Partial Harvest (Non-clearcut) Planning and Monitoring Guidelines

A Supplement to the Alberta Forest Management Planning Standard

Forest Management Branch
Forestry Division
Sustainable Resource Development
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Prepared By: **Ken Greenway**
Grant Klappstein
Barry White

1. Introduction

These guidelines outline Forest Management Branch (SRD) expectations for operational stand-level planning of various partial harvest or non-clearcut systems. The guidelines are a more detailed supplement to the standards found in Appendix C, Annex 1 of the *Alberta Forest Management Planning Standard*. The guidelines are designed to provide direction to forest industry staff in developing partial harvest stand-level crop plans and monitoring of results, and to provide direction to SRD staff in reviewing and approving such plans.

The purpose of having these guidelines is to ensure that actual risks associated with unproven techniques and unknown growth responses are objectively assessed, while ensuring that all stand-level activities are also accounted for at the forest management unit or landscape level and the associated Forest Management Plan.

The types of partial harvest considered in these guidelines are:

1) Harvest of deciduous overstorey with coniferous understorey protection
2) Commercial thinning
3) Other partial harvests (pre-commercial thinning, shelterwood, seed tree, selection harvesting, fire hazard reduction - FIRESMART).

2. Understorey Protection

Vertically stratified mixedwood stands can provide operational challenges as well as opportunities for maintenance of additional forest-level values if managed to optimise the flow of both species over time. Understorey protection harvests (UPH) are becoming routinely practiced in much of Alberta's boreal white spruce and aspen/balsam poplar forests yet there is a lack of consistency as to how these stands are evaluated post harvest, when the harvest is sequenced, and the regulatory framework that guides the harvest operations.

Standards for understorey protection harvest are found in the *Timber Harvest Planning & Operating Ground Rules* established for each FMA or FMU. The following are more detailed guidelines to supplement the standards in the ground rules.

The **objective** is to retain 50% of acceptable trees (undamaged) in the understorey through understorey protection.

Purpose of Understory Protection Harvests

Protection of sub-merchantable understory trees during harvesting operation can provide for multiple benefits including increased fibre availability through capture of higher merchantable conifer volumes or reduced effective rotation age; reduced silviculture costs through the trading of preserved understories for reforestation responsibilities in other areas; and enhancement of non-fibre value objectives through increase retention of structural diversity (species and size classes) or through increased aesthetic value of areas harvested with understory protection strategies.

Types of Understory Protection Harvests

Two broad classes of UPH are identified based on the level of protection and incremental harvest costs associated with the protection:

1) **Understory Avoidance** – Used on the deciduous landbase (as defined in the applicable Forest Management Plan), in white spruce overstorey with a white spruce understorey, and low density stands and/or highly aggregated (clumped) understorey distribution. Wind buffering tactics and pre-planning are not normally required. Harvesting provides minimal protection with marginal additional harvesting costs. The objective is to identify and retain understories through either non-harvesting areas with understory, or harvesting of the overstory aspen with protection from direct harvest impact of the understories at the harvest, skidding and reforestation phases.

2) **Understorey Protection** - Used on the coniferous landbase (as defined in the applicable Forest Management Plan). Wind buffering tactics are utilized through structure retention and pre-planned strip harvesting and skid trails. This approach is designed for maximum protection of understories with additional harvesting costs to attain this protection. Such harvests typically are designed with wind-buffering as a primary goal and are practiced in stands with heavy and relatively uniform understories. Understory protection harvesting is designed to create a future forest condition that utilizes the advanced growth spruce. Protection harvesting may, therefore create a two-stage harvest design (Figures 1 & 2) where the initial entry harvest (the understory protection harvest) and the final entry harvest (the removal of the protected spruce and any merchantable aspen) are designed and planned together. The stand condition created by the understory protection harvest (post UP harvest condition- PUPC) must equate to the necessary condition to achieve the final harvest condition (FHC) that is assumed. The assumed final harvest condition must, therefore be explicitly defined in order that both the interval between the understory protection harvest and the final harvest (the Period of Release –'POR' – Figure 1) and the necessary PUPC be determined.

Figure 1. Hypothetical stand yield for two-stage harvest of aspen overstory and evenly distributed white spruce understory.

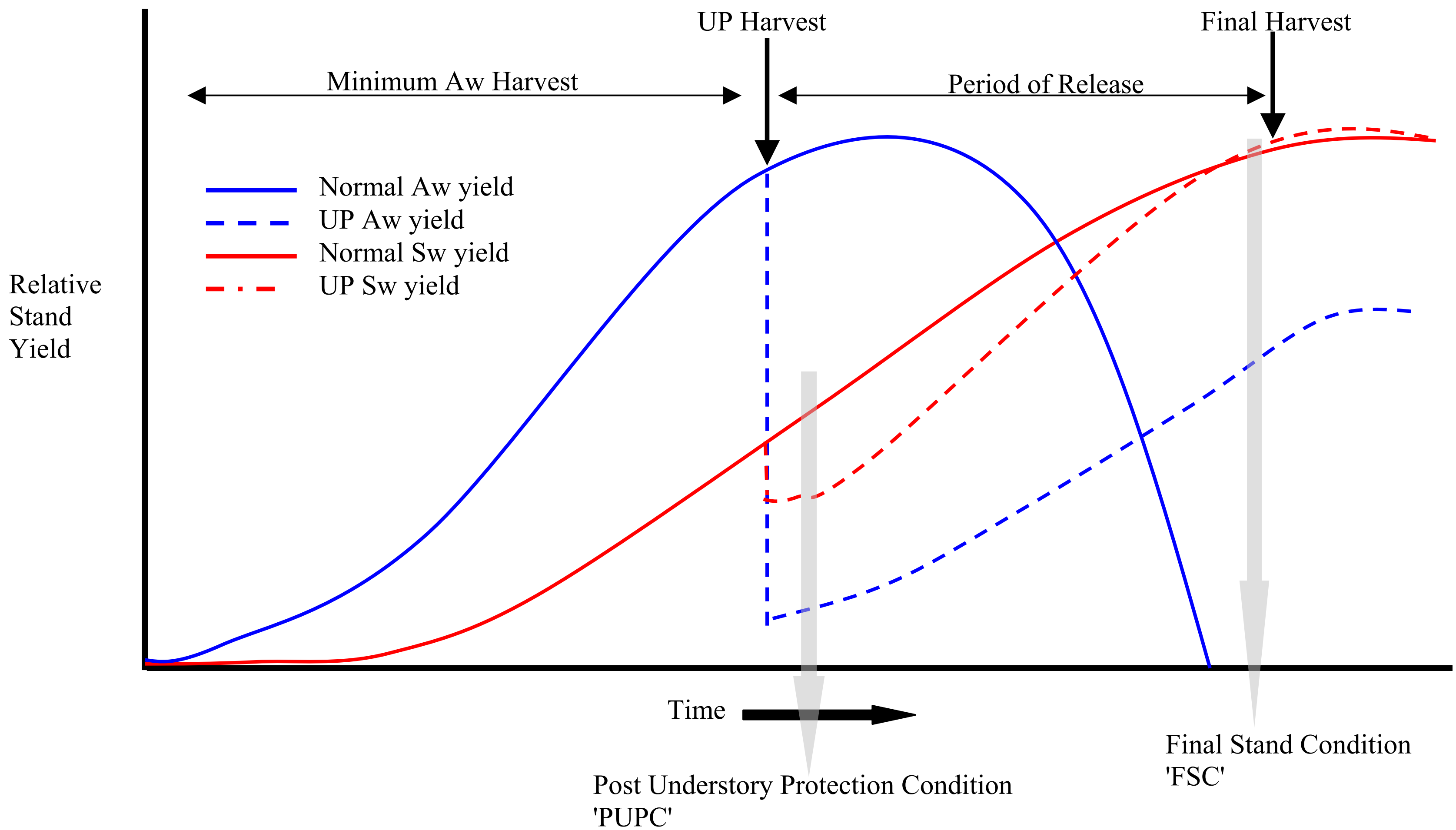
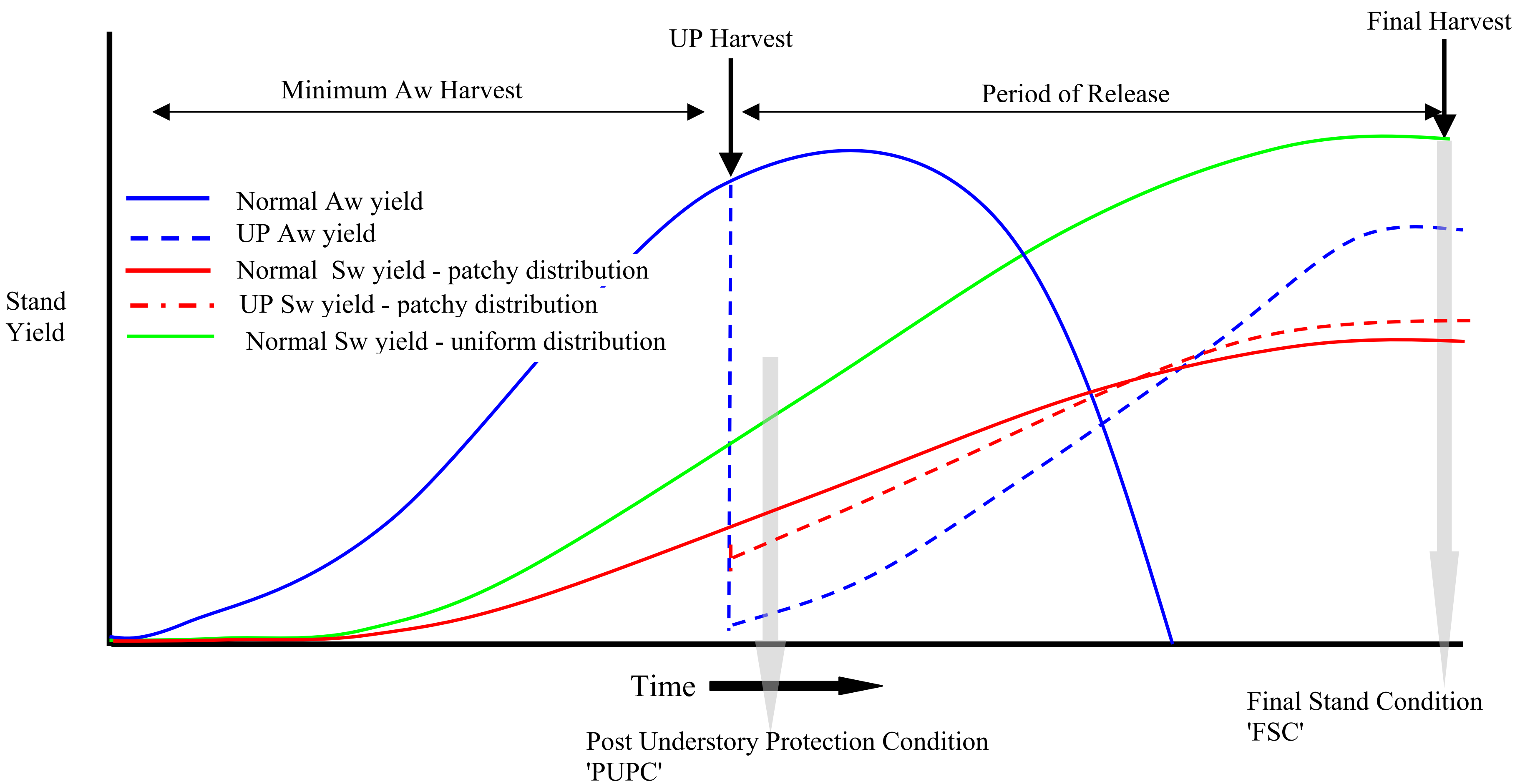


Figure 2. Hypothetical stand yield for two-stage harvest of aspen overstory and patchy distributed white spruce understory.



Guiding Principles for Understorey Protection

Understory spruce represent a potential forest value that should be retained subject to an assessment of their condition and the forest management goals for the harvested area. Not all understories should be retained. The value of any retention must be balanced against the future stand condition being created, the viability of the retained understory, and any higher level plans' assumptions as to the management of such understories.

Understory harvests must be designed with full consideration of the future stand harvest assumptions. Understorey harvests create unique stand conditions and the assumed post-harvest developmental trajectory must be part of the protection harvest plan to ensure that the stand level goals are achieved.

Parties that incur the benefits of understory protection practices should also incur any incremental costs directly attributable to the understory protection practice. Understory protection harvesting typically requires increased forest management costs over traditional clearcut harvest. Where these costs and benefits of protecting understories accrue to the same party, an increased level of commitment to achieve the protection goals is likely to result.

Site and Stand Selection Criteria

Understory protection techniques (avoidance or protection) must be practiced in all stand types which the applicable timber supply analysis assumes the understory crop will contribute to the sustained yield timber supply for the Forest Management Unit, or where achieving non-fibre objectives of a higher plan are dependent on the preservation of the understory. Balsam fir understorey does not specifically require protection unless the stand is approved by Alberta as meeting the criteria outlined in FMB Directive 2001-1.

In stands where understories are present, they are to be preserved if found in patches larger than 1.0 ha and where the understory trees are determined to be viable. **Viability** shall be based the understory containing at least 400 evenly distributed *acceptable* stems/ha with an average understory stand height equal to or greater then 5m. Individual tree acceptability is defined by being free of obvious signs of disease and/or insects, having a live crown ratio in excess of 30%, being of an acceptable species, and having the potential to attain a height necessary to be merchantable at the final harvest (detailed below).

Amount of Understory

Understory stand viability (relative to meeting future stand harvest assumptions) must be considered with respect to total number of stems, the number of acceptable stems, and the spatial distribution of the retained trees. Furthermore, understorey stands are often characterized by having a very wide range of tree heights where enumeration of all trees (regardless of size) may lead to an unrealistic assumption of final harvest densities and yield. The final harvest entry white spruce yield will be defined largely by the size of the spruce at the UPH, the length of the POR, and the *final* distribution of the understory after the UPH. Use of density (stems/ha) alone as the definition of a viable understory is inappropriate as a simple density number assumes all stems have equal value at final harvest. Where a high variation in stem height exists, and/or where spatial distributions are highly aggregated all retained stems can not be considered as contributing towards the final harvest yield as the final entry harvests assume a minimum tree size. As such small trees retained by the UPH cannot be considered to contribute to the final harvest spruce yield unless the POR is defined to explicitly ensure their merchantability at the time of the final entry. Therefore the assessment of a viable understory, in part, is a function of the final harvest entry timing. Furthermore, "averaging" stem counts from dense localized patches of understory with areas lacking an understory, falsely inflates projected yields based solely on the average density. Thus the enumeration of a viable understory must consider *both* the minimum tree size necessary to attain final entry harvest assumptions and the minimum inter-tree distance necessary to ensure the survival *and* minimum stem merchantability limits assumed, in addition to the biological factors noted below.

Uniform strip understory protection strategies generally retain 50% of the original understory stems in a similar spatial distribution as found prior to harvest. It is expected therefore, that where viable understories are to be protected, at a minimum 50% will be retained in the post-understory harvest condition. Where individual patches (in excess of 1.0ha) are sporadically located within a cut block, preservation strategies should be employed where patches are retained largely intact and appropriate wind buffering tactics are to be employed to help ensure their continued growth.

A higher or lower percentage of retention may apply to a particular stand depending on its yield assumption in the timber supply analysis. Uniform strip harvesting can produce up to 70% protection in certain instances.

Stand and Site Factors

<u>Stand Age</u>: Available evidence has shown that individual tree age is not an important limiting factor in an understory white spruce stand's response to overstory removal. White spruce trees as old as 200 years can respond positively to a reduction in competing trees. However, as the understory stand's time to minimum/optimum merchantability (Period of Release- POR) is lessened, the loss in stand conifer yield due to the understory protection harvest operations (relative to the non-UPH condition) may exceed the ability of the stand to recapture this volume even with the accelerated growth from the removal of the aspen canopy. Hence the value to the final entry spruce yield may be reduced in older stands subjected to UPH relative to leaving the stand to mature naturally. This age/developmental stage threshold is, however, not consistent due to the variability in the harvest designs, understory condition, and acceptable limits on the length of the POR. UPH plans must address how the UPH will attain the final harvest conditions assumed for this stratum.

<u>Tree/Stand Vigour & Size</u>: Apart from any insect/disease factors, trees with longer crowns are likely to respond faster and a have lower risk of post-release mortality than

trees with very small crowns. Tree vigour may be estimated visually by assessing crown condition/size or more quantitatively through estimates of sapwood area; trees of good vigour have more sapwood area than those of poor vigour. A minimum live crown ratio of 30% on understory spruce trees is necessary to ensure optimal growth response.

Tree size and position within the understory canopy are highly related to response post-release. Absolute growth is a function of size, such that in general taller trees tend to grow faster than shorter trees (Claveau et al. 2001). Based on the range of tree size data in established spruce release treatments, Man (2003) found that released spruce in the height range of 14-18 m had the overall highest relative increase in growth, however, released trees of all size classes grew significantly better than unreleased control trees. Thus retention of trees of all size classes may provide for the greatest subsequent yield recovery at the final entry harvest.

However, unless the time to final harvest (the Period of Release, POR, Fig.1) is sufficiently long the small understory trees in the understory population are not likely to reach merchantability at the time of the final entry. Unless a harvest plan explicitly address an alternative method of defining the minimum understory tree size, any understory tree within 75% or two metres (which ever is less) of the height of the average viable understory white spruce tree, can not be assumed to be merchantable at the time the average viable trees will be harvested. The average tree height is calculated based on a ground survey. If, however, the POR is determined as a function of the time necessary to attain merchantability of the defined “smallest” tree, (from an appropriate growth projection system) then all understory trees exceeding this defined minimum threshold may be considered available for final harvest. In all harvest plans, the minimum understory tree size threshold, and the methodology for determining this threshold must be provided.

Site Conditions: Sites that are temporarily (spring flooded) or permanently (high water table) in conditions of excessive moisture should be avoided.   High water tables promote shallow rooting that in turn leads to poor stability and a high likelihood of post-release wind throw. Excessive moisture may also limit the rate of increased growth in the residual trees as well as an increasing risk of soil compaction and direct root injuries from machine activities during harvest operations in unfrozen soil conditions.

Species: White spruce has been shown to be highly responsive to release, though a lag of 2-5 years before accelerated growth occurs is often seen. Balsam fir, while also commonly found in the understory, is less able to acclimate to the post-release environment. Retention of balsam fir in accordance with DFMP stated fir utilization rates may be considered, however post release monitoring will be critical as there is presently a lack of Alberta data on its post release performance. Retention of balsam fir must also be considered in the light of any localized spruce budworm incidences. Balsam fir is highly susceptible to budworm attack, and the retained fir is not likely to be available for the future harvest in areas of high levels of budworm. Furthermore, fir retention may exacerbate a budworm outbreak.

Treatment Methodologies

Understory protection harvest methodologies must be consistent with the final stand condition assumed present at the final entry harvest. Furthermore the methodologies must be tailored to the specific site and stand conditions found in each harvested block. Pre-harvest assessments are necessary to identify limiting site conditions, spatial distribution and conditions of the understory trees. Strip harvesting has been shown to be operationally efficient where dense uniformly distributed understories are found; whereas patch retention is widely used where localized dense areas of understory are encountered.

Timing: Precisely when an entry into a stand occurs can play an important role in determining the success of the harvest. The earliest UPH entry is usually set by the minimum merchantability criteria for aspen.

Timing of the UPH should aim to optimize the future operability in the treated stand and optimize the total stand yield. Stands with decreasing overstorey aspen MAI and marginally subordinate (2-4m) well distributed understorey spruce are not likely to optimize the available stand volume if an understorey protection harvest is practiced. Sequencing such stands later in the planning horizon may provide a greater value as the increase in spruce yield more that offsets the loss in aspen yield relative to an understorey protection harvest timed at minimizing the aspen volume loss. However, this trade off is clearly related to both specific stand conditions and the timber flow constraints in the area.

Adjacency constraints such as buffers must be considered. Proposals may not involve retreatment of a stand or entry into an adjacent buffer within five years of a previous treatment. The protection of residual trees and buffers must be maintained for at least five years to allow time for root systems, foliage and/or slenderness coefficients to respond to the previous treatment. Stands with adjacency constraints that prevent optimal sequencing will be given priority. This will allow the harvest to capture increasing volumes of mortality without compromising the cover retention required because of adjacency.

Harvest Damage: Damage to the retained understory trees can significantly compromise individual tree and stand performance. Common damage types include bole scarring from the skidding phase operations and crown stripping during felling.

Felling damage to crowns can be controlled through the use of harvesting equipment capability of lifting and placing overstory aspen on extraction trails rather than directional felling equipment. Trees which have had 30% or more of their live crown ratio lost on one side due to crown stripping and/or with 25% or more of the crown lost through top breakage can not be considered as crop trees available for final harvest.

Bole damage can largely be prevented through the use of strategically place rub stumps and through ensuring straight extraction trails. Excessive bole damage shall be defined as any tree with the bark removed to the cambium that is 10cm long and in excess of 20% of the bole circumference.

Reforestation Requirements

Reforestations requirements are related to both the stated objective of the treatment(s) and post harvest condition created by the harvest. Understory protection harvests where the objectives are to increase yield of the understory spruce (volume and/or economic value), reforestations obligations will not normally be applicable until the final entry is complete. Where objectives are to access fibre and establish a second regenerating crop, reforestation success relative to the stated stand objectives shall be required to be substantiated through a block survey.

Understorey protection harvests with yield recovery objectives:

Where UPH are practiced with the intent of maximizing final entry spruce volume, the harvest design and POR generally preclude the successful reestablishment and/or growth of any regeneration. Unless an uneven aged management plan is proposed where multiple harvest entries are committed to, reforestation obligations will normally be waived as part of the approval process.

However, in instances where the UPH has resulted in unacceptable increased risk of loss to the residual stand, at the discretion of the Area Manager, reforestation obligations shall be reinstated. Situations where reforestation may be required include blowdown, severe insect infestation or disease outbreak, or excessive mechanical damage. Where damage thresholds stated as a condition of the AOP approval are not met, a penalty for contravention of Section 100(a) of the Timber Management Regulation may also be considered.

Where UPH are proposed strictly to enable small-scale research trials, approval may be granted for treatments that would normally have reforestation obligations associated with them. Individual project approval may be granted where it is deemed that the unique research findings merit a waiving of reforestation requirements. Such proposed research projects must meet the requirements as outlined in the Submission, Review and Approval section of this guide.

Understory protection harvests with Reforestation Objectives:

If a UPH assumes the final harvest to contain a component of volume achieved from regenerating trees (of any species) reforestation obligations apply. An altered reforestation standard and survey system has been developed that will guide the assessment of the degree to which the post understory protection stand conditions align with the provincially recognized four stand types (C, CD, DC, D).

Regeneration Standards

The modified standards are summarized here. For stands where the post harvest average crop understory spruce height is determined from a ground survey to be less than 8m, the declared reforestation strata standards apply (as found in the *Alberta Regeneration Survey Manual*, 2003). In stands where the post-understory harvest average crop understory spruce height is in excess of 8m, alternate standards have been developed under an assumption of either full stocking (C, D density) or less-than-full stocking (B density). (see Tables 1 and 2 below)

Table 1. *Minimum Stocking for Block Designation and Natural Subregion for fully stocked understories (C or D density pre-harvest)*

Cutblock Designation	Natural Subregion	Sw height <8m		Total stocking @ block age		Sw height ≥ 8m	
		Conifer	Decid	= 0	≠ 0	Conifer	Decid[2]
C	Subalpine, Montane, & Upper Foothills	80	0	**80**	**65**	60	0
C	Lower Foothills; Central, Dry, and Northern Mixedwood; & Lower and Upper Boreal Highlands	70	0	**80**	**65**	55	0
CD	All	50	30	**80**	**65**	40	25
DC	All	30	50	**80**	**65**	25	40
D	All	0	60	**80**	**65**	n/a	n/a

[1]Arithmetic mean understorey crop tree height in post-UP harvest stand.
[2]Stocking assumes all existing mature aspen are retained until final harvest and regenerating aspen are not merchantable at that time.

Table 2. *Minimum stocking criteria by block designation and natural subregion for B density pre-harvest understories.*

Cutblock Designation	Natural Subregion	Sw height[1] <8m		Total Stocking Block Age		Sw height[1] ≥ 8m	
		Conifer	Decid	= 0	≠ 0	Conifer	Decid[2]
C	Subalpine, Montane, & Upper Foothills	65	0	**65**	**60**	50	0
C	Lower Foothills; Central, Dry, and Northern Mixedwood; & Lower and Upper Boreal Highlands	60	0	**65**	**60**	45	0
CD	All	40	30	**70**	**60**	35	25
DC	All	25	50	**75**	**60**	20	40
D	All	0	60	**80**	**n/a**	n/a	n/a

[1]Arithmetic mean understory crop tree height in post-UP harvest stand.
[2]Stocking assumes all existing mature aspen are retained until final harvest and regenerating aspen are not merchantable at that time.

Information Requirements

There is limited existing data that clearly identifies all factors important in determining the growth response of UPH. Through documentation of the planned harvest practice, post-understory protection harvest condition, and the anticipated final harvest outcomes, our understanding of the important controlling factors and magnitude of the growth response can be significantly increased. The following outlines information required for planning and monitoring of understorey protection harvests.

Proposals for understory protection harvests must include a crop plan with the following components:

(1) Specific objectives of proposed treatment(s).
(2) Description of treatments (i.e. what is to be removed), methods, and timing. Plans must relate the number and type of trees to be removed and retained and the proposed desired future stand condition.
(3) Pre-harvest assessment data consisting of site type, species composition, stand structure (height/density, stand table), live crown ratio, slenderness coefficient, and total stand volume.
(4) Preventative measures to be implemented to mitigate against treatment-induced mortality due to windthrow, root injuries, disease or insect.
(5) Impact of proposed treatment(s) on non-fibre values, fuel loading, aesthetics and forest-level values.
(6) Proposed mitigative measures to be adopted if the desired post understory protection harvest stand condition is not achieved.
(7) RFP signature.

Monitoring - Assessment of Stand Response

Assessments fall into two categories, assessments related to attainment of the specific harvest objective(s) (specific stand level response) and documentation of the nature of the stand growth response over time (strata level response).

The first assessment shall be required for each stand treated with an understory protection harvest and must be completed within 3-5 years of the harvest. The assessment is a modified regeneration survey systems as outlined below. For UPH where no reforestation obligations exist, an approved aerial assessment demonstrating the level of stocking and the maintenance of the retained understory with 3-5 years of the UPH shall be deemed as sufficient for ensuring the harvest treatments objectives have been met.

Monitoring for the purposes of establishing the stand growth response shall be required using Permanent Sample Plots (PSP). At the present, the Mixedwood Management Association (MWMA) has proposed a monitoring strategy and matrix of stand types within which monitoring shall be established. PLFD is currently reviewing the proposed system and proponents participating in the approved MWMA monitoring system may not be required to establish additional PSPs. Where proponents harvest objectives and/or harvest designs deviate significantly from the MWMA monitoring system, or where insufficient PSPs have been established, additional PSP may be required.

Objectives:
- To provide a protocol to quantifiably establish the condition of a stand harvested with a strip cut understory protection harvest;
- To provide stand assignment criteria in terms of stocking, height, and species composition to allocate UP harvested stands to one of C, CD, DC or D stand types.

Post-harvest Type Declaration: Understory protection harvests may create stands with a variety of species compositions and stand structures. The intended final state (defined by the final harvest entry), its associated post understory protection harvest state (the resultant stand created by the UP harvest) and stand type (D, DC, CD, C), and the expected timing and harvest design any subsequent entries must be provided for each understory protection harvest operating plan. Furthermore, the proponent shall provide strategies to be pursued to mitigate any effects of differences between the intended and actual post harvest stands created as a result of the UP harvest operations.

Defining the Period of Release (POR): It is crucial to select a criterion upon which the final harvest entry timing will be governed as this will determine the Period Of Release (Fig. 1). In turn the POR will affect the criteria used for assessing the post UP harvest condition (PUPC) and provide links to the timber supply analysis (TSA) with a rule(s) for determining the harvest scheduling of stands subjected to an UP.

Three methods for determining the POR are suggested (others may be proposed):
1. A fixed time interval: A time interval may be selected based on *apriori* stand development knowledge, such that the final harvest entry is defined by the time since either original stand establishment or from the time of the UP harvest.
2. Defined minimum spruce rotation: The final entry may be set based on a minimum harvest entry criteria (such as spruce age, stand volume or piece size) that is part of the TSA assumptions. Defining the POR by such threshold criteria must be done in a logical defendable manner that is consistent with any other such criteria in the TSA.
3. Time required to achieve the desired harvest of understory trees: The final entry is defined as the time necessary to enable an understory stand to achieve a defined future stand condition (i.e. a minimum piece size or stand volume). In this case the POR must be calculated such that the minimum understory condition (an operator chosen value) is reasonably likely to attain the desired future stand condition. Selection of a POR via this method will necessitate the use of a credible understory spruce growth prediction system and based on specific stand conditions created by the understory protection harvest.

Selection of a POR must be consistent with the planned stand developmental trajectory for a post understory protection harvest stand. Thus, for example, if a key final harvest outcome is the regrowth of the aspen component of the stand, then the POR must be linked to the minimum aspen harvest condition (stem size, max MAI, etc). Similarly, where final understory spruce yield objectives are the focus of an understory protection harvest, the POR must be selected to maximize the likelihood of attaining these objectives. This assessment protocol should, therefore, document the necessary tree and stand conditions resultant from a UP harvest that will indicate the likely attainment of the stand at the final entry.

Post-harvest effective stand age: Where a final harvest entry is defined by a minimum spruce entry age/size (#2 above) the stand-age of the post understory protection stand must be determined. Where one of the UP harvest's objective is the reforestation of deciduous stems the effective stand age shall be considered to be zero. Where the retained understory spruce stand advanced growth is the UP harvest objective, the effective stand age may also be chosen to be zero, or may it may be calculated as follows:

1. Using the provincial average spruce Site Index (SI) curve for a SI of 16 (average site) OR
2. Using an actual SI value currently available for the understory, OR
3. Using an alternative approved method of assessing the actually understory SI,

The measured average crop spruce tree height as determined by the post-harvest assessment protocol is looked up in the appropriate SI curve (as determined in #1-3 above) and the age associated with this average tree height is assign as the "effective stand age".

For example, for a understory stand with retained crop tree spruce found to be 8.1 metres tall, and based on the provincial average SI of 16m, the effective stand age is found to be 25 years.

Timing: This assessment survey shall be conducted no earlier than 3 years and no later than 5 years after an understory protection harvest is complete.

Applicability: This survey is to be completed on all blocks that have been harvested with understory protection harvest designs that utilize a systematic strip harvest layout. Blocks harvested for understory protection with highly aggregated understories typically operated with an "operator avoidance" approach or where understory patches are left uncut, shall be subject to the regeneration survey protocol and reforestation standards as stipulated in the *Alberta Regeneration Survey Manual* ("RSM").

Assessment Parameters:

1. Stocking & Density – the number and spatial distribution of crop trees with the designated understory protection area must be a key component.
2. Height of crop trees – a minimum tree height ensures that stocking is derived only for those plots with trees likely to become harvestable at the planned final entry.

Crop tree criteria: An acceptable crop tree whether from seed/suckering or as advanced growth is defined as one that:

1. is an acceptable species (see RSM) and,

2. has achieved the minimum height requirement as defined below and,
3. is alive, shows good health and vigor, is undamaged. Any tree where a bole scar extends for greater than 10cm in length and is greater than 20% of the bole circumference OR, where the crown volume has been reduced by greater than 15 % through breakage of top or stripping of the lateral branches, shall be considered as unacceptably damaged and may not be counted as a crop tree and,
4. has grown onsite for a minimum of three years and,
5. has originated from seed, suckering or coppice but **not** from layering,
6. has a well defined stem with not more than two stems originating at the base nor more than three multiple lateral shoots not originating at the base (this does not apply to those deciduous species that regenerate through coppice growth. Each healthy stem in coppice growth may be considered a separate crop tree).

Advance growth is a specific tree that meets all of the above criteria and, in addition, the following:

1. Was established in advance of the harvest and will probably be alive when the rest of the crop trees are harvested and,
2. has a live crown that extends at least 30% of the tree height. The crown cover requirement does not apply to deciduous trees.

Regeneration Survey Method

The **basic survey technique** shall be a grid survey system as described in the Regeneration Survey Manual, with the number of plots, plot size and rules for moving/deleting plots noted therein (Section 5.0 *Field Survey Procedures)*.

Retained canopy aspen used as **wind buffers** may be considered as uncut patches (as per the RSM) at the discretion of the operator and so not considered part of the harvested area at the discretion of the proponent. However, if the final entry harvest is scheduled such that mature aspen in the buffers are assumed to contribute to final yield (i.e. the aspen are likely to be still merchantable at the final entry) wind buffers may be used to contribute towards the stand deciduous stocking. In order to facilitate a more uniform assessment of the probability for aspen in wind buffers being available at final harvest, the proposed Period of Release (POR) is added to the mean aspen age (as determined by actual aspen aging). If this value is less than or equal to 110 years, the aspen shall be considered as likely to be available at final harvest. Alternatively, where localized data would suggest an alternate aspen mortality age, this value should be utilized to set the rule as to whether mature aspen will be available for harvest at the proposed final entry.

For the purposes of estimating the aspen stand age, a minimum of three (3) breast height ages shall be required from each recognizable aspen strata within each understorey protection block where the retained aspen is assumed available at the final harvest. As aspen longevity varies, localized data should be utilized to adjust this value to better reflect local conditions.

As an example, based on the retained spruce understorey in an understorey protection harvested stand, the effective stand age was calculated (calculation method above) as 45 years and the aspen are aged at 75 years. The final harvest is predicted to occur in 50 years (based on the effective stand age and spruce yield objectives) such that the retained aspen will be 125 (75+50) years at final harvest. The effective aspen life expectancy is 110 thus the aspen age at final harvest (125) is greater than the aspen life expectancy and so the aspen are not expected to contribute to the yield at the final harvest.

The **survey control line** angle should be off-set at a 45 degree angle to the axis of the majority of the harvested strips to ensure that the survey lines sample across the treatment types created by the harvest. However, where complex block topography and/or block shape make this impractical, the survey control line should be placed to minimize survey lines from paralleling the harvested strips.

Minimum stocking criteria have been developed to assign post UP harvest stands to one of the four provincially recognized stand types. Since understorey protection harvests assume a final entry harvest occurring some time in the future, (likely to be based largely on the size of the protected understorey) and since future developmental trajectories will vary also largely based on the size and density of the retained understorey, the stand stocking criteria used to assign the stand to a likely developmental trajectory will vary based on the average post-understorey spruce height.

Where the retained **mean understorey spruce height** (as determined by the post harvest assessment survey) **is < 8.0 metres**, stocking criteria to define the post-harvest stand type are as per the RSM for a specific stand reforestation designation and natural subregion. Conifer minimum tree heights to determine whether a plot is stocked shall be the greater of the following: Equivalent to the Performance Survey heights (from the RSM), OR the smaller of an absolute height difference of < 2.0 meters or 75% of the average conifer tree height (as determined by the post harvest assessment protocol). Deciduous tree minimum heights shall be the minimums as defined for the Establishment Survey (from the RSM) where the final harvest entry is determined by an aspen rotation. Where the final harvest entry is determined by the TSA assumed minimum harvest age for the spruce, and absolute limit of not more than 4.0 meters less than the calculated average crop spruce tree height shall be the lower height limit for deciduous trees.

For stands where the **retained understorey spruce are ≥ 8.0 but < 14m** in height, the stocking attributes for each stand type are as per Table 1. These stands are intermediate in that spruce size and timing to final harvest would suggest that there stocking characteristics should be more alike that of ‘mature’ spruce, yet they are still not equivalent to mature stands. Minimum height criteria to be considered “stocked” are as per the stands with mean spruce heights less than 8 meters.

Block level stocking is calculated by summing plots are considered ‘stocked’ where the crop tree attained the required minimum tree height. Based on the retained spruce height and the assumed final harvest timing, the required stocking to achieve the stand designations varies from 65 to 80% of plots stocked.

Where the post understorey protection harvest stand mean understorey height is ≥ 14 m, no formal ground assessment survey shall be required to assigned the post harvest stand to a stand type. As the final harvest will likely occur within 20 years, an approved aerial assessment that establishes a C/D density stand with a mean conifer height of ≥ 14m conducted between 3-5 years post harvest will constitute evidence of the appropriate post harvest stand conditions being met.

The use of **overlapping plots** to achieve these stocking standards are applicable as per detailed in the RSM if the crop deciduous stem meets the minimum height requirement for the stand type. However, within overlapping plots, minimum tree size for "countability" are defined by the 75% or 2.0 meter rule for all species to recognize that where spatial differentiation is not present, plots truly stocked to both trees must be similar in tree height to achiever merchantability at final harvest.

3. Commercial Thinning

The total growing stock on the site is fixed by the site's carrying capacity, such that as individual trees grow larger in size, fewer can be accommodated on the site. Stand density will remain relatively constant to the point where self-thinning begins (as a stand enters the Zone of Imminent Competition Mortality – ZICM, Fig. 1). As trees continue to grow in size within the latter zone, stand density also is reduced. The goal of optimal stand density management is to maintain a stand within the zone of optimum stocking (between relative density of 0.40 and 0.55 – Fig. 1). Where the reduction in density (mortality) is from the loss in trees of a merchantable size, this fibre can be captured through a commercial thin.

It is important to note that commercial thinning prescriptions are not aimed at increasing stand productivity, but rather to capture a greater proportion of the total growing capacity in merchantable trees. Indeed, commercial thinning will not produce an increased final harvest volume (relative to the untreated condition), since the physical and biological factors that limit productivity cannot be typically increased through commercial thinning alone.

Benefits of Commercial Thinning

It is important to note that the benefits of commercial thinning remain debated within the Canadian forestry profession and academia.

Arguably, the primary benefit of commercial thinning is the increased fibre yield through the capture of natural mortality during early to mid stages of stand development. Figure 2a illustrates a commercial thinning scenario where stand density is reduced. The stand moves from a position within the Zone of Imminent Competition Mortality to the minimum density required to meet the requirement of full site occupancy (also known as B-level stocking). It is important to note that this reduction in stand density does not change either the timing of the original harvest (H_o Fig. 2B), or the realized yield at that harvest time. The treatment has only removed that level of growing stock that would otherwise be lost through natural mortality.

Commercial thinning reallocates site resources (space, water, nutrients, light etc.) to a reduced number of stems resulting in final piece size that is typically larger in thinned stands. Hence, the value of the end product may be increased over what would be expected if a commercial thin had not carried been implemented.

Commercial thinning, when properly implemented, may increase a stand's resilience to environmental and some pest stressors. Sanitation treatments and/or reduction in stand density may favour crown development such that residual tree's risks of mortality may be reduced. Partial harvests of this nature can be designed and implemented where evidence has shown that the proposed treatment regime provides the best management option to mitigate the stressor. It is recommended that treatments that form a component of an overall pest management system be submitted to pest management specialists for review and input.

Risks Associated with Commercial Thinning

Commercial thinning in Alberta should be considered, as it is in other Canadian jurisdictions, a high-risk silvicultural practice.

Primary risk is excessive reduction in stand growing stock that reduces final harvest yield below that realized without treatment. Where capturing stand mortality is the goal of the “planned” treatment, it is essential that the “actual” reduction in stand density be such that the final harvest volume at the planned rotation is equivalent to that forecasted in the absence of the partial harvest.

Partial harvests that reduce a stand’s growing stock to levels below the zone of optimum stocking will result in a reduced yield at final harvest. For example, where the reduction in density is only slightly below the 0.40 relative density line (Fig. 3A), a stand’s total originally volume will likely be attained, though only if the original rotation is delayed (Fig. 3B). In this case, the prescription has prematurely harvested volume originally allocated to the final harvest. Should the Timber Supply Analysis (TSA) not account for this early volume withdrawal, the sustainability of the timber resource will have been compromised.

Where a partial harvest substantially reduces the density below the zone of optimum stocking (Fig. 4A), growing stock will have been reduced to a level such that the yield from these residual stems will never reach the yield forecasted in the absence of the partial harvest (Fig. 4B). Under this scenario, the stand can only achieve full-stocking through the recruitment of new seedlings and the rotation age at which the stand would yield a volume similar to the untreated conditions is significantly postponed. In this scenario, fibre sustainability is seriously compromised as future allocated volume is withdrawn prematurely, and the site may remain understocked unless reforestation actions are initiated.

Forecasts of increased value may not be realized at time of final harvest due to volatile market conditions and/or product substitutions. Furthermore, forecasted value gains may not be realized due to inaccurate predictions of residual tree/stand responses to the proposed treatments.

Commercial thinning may result in physical damage to residual growing stock during thinning operations leading to operationally induced mortality of residual growing stock. Increased windthrow or stem breakage of the residual trees will further reduce growing stock. These operationally induced reductions in growing stock may inadvertently reduce stand density below full site occupancy.

Reductions in stand density may affect understory vegetation, thermal and hiding cover, as well as tree species composition and size impacting the arboreal habitat characteristics. The impacts of commercial thinning on these values should be carefully considered. It is also important that this stand management activity be assessed in the forest/landscape context. The amount, timing and spatial distribution of these treatments may alter habitat availability and cumulatively impact wildlife.

Stand Selection Criteria

Commercial thinning proposals must consider both stand and site conditions in the selection of stands that will maximize the return on investment, while simultaneously minimizing risk of failure and negative impact on non-timber values. The following criteria are suggested:

1. Stands with the highest site index typically respond to thinning with the greatest absolute increase in yield and should be given priority. In contrast, poorer sites should be avoided since reduced absolute gain would result in lower economic yields.

2. Stands that are understocked prior to treatment will not be considered for thinning since a reduction in growing stock will reduce final harvest volume and/or timing.

3. Stands that have developed within the ZICM should be considered poor candidate stands. These stands typically have trees with poor crown form (LCR < 30%) and high height to diameter ratios (>100:1) that will retard the stand response to thinning and increase the residual growing stock's risk of loss due to windthrow or stem breakage.

4. There is currently a lack of evidence that tree age per se is an important limiting factor in a stand's response to thinning. However, trees in over mature stands will typically have poor crown and stem characteristics making them poor choices for treatment. In addition, there is little, if any, opportunity to capture volume expected to be lost to density-induced mortality at late stages in stand development.

5. Stands with obvious signs of windthrow, breakage or insect and disease infestations should be avoided. Stands infected with minor levels of mistletoe or gall rust infestations may be given priority for treatment with a goal of stand sanitization. Approval of such treatments should be subject to review by forest health specialists.

6. Stands growing on poorly drained sites must be avoided. High water tables may promote shallow rooting leading to poor tree stability and high incidences of wind throw following treatment. Increased risk of soil compaction and direct root injuries from machine activities are also associated with harvesting on moist soils.

7. The focus for thinning treatments should be on younger stands preceding an age class gap. Volumes realized from CT may reduce the impact of reduced wood supply.

8. Mammal and insect population cycles that may result in increased tree mortality following thinning should be taken into consideration.

9. Proposals should not involve re-treatment of a stand or entry into an adjacent buffer within five years of a previous treatment. The protection of residual trees and buffers must be maintained for at least five years to allow time for root systems, foliage and/or diameter growth to respond to the previous treatment.

10. Stands with adjacency constraints that prevent optimal sequencing will be given priority. This will allow the harvest to capture mortality without compromising the cover retention required to meet adjacency requirements.

Treatment Methodologies

Commercial thinning treatments must be from ‘below’ (i.e. removing trees from the lower crown classes to favour dominant and codominant trees). Thinning from below captures volume at highest risk of mortality due to intraspecific competition. The remaining dominant/codominant trees are likely to be of better vigour and hence more likely to favourably respond to new stand conditions. The removal of individual dominants and co-dominants will only be approved to release adjoining trees of identical crown class (i.e. dominant and co-dominant trees are not to be removed to release intermediate trees), to sanitize the stand, to allow for machine access, or to remove wolf trees. The later are trees that have deformed stems and/or heavy branching such that an increase in growth will not result in a concomitant increase in stem value.

Physical damage to residual growing stock during thinning operations must be minimized. For thinning operations, unacceptable bole damage is defined as any area greater than 400 cm^2 where bark is removed to the cambium layer. A post-operation survey must be undertaken to assess damage. A maximum of 5% (unless otherwise approved) of the residual trees in a thinned stand may be damaged. This maximum level of acceptable damage has been shown to be reasonable by operators in Alberta as well as in other jurisdictions.

AAC Chargeability

As per Forest Management Branch (FMB) Directive 98-03 “Quota Production Chargeability” volumes from commercial thinning will only be non-quota chargeable under a Department approved thinning plan.

In cases where excessive damage or mortality has occurred in response to thinning, the Area Manager will consider whether the post-treatment stand’s ability to respond has been compromised and may direct the operator to harvest the entire remaining stand, resulting in a reassessment of timber dues and all harvested volume being charged against the operator’s AAC.

Reforestation Requirements

Reforestation obligations will not normally be applicable to appropriately conducted commercial thinning treatments. However, if a stand's density falls to a level below full site occupancy as a result of either harvest or subsequent damage attributed to the treatment, the operator may be required, at the discretion of the Area Manager, to clearcut the stand and reforest it within two years, as described in S. 141, regardless of when the final harvest is scheduled. Hence, reforestation liability must never be waived.

Situations where reforestation within two years will be required include blowdown, severe insect infestations or disease outbreaks, or excessive mechanical damage. Such a finding will necessitate the reassessment of timber dues and all harvested volume being charged against the operator's AAC. Where damage thresholds stated as a condition of the AOP approval are not met, a penalty for contravention of Section 100(a) of the Timber Management Regulation may also be considered.

Submission, Review and Approval

The review and approval of proposals must proceed cautiously due to the potential adverse effect on allocated timber supply. Plans should be evaluated subject to these guidelines and their compatibility with objectives as stated an approved DFMP. The Area Manager will approve operations through the AOP approval process.

Though commercial thinning is implemented at a stand-level, there should be an accounting of its impact at the forest level and a reconciliation of its objectives as related to Detailed Forest Management Plan (DFMP). For example, thinning may increase total volume yield from a stand, yet adversely impact non-timber objectives such as wildlife habitat value, wildfire risk rating, biodiversity or contradict goals in the approved DFMP.

Commercial thinning proposals must include a crop plan that, as a minimum, addresses each of the following:

a. Specific objectives of proposed treatment(s).
b. Description of treatments (i.e. what is to be removed), methods, and timing. Prescriptions based on "percentage removals " should be strongly dissuaded due to the lack of uniformity between candidate stand conditions. Rather, crop plans must relate the number and type of trees to be removed to the desired future stand structure.
c. Pre-harvest assessment consisting of species composition, stand structure (height/density, stand table), live crown ratio, slenderness coefficient, total stand volume, and site index.
d. Projection of total and merchantable yield and product value expectations for both treated and non-treated scenarios. It is up to the proponent to provide defensible evidence that the treatment will not reduce final harvest volume below that of the non-treatment scenario, nor increase rotation length.
e. Preventative measures to be implemented to mitigate against treatment-induced mortality due to windthrow, root injuries, disease and insect.

f. Impact of proposed treatment on specific wildlife species, fuel loading, and aesthetics.
g. RFP signature.

Commercial thinning proposals that include a research component must be forwarded to Forest Management Branch for approval, which will only be granted if the proposal addresses a clearly defined knowledge gap. Research-based treatments must include provisions for scientific controls and measurement protocols.

Monitoring Requirements

The monitoring of biological response resulting from commercial thinning is critical to the success of future treatments and any subsequent adjustment in AAC levels. Monitoring will allow both the operator and the Department to measure the benefits of certain treatment regimes within a variety of stand structures and ages and to determine if treatment objectives have been obtained. By developing growth and yield data for each treatment type and situation, future treatments can be modelled more accurately. These impacts can be used to project new AAC levels, as well as help in the design of future crop plans. As the information base regarding thinning treatments evolves, the information requirements will decrease.

Until such time as a clear understanding is developed as to what information is required and what is simply optional, the below outlines what information must be included in the crop plan submission. All raw and summarized data regarding treatment response must be made available, free of charge and in an acceptable electronic format, to the PLFD in order to calibrate and refine existing growth models. This data will not be released by the Department to 3rd parties without the operator's approval.

Monitoring Sample Design

1. For cutting units approved for commercial thinning operations there must be a designation of control areas. These areas must be representative of the stand and within the area approved for thinning, and require sufficient plot buffer area to ensure that the thinning operations do not impact the growth within the control area.

2. All cutting units of 10 ha or greater require a minimum of one treatment/control PSP pair.

3. In the case of a cutting unit which incorporates several variations on treatment, it is recommended that a randomized block design be applied, with the control forming one of the blocks.

4. One control/treatment PSP pair is required for each 25 ha proposed to be thinned in an AOP (i.e. a total of 1000 ha proposed to be thinned would require 40 PSP pairs). Large programs may be approved with lower sample intensities.

5. PSPs must have a minimum size of 400 m^2, and may be round or square in configuration.

6. Machine access corridors must be dealt with by the use of a systematic design to ensure representative area based sampling of access corridors within the PSPs.

Measurement schedule

1. Pre-treatment measurements are required for all PSPs.

2. After pre-treatment measurements are completed it is required that the treatment PSPs be disguised to avoid operator bias due to knowledge of the PSP location.

3. Re-measurements are required at years 1, 5, 10, 20 and 30 following treatment. The control PSP is not re-measured at year 1.

Measurement protocols

1. Stand variables must be assessed and include species, dbh, stand table, DBH_Q and Ht for all trees greater than 1.3 m in height.

2. Ages and live crown ratios are required for 4 codominant or dominant trees for each species in each PSP.

3. An operations damage assessment is required for all trees in each PSP located in treated areas.

4. GPS locations are required for all plot centres.

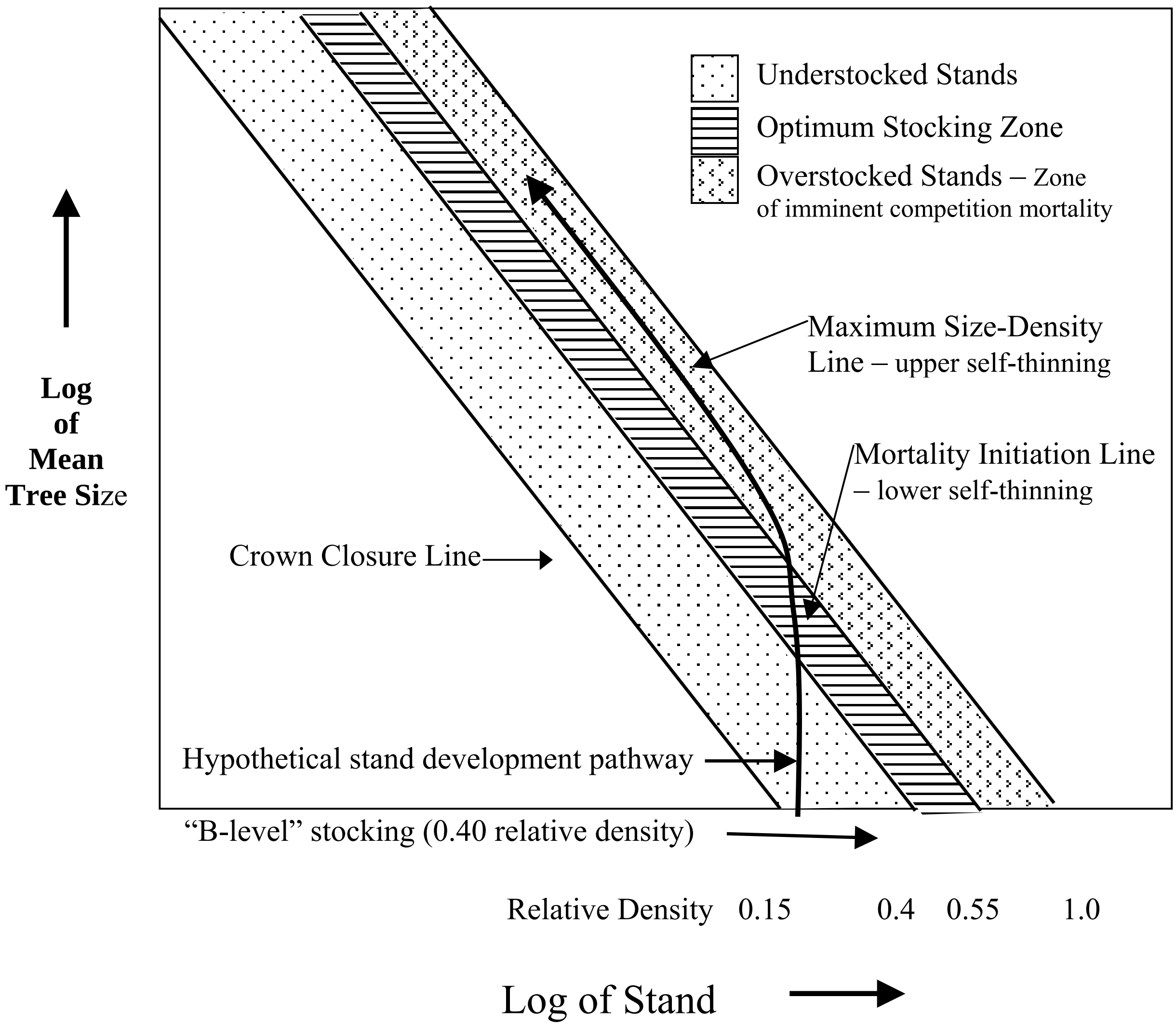


Figure 1. Stand Density Management Diagram illustrating zones of interest and relative density threshold values. Note axis are logrithmetic scale. Actual axis values are specific to species (adopted from Woods, 1999).

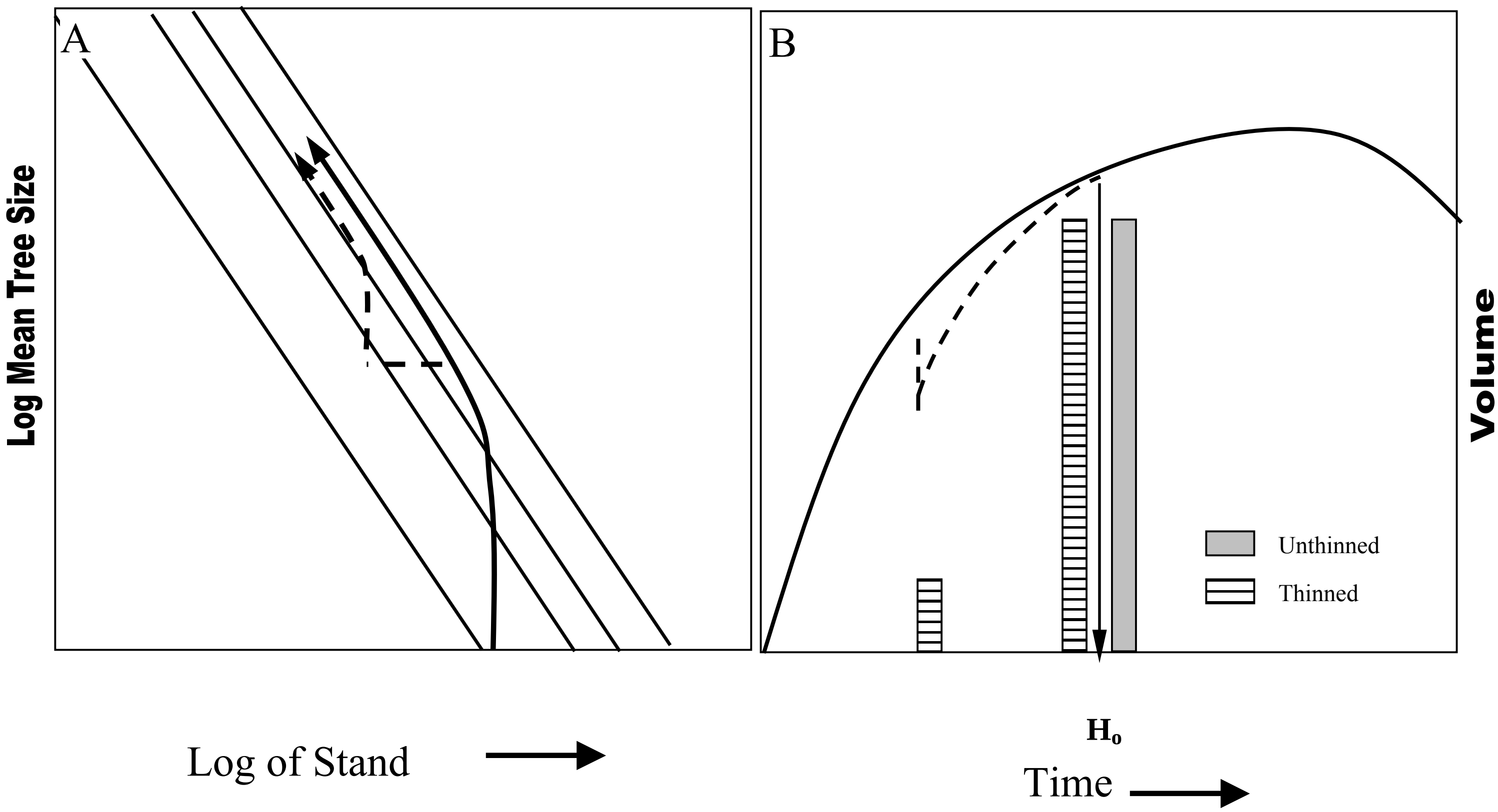


Figure 2. Schematic representation of SDMD (A) and stand volume (B) for a thinning regime where the original harvest volume is attained at the original rotation age (H_o).

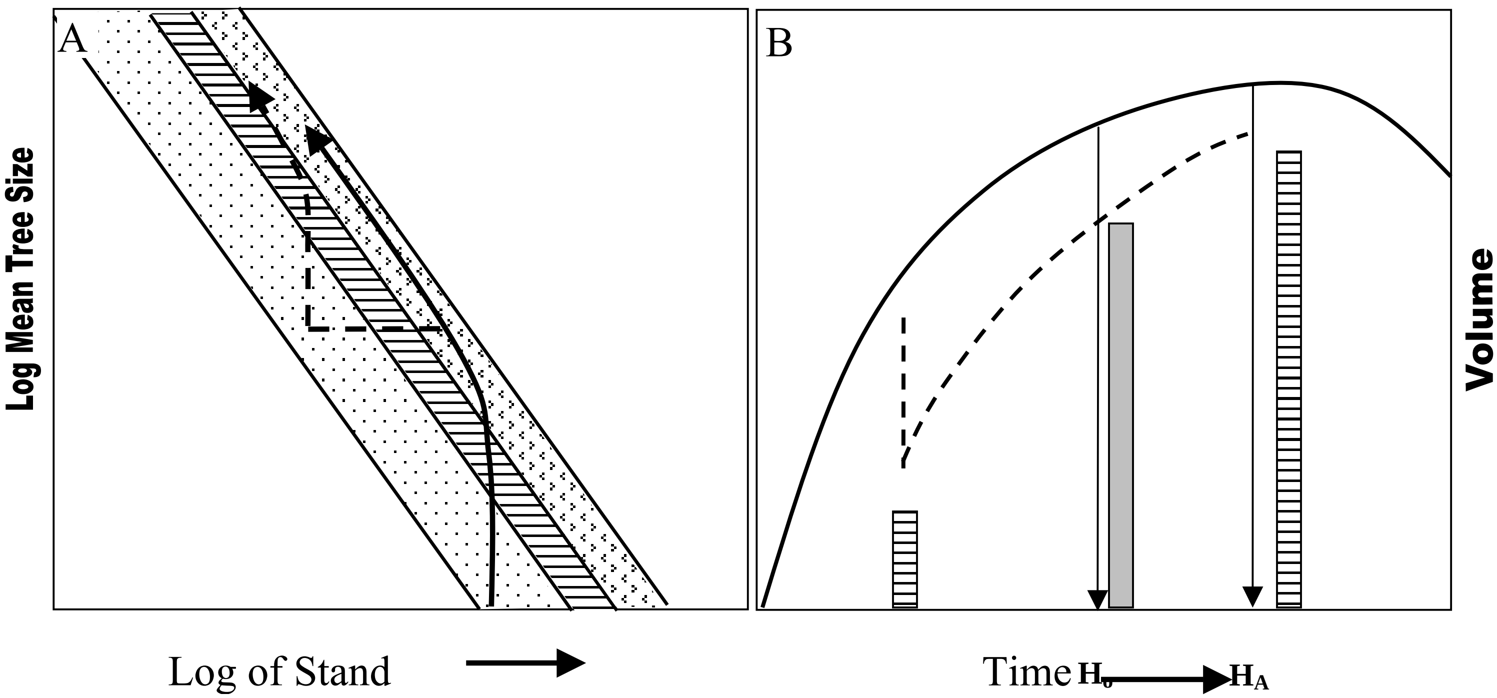


Figure 3. Schematic representation of SDMD (A) and stand volume (B) for a thinning regime that removes excessive growing stock such that to achieve the original harvest volume a later rotation age must be used (H_A).

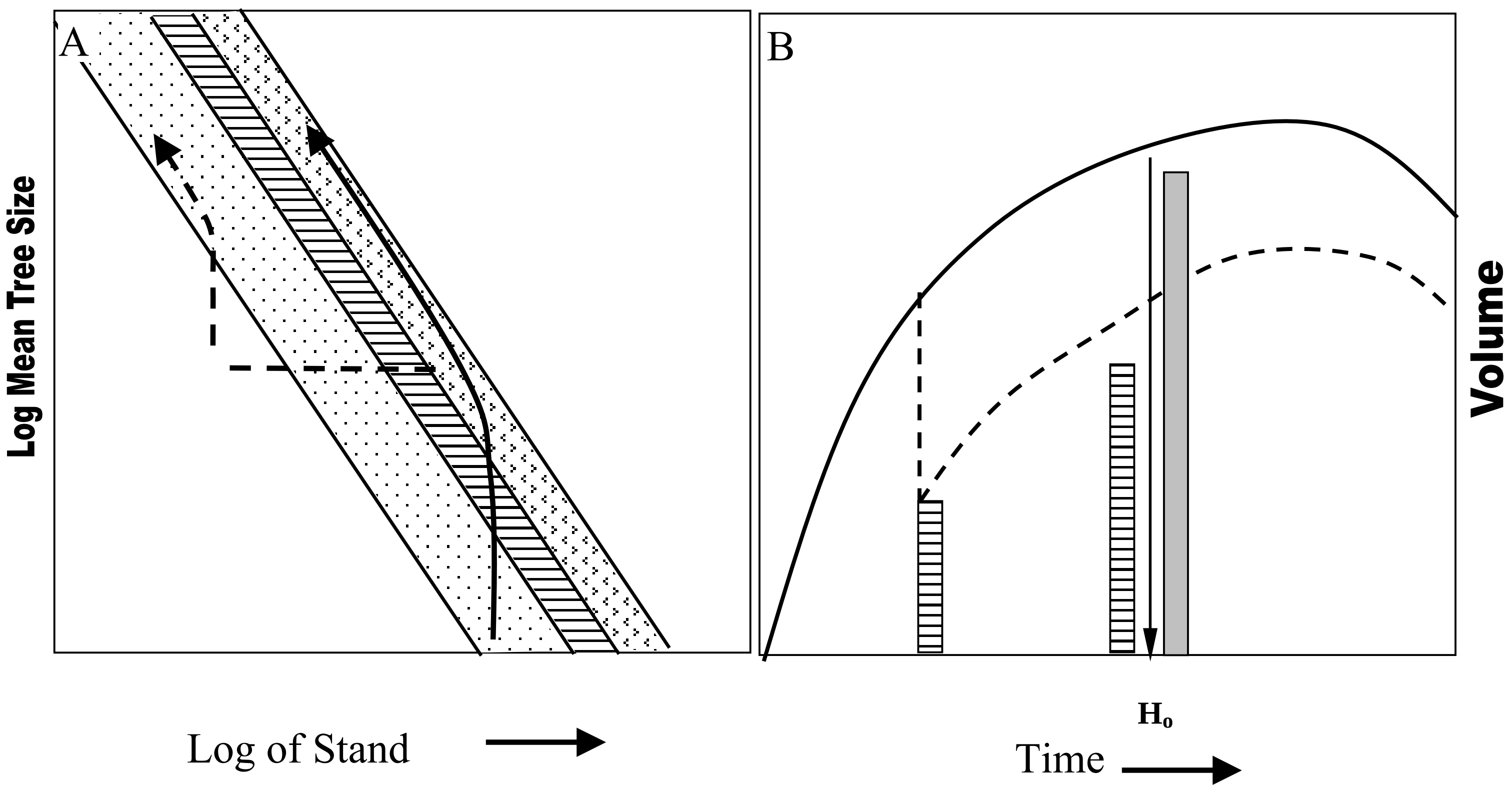


Figure 4. Schematic representation of SDMD (A) and stand volume (B) for a thinning regime that removes excessive growing stock such that the stand is now understocked to the point where the original stand volume is unattainable from the existing growing stock.

4. Other Partial Harvest Systems

Some partial cutting systems under consideration in Alberta other than thinning and understorey protection include shelterwood harvesting designed to establish Douglas fir regeneration in the Porcupine Hills area of the C5 Forest Management Unit, and partial harvesting to reduce fire hazard as part of the provincial FIRESMART Program. Other reasons for partial cutting have been under discussion as well – for wildlife habitat, in particular caribou, in order to enhance lichen or food production.

A separate document developed by Forest Management Branch entitled *Porcupine Hills Harvesting & Silviculture Strategies, July, 2004* deals with harvesting, reforestation, and monitoring guidelines for Douglas Fir regeneration in the Porcupine Hills of the C5 FMU.

FIRESMART

Forest Management Branch discourages the use of partial cutting for fire hazard reduction unless it is required for aesthetic or community concerns. Because the objective is to remove fuels that are hazardous, there is a conflict with regeneration and growth & yield objectives. Stands that are not conducive to regenerating under a partial cut approach (such as Lodgepole pine) are often the same stands targeted for hazard reduction. For this reason, FMB prefers to see such stands clearcut to ensure the stands continue to contribute to the productive forest landbase and Annual Allowable Cut.

Where partial cutting is approved for FIRESMART purposes, the following guidelines should be employed.

The post harvest stand should be windfirm. Pre-harvest assessment and planning will be necessary to ensure this.

A post harvest survey should be conducted to confirm the resulting stand inventory covertype 3-5 years post-harvest (allows for windfirmness to establish). Such information will be used for timber supply assessment in the next forest management plan to ensure that actual stand composition is accounted for in the existing and subsequent forest management plan.

Where the objective is to retain FIRESMART partial cut stands in the productive forest landbase, a crop plan to final harvest is required to ensure that acceptable harvest and regeneration strategies will be employed to ensure the stand will remain productive after the initial FIRESMART harvest.

Planning Requirements

From Section 3.1, Appendix C of Annex 1 of the Alberta Forest Management Planning Standard. The following information is required for stand-level crop plans for partial harvesting:

- Specific objectives of proposed treatment(s) – e.g. regeneration of Douglas fir, minimizing wildfire risk.
- Description of the silviculture system being employed (ie. Shelterwood, seed tree) and rationale for choice of system.
- Description of treatments – structure to be retained, in what distribution (mapped to 1:5000), silviculture treatments, and timing of treatments.
- Preventative measures to be implemented to mitigate treatment-induced mortality due to windthrow, root injuries, insects and diseases.
- Any proposed variation to regeneration survey timing, or alternate survey method and standard in the case of uneven-aged management.
- RFP validation.

Glossary

Commercial Thinning: A silvicultural activity in which trees of a merchantable size are removed from a stand before its minimum rotation age, while maintaining the stand's growth rate or enhancing the value of final crop trees. Typically used to capture volume likely to succumb to competition induced mortality.

Even Aged Stand: A stand in which relatively small age differences exist between individual trees. The differences in age will not usually be more than 10 years.

Pre-commercial Thinning : A silvicultural activity to reduce tree density in young stands, carried out before the stems reach merchantable size. The intent is to concentrate the site's resources on fewer trees typically resulting in increased average diameter, increased live crown ratio, and reduced time to operability.

Quadratic Diameter: The diameter of the tree with average basal area for a given stand.

Selection Harvesting: A silvicultural activity used to create or maintain uneven aged stands. Usually accomplished through the periodic removal of groups of trees or individual trees, while full residual stand growth rates are maintained and natural regeneration from overstory trees is encouraged. Not to be confused with selective harvesting, or high-grading, where trees are selected and removed periodically based solely on economic criteria. Selective harvest is not designed to improve the growing conditions of the remaining crop trees.

Slenderness Coefficient: The ratio of tree height to diameter. Used to estimate windthrow and stem breakage potential of a stand.

Spacing Factor: The inter-tree distance expressed as a percentage of the stand's top height.

Stand Density Management Diagram (SDMD): A schematic diagram based on data from the -3/2 power law for self-thinning. Illustrates the relationship between diameter and height across a range of stand densities.

Zone of Imminent Competition Mortality (ZICM): The density at which mortality loss has occurred due to intra-specific competition.

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