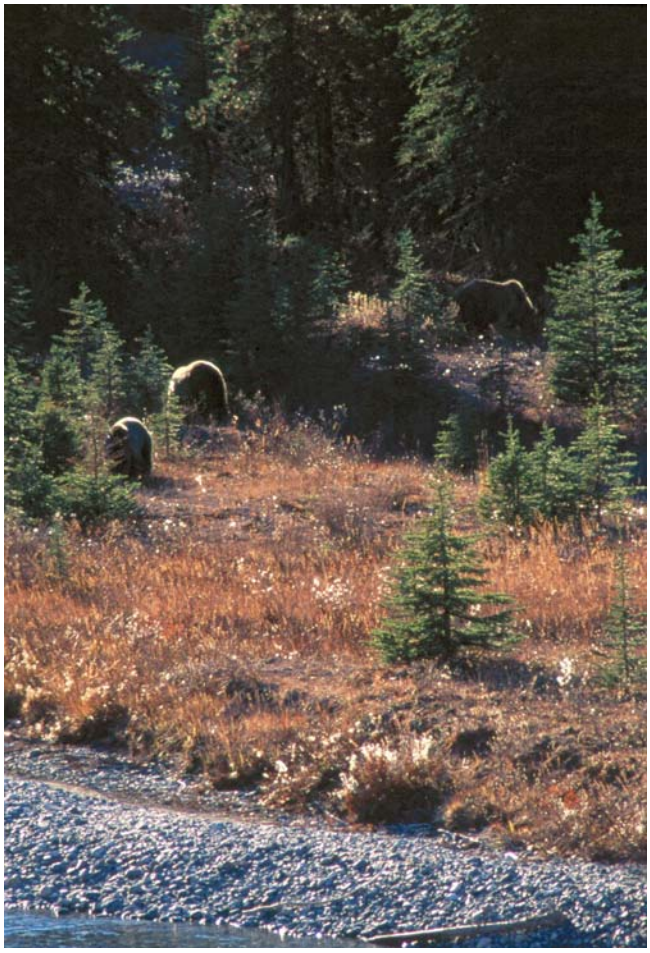
Silviculture Guidelines and Practices for Maintaining or Recruiting Key Habitat Objectives



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1.0 Executive Summary

Ten key, broad level habitat objectives were identified which can be managed (i.e., maintained or recruited) using silviculture treatments (i.e., including appropriate harvesting and retention strategies; post-harvest regeneration and stand tending regimes; additional habitat restoration practices). These habitat objectives, as follows, were chosen because of their applicability to many forested regions of British Columbia, and their particular biological, ecological or management significance:

1. Maintenance and or recruitment of coarse woody debris (CWD).
2. Retention and or recruitment of wildlife tree patches (WTPs).
3. Maintenance and or recruitment of habitat structure and function in riparian management areas (RMAs).
4. Maintenance and or recruitment of landscape level biodiversity functions/objectives (including seral stage distribution and landscape connectivity).
5. Maintenance and or recruitment of habitat elements for the general range of primary cavity excavating birds.
6. Maintenance and or recruitment of habitat elements for Northern Goshawk reproduction and foraging.
7. Maintenance and or recruitment of coastal black-tailed deer and Roosevelt elk winter range.
8. Maintenance and or recruitment of mule deer winter range.
9. Maintenance and or recruitment of mountain caribou winter range.
10. Maintenance and or recruitment of habitat elements for grizzly bear forage & security cover.

This report was written to provide operational management guidelines to forest managers for maintaining the above broad-level habitat objectives. In the context of this report, management guidelines are *generally accepted non-mandatory guidance and management recommendations based on the best available data and expert opinion.* These guidelines are intended to **apply to specified areas (i.e., generally areas of high habitat suitability or capability) where the management objectives include habitat for a particular species or habitat attribute**. For example, a certain grizzly bear habitat management regime (i.e., recommended silvicultural practices) may be applicable to a specific BEC subzone within a watershed, but are not applicable to a different subzone within the same watershed. Consequently, the location, circumstances and conditions where a recommended silvicultural guideline applies, must be clearly defined within the associated forest stewardship plan.

This report is also intended to be a companion document to the various provincial and regional forest management guidelines that have already been developed for managing selected species and habitats. Consequently, it provides a useful summary of current knowledge and

recommended guidelines for managing the key habitat objectives described above, and is compatible with existing silviculture standards guidelines (e.g., *Establishment to Free Growing Guidebooks*). Information on habitat restoration practices is also provided.

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Title page photo: Alex Inselberg

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2.0 Introduction

To date, the *Establishment to Free Growing Guidelines* (MoF 2000) have been the primary basis for applying silviculture treatments in British Columbia. Most of the *Free Growing Guidelines* focus on meeting timber objectives, and are often applied as "Standards" with little deviation toward meeting other objectives such as habitat attributes or identified wildlife species. As well, silviculture practices are sometimes employed without due consideration for their effects on non-timber values, often because existing habitat knowledge is not incorporated into the planning or prescription processes.

Consequently, there is a need to revisit the existing *Free Growing Guidelines (*stocking standard information) as they apply to the stages of forest development, and identify opportunities where these guidelines can be modified to address non-timber values and ecosystem restoration needs. For example, the long-term habitat needs of the Blue-listed Williamson's Sapsucker (*Sphyrapicus thyroideus* - found mainly in the Interior Douglas-fir zone of the southern interior), can be enhanced by modifying stocking standards (e.g., planting densities and species selection), stand management treatments (e.g., spacing and thinning densities to create open grown stands), and harvesting regimes (e.g., partial cutting with individual live tree retention, fungal inoculation and extended rotation lengths for portions of the stand). This strategy will create habitats with some large diameter western larch (*Larix occidentalis*) that contain heart rot (i.e., as primary nesting habitat for sapsuckers), interspersed within a matrix of younger forest which provides feeding and cover opportunities.

The following report was written in order to provide operational guidelines to forest managers for maintaining 10 broad-level habitat or species management objectives (see list below). These objectives were identified provincially as having particular biological, ecological or management significance.

The management guidelines recommended in this report will apply to Forest Investment Account (FIA) funded activities for licensees under the Land Base Investment Program (LBIP). Licensees use FIA funds for a variety of silviculture and restoration activities, and standards, guidelines and Management Guidelines form a collection of information to support the delivery model. These guidelines could also apply to forest practices under the *Forest and Range Practices Act* (FRPA). Default standards will be established by management unit, and licensees will be encouraged to provide scientific justification if they want to change or deviate from the default standards. The intent is to build on the recommendations in this document as more field trial results are analysed.

Secondly, the guidelines contained in this report are **intended to apply to specified areas where the management objectives include habitat for a particular species or habitat attribute**. For example, a certain grizzly bear habitat management regime (i.e., recommended silvicultural practices) may be applicable to a specific biogeoclimatic subzone within a watershed, but are not applicable to a different subzone within the same watershed. Consequently, the location, circumstances and conditions where a recommended silvicultural guideline applies, must be clearly defined within the associated forest stewardship plan.

The 10 broad-level objectives described in this report are:

1) Coarse woody debris (CWD)
2) Wildlife tree patches (WTP)

3) Riparian Management Areas (RMA)
4) Landscape level biodiversity function (seral stage distribution and connectivity)
5) Habitat elements for primary cavity excavating bird species
6) Habitat elements for Northern Goshawk
7) Winter range for coastal black-tailed deer and Roosevelt elk
8) Winter range for mule deer
9) Winter range for mountain caribou
10) Habitat elements for grizzly bear forage and security cover.

Figure 1: Gaps and patchy habitat can be created through various silvicultural and harvesting regimes. Photo: Alex Inselberg.

This report is also intended to be a companion document to the various provincial and regional forest management guidelines that have already been developed for managing selected species and habitats (see section 8.0 for selected references). Forest management practitioners should consult local and regional higher level plans and associated guidelines and operating procedures, and local resource experts, when managing selected species or habitat attributes. However, this report provides a useful summary of current knowledge and recommended guidelines concerning the management of key habitat objectives, and is compatible with existing silviculture standards guidelines. In addition, information on habitat restoration practices is provided in this report which may not be found in other current documents.

3.0 Methodology

In order to summarize current knowledge and develop Management Guidelines for maintaining or recruiting key habitat objectives (see sections 4.0 and 7.0 for details), consultations with forest resource managers (wildlife and habitat biologists, and silviculture foresters, see Appendix 1 for a list of persons contacted), along with a literature and web-based review of species and habitat management guidelines and silviculture practices, were conducted. This process enabled selection of the 10 key habitat objectives described above.

The existing *Establishment to Free Growing* standards were modified in order to achieve the desired stand attributes for a given habitat objective – this necessitated use of even aged management treatments (e.g., manipulation of stocking densities and spatial distribution, tree species selection, modifiers for canopy gaps and clumpiness, etc.). Consequently, many of the silviculture regimes and practices recommended in the following sections **reflect only those associated with even aged silvicultural systems**. However, as specified for some of the key habitat objectives (e.g., mountain caribou winter range and mule deer winter range, see section 7.0), uneven aged management that targets retention of residuals post-harvest, should be practiced where appropriate.

Figure 2: Natural canopy gaps provide hydrological benefits and diversity in forage species succession, and in this example, proximity to valuable riparian habitat. Photo: Alex Inselberg.

A management account (section 7.0) was written for each key habitat objective using the following format:

- **name and goal of key habitat objective** – this includes a statement about maintaining and or recruiting specific habitat elements.

- **general statement about landscape level considerations** – this briefly describes the importance of linking information and objectives found in higher level plans with specific operational plans, prescriptions and practices at the stand level.

- **list of applicable biogeoclimatic (BEC) zones and subzones** – these are the BEC units which generally have high or moderately high habitat capability ratings[1] for a particular species or species group. This information was obtained from provincial habitat benchmark ratings for selected wildlife (MELP 1998), distribution and seasonal abundance of selected wildlife (Stevens 1995), and personal communications with various species and habitat management experts (Appendix 1). Where ecologically appropriate, some subzones were grouped together. BEC subzones were chosen as the preferred ecosystem unit because, in most cases, it is not practical to prescribe and implement Management Guidelines at a finer scale of habitat resolution (i.e., site series is too specific and habitat objectives may not be achievable at this scale). A summary of the BEC units (subzone names and codes) used in this report is found in Appendix 2.

  Obviously, some wildlife species will be found in BEC units not listed in the management account for that particular species or species group. In this case, if habitat management for that species is an objective, then the corresponding Management Guidelines described in the account should be followed in conjunction with any additional local or regional management plans and guidelines.

- **management guidelines and specific habitat objectives for access development and harvesting** – list of recommended management guidelines for achieving specific habitat objectives during access develop and forest harvesting.

- **management guidelines and specific habitat objectives for post harvest** – list of recommended management guidelines for achieving specific habitat objectives post harvesting. This includes sections on restoration, regeneration, brushing, spacing/thinning and pruning, and protection (fire, insects, disease, damage).

- **recommended silvicultural regimes** – provides specific management guidelines and related silviculture practices information. Recommendations are categorized according to soil moisture regime (e.g., subhygric to hygric sites).

- **stocking standard guidelines for establishment to free growing seral stage** – this table relates to the columns of the same name in the existing standards (*Establishment to Free Growing Guidebooks*, MoF 2000), and provides the following information:

  - **applicable ecosystems** (BEC units or groupings of BEC units as per above).

  - **soil moisture and soil nutrient regime**.

[1] Habitat capability is the ability of the habitat, under optimal natural seral conditions, to provide life requisites (e.g., reproduction, foraging, security cover) of a species. The benchmark is the highest capability habitat for the species in the province, against which all other habitats for that species are rated. Habitat capability ratings with a high value represent 100-76% of the provincial best habitat; a moderately high value represents 75-51% of the provincial best habitat. Capability ratings are very useful because they provide an index of that ecosystem's ability to meet the life requisites and associated habitat attributes of a given species for a specified season (e.g., mule deer winter range).

- **species selection** – preferred trees important for meeting the habitat objectives. This modifier simply provides information on what tree species are important to a particular habitat objective. For example, a broadleaf species such as black cottonwood (*Populus balsamifera trichocarpa*) could be considered a preferred species in BEC unit XYZ. (Typically, prescriptions tend to list only those species in the primary column of the existing stocking standards, as preferred). Where no tree species preference is indicated, then this column is blank and it is the discretion of the forest manager to select the preferred species.
- **stocking standard modifiers** – the term "stocking standard modifier" refers to the multiplicative factor applied to existing stocking standards contained within *Establishment to Free Growing Guidebooks*. For example, the existing stocking standards (well-spaced/ha) for CWHvm1 01 site series as found in the *Establishment to Free Growing Guidebook, Prince Rupert Forest Region*, equals TSSpa **900**, MSSpa **500**, MSSp **400**. The equivalent stocking standards (well-spaced/ha) for areas with maintenance and or recruitment of grizzly bear foraging and security habitat objectives would have a 0.67 stocking standard modifier (multiplicative) applied. Therefore, modified stocking equals TSSpa **600**, MSSpa **335**, and MSSp **270**. (TSS - target stocking standard. MSS – minimum stocking standard. pa – preferred and acceptable. p – preferred).

  The primary reason for using a multiplication factor rather than just stems/ha values, is to allow for the grouping of a range of site series thereby significantly reducing the size and complexity of the silviculture and restoration standards.

- **regeneration delay** – this column relates to the column of the same name in the existing standards. If required to address a stand attribute related to a particular key habitat objective, the regeneration delay can be modified. For example, a value of +1 would increase the delay by one year; a value of –1 would decrease the delay by one year. If no adjustments were required, "same" would be entered in the column. This column will only be adjusted in rare situations to perhaps address an administrative hurdle.

- **assessment time frame** – the assessment years, as with the regeneration delay, could be altered by providing forward or backward adjustments to the assessments years (e.g., +1, -1). If no adjustments are required, "same" would be entered in the column.

- **minimum tree height** – described relative to existing stocking standards tables.

- **percent trees over brush species** – this variable, though adjusted infrequently, could suggest changes to the column of the same name on the existing stocking standards table.

- **minimum inter-crop tree distance** – minimum and maximum inter-tree spacing values are specified on the existing stocking standards tables. No modifiers are applied to these values; rather new values have been developed. For example, the minimum inter-tree spacing could be reduced to 0.75 m and the maximum inter-tree spacing increased to 3.0 m (i.e., from a standard distance of 1.0 m). These values work in concert with any spatial distribution descriptors (e.g., cluster distribution tables, see description below).

- **maximum regen. density** – describes maximum density (stems/ha) at free growing. This density includes preferred and acceptable tree species, plus additional tree species relative to the key habitat objective. Where applicable to achieve habitat objectives, additional information such as the "minimum percentage of canopy gaps" may be attached to the regen. density column (e.g., min. 20% canopy gaps, based on random systematic free growing survey plots).

Note: Some of the above stocking standard information will be the same as that found in current *Establishment to Free Growing Guidebooks*. However, other components of the table are revised in order to help achieve specific stand structural attributes (e.g., patchy or clumpy regen. distribution to create openings for development of forage shrubs; or a closed, multi-layered canopy for snow interception and thermal cover).

- **cluster distribution table – establishment to free growing seral stage** – this table provides target information on stocking densities (trees/ha) and the corresponding trees per cluster in order to achieve a specified cluster density (either "x" clusters/ha or "y" metres triangular inter-cluster spacing). This information is applicable when trying to achieve regeneration which is unevenly distributed across the treatment unit (i.e., patchy or clumpy regen. which creates clusters with gaps in between – non crop-tree species such as berry producing shrubs will then grow in the gaps under suitable ecological conditions).

- **additional monitoring standards** – this section allows for some description of the silviculture regime outside of the stocking standards modifiers. Additional silvicultural practices and relevant information (e.g., silvicultural systems, retention targets, etc.) for achieving the key habitat objectives during the three major phases of forest development (establishment, juvenile and mature) are described.

- **selected references** – references (literature citations and/or website addresses) are provided for each key habitat objective.

4.0 Key Habitat Objectives

Ten key, broad level habitat objectives were identified which can be managed (i.e., maintained or recruited) using silviculture treatments (i.e., including appropriate harvesting and retention strategies; post-harvest regeneration and stand tending regimes; additional habitat restoration practices), as follows:

- maintenance and or recruitment of coarse woody debris (CWD).

- retention and or recruitment of wildlife tree patches (WTPs).

- maintenance and or recruitment of habitat structure and function in riparian management areas (RMAs).

- maintenance and or recruitment of landscape level biodiversity functions/objectives (including seral stage distribution and landscape connectivity/wildlife travel corridors).

- maintenance and or recruitment of habitat elements for the general range of primary cavity excavating birds.

- maintenance and or recruitment of habitat elements for Northern Goshawk reproduction and foraging.

- maintenance and or recruitment of habitat elements for coastal black-tailed deer and Roosevelt elk winter range – for winter forage supply, thermal protection (snow interception) and security cover.

- maintenance and or recruitment of habitat elements for mule deer winter range – for winter forage supply, thermal protection (snow interception) and security cover.

  NOTE: Guidance in section 7.6 covers two choices of silvicultural systems – for even-aged and uneven-aged management. For many areas in the central and southern interior regions of B.C., especially in mature and old Douglas-fir leading stands, uneven aged silvicultural systems are recommended for management of mule deer winter range. These types of uneven-aged forests provide a balance of thermal cover (snow interception) and forage availability. The decision of whether to apply uneven aged systems management *must* be based on the ecological suitability of the site and the desired management objectives (e.g., habitat, timber, operational, etc.).

  Even-aged silvicultural systems management should also be applied within ecological limits. In the northern region of the province, where deer winter ranges occur on spruce leading sites, even-aged systems may be ecologically appropriate and may recruit the necessary conditions for mule deer winter range.

- maintenance and or recruitment of habitat elements for mountain caribou winter range – for winter forage and security cover (not applicable to northern caribou).

- maintenance and or recruitment of habitat elements for grizzly bear forage and security cover.

Management guidelines for achieving the above 10 habitat objectives are described in section 7.0, with the exception of the riparian (RMA) objective (see below) and the landscape considerations objective (see section 5.0).

Figure 3: Riparian habitats with varied deciduous components are diverse habitats for wildlife. Photo: Alex Inselberg.

RIPARIAN AREAS are readily recognized as special habitats, and are often associated with specific flora, fauna, physiography, or micro-climate processes not common in the adjacent stand or landscape. Because of their high site productivity and more complex habitat structure (usually containing downed wood, snags, shrubs and mixed tree species composition), riparian areas are often the most heavily used wildlife habitats. These areas often act as linear travel corridors for wildlife, providing valley bottom and cross-elevational connectivity. Riparian areas usually have a buffered micro-climate compared to adjacent areas (i.e., warmer in winter and cooler in summer).

Figure 4: Landscape and elevational connectivity provide wildlife movement corridors (see section 5.0). Photo: Alex Inselberg.

Some recommended management **guidelines and practices for maintaining and or recruiting riparian habitat and function** are described briefly, as follows:

- to minimize introduction of unwanted plant species and to maintain natural water movement, choose silvicultural strategies and equipment which minimize ground disturbance within riparian areas.

- maintain and or recruit natural levels of coarse woody debris within the riparian area. CWD has additional value in riparian areas as habitat for a greater number of wildlife and plant species.

- all dead wildlife trees that do not pose a risk to worker safety should be left within riparian areas. If low value wildlife trees and dangerous trees have to be felled for worker safety reasons, then these stems should be retained on site as CWD or as future instream large woody debris (LWD).

- especially on rich, moist sites, a planned sequential regime of site prep., planting and brushing may be required to achieve successful establishment of desired conifer species which can contribute to future riparian forest structure.

- in locations that have had previous forest harvesting within the riparian management area, some form of riparian restoration may be considered.

Additional, more detailed information on riparian management area guidelines and recommended management practices for riparian zone silvicultural and restoration treatments can be found in the *Riparian Zone Handbook* (Bancroft and Zielke, 2002; see weblink URL:

http://www.for.gov.bc.ca/hfp/pubsriparianSilv.htm), and the *Riparian Management Area Guidebook* (MoF and MELP, 1995). The *Riparian Zone Handbook* also provides overall guidance on the following riparian related variables and functions, and is organized by stream classification:

- conifer large woody debris (LWD) recruitment for channel morphology;
- small organic debris (SOD);
- bank stability;
- shading (water temperature control); and
- riparian habitat (includes presence of unique ecosystems and species-specific management requirements).

In addition, riparian zone management practices are broken into the following categories:

- regeneration;
    - site preparation
    - planting
    - brushing
    - conifer release
    - animal damage
- juvenile spacing; and
- general considerations (e.g., wildlife tree management).

Figure 5: Brushing may be required to reduce shrub and herb competition to desired conifer seedlings. Photo: Alex Inselberg.

5.0 Landscape Level Planning and Management Considerations

Maintenance and or recruitment of landscape level biodiversity functions and objectives are essential to overall ecosystem functioning. The ten habitat objectives described in section 4.0, **cannot be achieved without due consideration for landscape processes and associated planning at the landscape scale**. However, implementation of these objectives does not need to occur on all portions of a landscape, but only in those areas which have been identified or zoned in higher level plans for that objective (e.g., Special Management Zones), and or in areas where the habitat capability ratings for that objective are high or moderately high.

Landscape level management objectives such as patch size distribution, landscape connectivity, seral stage targets, and access management should be described in higher level plans (including Sustainable Forest Management Plans; Land Use Plans; and Land and Resource Management Plans). It is important to link higher level plan objectives for a landscape unit or other planning area, with specific operational plans, prescriptions and Management Guidelines implemented at the stand level. Where regional level plans and guidelines have been developed for management of various habitat objectives (e.g., mule deer winter range), then these should be used as the primary guiding document, in conjunction with other guidelines and or Management Guidelines that may be available.

Figure 6: Varied and diverse stand structure and plant communities are important to maintain across the landscape. Photo: Alex Inselberg.

In addition to the general principles described above, the following information sources should be consulted where possible when trying to achieve key habitat objectives within a particular operational planning area:

- contact local government agency personnel responsible for habitat and wildlife management planning activities.

- identify any special landscape features (e.g., sensitive soils and slope stability concerns).

- identify any critical habitats (e.g., ungulate winter ranges, significant mineral licks, estuaries, etc.).

- confirm presence of special management areas [e.g., Old Growth Management Areas (OGMA), Ungulate Winter Ranges (UWR), Wildlife Habitat Areas (WHA)], and how these may link with achievement of key habitat objectives.

- determine whether any "species at risk" are found in the planning area which require special management considerations (i.e., *Identified Wildlife Management Strategy*), or which can link to other stand- or landscape-level management initiatives (e.g., an established marbled murrelet WHA which can also contribute to old seral targets for a particular landscape unit). For more information on planning and management guidelines for IWMS species, see http://wlapwww.gov.bc.ca/wld/identified/ , and ftp://ftp.env.gov.bc.ca/pub/outgoing/identified%20Wildlife/ .

- confirm any higher level plan objectives that may influence implementation of the desired habitat objective (e.g., landscape unit target limits for old seral forest).

- use forest inventory data, aerial photographs and GIS mapping tools to determine current and projected landscape level targets (spatially and temporally) for:

    1. seral stage distribution (i.e., relative proportions of young, mature an old forest);

    2. patch size distribution (includes opening sizes and forested patch sizes);

    3. landscape connectivity (includes inter-patch connectivity and cross-elevational and cross-valley connectivity). This often provides travel and dispersal corridors for wildlife;

    4. access management (influences habitat fragmentation and human disturbance); and

    5. visual cover (provides forested security cover for wildlife, especially in areas with abundant human access).

    These five landscape variables, in particular, can have significant influence on the successful achievement of desired key habitat objectives. For example, an inadequate access management plan and a highly fragmented landscape (i.e., with only small, isolated patches of mature and old seral forest), represents poor landscape condition for mountain caribou.

In addition to the landscape level targets described above, and the silviculture management guidelines and practices described in section 7.0, general stand-level biodiversity management principles should be adhered to where possible. These include:

- maintain a varied species composition in regenerating stands by:
  - leaving natural residuals (conifers and hardwoods) and advance regeneration; and
  - varying planting stocking with natural regeneration.
- maintain forest floor structure and understory diversity by:
  - leaving patches of undisturbed habitat (these could be wildlife tree patches, riparian reserves, variable retention patches, gully management zones, etc.);
  - minimizing soil disturbance and compaction; and
  - using patchy planting and juvenile spacing practices to promote herb and shrub production (as ecologically appropriate).

Additional references which provide information about landscape planning practices are cited in section 8.0. Also link to the B.C. Ministry of Sustainable Resource Management (MSRM) website for further information on landscape planning (http://srmwww.gov.bc.ca).

Figure 7: Fire is a natural disturbance and regeneration agent in forest ecosystems which affects seral stage and patch size distribution across landscapes. Photo: Alex Inselberg.

6.0 Future Work

Based on the key habitat objectives and related silviculture regimes and Management Guidelines that have been identified in this report, the following future work is suggested:

1. Development of silviculture recommendations for management of northern caribou (*Rangifer tarandus*) winter range. Various approaches to the management of pine-lichen woodlands and the response of terrestrial lichens to disturbance (e.g., canopy gaps, silviculture regimes, prescribed fire) must be evaluated before silviculture standards can be developed for northern caribou winter ranges.

2. Evaluation of the use and effectiveness of WTPs and other wildlife tree retention and or restoration strategies. These include variables such as size (area) and composition of WTPs (tree species and classes, basal area); distribution and density (stems/ha) and condition (age class, tree class) of individual leave trees retained post-harvest; and types of wildlife tree creation techniques (e.g., fungal inoculation).

3. Evaluation of the effectiveness of CWD management strategies. Variables to consider are the amount, condition (species and log class), and distribution of CWD retained post-harvest. Operational, economic (i.e., utilization) and forest health variables (e.g., insects, fire protection) must be considered in the context of this evaluation.

4. Analysis of the economic and operational impacts of the silviculture Management Guidelines and associated modifications to the free growing guidelines recommended in this report (see section 7.0). Forest management modeling using various growth and yield or other software (e.g., *TIPSY, PROGNOSIS, YDYP*) should be employed in order to evaluate the impact of each key habitat objective (and its associated management guidelines such as reduced stocking standards or lower spacing densities) on the timber resource. Through this exercise, new yield curves can be developed that could be utilized during future Timber Supply Reviews (TSR). By utilizing the new yield curves during TSR for the specific regeneration analysis units affected by the various management practices, the full effect (i.e., Timber Supply Area, Annual Allowable Cut impacts) of these practices can be measured on a localized level.

7.0 Key Habitat Objectives – Management Guidelines and Practices

7.1 Coarse Woody Debris

Key Habitat Objective

Retain and or recruit coarse woody debris (CWD).

General Measures

1. Retain CWD on site in a way that mimics its natural distribution of randomness and connectivity, with some clumping and layering.

2. Where present, maintain and or recruit a mixture of both coniferous and deciduous CWD. Coniferous CWD decays slower than deciduous CWD, providing ecological benefits for a greater period of time; however, deciduous CWD provides important short-term ecological benefits.

3. Where safe to do so, retain some standing live trees and dead trees (snags), and or mechanically harvested stub trees on site to provide sources of recruitment CWD. Retain larger diameter trees where present --- recommended > 70 cm dbh for coastal regions and > 50 cm dbh for interior regions.

Management Guidelines

1. Retain and or recruit a range of naturally occurring CWD ground cover on cutblocks, well distributed across the forest floor on site. Depending on the site (i.e., forest type and stand age), the amount will vary widely.

2. Retain and or recruit a range of CWD piece sizes (diameter and length) and decay classes (intact and hard to partially decayed; log decay classes 1-3 preferred, see Figure 8).

3. Retain and or recruit some larger CWD pieces, > 5 m long and > 40 cm diameter. Larger material decays more slowly, holds more moisture, presents less of a fire hazard, and provides more habitat value to a greater number of wildlife species for a longer period of time.

4. Maintain some CWD in loosely layered, low-height (< 1 m) piles of up to 3 m in width. Some longer pieces (> 5 m) of CWD should radiate from the pile to

provide linear travel corridors for small mammals.

5. Where mechanically harvested stub trees are left in cutblocks, arrange loosely stacked CWD piles around stubs, using the stub as the "central axis" of the pile. Stub trees used in this context should be cut as high as possible with the feller buncher, at least 5 m in height.

6. Where practical, buck, limb and top trees on site rather than at the landing. This approach can be applied over the whole cutblock and will minimize CWD accumulations at roadsides and landings.

7. Stand damage due to windthrow is usually classified as catastrophic or non-catastrophic by forest managers. Catastrophic windthrow will generally be harvested if that can be done safely. Some of this blowdown is usually left on site due to breakage, riparian management restrictions or economic inaccessibility, and will serve as future CWD. Non-catastrophic blowdown should be left unsalvaged and is a welcome source of continuous CWD input during the rotation of a stand.

Silviculture Practices

Following are recommended Management Guidelines for silviculture activities.

Site Preparation

- minimize piling and windrowing. However, if piling, minimize pile sizes and mix piling with scattered debris.
- minimize burning of piles and accumulations, but balance this practice with consideration for undue fire or forest health hazards
- if broadcast burning is required, burn under conditions (i.e., cooler and moister) which remove fine fuels but maintain CWD and the organic soil layer
- wherever possible, maintain CWD in place – don't disturb it with heavy equipment.

Reforestation

- vary target stocking levels and inter-tree distances, and use clumped planting patterns to accommodate accumulations of CWD and reduction of plantable spots (on some portions of the cutblock).

Stand Tending

To provide recruitment of CWD over the life of the stand and into the future:

- designate wildlife tree patches (WTPs) in spacing and commercial thinning areas
- use variable thinning densities within stands
- minimize removal of non-competing deciduous stems.

Regimes Component

Development of specific regimes to achieve the coarse woody debris objective will not be possible on a broad scale. Management for the CWD conditions described above must first be considered at the landscape level. Specific stand level management tactics that will create the desired CWD conditions through rotation are extremely varied. In general, existing stand level stocking standards as described in the Establishment to Free Growing Guidebooks will not prohibit forest managers from achieving suitable CWD conditions. Stand level management strategies and tactics that work towards providing the conditions described in the General Measures and Management Guidelines sections should be implemented across the landscape (as applicable). In addition, the Standards section briefly describes various considerations that should be made during stand interventions throughout rotation.

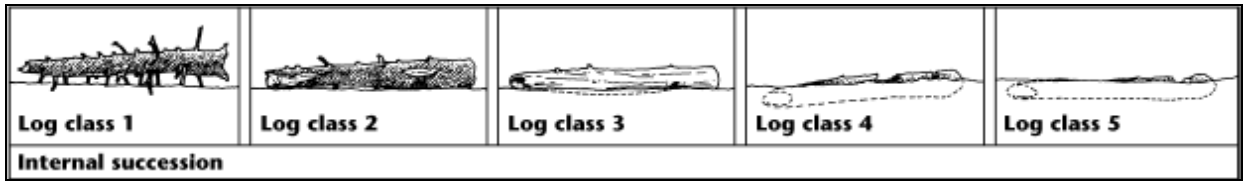

Figure 8: Coarse woody debris decay classes. Source: Wildlife Tree Committee (2001).

Standards Component

Establishment (Age 0-4 Years) Phase:

Refer to the General Measures and the Management Guidelines sections for management strategies through this portion of stand development. In general, manipulation of establishment densities and species choices will provide for the larger piece sizes and species that form a key component of CWD requirements. In addition to retention strategies at harvest, establishing new plantations which contain some areas with lower stocking at a greater than target inter tree distance (3-5 m) will aid in the development of larger piece sizes in a shorter period of time (future CWD recruitment). These areas often occur naturally across landscapes in the more extreme moisture regimes (hygric to subhygric sites); however, care should be taken during future crop planning to encourage their existence. Some sites with higher planting densities can also recruit CWD by increasing competition mortality between stems with subsequent breakage and input of CWD throughout the rotation.

Free Growing (Age 5-20 Years) Phase:

Refer to the General Measures and the Management Guidelines sections for management strategies through this portion of stand development. In general, existing establishment to free growing standards will not prohibit the achievement of desired stand conditions for CWD recruitment. However, several opportunities to augment CWD requirements exist through this period of stand development (e.g., targeting retention of a minor deciduous component during brushing; juvenile spacing small dispersed areas to minimum free growing densities thereby recruiting future large wildlife trees and subsequent CWD).

Juvenile (Age 20-60 Years) Phase:

Refer to the General Measures and the Management Guidelines section for management strategies through this portion of stand development. Existing stands within this age class may be managed to create the desired CWD composition through late juvenile spacing (e.g., space portions of treatment areas to 400-500 stems per ha for the recruitment of larger CWD) or commercial harvesting through thinning and retention strategies.

Mature (Age 60+ Years) Phase:

Refer to the General Measures and the Management Guidelines section for management strategies through this age class. In general, subsequent harvesting strategies should be implemented that are consistent with the recruitment strategies outlined.

Figure 10: CWD provides an important source of wildlife habitat and a future source of soil nutrients. Photo: Alex Inselberg.

Figure 9: Coniferous CWD typically decays slower than deciduous CWD and provides wildlife habitat for a greater length of time. Photo: Alex Inselberg.

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7.2 Wildlife Tree Patches

Key Habitat Objective

Retain and or recruit trees with valuable wildlife tree attributes.

General Measures

1. Integrate wildlife tree retention into higher level planning processes such as Landscape Unit Plans, as well as operational plans (e.g., Forest Stewardship Plans). In general, the amount and distribution of wildlife trees will be determined by biogeoclimatic subzone and will be based on the proportion of the Timber Harvesting Landbase (THLB) in the subzone and the amount of THLB that has already been harvested in the THLB without wildlife tree retention (i.e., stands < 80 years old); see BC Min. For. and BC Environ. 1999.

   Note: Site-specific factors such as the presence of ecological features of high habitat value or *Identified Wildlife Management* objectives, will influence the size and location of WTPs beyond those recommended for that subzone by the Landscape Unit planning guide.

2. Where possible, locate wildlife tree retention in association with valuable habitat features (e.g., mature or old forest patches, mixed-wood forest patches, upland hardwood patches, riparian areas, treed wetlands, and or gullies). WTPs should be sufficient in size and shape to maximize forest interior habitats.

   Note: A roughly circular patch shape, where topographically and operationally feasible, and ecologically appropriate (i.e., the patch contains the desired habitat attributes), will optimize forest interior habitat.

3. Locate WTPs in areas where there are high amounts of naturally occurring, quality wildlife trees and coarse woody debris (CWD).

4. Design wildlife tree retention to have a mix of management schemes, including patches and dispersed trees.

5. Retain a variety of tree species, including deciduous (particularly, trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*)) within WTPs.

6. Leave blowdown that occurs in WTPs as downed material for CWD.

Management Guidelines

1. Retain a range of tree diameters (starting at 20 cm dbh and greater) and tree classes (subject to safety requirements) within WTPs, (tree classes 2-6 are preferred for retention).

2. Retain larger trees (in the upper 10% of the diameter range distribution) that have one or more of the following characteristics. Minimum preferable diameters are **> 70 cm dbh for coastal areas and > 50 cm dbh for interior areas**.

    - show evidence of wildlife use
    - presence of heart rot decay (fungal conks may be visible)
    - large diameter (>100 cm dbh) hollow stems (particularly cedars which can function as bear dens or bat roosts)
    - stem scars
    - dead or broken tops
    - thick fissured bark or have well-branched structure.

3. Where available, use standing dead (class 3-7) or live defective trees (class 2) with characteristics as described in #2 above, as "biological anchors" around which WTPs can be designed. Having a green tree buffer around the anchor tree(s), will enhance the habitat value of these trees.

4. Maintain some WTPs beyond typical rotation periods (at least 60-100 years or greater) to allow mature and old forest attributes to develop.

5. When conducting juvenile spacing or thinning activities, space some sites to lower than target densities in order to create a more open stand. This will recruit larger, "wolfy" trees that can become better future wildlife trees.

6. Where necessary, use the dangerous tree assessment procedures found in the provincial "Wildlife/Danger Tree Assessor's course" (see WTC 2001) to evaluate potential tree hazards and risks to workers in areas where there are standing dead or defective trees. Use these techniques to retain standing dead structure in a safe manner in both harvesting and silviculture operations.

7. Where operationally feasible and ecologically appropriate, the following activities can be used to enhance wildlife tree densities in areas deficient of naturally occurring wildlife trees by:

- Planting upright snags with an excavator. This technique uses cull logs and is usually only recommended for activities such as road deactivation or other areas where no standing dead structure exists.
- Creating stubs (stems cut at 4-6 m high with a mechanical harvester). Stubs should be retained in small clusters; leave advance regeneration or deciduous trees around the stubs to provide additional cover.
- Inoculating live coniferous trees with endemic heart rot fungi. This is an ecosystem-specific technique bested suited to second growth stands and is currently being operationally tested in B.C. (see Manning 2003).

8. Trees considered for fungal inoculation should be reserved as "full cycle trees" (i.e., until they have decayed as CWD). Selected trees should typically be healthy, class 1, second growth trees, such as, dispersed trees or seed trees found in partial cutting silvicultural systems (recommended species for inoculation include Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*) and spruce (*Picea* spp.)).

Regimes Component

Development of specific silviculture regimes to achieve the wildlife tree patch objective will not be possible on a broad scale. Management for the WTP conditions described above must first be considered and incorporated into landscape level planning. Specific stand level management practices that will create the desired WTP conditions throughout rotation lengths are extremely varied. In general, existing stand level stocking standards as described in the Establishment to Free Growing Guidebooks will not prohibit forest managers from achieving suitable WTP conditions. Stand level management strategies and practices that work towards providing the conditions described in the General Measures and Management Guidelines sections should be implemented across the landscape (as applicable).

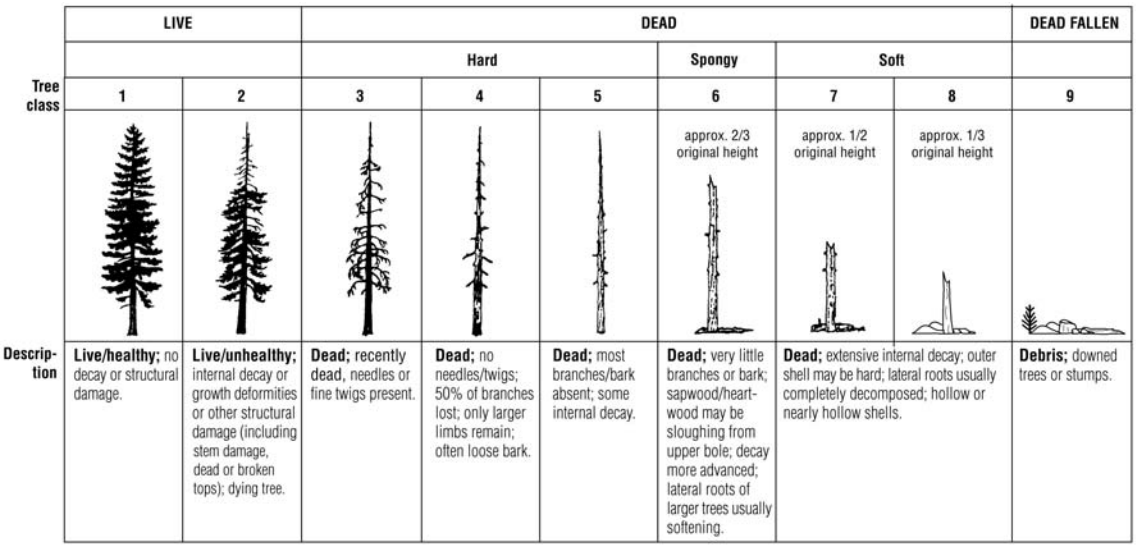

Figure 11: Coniferous wildlife tree decay classes. Source: Wildlife Tree Committee (2001).

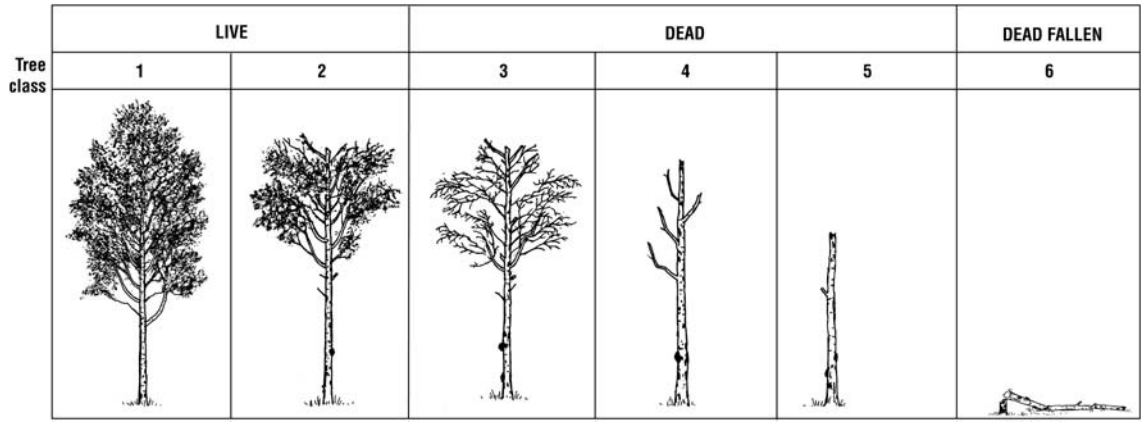

Figure 12: Deciduous wildlife tree decay classes. Source: Wildlife Tree Committee (2001).

Figure 13: Wildlife trees provide important habitat for various bird species, including great horned owls. Photo: Alex Inselberg.

Figure 14: Diverse stand structure provides CWD, varied shrub understory and a broad range of tree classes and sizes. Photo: Alex Inselberg.

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7.3 Primary Cavity Excavators

1. Key Habitat Objectives

Maintain and or recruit habitat elements for primary cavity excavators (includes 19 species of native birds) – for reproduction, roosting, and foraging.

Landscape Level: A discussion of landscape level considerations relevant to the management of wildlife trees is found in section 7.2 of this report.

Note: by providing habitat for primary cavity excavating birds, a variety of secondary cavity users benefit -- using the abandoned woodpecker cavities and excavations for nesting, denning and roosting (see WTC 2001 for additional information on wildlife tree-dependent species).

2. Forest Types or BEC Zones

BWBS mw, CDF all, CWH ds, ms, ws, xm, ICH dk, dw, mw2, xw, IDF all, MS dk, PP dh, SBPS dc, mk, SBS dk, dw, mc, mh, mk

Note: While primary cavity excavators occur in all BEC units which have suitable trees, the above zones or subzones are those that generally have "high" habitat suitability for a range of primary cavity excavating bird species. In addition, the following subzones have a "high" habitat suitability for specific woodpeckers:

- CWH vh, wh for "Queen Charlotte" Hairy Woodpecker (*Picoides villosus picoideus*) on the Queen Charlotte Islands
- BG xh, xw for ponderosa pine and cottonwoods for Lewis's Woodpecker (*Melanerpes lewis)*
- PP dh, xh for ponderosa pine for Lewis's Woodpecker
- ESSF for Three-toed Woodpecker (*P. tridactylus*).

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Retain standing dead trees (snags) and live defective trees (class 2 trees) where safe to do so. Include trees with dead tops, broken tops, thick fissured bark, lightning scars or stem cracks, fire scars, mechanical injury stem scars, or evidence of internal decay (i.e., presence of fungal conks, woodpecker cavities and excavations). See WTC (2001) for further **information on wildlife/danger tree assessment procedures** in harvesting operations and along roads.

2. Where possible, retain standing dead or defective trees located within green tree patches (i.e., Wildlife Tree Patches (WTPs), also see sec. 7.2). Using dead or defective trees as "biological anchors" around which WTPs are built, will increase the habitat value of these trees.

3. Retain some larger diameter healthy live trees (known as class 1 trees) across rotation lengths into the next rotation (at least 60-100 years, or greater) for recruitment of future wildlife trees. For operational efficiency and biological reasons, clumpy or patchy distribution is preferred to single tree, dispersed distribution. The latter, however, can also significantly add to meeting retention objectives.

4. In general, larger diameter and taller wildlife trees provide better habitat quality:
   - > 70 cm dbh conifers are preferable in coastal areas and the interior wet belt of B.C.
   - > 50 cm dbh conifers are preferable in interior areas of B.C.
   - > 15 m in height.

5. Retain large (> 40 cm dbh) trembling aspen (*Populus tremuloides*) and a range of sizes and decay classes of paper birch (*Betula papyrifera*) where they occur throughout interior B.C. Mixed wood stands containing these species are especially valuable.

6. Retain large diameter (> 50 cm dbh) black cottonwood (*Populus balsamifera trichocarpa*), especially in riparian areas.

7. In the PP, IDF and MS zones, where safe to do so, retain > 50 cm dbh ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*) and western larch (*Larix occidentalis*) that are decayed, structurally damaged, or have woodpecker cavities and excavations.

8. On the coast and interior wet belt, retain some large (>40cm dbh) red alder (*Alnus rubra*), preferably class 2 trees which have some stem defects such as scars, cracks or forks.

9. Leave some trees in the more advanced decay stages (classes 5-8, often referred to as "soft snags") as habitat for the weak primary cavity excavating bird species (e.g., nuthatches (*Sitta* spp.), chickadees (*Poecile* spp.) and some sapsuckers (*Sphyrapicus* spp.)). For operational and safety reasons, trees of this condition are best retained within WTPs and other treed reserves.

10. Consider recruiting future wildlife trees by inoculation with native heart rot fungi (see Restoration below).

Pileated Woodpecker (*Dryocopus pileatus*)

Because of their important role as a keystone species in forest ecosystems, specific Management Guidelines should be implemented to provide habitat for Pileated Woodpecker, as follows:

1. Provide large coarse woody debris (CWD) > 5 m in length and > 50 cm diameter to cover 10-20% of the forest floor (i.e., on the cutblock). Some of this material should be partly elevated, or in piles for slower decay and longer use. This in turn will provide habitat for carpenter ants (*Camponotus*

pennsylvanicus), Pacific dampwood termites (*Zootermopsis angusticollis*) (CDF mm) and other insects, which are food for Pileated Woodpeckers.

2. Where grand fir (*Abies grandis*) occurs (CDF, CWH, ICH zones), provide reserves of mature or old grand fir with > 60% canopy closure and > 10 grand fir (> 50 cm dbh) per ha, for nesting and roosting habitat. These areas can be identified in higher level or operational plans and can include old growth management areas, ungulate winter ranges, wildlife tree patches (> 2 ha in size), or other areas that contain mature or old forest.

3. Because of the large home range sizes of Pileated Woodpecker, provide at least 1 large diameter conifer per ha (> 70 cm dbh, tree classes 2-5 recommended) across the landscape for roosting, nesting or feeding habitat. Include grand fir, Douglas-fir, western larch or western redcedar (*Thuja plicata*) where present (preferably already "cat-face" scarred, or with evidence of heart rot or insect attack).

Williamson's Sapsucker (*Sphyrapicus thyroideus*) and **Lewis's Woodpecker** will benefit from the following specific habitat management practices. Also refer to the *Identified Wildlife Management Strategy* (see http://wlapwww.gov.bc.ca/wld/identified/, or ftp://ftp.env.gov.bc.ca/pub/outgoing/identified%20Wildlife/) for additional management guidelines concerning these two species.

Williamson's Sapsucker – in the ICH, IDF and MS zones of the Southern Interior and Southern Interior Mountains ecoprovinces:

1. Where safe to do so, retain all broken-topped western larch veterans (either live or dead) and veteran larch with fungal conks or presence of nest cavities.

2. Retain live western larch within a range of diameter classes to become future recruitment nest and roost trees.

Lewis's Woodpecker – in the IDF, PP and BG zones of the Southern Interior and Southern Interior Mountains ecoprovinces:

1. Retain larger live ponderosa pine and Douglas-fir (class 1 or 2, > 50 cm dbh), if available at a density of at least 2 trees per ha.

2. Retain large diameter (> 50 cm dbh) black cottonwood where present.

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. When harvesting in **second growth conifer stands**, consider fungal inoculation of some larger diameter (> 70 cm dbh in coastal areas and > 50 cm dbh in interior areas) live individual leave trees (Douglas-fir, western larch, ponderosa pine, spruce (*Picea* spp.) recommended) with native heart rot fungi (*Phellinus pini*, *Fomitopsis officinalis* or *Fomitopsis pinicola* recommended) to create heart rot decay. Selected trees should be **inoculated at least 10 m above ground**. These trees should be retained at least for the length of the rotation (60-100 years or more) and should accelerate recruitment of wildlife trees over natural decay dynamics, thereby increasing habitat supply for woodpeckers and other cavity users. See Manning (2003) for additional

information on fungal inoculation.

2. In dry ecosystems (BG and PP zones, and xeric to mesic IDF subzones), leave wildlife trees for primary cavity excavators in restoration cuts.

3. In fire maintained ecosystems (e.g., PP zones and drier IDF subzones) where fire suppression has allowed significant forest ingrowth, consider recruiting some larger diameter conifer stems within a more open stand by prescribing low intensity burning and reducing stocking densities. If some standing green trees are burned unintentionally, consider leaving them as wildlife trees.

4. Low intensity ground fires are beneficial to the maintenance or enhancement of large diameter veteran ponderosa pine, western larch and Douglas-fir stands. Stands may have to be thinned prior to burning in order to remove excess fuels and the possibility of destroying retained wildlife trees.

Regeneration:

1. Manage for inclusion or natural acceptance of some Douglas-fir, western redcedar, western larch, ponderosa pine or grand fir on sites where they are preferred or acceptable, even when otherwise managing for single species crops of other species such as lodgepole pine (*P. contorta*) or western hemlock (*Tsuga heterophylla*).

2. When prescribing free growing stocking standards for most sites, allow for variances in both stocking densities (e.g., some lower density patches of below minimum stocking for the development of large wildlife trees, especially in NDT4 ecosystems), and variances in species composition (e.g., a hardwood component such as red alder, trembling aspen, paper birch or black cottonwood).

3. Try to avoid damage to the root systems and boles of retained wildlife trees during mechanical site prep. activities.

4. In ecosystems with a naturally high diversity of tree species (e.g., ICHdw and ICHmw2), consider regenerating stands either naturally, or by planting a variety of representative tree species for the site.

Brushing:

1. When brushing, maintain some black cottonwood, paper birch, trembling aspen or red alder on suitable microsites, bench sites and flood plains.

2. When prescribing red alder brush treatments allow for partial screefing of up to 20 stems per ha of red alder (where it is present) which stresses the stem, thereby increasing its potential value as a wildlife tree.

Spacing/Thinning/Pruning:

1. Spacing or thinning of stands allows manipulation of species composition in order to retain a relatively larger proportion of the preferred wildlife trees for

a given ecosystem (e.g., grand fir on the coast, and western larch or ponderosa pine in the southern interior). In general, stand tending (pruning, spacing or thinning) tends to have the following beneficial effects on woodpecker habitat quality by affecting the volume and diameter of snags and CWD recruited into the stand:

- Stand tending decreases the future volume of CWD present in the stand but increases the average future size of the CWD.
- Spacing or thinning of stands increases tree incremental growth, thus recruiting trees to become larger snags at an earlier age.
- Allow for variable density thinning to minimum densities on some areas of a stand in order to recruit larger diameter wildlife trees of preferred tree species.

NOTE: consider retaining dead and defective trees as **wildlife trees in all of the above silviculture activities**. Consult the "Wildlife/Danger Tree Assessor's Course" (WDTAC, see WTC 2001) for information on tree assessment criteria and procedures. All consult the Wildlife Tree Committee of B.C. website (URL: http://www.for.gov.bc.ca/hfp/wlt/) for information on WDTAC course qualifications and registration contacts.

Protection (fire, insects, disease, damage):

1. Piling and burning of CWD should be avoided where possible, as feeding opportunities for various woodpeckers are greatly reduced. However, escaped fringe burns can dramatically increase both woodpecker feeding and nesting opportunities in some areas. Do not salvage burned trees in escaped fringe burns (unless they pose an unacceptable forest health or worker safety risk).

2. Where slash is piled for burning, large CWD should either be excluded from the piles, or piles should be left unburned (this will also benefit small mammals).

3. Root rot pockets (both *Phellinus* spp. and *Armillaria* spp.) will provide temporary feeding opportunities for primary cavity excavators. However, most immature or thrifty mature standing dead trees with sap rot provide poor quality nesting habitat for primary cavity excavators, but can be good foraging sites. Large diameter and veteran Douglas-fir and western larch which have root rot infections and which are dying from the crown down, are, on the other hand, suitable wildlife trees. **Infected trees in this condition should be retained singly or in wildlife tree patches**; therefore plant disease-resistant species around root rot patches to minimize spread into adjacent plantations. Root rot-killed trees are also important for weak primary cavity excavators such as nuthatches and chickadees.

4. Conifers infected by bark beetles are used by various woodpeckers for feeding and in some cases for nesting. When salvage harvesting such stands, some beetle killed, large diameter pine, spruce or Douglas-fir should be left in wildlife tree patches and preferably surrounded by other non-infected and/or non-susceptible green trees (e.g., hardwoods).

5. Recommended Silvicultural Regimes

- Development of specific regimes to achieve the desired habitat objectives for primary cavity excavators will not be possible on a broad scale. Management for these habitat conditions must first be applied at the landscape level. Specific stand level management tactics that will create the desired habitat conditions through rotation are extremely varied. In general, existing stand level stocking standards as described in the Establishment to Free Growing Guidebooks will not prohibit Forest Managers from achieving suitable habitat conditions for primary cavity excavators. Stand level management strategies and practices that work towards providing the conditions described in the Management Guidelines sections should be implemented across the landscape (as applicable, see suitable BEC zones noted above). In addition the Standards section briefly describes various considerations that should be made during stand interventions throughout rotation.

6. Monitoring Standards

Establishment (Age 0-4 Years) Phase:

Refer to the General Measures and the Management Guidelines sections for management strategies through this portion of stand development. In general, manipulation of establishment densities and species choices will provide for the larger piece sizes and species that form a key component of habitat requirements. In addition to retention strategies at harvest, establishing new plantations with areas that contain lower stocking at a greater than target inter tree distance (3-5 m) will aid in the development of larger piece sizes in a shorter period of time. These areas generally occur across a landscape naturally in the more extreme ecosystems (hygric to subhygric sites), however, care should be taken during future crop planning to ensure their existence.

Free Growing (Age 5-20 Years) Phase:

Refer to the General Measures and the Management Guidelines sections for management strategies through this portion of stand development. In general, existing establishment to free growing standards will not prohibit achievement of desired stand conditions for this habitat objective. However, several opportunities to augment habitat requirements exist through this period of stand development (e.g., by targeting retention of a minor deciduous component during brushing or by juvenile spacing small dispersed areas to minimum free growing densities, will allow for future recruitment of large wildlife trees).

Juvenile (Age 20-60 Years) Phase:

Refer to the General Measures and the Management Guidelines section for management strategies through this portion of stand development. Existing stands within this age class may be managed to create the desired larger stem sizes and species composition through late juvenile spacing (space portions of treatment areas to 400-500 stems per ha) or commercial harvesting through variable thinning and variable retention strategies.

Mature (Age 60+ Years) Phase:

Refer to the Management Guidelines section for management strategies through this age class. In general, subsequent harvesting strategies should be implemented that are consistent with the retention strategies outlined. Consider periodic monitoring to determine whether wildlife trees of suitable condition are being retained and managed for primary cavity excavators.

Figure 16: Wildlife trees provide forage habitat for pileated woodpeckers and other primary cavity excavators. Photo: Alex Inselberg.

Figure 15: Mixed-wood stands provide good nesting and foraging habitat for primary cavity excavators. Photo: Alex Inselberg.

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7.4 Northern Goshawk (*Accipiter gentilis atricapillus* and *A. g. laingi*) Reproduction & Foraging

1. Key Habitat Objectives

Maintain and or recruit habitat elements for Northern Goshawk – for reproducing and foraging (applicable to interior subspecies *A.g. atricapillus* and coastal subspecies *A.g. laingi*).

Landscape Level: Landscape level management objectives such as connectivity, patch size distribution and seral stage targets should be described in higher level plans and sustainable forest management plans. Provide a mosaic of mature or old forest reserves and forested corridors to provide habitat and habitat connectivity across landscapes. It is important to link higher level plan objectives such as mature/old forest targets and old growth management areas (OGMAs) for a landscape unit or other planning area, with specific practices implemented at the stand level (see Management Guidelines below).

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report. Also refer to the *Identified Wildlife Management Strategy* (see http://wlapwww.gov.bc.ca/wld/identified/ ,or ftp://ftp.env.gov.bc.ca/pub/outgoing/identified%20Wildlife/) for additional detailed management guidelines for Northern Goshawk.

2. Forest Types or BEC Zones

Interior: BWBS wk1, mw1, ESSF dk, ICH dw, mc1, mc2, mw2, xw, IDF dk, dm2, MS dk, dm2, SBS wk2; **Coastal:** CWH mm, vh, vm1, vm2, wh1, xm

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Maintain and or recruit forest structure [e.g., snags, wildlife tree patches (WTPs) and coarse woody debris (CWD)] in harvested areas which will provide foraging habitat after regenerated stands begin to self-thin.

2. Maintain and or recruit forest buffers around and travel corridors in between: riparian areas (including streams and wetlands), areas of significant forest structure (e.g., old forest patches), and topographical features such as gullies and rock outcroppings.

3. Maintain and or recruit mature and old forest canopy characteristics (e.g., a single-storied main canopy with a high overall canopy closure (60-90%);

canopy gaps; areas with multi-layered canopies; some dispersed single or imbedded patches of hardwood components (e.g., trembling aspen (*Populus tremuloides*) in the interior and red alder (*Alnus rubra*) on the coast); and average main canopy tree height > 20 m in the interior and >35 m on the coast.

4. Implement partial cutting and retention strategies that create a mosaic of accessible, semi-open foraging habitats as well as some areas with higher canopy closure (>60%) containing some large diameter trees (i.e., as suitable nest trees).

5. On slopes, give priority to habitat enhancements located at low-mid slope positions and on slope benches. Benches appear to be preferred locations for nest sites.

6. Because of their more open canopy structure, old roads, trails and railway grades are often used by goshawks as flight paths and for foraging.

7. In the interior, retain and recruit large diameter trembling aspen (> 40 cm dbh) where present, as these are often used as nest trees by both goshawks and some of their prey species (i.e., woodpeckers).

8. In the ICH, manage for western hemlock (*Tsuga heterophylla*) as the leading conifer species (refer to stand characteristics in #3 above).

9. In the CWH, manage for Douglas-fir (*Pseudotsuga menziesii)* or western hemlock as the leading conifer species (refer to stand characteristics in #3 above).

10. In the BWBS, manage for mixed coniferous/deciduous stands (refer to stand characteristics in #3 above).

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. In **second growth conifer stands**, consider fungal inoculation of some larger diameter (> 30 cm dbh in the interior; > 50 cm dbh on the coast) **live** individual leave trees (Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), white spruce (*Picea glauca*) recommended) with endemic heart rot fungi (*Phellinus pini* recommended) to create heart rot decay. These trees should be retained for the length of the rotation or several rotations (≥ 60 years), to accelerate wildlife tree recruitment (i.e., to create trees which can accommodate cavity excavators/dwellers) and thereby increase habitat supply for the goshawk prey base.

Regeneration:

1. Regenerate with the preferred and acceptable species for the indicated microsites with the overall aim to achieve closed, raised canopies as soon as

possible in order to reduce dense understory and achieve self-pruning of the low to mid boles. Allow for some species mixes by planting or natural ingress singly, in dispersed groups or patches, as well as scattered brushy openings and hardwood components for diversity of prey species (e.g., small mammals, songbirds and grouse).

Brushing:

1. Early plantation brush treatments will release and manage distribution, future stem density and tree species composition. Early brush treatments per se will have little direct influence on actual understory brush densities at the time of goshawk use (later in the rotation). However, these treatments will create or maintain some brushy openings in a stand as habitat for passerine bird prey species and grouse habitat.

2. Maintain, through brushing treatments, low to moderate levels of ground vegetation cover (< 40%), and relatively open understories.

3. Maintain some open grown areas with brush, hardwood components or other prey species (e.g., passerine birds and grouse) habitat for future maintenance within an otherwise densely managed coniferous stand.

Spacing/Thinning/Pruning:

1. Thin and space early seral stands to reduce successional time for a stand to exhibit mature and old forest characteristics.

2. Maintain and or recruit, through spacing and thinning treatments, low to moderate levels of ground vegetation cover (< 40%), and relatively open understories.

3. Space on sites where understory western hemlock ingress is high (e.g., coastal 03 to 01 site series). Ensure that the first spacing is done well after overstory crown closure and that all understory western hemlock are cut below the lowest live limb.

4. Target an overall stand matrix with raised coniferous canopies (with crown closures >60%), low to moderate understory vegetation, and fairly high stem densities. Within these stands, create or maintain some diverse openings for shrubs and single trees, or scattered patches of hardwoods to create and or maintain goshawk prey habitat.

Fertilization:

1. Forest fertilization can be expected to accelerate overall stand development by increasing bole diameters, canopy closure and accelerating understory brush die-back and self-pruning below the canopy.

2. Fertilize at an early seral stage (usually at the time of, or soon after juvenile spacing) to reduce successional time for a stand to achieve crown closure, self-pruning and understory brush suppression.

Protection (fire, insects, disease, damage):

1. Maintain some unburned slash piles to create goshawk prey habitat (e.g., small mammals and birds) within the future stand.
2. Maintain large CWD and slash accumulations, non-catastrophic blowdown to achieve similar results.
3. Insect and disease pockets of dead standing and downed CWD trees will maintain scattered prey habitat niches in a stand.

5. Recommended Silvicultural Regimes (Even Aged Systems)

BEC – Zones	**Submesic to Subhygric sites**:
BWBSwk1, mw1, ***CWHvm1, vm2, xm, mm, vh, wh1*** ***ESSFdk*** ***ICHmw2, dw, xw, mc1, mc2*** ***IDFdk, dm2*** ***MSdk, dm2*** ***SBSwk2***	Management of these sites should focus on the enhancement and or recruitment of stand structure and habitat elements for goshawk. The associated standards reflect this goal, primarily the desire to move to closed canopies with little understory vegetation as rapidly as possible. **The following regimes reflect only those possible regimes associated with even aged silvicultural systems.** • Silvicultural systems that may be applicable for this objective include: Clearcut with reserves, Variable Retention Cut, Seed Tree, and Shelterwood systems. • Where safe to do so, all site preparation treatments should protect wildlife trees retained during harvesting and should maintain some slash piles unburned when machine piling. • Establish plantations on a uniform pattern to encourage earlier crown closure. The intent is to have the wetter and drier ecosystems across a landscape naturally provide the canopy gaps that goshawks require. Therefore, management of submesic to subhygric ecosystems is intended to develop closed canopy stands containing some gaps as rapidly as possible, with little understory vegetation (except in the gaps). • Maintain low levels of competing vegetation through the establishment phase by manual, or possibly chemical, treatments (ensure adequate buffers adjacent to nesting areas). Other opportunities that may be available through the establishment phase that can coincide with brushing treatments include girdling of retained green wildlife trees to initiate stem decay for snag recruitment and future CWD. • Implement juvenile spacing programs as required (max density 4000 stems per ha) to ensure an even distribution of crop trees and even rapid crown closure occurs. Post spacing standards should equal the target stocking standard for single entry spacing. Opportunities to initiate stem decay for snag recruitment and CWD requirements should be considered during spacing operations (e.g., girdling or fungal inoculation of existing green trees, see Restoration section).

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.1 – Stocking Standard Guidelines

Applicable Ecosystem (BEC)			Stocking Standard Modifiers									
Zones	**Subzones**	**Moisture Nutrient Regime**	**Species Selection**	**Stocking Standard Modifier**	**Regen Delay**	**Assessment Time Frame**	**Minist. Tree Ht.**	**% Tree Over Brush**	**Min Inter Tree Distance**	**Max Density**	**Survey Method**	**Comments**
BWBS	wk1, mw1	3-5/B-E	Broadleaf[1]	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
CWH	vm1, vm2, xm, mm, vh, wh1	3-5/B-E	Same	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
ESSF	dk	3-5/B-E	Same	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
ICH	mw2, dw, xw, mc1, mc2	3-5/B-E	Same[3]	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
IDF	dk, dm2	3-5/B-E	Same	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
MS	dk, dm2	3-5/B-E	Same	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	
SBS	wk2	3-5/B-E	Same	Same	Same	Same	Same	Same	2.0	Footnote 2	Same	

1. Broadleaf species management for mixed coniferous/deciduous stands should be seriously considered where applicable for this management objective. Utilize the appropriate broadleaf species as a primary or secondary species as indicated in the Establishment to Free Growing Guidebooks.
2. Maximum density is 4000 stems per ha for these ecosystems. Post spacing densities should equal target stocking standard densities. The relatively narrow range from MSS to max density is intended to provide for a rapid move to old forest canopy characteristics (e.g., a single-storied main canopy with a high overall canopy closure (60-90%) and relatively open understories).
3. In the ICH manage for western hemlock as the leading conifer species where present.

6. Monitoring Standards – Additional

Establishment (Age 0-4 Years) Phase:

N/A. Refer to the Management Guidelines section for management strategies through this portion of stand development.

Juvenile (Age 20-60 Years) Phase:

No specific standards are developed for this point in stand development. Management of younger age classes (e.g., establishment to free growing 0-20 years) is intended to develop suitable stand conditions through this age class. Existing stands within this age class may be managed to create the desired closed, even canopy conditions through late juvenile spacing or commercial thinning.

Mature (Age 60+ Years) Phase:

No specific standards are applicable for this age class. In general, subsequent harvesting strategies should be implemented that are consistent with the Management Guidelines outlined. Consider monitoring as appropriate to determine if desired structural characteristics have been achieved.

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7.5 Coastal Black-Tailed Deer (*Odocoileus hemionus columbianus*) and Roosevelt Elk (*Cervus elaphus roosevelti*) Winter Range

1. Key Habitat Objectives

Maintain and or recruit habitat elements for coastal black-tailed deer and Roosevelt elk winter range – for winter forage supply, thermal protection (snow interception) and security cover.

Landscape Level: Landscape level management objectives such as connectivity, patch size distribution and seral stage targets should be described in higher level plans and sustainable forest management plans. It is important to link higher level plan objectives such as mature/old forest targets for a landscape unit or other planning area, with specific practices implemented at the stand level (see Management Guidelines below for ungulate winter ranges).

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report.

NOTE: The Management Guidelines described below are intended for areas of **high ungulate winter range suitability**.

2. Forest Types or BEC Zones

CDF mm; CWH dm, mm, vm, xm

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Retain and or recruit critical winter habitat (i.e., mature forests in low snowpack zones; old forests in moderate or deep snowpack zones). These stands should be predominantly Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) leading with closed, multi-layered canopies (generally > 60% canopy closure), located on moderate to steep slopes (approximately > 40%) on warm, southerly aspects in low, moderate and deep snowpack areas. This stand structure provides a balance of snow interception and browse/litter fall availability.

2. Retain and or recruit winter forage and some understory cover (e.g., western hemlock and western redcedar) in mature and old forest stands on valley bottoms and slopes that receive winter sun that are < 1000 m in elevation.

3. Minimize the width (< 120 m or two tree lengths) of harvest openings to provide accessible security cover for foraging ungulates.

4. Security cover patches should be a minimum of 100-300 m wide for deer and 100-500 m wide for elk.

5. Maintain and or recruit forage areas through alternative silvicultural practices (e.g., sequential harvesting, single heavy thinning, or repeated lighter thinning and or pruning/thinning combinations).

6. Maintain and or recruit forage areas by creating openings with small group selection or clumpy single tree selection (i.e., maximum opening width of 2 tree lengths with sizes ranging from 0.2-0.6 ha).

7. Maintain and or recruit openings adjacent to rock outcroppings, particularly down slope and or southerly aspect to maximize solar exposure.

8. Reduce slash to a depth of < 20 cm on 75% of treatment areas in important foraging habitat.

9. Minimize the amount and size of roads and landings in important forage habitat. Where possible, new roads should not be constructed within designated ungulate winter ranges unless there is no other practicable option and the quality of the winter range will not be significantly affected.

10. Retain and or recruit vegetation or incorporate topographical relief into cutblock layout that visually screens ungulates from roads and access points.

11. Retain and or recruit deciduous tree components, particularly in wetter or nutrient rich sites.

12. Retain and or recruit ungulate forage species such as Douglas-fir, western hemlock, western redcedar, western yew (*Taxus brevifolia*), black cottonwood (*Populus balsamifera*), *Vaccinium* spp., willow spp. (*Salix* spp.), red elderberry (*Sambucus racemosa*), Pacific ninebark (*Physocarpus capitatus*), bitter cherry (*Prunus emarginata*), Pacific crabapple (*Malus fusca*), cascara (*Rhamnus purshiana*), red-osier dogwood (*Cornus stolonifera*), Douglas maple (*Acer glabrum*), dull Oregon-grape (*Mahonia nervosa*), salal (*Gaultheria shallon*), deer fern (*Blechnum spicant*), sword fern (*Polystichum munitum*), bunchberry (*Cornus canadensis*), arboreal lichens, grasses (*Poaceae* spp.) and sedges (*Carex* spp.).

13. For deer, retain and or recruit mature and old stands with high canopy cover (60-90%) in moderate to steep slopes (> 40%), on warm aspects (110-250^{o}) that receive winter sun and have spring range located within 2 km.

14. For elk, retain and or recruit mature and old stands with high canopy cover (60-90%) in lowland areas with gentle slopes (< 10%), particularly in river floodplains, riparian areas, or sites with rich, moist soils.

15. For both deer and elk, retain some red alder (*Alnus rubra*), red alder/bigleaf maple (*Acer macrophyllum*) or black cottonwood patches, especially on site rich floodplains where early spring herb and shrub forage will be available before hardwood canopies leaf-out.

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. Wherever cover seed mixes are used for stabilization, prefer legumes or legume-grass mixes over grass alone, for higher forage value. Where shrubs such as willows are used to stabilize slopes, slides, cut banks and riparian zones, consider also adding additional forage species such as Pacific ninebark, elderberry, red-osier dogwood and tree species such as black cottonwood.

Regeneration:

1. On hygric and sub-hygric site series, periodically flooded areas, very rich and brush prone riparian areas, seepage sites, slide paths, slide fans and areas where the remaining old growth stumps indicate very low previous old growth stocking, consider a variance for lowering stocking standards as compared to the adjacent plantation; also consider wide cluster planting on available micro-sites only. On these sites, consideration should be given to plant or accept some hardwood species such as black cottonwood, red alder or bigleaf maple (or trembling aspen (*P. tremuloides*) in transition zones).

2. On some site series of the CDF, CWH and ESSF transition zone and other sites where Douglas-fir may only be an alternative species on suitable microsites to the otherwise indicated main crop species, consider planting fir or a component of fir for snow interception, especially on south or west facing slopes. In a similar way, western redcedar should be planted together with the main crop species on suitable microsites in order to provide an understory nurse and cover crop, additional ungulate forage, or for disease resistancy.

3. Consider reducing stocking standards in areas where spring forage maintenance is a priority (e.g., burned sites near UWRs).

Brushing:

1. Before prescribing brush treatments, consider leaving some less competitive species unbrushed as forage, including cascara, bitter cherry, willow spp. and red-osier dogwood, while still obtaining the required stocking targets.

Spacing/Thinning/Pruning:

1. Spacing between clusters should be adjusted to reflect site conditions and microsite location. Uniform distribution of clusters over the block is appropriate where site conditions are relatively uniform. However, clusters should be located on appropriate planting sites, taking advantage of natural site features such as elevated hummocks or stumps.

2. Inter-cluster spacing is measured from the centre of one cluster to the centre of the adjacent ones on a square grid. However, where sites are undulating,

clusters should be located on appropriate planting sites to take advantage of natural features such as elevated hummocks or stumps. Inter-cluster distances should be varied in order to optimize microsite selection.

3. Inter-cluster spacing is recommended to be a minimum of 80% and a maximum of 120% of that required to achieve the desired planting target. This range should result in achieving the overall desired stocking density, within acceptable statistical limits, when a stocking survey is applied across the area.

4. "Dispersed or non-uniform cluster" uses a mix of cluster densities across the block, and is appropriate for some blocks where microsites suitable for clusters (e.g., elevated hummocks) are not evenly distributed.

5. For dispersed cluster planting, the minimum inter-tree distance within a cluster is 1.5 m on suitable microsites. The number of suitable clusters per ha should be estimated from a reliable survey that covers the entire area. The minimum/maximum inter-cluster distances may vary substantially, as long as the overall target density is met.

6. When spacing to target spacing densities where the stand contains an understory component of western redcedar, at least 200 stems per ha of understory western redcedar should be kept and additional understory western redcedar may be cut at 1+ m height to create browsing bushes for winter forage.

7. Do not space or thin brush pockets, open slide areas, or dry vegetated bluffs. If these types of natural openings are uncommon in the local area, similar openings can be created by either spacing portions of the area to much lower densities (e.g., as low as 150-250 stems per ha on the coast, or by spacing out actual small openings of 8-10 m radius (preferably around still living preferred forage species such as red elderberry, red-osier dogwood, or *Vaccinium* spp). Creation of these types of openings is most valuable in areas near existing ungulate winter ranges.

8. Pruning may be beneficial along south facing ledges, slide paths, bluffs and bank drop-offs in order to increase lateral light incidence for shrub development and early spring bedding warmth.

Protection (fire, insects, disease, damage):

1. Most prescribed fire methods will be of benefit to both deer and elk by:

   a) rejuvenating shrub and herb forage growth and nutrient quality; and
   b) reducing slash loading, which could interfere with animal movement and suppress shrub and herb development.

2. Where catastrophic insect infestations, disease or catastrophic windthrow on important deer and elk winter ranges result in larger than otherwise planned for harvest openings (because of salvage operations), an effort should be made to maintain still-existing patches, groups or individual trees which were either unaffected by the disturbance event or are resistant to the insects and diseases of concern. In most cases this will include western redcedar and Douglas-fir. Recruitment and or replacement of the UWR with a nearby stand should be considered where the quality of the UWR has been significantly affected.

3. *Armillaria* spp. root disease occurrence on the coast can be beneficial on ungulate ranges by acting as a natural spacing agent, creating more inter-tree forage.

5. Recommended Silvicultural Regimes (Even Aged Systems)

BEC – Zones

CWH xm, dm, mm, vm

CDFmm

Subhygric to Hygric sites:

Management of these sites should focus on the enhancement and or recruitment of areas for woody ungulate forage species. The following regimes reflect only those possible regimes associated with even age silvicultural systems.

- Silvicultural Systems that may be applicable for this objective include: Clearcut, Patch Cut, Shelterwood, Retention, Seed Tree, and Selection systems. The season of harvest should be limited to conditions that will limit soil and root disturbance.
- Consider establishing new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section.
- Management Plans should detail how herbicide users will maintain important ungulate forage habitats. Consider selective herbicide treatments such as stem injection, basal bark and selective backpack treatments as alternatives to broadcast herbicide treatments.
- During brushing and or spacing treatments ensure that forage production between clusters can be sustained or enhanced for a longer period by employing spacing regimes that allow for at least some widely spaced areas or pockets.
- Implement juvenile spacing programs as required to ensure canopy gaps linked to forage production will be present later into stand development (20-60 years). Keep in mind that spacing width is directly related to canopy gap maintenance and forage availability. Any spacing regime over 500 stems/ha will have canopy closure within less than 5-7 years with the resultant shading out of shrubs and diminishing forage nutrient values. Therefore, in order to maintain forage opportunity for longer periods, space some portions at low densities (this density will depend on a number of factors including tree species, site index, slope and drainage, but for example, may be as low as 150-250 stems/ha).

Subxeric to Submesic sites:

Management of these sites should focus on the enhancement and or recruitment of areas for thermal protection (snow interception). The following regimes reflect only those possible regimes associated with even age silvicultural systems. Uneven aged management targeting variable residual post harvest densities may be practiced where ecologically appropriate.

- Silvicultural Systems that may be applicable for this objective include: Clearcut with Reserves, Patch Cut, Shelterwood, Retention, Seed Tree, and Selection systems.

	• Establish plantations on a uniform pattern to encourage earlier crown closure. The intent is to have the mesic and drier ecosystems across a landscape provide the canopy cover required for effective thermal interception. Management of these ecosystems (subxeric to submesic) is to develop closed canopies as rapidly as possible. • Maintain low levels of competing vegetation through the establishment phase by manually or possibly chemical treatments to promote the rapid development of closed canopy conditions. • Implement juvenile spacing programs as required to ensure an even distribution of crop trees and that rapid crown closure is occurring. Post spacing standards should equal the target stocking standard for single entry spacing, however, a more desirable option would be to plan for a two-entry spacing regime. The first entry could target 3000 stems per ha with a second spacing entry (approximately at age 20 years) reducing the density to target levels.

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.1 – Stocking Standard Guidelines

Applicable Ecosystem (BEC)			Stocking Standard Modifiers									
Zones	**Subzones**	**Moisture Nutrient Regime**	**Species Selection**	**Stocking Standard Modifier[1]**	**Regen Delay**	**Assessment Time Frame**	**Minist. Tree Ht.**	**% Tree Over Brush**	**Min Inter Tree Distance**	**Max Density**	**Survey Method**	**Comments**
CWH	xm, mm, vm, dm	2-3/A-E	Same	1.2	Same	Same	Same	Same	1.5	Footnote 2	Same	
CWH	xm, mm, vm, dm	5-6/C-E	Same	0.8	Same	Same	Same	Same	1.5	Footnote 2	Footnote 3	
CDF	mm	2-3/A-E	Same	1.2	Same	Same	Same	Same	1.5	Footnote 2	Same	
CDF	mm	5-6/C-E	Same	0.8	Same	Same	Same	Same	1.5	Footnote 2	Footnote 3	

1. The term Stocking Standard Modifier refers to the factor applied to existing stocking standards contained within Establishment to Free Growing Guidebooks. For example: the stocking standards (well-spaced/ha) for CWHvm1 06 site as found in the Establishment to Free Growing Guidebook, Vancouver Forest Region equals = TSSpa **900**, MSSpa **500**, MSSp **400**. The equivalent stocking standards (well-spaced/ha) for areas with maintenance and or recruitment of forage supply, stand structure and habitat elements for the black-tailed deer and Roosevelt elk winter range objectives would be TSSpa **720**, MSSpa **400**, MSSp **320**. TSS – target stocking standard, MSS – minimum stocking standard, pa – preferred and acceptable, and p – preferred.

2. A guideline for maximum density is 4000 stems per ha for these ecosystems. Densities exceeding this threshold at the free growing stage will severely limit the suitability of forage (5-6 sites) and or security (2-3 sites) habitat requirements through subsequent stand development. In addition, stands will not be considered free growing unless they are demonstrated to contain a minimum of 20% canopy gaps. This is to be assessed based on the establishment of random systematic free growing survey plots as discussed in point 3 below. If inadequate gap creation exists, then a juvenile spacing entry must be completed to provide the required gaps. Spacing is to target leaving gaps in areas with abundant forage.

3. The survey methodologies used to assess the success of meeting the forage objectives should be consistent with existing methodologies. However, do not stratify areas to units smaller than one ha, or used dispersed stratum methodologies. In general, more plots will be required to prove obligations are met due directly to the desired patchy nature of the target stocking desired. The maximum number of plots required will be 1.5 per ha. The statistical requirements for these areas will be consistent with existing methodologies. In addition to meeting the stocking requirement for these stands it is imperative that gap creation has occurred by the free growing determination stage. To test if adequate gap creation exists, a minimum of 20% (per standards unit) of the randomly systematic established plots ($50m^2$) must contain less than or equal to one conifer (> 50 cm height), or the equivalent of 200 stems per ha.

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.2 – Cluster Distribution

Stocking (tress/ha)	Clusters per ha – Trees per cluster								Triangular Inter-cluster spacing (m) – Trees per cluster							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
200	25	29	33	40	50	67	100	200	21.5	20.1	18.6	17.0	15.2	13.2	10.7	7.6
250	31	36	42	50	63	83	125	250	19.2	18.0	16.6	15.2	13.6	11.8	9.6	6.8
300	38	43	50	60	75	100	150	300	17.5	16.4	15.2	13.9	12.4	10.7	8.8	6.2
350	44	50	58	70	88	117	175	350	16.2	15.2	14.1	12.8	11.5	9.9	8.1	5.7
400	50	57	67	80	100	133	200	400	15.2	14.2	13.2	12.0	10.7	9.3	7.6	5.4
450	56	64	75	90	113	150	225	450	14.3	13.4	12.4	11.3	10.1	8.8	7.2	5.1
500	63	71	83	100	125	167	250	500	13.6	12.7	11.8	10.7	9.6	8.3	6.8	4.8
550	69	79	92	110	138	183	275	550	13.0	12.1	11.2	10.2	9.2	7.9	6.5	4.6
600	75	86	100	120	150	200	300	600	12.4	11.6	10.7	9.8	8.8	7.6	6.2	4.4
650	81	93	108	130	163	217	325	650	11.9	11.2	10.3	9.4	8.4	7.3	6.0	4.2
700	88	100	117	140	175	233	350	700	11.5	10.7	9.9	9.1	8.1	7.0	5.7	4.1
750	94	107	125	150	188	250	375	750	11.1	10.4	9.6	8.8	7.8	6.8	5.5	3.9
800	100	114	133	160	200	267	400	800	10.7	10.1	9.3	8.5	7.6	6.6	5.4	3.8
850	106	121	142	170	212	283	425	850	10.4	9.8	9.0	8.2	7.4	6.4	5.2	3.7
900	112	129	150	180	225	300	450	900	10.2	9.5	8.8	8.0	7.2	6.2	5.1	3.6
950	119	136	158	190	238	317	475	950	9.9	9.2	8.5	7.8	7.0	6.0	4.9	3.5
1000	125	143	167	200	250	333	500	1000	9.6	9.0	8.3	7.6	6.8	5.9	4.8	3.4

Note: When cluster planting is prescribed, silviculture prescriptions should specify target trees per cluster and target clusters per ha, in addition to the target stocking standard.

Two methods have been developed to determine the prescribed number of clusters per ha.

1. Final Crop Tree Method

   The final crop tree formula is the preferred method of determining the number of clusters. Managers must first determine the number of crop trees desired at rotation. Working backward from the density at final rotation, free growing targets and planting targets should be established based on appropriate mortality factors for the site. The following should be considered when deriving a mortality factor: species selection (e.g., shade-tolerant species show less mortality), availability of suitable microsites (e.g., moisture and nutrient requirements, likelihood of flood events), vegetative competition, and anticipated mortality due to stock handling. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha.

   Number of clusters per ha = planting target/ trees per cluster

2. Target Stocking Method

   Managers wishing to use the target stocking method should first consult stocking standards table to determine the free growing target stocking recommended for the site series. Next, they should establish a mortality factor based on the site series and conditions, as in the final crop tree method, to derive the planting target. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha. The cluster distribution table above can be consulted to help verify the calculated figure.

   Number of clusters/ha = planting target/# trees per cluster *(Triangular inter-cluster spacing = The square root of 11547/# of clusters per/ha)*

6. Monitoring Standards – Additional

Establishment (Age 0-4 Years) Phase:

N/A. Refer to Management Guidelines section for strategies through this portion of stand development.

Juvenile (Age 20-60 Years) Phase:

No specific standards are developed for this point in stand development. Management of younger age classes (e.g., establishment to free growing 0-20 years) is intended to develop suitable stand conditions through this age class. Existing stands within this age class may be managed to encourage forage production by creating gaps through late juvenile spacing or commercial harvesting.

Mature (Age 60+ Years) Phase:

No specific standards are applicable for this age class. In general, subsequent harvesting strategies should be implemented that are consistent with the Management Guidelines outlined above.

Figure 18: Old forest with multiple canopies provide a combination of thermal cover and foraging habitats. Photo: Alex Inselberg.

Figure 17: Old forest with an open crown closure provide varied habitats for foraging ungulates. Photo: Alex Inselberg.

Selected References:

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7.6.1 Mule Deer (*Odocoileus hemionus hemionus*) Winter Range Even-aged Systems

1. Key Habitat Objectives

Maintain and or recruit habitat elements for mule deer winter range – for winter forage, thermal protection (snow interception) and security cover**.**

Landscape Level: Landscape level management objectives such as connectivity, patch size distribution and seral stage targets should be described in higher level plans and sustainable forest management plans. It is important to link higher level plan objectives such as mature/old forest targets for a landscape unit or other planning area, with specific practices implemented at the stand level (see Management Guidelines below).

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report.

2. Forest Types or BEC Zones

BG all, BWBS dk, mw, ICH dk, dw, mk, IDF all, MS dk, PP xh, SBS dh, dw, mh

Note: There will be some variation in the harvesting and silviculture Management Guidelines recommended below, based on site-specific ecosystem variation. Site variables such as soil moisture regime will influence the growth characteristics of stands on those sites, thereby affecting stand structural features such as canopy height and crown closure.

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Retain and or recruit critical winter habitat (i.e., mature and old forests (predominantly Douglas-fir (*Pseudotsuga menziesii*) leading in the southern and central interior) with closed, multi-layered canopies (generally > 60% canopy closure), on moderate to steep slopes (approximately > 40%), on warm, southerly aspects in low and moderate snowpack areas). This stand structure provides a balance of snow interception and browse/litterfall availability. Other slopes and aspects in association with the warmer aspect stands are often important components of winter ranges.

2. Retain and or recruit winter forage in mature and old forest stands on valley bottoms and slopes that receive winter sun that are <1000 m in elevation.

3. Minimize the width (< 120 m) of clearcuts to provide accessible security cover for foraging.

4. Security cover patches should be a minimum of 100-300 m wide for deer.

5. Maintain and or recruit forage areas through alternative silvicultural practices (e.g., sequential harvesting).

6. Minimize the amount and size of roads, skid trails and landings in important forage habitat.

7. In general, harvest according to topographic profile - deer tend to use ridges and topographic breaks frequently, these areas should be avoided where possible.

8. Retain and or recruit vegetation or incorporate topographical relief into cutblock layout that visually screens ungulates from roads and access points.

9. Maintain and or recruit forage areas by creating openings with small group selection or clumpy single-tree selection (i.e., maximum opening width of 1 tree length for clumpy single tree selection, or 2 tree lengths with sizes ranging from 0.2-0.6 ha for group selection).

10. Maintain and or recruit openings adjacent to rock outcroppings, particularly downslope and or southerly to maximize solar exposure.

11. Retain and or recruit ungulate forage species such as Saskatoon (*Amelanchier alnifolia*), tall Oregon-grape (*Mahonia aquifolium*), big sagebrush (*Artemisia tridentata*), Douglas maple (*Acer glabrum*), red-oiser dogwood (*Cornus stolonifera*), *Vaccinium* spp., wild rose (*Rosa* spp.), willow (*Salix* spp.), arboreal lichens, grasses (*Poaceae* spp.) and forbs.

12. Retain and or recruit large, old Douglas-fir trees to provide snow interception and thermal cover, litterfall, and substrate for arboreal lichen. Douglas-fir foliage litterfall becomes increasingly important as winter food, especially as snow deepens.

13. Reduce slash to a depth of < 20 cm on 75% of treatment areas in important foraging habitat.

14. Maintain and or recruit components of western redcedar (*Thuja plicata*) on warm aspects in the deep and very deep snowpack zones.

15. Minimize harvest or damage to residual Douglas-fir stems to ≤ 5% (including skid road development) of the pre-harvest basal area of stems > 12.5 cm diameter at breast height (dbh).

16. Regenerate Douglas-fir as much as ecologically possible and protect and promote established Douglas-fir regeneration.

17. In shallow and moderate snowpack zones, where possible:

    - On warm aspects (135-270^{o} aspect), use small group harvest (0.1- 0.3 ha in size) on flat slopes (0-10% slope) and single tree harvest on steeper slopes (> 10% slope).

- On moderate aspects (270-315^{o} and 90-135^{o} aspect), use small group harvest (0.2-0.4 ha in size) on flat to moderate slopes (0-30% slope), small group harvest (0.1-0.3 ha in size) on steep slopes (31-60% slope), and single tree harvest on very steep slopes (> 60% slope).
- On cool aspects (315-90^{o} aspect), use small group harvest (0.2-0.4 ha in size) on flat to moderate slopes (0-30% slope), and small group harvest (0.3-0.5 ha in size) on steeper slopes (> 30% slope).

18. In deep and very deep snowpack zones, where possible:

    - On warm aspects (135-270^{o} aspect), use small group harvest (0.2-0.4 ha in size) on flat and moderate slopes (0-30% slope) and single tree harvest on steeper slopes (> 30% slope).
    - On moderate aspects (270-315^{o} and 90-135^{o} aspect), use small group harvest (0.3-0.5 ha in size) on all slopes.
    - On cool aspects (315-90^{o} aspect), use small group harvest (0.3-0.5 ha in size) on flat to moderate slopes (0-30% slope), and small group harvest (0.4-0.6 ha in size) on steeper slopes (> 30% slope).

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. In shallow snowpack zones (< 100 cm/year) maintain 40% of the habitat as low crown closure (< 35% canopy closure) habitat, 40% as moderate crown closure (36-65% canopy closure) habitat, and 20% as high canopy closure (> 65% canopy closure) habitat. Increasing crown closure results in increased snow interception.

2. In moderate snowpack zones (100-150 cm/year) maintain 1/3 each of low, moderate and high crown closure habitats.

3. In deep snowpack zones (150-200 cm/year) maintain 1/3 of the habitat as low crown closure habitat and 2/3 as high crown closure habitat.

Regeneration:

1. On subhygric to hygric sites utilizing even aged management to target desirable forage conditions, consider establishing new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section.

2. On subxeric to submesic sites utilizing even aged management to target desirable thermal and security conditions, establish plantations in a uniform pattern to encourage earlier crown closure. The intent is to have the mesic and drier ecosystems across a landscape provide the canopy cover required for effective thermal protection (snow interception) and security cover. Management of these ecosystems (subxeric to submesic) should focus on developing closed canopies as rapidly as possible.

3. Regenerate to Douglas-fir on all sites where Douglas-fir is ecologically appropriate and or viable.

Brushing:

1. On subhygric to hygric sites utilizing even aged management to target desirable forage conditions, do not employ broadcast brushing techniques such as herbicides. In addition, during brushing and or spacing treatments, ensure that forage production between clusters can be sustained or enhanced for a longer period.

2. On subxeric to submesic sites utilizing even aged management to target desirable security conditions, maintain low levels of competing vegetation through the establishment phase by manual, or possibly chemical, treatments to promote the rapid development of closed canopy conditions.

Spacing/Thinning/Pruning:

1. Maintain and or recruit forage areas through alternative silvicultural practices (e.g., single heavy thinning, or repeated lighter thinnings).

2. Maintain and or recruit long-term forest structure by thinning pole layer (trees 12.5-37.5 cm dbh) in ungulate management areas.

Protection (fire, insects, disease, damage):

1. Where possible, use single tree harvesting of stems currently infested with Douglas-fir bark beetles (*Dendroclonus pseudotsugae*). Avoid damage or removal of non-affected stems.

2. In mixed Douglas-fir/lodgepole pine (*Pinus contorta*) stands currently infested with mountain pine beetle (*D. ponderosae*), minimize harvest and damage of Douglas-fir by:

   a) harvesting pine only in areas where there is a reasonable expectation of beetle control; and
   b) careful harvest block and skid trail design and layout.

5. Recommended Silvicultural Regimes (Even Aged Systems)

BEC – Zones ***BG all*** ***BWBSdk, mw*** ***ICHdk, dw, mk*** ***IDF all*** ***MSdk*** ***PPxh*** ***SBSdh, dw, mh***	**Subhygric to Hygric sites**: Management of these sites should focus on the enhancement and or recruitment of areas for woody ungulate forage species. The following regimes reflect only those possible regimes associated with even aged silvicultural systems. **However, uneven aged management targeting variable residual post harvest densities should be practiced wherever possible.** • Silvicultural Systems that may be applicable for this objective include: Clearcut, Patch Cut or Small Group Selection, Shelterwood, Retention, Seed Tree, and Selection systems. The season of harvest should be limited to conditions that will limit soil and root disturbance. • Consider establishing new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section. • Do not employ broadcast-brushing techniques such as herbicides. In addition, during brushing and or spacing treatments, ensure that forage production between clusters can be sustained or enhanced for a longer period. • Implement juvenile spacing programs as required (max density 5000 stems per ha) to ensure canopy gaps linked to forage production will be present later into stand development (20-60 years). **Subxeric to Submesic sites**: Management of these sites should focus on the enhancement and or recruitment of areas for thermal protection (snow interception). The following regimes reflect only those possible regimes associated with even age silvicultural systems. Uneven aged management targeting variable residual post harvest densities should be practiced where possible. • Silvicultural Systems that may be applicable for this objective include: Clearcut, Patch Cut or Small Group Selection, Shelterwood, Retention, Seed Tree, and Selection systems. • Establish plantations in a uniform pattern to encourage earlier crown closure. The intent is to have the mesic and drier ecosystems across a landscape provide the canopy cover required for effective thermal protection (snow interception). Management of these ecosystems (subxeric to submesic) is intended to develop closed canopies as rapidly as possible. • Maintain low levels of competing vegetation through the establishment phase by manual, or possibly chemical, treatments to promote the rapid development of closed canopy conditions. • Implement juvenile spacing programs as required (max density 5000 stems per ha) to ensure an even distribution of crop trees and rapid crown closure is occurring. Post spacing standards should equal the target stocking standard for single entry spacing; however, a more desirable option would be to plan for a two entry spacing regime. For example, the first entry could target 3000 stems per ha with a second spacing entry (approximately at age 25 years) reducing the density to target levels.

6. Monitoring Standards – Establishment to Free Growing Seral Stage (Even Aged Systems)

Table 1.1 – Stocking Standard Guidelines

Applicable Ecosystem (BEC)			Stocking Standard Modifiers									
Zones	**Subzones**	**Moisture Nutrient Regime**	**Species Selection**	**Stocking Standard Modifier[1]**	**Regen Delay**	**Assessment Time Frame**	**Minist. Tree Ht.**	**% Tree Over Brush**	**Min Inter Tree Distance**	**Max Density**	**Survey Method**	**Comments**
BG	All	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
BG	All	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
BWBS	dk, mw	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
BWBS	dk, mw	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
ICH	dw	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
ICH	dw	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
IDF	dm, xh, xm	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
IDF	dm, xh, xm	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
MS	dk	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
MS	dk	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
PP	xh	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
PP	xh	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	
SBS	dh, dw	2-3/A-E	Broadleaf[2]	1.2	Same	Same	Same	Same	2.0	5000[3]	Same	
SBS	dh, dw	5-6/C-E	Broadleaf[2]	0.8	Same	Same	Same	Same	1.5	5000[3]	Footnote 4	

1. The term Stocking Standard Modifier refers to the factor applied to existing stocking standards contained within Establishment to Free Growing Guidebooks. For example: the stocking standards (well-spaced/ha) for IDFxm 08 site as found in the Establishment to Free Growing Guidebook, Cariboo Forest Region equals = TSSpa **1200**, MSSpa **700**, MSSp **600**. The equivalent stocking standards (well-spaced/ha) for areas with maintenance and or recruitment of forage supply, stand structure and habitat elements for mule deer winter range objectives would be TSSpa **960**, MSSpa **560**, MSSp **480**. TSS - target stocking standard, MSS – minimum stocking standard, pa – preferred and acceptable, and p - preferred.
2. Broadleaf species management should be seriously considered where applicable for this management objective. Utilize the appropriate broadleaf species as a primary or secondary species as indicated in the Establishment to Free Growing Guidebooks.
3. Maximum density is 5000 stems per ha for these ecosystems. Densities exceeding this threshold at the free growing stage will severely limit the suitability of forage (moisture regime 5-6 sites) and or security (moisture regime 2-3 sites) habitat requirements through subsequent stand development.
4. The survey methodologies used to assess the success of meeting these standards should be consistent with existing methodologies. However, do not stratify areas into contiguous units smaller than one ha, or use dispersed stratum methodologies. In general, more plots may be required to prove obligations are met due directly to the desired variable post-free growing density distribution targeted. The maximum number of plots required will be 1.5 per ha.

6. Monitoring Standards – Establishment to Free Growing Seral Stage (Even Aged Systems)

Table 1.2 – Cluster Distribution

Stocking (tress/ha)	Clusters per ha								Triangular Inter-cluster spacing (m)							
	Trees per cluster								Trees per cluster							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
200	25	29	33	40	50	67	100	200	21.5	20.1	18.6	17.0	15.2	13.2	10.7	7.6
250	31	36	42	50	63	83	125	250	19.2	18.0	16.6	15.2	13.6	11.8	9.6	6.8
300	38	43	50	60	75	100	150	300	17.5	16.4	15.2	13.9	12.4	10.7	8.8	6.2
350	44	50	58	70	88	117	175	350	16.2	15.2	14.1	12.8	11.5	9.9	8.1	5.7
400	50	57	67	80	100	133	200	400	15.2	14.2	13.2	12.0	10.7	9.3	7.6	5.4
450	56	64	75	90	113	150	225	450	14.3	13.4	12.4	11.3	10.1	8.8	7.2	5.1
500	63	71	83	100	125	167	250	500	13.6	12.7	11.8	10.7	9.6	8.3	6.8	4.8
550	69	79	92	110	138	183	275	550	13.0	12.1	11.2	10.2	9.2	7.9	6.5	4.6
600	75	86	100	120	150	200	300	600	12.4	11.6	10.7	9.8	8.8	7.6	6.2	4.4
650	81	93	108	130	163	217	325	650	11.9	11.2	10.3	9.4	8.4	7.3	6.0	4.2
700	88	100	117	140	175	233	350	700	11.5	10.7	9.9	9.1	8.1	7.0	5.7	4.1
750	94	107	125	150	188	250	375	750	11.1	10.4	9.6	8.8	7.8	6.8	5.5	3.9
800	100	114	133	160	200	267	400	800	10.7	10.1	9.3	8.5	7.6	6.6	5.4	3.8
850	106	121	142	170	212	283	425	850	10.4	9.8	9.0	8.2	7.4	6.4	5.2	3.7
900	112	129	150	180	225	300	450	900	10.2	9.5	8.8	8.0	7.2	6.2	5.1	3.6
950	119	136	158	190	238	317	475	950	9.9	9.2	8.5	7.8	7.0	6.0	4.9	3.5
1000	125	143	167	200	250	333	500	1000	9.6	9.0	8.3	7.6	6.8	5.9	4.8	3.4

Notes: When cluster planting is prescribed, silviculture prescriptions should specify target trees per cluster and target clusters per ha, in addition to the target stocking standard.

Two methods have been developed to determine the prescribed number of clusters per ha.

1. Final Crop Tree Method

   The final crop tree formula is the preferred method of determining the number of clusters. Managers must first determine the number of crop trees desired at rotation. Working backward from the density at final rotation, free growing targets and planting targets should be established based on appropriate mortality factors for the site. The following should be considered when deriving a mortality factor: species selection (e.g., shade-tolerant species show less mortality), availability of suitable microsites (e.g., moisture and nutrient requirements, likelihood of flood events), vegetative competition, and anticipated mortality due to stock handling. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha.

   Number of clusters per ha = planting target/ trees per cluster

2. Target Stocking Method

   Managers wishing to use the target stocking method should first consult the stocking standards table to determine the free growing target stocking recommended for the site series. Next, they should establish a mortality factor based on the site series and conditions, as in the final crop tree method, to derive the planting target. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha. The cluster distribution table above can be consulted to help verify the calculated figure.

   Number of clusters per ha = planting target/ trees per cluster *(Triangular inter-cluster spacing = The square root of 11547/# of clusters per/ha)*

- Spacing between clusters should be adjusted to reflect site conditions and microsite location. Uniform distribution of clusters over the block is appropriate where site conditions are relatively uniform. However, clusters should be located on appropriate planting sites, taking advantage of natural site features such as elevated hummocks or stumps.
- Inter-cluster spacing is measured from the centre of one cluster to the centre of the adjacent ones on a square grid. However, where sites are undulating, clusters should be located on appropriate planting sites to take advantage of natural features such as elevated hummocks or stumps. Inter-cluster distances should be varied in order to optimize microsite selection.
- Inter-cluster spacing is recommended to be a minimum of 80% and a maximum of 120% of that required to achieve the desired planting target. This range should result in achieving the overall desired stocking density, within acceptable statistical limits, when a stocking survey is applied across the area.
- "Dispersed or non-uniform cluster" uses a mix of cluster densities across the block, and is appropriate for some blocks where microsites suitable for clusters (e.g., elevated hummocks) are not evenly distributed.
- For dispersed cluster planting, the minimum inter-tree distance within a cluster is 1.5 m on suitable microsites. The number of suitable clusters per ha should be estimated from a reliable survey that covers the entire area. The minimum/maximum inter-cluster distances may vary substantially, as long as the overall target density is met.

6. Monitoring Standards – Additional

Establishment (Age 0-4 Years) Phase:

Refer to Management Guidelines section for strategies through this portion of stand development.

Juvenile (Age 20-60 Years) Phase:

No specific standards are developed for this point in stand development. Management of younger age classes (e.g., establishment to free growing 0-20 years) is intended to develop suitable stand conditions through this age class. Existing stands within this age class may be managed to encourage forage production by creating gaps through late juvenile spacing or commercial harvesting.

Mature (Age 60+ Years) Phase:

No specific standards are applicable for this age class. In general, subsequent harvesting strategies should be implemented that are consistent with the Management Guidelines outlined. In addition, review of Cariboo Forest Region Extension Note 25A (MoF 2000) is recommended prior to harvest planning.

Figure 19: Security cover provides important bedding habitat for mule deer. Photo: Alex Inselberg.

Selected References:

Resources Inventory Committee. 1998. British Columbia wildlife habitat rating standards. B.C. Minist. Environ., Lands and Parks, Resour. Inventory Comm., Wildl. Interpretations Subcomm., Victoria, BC. 108pp.

Stevens, V. 1995. Database for wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds and mammals in biogeoclimatic zones. Working Pap., B.C. Minist. Environ., Lands and Parks, Victoria, BC.

Wood, C. 1998. Habitat/ecosystem objectives and monitoring procedures for incremental and backlog silviculture treatments, ver. 2.0. B.C. Minist. Environ., Lands and Parks, Resour. Stewardship Branch, Victoria, BC. 70pp.

7.6.2 Mule Deer (*Odocoileus hemionus hemionus*) Winter Range Uneven Aged Systems

NOTE: The following habitat objectives and accompanying guidelines are intended to **apply to UNEVEN AGED silvicultural systems management**, and can be implemented **where uneven-aged systems are appropriate**. Consequently, stocking standard tables (establishment to free growing stage) are not included. Recommendations are provided for access development and harvesting, and post harvesting phases. Also refer to the **Selected References** section (below) for additional information on uneven aged systems management in mule deer winter range.

1. Key Habitat Objectives

Maintain and or recruit habitat elements for mule deer winter range – for winter forage, snow interception (thermal cover) and security cover**.**

Landscape Level: Landscape level management objectives such as connectivity, patch size distribution and seral stage targets should be described in higher level plans and sustainable forest management plans. It is important to link higher level plan objectives such as mature/old forest targets for a landscape unit or other planning area, with specific practices implemented at the stand level (see Management Guidelines below).

Cariboo-Chilcotin whole winter range (landscape) level objectives for deer winter ranges are as follows:

1. In shallow snowpack zones (approximately < 100 cm mean snowfall/year) maintain 40% of the habitat as low crown closure (< 35% canopy closure) habitat, 40% as moderate crown closure (36-55% canopy closure) habitat, and 20% as high canopy closure (> 55% canopy closure) habitat. Increasing crown closure results in increased snow interception.

2. In moderate snowpack zones (approximately100-150 cm mean snowfall /year) maintain 1/3 each of low, moderate and high crown closure habitats.

3. In transition snowpack zones (approximately 150-200 cm mean snowfall/year) maintain 20% of low, 40% of moderate, and 40% of high crown closure habitats.

4. In deep snowpack zones (approximately >-200 cmmean snowfall/year) maintain 1/3 of the habitat as low crown closure habitat and 2/3 as high crown closure habitat.

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report. Also refer to the Cariboo Chilcotin Land Use Plan Mule Deer Strategy (Dawson et al., 2002) for additional information on landscape level planning and related stand level management practices.

2. Forest Types/BEC Zones

BG all, BWBS dk, mw, ICH dk, dw, mk, IDF all, MS dk, PP xh, SBS all , SBPS all

Note: There will be variation in the harvesting and silviculture Management Guidelines recommended below, based on biogeoclimatic and site-specific ecosystem variation. Stand and landscape level recommendations for mule deer winter range management in the Cariboo Chilcotin are divided into four different ecological types: shallow, moderate, transition and deep snow-pack zones, which are defined on the ground as groups of biogeoclimatic subzones. Site variables such as soil moisture regime will influence the growth characteristics of stands on those sites, thereby affecting stand structural features such as canopy height and crown closure.

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Retain and or recruit critical winter habitat (i.e., mature and old forests (predominantly Douglas-fir (*Pseudotsuga menziesii*) leading in the interior) with closed, multi-layered canopies (with a variety of crown closure reflecting the three winter range habitat classes), on moderate to steep slopes (approximately > 20%), on warm, southerly aspects in low and moderate snowpack areas). This stand structure provides a balance of snow interception and browse/litterfall availability. Other slopes and aspects in association with the warmer aspect stands, are often important components of winter ranges.

2. Retain and or recruit winter forage and shelter in mature and old forest stands on lower elevation slopes that receive winter sun.. *(many winter ranges contain areas >1000 m, and the elevation of useful winter range is often highly dependent on the local topography and weather systems/snow shadows so it is probably best to just refer to generally lower elevation.*

3. Manage winter range stands using uneven-aged management to maintain suitable winter range conditions through time. Cariboo_Chilcotin management guidelines recommend patch width ranges from 0.3-1 tree lengths in shallow and moderate snowpack zones to a maximum of 2 tree lengths in the deep snowpack zone. These patches are harvested within the context of a clumpy single-tree selection system for shallow and moderate snowpack zones, and, primarily, small group selection systems in the transition and deep snow-pack zone.

4. Maintain and recruit Douglas-fir litterfall forage areas by maintaining stands composed of mature and old trees arranged in a clumpy distribution.

5. Minimize the amount and size of roads, skid trails and landings in winter range habitat.

6. Harvest according to topographic profile - deer tend to use ridges and topographic breaks frequently, these areas should be avoided or only lightly cut where possible.

7. Retain and or recruit vegetation or incorporate topographical relief into cutblock layout that visually screens ungulates from roads and access points.
8. Maintain and or recruit shrub forage areas by creating openings with small group selection or clumpy single-tree selection (i.e., maximum opening width of 1 tree length for clumpy single tree selection, or 2 tree lengths with sizes ranging from 0.2-0.6 ha for group selection).
9. Maintain and or create small openings adjacent to rock outcroppings, particularly downslope and or southerly aspect to maximize solar exposure.
10. Retain and or recruit ungulate forage species such as Saskatoon (*Amelanchier alnifolia*), tall Oregon-grape (*Mahonia aquifolium*), big sagebrush (*Artemisia tridentata*), Douglas maple (*Acer glabrum*), red-oiser dogwood (*Cornus stolonifera*), *Vaccinium* spp., wild rose (*Rosa* spp.), willow (*Salix* spp.), arboreal lichens, grasses (*Poaceae* spp.) and forbs. The appropriate shrub species will vary widely depending on the biogeoclimatic zone that the winter range is located within.
11. Retain and or recruit large, old Douglas-fir trees to provide snow interception and thermal cover, litterfall, and substrate for arboreal lichen. Douglas-fir foliage litterfall becomes increasingly important as winter food, especially as snow deepens.
12. Reduce slash to a depth of < 20 cm on 75% of treatment areas in important winter habitat.
13. Maintain and or recruit components of western redcedar (*Thuja plicata*) on warm aspects and toe slopes in the deep and very deep snowpack zones.
14. Minimize harvest or damage to residual Douglas-fir stems when selectively removing other species such as lodgepole pine from mixed species stands. Recommendations in the Cariboo-Chilcotin are: " Harvest or damage to Douglas-fir must not exceed 15% for stems 22.5-37.5 cm and 5% for stems >37.5 cm (including skid trail development) of the preharvest basal area of each of these two diameter class groupings.
15. Regenerate Douglas-fir as much as ecologically possible and protect and promote established Douglas-fir regeneration.
16. In shallow and moderate snowpack zones, a specialized, clumpy single tree selection is recommended. Prescriptions would first target non-Douglas-fir species for harvest. Additional harvest of Douglas-fir would include various amounts of three types of cutting depending on the initial stand structure and the stand structure objectives. The 3 types of cutting include: 1) thinning from below of suppressed and intermediate stems of poor to fair vigour or quality; 2) harvest of small clumps of trees (2-8 trees) of all diameter and crown classes producing small (0.3-1.0 tree length) regeneration openings; 3) harvet of single isolated stems that do not occur as part of a group. Long-term post-harvest basal area targets have been developed for IDF stems in the Cariboo Chilcotin (Dawson and Armleder, 2000).:
17. In transition and deep snowpack zones apply a small group selection silviculture system.

    Recommendations from the Cariboo-Chilcoltin for group selection objectives include:

    - Small harvest patch sizes (0.- 0.7 ha in transition zone and 0.1 -1.0 ha in deep zone) depending on the slope and aspect
    - In the Transition snowpack zone, create harvest patch sizes 0.1 - 0.3 ha on warm aspects and frost prone micro sites

- In the Deep snowpack zone, create openings 0.1- 0.4 ha on warm aspects and frost prone microsites and create harvest openings 0.1-1.0 ha (average 0.6 ha) on other aspects.
- A minimum cutting cycle of 40 years
- Area harvested per pass of 20, 25 and 33% for high, moderate and low stand structure habitat classes, respectively

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. In shallow snowpack zones (approx. < 100 cm mean snowfall/year) maintain 40% of the habitat as low crown closure (< 35% canopy closure) habitat, 40% as moderate crown closure (36-55% canopy closure) habitat, and 20% as high canopy closure (> 55% canopy closure) habitat. Increasing crown closure results in increased snow interception. Decreasing crown closure results in increased shrub forage production. However, forests managed with small group selection or clumpy simple tree selection will incorporate small shrub producing openings throughout the stand.
2. In moderate snowpack zones (approx 100-150 cm mean snowfall/year) maintain 1/3 each of low, moderate and high crown closure habitats.
3. In transition snowpack zones (approximately 150-200 cm mean snowfall/year) maintain 20% of low, 40% of moderate, and 40% of high crown closure habitats.
4. In deep snowpack zones (approx >200 cm mean snowfall/year) maintain 1/3 of the habitat as moderate crown closure habitat and 2/3 as high crown closure habitat.

Regeneration:

1. Regenerate to Douglas-fir on all sites where Douglas-fir is ecologically viable. Regeneration objectives should be addressed during the harvesting phase by:

   a) protecting regeneration from harvesting damage where possible;
   b) using opening sizes and/or silvicultural systems that do not cause frost problems for Douglas-fir regeneration.

2. Residual stems and natural regeneration may be sufficient for many areas. Other areas, especially where group selection is used, may require some planting to meet regeneration objectives. The intent is to maintain or create uneven-aged Douglas-fir dominated stands in a fine scale mosaic of tree patches of various sizes and ages. This mosaic of patches will provide snow interception, thermal and security cover as well as litterfall, lichen and shrub forage. High, moderate and low crown closure variation in this basic structure will provide different mixes of forage and cover benefits.

Brushing:

1. Brushing will seldom be required on mule deer winter ranges except possibly in some sites in wetter subzones. The minimum level of brushing required to establish the regeneration should be used.

Spacing/Thinning/Pruning:

1. Maintain and or recruit long-term forest structure by thinning pole layer (trees 12.5-37.5 cm dbh) in ungulate management areas. Thinning should be a light (maximum of 25%) thinning from below that concentrates harvesting on trees in suppressed and intermediate canopy layers.

Protection (fire, insects, disease, damage):

1. Where possible, use single tree harvesting of stems currently infested with Douglas-fir bark beetles (*Dendroclonus pseudotsugae*). Avoid damage or removal of non-affected stems.

2. In mixed Douglas-fir/lodgepole pine (*Pinus contorta*) stands currently infested with mountain pine beetle (*D. ponderosae*), minimize harvest and damage of Douglas-fir by:

   a) harvesting pine only in areas where there is a reasonable expectation of beetle control; and
   b) careful harvest block and skid trail design and layout.

5. Additional Long-Term Habitat Management Objectives

Long-term Objectives for High, Moderate and Low Stand Structure Habitat Types:

For each of the three stand structure habitat classes , objectives for long-term stand structure are provided in the Mule Deer Handbook (Armleder *et al.* 1986) and Extension Note 25A (Dawson and Armleder, 2000). The key objectives for shallow and moderate snowpack winter ranges in the Cariboo-Chilcotin are:

- **Basal Area** – Meet basal area requirements described in table 2 in Extension Note 25A (Dawson and Armleder, 2000). These describe the post-harvest total basal area (m^2 of Douglas-fir stems > 12.5 cm dbh) and the post-harvest basal area of large trees (m^2 of Douglas-fir stems > 37.5 cm dbh).

- **Cutting Cycle** – The basal area values given apply to cutting cycles of 30 years or greater. Shorter cutting cycles would require substantially greater residual basal area values.

- **Canopy Openings** – Recommended silvicultural systems combine thinning from below with creation of small canopy gaps. Create canopy openings ranging in diameter from 0.3-1 of the local mature tree height, with an average opening diameter of 1/2 of a mature tree height. For example, in a stand with mature trees 30 m in height, the average diameter of canopy openings created by harvesting would be 15 m.

- **Access Development** – Carefully minimize area in roads, landings and skid trails. Skid trails must cover no more than 10% of the net harvested area in moderate and high stand structure habitat types. **Clumpiness** – Maintain and promote a clumpy distribution of residual Douglas-fir trees.

- **Species Composition** – Maximize the proportion of Douglas-fir by all possible means. Always harvest in a way that optimizes the maintenance and regeneration of Douglas-fir. Do not plant pine or spruce unless these are the only silviculturally viable option.

- **Tree Size Distribution** – Maintain and promote multi-layered, uneven-aged stands dominated by mature Douglas-fir, with deep, wide crowns and a high component of large, old trees. Recommended B, D and q values in Table 3 of Extension Note 25A (Dawson and Armleder, 20002000) will provide guidance on recommended diameter distributions. The values in Table 3 quantitatively describe a type of desired stand structure. The relatively low values for 'q' describe a stand that has much of its volume in larger trees. The relatively high values for 'D' mean that some trees with large diameters are desirable.

- **Snags and Declining Trees** – Maintain a high level of snags and declining trees especially in stands managed for moderate and high habitat classes. Extra care is required in these stands because Workers' Compensation Board (WCB) regulations combined with the short cutting cycle could easily result in stands with few snags.

- **Trees on Special Topographic Features** – Maintain higher than average tree cover on ridges, topographic breaks, and knolls. Manage these microsites to maintain a higher basal area than that prescribed for the surrounding polygon as a whole.

Long-term Objectives for Topographic Buffers:

Topographic buffers are identified on winter range maps around major topographic breaks, knolls and ridges because these features receive very high use by mule deer.

- Any new roads should be designed to avoid these buffer areas. Exceptions to this can be made where a road needs to cross the buffer area and no other suitable location for the road can be found. In these cases, the road should cross perpendicular to the buffer to minimize road within the buffer.
- Skid trails must be minimized in this zone, but are acceptable if they run perpendicular to the buffered ridge or break to minimize skid trail within the buffer.
- Note that smaller scale ridges and breaks, not identified on the long-term spatial objectives maps are also important stand level features that need to be appropriately managed when conducting road building and harvesting operations. As with the larger scale topographic features, skid trials must not be located along these smaller scale ridges and breaks.

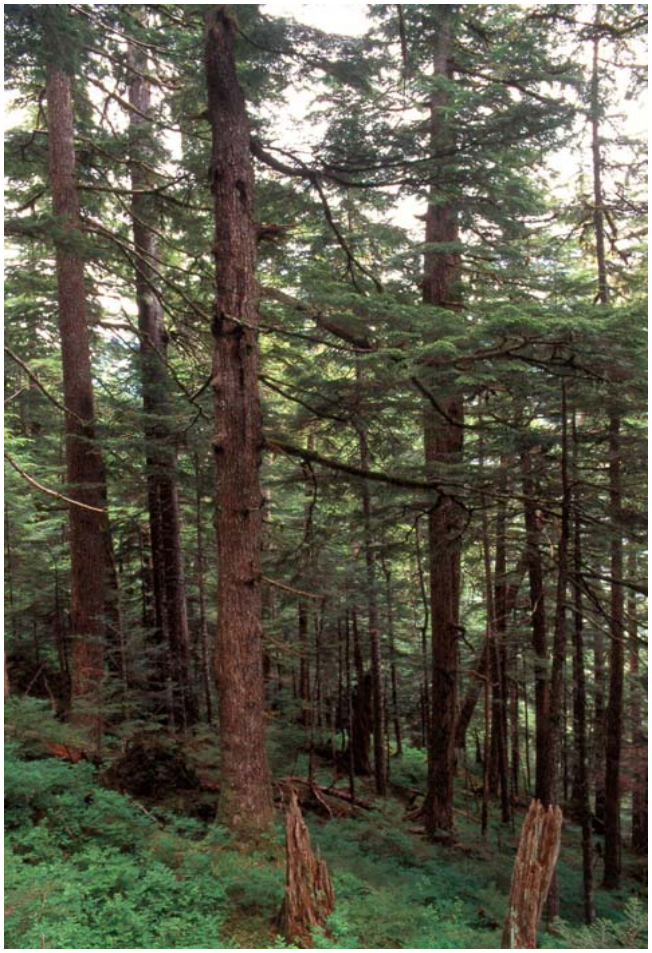

Figure 20: Old forest with large limb structure provide snow interception in deer winter ranges. Photo: Alex Inselberg.

Selected References:

Armleder, H.M., R.J. Dawson and R.N. Thomson. 1986. Handbook for timber and mule deer management co-ordination on winter ranges in the Cariboo Forest Region. B.C. Minist. For., Res. Branch, Land Manage. Handb. No. 13, Victoria, BC. 98pp.

B.C. Ministry of Forests. 1998. Silvicultural systems for Douglas-fir stands on very deep snowfall mule deer winter ranges. B.C. Minist. For., Res. Sect., Extension Note 23., Williams Lake, BC. 5pp. URL: http://www.for.gov.bc.ca/cariboo/research/research.htm

Dawson, R.J. and H.M Armleder.. 2000. Structural definitions for management of mule deer winter range in the interior Douglas-fir zone. B.C. Minist. For., Res. Sect., Extension Note 25A., Williams Lake, BC. 8pp. URL: http://www.for.gov.bc.ca/cariboo/research/research.htm

Dawson, R.J., H.M. Armleder, B.Bings, and D. Peel. 2002. . Management Strategy for Mule Deer Winter Range in the Cariboo-Chilcotin, Part 1a: Management Plan for Shallow and Moderate Snowpack Zones. CaribooChilcotin Land Use Plan Report . URL: http://wlap.gov.bc.ca/car/evn_stewardship/ecosystems/mdwr_strat/mgmtplan.html

Cariboo-Chilcotin Land Use Plan (CCLUP). 2000. Regional mule deer winter range strategy. Update: recommended interim management guidelines for mule deer winter range, November 2000. CCLUP Mule Deer Strategy Committee, 17pp. URL:http://wlap.gov.bc.ca/car/evn_stewardship/ecosystems/mdwr_strat/mgmtplan.html

Resources Inventory Committee. 1998. British Columbia wildlife habitat rating standards. B.C. Minist. Environ., Lands and Parks, Resour. Inventory Comm., Wildl. Interpretations Subcomm., Victoria, BC. 108pp.

Stevens, V. 1995. Database for wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds and mammals in biogeoclimatic zones. Working Pap., B.C. Minist. Environ., Lands and Parks, Victoria, BC.

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7.7 Mountain Caribou (*Rangifer tarandus caribou*) Winter Range

1. Key Habitat Objectives

Maintain and or recruit habitat elements for mountain caribou – for forage and security in winter range (**not applicable to northern caribou**).

Landscape Level: Landscape level management objectives such as connectivity and habitat fragmentation, patch size distribution and seral stage targets, as well as **access management**, should be described in higher level plans and forest stewardship plans. It is important to link these higher level plan objectives with specific practices implemented at the stand level (see Management Guidelines below).

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report.

2. Forest Types/ BEC Zones

ESSF dk, mm, vc, vv, wc, wk, wm, ICH mk2, mm, mw, vk, wk

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

NOTE: the following guidelines are intended to apply only to areas where harvesting is permitted through a Higher Level Plan.

1. Maintain and or restore forested connectivity corridors to facilitate predator avoidance and movement of caribou between seasonal ranges.

2. Protect caribou from access-related impacts by developing a road/access management plan. Try to reduce access and habitat fragmentation adjacent to caribou summer habitats where possible.

3. Where forest harvesting is planned in mountain caribou winter range, maintain most of the stand in a late seral condition by using partial cutting techniques with low (< 30%) volume removal and long cutting cycles. For example: 30% volume removal at intervals of 80 years, or 25% removal at intervals of 60 years. Coordinate harvest entries with an access management plan in order to minimize any increase in human access or natural predation.

   Note: Harvest cycles of this duration are intended to ensure that the regeneration from the first entry will be of sufficient size to provide travel habitat and have an inner defoliated zone, which is important for lichen forage development.

4. Maintain pre-harvest tree species composition.

5. In the ICH and on the ICH/ESSF ecotone, minimize disturbance of soil and vegetation during harvesting and silvicultural activities in order to:
   - Maintain low evergreen shrubs and herbs with persistent green leaves (e.g., falsebox (*Pachystima myrsinites*), bunchberry (*Cornus canadensis*), foamflower (*Tiarella* spp.), and wintergreen (*Pyrola* spp.))
   - Avoid enhancing shrub species such as willow (*Salix* spp.), red-osier dogwood (*Cornus stolonifera*) and Douglas maple (*Acer glabrum*), which are preferred by moose, deer and elk.
6. Avoid excessive physical obstructions (such as wind-rowed slash or many downed trees).

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. Young or mid-seral stands that are dense or homogeneous may be spaced or thinned to encourage development of a multi-layered structure with heterogeneous spacing.

Regeneration:

1. Minimize visual obstructions and maintain freedom of movement for caribou by keeping regeneration density low.

2. Maintain a clumped stand structure where it occurs naturally, and by cluster planting where possible (see Additional Planting Information, section 6).

Brushing:

1. In the ICH and on the ICH/ESSF ecotone, vegetation management should be planned to discourage woody browse species.

Spacing/Thinning/Pruning (or associated practices):

1. **In the ICH** and on the **ICH/ESSF ecotone**, manage for a multi-layered stand structure and heterogeneous spacing – some areas should have more open spacing to encourage production of forage lichens, and other areas should have higher canopy closure and dense, wide, long crowns to provide snow interception. Overall, manage for approximately 300 live and 25-30 dead stems/ha (> 19 cm dbh) at age 140 years. To achieve this stand structure:
   - Conserve some advance regeneration during harvesting.

- Plant widely spaced trees, and allow natural regeneration of western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*).
- Space trees to encourage variable stem densities and support advance regeneration. Dense thickets of regeneration that interfere with sight distances may be reduced.

  Note: Pruning does not significantly affect caribou forage in the ICH, where there is little forage lichen within reach. Pruning can actually be used to improve sight distances in these stands.

2. **In the ESSF**, manage for a multi-layered stand with clumped trees separated by gaps. Overall, manage for approximately 300 live and 25-30 dead stems per ha (> 19 cm dbh) at age 140 years. To achieve this stand structure:

   - In the prescription, reduce acceptable inter-tree spacing to 1 m.
   - Conserve some advance regeneration during harvesting.
   - Cluster-plant on naturally raised microsites or on clumped mounds. For example, plant an average of 4 seedlings per clump and space clumps approximately 5-7 m apart.
   - Avoid pruning in areas where arboreal lichens on low branches are important forage for ungulates.

     Note: It is important to avoid pruning in the ESSF, where caribou eat lichens directly off the lower branches of trees.

Protection (fire, insects, disease, damage):

1. Mountain caribou are adapted to forests that regenerate through gap-dynamics processes. Caribou winter ranges should be protected from extensive stand-destroying fires.

5. Recommended Silvicultural Regimes

BEC – Zones ***ESSFdk mm, vc, vv, wc, wk, wm*** ***ICHmk2, mm, mw, vk, wk***	Uneven-aged management with high retention of residuals should be practiced where possible. However, the following silvicultural regimes apply to even-aged stands where recruitment of future caribou habitat is a management objective. Examples would be pre-existing even-aged stands, or harvest blocks within movement corridors that are being managed to provide snow-interception habitat in the future. The use of moderate, rather than low densities early in stand history discourages browse species and encourages dieback of lower branches, which improves sight distances. Later management should focus on the enhancement and or recruitment of heterogeneous stem density and inter-tree spacing throughout the stand rotation. The associated standards reflect this goal. **Modified standards are provided only for submesic to subhygric sites** in an effort to create conditions across a landscape that will contain various free growing densities (e.g., a bell curve density distribution). • Silvicultural Systems that may be applicable for this objective include: Patch Cut, Shelterwood, Retention and Selection systems. Harvesting practices should ensure that post harvest debris loading does not create excessive physical obstruction to animal movements. • Site preparation treatments should not create excessive physical obstructions (such as windrows) and must preserve retained advance regeneration. • On subhygric sites establish new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern. On submesic sites establish plantations in a uniform pattern to encourage earlier crown closure. • Do not employ broadcast-brushing techniques such as herbicides. In addition, during brushing and or spacing treatments ensure that variable density distribution of target crop trees is achieved. • Implement juvenile spacing programs as required (max density 5000 stems per ha) to ensure the desired variation in stand densities and inter tree spacing is achieved. Post spacing standards can range significantly and it is preferable to obtain a non uniform spacing throughout an area post treatment, this will help to ensure heterogeneous canopy conditions will be present later into stand development (20-60 years).

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.1 – Stocking Standard Guidelines

Applicable Ecosystem (BEC)			Stocking Standard Modifiers									
Zones	**Subzones**	**Moisture Nutrient Regime**	**Species Selection**	**Stocking Standard Modifier[1]**	**Regen Delay**	**Assessment Time Frame**	**Min. Tree Ht.**	**% Tree Over Brush**	**Min Inter Tree Distance**	**Max Density**	**Survey Method**	**Comments**
ESSF	dk, mm, un, vc, vv, wc, wk, wm	5/A-E	Footnote 2	0.8	Same	Same	Same	Same	1.0	Footnote 3	Footnote 4	
ESSF	dk, mm, un, vc, vv, wc, wk, wm	3/A-E	Footnote 2	1.2	Same	Same	Same	Same	2.0	Footnote 3	Footnote 4	
ICH	mk2, mm, mw, vk, wk	5/A-E	Footnote 2	0.8	Same	Same	Same	Same	2.0	Footnote 3	Footnote 4	
ICH	mk2, mm, mw, vk, wk	3/A-E	Footnote 2	1.2	Same	Same	Same	Same	2.0	Footnote 3	Footnote 4	

1. The term Stocking Standard Modifier refers to the factor applied to existing stocking standards contained within Establishment to Free Growing Guidebooks. For example: the stocking standards (well-spaced/ha) for ESSFwk 05 site as found in the Establishment to Free Growing Guidebook, Cariboo Forest Region equals = TSSpa **1200**, MSSpa **700**, MSSp **600**. The equivalent stocking standards (well-spaced/ha) for areas with maintenance and or recruitment of forage supply, stand structure and habitat elements for the mountain caribou winter range objective would be TSSpa **960**, MSSpa **560**, MSSp **480**. TSS - target stocking standard, MSS – minimum stocking standard, pa – preferred and acceptable, and p - preferred.

2. Lodgepole pine (*Pinus contorta*) should be managed as a minor (< 20%) stand component for areas with caribou management objectives.

3. Maximum Density is 5000 stems per ha for these ecosystems. Post spacing densities should range significantly (1000-3000 stems per ha) on a given area in an effort to provide varied post free growing inter tree spacing and total density per ha.

4. The survey methodologies used to assess the success of meeting these standards should be consistent with existing methodologies. However, do not stratify areas into contiguous units smaller than one ha, or use dispersed stratum methodologies. In general, more plots may be required to prove obligations are met due directly to the desired variable post free growing density distribution targeted. The maximum number of plots required will be 1.5 per ha. The statistical requirements for these areas will be consistent with existing methodologies.

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.2– Cluster Distribution

Stocking (tress/ha)	Clusters per ha								Triangular Inter-cluster spacing (m)							
	Trees per cluster								Trees per cluster							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
200	25	29	33	40	50	67	100	200	21.5	20.1	18.6	17.0	15.2	13.2	10.7	7.6
250	31	36	42	50	63	83	125	250	19.2	18.0	16.6	15.2	13.6	11.8	9.6	6.8
300	38	43	50	60	75	100	150	300	17.5	16.4	15.2	13.9	12.4	10.7	8.8	6.2
350	44	50	58	70	88	117	175	350	16.2	15.2	14.1	12.8	11.5	9.9	8.1	5.7
400	50	57	67	80	100	133	200	400	15.2	14.2	13.2	12.0	10.7	9.3	7.6	5.4
450	56	64	75	90	113	150	225	450	14.3	13.4	12.4	11.3	10.1	8.8	7.2	5.1
500	63	71	83	100	125	167	250	500	13.6	12.7	11.8	10.7	9.6	8.3	6.8	4.8
550	69	79	92	110	138	183	275	550	13.0	12.1	11.2	10.2	9.2	7.9	6.5	4.6
600	75	86	100	120	150	200	300	600	12.4	11.6	10.7	9.8	8.8	7.6	6.2	4.4
650	81	93	108	130	163	217	325	650	11.9	11.2	10.3	9.4	8.4	7.3	6.0	4.2
700	88	100	117	140	175	233	350	700	11.5	10.7	9.9	9.1	8.1	7.0	5.7	4.1
750	94	107	125	150	188	250	375	750	11.1	10.4	9.6	8.8	7.8	6.8	5.5	3.9
800	100	114	133	160	200	267	400	800	10.7	10.1	9.3	8.5	7.6	6.6	5.4	3.8
850	106	121	142	170	212	283	425	850	10.4	9.8	9.0	8.2	7.4	6.4	5.2	3.7
900	112	129	150	180	225	300	450	900	10.2	9.5	8.8	8.0	7.2	6.2	5.1	3.6
950	119	136	158	190	238	317	475	950	9.9	9.2	8.5	7.8	7.0	6.0	4.9	3.5
1000	125	143	167	200	250	333	500	1000	9.6	9.0	8.3	7.6	6.8	5.9	4.8	3.4

Notes: When cluster planting is prescribed, silviculture prescriptions should specify target trees per cluster and target clusters per ha, in addition to the target stocking standard.

Two methods have been developed to determine the prescribed number of clusters per ha.

1. Final Crop Tree Method

   The final crop tree formula is the preferred method of determining the number of clusters. Managers must first determine the number of crop trees desired at rotation. Working backward from the density at final rotation, free growing targets and planting targets should be established based on appropriate mortality factors for the site. The following should be considered when deriving a mortality factor: species selection (e.g., shade-tolerant species show less mortality), availability of suitable microsites (e.g., moisture and nutrient requirements, likelihood of flood events), vegetative competition, and anticipated mortality due to stock handling. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha.

   Number of clusters per ha = planting target/ trees per cluster

2. Target Stocking Method

   Managers wishing to use the target stocking method should first consult the stocking standards table to determine the free growing target stocking recommended for the site series. Next, they should establish a mortality factor based on the site series and conditions, as in the final crop tree method, to derive the planting target. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha. The cluster distribution table above can be consulted to help verify the calculated figure.

   Number of clusters per ha = planting target/ trees per cluster *(Triangular inter-cluster spacing = The square root of 11547/# of clusters per/ha)*

- When cluster planting is implemented, spacing between clusters should be adjusted to reflect site conditions and microsite location. Uniform distribution of clusters over the block is appropriate where site conditions are relatively uniform. However, clusters should be located on appropriate planting sites, taking advantage of natural site features such as elevated hummocks or stumps.
- Inter-cluster spacing is measured from the centre of one cluster to the centre of the adjacent ones on a square grid. However, where sites are undulating, clusters should be located on appropriate planting sites to take advantage of natural features such as elevated hummocks or stumps. Inter-cluster distances should be varied in order to optimize microsite selection.
- Inter-cluster spacing is recommended to be a minimum of 80% and a maximum of 120% of that required to achieve the desired planting target. This range should result in achieving the overall desired stocking density, within acceptable statistical limits, when a stocking survey is applied across the area.
- "Dispersed or non-uniform cluster" uses a mix of cluster densities across the block, and is appropriate for some blocks where microsites suitable for clusters (e.g., elevated hummocks) are not evenly distributed.
- For dispersed cluster planting, the minimum inter-tree distance within a cluster is 1 m on suitable microsites. The number of suitable clusters per ha should be estimated from a reliable survey that covers the entire area. The minimum/maximum inter-cluster distances may vary substantially, as long as the overall target density is met.

6. Monitoring Standards – Additional

Establishment (Age 0-4 Year) Phase:

N/A. Refer to the Management Guidelines section for management strategies through this portion of stand development.

Juvenile (Age 20-60 Year) Phase:

No specific standards are developed for this point in stand development. Management of younger age classes (e.g., establishment to free growing 0-20 years) is intended to develop suitable stand conditions through this age class. Existing stands within this age class may be managed to create the desired variable inter tree spacing and total density per ha through late juvenile spacing or commercial harvesting.

Mature (Age 60+ Year) Phase:

No specific standards are applicable for this age class. In general, subsequent partial cutting harvesting strategies should be implemented that are consistent with the Management Guidelines outlined.

Figure 22: Single tree selection with a zero-tail-swing feller buncher minimizes damage to caribou habitat. Photo: Darwyn Coxson.

Figure 21: Old forests with arboreal lichens provide winter forage for ungulates. Photo: Alex Inselberg.

Figure 24: Partial cutting, both single-tree and group selection, maintain habitat attributes for caribou. Photo: Darwyn Coxson.

Figure 23: Group selection harvesting provides openings for caribou foraging habitat. Photo: Susan Stevenson.

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7.8 Grizzly Bear (*Ursus arctos horribilis*)

1. Key Habitat Objectives

Maintain and or recruit habitat elements for grizzly bears – for forage and security cover.

Landscape Level: Landscape level management objectives such as patch size distribution and seral stage targets should be described in higher level plans and sustainable forest management plans. It is important to link higher level plan objectives such as seral stage targets for a landscape unit or other planning area, with specific operational plans and practices implemented at the stand level.

A further discussion of landscape level considerations is found in the Landscape Considerations section of this report. Also refer to Extension Note 54 (MoF 2001) for additional information on landscape planning and stand-level forest management practices (silviculture treatments) in grizzly bear habitat.

2. Forest Types or BEC Zones

BWBS dk, CWH all, ESSF all, ICH dw, mc, vc, wk, MH mm, MS dk, SBS mc, mk, mm, wk, SWB dk, mk

3. Management Guidelines and Specific Habitat Objectives for Access Development and Harvesting

1. Retain and or establish forested travel corridors between riparian habitats, using subhygric and wetter site series where possible. These areas should provide security and escape cover for bears as they travel.

2. Leave buffer strips of forested habitat to provide security cover and bedding areas adjacent to important foraging areas (e.g., avalanche chutes, wet meadows, estuaries, riparian habitats, skunk cabbage (*Lysichiton americanum*) swamps, seeps and alder swales) and existing den sites. Avoid planting of these forage sites. These areas will often provide additional habitat elements such as mark and rub trees, as well as connectivity and escape habitat.

3. Minimize new road placement near important bear foraging areas. Use access management plans to minimize potential human grizzly interactions.

4. If roads have been previously located near areas important for bear foraging, permanently deactivate these roads when they are no longer required for access. Restrict grass seeding to > 500 m away from active roads.

5. Blowdown patches, large root wads, large diameter black cottonwood (*Populus balsamifera*) and western redcedar (*Thuja plicata*), caves, or overhanging banks that can be dug out, all make potential den sites. Where possible, include these habitat elements in wildlife tree patches or riparian reserves to provide a buffer around them.

6. In areas where fish are an important part of the diet, retention of security cover and escape terrain along streams, rivers and estuaries are critical. This applies to any watersheds that drain to the Pacific Ocean (i.e., coastal watersheds including the Skeena and Fraser river systems).

7. Schedule stand entry activities outside of expected times of grizzly bear use of that area.

8. Maintain and or recruit canopy gaps, in a variety of shapes and sizes, to create a range of light and growing conditions for forage species production. Newly created gaps should range in size between 0.1-2.0 ha and be grouped (i.e., within 500 m of one another). Gaps of this nature should be considered regardless of the silvicultural system and harvest opening size. Total area retained in gaps should be similar to pre-harvest natural gap levels, which can be identified at the cutting permit scale.

4. Management Guidelines and Specific Habitat Objectives Post Harvest

Restoration:

1. Maintain and or recruit berry production through controlled, light impact broadcast burns in dense berry forage areas.

2. Maintain and or recruit areas of important grazing species (i.e., grass (*Poaceae* spp.), sedge (*Carex* spp.) or clover (*Trifolium* spp.), through scarification in areas > 500 m from access roads. This should be practiced on < 20% of prescription sites in a planning area.

3. Remove clover from the grass seed mixtures when close to active roads (< 500 m), so that these areas are less preferred by grizzlies for foraging.

4. Maintain and or recruit habitat for ants (e.g., carpenter ants (*Camponotus pennsylvanicus*), particularly on drier site series, by not disturbing large naturally occurring pieces of coarse woody debris (CWD), by enhancing levels of CWD across a prescription area, and by leaving high cut stumps (minimum of 0.5 m tall).

5. Forage quality depends, to a large extent, on herb and shrub cover, which in turn is influenced by seral stage, stand density and canopy closure. Higher forage value is usually associated with wetter site series and higher shrub cover (> 50% cover between clusters). This relationship is most valid in the CWH (except Douglas-fir (*Pseudotsuga menziesii*) dominated stands), and wet subzones of the ICH and SBS, but is also applicable to other subzones where berry forage is found. In areas where there are important forage species for bears, at the landscape level, manage the seral stage distribution and at the stand level manage for stand structure that has gaps of sufficient size to promote forage production. Three strategies to provide gaps at the stand level are:

   i) protecting existing natural gaps;
   ii) cluster planting; and
   iii) patchy spacing treatments (see below).

Regeneration:

1. Planting a mix of tree species should be considered when the number of trees per cluster is high. For cluster planting, a range of 10-30 conifer seedlings per cluster is recommended.

2. Plant a mixture of tree species and retain a deciduous component in the stand. Do not plant through existing alder swales, non-commercial cover, shrub fields, etc., that have been identified in operational plans as forage habitat.

3. Target tree stocking in clumps or patches so that berry forage production between clumps can be sustained for a longer period. A range of 10-30 conifer seedlings per cluster is recommended.

4. For clumpy planting (i.e., cluster planting), a reduced minimum inter-tree spacing and a lower maximum density are prescribed.

5. Shade-tolerant species (e.g., western hemlock (*Tsuga heterophylla*)) or species subject to epicormic branching (e.g., Sitka spruce (*Picea sitchensis*)) should be planted in the centre of a cluster, with less shade-tolerant species planted around the cluster perimeter.

6. The recommended inter-crop tree distance within clusters is 1-2 m (closer to 1 m for small clusters; and closer to 2 m for large clusters where more tree growing space is required).

7. Use the existing distribution of forage, crop trees and available microsites to roughly determine the target number of clusters per ha. Fewer clusters may be more suitable on uneven, wet, brushy or hummocky sites.

8. Manage seral stage distribution and stand structure to create gaps of sufficient size to promote forage production through cluster planting.

9. Avoid planting in important foraging areas (e.g., avalanche chutes, wet meadows, estuaries, riparian habitats, skunk cabbage swamps, seeps and alder swales).

10. Minimize soil and root disturbance between clusters to reduce damage to forage species root systems.

11. Spacing between clusters should be adjusted to reflect site conditions and microsite location. Uniform distribution of clusters over the block is appropriate where site conditions are relatively uniform. However, clusters should be located on appropriate planting sites, taking advantage of natural site features such as elevated hummocks or stumps.

12. Inter-cluster spacing is measured from the centre of one cluster to the centre of the adjacent ones on a square grid. However, where sites are undulating, clusters should be located on appropriate planting sites to take advantage of natural features such as elevated hummocks or stumps. Intercluster distances should be varied in order to optimize microsite selection.

13. Inter-cluster spacing is recommended to be a minimum of 80% and a maximum of 120% of that required to achieve the desired planting target. This range should result in achieving the overall desired stocking density, within acceptable statistics limits, when a stocking survey is applied across the area.

14. “Dispersed or non-uniform cluster” uses a mix of cluster densities across the block, and is appropriate for some blocks where microsites suitable for clusters (e.g., elevated hummocks) are not evenly distributed. For dispersed cluster planting, the minimum inter-tree distance within a cluster is 1 m on suitable microsites. The number of suitable clusters per ha should be estimated from a reliable survey that covers the entire area. The minimum/maximum inter-cluster distances may vary substantially, as long as the overall target density is met.

Brushing:

1. Use crop-tree centered brush treatments. Avoid herbicide application or spot treat in areas containing important forage species (i.e., *Vaccinium* spp., cow parsnip (*Heracleum lanatum*), fireweed (*Epilobium angustifolium*), devil's club (*Oplopanax horridus*), salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus racemosa*), gooseberries and currants (*Ribes* spp.), red-osier dogwood (*Cornus stolonifera*), soopolallie (*Shepherdia canadensis*), black twinberry (*Lonicera involucrata*), horsetail (*Equisetum* spp.) and sedges (*Carex* spp.).

2. Brush treatments should be limited to within and immediately adjacent to clusters, using backpack chemical applications or manual brushing methods.

Spacing/Thinning/Pruning:

1. As stands mature, use thinning to create partially open canopies (40-60% crown closure) to promote shrub forage production.

2. A combination of cluster planting and patchy spacing treatments can be used to achieve this stand structure.

3. Manage seral stage distribution and stand structure to create gaps of sufficient size to promote forage production through patchy spacing treatments.

4. Spacing can be used to open the canopy, or enlarge or create gaps; determine which method is most appropriate for the specific stand. Maintain a deciduous tree component after spacing or brushing treatments. Prescribe a range of spacing densities across a site, higher densities should be maintained along roads and adjacent to special habitats for security cover.

Protection (fire, insects, disease, damage):

1. Management of catastrophic and endemic stand damaging events must be done in the context of a well thought out access management strategy.

5(a) Recommended Silvicultural Regimes (Interior Sites)

Interior BEC – Zones

BWBS

ESSF

ICH

SBS

SWB

MS

Subhygric to Hygric sites:

Management of these sites should focus on the enhancement and or recruitment of areas for berry and forb forage at the stand level. As well, where these areas are a part of a riparian system, they can be important travel corridors and feeding areas for fish. The strategies and regimes that may achieve these objectives include:

- All silvicultural systems may be applicable for this objective. The season of harvest should be limited to conditions that will limit soil and root disturbance.
- Site preparation treatments should consider light controlled broadcast burns to promote maintenance and recruitment of berry forage.
- Establish new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section. Establish a target percent area of gap retention that will be maintained so this objective can be measured at the free-growing survey.
- Use brush treatments that center around crop trees.
- Do not use broadcast brushing techniques such as herbicide treatment.
- During brushing and or spacing treatments ensure that berry forage production between clusters can be sustained or enhanced for a longer period by pruning shrub species to increase forage quality, or pruning crop trees on the edge of clusters to allow light to enter gaps.
- Use spacing to reduce crown cover or actually create canopy gaps that will persist later into stand development (20-60 years).

Submesic to Mesic sites:

Management of these sites should focus on the enhancement and or recruitment of areas for berry and herbaceous forage at the stand level. This is especially important in areas with south aspects that can produce spring forage. The strategies and regimes that may achieve this objective include:

- All silvicultural systems may be applicable for this objective. The season of harvest should be limited to conditions that will limit soil and root disturbance.
- Site preparation treatments could include light controlled broadcast burns to promote maintenance and recruitment of berry forage and or mechanical scarification methods followed by grass seeding to promote forage opportunities. This treatment should not be conducted near roads and on < 20% of a cutblock area.
- Establish new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section.

Interior BEC – Zones ***BWBS*** ***ESSF*** ***ICH*** ***SBS*** ***SWB*** ***MS***	• Do not employ broadcast-brushing techniques such as herbicides. In addition, during brushing and or spacing treatments ensure that berry forage production between clusters can be sustained or enhanced for a longer period. • Implement juvenile spacing programs as required to ensure canopy gaps will be present later into stand development (20-60 years). **Very Xeric to Submesic sites:** Management of these sites should focus on the enhancement and or recruitment of areas for insects (ants) and shrubby forage species (e.g., Soopolallie/dry *Vaccinium* spp.) production at the stand level. This is especially important in non-Pacific drainages and when berry crops are low. All silviculture systems may be applicable for this objective. Harvesting should be conducted to a lower utilization standard to provide high stumps (> 0.5 m) and larger pieces of CWD to provide a substrate for ants and small mammal forage. The interim CWD strategy (MOF 2002) is $4m^3$/ha dry belt, $10m^3$/ha transitional, and $20m^3$/ha in the interior wet belt and coastal areas. Where possible, minimum CWD piece sizes dispersed throughout the harvest area (recommended > 10 cm dbh and > 6 m long (NSC 2002). • Site preparation treatments should be avoided, as the disturbance of existing CWD will reduce piece size and increasing decay rates. • Establish new plantations through planting or retention of natural advance regeneration in a uniform fashion so that subsequent crown closure will provide screening and security habitat, in particular, along roads, travel corridors and identified bear habitat features.

5(b). Recommended Silvicultural Regimes (Coastal Sites)

Coastal BEC – Zones ***CWH*** ***MH***	**Subhygric to Hygric sites**: Management of these sites should focus on the enhancement and or recruitment of areas for berry and forb forage at the stand level. The strategies and regimes that may achieve this objective include: • All silvicultural systems are applicable for this objective. The season of harvest should be limited to conditions that will limit soil and root disturbance. • Site preparation treatments should consider light controlled broadcast burns (where possible) to promote maintenance and recruitment of berry forage. • Establish new plantations through cluster planting or retention of natural advance regeneration in a cluster pattern as per the Additional Planting Information section. • Use brush treatments that center around crop trees. • Do not use broadcast brushing techniques such as herbicide treatment. • During brushing and or spacing treatments ensure that berry forage production between clusters can be sustained or enhanced for a longer period by pruning shrub species to increase forage quality, or pruning crop trees on the edge of clusters to allow light to enter gaps. • Use spacing to reduce crown cover or actually create canopy gaps that will persist later into stand development (20-60 years).

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.1 – Stocking Standard Guidelines

Applicable Ecosystem (BEC)			Stocking Standard Modifiers									
Zones	**Subzones**	**Moisture Nutrient Regime**	**Species Selection**	**Stocking Standard Modifier[1]**	**Regen Delay**	**Assessment Time Frame**	**Minist. Tree Ht.**	**% Tree Over Brush**	**Min Inter Tree Distance**	**Max Density**	**Survey Method**	**Comments**
BWBS	dk	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
CWH	All	3-5/D-E	Same	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
ESSF	All	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
ICH	dw, mc wk, vc	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
MH	mm	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
MS	dk	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
SBS	mm, mk mc, wk	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	
SWB	dk, mk	4-6/A-E	Broadleaf[2]	0.67	Same	Same	Same	Same	1.0	4000[3]	Footnote 4	

1. The term Stocking Standard Modifier refers to the factor applied to existing stocking standards contained within Establishment to Free Growing Guidebooks. For example: the stocking standards (well-spaced/ha) for CWHvm1 01 site as found in the Establishment to Free Growing Guidebook, Prince Rupert Forest Region equals = TSSpa **900**, MSSpa **500**, MSSp **400**. The equivalent stocking standards (well-spaced/ha) for areas with maintenance and or recruitment of grizzly bear foraging and security habitat objectives would be TSSpa **600**, MSSpa **335**, MSSp **270**. TSS - target stocking standard, MSS – minimum stocking standard, pa – preferred and acceptable, and p - preferred.

2. Broadleaf species management for mixed coniferous/deciduous stands should be seriously considered where applicable for this management objective. Utilize the appropriate broadleaf species as a primary or secondary species as indicated in the Establishment to Free Growing Guidebooks.

3. Maximum density is 4000 stems per ha for these ecosystems, this max density standard is inclusive of deciduous species. Deciduous stems will contribute to maximum density calculations in the same fashion as coniferous stems. In addition, stands will not be considered free growing unless they are demonstrated to contain a minimum of 20% canopy gaps. This is to be assessed through the establishment of random systematic free growing survey plots as discussed in point 4 below. If inadequate gap creation exists, then a juvenile spacing entry must be completed to provide the required gaps. Spacing is to target leaving gaps in areas with abundant forage present.

4. The survey methodologies used to assess the success of meeting the forage objectives should be consistent with existing methodologies. However, do not stratify areas to units smaller than one ha, or use dispersed stratum methodologies. In general, more plots will be required to prove obligations are met due directly to the desired patchy nature of the target stocking desired. The maximum number of plots required will be 1.5 per ha. The statistical requirements for these areas will be consistent with existing methodologies. In addition to meeting the stocking requirement for these stands it is imperative that gap creation has occurred by the free growing determination stage. To test if adequate gap creation exists, a minimum of 20% (per standards unit) of the randomly systematic established plots ($50m^2$) must contain less than or equal to one conifer (> 50 cm height), or the equivalent of 200 stems per ha.

6. Monitoring Standards – Establishment to Free Growing Seral Stage

Table 1.2– Cluster Distribution

Stocking (tress/ha)	Clusters per ha								Triangular Inter-cluster spacing (m)							
	Trees per cluster								Trees per cluster							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
200	25	29	33	40	50	67	100	200	21.5	20.1	18.6	17.0	15.2	13.2	10.7	7.6
250	31	36	42	50	63	83	125	250	19.2	18.0	16.6	15.2	13.6	11.8	9.6	6.8
300	38	43	50	60	75	100	150	300	17.5	16.4	15.2	13.9	12.4	10.7	8.8	6.2
350	44	50	58	70	88	117	175	350	16.2	15.2	14.1	12.8	11.5	9.9	8.1	5.7
400	50	57	67	80	100	133	200	400	15.2	14.2	13.2	12.0	10.7	9.3	7.6	5.4
450	56	64	75	90	113	150	225	450	14.3	13.4	12.4	11.3	10.1	8.8	7.2	5.1
500	63	71	83	100	125	167	250	500	13.6	12.7	11.8	10.7	9.6	8.3	6.8	4.8
550	69	79	92	110	138	183	275	550	13.0	12.1	11.2	10.2	9.2	7.9	6.5	4.6
600	75	86	100	120	150	200	300	600	12.4	11.6	10.7	9.8	8.8	7.6	6.2	4.4
650	81	93	108	130	163	217	325	650	11.9	11.2	10.3	9.4	8.4	7.3	6.0	4.2
700	88	100	117	140	175	233	350	700	11.5	10.7	9.9	9.1	8.1	7.0	5.7	4.1
750	94	107	125	150	188	250	375	750	11.1	10.4	9.6	8.8	7.8	6.8	5.5	3.9
800	100	114	133	160	200	267	400	800	10.7	10.1	9.3	8.5	7.6	6.6	5.4	3.8
850	106	121	142	170	212	283	425	850	10.4	9.8	9.0	8.2	7.4	6.4	5.2	3.7
900	112	129	150	180	225	300	450	900	10.2	9.5	8.8	8.0	7.2	6.2	5.1	3.6
950	119	136	158	190	238	317	475	950	9.9	9.2	8.5	7.8	7.0	6.0	4.9	3.5
1000	125	143	167	200	250	333	500	1000	9.6	9.0	8.3	7.6	6.8	5.9	4.8	3.4

Notes: When cluster planting is prescribed, silviculture prescriptions should specify target trees per cluster and target clusters per ha, in addition to the target stocking standard.

Two methods have been developed to determine the prescribed number of clusters per ha.

1. Final Crop Tree Method

   The final crop tree formula is the preferred method of determining the number of clusters. Managers must first determine the number of crop trees desired at rotation. Working backward from the density at final rotation, free growing targets and planting targets should be established based on appropriate mortality factors for the site. The following should be considered when deriving a mortality factor: species selection (e.g., shade-tolerant species show less mortality), availability of suitable microsites (e.g., moisture and nutrient requirements, likelihood of flood events), vegetative competition, and anticipated mortality due to stock handling. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha.

   Number of clusters per ha = planting target/ trees per cluster

2. Target Stocking Method

   Managers wishing to use the target stocking method should first consult stocking standards table to determine the free growing target stocking recommended for the site series. Next, they should establish a mortality factor based on the site series and conditions, as in the final crop tree method, to derive the planting target. Dividing the planting target stocking by trees per cluster will result in the required number of clusters per ha. The cluster distribution table above can be consulted to help verify the calculated figure.

   Number of clusters/ha = planting target/# trees per cluster *(Triangular inter-cluster spacing = The square root of 11547/# of clusters per/ha)*

- Spacing between clusters should be adjusted to reflect site conditions and microsite location. Uniform distribution of clusters over the block is appropriate where site conditions are relatively uniform. However, clusters should be located on appropriate planting sites, taking advantage of natural site features such as elevated hummocks or stumps.
- Inter-cluster spacing is measured from the centre of one cluster to the centre of the adjacent ones on a square grid. However, where sites are undulating, clusters should be located on appropriate planting sites to take advantage of natural features such as elevated hummocks or stumps. Intercluster distances should be varied in order to optimize microsite selection.
- Inter-cluster spacing is recommended to be a minimum of 80% and a maximum of 120% of that required to achieve the desired planting target. This range should result in achieving the overall desired stocking density, within acceptable statistics limits, when a stocking survey is applied across the area.
- "Dispersed or non-uniform cluster" uses a mix of cluster densities across the block, and is appropriate for some blocks where microsites suitable for clusters (e.g., elevated hummocks) are not evenly distributed.

6. Monitoring Standards – Additional

Establishment (Age 0-4 Years) Phase:

No more than 10% of individual opening sizes created for areas with this objective are to be > 2 ha in size. In addition, no individual opening may exceed 5 ha in size (e.g., a 10 ha block created with a patch cut system may contain the following gap sizes 5, 2, 1, 0.5, 0.25, 0.4, 0.6 ha). These openings reflect the natural gap sizes found in ESSF and wet SBS ecosystems.

Juvenile (Age 20-60 Years) Phase:

No specific standards are developed for this point in stand development. Management of younger age classes (e.g., establishment to free growing 0-20 years) is intended to develop suitable stand conditions through this age class. Opening up existing stands by creating gaps through late juvenile spacing or commercial thinning may be strategies that could be implemented to encourage forage species.

Mature (Age 60+ Years) Phase:

No specific standards are applicable for this age class. At stand maturity, partial cutting harvest systems can be used to create a patchy network of new seral openings (i.e., which simulate canopy gaps and open areas for forage production) and nearby forested security cover. In general, subsequent harvesting strategies (regardless of the silvicultural system) will have to be implemented that are consistent with the gap creation strategies discussed.

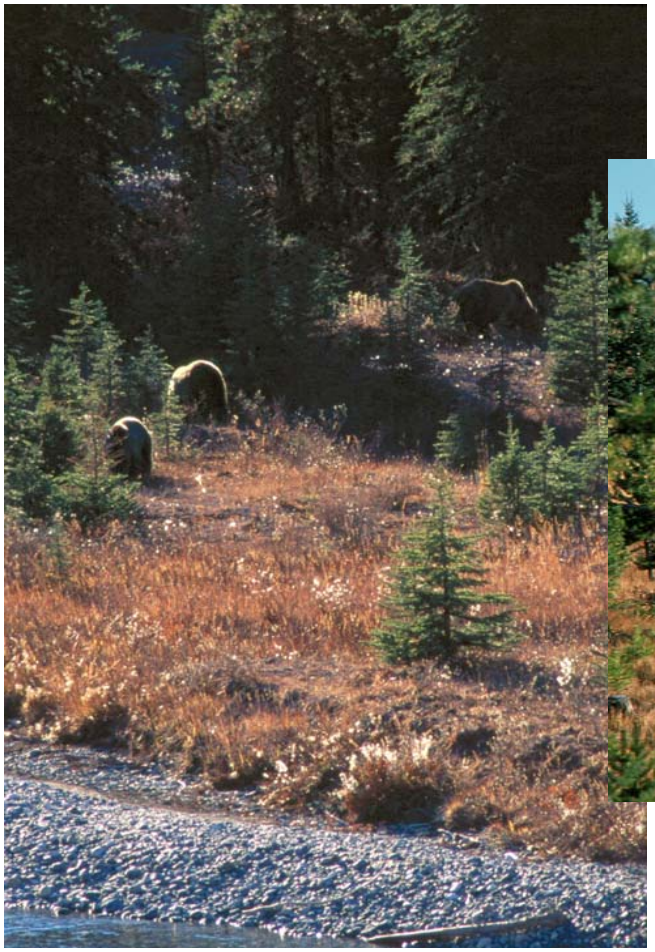

Figure 26: Planting and spacing regimes can mimic naturally occurring patchy, foraging habitat. Photo: Alex Inselberg.

Figure 25: Patchy and clumpy forest mosaic with shrubby openings provide forage and security habitat. Photo: Alex Inselberg.

Figure 27: Patchy and clumpy forest mosaic with heavy understory provide good security habitat. Photo: Alex Inselberg.

Figure 28: Patchy and clumpy forest mosaic with varied shrub and regeneration understory provides foraging and security habitat. Photo: Alex Inselberg.

Figure 29: Old forest with varied, berry-producing shrub understory provides important forage. Photo: Alex Inselberg.

Figure 30: Selective harvesting provides light penetration for shrub growth. Photo: Alex Inselberg.

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Glossary of Terms

Arboreal Lichen – A lichen species that tends to grow above ground, typically from the branches of standing trees.

Biodiversity (biological diversity) – The diversity of plants, animals, and other living organisms in all their forms and levels of organization, including genes, species, ecosystems, and the evolutionary and functional processes that link them.

Blowdown – A tree or trees uprooting by the wind. Often referred to as windthrow.

Bole – The trunk of a tree.

Broadcast Burning – A controlled burn, where the fire is intentionally ignited and allowed to proceed over a designated area within well-defined boundaries, to reduce fuel hazard after logging or to prepare the site before planting.

Brushing – A silviculture activity done by chemical, manual, grazing, or mechanical means to control competing forest vegetation and reduce competition for space, light, moisture, and nutrients with crop trees or seedlings.

Buffer – A strip of land (often including undisturbed vegetation) where disturbance is not allowed or is closely monitored to preserve or enhance aesthetic and other qualities along or adjacent to roads, trails, watercourses and recreation sites.

Canopy – The forest cover of branches and foliage formed by tree crowns.

Canopy Closure – The percentage of the ground surface covered when the canopy crown is projected vertically.

Canopy Gap – A distinct air-space or hole between the foliage of the canopy crown.

Closed Canopy – The condition when the crowns of trees touch and effectively block sunlight from reaching the forest floor.

Clumpy – Refers to the pattern of distribution of vegetation in an area such as a harvest opening, and can include the distribution of trees, regeneration, or shrub cover. A clumpy distribution is characterized by groups or clusters of vegetation, as opposed to uniformly or randomly distributed vegetation. “Clumpy” is often used in the context of planting and juvenile spacing treatments, and is also referred to as “patchy”.

Commercial Thinning – A silviculture treatment that removes or cuts stems that can be used commercially (e.g., fence posts) from an immature stand to help accelerate the growth and diameter size of the remaining stems.

Conk – A hard, fruiting body that typically grows on the trunk of a tree, which contains spores of a wood-decaying fungus

Connectivity – To have forest stands or habitat areas attached or linked to one another across the landscape.

Critical Winter Range – Forested habitat, usually stands of mature or old-growth conifers, which provides ungulates with resources critical to survival during severe winters.

CWD (Coarse Woody Debris) – Above ground, dead woody material in various stages of decomposition that is not self-supporting and provides habitat for plants, animals, and insects and is a source of nutrients for soil development.

CWD Decay Classes – A five-category system that describes the amount of decay that is present on a downed piece of wood >7.5 cm in diameter (i.e., class 1 is intact, hard and elevated above ground; class 5 is decayed into many small pieces with soft portions that is partly sunken into the ground).

Danger Tree (Hazard Tree) – A live or dead tree whose trunk, root system or branches have deteriorated or have been damaged to such an extent as to be a potential danger to human safety.

DBH (Diameter at Breast Height) – The stem diameter of a tree measured at breast height, 1.3 metres above the ground.

Deactivation – Measures taken to stabilize roads and logging trails during periods of inactivity, including the control of drainage, the removal of sidecast where necessary, and the re-establishment of vegetation for permanent deactivation.

Disturbance – A discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

Edge Habitat – Habitat conditions that exist along the outer band of a forested patch that are significantly different (e.g., differences in humidity, vegetation heights, plant associations, and exposure to light or wind) from the interior of the patch.

Exotic Species – A species introduced accidentally or intentionally to a region beyond its natural range. "Exotic" is a preferred synonym for "alien", "foreign", and "non-native".

Forest Floor – The layers of fresh leaf and needle litter, moderately decomposed organic matter, humus or well-decomposed organic residue found on the ground within a forest stand.

Fragmentation – The process of transforming large continuous forested areas into one or more smaller patches surrounded by human-made or naturally occurring disturbed areas.

Fungal Inoculation – An artificial means of introducing wood-decaying fungal spores into a live tree to increase decay and wildlife value.

Girdling – To kill a tree by severing or damaging the cambium layer and interrupting the flow of food between the leaves and the rest of the tree.

Habitat – The place where an organism lives and/or the conditions of that environment, including the soil, vegetation, water, and food.

Habitat Feature (elements) – An element of a forest stand that is used by a wildlife species for sustaining its ecological role, i.e., a snag, hollow log, mossy covered branch, forked limb crotch, rocky outcropping, etc.

Habitat Matrix – A series of linked habitat areas that maintain large-scale ecological processes at the landscape level.

Hard Forest Edge – An immediate, well-defined boundary between two or more distinctly different seral stages (i.e., the edge between an early seral stage and a late seral stage).

Herb Layer – All herbaceous plants (regardless of height) and low woody plants <15 cm tall.

Interior Forest Habitat – Microclimate conditions (i.e., light intensity, temperature, wind, relative humidity and moisture levels) found deep within forests, away from the effects of open areas.

Juvenile Spacing – A silvicultural treatment to reduce the number of trees in young stands, often carried out before the stems removed are large enough to be used or sold as a forest product. Also called precommercial thinning.

Landscape Level – The level of forest management at which ecosystem processes, habitat types and seral stage distribution are managed for large, geographically separate areas.

Landscape Unit – A planning area, up to 100 000 ha in size, based on topographic or geographic features such as a watershed or series of watersheds.

Landing – An area modified by equipment that is designed for accumulating logs before they are transported.

Leave Trees – All trees, regardless of species, age, or size, remaining on a harvested area as a result of a predetermined silviculture prescription to address a possible range of silviculture or resource needs.

Maintain – To stay at, or approximate, current natural levels of forage or other habitat attributes.

Management Guideline - Generally accepted non-mandatory guidance and management recommendations based on the best available data and expert opinion.

Mature Forest – The stage at which trees in a narrowly even-aged stand attain full development, particularly in height and seed production.

Natural Disturbance Regime – The historic patterns (frequency and extent) of fire, insects, wind, landslides and other natural processes and disturbances in an area.

Old Forest – Over-mature, structurally complex stands consisting of live and dead trees of various sizes, species, composition, and age class structure.

Overstory – Foliage within the shrub and canopy layers of a forest stand that obstruct sunlight from reaching the forest floor.

Partial Harvesting – A general term referring to silvicultural systems other than clearcutting, in which only selected trees are harvested.

Patch Cutting – A silvicultural system that creates openings less than 1 hectare in size and is designed to manage each opening as a distinct even-aged opening.

Patchy – Refer to definition of Clumpy

Prescribed Burning – The knowledgeable application of fire to a specific unit of land to meet predetermined resource management objectives.

Pruning – The manual removal, close to or flush with the stem, of side branches, live or dead, and of multiple leaders from standing, generally plantation-grown trees.

Recruit – To restore forage or other habitat attributes to previous natural equilibrium levels. Recruit can also be used in the context of enhancement, which means to increase forage or other habitat attributes above previous natural equilibrium levels.

Red List – Includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered, or Threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed.

Retention – To retain or save a portion of the original stand in a cluster or clump.

Riparian – an area adjacent to a stream, lake, pond or wetland where water influences the vegetation.

Riparian Management Area (RMA) – Means an area of width (as determined in accordance with standards described in the Forest Practices Code Operational Planning Regulations) that

is adjacent to a stream, wetland or lake. The RMA consists of a riparian management zone **(RMZ)** and, depending on the riparian class of the stream, wetland or lake, a riparian reserve zone **(RRZ)**. The riparian class is determined by the attributes of the stream, wetland or lake, as well as the adjacent terrestrial ecosystems. Attributes include channel width, size (area) of the wetland, presence of fish, domestic water use, and gully status (stream gradient and sidewall slope).

Riparian Reserve Zone (RRZ) – The portion of a riparian management area that borders the stream channel. RRZs are determined by the stream class and associated attributes (see RMA). Forest management activities are restricted in RRZs.

Rotation Period – The planned number of years between the formation or regeneration of a tree crop or stand and its final cutting at a specified stage of maturity.

Scarification – A method of seedbed preparation that consists of exposing patches of mineral soil through mechanical action.

Second Growth – A forest or stand that has grown up naturally after removal of a previous stand by fire, harvesting, insect attack or other cause.

Security Cover – Vegetation structure or topographical features, or both, that provide an animal with security or a means of escape from the threat of predators or harassment.

Selective Harvesting – The removal of certain trees in a stand as defined by specific criteria (species, diameter at breast height, height or form).

Seral Stage – Any stage of development of an ecosystem, from a disturbed, unvegetated state to a climax plant community.

Shrub Layer – All woody plants <10 m and >15 cm tall.

Silviculture – The theory and science of controlling the establishment, growth, composition, health and quality of forests and woodlands.

Silviculture Prescription – A site-specific, integrated operational plan to carry out one or a series of silviculture treatments.

Single Tree Selection – A silvicultural system that removes mature timber either as single scattered individuals or in small groups at relatively short intervals.

Slash – The residue left on the ground as a result of forest and other vegetation being altered by forest practices or other land use activities.

Small Group Selection – A silvicultural system that removes mature timber in a small area or grouping, typically $\leq$0.5 ha in size.

Snag – A standing dead tree.

Snag Classes – A nine-category system that describes the amount of decay that is present on a standing tree (i.e., class 1 is a live tree with no rot or decay present; class 9 is a fully decayed stump partially incorporated into the forest floor).

Soft Forest Edge – A gradual, transitional boundary between two or more seral stages (i.e., the edge between an middle seral stage and a late seral stage).

Soil Moisture Regime – The available moisture supply for a soil relative to other sites and soil types.

Soil Nutrient Regime – The available nutrient supply for a soil relative to other sites and soil types.

Spacing – The removal of undesirable trees within a young stand to control stocking, to maintain or improve growth, to increase wood quality and value, or to achieve other resource management objectives.

Stand Attribute – A measurable component of a forest stand (i.e., canopy closure, basal area, stem distribution, or seedlings/ha, etc.)

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 Structure – The distribution of trees in a stand, which can be described by species, vertical or horizontal spatial patterns, size of trees or tree parts, age, or a combination of these.

Stocking – A measure of the area occupied by trees, usually measured in terms of well-spaced trees per hectare, or basal area per hectare, relative to an optimum or desired level.

Stub Tree – An artificially created wildlife tree, mechanically cut from a class 1, 2 or 3 tree.

Succession – The gradual supplanting of one community of plants by another.

Thermal Cover – Vegetation structure and or topographical features that provide an animal a means to thermoregulate.

Thinning – A silviculture treatment that removes or cuts stems in an immature crop or stand primarily to accelerate diameter increment but also, by suitable selection, to improve the average form of the trees that remain.

Treatment Area – A productive forest land area designated in a prescription for a specific silviculture activity or series of treatments.

Tree Layer – All woody plants >10 m tall.

Understory – Any plants growing under the main tree canopy, particularly those found in the herbaceous and shrub layers.

Veteran Tree (Vet) – A tree that is significantly older (usually $\geq$150 years of age) than the trees of the main forest canopy. Veteran trees may have survived one or more fires as evidenced by fire scars, and are usually isolated in distribution and often extend well above the main tree canopy. Because of their large size, they usually provide valuable wildlife tree habitat for many decades.

Wildlife Corridor – A strip or band of habitat that wildlife use to travel from one habitat area to another.

Wildlife Tree – A standing dead or live tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife.

Wildlife Tree Patch (WTP) – An area specifically identified for the retention and recruitment of suitable wildlife trees that is reserved from harvest for at least 1 rotation length.

Winter Range – A range, usually at lower elevation, used by ungulates during the winter months that is typically better defined and smaller than summer range.

Yellow List – Any indigenous species or subspecies (taxa) that is not at risk in British Columbia.

Young Forest – A loose term applied to all stages of forest after it is established and before it becomes mature.

Appendix 1. List of Persons Contacted for Technical Information or Review Comments

- Harold Armleder – Wildlife Research Ecologist, Ministry of Forests, Southern Interior Forest Region, Williams Lake, B.C.
- Bryce Bancroft – Forestry Consultant. Symmetree Consulting Group, Victoria, B.C.
- Liesbet Beaudry – Wildlife/Forestry Consultant. P. Beaudry and Associates, Prince George, BC.
- Kim Brunt – Wildlife Biologist. Ministry of Water, Land and Air Protection, Nanaimo, BC.
- Michael Burwash – Senior Ecosystem Biologist. B.C. Ministry of Water, Land and Air Protection, Kamloops, BC.
- Rick Dawson – Wildlife Research Ecologist. B.C. Ministry of Forests, Cariboo Forest Region, Williams Lake, BC.
- Nancy Densmore – Biodiversity Specialist, B.C. Ministry of Forests, Forest Practices Branch, Victoria, BC
- Frank Doyle – Wildlife Consultant. Wildlife Dynamics Consulting, Telkwa, BC.
- Doug Folkins – Silviculture Forester. Canadian Forest Products Ltd., Woss, BC.
- Les Gyug – Wildlife Consultant. Merritt, BC.
- Tony Hamilton – Provincial Bear Biologist. B.C. Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC.
- Trevor Kinley – Wildlife Biologist. Sylvan Consulting Ltd., Invermere, BC.
- Marlene Machmer – Wildlife Consultant. Pandion Ecological Research, Nelson, BC.
- Erica McClaren – Inventory Specialist. B.C. Ministry of Water, Land and Air Protection, Wildlife Branch, Nanaimo, BC.
- Ian McDougall – Senior Forest Planner. B.C. Ministry of Sustainable Resource Management, Campbell River, BC
- Brian Raymer. Silvicultural Operations Forester. B.C. Ministry of Forests, Forest Practices Branch, Victoria, BC
- Chris Ritchie – Ecosystems Section. B.C. Ministry of Water Land and Air Protection, Prince George, BC.

- Dale Seip - Wildlife Research Ecologist, Ministry of Forests, Northern Interior Forest Region, Prince George, BC.

- Chistoph Steeger – Wildlife/Forestry Consultant. Pandion Ecological Research, Nelson, BC.

- Richard Thompson – Effectiveness Monitoring Specialist. Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC.

- Guy Woods – Wildlife Biologist. B.C. Ministry of Water, Land and Air Protection, Nelson, BC.

- Jim Young – Wildlife Biologist. B.C. Ministry of Water, Land and Air Protection, Williams Lake, BC.

Appendix 2. Biogeoclimatic Subzones of British Columbia

Zonal Group	Biogeoclimatic Zone	Subzone	Subzone Code
Coastal	Coastal Douglas-fir	Moist Maritime	CDFmm
	Coastal Western Hemlock	Wet Hypermaritime	CWHwh
		Very Wet Hypermaritime	CWHvh
		Very Dry Maritime	CWHxm
		Dry Maritime	CWHdm
		Moist Maritime	CWHmm
		Wet Maritime	CWHwm
		Very Wet Maritime	CWHvm
		Dry Submaritime	CWHds
		Moist Submaritime	CWHms
		Wet Submaritime	CWHws
Mountain Hemlock	Mountain Hemlock	Wet Hypermaritime Parkland	MHwhp
		Wet Hypermaritime	MHwh
		Moist Maritime Parkland	MHmmp
		Moist Maritime	MHmm
Dry Interior	Bunchgrass	Very Dry Hot	BGxh
		Very Dry Warm	BGxw
	Ponderosa Pine	Very Dry Hot	PPxh
		Dry Hot	PPdh
	Interior Douglas-fir	Very Dry Hot	IDFxh
		Very Dry Warm	IDFxw
		Very Dry Mild	IDFxm
		Dry Mild	IDFdm
		Dry Cool	IDFdk
		Moist Warm	IDFmw
		Wet Warm	IDFww
	Montane Spruce	Very Dry Very Cold	MSxv
		Very Dry Cool	MSxk
		Dry Cold	MSdc
		Dry Cool	MSdk
		Dry Mild	MSdm
Interior Cedar-Hemlock	Interior Cedar-Hemlock	Very Dry Warm	ICHxw
		Dry Warm	ICHdw
		Moist Warm	ICHmw
		Moist Mild	ICHmm
		Wet Cool	ICHwk
		Very Wet Cool	ICHxk
		Dry Cool	ICHdk
		Moist Cool	ICHmk
		Moist Cold	ICHmc
		Very Wet Cold	ICHvc

Zonal Group	Biogeoclimatic Zone	Subzone	Subzone Code
Central Plateau	Sub-boreal Pine-Spruce	Very Dry Cold	SBPSxc
		Dry Cold	SBPSdc
		Moist Cool	SBPSmk
		Moist Cold	SBPSmc
	Sub-boreal Spruce	Dry Hot	SBSdh
		Dry Warm	SBSdw
		Dry Cool	SBSdk
		Moist Hot	SBSmh
		Moist Warm	SBSmw
		Moist Mild	SBSmm
		Moist Cool	SBSmk
		Moist Cold	SBSmc
		Wet Cool	SBSwk
		Very Wet Cool	SBSvk
Engelmann Spruce-Subalpine Fir	Engelmann Spruce-Subalpine Fir	Very Dry Cold	ESSFxc
		Dry Cool	ESSFdk
		Dry Cold	ESSFdc
		Dry Very Cold	ESSFdv
		Moist Warm	ESSFmw
		Moist Mild	ESSFmm
		Moist Cool	ESSFmk
		Moist Cold	ESSFwc
		Moist Very Cold	ESSFmv
		Wet Mild	ESSFwm
		Wet Cool	ESSFwk
		Wet Cold	ESSFwc
		Wet Very Cold	ESSFwv
		Very Wet Cold	ESSFvc
		Very Wet Very Cold	ESSFvv
Boreal	Boreal White and Black Spruce	Dry Cool	BWBSdk
		Moist Warm	BWBSmw
		Wet Cool	BWBSwk
	Spruce-Willow-Birch	Dry Cool	SWBdk
		Moist Cool	SWBmk
		Dry Cool Scrub	SWBdks
		Moist Cool Scrub	SWBmks
Alpine Tundra	Alpine Tundra		AT

Source: Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Minist. For., Spec. Rep. Ser. 6, Victoria, BC.