GUIDELINES *for*

Commercial Thinning

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Preface

Commercial thinning is an intermediate harvest where the merchantable wood removed should cover part or all of the cost of harvesting. It is defined as a thinning "in which all or part of the felled trees are extracted for useful products…" (Smith, 1986). Commercial thinning, when carried out on the right stands at the right time under appropriate stand conditions, is a valuable strategic management tool that increases the flexibility in the timing and quantity of wood flow available at the forest estate level.

The *Guidelines for Commercial Thinning* were developed with input from industry (COFI), Ministry of Environment, Lands and Parks, MOF regions and districts, Research Branch, Economics & Trades Branch, Resource Tenures & Engineering Branch, Compliance and Enforcement, and Forest Practices Branch staff.

These guidelines provide information to forest practitioners considering commercial thinning and those that are currently planning and implementing commercial thinning programs in BC.

This document provides important information on:

1. the effects of commercial thinning on the growth of trees and stands
2. the importance of planning at the regional, landscape and stand levels
3. the guidance for inclusion of silviculture prescription data elements for commercial thinning
4. project preparation and administration.

To be successful, a commercial thinning program must be based on a clear statement of objectives, and have the appropriate age class structure and stand conditions to implement the program. This document provides background information for practitioners to assist in planning and implementing a commercial thinning program. Deviation from the guidelines outlined in this document should be based on dialogue between industry and government foresters.

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Introduction

Commercial thinning is an intermediate harvest where the merchantable wood removed should cover part or all of the cost of harvesting. It is defined as a thinning "in which all or part of the felled trees are extracted for useful products…" (Smith, 1986). As practiced in British Columbia, commercial thinning is usually a single-entry, partial cutting in stands between 30 and 80 years old, with no regeneration objectives.

Commercial thinning is generally part of an even-aged silvicultural system (see Figure 1). However, options exist for combining commercial thinning with any silvicultural system. Due to current experience, this guideline concentrates on commercial thinning as part of the clearcut silvicultural system. The intent of commercial thinning is a partial harvest, not regeneration.

Most of what we know about the theory and practice of commercial thinning is derived from experience and research in Europe and eastern North America. Limited commercial thinning has been undertaken in British Columbia, the majority in the Sayward Forest on Vancouver Island.

The traditional objectives of commercial thinning are:

- to obtain wood volume or revenue earlier than the final harvest
- to improve the growth of residual trees
- to improve the quality of the stand by removing dead, diseased and deformed trees
- to capture some of the production that would otherwise be lost to mortality.
- to obtain certain species and size classes for specialty products

Figure 1. Commercial thinning is part of an even-aged silvicultural system.

In B.C., increased flexibility of wood flow at the forest level is a primary goal. Commercial thinning can provide flexibility by:

- redistributing harvest over time
- acquiring volume while meeting visual quality objectives and adjacency constraints
- breaking up concentrations of stands in similar seral stage conditions.

Additional objectives may include:

- to modify stand structure for wildlife habitat or biodiversity
- to restore historical ecosystem structure, condition, species composition and processes
- to improve the health and vigour of the residual stand by removing diseased, stressed, wolf or other trees in an improvement thinning
- to utilize smaller forest residues that are available for harvest but not currently harvested due to technical or wood quality restraints
- salvaging mortality volume.

The fundamental technical details of commercial thinning are:

- choosing how many trees to cut (*thinning intensity*)
- choosing residual stand structure, density, residual basal area and species to leave for the final crop (*spatial distribution*)
- choosing which crown classes to harvest (*thinning type*)
- deciding when to harvest (*timing*).

Most rules or guidelines for thinning intensity and type are closely tied to traditional objectives and thinning methods. Nearly all have been developed for low thinnings in even-aged, single-species stands. With increasing interest in other objectives for thinning, the traditional guidelines and rules should be considered carefully but should not limit new ideas.

A commercial thinning program must be consistent with the management objectives of higher level plans or strategic direction. If there is potential for commercial thinning to help achieve these objectives, such opportunities should be investigated.

Workers' Compensation Board regulations must be met during commercial thinning operations.

The objective of a thinning treatment will determine the technical details of the treatment regime. The stand attributes derived from a commercial thinning treatment will vary greatly depending on the type, timing and intensity of the thinning. To maximize volume from the stand, a regime of frequent light thinnings is necessary. A single thinning leaving a low number of residual stems will often maximize stand value (net present value).

Commercial thinning can aid in smoothing out timber flow in certain situations. Figure 2 shows a commercial thinning program that provides some volume earlier than would have occurred with normal harvest rotations. Part of the harvest is delayed due to the lengthened rotation of the residual stand.

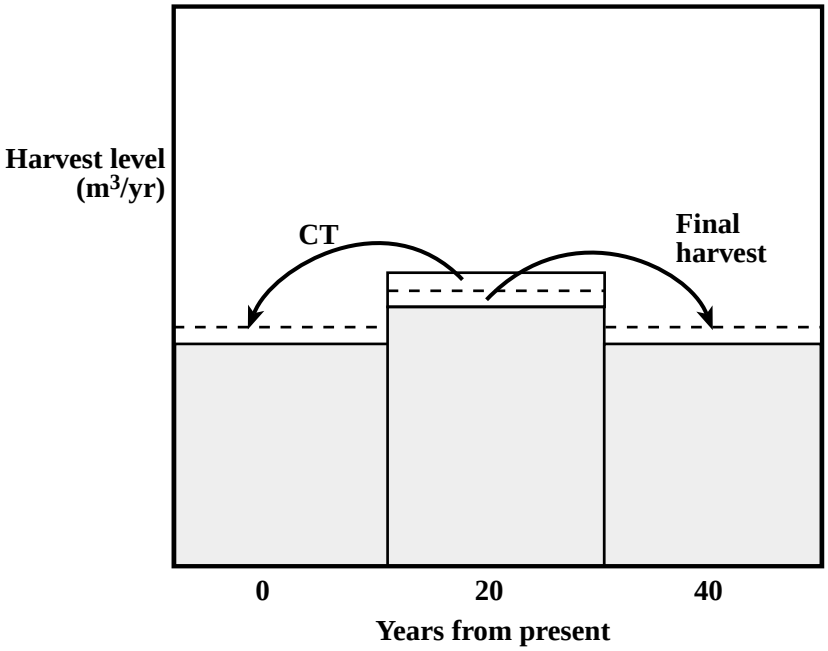


Figure 2. Harvest forecast for a hypothetical timber supply area showing the impact of commercial thinning on harvest flow.

Planning for commercial thinning (see Figure 3) flows from:

1. the subregional level (higher level plan – e.g., resource management zone), where objectives are set and it is determined that commercial thinning is necessary to help meet these objectives
2. the landscape level (e.g., landscape unit, total resource plan) where appropriate surveys can locate stands that best fulfill objectives
3. the stand level where regimes are set.

Commercial thinning a stand should pay for itself. In light of this, consider the following points:

- Total revenue from thinning should cover the cost of the thinning.
- Stumpage revenue for the Small Business Forest Enterprise Program (SBFEP) should cover administrative costs.
- The net present value (NPV) of the thinned stand should be the same or higher than if thinning was not done.

These criteria may not be met in the early stages of commercial thinning development in an area or where the objective of the thinning is not related to wood supply. However, treatments that decrease stand potential volume should be avoided.

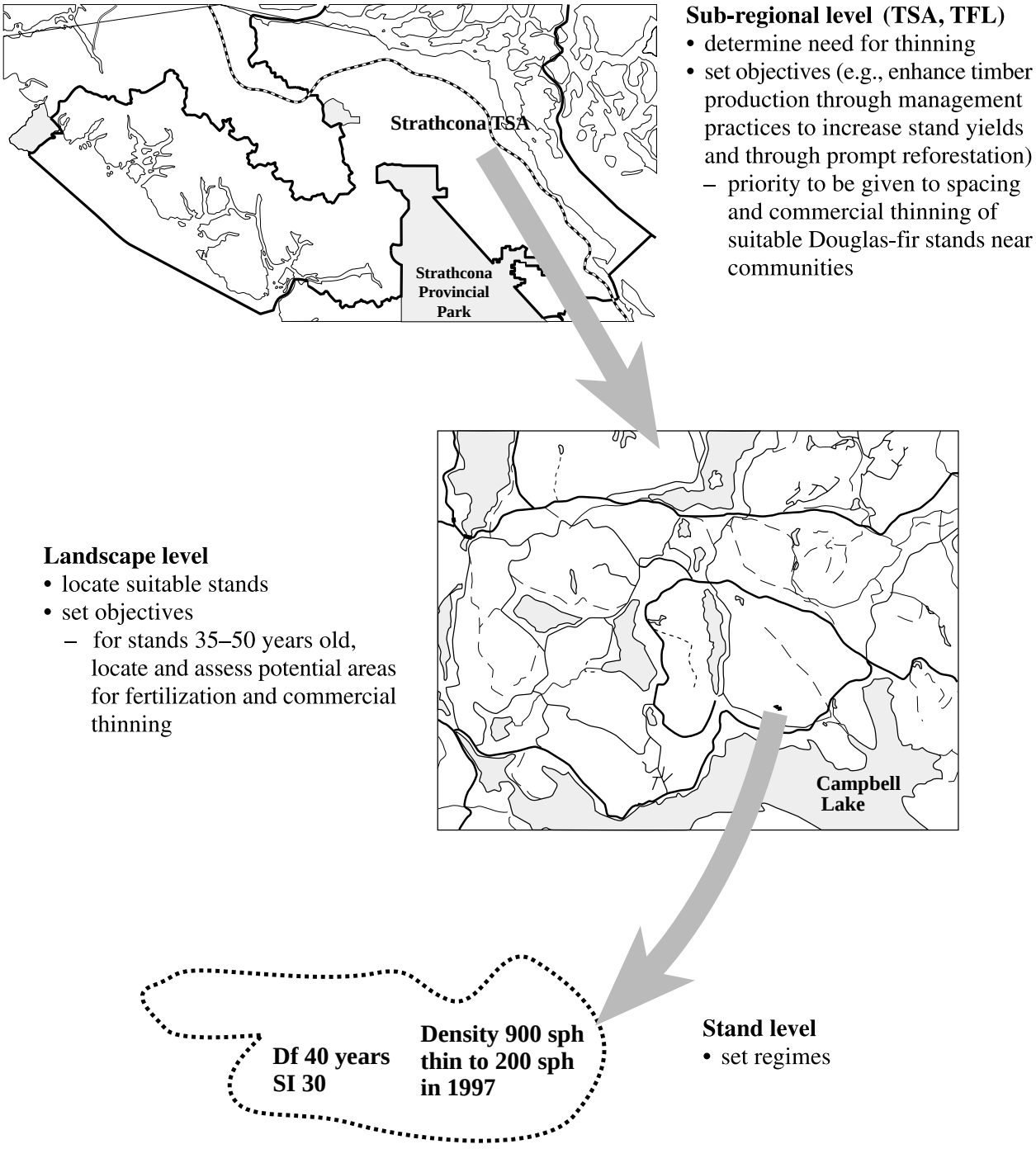


Figure 3. Planning for a commercial thinning program starts at the forest level and flows to the landscape and stand level.

Commercial Thinning and the Forest Practices Code

Forest Practices Code of British Columbia Act

Under the *Act*, commercial thinning is treated as a harvest entry. The *Act* provides the legislative framework and authority for the regulations and requirements related to commercial thinning and treats it the same as all other harvest entries. The *Act* includes the following requirements that relate to commercial thinning:

- forest development plans
- requirements for review and comment
- protection of the environment
- soil conservation
- road maintenance
- timber harvesting
- damage to trees and site
- excavated or bladed trails
- silviculture prescriptions
- penalties
- remediation orders
- penalties for unauthorized timber harvesting.

Operational Planning Regulation

Within the regulation, there are differences identified for commercial thinning. These relate to no requirement for regeneration objectives for commercial thinning entries.

The *Operational Planning Regulation* details the planning and review requirements for commercial thinning including:

- review and comment on plans and prescriptions
- content of forest development plans
- maximum cutblock size, if thinning is planned to leave <40% pre-harvest basal area
- identification of unstable or potentially unstable terrain
- visual impact assessment
- assessment of streams, wetlands and lakes
- evaluation of forest health factors
- excavated or bladed trails and landings
- protection of resource values

- detailed content requirements for silviculture prescriptions
- soil disturbance
- silviculture treatments
- species selection.

Commercial thinning prescriptions need to conform with all normal aspects of the planning and review process. Regulation specific to commercial thinning are as follows:

For commercial thinning, stocking requirements are:

- the preferred and acceptable species of trees
- the stand structure and composition goals, including the planned basal area or density per hectare
- the species and function of any trees that will be left standing to satisfy non-timber resource objectives.

For commercial thinning prescriptions without regeneration objectives, the following prescription requirements are **not** required:

- description of the silvicultural system to be used
- whether livestock grazing is proposed for vegetation management
- the regeneration date
- the free growing assessment period.

The silviculture prescription must specify that the prescription only covers commercial thinning, harvesting of poles, sanitation treatments or other intermediate cuttings without regeneration objectives.

Silviculture Practices Regulation

The *Silviculture Practices Regulation* details the Code requirements for commercial thinning. They are consistent with all other harvesting prescriptions, except:

- There is no requirement to specify a regime of silviculture treatments that can reasonably be expected to produce target stocking levels as per prescriptions with regeneration objectives.
- Reporting is also somewhat different for commercial thinning. The silviculture survey requirement for the nature and extent of permanent access structures and soil disturbance are the same as other harvesting prescriptions. However, instead of the traditional regeneration and free growing surveys, a survey must be undertaken no earlier than 12 months after the completion of harvesting and should include:
  - the identification of the area under the silviculture prescription and, if the report is required of a major licence, the agreement and the name of the holder of the agreement

- for the net area to be reforested
  - the area
  - the biogeoclimatic ecosystem classification
  - the incidence of damage by forest health factors affecting trees
  - the post-harvest inventory label, including species component, age, height, density, basal area and volume per hectare, and site index
  - the number of acceptable and preferred trees per hectare.

Effect of Commercial Thinning on the Growth of Trees and Stands

Intensity, timing and type of thinning are factors that can be manipulated in a commercial thinning regime to meet stand-level objectives. The stand condition before thinning will affect the way the stand responds to commercial thinning.

Thinning intensity

Cutting some trees increases the growing space available to the remaining crop trees. Growing space refers to a tree's share of total site resources, not just the physical space it occupies. Trees use the increased share of resources to produce more foliage, more roots and more wood. Branches at the base of the live crown receive more light than they would have otherwise and consequently live longer. Crown recession thereby slows or stops. As the tree grows in height, the length of live crown increases, as does the live-crown ratio. On the main stem, the distribution of increment is altered, affecting both taper and form. The bole will become more tapered and more conical over time than it would have without the additional growing space.

The post-thinning growth of a residual tree depends on the amount of new growing space created as well as factors such as site quality, species, age and vigour. For a vigorous tree, growth is generally proportional to growing space, up to the point where a tree is growing at its full potential and is largely unaffected by neighbours. A less vigorous tree (e.g., low live crown ratio, suppression, injury, disease) may not be able to realize all the benefits of the additional growing space. In some cases the effects of thinning may be so dramatic that the tree might suffer 'thinning shock' and perhaps die. The highest growth rates per tree are associated with heavy thinning.

At the stand level, the highest rates of growth per hectare are achieved when the site is fully occupied. Stands that have been heavily thinned will generally produce less volume than stands that have been lightly thinned. Although individual-tree growth will be greater with heavy thinning, the use of site resources will not be fully utilized compared to lighter thinnings.

There are several methods for quantifying thinning intensity. Recommendations can be expressed as a residual stem count or residual basal area. Another common parameter is 'percent normal basal area,' where normal means 'fully-stocked.' A limitation of this technique is the need to know what 'normal' basal area is for any particular combination of site and stand age. That limitation has lead to the search for expressions of stand density that are independent of site and age. Several have been developed, including Reineke's (1933) stand density index (SDI), Drew and Flewelling's (1979) relative density index (RDI), Curtis's (1982) relative density and Wilson's (1946) relative spacing index.

SDI and RDI are useful measures for ranking stands for commercial thinning.

Thinning type

Thinning type or method describes how the cut and leave trees are selected, based on the their canopy position or crown class. Historically, four types of thinning have been recognized (see Figure 4):

- **Low thinning** – (sometimes called 'thinning from below') favours the tallest trees in the stand by removing the lower crown classes.
- **Crown thinning** – removes some trees in the middle and upper crown classes to favour the best dominant and codominant trees.
- **Selection or high thinning** – removes dominant and codominant trees to release trees in the lower crown classes.
- **Systematic or geometric thinning** – removes trees according to some predetermined pattern, such as rows, without regard to crown class.

Thinnings that do not conform to any of the above types are sometimes referred to as 'free thinnings.' In practice, silviculturists often strive for a uniform spatial distribution of residual trees in either the low, crown or selection thinnings.

The type of thinning affects the revenue derived from the thinnings. Thinnings that remove large trees will often be more profitable than thinnings that remove the same number of smaller trees. The type of thinning also influences the subsequent growth of the residual stand because all the trees in the stand are not equally vigorous or able to respond to release. For even-aged, single-species stands the vigour of trees is closely related to their position in the canopy. The tallest trees tend to be the most vigorous and the suppressed trees are the least vigorous. The difference in post-thinning basal area growth between leaving the most vigorous trees and leaving the same basal area of the least vigorous trees can be more than 30 percent (Larson and Cameron, 1986). Inappropriate use of selection thinning can be regarded as high grading.

The most common quantitative expression of thinning type is the thinning ratio, d/D, where:

d = mean diameter breast height (dbh) of cut trees

D = mean stand dbh *before* thinning.

The thinning ratio is usually less than 1.0 for low and crown thinnings, greater than 1.0 for selection thinnings and close to 1.0 for systematic thinnings. It is, however, not an ideal descriptor of thinning type. Radically different thinning prescriptions can produce the same thinning ratio. It also is not independent of thinning intensity. For many thinning operations the best description of the type of thinning is a sample of the diameter distribution before and after thinning.

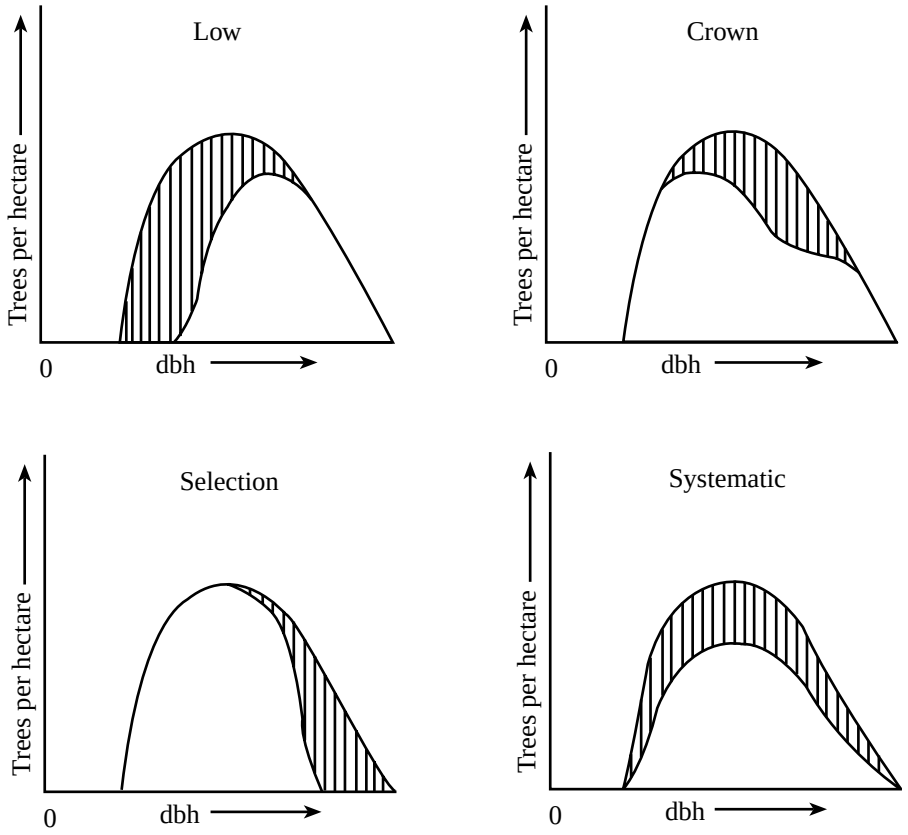


Figure 4. Thinning types. Diameter distributions for the same even-aged stand showing, by crosshatching, the parts that would be removed in the four different methods of thinning. In each case, about one-third of the basal area is represented as having been removed. It is assumed that no overtopped trees are salvaged in the crown and selection thinnings, that the stands have not been treated previously, and that dbh is closely correlated with crown class. (Adapted from *The Practices of Silviculture*, Smith 1986, John Wiley and Sons Inc.)

Timing of thinning

Commercial thinning traditionally is carried out during the active height growth period of a stand to foster a growth response in the remaining trees. Traditional commercial thinning is done prior to culmination of mean annual increment (MAI) (stand age ranging from 30–60 years, depending on growth potential).

The timing of the commercial thinning, relative to the age of the stand, affects the volume and value of the final stand. In an older stand where height growth of the dominant and codominant trees is already slow (i.e., flat portion of height/age curve past culmination of MAI), there will not likely be a growth response to thinning. Any commercial thinning of such stands should have clearly set objectives. Late thinning may be considered in stands where it is desirable to significantly extend the rotation in order to achieve specific management objectives. These objectives would not include increasing growth of the residual stand.

Delayed thinning results in a decline in release potential, higher risk of windthrow, and volume lost to natural mortality. Heavy, late thinnings will result in a reduced total volume and lengthened physical rotation.

Late thinning on stands that are considered windfirm can be done to achieve several objectives. For example:

- preharvest of small trees that could be harvested but that are not currently harvested for technical non-merchantable size or wood quality reasons. Removing small diameter trees in a pre-harvest can significantly reduce final harvest costs.
- harvest of some volume from stands with adjacency constraints (e.g., greenup)
- a stage in the conversion from even-age to uneven-age silvicultural systems.

Early timing of thinning is preferable. However, it cannot be so early that trees have not reached merchantable size, market opportunities are limited, or piece size greatly reduces value. Dense lodgepole pine stands may not reach merchantable thinning size before the stand is too old to respond well.

It is preferable that early thinnings cover costs. Nonetheless, consider the impacts over the entire rotation. An early non-profitable thinning may be acceptable if stand value is increased sufficiently.

A multiple thinning schedule involving frequent, light and early thinnings, has the potential to maximize the salvage of volume that would otherwise be lost to mortality.

Sub-regional Level Planning

Sub-regional level objectives

The decision to commercial thin should be made at the sub-regional or management unit (TSA, TFL) level in the context of higher level plans.

The Ministry of Forests policy for commercial thinning identifies broad strategic objectives that commercial thinning can be used to help achieve. These include:

- timber flow
- environmental values
- socio-economic values.

Within this context, opportunities for commercial thinning can be pursued, subject to economic feasibility.

Higher level planning sets the stage and context for timber supply availability, and thus the suitability of commercial thinning. Decide whether there is a forest-level management problem that commercial thinning can help solve. For example, an age class imbalance may contribute to a wood flow problem where commercial thinning is identified as a possible solution. Before implementing a full-scale commercial thinning program, determine whether there are enough suitable stands to mitigate the timber flow problem. If so, commercial thinning should be promoted as a management strategy for a forest.

Designing the solution usually requires a detailed understanding of the resource base and the long-term potential for thinning. Where extensive programs are not anticipated, a planning shortcut directly to the stand level is possible. This may occur with small landscape units where short-term restrictions are impacting timber availability. Wherever possible, the solution to wood flow problems should be multi-faceted and include a wide range of harvesting options.

Higher level objectives should therefore guide the setting of commercial thinning regimes. Consider the stand level trade off between value and volume (see "Economic considerations for thinning regimes" section). The role of thinning should be assessed with respect to guidelines applied for watershed hydrology, riparian zones, biodiversity, landscape units and wildlife habitat. Finally, specific objectives may be required to address social values.

Ultimately, stand-level commercial thinning objectives must be consistent with the objectives of higher level plans.

A long-term plan to help meet higher level objectives with commercial thinning requires an investment in surveying. Initially, the surveys will be of unmanaged stands. The decision in unmanaged stands is often dependent on whether:

1. sufficient merchantable volume per hectare is present
2. the thinning is too late to expect a growth response from the stand
3. the residual stand will be windfirm.
4. current stand structure will allow the creation of the desired residual stand structure

The plan will usually show a gradual conversion to managed stands over time. Eventually, managed stands will constitute the major source from which stands suitable for commercial thinning will be selected.

Impacts of commercial thinning

Timber flo

Commercial thinning can redistribute timber supply over time. A single-entry thinning will not add significant volume and can reduce overall stand volume. At the stand level, commercial thinning creates a broader window of opportunity for planning harvesting patterns. Like spacing, commercial thinning extends the culmination age of a stand. This must be considered when planning final harvest after a stand has been commercially thinned.

The intermediate harvest can help to fill in projected shortages in timber availability due to a forest age class imbalance or adjacency constraints (see Figure 2).

Timber availability

Timber availability is often constrained by the need to conserve other resource values. These constraints include:

- guidelines that stipulate the makeup of a forest by such factors as seral stages (immature, mature, old growth); see *Biodiversity Guidebook*
- adjacency restrictions (green up); see *Visual Landscape Management Guidebook* and *Green-up Guidebook*
- visual quality objectives (percent alteration of landscape unit); see *Visual Landscape Management Guidebook*
- wildlife habitat requirements (e.g., maximum distance to cover); see *Managing Identified Wildlife: Procedures and Measures*
- hydrological restrictions (effective equivalent clearcut percentage); see *Interior Watershed Assessment Procedure Guidebook* or *Coastal Watershed Assessment Procedure Guidebook*
- special management areas that restrict frequency, size, distribution and timing of clearcuts (see local forest development plan).

With many of these constraints, commercial thinning will allow timber extraction where or when a clearcut is not feasible. The flexibility of harvest timing through commercial thinning can improve the wood flow potential at the sub-regional level.

Socio-economic values

If there is a market for small wood, revenue can be generated from stands at an earlier age than the final harvest. There may also be employment benefits for a community. The number of jobs per cubic metre for commercial thinning is normally greater than from a comparable clearcut operation. The impact of commercial thinning on smoothing out timber flow can help to keep mill operations viable.

Commercial thinning has the potential to modestly increase the net present value of thinned stands compared to unthinned stands (Stone 1993, 1995).

Environmental values

Commercial thinning influences spatial and temporal forest cover diversity. As with wood supply, other resources can benefit from a suitable mix of attributes within the forest. Wildlife requires a mixture of habitats, including early and late seral stages. Thinning can play a role in accelerating the development of some old growth characteristics in second growth stands. This can assist in the creation of second growth forest ecosystem networks.

Landscape-level Planning

Resource values other than timber can affect the planning at the sub-regional, landscape and stand levels. The decision to commercial thin is best made at the sub-regional level. The decision of where to thin is made at the landscape and stand level.

Visual landscapes

The *Visual Landscape Management Guidebook* specifies a range of stand types that can be left on site to meet visual quality objectives. Commercial thinning can be planned so that sufficient forest cover is retained to meet the most restrictive visual quality objectives (VQO). There are no restrictions on opening size, as long as a sufficient number and distribution of overstorey trees are retained to meet the VQO. Road locations may still constrain the use of commercial thinning in areas of highly restrictive VQOs.

Biodiversity

Commercial thinning can have an impact on the biodiversity of both a forest and a stand.

In areas of extensive second growth, commercial thinning may increase the variety of seral stages. A variety of final rotation ages will create a mosaic of stands with varying degrees of crown closure, stocking and diameters. Commercial thinning is one technique that can alter timing of final harvest, particularly when necessary due to VQO or adjacency constraints. Some stands can be left for extended rotations and will eventually mimic some old-growth characteristics (see Figure 5).

Forest health

Commercial thinning can be planned to meet forest health objectives. These may include reducing the risk of bark beetle infestations in a landscape of susceptible stands, or managing stands with low level infections of laminated root rot in order to maximize timber volume production. The following issues should be considered:

- the value and pest risk of the thinning versus “no treatment” should be estimated on a variety of candidate stands in the area
- stand-level treatments should be consistent with higher level plans. Reduction of risk from forest health agents is normally consistent with higher level plans.

Figure 5. Commercial thinning may enable removal of timber from visually sensitive or scenic areas.

Stand-level Planning

Stand-level planning identifies silvicultural actions to meet the goals of the higher level plan (e.g., wood supply, biological diversity, visual quality, wildlife habitat and recreation). Stand-level resource objectives for a site should be consistent with forest resource objectives stated in higher level plans (see *Silvicultural Systems Guidebook*). Without goals identified in higher level plans, stand-level objectives may not adequately address the timber and non-timber values.

Management objectives

Site-specific management objectives are required for timber and non-timber values. The silviculture prescription will provide the standards chosen to attain these management objectives.

Stand-level management objectives include:

a) Timber

- target piece size for operability concerns
- salvage mortality volume
- diameter distribution of remaining crop trees after commercial thinning
- manipulation of timber flow and availability
- target volume at thinning and final harvest
- target basal area or volume to leave after commercial thinning
- economic factors such as net present value and timber value.

b) Stand Structural diversity

In a managed stand, the biodiversity considerations specified in a silviculture prescription should focus on maintenance of structural diversity (usually buffer strips and reserves) brought forward from the spaced stand and/or the previous harvest treatment (Figure 6). Stand structural diversity in unmanaged stands may require more creative solutions, and consultations with MoELP staff, to develop appropriate diversity.

Structural diversity can be enhanced through various management practices (e.g., leaving a portion of the block unthinned). Riparian zones and buffers may partially achieve such an objective. Wet areas within blocks may be left unthinned primarily in consideration of trafficabilty. Openings can also be created by thinning areas of the block to less than target density. Planning for root rot treatments and salvage can create some openings. If there are reforestation objectives for the openings, normal silviculture prescription requirements apply. These areas can be valuable additions to a block’s structural diversity.

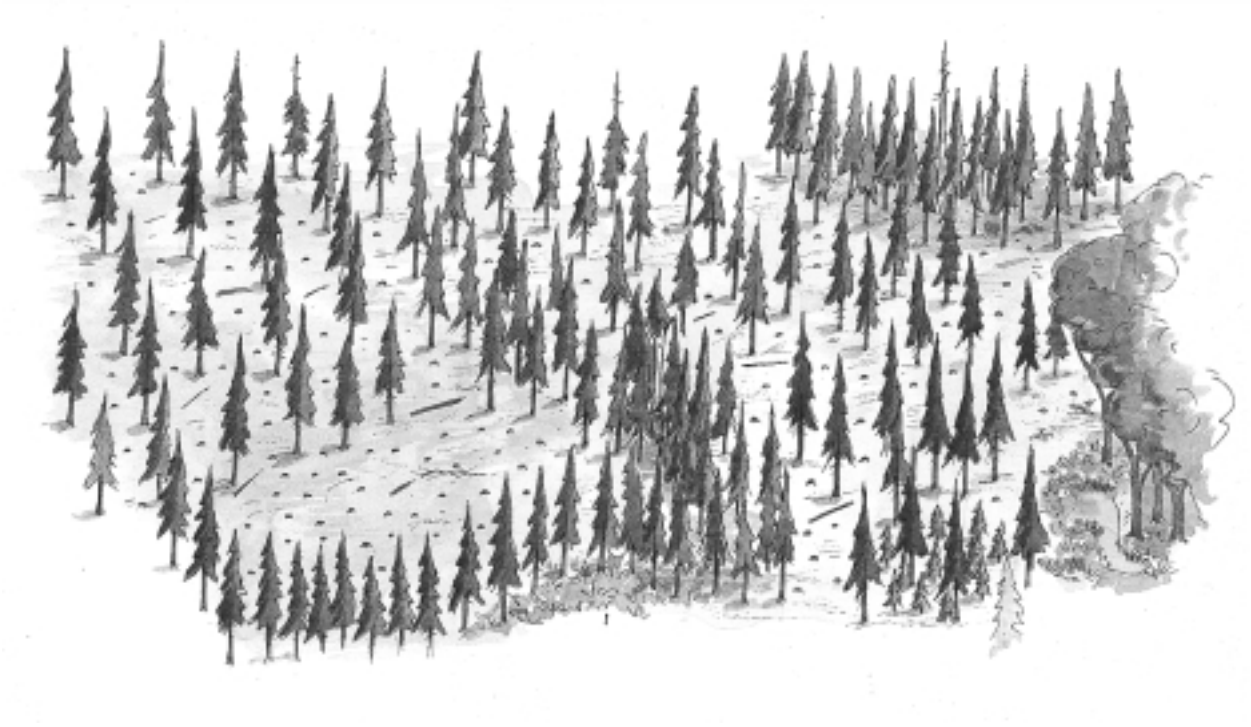


Figure 6. Vary stand density for structural diversity objectives – maintain openings and thickets, encourage forage growth, and develop large diameter, full crown trees.

Stand manipulations can include:

- variation in density so some trees have sufficient room to form large, full crowns and other areas are left as thickets
- growing larger diameter trees and leaving more openings
- continued stocking control to maintain forage
- stocking control to maintain stand density, species composition, and basal area within the historic range of variability.

Commercial thinning may be designed to delay crown closure to meet range, wildlife habitat, biodiversity or other objectives.

Future retention areas should be identified for managed and unmanaged areas (see Figure 7). Such areas will be maintained beyond the final harvest of the current rotation. The presence of these retention areas may influence the choice of an appropriate harvesting method.

Consider the following points for structural diversity and commercial thinning:

- insert untreated buffers to avoid large continuous areas of thinning.
- Produce small openings, where feasible, by occasionally altering the normal spacing and creating a cluster effect. This effect is common on rich coastal sites that have regenerated naturally.

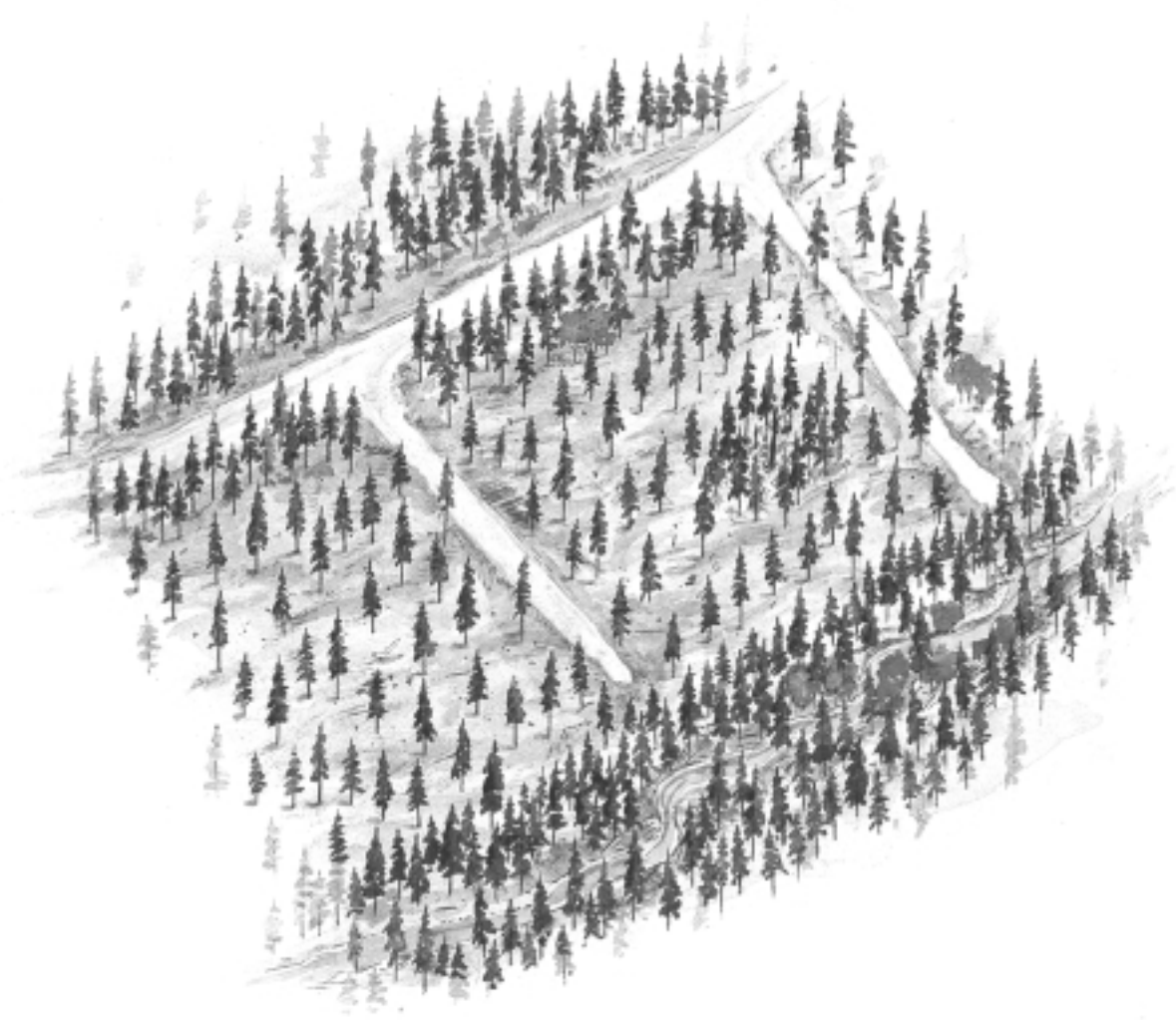


Figure 7. Future retention areas. The roadside buffer, wildlife tree patches and riparian management zone are examples of future retention areas. The roadside buffer and wildlife tree patch may be maintained beyond the final harvest to enhance structural diversity.

- Where safe to do so, retain some snags and poorly formed wolf trees to serve as wildlife trees in the next rotation. Safety considerations may require the establishment of a no-work zone within the treatment area.
- Preserve non-merchantable understorey trees where appropriate (understorey western redcedar can be carried into the next rotation).
- Use stands with low levels of root rot infection to enhance natural openings by removing bridge trees. This technique may not work where *Armillaria ostoyae* or *Phellinus* is prevalent. If openings are desired in a stand where root disease is prevalent, no action need be taken.
- Retain the occasional thicket of small trees (e.g., shade-tolerant understorey Hw).
- Avoid sensitive wet sites (see Figure 8).

Figure 8. Avoid sensitive wet sites.

- Retain species mixtures if ecologically suited.
- Retain species such as western redcedar, red alder and bigleaf maple that may enhance soil productivity.
- Retain large deadwood.
- Retain hardwoods that are not significant competitors to crop trees.
- Retain hardwoods to meet other management objectives.

c) Wildlife

Favourable conditions for wildlife can be promoted by:

- avoiding continuous overstocked conditions that reduce forage
- developing structural diversity by encouraging understorey development. This can provide security cover for ungulates
- identifying and reserving wildlife trees, deciduous trees and thickets
- varying stand density and identifying untreated buffer zones within a stand
- revegetating disturbed areas (landings, cutbanks, temporary roads) following harvesting
- maintaining visual buffers with no thinning along roads with frequent use.

d) Visual landscape

The following forest practices have the potential for reducing impacts on visually sensitive areas:

- commercial thinning can maintain or enhance the viewscape along well travelled corridors but only where windthrow risk is low
- minimize road widths and revegetate disturbed cutbanks or landings
- utilize small dispersed landings and hotload from skyline corridors where practical.

Stand selection

Some stands may be obvious candidates for commercial thinning. These are stands where a cut is desired, but a final harvest is not currently possible due to various constraints. Examples are stands:

- with adjacency constraints
- with visual quality objectives that can be met with commercial thinning
- requiring treatments to improve stand-level structural diversity or wildlife forage.

The main purpose of stand selection is to identify stands that will respond in volume or basal area growth as a result of thinning. Stand models (e.g., TASS – Tree and Stand Simulator or Prognosis^{BC}) can provide information about types of stands that may respond well to particular commercial thinning regimes. Multiple stand model runs are recommended. These runs should simulate the types of stands likely to be found in the area and their response to potential regimes.

Determine the stands where stocking, crown vigour, site quality and merchantability would indicate that commercial thinning is feasible. These are stands where mortality has not yet begun to have an impact and growth response to thinning is still possible. In cases of large tracts of second growth with many potential stands for commercial thinning, the following steps can be used for stand selection:

1. Landscape overview – use photos, GIS theme mapping, inventory and local experience to develop a list of candidate stands. GIS theme mapping will not only show where the potential ISIS openings are but also stands not in ISIS that may have potential based on locally-developed suitability criteria. Local experience is a valuable factor and will help to eliminate areas of unmerchantable stands. As information from stand management prescriptions is entered into corporate data bases (e.g., ISIS), such systems can be used to list stands set up for commercial thinning.
2. Field reconnaissance – walk through stands to assess stand structural characteristics such as tree stability, height/diameter ratios, windfirmness, crown lengths, forest health and water table in order to eliminate obviously unsuitable stands.
3. Stand data collection – collect sufficient information on tree size and stand density to be able to create stand and stock tables. A low intensity survey (e.g., a survey of four to eight plots per stand, depending on stand variability, may be

sufficient for this purpose.) More complex stands may require more plots. For example, Nelson Region reports one plot per 2.5 hectares in their lodgepole pine types provides reasonable volume estimates. In addition, their sampling intensity was enough to facilitate changes to the inventory type label if the stand had been misclassified.

Reconnaissance and stand data collection

a) Field reconnaissance: A reconnaissance determines the suitability of a stand for commercial thinning.

Walk the stand to assess:

- level of competition (stand density, height/diameter, crown lengths, basal area/hectare)
- merchantability
- potential for growth response to thinning
- signs of windthrow and snowbreak
- forest health concerns
- harvesting feasibility (topography, trafficability)
- approximate boundaries
- site productivity
- average diameter.

Check the last 10 years ring growth on those trees planned for retention. Stands with trees that have several years of severe ring growth decrease and live crowns less than 30% may have poor release potential. Use aerial photographs and reconnaissance information to establish strata.

Various techniques exist for screening out stands that are not silviculturally suitable. These are based on stand measurements for percent live crown, density, height and diameter; and calculations for basal area, mean diameter, site index and volume.

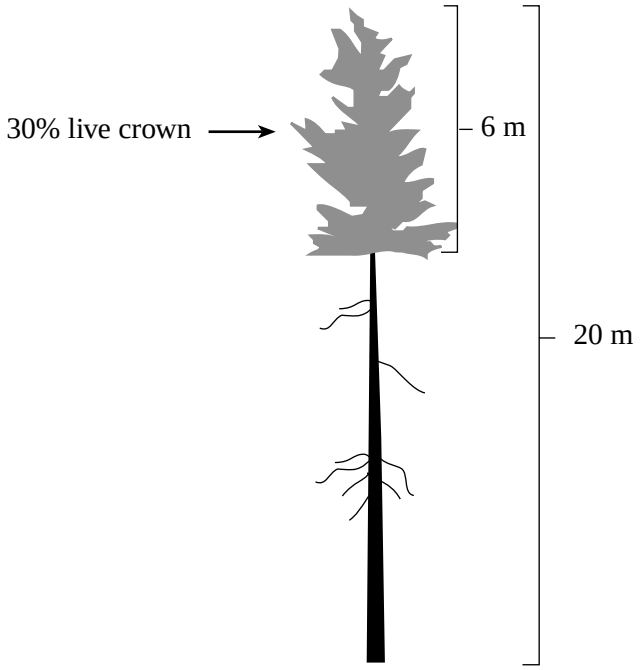
Percent live crown: This is indicative of individual tree vigour and potential for release. Percent live crown should be *at least* 30% on residual crop trees. Shade tolerant species should have more than 30% live crown. Avoid thinning when percent live crown is less than 30% for residual trees (see Figure 9).

Density: Stands with high densities will have many non merchantable stems that must be handled, potentially decreasing economic viability of a commercial thinning operation and increasing risk of stand damage. Exercise caution when thinning stands with pre-thinning densities greater than 3000 stems/ha.

Windthrow hazard: Windthrow is a serious concern for commercial thinning prescriptions. Windthrow hazard and risk can be assessed using the procedure outlined in the *Windthrow Handbook* and the windthrow field cards (FS 712-1-2-3). The results of the assessment should be used in designing appropriate residual densities and windfirm boundaries.

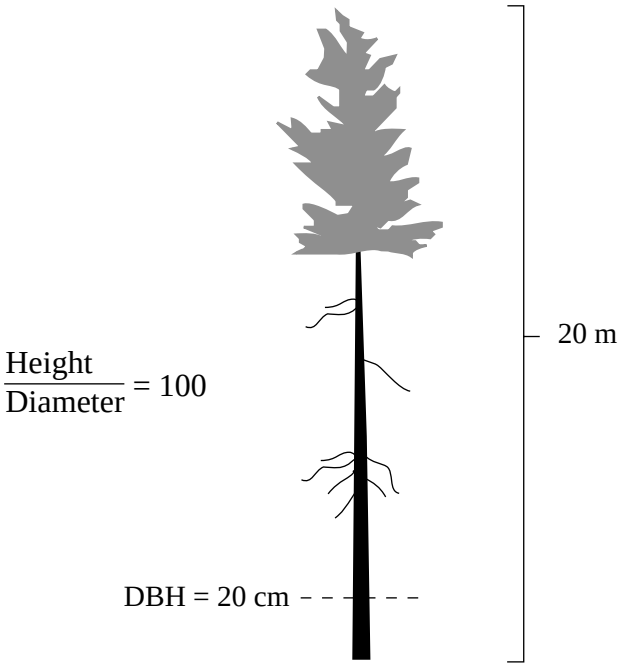
Height/diameter ratio: This ratio is an easily measured indicator of individual tree stability (see Figure 10). For a complete assessment of windthrow hazard use the procedure in the *Windthrow Handbook.* Height and diameter are measured in the same units (e.g., both height and diameter measured in centimetres). A high height/diameter ratio means that windthrow, stem breakage and stem bending is likely. Thus, thinning where residual trees have height/diameter ratios greater than 100 is risky:

- Residual tree ratios in excess of 90 for lodgepole pine indicate low residual stand stability following thinning.
- With Douglas-fir, a ratio of residual trees above 80 on poor sites, with weak expression of dominance, signifies a higher risk.



Percent live crown of leave trees should be 30% or greater

Figure 9. Percent live crown.



Height/diameter ratio of leave trees should be less than 100

Figure 10. Height/diameter ratio.

Develop a list of stands that are likely candidates for thinning. Stands can be selected if they:

- meet objectives identified at the forest planning level
- have a minimum merchantable diameter (e.g., 25 cm for coast produces J grade logs)
- fulfill economic criteria, including consideration for access costs (see the section on "The economics of commercial thinning")
- are silviculturally suitable (leave trees have the ability to release)
- have an acceptable level of risk (windfirmness, tree stability).

b) Stand data collection

Stands chosen as candidates after the field reconnaissance stage should have a survey done to collect stand data. Establish sufficient plots per stratum to build a stand table and determine site index. Information collected can be used to estimate cut and residual volumes using standard cruise compilation techniques.

A guide to the minimum number of plots to establish is:

<10 ha block	2 plots
10–20 ha	4 plots
20–40 ha	6 plots
>40 ha	8 plots

Locate plots to capture representative strata. Establish more than the recommended minimum number of plots if you are uncertain whether you have an accurate stand table that reflects the strata.

Sample the stand using the variable (prism) plot method. Select a basal area factor that gives an average tree count of six to 12 trees per sweep. For example, a BAF 3 prism works well in dense interior lodgepole pine stands.

Measure or estimate the diameter of all merchantable trees within the plot and estimate all heights. It is recommended that 7.5 cm be the smallest merchantable diameter that is compiled for targeting small sawlog material. Lower utilization standards can be used for other small wood products such as orchard props, posts and dowels. The cruise compilation reports can then provide potential volumes for a wide range of merchantability limits and species.

Note: Cruise compilation reports can provide information on potential volumes for a wide range of merchantability limits and species. This information provides good stand and stock table and stand structure information; critical when developing the silviculture prescription.

Sample tree measurements for age and height need to be taken. Information from sample trees is necessary for site index determination. Refer to Research Branch Land Management Handbooks *Site Index Curves and Tables for British Columbia – Coastal Species* and *Site Index Curves and Tables for British Columbia – Interior Species* to identify the site index for your site.

Other information to be collected at this time may include:

- presence of forest health concerns and indication of which stands may need an intensive forest health survey
- biodiversity concerns (e.g., presence of wildlife trails, deciduous areas and wildlife trees)
- description of access (e.g., existing trails or landings)
- constraints that guide selection of trees (e.g., maximum basal area removal or retention in watersheds so that commercial thinning does not get added to the Equivalent Clearcut Area (ECA) or to avoid adjacency constraints)
- identification of cut/leave trees in each plot.

The potential volume available to be cut can be estimated based on a minimum merchantable diameter. Use information collected to rank stands.

Site and stand limiting factors

Once a list of suitable stands for commercial thinning has been created, ranking can proceed considering, but not limited to, the following factors:

Size: Thinning can occur when a merchantable tree size or piece size is reached. Species and piece size have a significant impact on revenue. There must also be sufficient market demand so that stumpage and net present value goals can be met. Avoid thinning where cut trees have not reached merchantable diameters.

Age: Thinning response declines with age as height growth of the dominant and subdominant trees naturally slows. The first consideration in older stands is the stand and tree stability and release potential. Stands with low live crown ratios and high height/diameter ratios are not good candidates for thinning.

Site productivity: A better site translates into taller trees, higher volume, or higher net present value. Analyses for sawlogs and pulpwood markets indicate thinning on stands with a site index less than 18 for Pl and less than 24 for Fdc are less economically desirable than commercial thinning on better growing sites. Harvesting for other products such as fenceposts, orchard props or other specialty items may allow consideration of stands with lower site indices.

Species: Variability in shade tolerance (there is more flexibility in scheduling thinnings for stands of shade tolerant species since these species hold their crown longer under competition), susceptibility to damage (bark thickness, rooting habit), and differential growth between individual trees (dominance), can influence stand selection.

Sensitivity of soils to disturbance: Increased site sensitivity (risk of compaction or soil erosion), may limit the choice of harvesting methods, increasing costs and reducing the potential desirability of the treatment.

Windthrow hazard: Perform an assessment according to the *Windthrow Handbook for British Columbia Forests*.

Road access: High access costs will reduce the value of the thinning and make the "thinning" option less attractive. Appropriate choice of season of operation can greatly reduce road building costs (e.g., use of temporary frozen roads).

Distance to mills can also play a significant role in limiting the attractiveness of commercial thinning.

Harvest metho : The terrain (steepness and shape of slope) will often affect choice of harvesting equipment and impact the economic viability of the operation. See Appendix 2 for an overview of harvesting methods suited to commercial thinning.

Volume/hectare: Minimum volumes per hectare required for a viable operation are lower for harvesting methods with smaller capital investment (horses, tractors, and some small wood yarders/forwarders). Road costs are proportionately higher with low volumes per hectare. This can potentially be offset by harvesting methods with forwarding capability, requiring fewer roads.

Forest health: See the following section.

Forest health

Consider the intensity and distribution of disease pathogens. The following guidebooks should be referred to when considering commercial thinning in stands with insect or disease problems:

- *Tree Wounding and Decay Guidebook*
- *Bark Beetle Management Guidebook*
- *Defoliator Management Guidebook*
- *Root Disease Management Guidebook*
- *Dwarf Mistletoe Management Guidebook.*

Stand-level planning for commercial thinning when forest health concerns are present, consists of:

- estimating the percentage or magnitude of an infection
- considering the distribution of the infection and whether it can be mapped (e.g., root rot centres)
- assessing the risk to the stand of thinning or not thinning
- developing a strategy to address pest concerns, which may be referenced to a forest health strategy in a higher level plan.

Some of the more common forest health concerns for commercial thinning are listed below.

Tree decays

There are rarely signs of decay-causing fungi at the time of commercial thinning. However, they should be considered in any silviculture treatment that involves partial retention of stems. The impact of tree decays depends on the retention period for the remaining final crop trees, the tree species, and the degree of wounding caused by harvesting.

Two of the most common forms of stem damage are wounds and gouges. A **wound** is defined as the removal of outer bark and cambium from the stem with no penetration into the sapwood. A **gouge** involves penetration into the sapwood or deeper.

The impact of tree wounding in a commercially thinned stand depends in part on the leave tree species. Tree species may be grouped into categories based on their susceptibility to decay pathogens. Susceptibility to decay depends on a variety of factors including the biogeoclimatic zone in which the species is found, the bark thickness and the ability of the tree species to produce resin.

Species susceptibility to decay ranked from greatest to least:

Relative susceptibility	Tree species	
Most susceptible	1. Broadleaved	
	2. B, H, Ss	Cw <60 years
	3. Yc, S, Lw	Cw >60 years
	4. Fd, Pw	
Least susceptible	5. Pl, Py	

Fd = Douglas-fir, coastal or interior
H = hemlock species
B = Abies species
Lw = western larch
Py = Ponderosa pine
Ss = Sitka spruce
Yc = yellow-cedar
Cw = western redcedar
S = spruce species
Pw = western white pine
Pl = lodgepole pine

Note: **Spring harvest, when the sap is running, makes most tree species particularly vulnerable to tree wounding caused by skidding or yarding activities.**

For more detail on tree species susceptibility and management considerations consult the *Tree Wounding and Decay Guidebook*.

A critical aspect of conducting a successful partial cut is operator experience and care. Whether hand falling, horse-logging, or using machinery, the experience of the operator can significantly reduce the level of damage left in a stand after harvest. Some of the following general principles extracted from Wright and Isaac (1956) may assist in planning a partial cut:

- *Relation of wound height to percent stem removal* — light cutting (<30% volume) can produce more wounds at the base of residual trees than heavy (>45%) removal. More stems left during a light cut results in more obstacles to avoid during falling and skidding. Heavy cuts also tend to reuse skid trails thereby damaging fewer stems. Stems that are damaged can be identified for later removal. Heavy cuts tend to cause more damage above dbh mainly due to injuries caused by felling.
- *Relation of wound height to occurrence of decay* — the frequency of infection decreases rapidly from the ground up. The probable reason is higher moisture levels closer to the ground promoting decay.

- *Relation of percent stem removal to occurrence of decay* — from the previous two comments, a large number of wounds low on the stem caused by a light cut results in a higher incidence of decay. With more stand entries, there is a higher probability of creating wounds and allowing decay fungi to establish in crop trees. This effect may be offset by preferentially removing damaged trees in later entries.
- *Relation of wound size to occurrence of decay* — small wounds are usually more numerous but less likely to result in decay. For hemlock, the threshold level where half the wounds develop decay, appears to be around 30×30 cm in size. However, any decay in crop trees is undesirable.

The target for bark damage in commercial thinning is **zero damage.** Even minor damage can detract from wood quality at final harvest. In many locations, particularly fire origin Pl stands, a small reduction in wood volume growth may nullify any economic gains at final harvest.

However, it is understood that some damage may be unavoidable. This level of damage should become insignificant as managed stands are widely utilized and harvesting crew skill levels advanced. The use of rub trees during harvest will significantly reduce damage to leave trees.

Dwarf mistletoes (Arceuthobium *spp.*)

Commercial thinning in moderately infected stands may be possible if regeneration is likely to be destroyed at the final harvest phase. Any regeneration of susceptible species will be subject to an increased rain of mistletoe seeds. However regeneration is not normally an objective of a commercial thinning treatment. See the *Dwarf Mistletoe Management Guidebook* for a description of the rating system for mistletoe infection. Leave trees with an infection rating of four or less can be chosen. Leave trees with higher levels of infection will not likely respond sufficiently to take advantage of the additional growing space.

Root diseases

The *Root Disease Management Guidebook* provides a range of disease assessment methodologies and stratification survey methods. For example, a silviculture survey that shows greater than the following incidences should trigger a formal root disease survey.

- ≥10 trees/ha for *Armillaria ostoyae* or *Phellinus weirii*
- ≥5 trees/ha for *Inonotus tomentosus.*

Depending on the severity of the disease determined by the chosen survey, the *Root Disease Management Guidebook* recommends three levels of disease treatment: minimal, alternate and intensive. Partial cutting, including commercial thinning, is not recommended with high levels of root disease. With medium levels of root rot commercial thinning is only recommended if other cutting methods cannot be applied. Please note that if a stand is a candidate for commercial thinning, no physically damaging assessment should be conducted on any live standing tree

(i.e., no removal of bark at the base of the tree or root excavation) unless the tree is clearly designated for removal.

A preliminary guideline for laminated root rot (*Phellinus weirii*), is available in Forest Resource Development Agreement (FRDA) Research Memo Number 219 (April 1994). The guideline suggests that commercial thinning is still possible with less than 15% infection, and that the incidence of the disease can be reduced. Commercial thinning should only be done where the disease can be localized into mappable units. *Phellinus* centres can be isolated or "corralled" by harvesting "bridge trees":

- Stands that have not reached a desired average diameter, can continue to grow while expected root rot mortality is harvested.
- Infection centres can be both identified and stocked, with either short rotation, fast growing, resistant, deciduous species; or less susceptible coniferous species that can be left as unharvested reserves at final rotation.

Disadvantages include the increased susceptibility to windthrow and the failure to address the root rot within the centres, except in terms of the planting of alternative species. Pushover logging may be considered at the time of thinning. More likely, pushover logging would not be used unless additional root rot became evident at the final harvest. The centres will need treatment at final harvest since *Phellinus* can remain infective for several decades.

Where root rot pockets are easily identified and large enough to warrant treatment (e.g., ≥0.25 ha), a regeneration cut may be used and the patches treated as separate standards units. Free growing declaration would be based on the dates specified in the SP by standards unit.

Mountain pine beetle (Dendroctonus ponderosa)

Commercial thinning in lodgepole pine stands can be done to reduce the susceptibility of the stand to beetle attack. In turn, the harvesting of large areas of beetle infested/susceptible stands can be spread over a longer period. Research is presently being conducted to assess the merits of "beetle proofing," both from the standpoint of reduced risk and to assess the potential increases in residual tree volume growth.

Defoliators

Defoliators are a concern if a regeneration layer will be maintained through commercial thinning and the final harvest. This subordinate layer could be killed by current or future defoliation episodes. In addition, residual dominant trees can be heavily stressed by a defoliation soon after a commercial thinning. In areas with high populations of defoliators:

- Proceed with the commercial thinning if direct control measures are occurring.
- Delay the commercial thinning until defoliator populations have decreased if there are no direct control measures occurring.

Where commercial thinning is considered for a stand and forest health concerns are present, but apparently are not critical, the following should be considered:

- Consult the appropriate guidebook for the management implications of thinning the stand.
- Consider alternative strategies such as commercial thinning with sanitation, immediate harvest, or no treatment. Assess these strategies from a financial, timber supply and forest health viewpoint.
- For root rots, use intensive surveys to define the level of infection and map its distribution.
- Assess the implications for understorey development (if desired) where an infected overstorey exists (e.g., dwarf mistletoe on western hemlock).
- Consider the risk associated with high leave-tree densities and potential damage to species susceptible to disease through wounding (e.g., *Heterobasidion annosum* affecting western hemlock).

The economics of commercial thinning

Commercial thinning programs are mostly concerned with the removal and marketing of small wood. Due to the high value of the forest resource, it is the intent of the Ministry of Forests to promote economically viable (profitable) harvesting operations. Therefore, commercial thinning operations should not be subsidized unless the harvest is required to meet non-timber objectives set in higher level plans or to meet short-term wood flow objectives. Because commercial thinning is using some of tomorrow's wood today, it is essential that the remaining forest be left in a healthy productive condition to preserve future options.

Economically, commercial thinning is an intermediate harvest and not a silvicultural investment. Increased net present values due to commercial thinning are modest, but still can be worth pursuing subject to the timber demands of the day.

Guidelines for decision making

Candidate stands for commercial thinning should be able to provide a positive return if the thinning is to be done. This means that the following points should be considered:

- Total revenue from thinning should cover the cost of the thinning.
- Stumpage revenue for the Small Business Forest Enterprise Program should cover administrative costs.
- The NPV of the thinned stand should be the same or higher than if thinning was not done.

For more information on economic decision making and benchmark regimes, see Appendix 1.

Not all of these economic considerations may be met in the first few years of a commercial thinning program. During the startup of a program, high initial costs may limit the generation of revenues from commercial thinning. Subsidies should only be

considered in cases where the main commercial thinning objectives are other than timber supply. These decisions should be well documented.

It will likely be difficult to meet the first two points in areas where major access structures are required.

Economic considerations for thinning regimes

The higher NPV provided by some commercial thinning regimes can be attributed to two factors:

- the thinnings produce early revenues and future harvesting costs are reduced
- the additional growing space given to residual trees produces greater growth and higher expected value.

The NPV of thinning regimes typically drops off as the thinning intensity is reduced. This highlights the economic advantage obtained from an early financial return from the stand. Using an investment analogy, if the stand is viewed as an investment portfolio and each tree as a separate stock, then the commercial thinning may be viewed as the liquidation of those stocks producing the poorest investment yields. The thinning also has the advantage of increasing the returns on the remainder of the investment portfolio – the leave trees.

A thinning objective to maximize volume, requires crown closure to be quickly re-established. To avoid excessive stand volume loss, avoid excessive volume or basal area removal in a commercial thinning phase. This avoids the loss of volume due to incomplete site occupancy. Figure 11 shows that there is a trade off between volume and value when determining commercial thinning regimes. Volumes are maximized at higher residual densities; net present value is maximized at lower residual densities.

Thinning Douglas-fir in the range of 200 to 400 leave trees/ha between age 40 to 60 years has been shown by growth and yield simulations to be economicall superior to the corresponding unthinned regime for simulations of site index 36 and many site index 30 regimes (Stone [1993]). The optimum thinning regime may potentially increase the NPV of the stands by 10–20% at site index 36 and by 3–30% at site index 30, depending on the thinning age and initial stand density. Poor results achieved at site index 24 indicates that this is probably the lower limit for viable commercial thinning operations for coastal Douglas-fir, at least under current log prices and harvest costs.

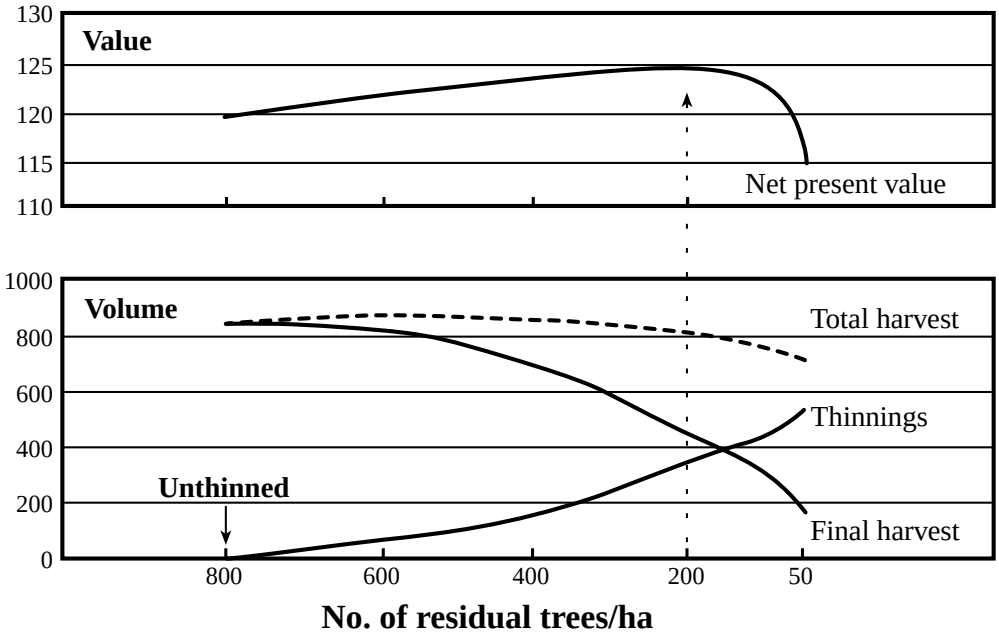


Figure 11. Trade off between volume and value. Coastal Douglas-fir, site index 36. Juvenile spaced to 800 stems/ha (sph) at age 14. TASS runs showing volume and value for control (spaced only) and commercial thinning to 600, 400, 200 and 50 sph at age 50. Final harvest at age 60.

Effect of planned rotation ages

The comparison of NPV for thinned and unthinned stands was based on the comparison of the maximum NPVs at economic rotation age. The economic rotation ages for the unthinned stands were quite short, ranging from 60–65 years of age at site index 36 and from 60–70 years of age at site index 30 and 24. Thinning will increase the economic rotation age by five to ten years at site index 36 and by five to 30 years at site index 30 and 24. In the unthinned stands, culmination of mean annual increment (MAI) occurred at ages ranging from 75–100 years. If the NPVs of the various regimes are compared at the physical rotation age the viability of commercial thinning is even further enhanced, particularly with the site index 24 simulations. The economic study of Douglas-fir illustrates this point. The NPV of the unthinned stands drops faster after the culmination of NPV than do the thinned stands. The difference between the thinned and unthinned NPV therefore gets larger as the stand ages (see Figure 12). Thus, when rotation ages longer than the economic rotation age are planned, commercial thinning becomes an even more attractive forest management option. This will be an important consideration for stands that cannot be harvested immediately because of adjacency constraints or where creation of old growth attributes and wildlife habitat is a goal.

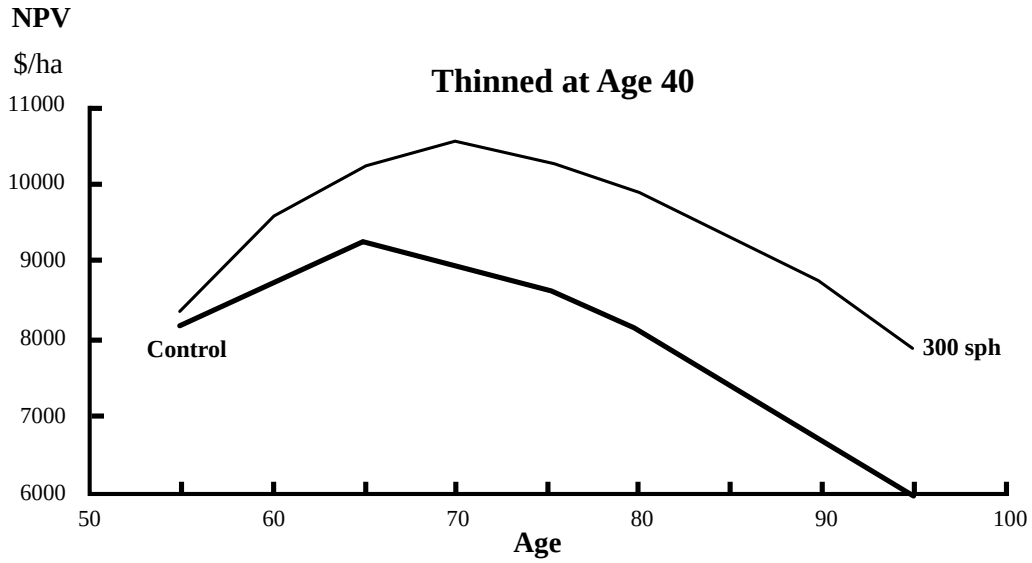


Figure 12. Change to net present value with longer final rotations of site index 36 coastal Douglas-fir stand. The control is spaced to 1100 sph. The treated stand is spaced to 1100 sph and then commercial thinned at age 40 to 300 sph.

Table 1 shows changes in physical, and economic rotation ages, with and without thinning, for a coastal Douglas-fir stand on three sites.

Note: Merchantable piece size is critical for maximizing value in small wood. The greatest effect of diameter on value occurs within a narrow range usually found between 15 to 25 cm in diameter. Between 20 cm and 25 cm, stem values tend to plateau. They then rise again on the expectation of recovering premium lumber grades on the coast and larger dimension lumber in the interior. Experience with coastal Douglas-fir suggests that diameters for cut trees should be targeted at 22 to 25 cm. The minimum volume required to make commercial thinning economically feasible will depend on market price, stumpage, site and stand conditions, equipment costs and other factors.

The target piece size of thinnings is dictated by the price of the products to be obtained (e.g., pulp, lumber, fence posts, poles). These prices can fluctuate widely, particularly in the interior. For example, higher pulp prices can mean it is worthwhile for operators to harvest smaller pieces. No general target diameter is listed in this guideline for lodgepole pine.

Targeting lodgepole pine areas to reach a certain piece size prior to thinning is practical for managed stands. However it is unlikely to be achievable where excessive density or low site quality constrain growth rates.

Economic return has been shown to be sensitive to any stand damage occurring during a thinning operation. This highlights the need to minimize any stand damage if commercial thinning is to remain economically viable.

Table 1. Rotation ages for coastal Douglas-fir, established at 2500 sph

Space to 500 sph @ 6 m height No commercial thinning				**Space to 800 sph @ 6 m height Commercial thin to 300 sph @ 50 years**			
Rotation type	**Rotation length at 3 site indices**			**Rotation type**	**Rotation length at 3 site indices**		
	36	**30**	**24**		**36**	**30**	**24**
Physical	85 yrs	100 yrs	100 yrs	**Physical**	90 yrs	100 yrs	105 yrs
Max MAI (m^3/ha)	14.5	9.6	5.7	Max MAI (m^3/ha)	15.1	9.9	5.8
NPV ($/ha)	5164	2592	1216	NPV ($/ha)	11 872	5113	1415
Economic	60 yrs	70 yrs	70 yrs	**Economic**	75 yrs	80 yrs	65 yrs
Max NPV ($/ha)	6602	3741	1596	Max NPV ($/ha)	14 554	5974	1737
MAI (m^3/ha)	13.4	8.5	5.3	MAI (m^3/ha)	14.8	9.7	5.4

Silviculture Prescriptions

Silviculture prescription: A silviculture prescription (SP) is required for blocks to be harvested. It is required for all commercial thinning operations.

Components of a silviculture prescription for commercial thinning

Commercial thinning is an intermediate entry within a stand prior to final rotation. By definition, commercial thinning does not normally have a regeneration objective.

The *Operational Planning Regulation* outlines the content requirements for silviculture prescriptions. Section 39 defines some of the requirements. The following guidelines are intended to help the forester develop a silviculture prescription for commercial thinning.

Within the stocking section of the prescription describe the preferred and acceptable tree species. For commercial thinning most leave tree species will be considered as preferred, as this entry promotes the final crop species near rotation. There may be a distinct reason to separate a species to ensure that it constitutes at least a minimum proportion of the species mix. For example, Cw in some parts of the Queen Charlotte Islands may be designated as preferred with other species designated as acceptable.

The prescripton must specify the preferred and acceptable species of trees and the stand structure and composition goals, including the planned residual basal area or density per hectare. The planned number of residual stems will depend on the objectives for the stand. Additionally the species and function of any trees left standing to satisfy non-timber resource objectives must be specified. A stand and stock table, showing the present stand and the post-thinning stand, can be used to meet these requirements. For example:

Stand structure goals must be stated for thinning and should be stated for final harvest.

Stand structure goals include:

i) Post thinning

- species composition
- density of residual stand in terms of stems/ha or basal area/ha (use a range that is achievable)
- crown class of residual stand (e.g., dominant/co-dominant) and type of thinning
- species and characteristics of trees reserved from cutting to meet other resource value objectives (deciduous/wolf trees)
- understorey conditions, which include vegetation reserved from cutting for purposes such as soil nutrition, and security cover for wildlife.

ii) Final harvest

- species composition
- rotation length (age)
- targets for stand diameter (piece size), and volume (mean tree volume and stems/hectare or merchantable volume from managed stand yield tables for commercial thinning)
- log grade or end use.

The regimes required to achieve the stand structure goals largely involve the manipulation of stand density through variations in intensity, timing, type of thinning and number of entries.

Older unmanaged stands offer fewer options for commercial thinning. This is often referred to as a late harvest entry and may be useful to meet non-timber objectives. However, these late entries may occur too far along in the development of a stand to provide a growth response from the residual trees. As well, these stands may have a high windthrow potential and must be managed accordingly.

The following is an example of structural goals for a stand:

Species: Hw

Site index: 28

Initial density: 6000 stems/ha

Spaced: 800 stems/ha

Rotation selected: Physical (culmination of MAI)

	After commercial thinning	At final harvest
Age (years)	40	80
Density (stems/ha)	400	380
Average dbh (cm)	28.5	47.7
Merch. yield (m^3)	110	699
Crown (%)	40	35

Appendix 1 lists some benchmark commercial thinning regimes for lodgepole pine and coastal Douglas-fir. The volume and value achieved by these regimes at representative rotation lengths are given. Variations in these regimes are necessary to meet site-specific objectives.

The prescription should describe the silvicultural system to be used including the characteristics, species and function of any leave trees to be left standing. Your commercial thinning harvest entry can set the stage for a range of silvicultural system establishment cuts. The silvicultural system that will likely be used to manage the stand into the next regeneration phase should be specified in the

prescription. In some cases this will not be known for sure but a 'best estimate' should be used. An example of the level of detail for leave trees is as follows:

- Fdc >30 cm dbh
- live crown ≥40% of the total height
- no wounds or pathological indicators.

The silviculture prescription need not describe the general method of harvesting but must describe any critical site conditions that affect the timing of operations and the manner in which they affect them. For commercial thinning operations, thin barked species (e.g., Hw, true firs), may present limitations on harvesting during periods of sap flow because of ease of wounding. Operator experience, species mix and site conditions will affect seasonal restrictions. Where possible minimize harvest during periods of peak sap flow (spring and early summer).

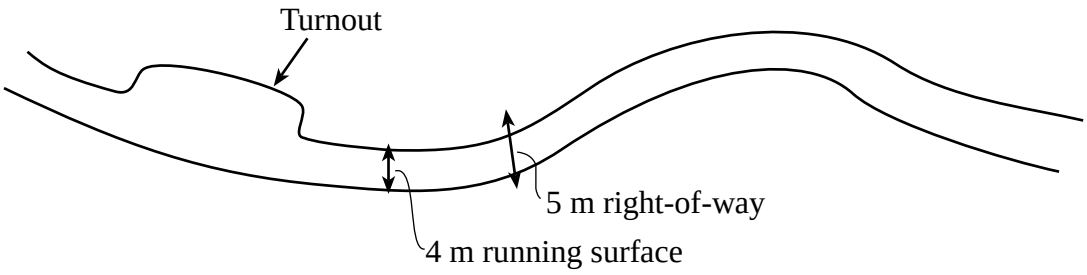
The silviculture prescription must specify the:

- the gross area of the block. For commercial thinning this would include all areas within the prescription.
- the net area to be reforested (NAR). In the case of commercial thinning, where there is no regeneration objective, the net area to be reforested would be considered the total merchantable area to be harvested, less any permanent access structures such as landings and roads.
- the maximum proportion of the gross area that may be occupied by permanent access structures.
- must set out the maximum proportion, if any, of the net area to be reforested that may be occupied by soil disturbance.

For commercial thinning, anticipated thinning revenues may not allow for major expenditures for access. This necessitates careful planning to minimize access structures (see Figure 13) and keep soil disturbance levels low and within the prescription. Wherever possible avoid excavated or bladed trails within the block. Restriction of season of operation can minimize the need for road construction (e.g., frozen or dry soils).

The access structures necessary for final harvest may or may not be the same ones used at time of thinning.

Rehabilitation of excavated or bladed trails should not be used to decrease soil disturbance after completion of thinning. Rehabilitation using machinery should not be done in areas of standing timber. Rehabilitation by digging or ripping will likely further impact tree roots disturbed by the initial trail building and create entry points for rot in the remaining stand.



- design speed –10 km/h
- minimum ratio of curves – 15 m
- minimum five turnouts per km, each of 10 m length
- sufficient ballast to carry loaded logging trucks without detrimental rutting or deforming of surface
- culverts as required to maintain natural drainage pattern

Figure 13. Example dimensions for a seasonal spur road within a commercial thinning block.

Topography and slope will impact harvesting method and road density. However, with small wood, innovative options are available that increase yarding distances and reduce road requirements. For example forwarders can move larger loads than is possible with skidders. These large loads make it practical to have longer forwarding trails, thus decreasing the need for roads.

Some suggested actions:

- Use existing access wherever possible.
- Choose harvesting methods in consideration of the amount of new road they will require.
- Where seasonal access standards are used to control costs, ensure temporary closure restrictions are enforced during unseasonable wet periods.
- Design specific standards for thinning roads and landings that minimizes the loss of productive ground due to permanent access, and reduces the incremental impact of additional access at final harvest.
- If possible, avoid constructing major ditches along roads. Such ditches will sever roots and may necessitate the removal of unstable trees.
- Landings should be located to minimize loss of growing stock and productive ground—wherever possible incorporate landings with existing roads or openings (see Figure 14).
- With good planning and layout, permanent access can be kept at:
  - 3% for gentle slopes (<20%), and
  - 5% for moderate slopes (20 to 30%).

Because commercial thinning is an intermediate entry that will have future entries in a relatively short period, the definition of permanent access may need further clarification.

Figure 14. Wherever possible, incorporate landings with existing roads or openings.

A suggestion is to designate as *permanent access* any *bladed or excavated trails* as described in the *Soil Conservation Guidebook*. Also designate as *permanent access* the non-bladed skidding/forwarding trails that will be required for future entries beyond the next regeneration period.

For example:

- An even-aged stand is commercially thinned now as an improvement/ preparatory cut.
- The intention is to use group selection system in the future.
- The next entry is scheduled in 20 years to create small openings and recruit regeneration.
- The trail network will be continually used every 20 years after that.

The trail network is not intended to grow trees. It is intended as an access network for the long-term (considerably beyond the end of this rotation). The trail network should be added together with potential losses of site occupancy by permanent roads and landings to set limits for permanent access. Occasionally a permanent access limit greater than that suggested in the guidelines may be allowed, provided:

- the rationale for such a level of permanent access is sound
- the trails are well planned and located
- soil disturbance levels and site impacts on the trails are minimized

- the soil disturbance associated with the trails will not increase risks to other resource management objectives
- negligible disturbance is incurred between the trails (in the NAR).

Designate as *permanent access* any potential "heavy-impact trail" that will be re-used in the next entry.

For example:

- The main speed trails used by a grapple skidder, where horses or small track vehicles skid the wood to these main trails.
- The major forwarding trails in a stand thinned by a single-grip harvester.

These trails should be pre-located and mapped. Where practical the trails should be used again in the next entry, whether it is a clearcut, or partial cut.

For commercial thinning operations dispersed trails should be kept as narrow as possible. The distance between these trails should be maximized (e.g., 40 to 50 m apart) to reduce potential impacts on the roots of remaining trees. Exact size and location of trails will depend on factors such as terrain, slope, size and type of skidding equipment, tree length, skidding pattern and felling pattern. Remember there is a trade-off between inter-trail distance and the possibility of wounding leave trees. In some cases reduced distances between trails is preferable. Forwarders should utilize slash to reduce impacts to acceptable levels.

Variability in slope within a block may lead to treatment units where different harvesting methods are required in order to minimize soil disturbance. Flexible methods (cable, forwarding) have an advantage on such sites, especially if they are cost effective.

Do not expect frost heaving to alleviate soil disturbance. It has limited effect in restoring productivity loss due to compaction.

Portions of a block should be reserved from thinning if harvesting those areas would cause excessive soil disturbance. Examples are areas with high water table, lack of windfirmness, shallow soil, low productivity or high erosion potential.

(See also the *Soil Conservation Guidebook* for suggested values.)

Note: Commercial thinning prescriptions must adhere to the same soil conservation standards as other harvest entries.

The silviculture prescription should identify:

- the maximum proportion, if any, of the net area to be reforested that may be occupied by temporary access structures. The *Soil Conservation Guidebook* suggests all temporary access structures be rehabilitated post-harvest to meet silvicultural obligations. As mentioned previously, no ripping or rebuilding of access structures within the stand is recommended. For commercial thinning, access should be considered as either permanent, or if dispersed, as part of the allowable disturbance in the net area to be reforested.

- the general location of excavated or bladed trails and the estimated distance between them along with the maximum allowable depth and width of excavation into mineral soil, and maximum allowable gradient of the trails. This is no different for commercial thinning than for other harvesting operations (see the *Soil Conservation Guidebook* for further information).

The silviculture prescription should also describe the actions, if any, that will be taken to:

- abate fire hazards
- accommodate coarse woody debris objectives
- accommodate the forest resources identified in any higher level plans or in the forest development plan that applies to the area under the prescription
- address the sediment and debris transport potential if the area is in a gully on the coast.

It should also contain a reasonable assessment of the non-timber forest resource values known to be on or adjacent to the area and describe the action, if any, that will be taken in the area to accommodate those values.

A post-harvest assessment period should be specified in the prescription. It is suggested that the post harvest assessment period be set at between one to four years after the completion of harvest to allow for a survey of the block to identify any conditions that may require a further prescription to be prepared (e.g., excessive blowdown).

The prescriber must ensure, for the area under a silviculture prescription and the area adjacent to that area, that the prescription describes or contains:

- the location of known resource features that are identified in the forest development plan that applies to the area
- for each stream and wetland,
  - the riparian class
  - the riparian reserve zone and any proposed forest practices for that zone
  - the riparian management zone and any proposed forest practices for that zone
- for each lake in and adjacent to the area,
  - the riparian class and, where applicable, the known lake class
  - the riparian reserve zone and any proposed forest practices for that zone
  - where applicable, the width of the lakeshore management zone and the riparian management zone, and any proposed forest practices for those zones
- any proposed group reserves, including wildlife trees
- any wildlife habitat areas.

Scheduling a thinning to meet stand structural goals

Stands can be assessed for treatment by observing the relationship between live crown and diameter growth. Once a merchantable piece size is reached, thinning should proceed before loss of crown starts to impact diameter.

For dense stands, the time to reach a merchantable diameter increases and with subsequent loss of crown, the likelihood of release diminishes.

Wherever possible, thinning schedules and long-term plans (e.g., 20-year plan) should be made in conjunction with managed stand yield tables. This provides a basis for defining the desired stand conditions. It is important to have a good estimate of site index to determine when stand conditions are met.

Consideration for multiple thinning regimes

Simulation and research trials have shown that under ideal conditions, multiple, light, low thinnings can increase recoverable volumes modestly.

For a volume increase to be realized, thinnings must be:

- in fully stocked stands
- light, and starting early in rotation
- low (removing from the lower crown classes)
- frequent (every five to ten years), over the length of the rotation
- with minimal loss in site occupancy due to permanent or temporary access
- with minimal losses due to windthrow or disease.

Such multiple thinnings must be light initially, and done early in the rotation (30- to 40-year-old stands). First thinnings are generally unable to pay for the cost of harvesting. The likelihood of such early thinnings breaking even will be dependent largely on pulp and special product prices.

Any increased volume from multiple thinnings comes from the harvesting of potential mortality, and the ability to carry heavier stocking. Whereas a single entry thinning might carry 750 trees/ha prior to thinning, a double or triple entry could leave 1000 trees/ha after the first thinning. With lighter multiple thinnings, a site is also more fully occupied throughout the rotation, as crowns are manipulated to maintain the ability for prompt release.

The economics of thinning is related to piece size, volume removed, stand and site damage, harvesting costs and product markets. The risk of increased soil disturbance and damage to leave trees increases with multiple thinnings as well as with terrain complexity and steepness.

An early first thinning is key when considering multiple thinnings of shade intolerant species. However, the situation is different with shade tolerant species such as western hemlock. Multiple thinnings may not harvest significant mortality as the rate of mortality is very low in a hemlock stand. Trials with up to six thinnings have

indicated volume increases of only 10% over controls. Thinning can be done to improve operability and increase net present value. Multiple thinning of western hemlock can be done, but its shade tolerance and quick release suggest that a single heavy thinning on a short economic rotation may be the best regime.

Fertilization

Fertilizing stands following commercial thinning can provide a positive economic return. Prior to treatment, determine if the species will respond to fertilization and if the stand is windfirm. A stand management prescription must be prepared for any fertilization treatment.

For Douglas-fir, fertilization should be considered in conjunction with commercial thinning, as it appears to be an economically feasible silviculture investment.

Lodgepole pine stands respond favourably to fertilization. Lodgepole pine, providing it is windfirm, is rated as a high priority for fertilization on good and medium sites following commercial thinning.

Western hemlock is recommended for fertilization trials only following thinning. See the *Fertilization Guidebook* for further information on rates and timing.

Damage assessment

Commercial thinning requires skill and care during all parts of the planning and implementation phases to minimize damage to residual crop trees. The intent of this section is to provide guidance for determining unacceptable levels of leave tree damage. The limits suggested have been set to capture damage that may result in future decay (see *Tree Wounding and Decay Guidebook*). Limits have also been set to identify damage that could result in growth reductions or abnormal growth patterns potentially reducing the value of the stand in the future.

There may be circumstances where the district manager may wish to allow variance in the damage threshold levels. Some examples might include an urgent need to harvest a stand (due to pest, environmental or seasonal conditions); facilitate a learning curve required for new harvesting techniques and equipment; encourage contractors to develop expertise where commercial thinning is not yet practised. The variance and the reasons for it should be included in the SP.

Precautions to minimize leave tree damage should be part of any commercial thinning operation. Damage can be minimized in a number of ways (see Figure 15):

- Choose appropriate harvesting equipment
- Use rub trees, protective barriers on trees, and barriers along trails
- Keep trails as straight as possible
- Use a short log system
- Avoid thinning in the spring when bark is loose
- Establish good communication between the harvesting crew and the contract supervisor
- Maintain flexibility – be prepared to change the plan if it's not working.

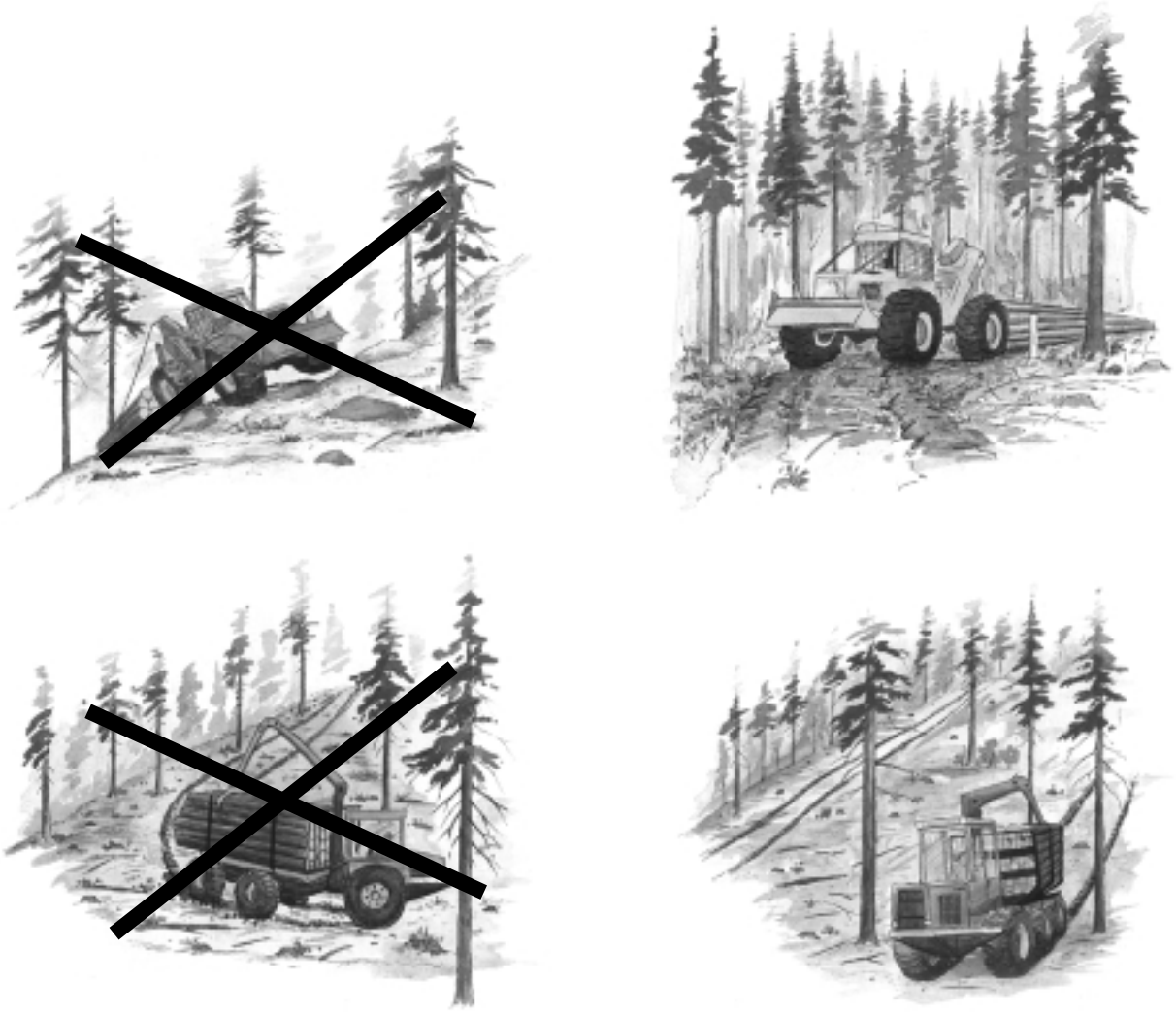


Figure 15. Minimize damage.

Rub trees can be left standing along the side of thinning corridors until final yarding takes place in that corridor. Physical barriers such as culvert sections or used tires can be placed around susceptible leave trees, although these alternatives are less reliable than rub trees. Fence posts have been successfully used as a barrier along corridors. Felling of merchantable trees should be at an angle to thinning corridors so as to minimize bark damage to leave trees during yarding. Keep all cable lines clear of residual crop trees during yarding operations.

This section describes suggested damage criteria. For a particular block, site-specific criteria may be used to provide a closer linkage between damage and objectives. For example, no wounds of any size may be the limit for areas adjacent to a highly used recreation site. Less onerous damage criteria may be appropriate for highly resinous species that are planned for final harvest in a short time span. The silviculture prescription should contain the damage criteria and percentage of allowable damaged trees for the block.

All damage to trees within inspection plots or strips should be tallied (see Appendix 3). Wounds less than 400 cm^2 are not considered a fault unless more than 10% of residual trees are affected. Any wound greater than 400 cm^2 is considered a fault. Faults can be penalized, depending on seriousness, according to the *Forest Practices Code of British Columbia Act.*

a) Damage to roots, stem, crown

The following are considered unacceptable damage during a thinning operation (see the section "Tree decays" for definitions of a wound and a gouge):

- >400 cm^2 wound damage on the stem at any one location on a tree
- 900 cm^2 cumulative wound damage on a single tree
- a wound that girdles more than one-third of the stem
- a wound on a supporting root (>2 cm in diameter) less than 100 cm from the base of the stem (outside of bark)
- a leave tree with greater than 25% of its live crown mass lost due to the commercial thinning operation
- a gouge on the stem or a major root
- >10% of the crop trees with wounds of less than 400 cm^2
- unauthorized felling of a designated leave tree, or in the case of faller select, incorrect selection of trees based on specifications in the cutting permit or licence document.

b) Species/stocking and soil conservation standards

A standards unit refers to an area with uniform application of species/stocking and soil conservation standards. Included in these standards must be the species composition at the time of thinning.

The standards unit should be maintained for a period of time following harvest. Usually this period is tied to the completion of post-harvest activities and the risk of stand damage due to windthrow, insects, disease or other damaging agents. A free growing survey must be conducted no earlier than one year after completion of harvest.

The objective of the free growing survey should be to:

- confirm the stocking (stems/hectare) and species composition
- identify forest pathogens that might impact the stand strategy
- identify windthrow trees for potential salvage
- confirm future treatments (fertilization, thinning) or identify reasons as to why the stand strategy might need to be reviewed
- produce an updated map label and forest cover description.

Standards units, at time of thinning, may reflect variations in site sensitivity that require different harvesting methods. Standards units might correspond to changes in stand-level objectives. For example, objectives might focus on wildlife values, and therefore densities might change. Biodiversity objectives might influence species composition, or the identification of reserve or no treatment areas.

Project Preparation

Once stands have been selected for commercial thinning (see section on "Stand selection") the following project preparation steps should be taken prior to harvesting. These steps are the same as other partial cutting prescriptions.

Site assessment for silviculture prescription

Includes:

- draft map of boundary and road location (will require boundary to be ribboned in the field, taking note of windfirmness and sensitive sites)
- definition of standards units based on soil sensitivity and harvesting method restrictions
- stream mapping and classification
- identification of non-treatment areas or reserves
- identification of non-timber values.

Block layout and engineering

Road layout is an integral part of boundary layout as roads are the control points for yarding distance and deflection:

- Engineer roads and lay out boundaries according to harvesting method, and recommendations for road location derived from the site assessment.
- Utilize local standards for commercial thinning road classification and guidelines for site degradation with respect to harvesting constraints.
- Traverse the boundary.
- involve a local Workers' Compensation Board (WCB) officer at the layout stage to help choose cable yarding methods in order to get landing clearance in accordance with WCB regulations.

Forest development plan

Commercial thinning blocks, like all other cutblocks for which a cutting authority must be issued, are required to be identified on the forest development plan (FDP) map. Depiction of proposed blocks provides an opportunity for comment in the review process of the plan. The general planning considerations and assessments required for FDP cutblocks apply. For example, terrain stability, riparian assessments, cultural heritage resources, etc. may be considered. Some considerations, such as green-up adjacency and cutblock size do not apply. Other considerations, such as visual quality objectives and higher level planning objectives, are readily accommodated by these blocks. As a consequence, there is good flexibility and opportunity to incorporate commercial thinning blocks within the FDP.

Silviculture prescription

Utilize the information from the field reconnaissance and data collection phase of stand selection (see section on stand selection) to assist in completing the prescription. Prepare a map at the appropriate scale to show the required level of detail on the block.

Marking

Marking should not be required for stands that are fairly uniform, providing that specifications can be established for residual trees (e.g., residual basal area or inter-tree spacing, vigour, form and size). Penalties should be specified for improper selection. If marking is prescribed, a 1:5000 map may be necessary for marking or the tendering of a marking contract.

Since marking is a crucial link between the recce/cruise phase and the actual thinning operation, the same criteria for cut/leave trees, residual volume or basal area that are in the silviculture prescription (and will be used in the cutting permit document) should be included in the marking contract.

Clear instructions for tree selection must be provided to the marking crew to ensure a successful implementation.

Cruising

Timber cruises of potential commercial thinning areas often result in estimates of stand attributes with a large standard deviation. For small sales, less than 2000 m^3, use historic scale data (see Ministry of Forests *Coast and Interior Appraisal Manuals*) to get information on log grades and an estimate of volume. For larger sales, or where no representative historic scale data is available, use standard cruising procedures (see Ministry of Forests *Cruising Manual*). This information is used in the bidding process and for stumpage appraisal.

Cutting permit

The cutting permit (or Timber Sale document used in SBFEP sales), should be designed to ensure that the silviculture prescription standards are met.

The cutting permit should:

- specify the utilization and cutting specifications
- describe any trees or areas reserved from cutting
- describe the harvesting methods to be used
- describe the utilization standards
- identify any conditions that may restrict equipment operations (e.g., weather and ground conditions)

- describe skidding and yarding direction. Note: consider the felling pattern to ensure that skidding/yarding is done efficiently in order that residual tree damage and soil disturbance are minimized.
- describe how the soil resource will be protected during the harvesting phase. This includes a description of all permanent and temporary access structures
- include a detailed silviculture prescription map. Give special attention to the location of rub trees or barriers to protect leave trees.

Project Administration

Standard cutting permits and timber sale licences should be used to authorize commercial thinning. Subsidies or silviculture contracts should be avoided.

For Small Business Forest Enterprise Program (SBFEP) commercial thinning operations, a timber sale licence (TSL) should be advertised for competition under section 20 of the *Forest Act*.

If no applications are received for an advertised timber sale, the district manager must determine if the reasons for performing the commercial thinning are sufficient to warrant continuation of the project. If the project is still deemed necessary then:

- The district manager may enter into a silviculture contract to perform the thinning. The ministry retains ownership of the decked logs. These will be sold competitively.
- In limited cases, where no applications are received for an advertised timber sale, the district manager may award a timber sale directly, under section 23 of the *Forest Act*, in conjunction with a silviculture contract. Normal competitive rules apply for the silviculture contract. In addition to meeting the statute requirements of section 2, this option should only be used in cases where:
  - the harvesting is necessary for other than timber extraction purposes (e.g., maintenance of forest health)
  - timber utilization must be encouraged
  - the risk of the contractor unduly removing crop trees is low
  - competition for the decked logs would be unlikely if they were sold separately.

Timber sale documentation and tendering for the Small Business Forest Enterprise Program

Information packages should be made available to all prospective thinning operators. This is to assist them in understanding the objectives, standards and procedures.

The general types of acceptable harvest methods and equipment should be identified in the tender packages. Choice of harvesting and road construction equipment is critical to the avoidance of damage to roots, stems and crowns of leave trees, as well as to soil conservation.

Timber sale administration

Commercial thinning sales are generally considered high risk due to the potential for damage to residual trees, inexperienced operators, and soil disturbance. Close monitoring is required with prompt applications of Forest Practices Code administrative remedies.

A pre-work conference should be utilized to ensure that the conditions and content of the timber sale licence are understood by the contractor. Frequent inspections are required in the early stages of developing a commercial thinning program, and with inexperienced operators. Monitoring must include inspections for compliance with the timber sale licence, and the silviculture prescription. A high priority should be placed on confirming that there is compliance with stand damage and soil conservation standards.

Deactivation and post-harvest inspection

By the time a commercial thinning operation is finished, the site will have been walked many times. All problems should normally be sorted out early in the operation.

Immediately after harvest completion assess:

- waste
- total soil disturbance
- stand damage
- final stand density or basal area.

If it appears that management objectives have been met, the post-harvest assessment is complete. If there is concern, more formal measurements should be taken (see Appendix 3).

A survey is required no earlier than 12 months after the completion of harvesting to assess:

- the area within the net area to be reforested
- the biogeoclimatic classification
- the incidence of damage by forest health factors affecting trees
- the inventory label, including species component, age, height, density, basal area and site index
- the number of preferred and acceptable trees/ha.

This information is entered into the Major Licence Silviculture Information System (MLSIS) Form C for major licensee commercial thinning and in the Integrated Silviculture Information System (ISIS) for small business commercial thinning, and added to forest cover maps.

Deactivate roads and restrict access as required. If necessary, revegetate landings and disturbed areas for forage or site stabilization.

Appendix 1. Economic decision making and benchmark regimes

Thinning revenue covers cost

Thinning revenue covering costs is dependent on stumpage and logging costs. Tables have been produced for Douglas-fir and lodgepole pine (see Stone [1993, 1995]) that can be used to estimate whether a positive economic return is expected according to certain management regimes. The variables used were age of thinning, age of final harvest, pre- and post-thinning densities, and site index. Results are based on cost and price estimates for pulp and sawlogs from the time the reports were written and regimes ranked based on profitability. They give a relative ranking of regimes. Actual results will vary according to current stand conditions and local cost and price information.

Revenues are very sensitive to piece size. This will be significant for dense stands where diameters are near the minimum for merchantability.

Small Business Forest Enterprise stumpage revenue cover administrative costs

Stumpage revenue covering administrative costs is primarily a consideration of competitive bidding and market demand. Although stumpage bids may not cover administrative costs initially, it is expected that market demand will eventually lead to a viable program in much of the province. Stumpage, however, should reflect the true value of the harvested trees. An exception may be where higher stumpage levels due to thinning is anticipated at final harvest.

The amount of stumpage revenue per unit sale will likely increase as:

- operators become more experienced and harvesting costs decrease
- competitive thinning sales grow in number.

NPV of thinned stand is equal to or higher than unthinned stand

To confirm that NPV of thinned stands is equal to or higher than in unthinned stands, one must look at the estimated NPV for the thinning and final harvest combined. The maximum NPV for a chosen regime, species, site index and final harvest age should be compared to the NPV for the comparable unthinned stand. Final harvest age is estimated considering adjacency constraints, timing of wood flow and stand-level economics. (For Douglas-fir, see Table 6-4 in Stone [1993]. For lodgepole pine, see Table 6-1 and Figures 6-1 through 6-9 in Stone [1995]). A negative NPV signifies a stand that should not be thinned for reasons of timber value. Other forest-level objectives should justify the thinning.

Consideration of NPV should normally eliminate stands where commercial thinning is economically infeasible. Poor sites, light thinning and thinning too late, are included in this group.

Statistics on the yield and financial return from simulated commercial thinning regimes are provided in benchmark tables. The regimes selected are a subset of the numerous regimes analyzed in Stone (1993) for Douglas-fir and in Stone (1995) for lodgepole pine. The regimes span a wide range of site quality and commercial thinning intensity. Commercial thinning ages were chosen from the middle of the range used in the original reports. Final harvest ages are close to the culmination age of mean annual increment (MAI). NPV figures shown in the tables would be higher at the economic rotation, which is usually earlier than the culmination of MAI. However, the use of a single harvest age for each table gives a relative ranking of the regimes in terms of volume production and value.

For all sites and species shown, the financial gain is largest with the lowest thinning residual density. However, there is no guarantee that the optimum NPV may not lie between the lowest and second lowest densities simulated. Volume production is maximized at the higher commercial thinning residual densities.

These benchmarks are given as example regimes only. Gains may or may not be realized depending on operational factors. Gains in these tables may differ from those derived from other decision aids. Regimes should be tailored to meet objectives for each site.

Basic assumptions and definitions

The commercial thinning tables in this section are examples only, and are not promoted nor supported by the Ministry of Forests.

Initial density (sph) represents the establishment density. A naturally regenerated stand for pine and a planted site for Douglas-fir.

PCT (*pre-commercial thinning*, also known as spacing) is done at approximately 4 m height for lodgepole pine and 6 m for coastal Douglas-fir.

CT (commercial thinning) usually is thinning from below with some spatial considerations.

Basal area (m^2/ha) indicates the basal area before and after CT.

d/D is the thinning ratio, the ratio of the mean DBH of cut trees (d) to the mean DBH of the stand before thinning (D).

Thinning volume (m^3/ha) represents the volume removed in the thinning.

Final harvest volume represents the final harvest at the specified age in m^3/ha.

Total volume cut is the sum of the thinning volume plus the final harvest volume.

% gain volume compares the total volume cut for a CT regime to the final harvest of the comparable regime without CT or without both CT and PCT.

NPV (net present value) is the difference between the discounted revenues and discounted costs for a CT regime. Revenues and costs were discounted back to the time of commercial thinning, using a 4% discount rate. Planting and PCT costs were not included.

% gain NPV compares NPV achieved to the *control*.

Commercial Thinning Benchmarks for Lodgepole Pine*

Site Index 18 m

Commercial thinning at age 60
Final harvest at age 110

	Regime description					Volume production				Financial return	
Initial density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
5000	–	–	46/46		0	454	454	0	0	521	0
5000	–	1200	46/36	0.72	26	444	470	+4	+4	621**	+19
5000	–	900	46/30	0.78	56	409	465	+2	+2	653	+25
5000	–	600	46/23	0.85	95	345	440	–3	–3	855	+64
5000	2000	–	46/46		0	466	466	0	+3	585	0
5000	2000	1200	46/39	0.73	24	452	476	+2	+5	552**	–6
5000	2000	900	46/32	0.80	55	416	471	+1	+4	698	+19
5000	2000	600	46/24	0.86	99	349	448	–4	–1	880	+50
5000	1600	–	45/45		0	472	472	0	+4	646	0
5000	1600	1200	45/41	0.71	13	467	480	+1	+6	582**	–10
5000	1600	900	45/34	0.81	48	426	474	0	+4	729	+13
5000	1600	600	45/25	0.87	97	351	448	–5	–1	934	+45
5000	1200	–	43/43		0	470	470	0	+4	733	0
5000	1200	900	43/38	0.80	24	446	470	0	+4	735**	0
5000	1200	600	43/29	0.86	72	379	451	–4	–1	978	+35

* Modified after Stone 1995.

** Thinning volume is less than 40 m^3/ha – use results with caution.

Commercial Thinning Benchmarks for Lodgepole Pine*

Site Index 20 m

Commercial thinning at age 50
Final harvest at age 100

	Regime description					Volume production				Financial return	
Initial density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
5000	–	–	46/46		0	493	493	0	0	923	0
5000	–	1200	46/35	0.74	32	482	514	+4	+4	960**	+4
5000	–	900	46/29	0.79	59	450	509	+3	+3	1107	+20
5000	–	600	46/22	0.85	98	382	480	–3	–3	1206	+31
5000	2000	–	45/45		0	506	506	0	+3	1052	0
5000	2000	1200	45/38	0.72	24	498	522	+3	+6	1052**	0
5000	2000	900	45/32	0.80	54	465	519	+3	+5	1266	+20
5000	2000	600	45/23	0.86	97	395	492	–3	0	1454	+38
5000	1600	–	44/44		0	512	512	0	+4	1103	0
5000	1600	1200	44/40	0.74	16	508	524	+2	+6	1003**	–9
5000	1600	900	44/33	0.81	48	473	521	+2	+6	1200	+9
5000	1600	600	44/24	0.88	94	400	494	–4	0	1449	+31
5000	1200	–	42/42		0	519	519	0	+5	1267	0
5000	1200	900	42/37	0.80	23	497	520	0	+5	1249**	–1
5000	1200	600	42/28	0.86	72	425	497	–4	+1	1500	+18

* Modified after Stone 1995.
** Thinning volume is less than 40 m^3/ha – use results with caution.

Commercial Thinning Benchmarks for Lodgepole Pine*

Site Index 22 m

Commercial thinning at age 50
Final harvest at age 90

	Regime description					Volume production				Financial return	
Initial density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
5000	–	–	50/50		0	517	517	0	0	1542	0
5000	–	1200	50/40	0.73	35	512	547	+6	+6	1377**	–11
5000	–	900	50/33	0.78	69	481	550	+6	+6	1452	–6
5000	–	600	50/25	0.84	117	411	528	+2	+2	1885	+22
5000	2000	–	49/49		0	535	535	0	+3	1687	0
5000	2000	1200	49/43	0.74	27	531	558	+4	+8	1728**	+2
5000	2000	900	49/36	0.80	64	499	563	+5	+9	1907	+13
5000	2000	600	49/27	0.86	120	420	540	+1	+4	2154	+28
5000	1600	–	49/49		0	539	539	0	+4	1797	0
5000	1600	1200	49/45	0.76	19	541	560	+4	+8	1724**	–4
5000	1600	900	49/38	0.80	57	508	565	+5	+9	1936	+8
5000	1600	600	49/28	0.87	117	426	543	+1	+5	2228	+24
5000	1200	–	47/47		0	555	555	0	+7	2075	0
5000	1200	900	47/42	0.80	28	535	563	+1	+9	2302	+11
5000	1200	600	47/31	0.86	90	454	544	–2	+5	2388	+15

* Modified after Stone 1995.
** Thinning volume is less than 40 m^3/ha – use results with caution.

Commercial Thinning Benchmarks for Coastal Douglas-fir*

Site Index 24 m

Commercial thinning at age 60
Final harvest at age 100

	Regime description					Volume production				Financial return	
Planting density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
2500	–	–	54/54		0	641	641	0	0	1749	0
2500	–	600	54/34	0.75	100	537	637	–1	–1	1363	–12
2500	–	200	54/15	0.90	247	311	558	–13	–13	2039	+17
2500	1100	–	48/48		0	639	639	0	0	1826	0
2500	1100	600	48/38	0.71	58	591	649	+2	+1	1729	–5
2500	1100	200	48/16	0.90	223	329	552	–14	–14	2684	+47
2500	800	–	45/45		0	624	624	0	–3	1255	0
2500	800	400	45/31	0.80	93	526	619	–1	–3	1352	+8
2500	800	200	45/18	0.90	194	348	542	–13	–15	1726	+38
2500	500	–	39/39		0	572	572	0	–11	1216	0
2500	500	200	39/12	0.89	130	374	504	–12	–21	1760	+45

* Modified after Stone 1995.

Commercial Thinning Benchmarks for Coastal Douglas-fir*

Site Index 30 m

Commercial thinning at age 50
Final harvest at age 90

	Regime description					Volume production				Financial return	
Planting density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
2500	–	–	58/58		0	922	922	0	0	4275	0
2500	–	600	58/40	0.70	101	838	939	+2	+2	3751	–12
2500	–	200	58/19	0.88	286	551	837	–9	–9	5950	+39
2500	1100	–	54/54		0	892	892	0	–3	4048	0
2500	1100	600	54/44	0.68	63	861	924	+4	0	4062	0
2500	1100	200	54/20	0.89	263	564	827	–7	–10	6429	+59
2500	800	–	51/51		0	891	891	0	–3	4399	0
2500	800	400	51/37	0.77	104	806	910	+2	–1	4809	+9
2500	800	200	51/22	0.88	233	578	811	–9	–12	6498	+48
2500	500	–	46/46		0	862	862	0	–7	4682	0
2500	500	200	46/25	0.88	164	637	801	–7	–13	6440	+38

* Modified after Stone 1995.

Commercial Thinning Benchmarks for Coastal Douglas-fir*

Site Index 36 m

Commercial thinning at age 40
Final harvest at age 85

	Regime description					Volume production				Financial return	
Planting density	Pct residual density	Ct residual density	Basal area before/after	d/D ratio	Thinning volume	Final harvest volume	Total volume cut	Volume gain (%) (no Ct)	Volume gain (%) (no Pct or Ct)	NPV	NPV gain (%) (no Ct)
2500	–	–	58/58		0	1239	1239	0	0	7160	0
2500	–	600	58/40	0.69	96	1188	1284	+4	+4	6369	–11
2500	–	200	58/19	0.88	282	900	1182	–5	–5	8689	+21
2500	1100	–	54/54		0	1259	1259	0	+2	7390	0
2500	1100	600	54/44	0.67	61	1271	1332	+6	+7	7301	–1
2500	1100	200	54/21	0.88	263	946	1209	–4	–2	9661	+30
2500	800	–	51/51		0	1272	1272	0	+3	7504	0
2500	800	400	51/37	0.75	101	1185	1286	+1	+4	7761	+3
2500	800	200	51/22	0.88	232	968	1200	–6	–3	9602	+28
2500	500	–	45/45		0	1234	1234	0	0	7644	0
2500	500	200	45/25	0.88	164	1017	1181	–4	-5	9025	+18

* Modified after Stone 1995.

Appendix 2. Harvesting methods for commercial thinning

Horse

Advantages:

- damage to residual trees usually involves root systems and can be easily controlled
- inexpensive/low overhead
- great public relations
- can achieve low levels of soil disturbance on growing site if trails are spread out into a tributary pattern and concentrations around landings are minimized.

Disadvantages:

- low productivity and restricted to small/moderate piece size
- limited to <10% slope, smooth topography
- short skidding distance
- concentrates site degradation when trails radiate out from landing.

Water may be channeled due to the trenching effect of dragging logs. However, this can be minimized by shovel deactivation, use of slash, use of arches, or appropriate location of landings. Horse logging is generally the least cost-effective harvest method.

Skidder

Advantages:

- versatile in blocks with irregular boundaries
- inexpensive/readily available
- high production with low harvesting cost/m^3
- suitable for harvesting in stands with low to moderate volumes.

Disadvantages:

- requires careful layout of skid trails and landings
- limited to low sensitivity sites or seasonal constraints
- potentially high damage levels to residual trees especially with large skidders and inexperienced operators
- potential of high levels of detrimental soil disturbance.

Avoid thin soils, high water table, rough terrain, steep slopes (>30%), moderate to fine-textured soils, shallow rooted species (Hw). It is generally preferable to use small sized and low ground pressure skidders.

Skyline

Advantages:

- moderate production (in some cases the removal of high volume per hectare may be required to make the operation pay)
- minimal growing site impact and can work all year round with properly built roads
- a suitable method for slopes >30%
- effective on sensitive sites where thin soils or high water tables restrict ground based methods
- potential for yarding distance of 300 m+ on favourable slopes
- narrow corridors (2.5 m) minimize impact on residual stocking.

Disadvantages:

- harvesting costs are generally higher than ground-based harvesting methods, although short towers are customized for thinning
- roads must be well engineered, particularly with larger equipment and wet season logging
- not suitable for broken terrain with short yarding distances and poor deflection
- availability of equipment
- damage usually due to cables rubbing on leave trees along corridors
- skidder often required to forward wood to landings where hot loading not possible at end of corridor
- not cost effective with small wood
- re-marking of corridor trees is often required once corridor is in.

Careful planning and layout is required to ensure proper deflection along yarding corridors, to identify suitable tail spar trees and tailholds and to ensure that leave trees are adequately protected from yarding damage. Yarding corridors should be perpendicular to the slope and should not radiate from the landing.

Single grip harvester and forwarder

Advantages:

- falling, delimbing, bucking and piling with one machine
- effective with small wood
- can travel on slash trail to minimize impact
- can work on 0 to 30% slope
- high production rate
- can work all year round on certain sites if roads are engineered for all season operation

- effective in dense pine stands
- can reduce road construction with longer forwarding distances
- tree marking not required.

Disadvantages:

- equipment is expensive and availability may be limited
- requires large blocks for maximum cost effectiveness (this is a characteristic of all mechanical harvesting methods).
- inter-trail spacing is dependent on boom length (e.g., 20 m. inter-trail maximum).
- seasonal restrictions may be required

Small tractor highlead/forwarder methods

Advantages:

- inexpensive and readily available equipment
- versatile equipment using a four wheel drive farm tractor, loader/forwarder trailer, and small excavator can be configured many ways
- skyline set up or high lead using small tower on tractor or excavator
  - long lining and ground skidding with tractor
  - forwarding on low-impact trails built by excavator
- efficient with small wood, short log harvesting and low volumes per hectare
- can work in undulating topography, sensitive sites and steep slopes
- suitable where irregular block shape or topography would result in high road costs
- long forwarding distances allow for reduced permanent access structures
- forwarder trails can be widely spaced (60 to 80 m) and can use logging slash to lessen impact on soils.

Disadvantages:

- not widely used at present
- not efficient for full tree length harvesting and large piece sizes
- not as productive on sites with high volumes
- some seasonal restrictions may still be required on moderate to highly sensitive sites but less impact than heavier harvester/forwarders.

Pre-bunching

Small inexpensive equipment can be used to pre-bunch full payloads for more expensive equipment. For example, horses can pre-bunch for skyline.

Appendix 3. Commercial thinning inspection procedures

Introduction

The purpose of inspections is to ensure that the long-term productivity of a stand and site are not compromised by poor logging practices during commercial thinning. A stand's potential productivity can be severely reduced through improper harvesting techniques. The allowable limits for permanent and temporary access structures, soil disturbance, crop tree damage and other factors are described in the silviculture prescription (SP).

The inspection process should be an ongoing review between the forest officer and the contractor beginning with approval of the proposed logging plan and continuing through the final inspection and assessment after completing the harvest. The logging contractor and the loggers must understand their responsibilities and the stringent requirements of commercial thinning.

Inspections of licensee projects should be done according to the same post-treatment survey procedures as Small Business Forest Enterprise Program (SBFEP) sales.

Commercial thinning inspections and the Forest Practices Code

Commercial thinning policy states:

> *"All commercial thinning operations will have a post-harvest assessment immediately after harvesting to determine final stand structure, species composition, soil disturbance, stand damage, and waste."*

The timber sale licence and cutting permit must be consistent with the specifications in the SP.

The following regulations and guidebooks should also be reviewed before carrying out inspections:

Operational Planning Regulation

Soil Conservation Guidebook

Soil Conservation Surveys Guidebook

Silviculture Surveys Guidebook

Tree Wounding and Decay Guidebook.

Standards of acceptance

Residual stand characteristics

Stand composition after harvesting must be specified in the SP. This is usually described by species, stand structure, and number of stems per ha and/or basal area based upon diameter limits. A typical tolerance on tree density (stems/ha) is ±10%.

Damage evaluation

The recommended levels for damage to crop trees on a tree and stand basis are described in the section "Damage assessment."

If damage to crop trees exceeds the amount specified, and no substitute trees are available, penalties may be assessed according to the enforcement options under the *Forest Practices Code of British Columbia Act*.

For SBFEP sales, trees marked to leave must be left unless substitution has been authorized by the forest officer. Similarly, trees marked to cut must be cut unless otherwise directed by the forest officer. If tree selection is determined by the faller, then a survey may be required to confirm that the appropriate residual density specified in the SP has been met.

Selecting residual crop trees during commercial thinning by major licencees will be the responsibility of the licencee. A survey upon completion may be required to confirm compliance with the SP.

Where there is unauthorized felling of designated leave trees, evaluate the impacts on the objectives for the stand.

Soil disturbance

Soil disturbance is defined in the *Forest Practices Code of British Columbia Act* and the *Operational Planning Regulation.*

Under the code there are two main types of soil disturbance:

- the proportion of the cutblock occupied by permanent access structures
- soil disturbance within the net area to be reforested (NAR).

Separate limits are set for each, and assessment of compliance is done separately.

Permanent access structures including roads, permanent skid trails and landings must not exceed the amount specified in the SP. Temporary access structures must not exceed the limit specified in the SP. Skid trails not required for repeated stand entries should be evaluated as dispersed soil disturbance and are considered part of the NAR.

Waste assessment

Utilization of timber is to be assessed as per the procedures in the *Provincial Logging Residue and Waste Measurement Procedures Manual*. Charges for non-removal are to be charged at the recommended stumpage rates.

Contract monitoring

Before harvesting starts, meet with the contractor to review the requirements of the SP, timber sale licence or cutting permit.

Following are some important considerations during monitoring:

- Regularly inspect the area by doing a walk-through with plots to check for compliance with these plans. If infractions are observed, an administrative remedy can be used to ensure the objectives of the block are met.
- New or inexperienced contractors will require more frequent checking.
- After harvesting is complete, do a final inspection noting stand damage, soil disturbance, unauthorized harvesting, road deactivation and waste residue.

If the criteria set out in the SP, logging plan and tenure documents have been met, there is no need to do any formal surveys.

If the criteria set out in the SP do not appear to have been met, then do a more detailed and systematic survey.

See Figure A3-1 for a diagram illustrating the inspection process.

Survey objectives and procedures

Survey objective(s) must be clearly understood before starting. Upon completion of commercial thinning operations, it is necessary to do a post-harvest assessment immediately after harvesting to determine final stand structure, species composition, soil disturbance, stand damage and waste.

The following are a number of survey methods which can be used to measure compliance with individual silviculture prescription standards.

Survey methods are described for post-harvest assessments, of crop trees, permanent access structures and soil disturbance.

Post-harvest assessment

Formal surveys are a component of managing a commercial thinning operation. Prior to a formal survey, conduct visual inspections to estimate thinning quality.
Figure A3-1 provides a general decision tree for post-harvest assessment procedures.

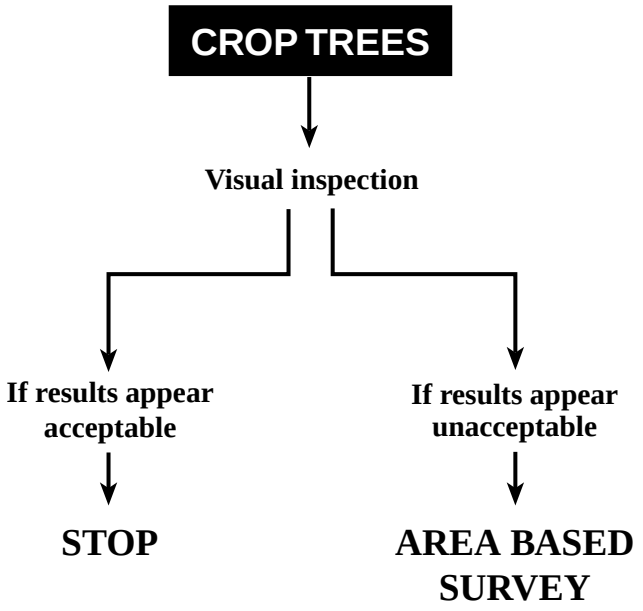


Figure A3-1. Post-harvest assessment procedures.

It is expected that standard Ministry of Forests plots or cruise strips will be used for describing the residual stand structure and species composition. Refer to the *Silviculture Surveys Guidebook* for more direction.

Crop trees with wounds exceeding 400 cm^2 or gouges should be rare. As a result, a random survey is unlikely to locate them. Therefore it is expected that areas of high risk such as skid trails and yarding corridors may be assessed by visually identifying those trees exceeding allowable damage limits.

If the total number of damaged trees appears to be excessive, a survey over the whole block may be required to determine whether or not the 10% limit is exceeded.

Surveys: species composition, stand structure and stand damage

A fixed-area plot is commonly used to assess final stand composition and structure. The final density of the stand will guide what type of plots to establish. With stands of low residual densities, larger sized circular plots may be necessary to properly assess crop trees. Check for appropriate crop tree selection in stands where crop trees have been pre-marked.

Circular plots: For final stand densities establish plots of a size sufficient to have six or more crop trees per plot. Establish one plot per hectare with a minimum of five plots per stratum (standards unit). During the survey, note species composition of crop trees, tree damage and any other concerns within the plot. Species composition, tree counts and diameters can be estimated from the sample. If required, prism plots can also be established at the same frequency to determine the remaining basal area.

If the residual basal area is less than the minimum specified, refer to more formal survey methodologies in the B.C. Ministry of Forests *Cruising Manual*.

Either of these survey techniques may also be used to record the number of residual trees with scars. Since the proportion of trees with wounds should be small, it may be necessary to add some plots to obtain a reasonable sample of the damaged trees.

Cruise strip method (Young, 1994): This procedure is most appropriate for stands with low residual densities. A cruise strip can also be done concurrently with methods for surveying dispersed soil disturbance in the NAR.

The following procedures are used to implement the cruise strip method:

- Determine sampling intensity.
- Determine a suitable layout on a map, using a bearing that will intercept a majority of trails and efficiently cover the whole of the cut block area. Typical spacing should be 50 to 100 m between strips.
- Width of the cruise line can be determined by the following equation:

$$\text{width of cruise line [m]} = \frac{(\text{sampling intensity [\%]}) \times (\text{total area [m}^2\text{]})}{\text{length of cruise line([m])}}$$

- On a survey card, note species composition of crop trees, tree damage (wound size, and position on bole or root) and any other concerns within the cruise strip as determined in the survey objectives.
- Tally up survey information to assess the whole site.

Visual assessment: Where an assessment has shown that tree or stand damage is localized, a detailed survey is not necessary. Walk the block actively seeking out damaged areas or trees along the skid trails, yarding corridors, back spar trails, landings or any other area where damage to the NAR or crop trees is expected. Essentially these areas become separate strata with regard to damage and the survey is considered to be a *tree-based survey*. Measure and record the amount of damage found. The information collected represents the number of damaged trees present in that strata. It cannot be applied to the whole block.

For example, if three trees are found to have wounds that exceed the suggested maximum level then any assessments will be based only upon those three trees.

Surveys – permanent access structures

Visual inspection: Monitoring during harvesting will normally indicate if non-approved roads, landings or other permanent access structures have been built.

Traverse survey: If visual inspection reveals unauthorized permanent access structures have been built, follow the survey procedures for formal compliance described in the *Soil Conservation Surveys Guidebook*.

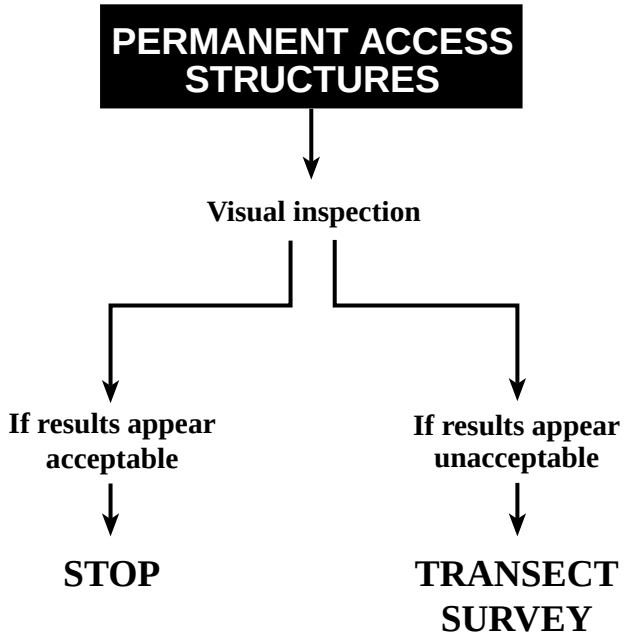


Figure A3-2. Procedures for post-harvest of permanent access structures.

Surveys – soil disturbance within the net area to be stocked (NAR)

Visual inspection: Visual checks should be ongoing during the harvest to ensure the limits set for disturbance are not being exceeded. After final harvest, an inspection of the block using a shovel, a block map and a tape measure will help identify which areas may have excessive soil disturbance.

Transect survey: If visual inspection indicates the soil disturbance limits set in the SP appear to have been exceeded, follow the survey procedures for formal compliance described in the *Soil Conservation Surveys Guidebook*.

Final reporting requirements

The post-commercial thinning report confirms that the post-thinning standards specified in the SP have been met.

This report is done no sooner than 12 months after the completion of harvest. If the stand appears unchanged from immediately after harvest, then the surveys conducted may be used to describe the stand and assign a new forest inventory label.

If there is a substantial change in the composition of a stand, from that described in the SP, where regeneration is now seen as an objective, a new SP will likely be required.

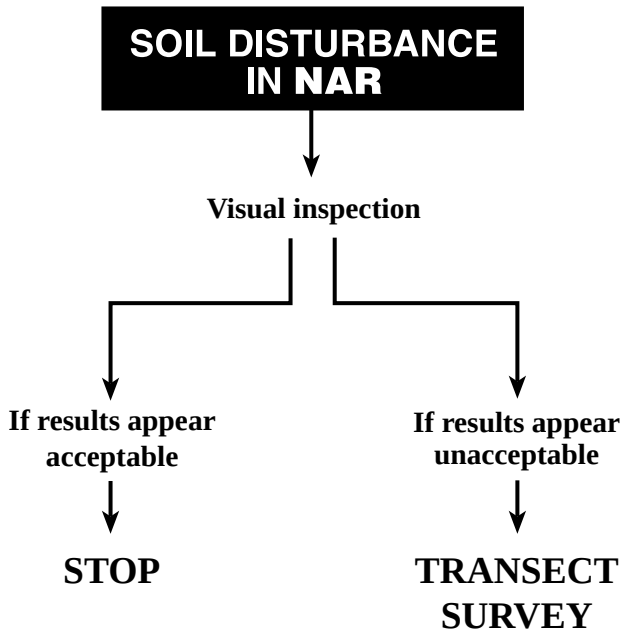


Figure A3-3. Procedures for post-harvest soil disturbance within the net area to be stocked.

Report requirements

The report of a survey for an area under a silviculture prescription without regeneration objectives must confirm the following information:

- the identification of the area under the silviculture prescription and, if the report is required of a holder of a major licence, the agreement and the name of the holder of the agreement
- for the net area to be reforested:
  - the area
  - the biogeoclimatic ecosystem classification
  - the incidence of damage by forest health factors affecting trees
  - the inventory label, including species component, age, height, density, basal area and site index
  - the number of acceptable and preferred trees per hectare.

Reporting periods

A holder of a major licence who is required to establish a free growing stand on an area under a silviculture prescription must submit each year to the district manager the following report:

- on or before July 31 and January 31, a report in Forms B and C, together with an accurate map, describing the timber harvesting activity completed in the harvest area as of the date four weeks before the prescribed dates.

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Biodiversity

Boundary Marking

Coastal Watershed Assessment Procedure

Defoliator Management

Dwarf Mistletoe Management

Establishment to Free Growing

Interior Watershed Assessment Procedure

Managing Identified Wildlife:Procedures and Measures

Root Disease Management

Silviculture Prescription

Silviculture Surveys

Silvicultural Systems

Soil Conservation

Soil Conservation Surveys

Stand Density Management Guidebook

Stand Management Prescription

Tree Wounding and Decay

Visual Landscape Management

Other

Ministry of Forests *Cruising Manual*

Ministry of Forests *Coast and Interior Appraisal Manual*