)[a] for alluvial ecosystems in the BWBS biogeoclimatic zone in NDT3

Note: These values represent a vision of desired future conditions and will not necessarily be initially achievable in a watershed where forest operations are just beginning.

Patch size (ha)	% Forest area within landscape unit
<20	30–50
20–40	30–50
40–80	10–30

a Patch size refers to a single cutblock or an aggregate of cutblocks.

Recommendations:

- Patch sizes greater than 40 or 60 ha can be created by harvesting the entire larger patch at one time or by aggregating small cutblocks over time. In either case, structural attributes (i.e., live and dead trees) consistent with the natural disturbance type are to be retained within the patch. If smaller cutblocks are aggregated over time, the district manager may waive or reduce green-up requirements to accomplish this. When approved cutblocks exceeding 40 or 60 ha are advertised, and appear in the *Gazette*, the fact that they meet biodiversity retention objectives should be indicated.
- The size range of leave areas should be the same as that for openings.

Old seral stage retention and representativeness (NDT3)

The target for old seral stage retention in this natural disturbance type is described in the recommendations below.

Recommendations:

- The total area that should be retained within the landscape unit in old seral stage condition is shown in Table 11. Rare site series should be retained in this condition in greater proportion than is their occurrence in the landscape unit; other site series should generally be retained in proportion to their occurrence in the landscape unit. Where site series mapping is not available, a combination of forest cover and site productivity or site index information should be used to determine representativeness.
- The old seral stage retention objective should include patches designed to provide some forest interior conditions across a landscape unit. Where a lower biodiversity emphasis is chosen, the target for forest interior

conditions may be as low as 10% of the old seral area indicated in Table 11. If an intermediate or higher biodiversity emphasis is chosen, the target should be 25% the area indicated in Table 11. Objectives for obtaining forest interior conditions can sometimes be accomplished most efficiently by increasing old seral stage retention around wildlife habitat areas, riparian management areas, or other suitable areas. (For a description of forest interior, see Appendix 1.)

- Old seral retention objectives set in Table 11 sometimes cannot be met because of previous harvesting or natural disturbance history.
  - For a higher or intermediate biodiversity emphasis area, all the existing old seral forest should be retained and additional areas designated to be left to become old seral forest and make up the shortfall in the future.
  - For a lower biodiversity emphasis area, the economic and social consequences of halting the timber harvest of old seral forest may be politically unacceptable. If so, some additional harvesting of old seral stands may proceed, and the area equivalent to the shortfall in old seral area must be recruited over time, according to an approved long-term recruitment plan. The old seral retention objective must be in place by the end of three rotations. In this situation a much higher risk to biodiversity exists until the old seral requirements in Table 11 are in place.

Landscape connectivity (NDT3)

In this natural disturbance type, wetland complexes, riparian stands, and the mature forests between them account for most of the connectivity among old seral stage stands. This disturbance type covers a very broad ecological range and has a large degree of variation in the natural connectivity of old and mature forests. The SBPS biogeoclimatic zone in the Cariboo Forest Region and some of the SBS biogeoclimatic subzones in the Prince George Forest Region probably had little connectivity across the forest matrix. Landscape connectivity, however, was provided along riparian corridors. The other biogeoclimatic subzones in this disturbance type (MS, some SBS, ICH, and ESSF) historically had a higher proportion of mature and old forests and a greater degree of old seral stage ecosystem connectivity.

Connectivity can be maintained through the delineation of forest ecosystem networks (see the section "Designing forest ecosystem networks"). It can also be achieved at a broader scale within landscape units, according to the recommendations under "Temporal and spatial distribution of the cut and leave areas," above. The methods selected should depend on the connectivity objectives of the landscape unit.

Management to reduce fragmentation and maintain connectivity in managed forest landscapes should be guided by the type and degree of connectivity found in each disturbance type. Connectivity can be maintained by a combination of the following methods:

- Maintenance of late successional forest linkages as part of forest ecosystem networks (see "Designing forest ecosystem networks"). These linkages should mimic the type and degree of connectivity found in each disturbance type.
- Management of the forest matrix (the forest between the defined linkages) to maintain additional connectivity through the use of:
  - seral stage and patch size guidelines
  - stand remnants left during harvesting operations (such as small unharvested patches or advanced regeneration)
  - stand management to maintain some of the structural attributes of older forests.

Recommendation:

- Connectivity should be maintained or provided for – especially in those areas identified as "high" in Table 15 – using variable width linkages as part of forest ecosystem networks. The full spectrum of biogeoclimatic subzones and variants within a landscape unit should be represented.
- Tailor the application of seral stage, patch size, and stand structure recommendations to manage the area outside of defined linkages to meet the specific connectivity objectives of the landscape unit.

Table 15. The frequency with which connectivity characteristics of natural mature/old seral stage ecosystems occur for all biogeoclimatic subzones of NDT3

	Frequency of occurrence by biogeoclimatic unit		
Natural connectivity characteristics[a]	SBPS SBSdk SBSmk SBSmc3 SBSwk1 SBSdw BWBSmw BWBSdk BWBSwk	MSxv	All other subzones
upland to upland	low	moderate–high	low–moderate
upland to stream	low	moderate–high	low–moderate
upland to wetland	low	moderate–high	high
cross-elevational	low	low	moderate
wetland complex	high	high	moderate
stream riparian	low	low	high
island remnants	high	moderate	moderate

[a] See glossary definition of "connectivity."

If an intermediate or higher biodiversity emphasis is chosen, the areas that are identified as old seral linkages may be incremental to the areas indicated in Table 11. If a lower biodiversity emphasis is chosen, linkages should not result in the areas of old seral stage exceeding objectives in Table 11.

Stand structure (NDT3)

Management for even-aged stands is important for maintaining biodiversity. Therefore, where present, large old Douglas-fir and larch trees should be maintained during forestry operations because they provide structural diversity in this disturbance type. In addition, a component of older seral stages that did not burn historically should be reserved from cutting.

Recommendations:

- Even-aged management systems with wildlife tree patches most closely simulate natural disturbances in much of this NDT. Note, however, that these wildlife tree patches should not be additive to those recommended in the section "Stand management to maintain biodiversity."

- Partial cutting systems should be used in Douglas-fir and larch stands.
- Partial cutting systems should be used to maintain mature forest attributes in some spruce and true fir stands.
- Some mature Douglas-fir and larch should be retained in stands where they constitute a minor component of the stand.
- Where Douglas-fir or larch is a component of a stand, it should also form a component of the regenerating stand.
- Practices for maintaining stand structure should be considered for all stands and applied as outlined in "Stand management to maintain biodiversity."

Species composition (NDT3)

Natural forest succession provides for a mosaic of different successional stages in this NDT. Species composition within these successional stages varies from early seral communities to climax communities. Maintaining that variety of species composition within seral stages is an important component of maintaining biodiversity. Where fire has historically been an important part of ecosystem processes, prescribed burning may be used as a management tool to assist regeneration of fire-adapted species.

Rare ecosystems within the landscape unit also contribute significantly to the richness of species composition and to the maintenance of diversity.

The section "Stand management to maintain biodiversity" recommends stand level practices for maintaining species composition.

Recommendations:

- A significant component of the landscape unit should be maintained in communities with plant species composition similar to that in communities that have developed through natural succession.
- Extensive conversion from climax to young seral species, or from young seral to climax or non-native species, should be avoided.
- Rare forest stand types within the landscape unit (that is, those accounting for less than 2% of the area, such as birch, cottonwood, aspen, alder, and maple) should be maintained over the rotation.
- The proportion and distribution of the deciduous broadleaf components of stands should be maintained—in both mixed wood and pure stands—within the range found in unmanaged stands in the landscape unit.

Natural disturbance type 4: ecosystems with frequent stand-maintaining fires

This NDT includes grassland, shrubland, and forested communities that normally experience frequent low-intensity fires. On grasslands, these fires limit encroachment by most woody trees and shrubs. Late seral and climax grasslands and shrublands are typically restricted to droughty sites that occur at low elevations or on steep south-facing slopes or fire-prone areas.

Less arid sites are characterized by forests of large, old trees with thick fire-resistant bark. Patches of less fire-resistant species develop in areas that have escaped low-intensity surface fires. The varied intensity and frequency of fires across the landscape has created a natural mosaic of mostly uneven-aged forests interspersed with grassy and shrubby openings.

Low elevation grasslands and open forests were more widespread throughout the Bunchgrass and Ponderosa Pine biogeoclimatic zones and drier elements of the Interior Douglas-fir biogeoclimatic zone before European settlement. Some of the open forests and grasslands were maintained in a "fire-climax" state by periodic lightning-caused fires and aboriginal use of fire. Recent human activities have altered fire regimes in much of this NDT, fostering litter accumulation and forest encroachment in some grasslands, and changing canopy composition and density in some forested areas. An increase in fire activity in the late 19th and early 20th centuries likely increased the extent of these ecosystems, but fire suppression during the last six decades has had the opposite effect.

The Ponderosa Pine and Interior Douglas-fir biogeoclimatic zones have a history of periodic surface fires that consumed woody fuels, rejuvenated most herb and shrub species while selecting against others, thinned the younger stands, and raised the height to the live tree crowns. Fire was historically responsible for maintaining the vegetative species composition and forest stand structure, and also for regulating coarse woody debris loading.

While this regime of fire maintenance would normally be easy to duplicate in a managed forest, the situation is complicated by several decades of fire exclusion, which has caused many Ponderosa pine and interior Douglas-fir stands to fill in with young conifers. This has resulted in fuel accumulations, increased probability of crown instead of surface fires, loss of understorey forage, and insect and disease damage.

Surface fire return intervals for the PP and IDF biogeoclimatic zones historically ranged from 4 to 50 years; stand-initiating crown fires were rare in the PP and occurred at intervals ranging from at least 150 to 250 years or more in the IDF.

Much of the area within this NDT is rangeland (forested and unforested land used for grazing). Grasslands and dry open forests provide permanent range (areas that produce substantial livestock forage throughout most or all successional stages) due to the abundance of forage. Areas that succeed to closed forests are used as transitory range, because there is negligible livestock forage except during a brief period following stand-initiating fires or timber harvesting. Many sites support livestock grazing and logging together. Recommendations for rangelands and recommendations for forested areas both apply in these areas.

The natural biodiversity in this NDT has been significantly affected by unregulated livestock grazing during the initial period of European settlement. Introduced weeds became established on many sites and spread to other areas after natural or human disturbances. Non-native forage plants have been deliberately established in some areas for a variety of reasons. As well, a number of human influences have eliminated shrubs and trees from some areas and reduced their abundance and size elsewhere to the detriment of wildlife species that rely on them for forage, protective cover, and breeding. Livestock and wildlife grazing have also reduced residual cover—living and dead vegetation that persists over-winter and provides protective and breeding cover during critical periods in the following spring before new growth takes over this function. Conventional range management practices in this NDT have not re-created all of the important attributes required to restore natural biodiversity.

Biogeoclimatic units in NDT4

The following biogeoclimatic subzones and variants make up this natural disturbance type:

BGxh1	IDFdk1	IDFu	PPdh1
BGxh2	IDFdk1a	IDFww	PPdh2
BGxh3	IDFdk2	IDFxh1	PPxh1
BGxw1	IDFdk3	IDFxh1a	PPxh2
BGxw2	IDFdk4	IDFxh2	
	IDFdm1	IDFxh2a	
ICHxw	IDFdm2	IDFxm	
	IDFmw1	IDFxw	
	IDFmw2		

Seral stage distribution (NDT4)

Permanent range

Most permanent rangelands should be managed so as to achieve appropriate desired plant communities within the climax or late seral stages. Properly regulated livestock use has encouraged the recovery of damaged rangelands in some areas. Some sites, however, cannot be restored using existing tools, even with the complete exclusion of livestock.

Range management objectives should be established according to the potential natural community (PNC) concept. A PNC would be established by allowing succession to be completed without further human interference. Natural disturbances are inherent in the development of a PNC, and acclimatized or naturalized non-native plant species are included where there are no known methods to control them.

At present, much of the rangeland in these ecosystems is in an earlier seral stage than climax, and therefore late-seral to PNC-climax communities will take some time to establish.

The seral stage of the current plant community is determined on the presence and abundance of species compared to their status in the PNC. Early-seral stages have 0–25% of the composition of the PNC, mid-seral stages have 25–50% of the PNC, late-seral stages have 50–75% of the PNC, and PNC-climax stages have 75–100% of the PNC.

Rangelands in early seral condition often require several decades before an upward trend to mid-seral condition is completed, even under the most favourable management regime. Therefore, sufficient areas of rangeland in early to mid-seral condition should be managed to achieve seral targets in the long term. Those targets are shown below:

	Early seral	Late seral+climax	Climax
Percent of landscape unit	< 10%	> 85%	>12%

Note: The mid-seral stage, between early and late seral, is not designated. The minimum requirement for the climax seral stage is included in the "late seral + climax" category.

Despite the descrepancy between seral stage objectives for forestry (low biodiversity option) and seral stage objectives for range, practices should be modified to help address both forestry and range requirement.

Once available, biogeoclimatic units that provide permanent forest range shall be listed and should be managed to achieve landscape level objectives for both range and forested areas.

Recommendations:

- Areas of rangeland in early to mid-seral condition should be managed to a maximum of 50% utilization of seasonal production (by both livestock and wildlife) and monitored.

- Planned grazing systems that allow greater than 50% removal for specific vegetation management purposes may be used as long as: the excess removal is for the benefit of the range, an approved plan is in place, and the land is allowed time to recover. The rate of upward trend should be assessed at 20-year intervals and management practices revised accordingly.
- Where appropriate species and genotypes of native seed are available at reasonable cost, and seeding methods do not lead to unacceptable impacts on biodiversity, they should be favoured over non-native seed.

Forests

As a result of the more frequent and widespread stand-maintaining fires that occurred in these ecosystems before fire suppression became widespread, the landscape is characterized by mature and old mixed forests. To maintain the important aspects of these forests, selected partial cutting prescriptions should be used while considering forest health issues. Table 16 defines seral stages for each biogeoclimatic zone within this disturbance type; Table 17 recommends targets for seral stage distribution in the type.

Table 16. Seral stage definitions for biogeoclimatic zones in NDT4

Note: The mid-seral stage, between early and mature, is not designated.

Biogeoclimatic unit	Mean event interval[b]	Seral stage[a]		
		Early	Mature	Old
ICH	250 yr	<40 yr	>100 yr	>250 yr
IDF	250 yr	<40 yr	>100 yr	>250 yr
PP	250 yr	<40 yr	>100 yr	>250 yr

a Seral stages can be defined by the ages presented in this table or by stand-level attributes.
- The early seral column should be used for partially cut stands with less than 30% of natural stand volume.
- Younger stands or partially cut stands can be considered mature if they provide the important habitat attributes of a mature-aged stand (see Appendix 5).
- Older mature stands or partially cut stands can be considered old if they provide the important attributes of an old-aged stand (see Appendix 5).
- Silvicultural treatments may be used to accelerate the development of these attributes.
- Stand-level attributes and partial cutting prescriptions to meet mature and old seral stage objectives should be developed for each biogeoclimatic subzone or variant, based on natural stand characteristics, and approved by the resource agencies. Silvicultural systems should then be developed to create these attributes in young stands. Until these attributes and silvicultural systems are developed, managers can use the following approximation for partial cutting: A stand can meet the mature seral criteria if, after partial cutting, the residual stand volume and stand attributes (see Appendix 5) are greater than 70% of the natural stand (all original diameter classes are represented in proportion to the average stand profile for the subzone and variant).

b This represents an average value over large geographic areas for each NDT. Consequently, forests can be found that are older than the mean event interval, as the age definition of old seral sometimes specifies.

Table 17. Recommended seral stage distribution for NDT4 (% of forest area within the landscape unit)

Biogeoclimatic unit	Seral stage								
	Early			Mature + old[a]			Old		
	L[b]	I[b]	H[b]	L	I	H	L	I	H
ICH	n/a	<30	<23	>17	>34	>51	>13	>13	>19
IDF	n/a	<30	<23	>17	>34	>51	>13	>13	>19
PP	n/a	<30	<23	>17	>34	>51	>13	>13	>19

[a] The minimum requirement for the old seral stage is included in the "Mature + old" category.

[b] L designates the lower biodiversity emphasis option; I designates the intermediate biodiversity emphasis option; H designates the higher biodiversity emphasis option.

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

Recommendation:

- Seral stages should occur in a variety of patch sizes within the landscape unit.

Temporal and spatial distribution of patch sizes (NDT4)

Permanent range

An objective to restore and maintain at least 85% of rangeland in each landscape unit in late seral or climax potential natural communities will ensure that appropriate grazing regimes are applied over time. These targets will not be immediately attainable in areas currently dominated by early seral communities.

Recommendations:

- On patches of range greater than 5 ha which are in early to mid-seral stages, livestock grazing should be managed for a recovery rate that is at least 75% of that which would occur if grazing were excluded altogether.
- On site series within a landscape unit where more than 15% of range is in early to mid-seral stages, livestock grazing should be managed for a recovery rate that is at least 75% of that which would occur if grazing were excluded altogether.
- Fire may be used as a tool to control brush and tree invasion, and so restore and maintain the natural temporal and spatial distribution of range ecosystems. In some areas where low-intensity fires have been suppressed, the resulting heavy fuel accumulations may dictate pre-burn thinning or other fuel modifications.

- Rehabilitation treatments such as under-burning should be considered on stands that have become denser and shifted to greater Douglas-fir dominance as a result of fire suppression and past forest harvesting practices. Grassland succession away from natural fire-climax ecosystems can be controlled by properly managed grazing used to prevent excessive plant litter build-up.

Temporal and spatial distribution of the cut and leave areas (NDT4)

Forests

Partial cutting, combined with occasional smaller dispersed clearcuts, will approximate the pattern of the natural landscape. Each seral stage should be represented by the distribution of patch sizes (harvest units and leave areas) as shown in Table 18.

Table 18. Recommended distribution of patch sizes (harvest units and leave areas)[a] for NDT4

Note: These values represent a vision of desired future conditions and will not necessarily be initially achievable in a watershed where forest operations are just beginning.

Patch size (ha)	% Forest area within landscape unit
<40	30–40
40–80	30–40
80–250	20–30

a Patch size refers to a single cutblock or an aggregation of cutblocks.

Recommendations:

- Patch sizes greater than 40 or 60 ha can be created by harvesting the entire larger patch at one time or by aggregating small cutblocks over time. In either case, structural attributes (i.e., live and dead trees) consistent with the natural disturbance type are to be retained within the patch. If smaller cutblocks are aggregated over time, the district manager may waive or reduce green-up requirements to accomplish this. When approved cutblocks exceeding 40 or 60 ha are advertised, and appear in the *Gazette*, the fact that they meet biodiversity retention objectives should be indicated.
- The size range of leave areas should be the same as that for openings.
- Practices for maintaining stand structure should be considered for all stands and applied as outlined in "Stand management to maintain biodiversity."

Old seral stage rangeland retention (NDT4)

Recommendations:

- Permanent range chosen to represent PNC climax should be in the potential natural climax community and have no recent history of heavy use. It should also possess a substantial component of shrubs, trees, and residual cover characteristic of the PNC. Where this component is not available, it should be provided in the future by appropriate range management activities.
- At least 12% of each type of permanent range ecosystem present in each landscape unit should be maintained in PNC climax.

Old seral stage forest retention and representativeness (NDT4)

The characteristics of old seral stage forests in this disturbance type are generally maintained by low-intensity fires. Ecosystems developing under fire suppression are generally atypical and not adequate substitutes for old seral stage, fire-maintained stands.

Recommendations:

- The total area that should be retained within the landscape unit in old seral stage condition is indicated in Table 17. Rare site series should be retained in this condition in greater proportion than is their occurrence in the landscape unit; other site series should generally be retained in proportion to their occurrence in the landscape unit. Where site series mapping is not available, a combination of forest cover and site productivity or site index information should be used to determine representativeness.
- The old seral stage retention objective should include patches designed to provide some forest interior conditions across a landscape unit. Where a lower biodiversity emphasis is chosen, the target for forest interior conditions may be as low as 25% of the old seral area indicated in Table 17. If an intermediate or higher biodiversity emphasis is chosen, the target should be 50% of the area indicated in Table 17. Objectives for obtaining forest interior conditions can sometimes be accomplished most efficiently by increasing old seral stage retention around wildlife habitat areas, riparian management areas, or other suitable areas. (For a description of forest interior, see Appendix 1.)
- Old seral retention objectives set in Table 17 sometimes cannot be met because of previous harvesting or natural disturbance history.
  - For a higher or intermediate biodiversity emphasis area, all the existing old seral forest should be retained, and additional areas designated to be left to become old seral forest and make up the shortfall in the future.

- For a lower biodiversity emphasis area, the economic and social consequences of halting the timber harvest of old seral forest may be politically unacceptable. If so, some additional harvesting of old seral stands may proceed, and the area equivalent to the shortfall in old seral area must be recruited over time, according to an approved long-term recruitment plan. The old seral retention objective must be in place by the end of three rotations. In this situation a much higher risk to biodiversity exists until the old seral requirements in Table 17 are in place.

Landscape connectivity (NDT4)

Wetland complexes and mature forests between them are important and interrelated functional units for biological diversity. In this disturbance type, mature forest and late seral or climax rangeland corridors and connections will maintain biological functions.

Before fire suppression and domestic grazing, much of the landscape and most of the grasslands in these ecosystems were likely in a fire-maintained late seral or climax state. At the same time, however, stand-initiating fires, intense use by large wildlife, and insect outbreaks probably ensured that some of the landscape was usually in earlier seral stages. Connectivity is assumed to have been high among most parts of the landscape in this disturbance type.

Connectivity can be maintained through the delineation of forest ecosystem networks (see "Designing forest ecosystem networks"). It can also be achieved at a broader scale within landscape units, according to the recommendations under "Temporal and spatial distribution of the cut and leave areas," above. The methods selected should depend on the connectivity objectives of the landscape unit.

Management to reduce fragmentation and maintain connectivity in managed forest landscapes should be guided by the type and degree of connectivity found in each disturbance type. Connectivity can be maintained by a combination of the following methods:

- maintenance of late successional forest linkages as part of forest ecosystem networks (see "Designing forest ecosystem networks"). These linkages should mimic the type and degree of connectivity found in each disturbance type.
- management of the forest matrix (the forest between the defined linkages) to maintain additional connectivity through the use of:
  - seral stage and patch size guidelines
  - stand remnants left during harvesting operations (such as small unharvested patches or advanced regeneration)

– stand management to maintain some of the structural attributes of older forests.

Forests

Recommendations:

- Mature forest riparian areas around individual wetlands, wetland complexes, and streams should form the basis for connectivity in this disturbance type.
- Connectivity should be maintained or provided for—especially in those areas identified as "high" in Table 19—using variable width linkages as part of forest ecosystem networks. Orientation of linkages should be both along valleys and across elevational gradients. The full spectrum of biogeoclimatic subzones and variants within a landscape unit should be represented.
- Tailor the application of seral stage, patch size, and stand structure recommendations to manage the area outside of defined linkages to meet the specific connectivity objectives of the landscape unit.

Table 19. The frequency with which connectivity characteristics of natural mature/old seral stage ecosystems occur for all biogeoclimatic subzones of NDT4

	Frequency of occurrence by biogeoclimatic unit	
Natural connectivity characteristics[a]	IDFdk	All other subzones
upland to upland	moderate–high	high
upland to stream	moderate–high	high
upland to wetland	moderate–high	high
cross-elevational	low	high
wetland complex	high	low–moderate
stream riparian	low	high
island remnants	moderate	low

[a] See glossary definition of "connectivity."

If an intermediate or higher biodiversity emphasis is chosen, the areas that are identified as old seral linkages may be incremental to the areas indicated in Table 17. If a lower biodiversity emphasis is chosen, linkages should not result in the areas of old seral stage exceeding the distribution objectives in Table 17.

Rangelands

Recommendations:

- Manage ecosystem connectivity within permanent range. The majority of range within each landscape unit should be maintained in late seral or climax condition, and the structural characteristics of the PNC should be maintained such as the presence, abundance, and size of shrubs and trees and the retention of residual cover where required by wildlife to use the landscape linkages.
- Where possible, riparian corridors and connections should be maintained between individual wetlands within rangelands.

Stand structure (NDT4)

Maintaining a variety of canopy layers and gaps between and within stands is important for biodiversity in this NDT.

Recommendations:

- Stand management activities should maintain the natural variety of canopy layers and gaps among and within stands across the landscape.
- Silvicultural systems that maintain multi-storied stands should be used in Ponderosa pine and Douglas-fir forests.
- Some mature Douglas-fir trees should be maintained in mixed Douglas-fir and lodgepole pine stands.
- Some mature Ponderosa pine should be maintained in stands where it occurs.
- Even-aged silvicultural systems with wildlife tree patches are most appropriate for even-aged lodgepole pine stands. Note, however, that these wildlife tree patches should not be additive to those recommended in "Stand management to maintain biodiversity."
- Practices for maintaining the multi-storied stand structure of this disturbance type should be considered for all stands and applied as outlined in "Stand management to maintain biodiversity."
- Permanent range in late-seral to PNC-climax should be managed to maintain a component of the shrubs, trees, and residual cover that would occur in the corresponding PNC.

Species composition (NDT4)

Natural forest succession provides for a mosaic of different successional stages in this NDT. Species composition within these successional stages varies from early seral communities to climax communities for both forests and grasslands. Maintaining that variety of species composition within seral stages is an important component of maintaining biodiversity.

Rare ecosystems within the landscape unit also contribute significantly to the richness of species composition and to the maintenance of diversity.

The section "Stand management to maintain biodiversity" recommends stand level practices for maintaining species composition.

Recommendations:

- A significant component of the landscape unit should be maintained in communities with plant species composition similar to that in communities that have developed through natural succession.
- Extensive conversion from climax to young seral species, or from young seral to climax or non-native species, should be avoided.
- Rare forest stand types within the landscape unit (that is, those accounting for less than 2% of the area, such as birch, cottonwood, aspen, alder, and maple) should be maintained over the rotation.
- The proportion and distribution of the deciduous broadleaf components of stands should be maintained within the range found in unmanaged stands in the landscape unit.
- At least 75% of the permanent range within each landscape unit should be restored or maintained in late seral and climax PNC, with no more than 10% in early seral condition.

Natural disturbance type 5: alpine tundra and subalpine parkland

The ecosystems in this natural disturbance type occur above or immediately below the alpine treeline, and are characterized by short, harsh growing seasons. The vegetation is strongly patterned by variations in local topography. Fire can have a dramatic effect in this disturbance type, weakening or killing plants and causing long-term shifts in the position of the tree line. The harsh climate and short growing season restrict the rate of plant growth that can take place following a stand-initiating disturbance.

Windward slopes and exposed ridge crests remain free of snow for extensive periods during the winter. They also tend to be dry during the growing season and have low fertility, which limits plant growth. These dry conditions favour a high proportion of deep-rooted cushion and rosette plants. Snow often forms deep drifts on lee slopes, remaining there well into the growing season. This limits vegetation growth, but because moisture is less of a limiting factor, forbs, bunchgrasses and dwarf evergreens generally dominate the vegetation. Level areas and depressions, often collecting meltwater, are free of late-lying snow and less prone to desiccation. These areas tend to support the most productive vegetation, dominated by sedges, grasses, forbs, and lush forbs, often along with deciduous shrubs. Because parkland variants at the upper limit of the ESSF and MH biogeoclimatic zones often have extensive areas of unforested vegetation similar to that in plant communities within the AT, they are included in this disturbance type.

Grazing by wildlife and non-native species drives ecosystem change in many areas within NDT5. The most noteworthy large grazers include bighorn sheep, mule deer, elk, moose, and cattle. Mountain sheep often calve and winter on exposed slopes and favour more productive sites for summer range. Mule deer, elk, and moose generally make lighter use of the disturbance type, primarily for summer range. Cattle are often grazed here in late summer.

Given the short, harsh growing season and generally infertile soils of this disturbance type, vegetation can be rapidly altered by grazing animals. Plants with large reserves of nutrients and energy below ground may leaf out quickly after being grazed, but it may take years to replenish their root reserves. Repeated grazing, or a mixture of grazing and other stresses, can therefore exhaust plant reserves and cause plants to die out several years after the onset of intensified grazing. Species with small reserves may die out quickly in response to increased grazing pressure. Late-season grazing generally has the least effect on plant reserves, but because many species form their flower buds in the season before flowering, it may have a negative effect on seed production.

Trampling by large herbivores can also greatly affect some ecosystems. Sites that remain waterlogged well into the growing season are susceptible to trampling damage during early-season grazing; dry sites are susceptible to such damage during fall grazing, after the first snows have moistened soils. Some areas used to graze domestic sheep still show substantial impacts decades after sheep use was discontinued.

Biogeoclimatic units in NDT5

The following biogeoclimatic subzones and variants make up this disturbance type:

ESSFdcp1	ESSFmvp4	MHmmp1
ESSFdcp2	ESSFmwp	MHmmp2
ESSFdkp	ESSFvcp	MHwhp1
ESSFdvp	ESSFvvp	MHwhp2
ESSFmcp	ESSFwcp2	
ESSFmkp	ESSFwcp3	
ESSFmmp1	ESSFwcp4	AT
ESSFmmp2	ESSFwmp	
ESSFmvp1	ESSFwvp	
ESSFmvp2	ESSFxcp	
ESSFmvp3	ESSFxvp	

Seral stage distribution (potential natural community) (NDT5)

Despite fires, landslides, and wildlife grazing, the vast majority of areas within this NDT were climax communities prior to early settlement.

Recommendations:

- Livestock should be managed such that no more than 15% of the landscape is maintained in early to mid-seral condition.
- Range tenure plans for areas within this disturbance type should identify standards for determining seral stage and trend, and specify stocking rates and range readiness indicators that can be used to meet seral stage distribution criteria. Until this can be accomplished, livestock grazing in this disturbance type should only take place after the majority of flowering has occurred.

Temporal and spatial distribution of the cut and leave areas (NDT5)

Recommendation:

- Livestock grazing should be managed in a manner that limits patches in early to mid-seral condition to no greater than 5 ha.

Old-seral stage retention and representativeness (NDT5)

Recommendation:

- To retain old seral stages, 85% of each ecosystem in this disturbance type should be maintained in late seral or climax condition. This late seral/climax component should be well dispersed throughout the landscape unit, across the range of ecosystem types that occur in the biogeoclimatic subzone variant.

Landscape connectivity (NDT5)

Ecosystems in this disturbance type continue to exist as contiguous tracts of late seral to climax vegetation. Major stand-initiating events are still infrequent. Livestock grazing can reduce large portions to early or mid-seral states, but most areas within this type are not currently used to support livestock.

Recommendations:

- No new areas should be approved for livestock grazing unless adequate measures of range condition and trend are established for the ecosystems present, and the impacts of the proposed livestock use are consistent with the biodiversity objectives for this NDT. If livestock use is very low and transitory, range condition and trend measures are not necessary.
- No new areas should be approved for livestock grazing unless approval is obtained from the Ministry of Environment, Lands and Parks.

The characteristics of natural mature/old-growth ecosystem connectivity described in other disturbance types do not apply to this disturbance type.

Stand structure (NDT5)

Recommendation:

- Livestock grazing should be managed in a manner that does not lead to extensive trail creation or browse damage to shrubs and trees.

Designing forest ecosystem networks

This section provides planners with direction in designing landscape units that meet old-growth and connectivity objectives while minimizing negative impacts on timber and range resource values. The recommended long-term landscape management approach is that of creating forest ecosystem networks (FENs) within the landscape units.

A FEN is a contiguous network of representative old-growth and mature forests (some of which provide forest interior habitat conditions) delineated in a managed landscape. Not only does a FEN aim to meet the needs of native species and ecological processes, it also serves to maintain or restore the natural connectivity within a landscape unit.

FENs are composed of a variety of protected areas, as well as classified areas (such as riparian management areas and wildlife habitat areas), any other areas that have been designated as sensitive, high visual quality areas, and areas of unstable terrain or other conditions that make them inoperable.

Most landscapes already contain significant areas within which timber harvesting is constrained. FENs should therefore be designed to take advantage of these areas, using them to form the network "building blocks." This approach makes efficient use of the land base by allowing existing areas with harvesting constraints to serve the dual purpose of protecting a particular resource value while also contributing to the overall structure and composition of the FEN.

In mountain and valley ecosystems with wet climates, where contiguous old-growth forest was a dominant component of the natural landscapes, the delineation of FENs is especially important. However, FENs may also be used in other ecosystems to link important habitats such as wetlands. At the same time, not all components need to be connected and, overall, the need for connectivity varies among disturbance types.

Forest ecosystem networks provide the following benefits:

- They reduce the impact on landscape units of habitat fragmentation and old-growth conversion.
- They represent the full range of ecosystems in the landscape unit.
- They provide some forest interior habitat within each landscape unit.
- They provide wildlife species with areas of refuge during periods of disturbance on nearby sites, as well as acting as centers and corridors of dispersal for the re-colonization of historic ranges by certain species.
- They provide a continuum of relatively undisturbed habitat for indigenous species that depend on mature and old-growth forests.
- They provide daily and seasonal movement corridors for certain species.

Several general considerations in FEN design are:

- Some components of a FEN should be permanent reserves (for example, unstable slopes); others should be sensitive areas that retain important stand attributes (for example, riparian management areas).
- Riparian habitats (found adjacent to streams, rivers, lakes, and wetlands) provide many of the features necessary to maintain biodiversity at the landscape level. In many instances these should form the focal point in FEN delineation. Their linear nature provides species with movement opportunities between ranges at different altitudes, and their diverse vegetation provides species with the structural and functional attributes they need to be sustained. Nevertheless, while riparian areas are important to most species, FENs should not be composed entirely of riparian habitats.
- Where areas previously constrained (such as wildlife habitat areas, riparian management areas, areas with visual quality objectives) are used to meet old seral requirements, they will henceforth be managed as old-growth management areas.
- It is important that all ecosystems in a landscape unit be represented in the FEN designed for that unit. This means that upland habitats such as those on south aspect slopes and ridge tops, as well as habitats on cooler and moister northerly aspects, should be considered.
- A key component of FENs is, as the name implies, the requirement for important habitat features to be connected in a manner that forms a comprehensive landscape network. Ideally, this connectivity should be dominated by old-growth or mature timber and should be established to incorporate natural terrain features such as gullies and ridges. As shown in

each of the five disturbance type summaries, the characteristics of natural connectivity vary by NDT (see "Landscape connectivity" under each disturbance type summary).

- In designing FENs for any one landscape unit, planners should remember to consider the habitat conditions and management plans in adjacent landscape units, as these may affect issues of connectivity and age class distribution in the unit being designed (see Appendix 2).

Figures 6 and 7 illustrate how a landscape unit incorporating FENs, might be managed to maintain biodiversity.

Principal steps in designing a FEN

1. Identify and map representative and rare old-growth stands:
    - Establish a list of representative and rare ecosystems using site series or other mappable surrogates such as forest cover and soils/terrain maps.
    - Map the location and extent of rare and representative ecosystems.
    - Assess which forested habitats are of sufficient size to provide forest interior stand conditions.
2. Identify and map the forest areas that will not be harvested. Determine the extent to which they can meet old-growth retention objectives for rare and representative ecosystems.
    - A. Existing protected areas
    - B. Ecological reserves and wilderness areas
    - C. Areas subject to harvesting constraints:
        - riparian management areas
        - lake shore management areas
        - wildlife habitat areas
        - terrain sensitive areas
        - recreation areas
        - visually sensitive areas.
    - D. Inoperable areas
    - E. Areas that provide habitat for threatened or endangered species (contact the Conservation Data Centre for information)
3. Assess the complex of areas identified above and list representative and rare ecosystems not protected as potential old-growth management areas.

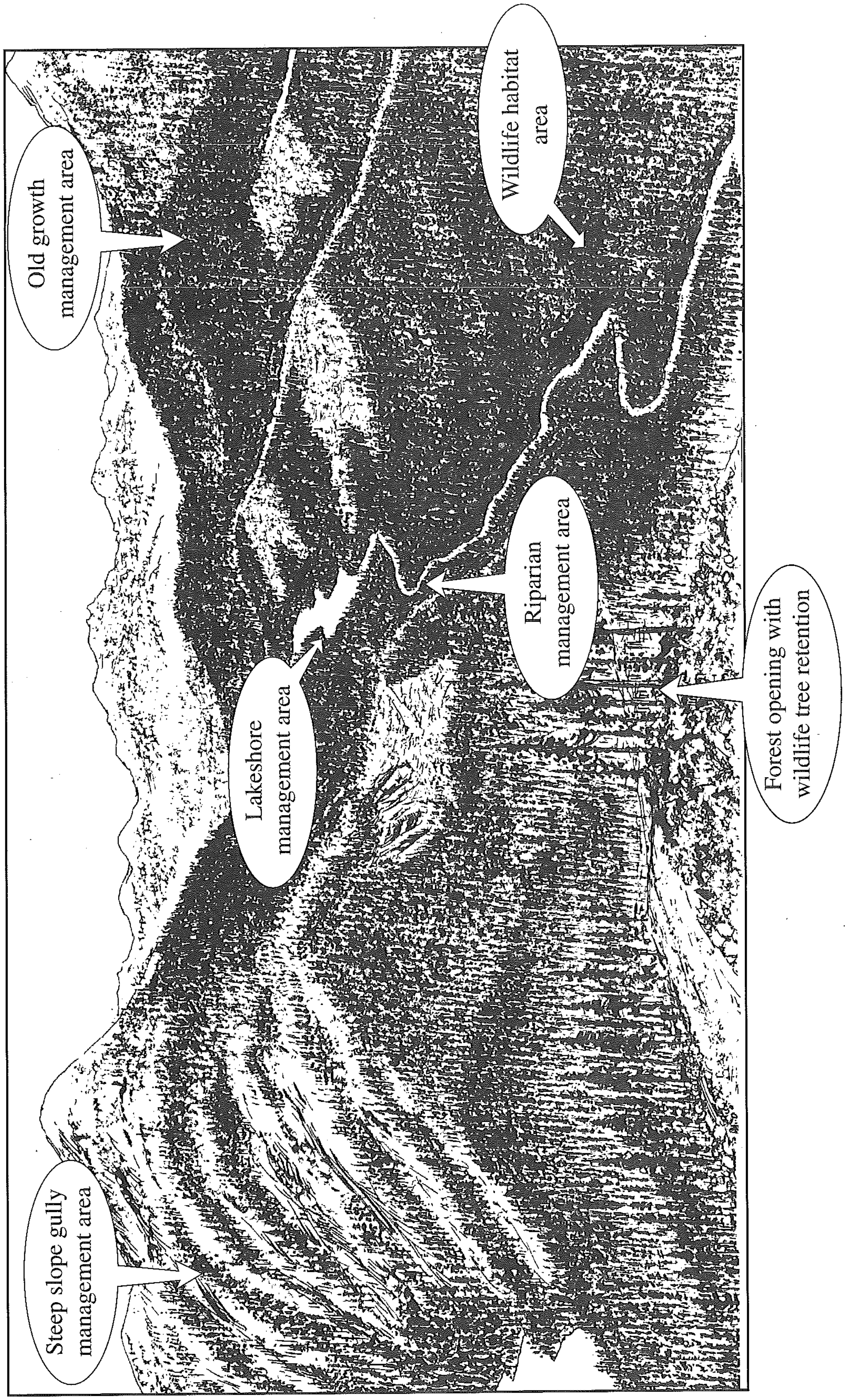


Figure 6. A landscape managed to maintain biodiversity.

Figure 7. A portion of the landscape managed to maintain biodiversity.

4. Where old-growth retention or representativeness objectives have not been achieved, create old-growth management areas (OGMAs) between the mapped areas.
   - Ensure that OGMAs are composed mainly of old-growth or mature forest. Use existing forests as models when considering the appropriate appearances of OGMAs.
   - Where second-growth forests must be used, consider applying silvicultural interventions to develop and enhance mature forest attributes (see Appendix 5). The objective is to provide these attributes in levels that meet the natural levels found on similar sites. Site productivity may be a factor influencing the ability of a stand to provide and sustain mature and old-growth attributes more quickly.
   - Distribute OGMAs among the low-, mid-, and high-elevation areas within each landscape.
   - Narrow OGMAs (less than 600 m) may include small linear landscape features such as gullies, ridges, or streams. Wide OGMAs (greater than 600 m) will provide forest interior conditions. Consider delineating wide OGMAs if such conditions are otherwise absent from the FEN.
   - Consider using riparian areas for a portion of an OGMA.
   - If there are relatively small gaps between mapped areas within a FEN, fill these in with OGMAs to aggregate the gaps into larger units.
   - Recognize that not all areas of harvesting constraint need to be linked.
5. Assess whether connectivity objectives have been achieved. If connectivity objectives were not achieved through retention or representation, use mature and old-growth forest in OGMAs to link stands.
6. Review the resultant FEN with respect to the biodiversity objectives for the landscape unit and check that, within the FEN:
   - all old-growth ecosystems, as represented by site series or a surrogate, are represented at the minimum level specified in the appropriate seral stage tables in the section on "Establishing landscape unit biodiversity objectives"
   - rare ecosystems are over-represented
   - forest interior condition requirements are met
   - connectivity needs are met.

Old-growth management areas

- OGMAs are intended to capture old growth within landscape units to meet retention objectives.
- Timber harvesting and silvicultural practices within an OGMA should be consistent with management objectives for the OGMA.
- OGMAs can be harvested when equivalent old seral stage areas are available.
- Replacement OGMAs can be brought on stream earlier than would naturally occur through silvicultural interventions designed to promote the key attributes, or through the retention of these attributes during harvesting.

Management within FENs

Recommendations:

- Roads through protected areas, wildlife habitat areas, and sensitive areas within FENs should be avoided.
- The number, length and width of rights-of-way for roads through FENs should be minimized.
- Prompt and appropriate steps should be taken to deactivate roads no longer in use in FENs.
- Where mature and old seral areas (but not areas designated as OGMAs) are identified to meet connectivity objectives, and provided the connectivity objectives can be maintained, some harvesting can occur within these linkage areas as long as the mature stand attributes are maintained (see Appendix 5).
- When natural disturbances such as wildfire, windthrow, or insect outbreak occur within, or threaten to enter, a FEN, the appropriate management action should be based on an evaluation of the disturbance's effect on the functioning of the FEN. Conversely, when a natural disturbance threatens to affect areas outside the FEN, the appropriate management action should be based on an evaluation of the impact on the adjacent commercial forest or leave areas.
- Where natural disturbances have affected a FEN, management actions such as salvage logging and site rehabilitation must be evaluated (to determine, for example, the value of the FEN and the value of the damaged timber) to ensure that such decisions do not compromise the integrity of the FEN, adjacent commercial forests, leave areas, or other forest values.

Stand management to maintain biodiversity

This chapter describes how specific objectives for maintaining stand structure, tree and vegetation species composition, and coarse woody debris can be determined.

A fundamental premise for maintaining biological diversity is to implement strategies at both the landscape and stand scales. There is a linkage between how much retention of stand structure is required at the stand scale and how much should be retained at the landscape scale. When landscape units have been designated and landscape level biodiversity objectives have been established then the requirement for maintaining biodiversity in individual stands can be reduced and the appropriate retention levels determined from Table 20(a). As a result, the development of landscape unit objectives will allow for greater flexibility at the stand level. When no landscape unit biodiversity objectives have been established, then appropriate retention levels should be determined from Table 20(b).

The recommendations in this chapter should be applied in the preparation of:

- forest development plans
- silviculture prescriptions and stand management prescriptions
- logging plans, fire management plans, and range use plans.

Objectives for wildlife trees and coarse woody debris must be included in the contents of a Forest Development Plan (OPR 15 (7) (b)). A Forest Development Plan (OPR 15 (2)) and a silviculture prescription (OPR 39 (2) (w)) must contain a reasonable assessment of non-timber resource values known to be on or adjacent to the plan area and must describe the actions to be taken to accommodate those values.

Stand level practices in this chapter are the recommended minimum requirements needed to meet the structural characteristics of natural openings (OPR 21(3)(b)).

When wildlife tree patches (group reserves) are larger than 2 ha (a patch that is isolated within the cutblock boundary and not included within the net area to be restocked) and also meet the age and structural requirements of old seral forest (see "Establishing landscape unit biodiversity objectives") then these larger, within-block patches can contribute to old-seral stage forest requirements within the landscape unit and be used in landscape level retention calculations (OPR 39 (3)(d)). A wildlife tree patch is synonymous with a group reserve in silvicultural terminology.

Given the high degree of ecological variability in our forests, managers need to consider biological diversity on a site-specific basis in order to most effectively apply the recommendations presented in this chapter. This variation may require exceeding the minimum retention requirements recommended in this guidebook.

The recommendations for maintaining biodiversity are an important component of ecosystem health and will have to be integrated with other objectives for forest health.

Maintaining stand structure

Stand level recommendations are designed to maintain or restore, in managed stands, important structural attributes such as wildlife trees (including standing dead and dying trees), coarse woody debris, tree species diversity, and understorey vegetation diversity. Appendix 5 discusses in more detail the importance of these structural attributes to the maintenance of biodiversity. The *Stand Level Biodiversity Course for Forest Workers and Stand Level Biodiversity Course for Forest Managers* offer a more in-depth approach to stand level biodiversity management. The *Wildlife/Danger Tree Assessor's Course Workbook* contains single stem safety assessment procedures.

Safe work practices

Safe work practices, as established in conjunction with Workers' Compensation Board, must be followed at all times when implementing the recommendations in this guidebook. Forest workers should have freedom to remove obstacles whenever necessary to maintain a safe working environment. Trees that are marked to leave or are outside the cutblock boundaries can be felled for safety reasons, but should be left on the ground as future coarse woody debris. This will retain the benefit these trees can have on site and remove any incentives for felling and harvesting.

Wildlife trees

A wildlife tree is any standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife. These trees have characteristics such as large size (diameter and height) for site, condition, age, and decay stage; evidence of use; valuable species types; and relative scarcity. They serve as critical habitat (for denning, shelter, roosting, and foraging) for a wide variety of organisms such as vertebrates, insects, mosses, and lichens.

Maintaining wildlife trees within harvest and silviculture units can be ecologically beneficial in a number of ways. While standing, they provide habitat for many species (birds, bats, and other small mammals) that perform roles in maintaining ecosystem functions. Standing green trees can provide for future wildlife tree recruits. Wildlife trees will, over time, become sources of coarse woody debris and finally, through decay and nutrient cycling, become incorporated into second-growth forests.

Wildlife tree management strategies can range from the retention of existing wildlife trees, as scattered individuals or in patches, to the creation of new wildlife trees. Many approaches can be applied within a single cutblock, though retention of patches is recommended as the priority approach in most cases. Wildlife tree requirements apply to the use of all silvicultural systems.

Wildlife trees patches (group reserves) and individual live tree retention

Wildlife tree patches (WTP) provide several advantages over other retention strategies. Snags or other potentially dangerous trees are more easily retained in patches than as individual trees and operational inconvenience is minimized. There is also evidence that clumps of trees provide better habitat for birds than do scattered individual trees, as well as an area of relatively undisturbed forest floor within cutblocks. However where scattered individual wildlife trees already exist they should be retained.

Wildlife tree patches should be well distributed across the landscape. The maximum distance between WTPs (500 m) has been based on territory size and dispersal requirements of wildlife.

Recommendations:

Area and distribution of patches or individual trees:

- The retention of wildlife trees should be based on the pre-activity assessment of the wildlife tree values and requirements on or adjacent to the proposed cutblock; and on the described actions that are required to accommodate these values.
- The amount of retention to be applied should be determined from Table 20(a). It is based on the proportion of each biogeoclimatic subzone in the landscape unit that is operable, and the degree of development that has occurred before the recommendations presented here are applied. The higher the proportion of operable area in a landscape or the more that previous development has reduced wildlife tree abundance, the greater the amount of retention required.
- Where landscape unit objectives have not been established, the application of Table 20(b) should be based on an interim landscape unit or a portion of a forest development plan that forms a contiguous geographic unit. In these cases, given the absence of landscape objectives for biodiversity, the percentages for wildlife tree patch retention in Table 20(b) are 3% higher than in Table 20(a).

- Suitable areas outside the cutblock, such as riparian management areas, can contribute to the required retention provided the inter-patch spacing requirements are met, and they are mapped and designated as wildlife tree patches in the forest development plan. It is assumed that up to 75% of wildlife tree patch area requirements on the coast, and up to 50% in the interior, will be met in riparian management areas and other constrained areas.

- Good candidates for retention: individual live wildlife trees that provide special wildlife habitat value (such as nest trees); veterans; and other large trees. Patches of deciduous or unmerchantable trees provide opportunities to accomplish this objective. Defective trees of the largest size are often most valuable. These large, live, unhealthy trees (Class 2 trees that are well branched) are important as future habitat since they provide recruitment wildlife trees over time (see Appendix 6 "Classes of wildlife trees").
- Wildlife tree patches can range in size from individual trees to patches of several hectares. Individual trees, outside patches, can contribute to the required retention area on a basal area equivalency basis. However, simple stem basal area does not equate to patch area. For example, a 1 ha patch containing trees, shrubs, rocky or wet sites, and other ground level diversity is not ecologically equivalent to "x" number of single green stems (such as seed trees) distributed around a harvest block. Therefore, the use of individual trees to contribute to required retention area targets must be planned and selected carefully on a site-specific basis.
- Single green trees chosen for retention should exhibit some characteristics of a valuable recruitment wildlife tree (such as being large and well branched). In order to optimize their habitat value within the harvest block, these trees should be located, wherever possible, near areas that already contain some structural elements of stand level diversity (for example, near a riparian area, rocky outcrop, gully, hardwood patch, or meadow opening). Single live trees left near a shallow gully running across a cutblock are more valuable ecologically than those same green trees distributed randomly throughout the block.
- Wildlife tree patches should be mapped and recorded as part of the documentation of the silvicultural or stand management prescription for the cutblock and be removed from the net area to be restocked.
- No timber harvesting is permitted in designated wildlife tree patches.
- The importance of wildlife tree patches within cutblocks increases with the size of the cutblock. Patches should generally be centered around the most suitable trees and distributed throughout the cutblock, with distances between patches (or other suitable leave areas outside the block) not to exceed 500 m.

- Patches should be located in a way that minimizes windthrow risk. Advantage can also be made of locating patches along small streams, wet areas, gullies or other locations that are likely to pose harvesting, yarding or regeneration problems (Figure 10).
- When partial cutting silvicultural systems are used, sufficient leave trees should be retained throughout the rotation, to meet retention objectives.
- Wildlife trees must be retained at least until other suitable trees can offer equivalent replacement habitat and structural diversity. In most cases this will take at least one rotation.

Patch and live tree retention characteristics:

- A range of tree diameters should be included within patches, favouring larger stems when possible. Care should be taken to include the upper 10% of the diameter distribution of the stand (taken from cruise data), because these are the most valuable wildlife trees.
- Both live and dead trees (subject to safety requirements) should be included in patches representing a range of wildlife tree classes (Appendix 7).
- A variety of tree species, including deciduous, should be represented.
- When possible, trees showing wildlife use or presence of heart rot, and those with a large size and well-branched structure should be retained.

Management principles for wildlife trees

- Wildlife tree management includes both the retention of suitable wildlife trees at the time of harvest and during silvicultural activities, and the provision for recruitment of suitable replacement wildlife trees over the rotation period.
- Generally, the most operationally feasible and biologically advantageous method for retaining wildlife trees is to leave patches of live and dead trees as no work zones and to exclude these from the net area to be reforested.
- The amount of wildlife tree area required for a specific cutblock depends on the level and distribution of existing and planned harvesting in the surrounding landscape (see Table 20(a) and (b)).

Table 20(a). Percentage of a cutblock area required as wildlife tree patches when landscape units have been designated and landscape level biodiversity objectives have been established

% of the area available for harvesting in a landscape unit that has already been harvested without recommended wildlife tree retention	% of the biogeoclimatic subzone within the landscape unit available for harvest				
	90	70	50	30	10
10	7	5	3	1	0
30	9	7	5	3	1
50	11	9	7	5	3
70	13	11	9	7	5
90	15	13	11	9	7

Note: The table axes refer to the area of the landscape unit.

Table 20(b). Percentage of a cutblock area required as wildlife tree patches when landscape units have not been designated

% of the area[a] available for harvesting that has already been harvested without recommended wildlife tree retention	% of the biogeoclimatic subzone within the landscape unit available for harvest				
	90	70	50	30	10
10	10	8	6	4	3
30	12	10	8	6	4
50	14	12	10	8	6
70	16	14	12	10	8
90	18	16	14	12	10

a Since no landscape unit objectives have been established, the area refers to the area of an interim landscape unit or a portion of a forest development plan that forms a contiguous geographic unit.

Application of table 20(a) and (b)

This is a one-time calculation for each biogeoclimatic subzone within the landscape unit (or interim landscape unit or portion of a forest development plan forming a contiguous geographic unit) unless the landscape unit objectives change, a new landscape unit is designated, or operability limits change (changing the area available for harvest). A separate prescription is made for each subzone within the landscape.

X-axis numbers (columns) are the proportion of the subzone within the landscape unit (or interim landscape unit or portion of a forest development plan forming a contiguous geographic unit) that is identified as available for harvest (that is, not inoperable or in some sort of reserve status, such as riparian or protected area). Y-axis numbers (rows) are the proportion of the available landscape (above) that has already been harvested without application of this guidebook's recommendations or similar prescriptions.

Example:

For each biogeoclimatic subzone in the landscape unit (Table 20(a)), calculate the area available for harvest (the X-axis). For example, if 30% of the SBSmc area is available for harvest, then, using the 30% column, the recommended minimum proportion of each cutblock to be managed for wildlife trees is between 1 and 9%. If 50% of the available area has already been harvested without application of these or similar guidelines (Y-axis), then 5% of each new cutblock would need to be left for wildlife tree patches. This can be distributed adjacent to cutblocks in riparian or other long-term leave areas when feasible. Where landscape units have not been designated, the same calculation can be done using Table 20(b).

Examples of how to apply this process to a proposed cutblock are shown in Figures 8 to 10.

Creating wildlife trees

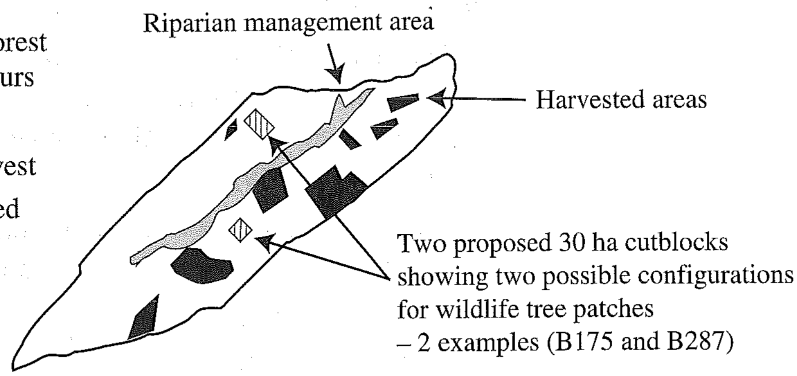
One method of creating wildlife trees is to high-cut stumps during the use of feller bunchers. This creates standing dead trees called "stubs" (see Figure 11). These provide structure within second-growth forests and create future coarse woody debris. They cannot, however, replace all attributes associated with full height wildlife trees and thus can not be used as a complete substitute.

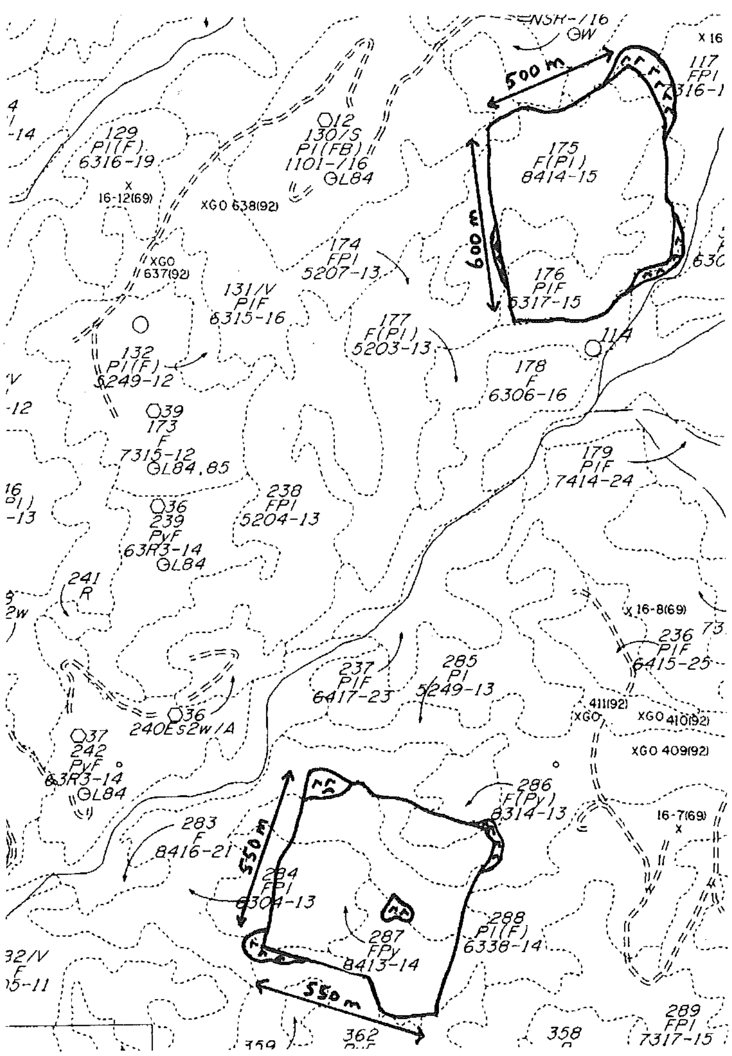
Recommendations:

- If mechanical harvesters are being used, snags and cull trees that must be felled should be left as high as can be reached safely. For dead trees, the maximum allowable height must be according to Workers' Compensation Board regulations.
- Stems suitable for stub creation should have some visible defect (such as canker, scar or conk) in the lower bole and little or no lean.
- Creation of wildlife trees by topping, blasting, and other methods should also be considered.

Landscape unit (e.g., IDFdm subzone) if established, or a part of the area under the forest development plan in which the cutblock occurs (e.g., portion of a drainage).

- 70% of planning unit available for harvest
- 50% of planning unit has been harvested without consideration for these recommendations





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No WTPs required within this block since the distance between WTPs or adjacent suitable habitat** does not exceed 500 m. Any new harvesting adjacent to this block must incorporate the required leave area (12% as determined from Table 20(b) as WTPs within their boundaries. This is necessary in order to fulfill the 500 m criterion for maximum distance between WTPs.

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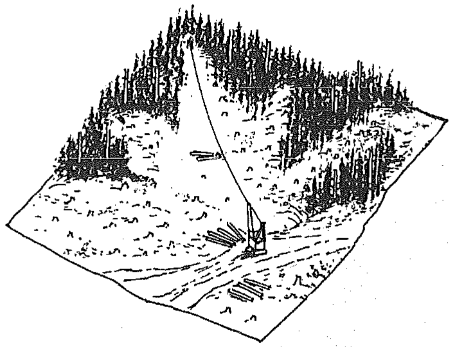
This block configuration requires WTPs within its boundaries in order to fulfill the 500 m criterion for maximum distance between WTPs or adjacent suitable habitat.** Four WTPs totalling 3.6 ha or 12% of cutblock area are planned (see Table 20(b) for calculation of percent area).

** Suitable habitat must contain the desired structural characteristics for wildlife tree patches as described in the section "Wildlife trees".

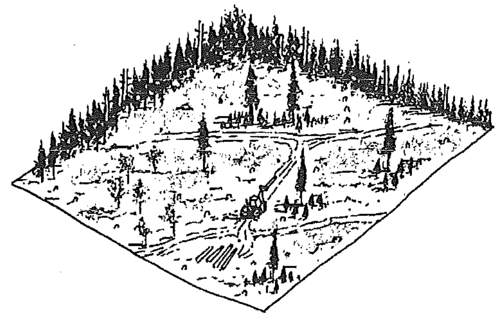
Legend: Scale 1:20 000

- adjacent suitable wildlife tree habitat or WTP
- creek
- forest cover polygon
- trail
- logging road

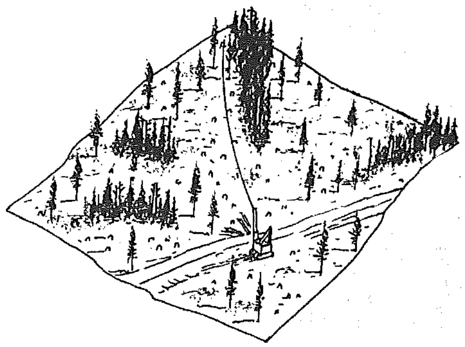
Figure 8. Applying wildlife tree management recommendations to a proposed cutblock.



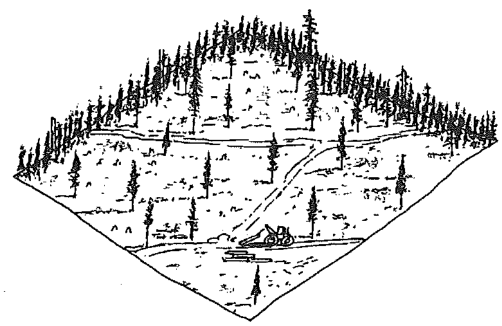
Clearcut with group reserve



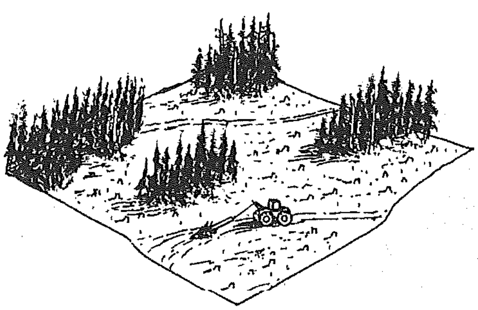
Clearcut with individual tree reserves
(some wildlife trees retained along back boundary)



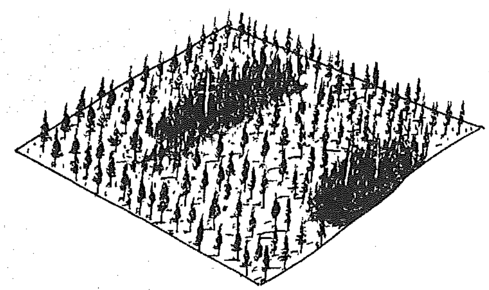
Uniform seed tree with group reserves



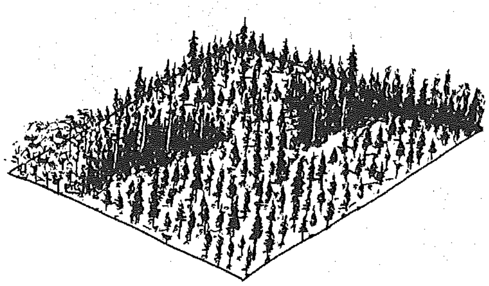
Uniform seed tree with individual wildlife tree reserves



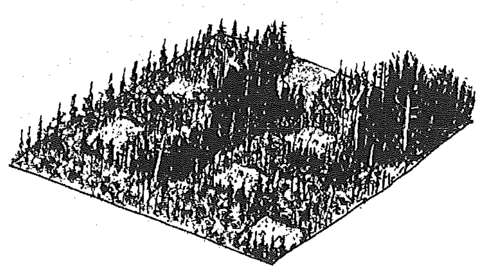
Group seed tree



Uniform shelterwood with group reserves



Single tree selection with group reserve



Group selection with group reserve

Figure 9. Reserves for wildlife trees incorporated into four silvicultural systems.

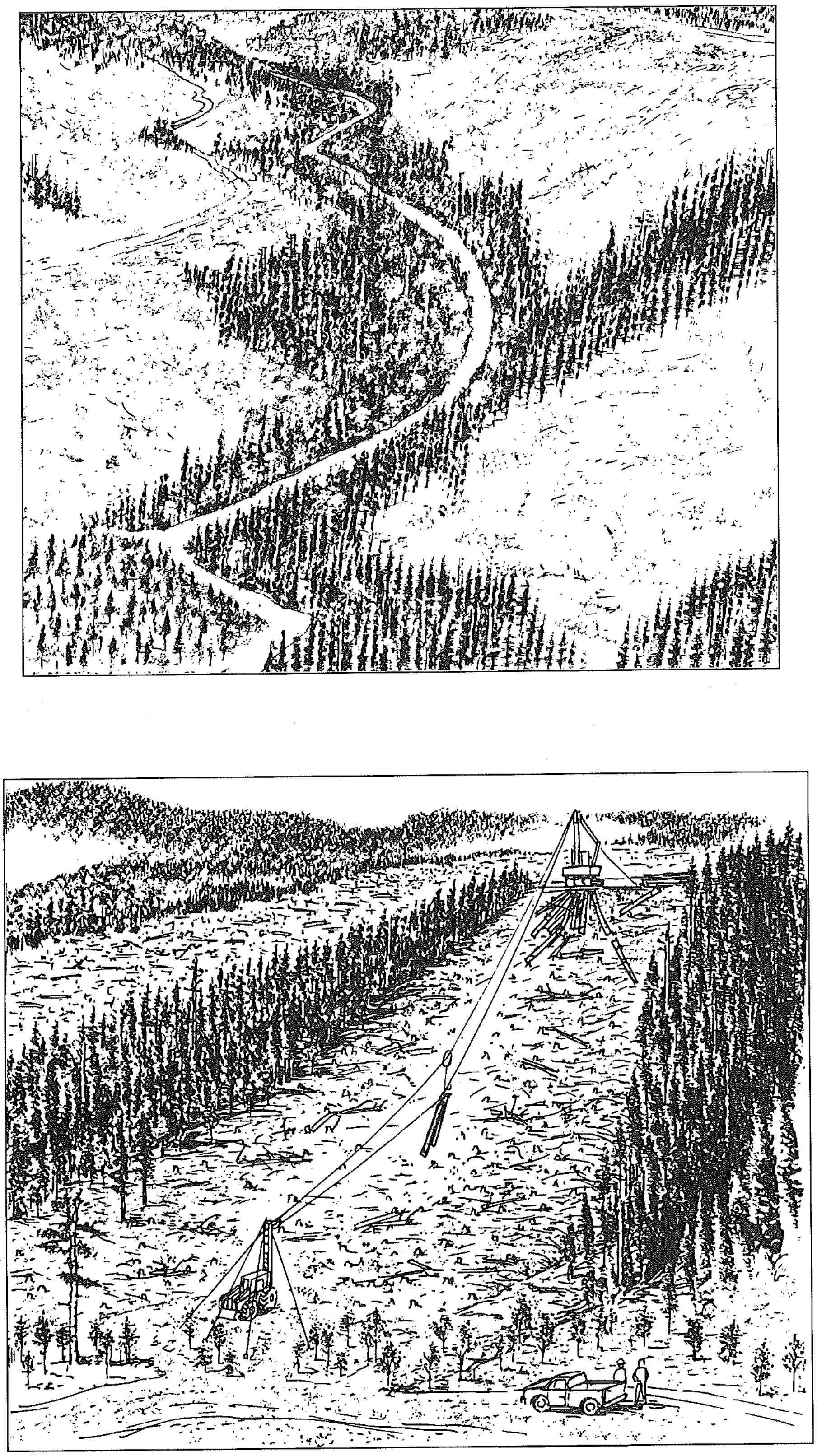


Figure 10. Harvesting areas with wildlife trees maintained in a riparian management area and a gully complex.

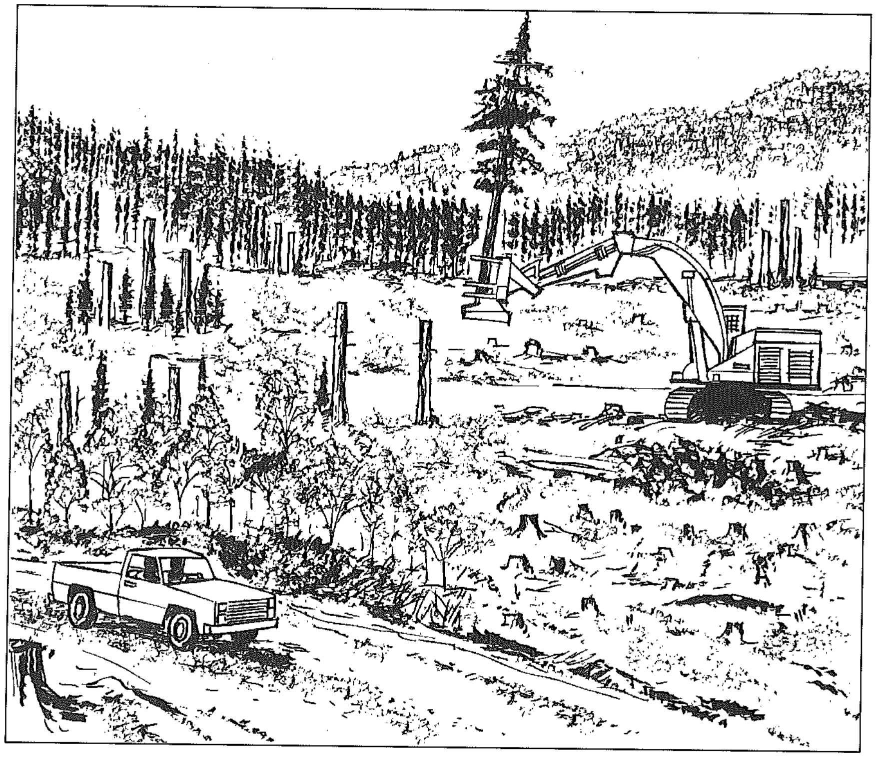


Figure 11. Artificially created wildlife trees (stubs).

Other stand structure recommendations

Any action that encourages structural diversity within managed stands can have value to biodiversity.

Recommendations:

- Some vertical and structural variability should be maintained throughout stands or rangelands. Within larger stands, this can be achieved by the use of variable stocking densities at planting, in combination with spacing or thinning activities. In rangelands, components of shrub communities should be retained.
- In vegetation management or thinning treatments, patches or strips can be left unthinned on some sites so that dense patches develop.
- Wider spacing of patches can be used to maintain a partially open canopy that will promote understorey vegetation.
- Non-merchantable defect trees should be left as recruitment snags rather than removed.
- Patches of advance regeneration can provide structural diversity.

- Range management should be designed to maintain a component of shrubs within rangelands, based on the shrub component found in undisturbed rangelands.
- Forest encroachment on rangelands can be reduced through management practices such as prescribed fires.
- During tree pest and disease treatments, some areas should be left untreated.
- Openings should be irregularly shaped to most closely reflect natural disturbance patterns.

Maintaining tree and vegetation species composition

The maintenance of the diversity of naturally occurring plant species is key to the maintenance of biological diversity within landscape units. Within cutblocks, several actions can help maintain that diversity.

Recommendations:

- The variety of native understorey plants and plant communities should be maintained across the landscape units.
- Vegetation management treatments can be designed to create variability among or within treatment areas. Effects on non-target plants should be minimized.
- A component of the deciduous species, both immature and mature, should remain after harvesting, spacing, vegetation management, and site preparation activities.
- Extensive conversion from climax to young seral species (such as Douglas-fir to lodgepole pine) or from young seral to climax should be avoided.
- Where suited to the site, stands should be regenerated with a mixture of tree species (natural and planted) rather than with a single species.
- Where mature hardwoods form a minor component of the stand (<20%), greater emphasis should be placed on maintaining these either singly or in clumps.
- Minor tree species such as yew, birch, alder, aspen and cottonwood should be maintained.

Maintaining coarse woody debris

Maintaining coarse woody debris after harvesting is a critical element of managing for biodiversity. However, it is recognized that this requirement conflicts with existing utilization standards. Work is under way to resolve this policy conflict. Until this issue is resolved, utilization standards will take precedence over requirements for coarse woody debris.

Despite this policy conflict, some existing practices can be modified to help address the requirements for coarse woody debris. For example, preliminary indications are that post-logging residue and waste can meet the volume requirements for coarse woody debris if it is well distributed across the entire stand. This will not be the case in situations of whole-tree harvesting, clean site preparation practices, or excessive salvage of material not considered merchantable under current utilization standards.

For the purposes of Operational Planning Regulation 38 (2) (W), a reasonable assessment of coarse woody debris should follow the standardized method outlined in the Resource Inventory Committee Vegetation Inventory Procedures Manual.

Recommendations:

- Modify whole-tree harvesting by limbing and topping on site.
- Maintain residue and waste well-distributed across the stand (avoid practices such as piling and burning).
- Leave non-merchantable material on site.

Glossary

biodiversity: the diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.

biogeoclimatic zone: a geographic area having similar patterns of energy flow, vegetation, and soils as a result of a broadly homogenous macro-climate.

clearcutting: The process of removing all trees, large and small, in a stand in one cutting operation. The previous stand is replaced with an even-aged crop of new trees through planting and/or natural regeneration (including advance regeneration).

coarse woody debris: sound and rotting logs and stumps that provide habitat for plants, animals, and insects and a source of nutrients for soil development. Material generally greater than 8–10 cm in diameter.

connectivity: a qualitative term describing the degree to which late successional ecosystems are linked to one another to form an interconnected network. The degree of interconnectedness and the characteristics of the linkages vary in natural landscapes based on topography and natural disturbance regime. Breaking of these linkages results in forest fragmentation. Fragmentation due to forest harvesting should be viewed and managed to mimic fragmentation resulting from natural disturbance. The degree and characteristics of this "natural fragmentation" vary with differences in landscape type. Specific types of connectivity are defined below:

- upland to upland connectivity – describes how well late successional forests in the upland portion of the landscape were linked over time
- upland to stream connectivity – describes how well late successional forests on the upland and stream riparian portions of the landscape were linked over time
- upland to wetland connectivity – describes how well late successional forests on the upland and wetland portions of the landscape were linked over time
- cross-elevational connectivity – describes how well late successional forests from low elevation valley bottoms and higher elevation portions of the landscape were linked with each other over time
- wetland complex frequency – a measure of how many wetland complexes are in this NDT relative to other NDTs
- stream riparian frequency – a measure of how many streamside riparian areas are in this NDT relative to other NDTs

- mean disturbance size – a measure of natural patch size in this NDT relative to other NDTs
- presence of island remnants – a measure of the importance of island remnants to landscape connectivity relative to other NDTs. Island remnants are the structures remaining after stand initiating disturbances and will therefore be most important where stand initiating disturbances are predominant.

endangered species: see "threatened or endangered species".

even-aged management: a silvicultural system that is designed to regenerate and maintain an even-aged stand. Clearcutting, seed tree and shelterwood are even-aged systems.

forest ecosystem network: a planned landscape zone that serves to maintain or restore the natural connectivity within a landscape unit. A forest ecosystem network (or FEN) consists of a variety of fully protected areas, sensitive areas, and old-growth management areas.

forest interior: see Appendix 1 "Edge effects and forest interior."

landscape: a watershed or series of similar and interacting watersheds, usually between 10 000 and 100 000 ha in size.

landscape unit: a planning area, generally up to about 100 000 ha in size, delineated according to topographic or geographic features such as a watershed or series of watersheds. It is established by the district manager.

managed forest: that portion of the landscape outside forest ecosystem networks in which forestry operations occur.

mature seral: forests composed primarily of co-dominant trees, with canopies that vary vertically, horizontally, or both. Generally refers to trees 80 to 120 years old or greater, depending on species and site conditions. The age and structure of mature seral vary significantly by forest type and from one biogeoclimatic zone to another.

natural disturbance type: an area that is characterized by a natural disturbance regime. See the section "Establishing seral stage objectives for natural disturbance types."

old-growth management areas: areas that contain or are managed to replace specific structural old-growth attributes, and that are mapped out and treated as special management areas.

old seral: old seral is a forest that contains live and dead trees of various sizes, species, composition, and age class structure Old seral forests, as part of a slowly changing but dynamic ecosystem, include climax forests but not sub-climax or mid-seral forests. The age and structure of old seral varies significantly by forest type and from one biogeoclimatic zone to another.

patch: a stand of similar-aged forest that differs in age from adjacent patches by more that 20 years. When used in the design of landscape patterns, the term refers to the size of either a natural disturbance opening that led to even-aged forests or an opening created by cutblocks.

planning unit: a sub-unit of the landscape planning unit; a biogeoclimatic subzone within a drainage, for example.

potential natural community: the plant community that would be established if succession were allowed to be completed without further human interference.

protected area: An area that has protected designation according to provincial or federal statute. Protected areas are land and freshwater or marine areas set aside to protect the province's diverse natural and cultural heritage.

rare ecosystem: an ecosystem (site series or surrogate) that makes up less than 2% of a landscape unit and is not common in adjacent landscape units.

reserve: an area of forest land that, by law or policy, is not available for timber harvesting or production.

residual cover: living and dead vegetation that persists over-winter and provides protective and breeding cover during critical periods in the following spring before new growth takes over this function.

seed tree system: an even-aged silvicultural system in which selected trees (seed trees) are left standing after the initial harvest to provide a seed source for natural regeneration. Seed trees can be left uniformly distributed or in small groups. Although regeneration is generally secured naturally, it may be augmented by planting. Seed trees are often removed once regeneration is established, or may be left as reserves.

seral stages: the stages of ecological succession of a plant community, for example, from young stage to old stage; the characteristic sequence of biotic communities that successively occupy and replace each other, altering in the process some components of the physical environment over time.

silvicultural systems: a planned cycle of activities by which a forest stand, or group of trees, is harvested, regenerated, and tended over time. Silvicultural systems used in British Columbia include clearcutting, seed tree, shelterwood, and selection. Each name reflects the type of stand structure created by harvesting.

site series: sites capable of producing the same late seral or climax plant communities within a biogeoclimatic subzone or variant.

stand attributes: the components of a forest stand. See Appendix 5.

stand level: the level of forest management at which a relatively homogeneous land unit can be managed under a single prescription, or set of treatments, to meet well-defined objectives.

stand-initiating events: occur when natural disturbances such as wildfire, wind, landslides, and avalanches significantly alter an ecosystem. In most cases there is considerable mortality of plant species, some degree of site disturbance and the initiation of successional processes that will form a new plant community with a different structure and likely a different composition than its predecessor.

stand-maintaining events: the fairly frequent occurrence of wildfires, either as surface or surface and crown fires, which serve to maintain an ecosystem at a particular successional stage. This may result in a "fire climax," such as is found in the Ponderosa pine or interior Douglas-fir types, or in a coastal forest of mid-seral tree species in relatively even-aged stands.

structural attributes: components of a forest stand (including living and dead standing trees, canopy architecture, and fallen dead trees) which together determine stand structure.

threatened or endangered species: indigenous species that are either threatened or endangered, and identified as "red listed" by the Ministry of Environment, Lands and Parks.

uneven-aged management: a silvicultural system designed to create or maintain and regenerate an uneven-aged stand structure. Single tree and group selection are uneven-aged silvicultural systems.

viable population: a self-sustaining population with a high probability of survival despite the foreseeable effects of demographic, environmental and genetic stochasticity and of natural catastrophes.

wildlife tree: a standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include large diameter and height for the site, current use by wildlife, declining or dead condition, value as a species, valuable location, and relative scarcity.

wildlife tree patch: an area specifically identified for the retention and recruitment of suitable wildlife trees. It can contain a single wildlife tree or many. A wildlife tree patch is synonymous with a group reserve.

Appendix 1. Landscape level biodiversity concepts

Forest habitats can be grouped into three categories at the landscape level: early seral stage, mid-seral stage and late seral stage (old growth). Species diversity is generally greatest in early and late seral stages.

Vertebrates tend to be associated with the structural attributes typical of a seral stage at a stand scale, rather than with stand age per se. It is therefore possible to maintain populations of most vertebrate species by providing the necessary structural attributes. What is less clear is how much habitat is required to do this.

Other species are believed to be tied to the interior microclimate conditions of late seral forests. These species include some plants, especially epiphytes, and invertebrates. Thus, to maintain populations of these species, it may be necessary to preserve blocks of old growth sufficiently large to provide suitable interior microclimate conditions.

Fragmentation

Fragmentation is the process of transforming large contiguous forest patches into one or more smaller patches surrounded by disturbed areas. This occurs naturally through such agents as fire, landslides, windthrow and insect attack. In the managed coastal forest, timber harvesting and related activities have been the dominant agent of disturbance during this century.

Fragmentation leads to declines in biodiversity in three ways. One is through the actual loss of habitat in the conversion of forests from natural to managed stands. The second is through the increase in microclimatic and biotic edge effects (see the following section) as the size of forest patches is reduced. The third is through the increasing isolation of the remaining forest patches, which can impose barriers to gene flow and dispersal.

Rate of cut, cutblock size and distribution, and silvicultural system all influence fragmentation. In British Columbia, the overall rate of cut is the major factor determining the amount of fragmentation that will occur. The higher the rate of cut, the faster the proportion of older seral stands will decline. If a landscape is dominated initially by older forest, some conversion to younger forest will increase the abundance of species which thrive in edge environments (see the following section). At some threshold, however, species requiring an older forest will begin to be lost. At what level of cut the threshold will occur is uncertain, though the higher the cut, the greater the risk to species requiring mature forest.

Edge effects and forest interior

At the boundary between older forest and newly harvested areas an edge environment is created which affects conditions within the forest. Along a transect from the open cutblock environment, through the edge, and into the forest there are strong gradients of light intensity, temperature, wind, relative humidity, and patterns of snow accumulation and melt. These microclimatic edge effects penetrate into the forest to varying distances depending on the variable measured, but very little edge influence penetrates farther than 100–200 m (2–4 tree heights in coastal British Columbia) into the forest. The magnitude of an edge effect is influenced by the surrounding vegetation and topography. The boundary between well-established second-growth and old-growth forest is less distinct than the boundary between a recent clearcut and the same old-growth. Similarly, an edge that is protected by topographic features such as bluffs or the margins of a gully is less influenced by the surrounding open environment than an edge that is fully exposed.

Biotic edge effects occur when species associated with open areas or edges penetrate the intact forest. These species affect forest interior dwellers through the processes of predation, competition, and parasitism. Biotic edge effects are less well understood than microclimatic edge effects, but can exert influence farther into the forest because of the mobility of animals and the invasive plants they disperse. As natural forests are converted to managed stands, remnant patches of forest become smaller. As patch size decreases, the edge becomes a greater proportion of the total forest area. Forest interior is the area uninfluenced by microclimatic or biotic edge effects. Edges have been traditionally viewed as good habitat for wildlife, and it is true that some important game species thrive in edge habitats during certain seasons.

However, forest edges have a negative effect on other species, notably some songbirds that experience increased levels of nest predation. Past attempts to increase edges in managed forests have increased some species at the expense of others.

A patch of forest 400 m wide will generally contain little, if any, forest interior. We recommend targeting 600 m as a minimum width when providing forest interior is a management objective. This should give a core of 200 m in the centre, which is buffered from most microclimatic edge effects. Managers wishing to protect the interior of a FEN from possible biotic edge effects should consider minimum sizes substantially greater than those required for microclimatic edge effects.

Reserves

Forest reserves are fragments of what were once much larger biotic communities. They may be areas requiring special management or even total protection from harvesting. Reserves are necessary within managed landscapes to maintain natural ecological conditions for those species that depend on them. They can be established, for example, to conserve tracts of old growth that are sufficiently large to maintain forest interior microclimate conditions, or to protect special areas such as wetlands, calcareous and serpentine bedrock exposures, and riparian ecosystems.

Biodiversity is not distributed evenly across the landscape. Certain areas are especially rich in the numbers of species or unique habitats they support. These areas may play critical roles in the maintenance of biodiversity at the landscape level and they therefore merit special attention. Estuaries and riparian ecosystems are important examples of such areas. Not only do they influence aquatic habitat, but they also offer a unique interface between terrestrial and aquatic habitats.

Forest managers should also strive to preserve representatives of the different types of forest ecosystems in British Columbia, because different types of forest harbour different species. Some of these ecosystems may harbour endangered or valuable species that have yet to be discovered, such as insects or fungi. Recent work on southern Vancouver Island by entomologists from the Royal British Columbia Museum and the University of Victoria suggests that there are hundreds of species of forest insects that are unknown to science.

Linkages among reserves

Unless they are extremely large, reserves will not be able to maintain viable populations or ecological and evolutionary processes the way whole ecosystems can. For example, while some species disperse well between forest fragments, others found in old-growth forests (such as flightless invertebrates) are poor dispersers and are thus vulnerable to isolation impacts. Small populations of animals and plants that are restricted to forest fragments and isolated by roads and other barriers may not survive in the long term.

To avoid this problem, reserves should be linked as much as possible. These linkages can provide important seasonal and annual movement corridors for some species, and critical habitat for the dispersal of other species among isolated habitat fragments.

Threatened and endangered species

The intent of these guidelines is to maintain habitat diversity at the landscape and stand levels so that viable populations of all native species can be maintained. Species known to be threatened or endangered may require specific habitat management strategies to address their needs if the general landscape level approach is inadequate. Where they are present, it is important that threatened and endangered species receive special emphasis. Actions needed to protect and enhance populations of threatened and endangered species are specified in the *Managing Identified Wildlife Guidebook.*

Appendix 2. Comparison of biodiversity emphasis options

Note: The lower biodiversity emphasis option was established based on the assumption that it would not be applied to more than approximately half of the area of any subzone within a subregional plan or Forest District.

	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	higher	intermediate	lower
Timber impact	lower	intermediate	higher
% Old seral area[a]	(natural %–12%) × .5	(natural %–12%) ×.5	(natural %–12%) × .75
% Mature seral area[a]	25% of natural	50% of natural	75% of natural
% Early seral area[a]	no limit[b]	2 × natural	1.5 × natural
Patch size distribution	Distribution as recommended	Distribution as recommended	Distribution as recommended
Connectivity and linkages	FENs up to % target for old seral area	FENs as recommended	FENs as recommended
% area in forest interior conditions	10–25% of old forest area	25–50% of old forest area	25–50% of old forest area
WTP area[c]	WTP[d] as recommended	WTP[d] as recommended	WTP[d] as recommended
WTP inter-patch distance	500 m	500 m	500 m
CWD[e]	50% natural	50% natural	50% natural

a See Appendix 4.
b Subject to old and mature area requirements being met.
c Wildlife tree patch; see the section "Stand management of maintain biodiversity."
d See Table 20.
e Coarse Woody Debris.

Appendix 3. Biogeoclimatic units, natural disturbance types and locations

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				
	BWBSdk – Dry Cool BWBS			
		BWBSdk1 – Stikine BWBSdk	NDT3	G, R
		BWBSdk2 – Liard BWBSdk	NDT3	G, R
	BWBSmw – Moist Warm BWBS			
		BWBSmw1 – Peace BWBSmw	NDT3	G
		BWBSmw2 – Fort Nelson BWBSmw	NDT3	G
	BWBSwk – Wet Cool BWBS			
		BWBSwk1 – Murray BWBSwk	NDT3	G
		BWBSwk2 – Graham BWBSwk	NDT3	G
		BWBSwk3 – Kledo BWBSwk	NDT3	G
	BWBSvk – 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]
	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, NDT3	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

a Biogeoclimatic units of British Columbia as of October 1994.

b Natural disturbance types:
- NDT1 Rare stand-initiating events
- NDT2 Infrequent stand-initiating events
- NDT3 Frequent stand-initiating events
- NDT4 Frequent stand-maintaining fires
- NDT5 Alpine tundra and subalpine parkland ecosystems.

c Forest regions: C – Cariboo, G – Prince George, K – Kamloops, N – Nelson, R – Prince Rupert, V – Vancouver.

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
	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
	ESSFvvp – Very Wet Very Cold Parkland ESSF		NDT5	K

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
ICH – Interior Cedar-Hemlock				
	ICHxw – Very Dry Warm ICH		NDT4	N
	ICHdk – Dry Cool ICH		NDT3	C
	ICHdw – Dry Warm ICH		NDT3	N
	ICHmc – Moist Cold 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
	ICHwc – Wet Cold ICH		NDT2	R
	ICHwk – Wet Cool ICH			
		ICHwk1 – Wells Gray ICHwk	NDT1	G, K, N
		ICHwk2 – Quesnel ICHwk	NDT1	C
		ICHwk3 – Goat ICHwk	NDT1	G
		CHwk4 – Cariboo ICHwk	NDT1	C, G
	ICHvc – Very Wet Cold ICH		NDT1	R
	ICHvk – Very Wet Cool			
		ICH ICHvk1 – Mica 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

a Biogeoclimatic units of British Columbia as of October 1994.

b Natural disturbance types:
- NDT1 Rare stand-initiating events
- NDT2 Infrequent stand-initiating events
- NDT3 Frequent stand-initiating events
- NDT4 Frequent stand-maintaining fires
- NDT5 Alpine tundra and subalpine parkland ecosystems.

c Forest regions: C – Cariboo, G – Prince George, K – Kamloops, N – Nelson, R – Prince Rupert, V – Vancouver.

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
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			
		MH MHmm1 – Windward MHmm	NDT1	R, V
		MHmm2 – Leeward MHmm	NDT1	R, V
	MHmmp – Moist Maritime Parkland			
		MH MHmmp1 – 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
	MSdc – Dry Cold MS		NDT3	K
	MSdk – 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	G, R
	SBPSmk – Moist Cool SBPS		NDT3	C
SBS – Sub-Boreal Spruce				
	SBSdh – Dry Hot SBS			
		SBSdh1 – McLennan SBSdh	NDT3	G
		SBSdh2 – Robson SBSdh	NDT3	G
	SBSdk – Dry Cool SBS		NDT3	G, R
	SBSdw – Dry Warm SBS			
		SBSdw1 – Horsefly SBSdw	NDT 3	C, G
		SBSdw2 – Blackwater SBSdw	NDT3	C, G
		SBSdw3 – Stuart SBSdw	NDT3	G
	SBSmc – Moist Cold SBS			
		SBSmc1 – Moffat SBSmc	NDT3	C
		SBSmc2 – Babine SBSmc	NDT3	C, G, R
		SBSmc3 – Kluskus SBSmc	NDT3	G
	SBSmh – Moist Hot SBS		NDT3	C, G
	SBSmk – Moist Cool			
		SBS SBSmk1 – Mossvale SBSmk	NDT3	G
		SBSmk2 – Williston SBSmk	NDT3	G
	SBSmm – Moist Mild SBS		NDT3	K
	SBSmw – Moist Warm SBS		NDT3	C, G

a Biogeoclimatic units of British Columbia as of October 1994.

b Natural disturbance types:
- NDT1 Rare stand-initiating events
- NDT2 Infrequent stand-initiating events
- NDT3 Frequent stand-initiating events
- NDT4 Frequent stand-maintaining fires
- NDT5 Alpine tundra and subalpine parkland ecosystems.

c Forest regions: C – Cariboo, G – Prince George, K – Kamloops, N – Nelson, R – Prince Rupert, V – Vancouver.

Zone	Subzone	Variant (if applicable)[a]	NDT[b]	Region(s)[c]
	SBSwk – Wet Cool SBS			
		SBSwk1 – Willow SBSwk	NDT2, NDT3	C, G
		SBSwk2 – Finlay-Peace SBSwk	NDT2	G
		SBSwk3 – Takla SBSwk	NDT3	G
	SBSvk – Very Wet Cool SBS		NDT2	G
SWB – Spruce–Willow–Birch				
	SWBdk – Dry Cool SWB		NDT2	G, R
	SWBdks – Dry Cool Scrub SWB		NDT2	G, R
	SWBmk – Moist Cool SWB		NDT2	G, R
	SWBmks – Moist Cool Scrub SWB		NDT2	G, R
	SWBvks – Very Wet Cool Scrub SWB		NDT2	G, R

Appendix 4. Estimation of natural seral stage distributions

With an estimate of the long-term average return interval of stand-initiating disturbance, the expected age-class distribution can be readily calculated. An assumption of the method is that the probability of disturbance is mostly independent of forest age. We applied disturbance return interval estimates for biogeoclimatic zones originally developed by the Protection Branch, Ministry of Forests, 1992 and modified by expert opinion of the regional Ministry of Forests research ecologists. These estimates are based on large areas over long periods of time, because disturbance patterns are highly variable.

The example in Table A4.1 is the cumulative distribution (% of landscape above or below the indicated age) for an average disturbance return interval of 200 years. Table A4.2 provides the summaries for age categories and return intervals used in calculating the percentage.

The method used for establishing seral stage definitions and distributions is as follows:

1. Define three seral stage categories of basic importance to biodiversity: early/young, mature, and old. Early/young forests are defined as generally being less than 40 years old (except 20 years for deciduous stands). Mature forests are defined as 80 years or older for productive coastal forests, and 100–120 years or older for the less productive high elevation forests. The development of mature forest characteristics is most rapid in low elevation coastal forests and slowest in high elevation interior forests. Old forests are defined as 140 years or older for zones with more frequent disturbance, and 250 years or older for less frequently disturbed zones. The age categories for mature and old are based on the estimated minimum age for developing structural attributes in even-aged management. These attributes may be achieved at earlier ages through structural retention or partial cutting strategies where appropriate.
2. Determine the approximate natural seral stage distribution based on estimates of the long-term average interval between stand-destroying events (Appendix 3).
3. Calculate a seral stage distribution with 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. For the old forest seral stage, the objectives are adjusted for the percentage of old forest in the biogeoclimatic zone (by Forest Region) already in protected areas (assumed to be 12% for these guidebook calculations, however it could be adjusted for actual percentage). For example: If the natural level of old growth is 38%, then the recommended minimum in each landscape unit is calculated as follows:

38% minus 12% in protected areas = 26%

then, 50% of 26% = 13% old seral stage.

Table A4.1. Cumulative age distribution using negative exponential equation with return interval of 200 years. The percentage greater than age t = exp(-[t/b]), where b is the average return interval.

	Percent of the landscape unit	
Age (yr)	Greater than	Less than
20	90	10
40	82	18
60	74	26
80	67	33
100	61	39
120	55	45
130	52	48
140	50	50
150	47	53
160	45	55
170	43	57
180	41	59
190	39	61
200	37	63
210	35	65
220	33	67
230	32	68
240	30	70
250	29	71

Table A4.2. Landscape percentage based on disturbance return interval

	Disturbance return interval (yr)					
Age (yr)	**100**	**125**	**150**	**200**	**250**	**350**
<20	18	15	12	10	8	6
<40	33	27	23	18	15	11
>80	45	53	59	67	73	80
>100	37	45	51	61	67	75
>120	30	38	45	55	62	71
>140	25	33	39	50	57	67
>250	8	14	19	29	37	49

The "natural" proportions in Table A4.2, when applied to subzones, was compared to the best available knowledge of natural age distributions by subzone to confirm this as a reasonable, objective (albeit simplified) ecologically based approach. Measured reconstructions of the natural proportions averaged across all landscapes within a zone or subzone would be the ideal starting point.

Appendix 5. Important stand attributes

To maintain or restore biodiversity in managed stands, some or all of the following attributes should be present. Table A5.1 shows how biodiversity attributes interact with management activities.

Dead wood

Many organisms depend on the natural decay cycle. Decaying wood, for example, provides habitat for numerous vertebrates, fungi, invertebrates, lichens, plants and micro-organisms. Dead wood also plays an important role in nutrient cycling. Standing dead trees (snags) and fallen logs (coarse woody debris) are important to retain, as are dying trees, which provide a source of future snags and downed logs.

Standing dead trees

Standing dead trees provide nesting and foraging habitat for a wide range of species. Providing snags in managed forests is probably the most important stand management practice to maintain biodiversity. Some existing snags should be retained, but equally important is ensuring that new snags will be recruited into the stand in the future. Small diameter snags are adequate for some species, while large diameter snags are required by other species and endure longer.

In order to maintain desired stand-level characteristics into the future, it is important to work with the attributes already present in each stand. In other words, habitat that is considered valuable for the maintenance and recruitment of standing dead trees should be assessed on a block-by-block basis, preferably during pre-harvest planning and development stages. Where no wildlife tree patches are planned within a particular block because of adequate representation nearby (for example, sufficient habitat representatives of that ecosystem exist within the wildlife tree reserve planning unit or in other leave strategies such as FENs), then specific high value habitat features that may be present on the block (such as eagle trees, largest live culls, or large snags along riparian areas) should be identified and retained where it is safe to do so. In general terms, lower numbers of suitable large-diameter standing dead trees are required within each harvest block if the FEN or other landscape leave strategy is able to provide this habitat across the planning unit, both currently and into the future. However, if few standing dead trees are present within the surrounding landscape, then the supply needs to come increasingly from harvest blocks at the stand level.

Techniques to maintain an adequate number of snags and provide future snags in managed stands include:

1. retaining some snags during harvesting where it is safe to do so (within wildlife tree reserve areas and along block boundaries)
2. retaining some live trees during harvesting as a source of large-diameter snags in the subsequent rotation
3. promoting a deciduous component in the stand as a source of snags
4. retaining snags during spacing and thinning (where it is safe to do so)
5. creating snags. More specific information on snags can be found in *Wildlife/ Danger Tree Assessor's Course Workbook.*

Coarse woody debris

Decaying logs on the forest floor provide cover, micro-climates, and breeding habitat for a wide variety of organisms. Woody debris should be retained in the stand when utilization standards are being applied and site preparation treatments undertaken. Larger size pieces are preferable, as they provide the greatest longevity and potential for nutrient cycling and wildlife use in the second-growth forests. Coarse woody debris is rarely evenly distributed, but it should be as well distributed as possible throughout the block.

Large living trees

Large, old living trees provide several unique habitat attributes and should be retained. For example, large mossy limbs provide marbled murrelet nest sites and a habitat for a variety of invertebrates. Arboreal lichens and other epiphytes are most abundant in older trees. Large living trees also provide a source of future snags.

Such trees can be retained through a variety of silvicultural systems and harvesting activities. For example, wildlife tree patches established to maintain snags are also good areas for retaining large living trees.

Tree species diversity

An ecologically appropriate variety of tree species, including hardwoods, should be retained in a stand. Such diversity can meet the habitat requirements for a greater variety of organisms than could be met in a homogeneous stand.

Tree species composition can be managed by choice of silvicultural system, harvesting, site preparation, planting, regeneration, and stand tending activities.

Structural diversity

An important attribute for maintaining biological diversity is a variety of canopy layers (vertical structure) and spatial patchiness (horizontal structure). This variety of layers includes the naturally occurring forest understorey of shrubs and forbs, which provide food and cover for numerous species. To maintain understorey vegetation, a partially open or patchy forest canopy is required. Structural variety creates more habitat and micro-climate diversity than homogeneous stands.

Vertical and horizontal structural diversity can be maintained or created by choice of silvicultural system, harvesting methods, and stand tending activities. Even-aged systems tend to create structural variety between stands that are at different seral stages, whereas uneven-aged systems tend to create structural variation within single stands. With either method, structural variety changes as forests grow.

Forest soils

Soil management has a major effect on the ecological characteristics and degree of biodiversity of any given stand. Soil structure, nutrient spectrum, organic matter content, water retention and drainage, and pH play a major role in determining the vegetative composition of ecosystems. Maintaining the full range of soil conditions and humus forms on the landscape is a prerequisite for the development and maintenance of a diverse flora and fauna.

Forest practices that minimize soil disturbance are the best way to maintain the below-ground biodiversity and ensure the continued functioning of the soil ecosystem.

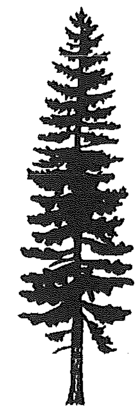
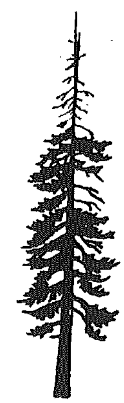
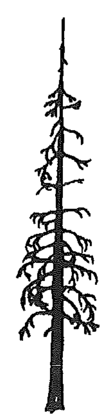
Table A5.1. Interaction of management activities and biodiversity attributes

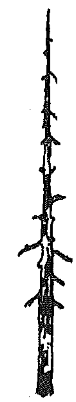
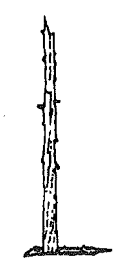
Management activities	Snags	Large green trees	Coarse woody debris	Tree species diversity	Understorey plant community	Vertical and horizontal structures
	Biodiversity attributes					
Silvicultural system	**	**	**	*	**	**
Harvest method	**	**	**	*	**	
Utilization standards		*	**			
Site preparation	*	**	**	**	**	**
Regeneration	*	*		**	*	**
Vegetation management	*	*		**	**	*
Spacing and thinning	**	*	*	**	**	**
Pest management	**	**	**	**	*	**

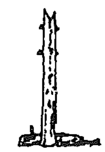
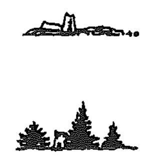
Note: ** Indicates significant interactions (where management activity has a major impact on the biodiversity attribute).

* Indicates an important but less significant interaction.

Appendix 6. Classes of wildlife trees

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of decomposition
1	**live/healthy** – no decay	nesting; roosting; perching; territory; large-limb eagle and Osprey nests; raptors; scavengers; Great Blue Heron colonies; Marbled Murrelet	
2	**live/unhealthy** – internal decay or growth deformities (including insect damage, broken tops); dying tree	nests/roosts – PCEs[a] (strong excavators); SCUs[b]; large-limb nests; insect feeders	
3	**dead**[c] – hard heartwood; needles and twigs present; roots stable	nests/roots – PCEs (strong excavators) SCUs; bats; large-limb nests; hunting/hawking perches; branch roots; insect feeders	

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of dccomposition
4	**dead** – hard heartwood; no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable	nests/roots – PCEs (weaker excavators) SCUs; insect feeders	
5	**dead** – spongy heartwood; most branches/bark absent; internal decay; roots stable for larger trees; roots of smaller trees beginning to soften	nests/roosts – PCEs (weakest excavators); SCUs; bats; insect feeders; salamanders	
6	**dead** – soft heartwood; no branches or bark; sapwood/heartwood sloughing from upper bole; lateral roots of larger ones softening; smaller ones unstable	SCUs; insect feeders; salamanders; small mammals	

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of decomposition
7–8	**dead** – soft heartwood; stubs; extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells	insect feeders; salamanders; small mammals	
9	**debris** – downed stubs or stumps	insect feeders; salamanders; small mammals; amphibians; drumming logs for grouse; flicker foraging, nutrient source	

[a] This classification system does not apply to downed logs and/or coarse woody debris.

[b] PCE = primary cavity excavator.

[c] SCU = secondary cavity user.

[d] The stability of dead trees is influenced by the cause of death. Dead trees can be unstable if killed by butt rot or root rot, depending on the species of the fungus. In general, *Phellinus* attack leads to instability; *Armillaria* attack must be assessed carefully on a site-specific basis.