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FOREST AND RANGE EVALUATION PROGRAM

Forest Stewardship Plan

Stocking Standards Evaluation

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Management of forest and range resources is a complex process that often involves the balancing of ecological, social, and economic considerations. This evaluation report represents one facet of this process. Based on monitoring data and analysis, the author offers the following recommendations to those who develop and implement forest and range management policy, plans, and practices.

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EXECUTIVE SUMMARY

The objectives of this Forest Stewardship Plan (FSP) stocking standards monitoring project are to evaluate:

- the consistency between stocking standards and timber supply review,
- the accuracy of stocking standards in RESULTS, and
- the implementation of stocking standards at the block level.

One FSP was randomly chosen from each forest region (Coast, Northern Interior and Southern Interior) and 15 blocks were randomly chosen from each FSP (however only nine blocks met the selection criteria for the Northern Interior) for evaluation in the office. Ten blocks each from the Coast and Southern Interior FSPs and 9 blocks from the Northern Interior FSPs were assessed in the field.

Despite the provisions in the Forest and Range Practices Act (FRPA) for licensees to develop new and innovative stocking standards, the stocking standards for all three FSPs examined under this project were, on the whole, very similar to the stocking standards that existed pre-FRPA. Therefore, for the key criteria of target and minimum densities, free-growing heights and acceptable species compositions, the FSP stocking standards are largely similar to the original stocking standards developed by the Ministry of Forests and Range over 20 years ago.

In general, for the three situations reviewed, there is a reasonable and improving linkage between stocking standards and timber supply review processes. The improvements are based on having separate timber supply review assumptions for existing managed stands versus future stands and on better linkages of timber supply review managed stand assumptions, the Biogoeclimatic (BEC) system and reforestation results and plans. This is a good framework for future improvements in stocking standards.

A transcription error occurred when transferring two components of the stocking standards for one FSP into RESULTs. These administrative errors will not likely lead to significant problems as the licensee is managing to the correct standards.

Given the generic nature of the existing stocking standards, they are being reasonably applied to most logged areas. However, there is room for improvement in ecological site identification, stratification and the identification and consideration of landscape-level forest health factors that could impact regenerated stands after free growing when developing reforestation prescriptions.

Silviculture treatments are consistent with achievement of the existing stocking standards.

Overall, in the majority of areas assessed under this project, stocking standards have played, and are playing, a positive role in good overall reforestation results. However, there is significant concern for the future development of pine-leading stands established according to the stocking standards in the area represented by the inspections of the FSPs in the Northern Interior region. The concerns relate to the impacts of the high incidence of hard pine stem rusts and/or the poor quality attributes of pine stands on medium to good sites grown to the densities targeted in the stocking standards. There should be concern about this situation given the:

- Widespread use of pine established at similar densities in the Interior,
- Widespread range and incidence of forest health agents which affect pine and the uncertainty about the impacts of these health issues on future stand development, and
- The importance of existing managed and future stands to the mid-term timber supply in mountain pine beetle-impacted forest management units.

Although the monitoring of projects in several of the areas, which are at high risk to forest health agents affecting pine, has confirmed that incidence levels are generally high, there is un-certainty about the future impacts. Better understanding of the potential impacts and, if needed, development of action plans to address the issues should be a top priority.

For the most part, stocking standards have not changed significantly over the last 20 years. In light of the recent mountain pine beetle infestation, changes in technology that are forecast to influence utilization limits and desired forest products and concerns for the impacts of climate change, it is timely to review many of the current FSP stocking standards in the context of changing landscape-level objectives and assumptions about the future.

As part of a holistic review of stocking standards, there are opportunities for improvement that should be explored. Most of these improvements involve better linkages between the site limiting factors and site productivities associated with the regional ecological classification systems, the stocking standards and the cost/benefits of silviculture.

Given the interrelationship between stocking standards and the rest of the forest policy and regulatory system, improvements in stocking standards on their own may only have a limited effect on overall reforestation performance. Changes to other policy areas may need to be considered.

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1.0 INTRODUCTION

Stocking standards define the early stand conditions that are believed to provide the highest probability of the regenerating stands achieving long term objectives for future forest conditions and yields of products and services. The first comprehensive set of stocking standards were developed by government with input from licensees in the mid-1980s. Since 1987, stocking standards have been one of the key tools used by government to ensure harvested areas in B.C. are adequately restocked relative to landscape-level management unit objectives (McWilliams, 2009).

Achievement of free growing[1] is the key point at which licensee's basic reforestation obligations have been fulfilled and subsequent stand management becomes the responsibility of the crown. As basic reforestation is the key (or only) required management on harvested areas and is paid for by licensees (with silviculture costs recognized by government through the stumpage appraisal system), the setting and achievement of stocking standards are of significant interest to industry and the government (McWilliams, 2009).

Under FRPA, stocking standards are included in FSPs. There are provisions in the Forest Planning and Practices Regulation for FSP holders to develop new and innovative stocking standards. The regulation provides guidance to licensees when they are developing stocking standards and sets bounds for what the Ministry of Forests and Range can require from licensees. Key considerations relate to:

- Where trees are to be established (even-aged management), the numbers and distribution of those trees to be established, and
- Where trees are to be maintained (uneven-aged management), the characteristics, quantity and distribution of those trees to be retained.

To be approved by the Ministry of Forests and Range, the delegated decision maker must be satisfied that the stocking standards meet several key tests or be satisfied stocking standards have reasonable regard for future timber supply. These key tests include:

- Maintenance of an economically valuable supply of commercial timber,
- Consistency with Timber Supply Review assumptions,
- Ecological suitability, and
- Resilience to known forest health agents.

Under FRPA, a licensee who has an obligation to establish a free growing stand must establish a stand that meets the applicable FSP stocking standards by the regeneration date and meets the applicable stocking standards by a date that is no more than 20 years from the commencement date.

For stocking standards to contribute to the achievement of FRPA's objectives, it is critical to monitor their development, application of, and impact on management. This project is part of this monitoring process.

1.1 Objectives

The objectives of this evaluation of FSP stocking standards are to determine if:

- FSP stocking standards (including amendments) are consistent with the assumptions of the timber supply review of the Forest Management Unit that it occurs within (or that considerations for the impact on timber supply for variations under FRPA s 26(5) have been considered),
- FSP stocking standards chosen for harvested areas are appropriate for the ecosystems and site conditions and if the standards are accurately recorded in RESULTS *(*Reporting Silviculture Updates and Landstatus Tracking System) and,
- Completed silviculture treatments are consistent with achievement of the stocking standards.

The wider purpose of this monitoring of FRPA stocking standards is to:

- Facilitate continuous improvement of policy and implementation,
- Help ensure policy and program objectives are defined and achieved, and
- Lead to improved forest practices.

1.2 Scope and Limitations

This project is a type of monitoring and was not designed as a formal audit. As a result, to de-emphasize any linkage between the results and recommendations and the FSPs selected for assessment, this report will not mention the names of the FSP holders. Appendix 1, which contains a summary of the FSP and block populations for which the

1 A free growing stand "means a stand of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs or other trees". FRPA, consolidated to May 29, 2008.

samples were chosen from and the FSP stocking standards, will be kept separate from the body of the report. A zip file with the Opening Detail Reports and Site Plans for the blocks assessed will be forwarded to the contract administrator. Appendix 1 and the electronic block files can be requested from the ministry.

2.0 METHODOLOGY

2.1 FSP Selection

Initially, the ministry provided a database listing the FSPs that had more than 15 blocks (logged to un-logged) with FSP stocking standards entered into RESULTS as of July 4, 2008[2]. The population was sorted by Forest Region; Coast (RCO), Southern Interior (RSI) and Northern Interior (RNI) and checked and confirmed. Blocks were assumed to have FSP stocking standards if the Cutting Permit authorizing harvest was issued after the FSP start date.

From the regional FSP populations (RCO=9 FSPs; RSI=16 FSPs and; RNI=8 FSPs), one FSP was randomly selected for each forest region using a random number generator. The selected FSPs were in the following FMUs; RCO=Kingcome TSA, RNI=Prince George TSA and RSI=Kamloops TSA (see Appendix 1 for the details about the populations and selected FSPs).

2.2 Block Selection

From the population of blocks for each of the three selected FSPs, 15 blocks were randomly chosen from each FSP using a random number generator. The blocks in each population to select from were RCO=35, RNI=22 and RSI=24.

The next task was to notify the holders of the FSPs selected for review (and affected ministry staff) about the project and inform them which of their blocks had been selected for review (see Appendix 1 for the details about the populations and selected blocks). At this time, copies of block-specific information (i.e.: Site Plans and supporting documents) were requested from the licensees. Finally, stocking standards, harvesting and silviculture treatment information for each block was downloaded from RESULTS.

During population verification with the FSP holder for the RNI, it was determined that only nine blocks actually met the selection criteria. As a result, all nine of these blocks were selected for review.

2.3 Evaluation of FSP Stocking Standards for Consistency with Timber Supply Review (TSR)

For each selected FSP, the FSP, including stocking standards, was obtained from the ministry via the FSP Tracking System.

For each selected FSP, the relevant timber supply review information, including Data Packages (if available) and Analysis Reports were attained from the internet or the ministry. ***Table 1*** summarizes the timber supply review information available for each management unit.

For this portion of the project, TSR 2 and TSR 3 yield assumptions were compared with the FSP stocking standards for the primary ecological units (site series 01 in the dominant Biogeoclimatic Ecosystem Classification (BEC) Subzone/Variants).

Table 1: *Summary of Relevant TSR Information and Release Dates*

Forest Region	RCO	RNI	RSI
TSR Forest Management Unit	Kingcome TSA	Prince George TSA	Kamloops TSA
Previous TSR Analysis Report release (TSR 2)	November 2001	October 2004	July 2001
New Data Package release (TSR 3)	June 2008	November 2008	July 2007
New TSR Analysis Report release	January 2009	Forthcoming	March 2007*

*the AAC determination used an alternate analysis: the Kamloops TSA Mountain Pine Beetle Horizontal Initiatives Project (Timberline 2007a).

2 Blocks where commencement had occurred but free to grow had not been declared prior to FSP approval and where licensees had notified the MFR that they wanted to apply FSP stocking standards were excluded from the populations.

2.4 Evaluation of the Selected Blocks against the Stocking Standards

First, for each selected block the stocking standards listed in RESULTS were compared with the appropriate BEC-based FSP stocking standard. Any discrepancies were noted.

Next, field inspections of 10 (9 for RNI) of the 15 selected blocks from each FSP were carried out. Blocks were selected based on consideration of:

- Ecology,
- Logging and silviculture treatment history, and
- Geography and logistics

The intention was to assess the range of these key attributes but focus on blocks in which silviculture treatments had been completed. The selected blocks for each FSP were assessed over approximately two days of field time with the inspections occurring between October and December, 2008. A helicopter was used for transport for RC0 blocks with a truck used for the RNI and RSI inspections. A licensee forester took part in the field inspections for the majority of the blocks.

Based on reviews of the Site Plans and information from the licensees about access and the locations of silviculture treatments and overview observations, several portions of the blocks were inspected for:

- Ecological classification and stratification into Standards Units,
- Presence of forest health agents,
- Consistency of completed silviculture treatments with the stocking standards.

Prior to field work, where information was available, the landscape-level risks associated with the primary forest health agents for the predominant stand types being managed for in each of the inspected areas (using MFR BEC-based forest health risk ratings) were reviewed.

Based on past knowledge of health and quality issues associated with some free growing pine leading stands in the area around the RNI blocks[3], field time in this region was allocated to assessing free growing age class 1 and 2 (i.e.: 10 to 40 years old) pine-leading stands in the vicinity of the selected blocks.

3 The author has participated in FRBC audits in the area and worked on the updated Type 1 Silviculture Investment Strategies for the Lakes and Prince George TSAs

In the other regions, stands in the vicinity of the selected blocks were observed for evidence of significant forest health issues. In all areas, managed stands were assessed for basic quality (i.e.: proportion of stems with forks/ crooks, high taper and large branches).

3.0 RESULTS AND DISCUSSION

This section is primarily devoted to an individual examination of the objectives of this study, which are to monitor (1) the consistency between stocking standards and timber supply review, (2) the accuracy of stocking standards in RESULTS, and (3) the implementation of stocking standards at the block level. We precede the examination of the objectives with a brief discussion of FSP stocking standards. We end this section with a discussion about the opportunities for improving stocking standards under FRPA.

3.1 FSP Stocking Standards

To be approved by the ministry under Section 26 of the Forest Planning and Practices Regulation (FPPR), proposed FSP stocking standards must meet the following key tests (Ministry of Forests and Range, 2006):

- Test 1 – Initial High Level Test – A high level review of all the proposed stocking standards to ensure there are no obvious omissions or issues that will not allow for approval. This test is not intended to replace the tests that follow.
- Test 2 – Ecological Suitability Test – The *Reference Guide to FDP Stocking Standards* (MFR, 2007) is considered the starting point for this test. Licensees can also use appropriately applied and credible new and emerging information.
- Test 3 – Forest Health Test – The key criteria for this test should be species acceptability based on known forest health factors.
- Test 4 – Economically valuable supply of commercial timber – Focuses on value (not volume) based on the proposed species and the associated potential risk with respect to future options for products and values. While this test acknowledges the difficulties associated with assessing these future values, the assumption is that maintaining or enhancing a mix of species is considered a reasonable strategy.
- Test 5 – Consistency with Timber Supply Review - To facilitate good forest management, stocking standards should be linked to local assumptions

for the sustainability of timber flows over time. Accordingly, standards that are "consistent" with the latest timber supply review should be considered "acceptable."

As the starting point for meeting most of these tests were the existing forest development plan standards, licensees could either roll their existing stocking standards into their FSPs or develop new or innovative stocking standards. Due to time constraints, uncertainty over the process for supporting the development of new standards, and the uncertainty of what would be acceptable to the delegated decision makers, most FSP holders elected to prepare FSP stocking standards that were similar to those previously approved under a forest development plan. Going back further, forest development plan stocking standards in place at the end of the pre-FRPA era had mostly been rolled over from stocking standards originally developed by the ministry (with amendments over time). Therefore, for the key criteria of target and minimum densities, free growing heights, and acceptable species compositions, most FSP stocking standards are largely similar to the original stocking standards developed by the Ministry of Forests and Range more than 20 years ago.

The stocking standards for all three FSPs examined under this project were, on the whole, very similar to the stocking standards that existed pre-FRPA. Examples of new or revised standards found within the selected FSP stocking standards are:

- Management for alder on a trial basis on some alluvial sites (RCO),
- Reduced minimum inter-tree distances (MITD) on special sites (i.e.: wet, colluvial, roadside, high cattle or wildlife use and mechanically site prepared areas) (RNI and RCO),
- Reduced MITD for occasional pairs of trees (RNI),
- At, Ac and Ep are not considered deleterious competition for up to 25% of Riparian Management Areas (RNI),
- Deciduous and brush are not considered deleterious competition within 5 metres of S4, S5 and S6 streams (RNI), and
- Exotic species used for small research trials can be considered preferred species.

During the field inspections, the only instances of the use of these new or revised standards were found on wet sites within the RNI and RCO blocks where reduced MITDs were utilized. Of the areas assessed in these regions, wet sites made up <5% of the area. On these sites, in most cases, the reduced MITDs were being used to facilitate planting of higher densities (relative to the naturally available microsites).

For example, in most cases in RNI, the localized small areas of wet sites were lumped into complexes with drier sites with target densities of 1,200 well-spaced stems per hectare. Almost all of the wet sites were mechanically site prepared and planted with densities of 1,200 to 1,400 stems per hectare (assuming limited utilization of the reduced MITD provisions). Based on the low number of merchantable stems harvested from, and the relatively high densities being planted on, most of the wet sites inspected, it appears that the reduced MITD provisions are contributing to superior reforestation densities.

Figure 1: *View of the results of mechanical site preparation and mixed planting of pine and spruce on a wet site under the RNI FSP.*

Of the non-wet sites inspected under the RNI FSP, there was no evidence that planting utilized the provision allowing for reduced MITD for occasional pairs of trees.

A limited number of sites were inspected under this project and it was also too early to properly assess all of the potential implications. Nevertheless, most of these changes have limited application to the areas covered by the FSPs, making it unlikely that any one of them could have a significant negative effect on reforestation results at the landscape level (and therefore TSR).

3.2 Consistency between FSP Stocking Standards and TSR

According to the MFR, `Consistency with Timber Supply Review' means that the proposed set of FSP Stocking Standards does not put the timber flows projected from

TSR at risk by their application over time (MFR, 2006). This consistency test is one part of a theoretical linkage and feedback process.

For instance, when a new TSR is undertaken, it should reflect the updated results of past management and assumptions of planned management. For managed stands, both sets of these estimates are indirectly to directly influenced by the stocking standards. On the other hand, before implementation of new stocking standards, it is important to assess the TSR implications of the changes. In this way, there is a cycle of two-way feedback between stocking standards and the TSR.

According to MFR guidance (2006), "standards that are "consistent" with the latest TSR should be considered to be "acceptable." Therefore, in most cases, as in theory the latest TSRs were developed to be consistent with current practices (which are based on achievement of the stocking standards), where licensees rolled over previously-approved FDP stocking standards into their FSPs, it was logical to assume that the standards were consistent with TSR[4]. As the three sets of FSP stocking standards assessed in this project were largely grandfathered FDP standards, the pertinent tests are whether the TSR assumptions are consistent with the stocking standards and practices (actual and planned). Regardless, it is important to test the linkages between TSRs and stocking standards. As a result, this section investigates the consistency between the relevant TSRs and the stocking standards for the three selected FSPs.

There are many technical challenges when comparing stocking standards with TSR assumptions. As guided by the MFR (2006), the framework for these assessments indicates stocking standards should be evaluated as a whole against the assumptions of TSR, and that it is neither practical nor necessary to do one-to-one comparisons between individual stocking standards and analysis units. Nevertheless, where some recent TSRs have based managed and future stand yield assumptions on the BEC system, it is now possible to more directly compare stocking standards and yield curve inputs. Examples of other challenges are[5]:

- Stocking standards are based on well-spaced trees while inputs to stand models that feed into TSR are in total trees (with some allowances for assuming different spatial distributions),
- Stocking standards specify ranges of acceptable performance (i.e.: for species composition, density and regeneration delays); actual performance can vary widely within the allowances,
- Aside from stocking standards, there are other key assumptions that affect managed stand yields (i.e.: site indices and Operational Adjustment Factors

Finally, when checking linkages between stocking standards and TSR, it is important to understand that TSRs estimate what is expected to happen in the future (from short to long term) based on modeling estimates about what exists and assumptions of what is expected to happen. As TSRs are typically redone every 5 to 10 years and support allowable annual cut determinations that last for 5 years, the assumptions, estimates and results are regularly updated. However, the results of this process are limited by the quality of the data and assumptions used. Given the importance of managed stands to short- and mid-term timber supply in many parts of B.C., it is important to have good estimates of the performance of stands regenerated based on the stocking standards (McWilliams, 2009). This information is also critical to assess whether the stocking standards are creating stands which meet TSR assumptions.

Following are the results of the comparisons between the relevant TSRs for each region and the FSP Stocking Standards:

RNI

The managed stand yield table assumptions in TSR2 (completed in October, 2004) were coarse relative to the stocking standards (Table 2 and Table 3). These managed stand assumptions cover existing stands and planned future stands. This assumes that future management will mimic past practices. For example, the TSR2 managed stand assumptions for the Vanderhoof Forest District have a single analysis unit representing pine-leading stands (making up 84% of the managed stand inventory). This analysis unit was assumed to be pure pine with an initial establishment density of 1,600 sph. Conversely, the stocking standards are linked to site series and are therefore more variable in species composition and site productivity. The commonness of pine as a preferred species in the stocking standards for site series 01 (the predominant site series) in the SBS variants (the dominant BEC zone) indicates it is a suitable major species in most of the area covered by the FSP. Together with a strategy that replants promptly after

4 There were a few instances where FSP stocking standards were developed for coastal TSAs with outdated TSRs which did accurately reflect current or past management practices (Leblanc, 2009).

5 For a additional information on the technical issues associated with linking stocking standards and TSR, see McWilliams, J., and E. 2009

harvest and favours pine with assumed initial densities higher than the target standards, it could be said the key TSR2 assumptions are not inconsistent with the FSP Stocking Standards.

However, for example, with the presence of spruce and Douglas-fir as preferred species in the stocking standards for several of the site series, there could be a future shift in management away from pine. In addition, even though the assumed regeneration delays are less than the maximums specified in the stocking standards, there could be changes in management which further reduce the delays or increase them. These changes are allowable within the stocking standards and as long as they are reflected in subsequent TSRs, are consistent with the process.

TSR3 (ongoing) managed stand yield assumptions for stands established after 1997 (Table 4) are based on BEC site series and are therefore more directly comparable to the stocking standards. Assumed TSR3 species compositions of all units in the SBS zone are within the allowances for the applicable stocking standards. As compared to TSR2, the current TSR species compositions for pine leading stands have more diversity (i.e.: pine between 62% and 88%) and include components of spruce and in some cases one to two other species. This is an example of TSR assumptions being updated for changes in management.

In comparing TSR3 species composition assumptions with the stocking standards for the ESSFmv1, site series 01 shows an apparent inconsistency. In this BEC unit, pine dominates the TSR assumptions at 72% composition, but is only acceptable in the stocking standard. According to Delong, et al. (1993), pine is ecologically viable on zonal sites in the ESSFmv1 but it is not a preferred regeneration species. Despite this recommendation, apparently in the past, these sites have been reforested to pine-leading stands. This is a case of TSR assumptions reflecting past management, with the current stocking standard reflecting a change to a more ecologically appropriate species composition. From a modelling perspective, the remedy for this situation is to differentiate existing MSYTs from future MSYTs in subsequent TSRs. In this way, the TSR can most accurately reflect what has been done and the impacts of the changes in management to meet the revised stocking standards[7]. If this is done and assuming pine-leading stands are not ecologically appropriate on ESSFmv1/ss01, it may be justifiable to reduce the assumed yields for the affected existing stands in the next TSR. A monitoring program could be used to determine the estimated adjustments to the yield curve.

The TSR3 initial density assumptions are either 1100 or 1200 sph, which represent average regeneration survey results for stands declared free growing post-1997 (from RESULTS) (Snowden, 2009). These densities reflect updated estimates for existing managed stands and are assumed to continue in the future. While the results are between the target and minimum stocking standards, they are considerable reductions from the TSR2 initial density of 1600 sph. By itself, in most analysis units this lowering

Table 2: *2001 TSR2 Yield Assumptions (Vanderhoof FD)[6].*

Existing Analysis Unit	THLB Area (ha)	% of THLB Area	Regenerated Species Composition	% to natural regen	Initial Density of Planted (sph)	Regen Delay of Planted (years)
Fir	4103	1%	Fd100	10	1600	2
Balsam	5041	1%	Sw90Bl10	0	1600	3
Spruce >12m SI	53976	7%	Sw90Bl10	0	1600	3
Spruce <12m SI	31430	4%	Sw75Bl25	5	1600	3
Pine	658198	84%	Pl100	5	1600	2
ESSF >1200m elev.	31693	4%	Sw75Bl25	5	1600	6

6 OAF1 = 85% and OAF2 = 95% in all yield tables

7 Separation of existing and future MSYTs is common for recently completed TSRs in other FMUs.

Table 3: *Stocking Standards for Site Series 01 in the main BEC variants for the RNI FSP.*

Site Series	Preferred Species 1	min ht.	2	min ht.	3	min ht.	Acceptable Species 1	min ht.	Well Spaced sph Target P+A	Min P+A	Min P	Max Regen Delay (years)
ESSFmv1/01	Bl	0.8	Sx	0.8			Pl	1.6	1200	700	600	4
SBSdk/01	Pl	2	Sx	1	Fd	1.4			1200	700	600	7
SBSdw2/01	Pl	2	Sx	1	Fd	1.4			1200	700	600	7
SBSdw3/01	Pl	2	Sx	1	Fd	1.4			1200	700	600	7
SBSmc2/01	Pl	1.6	Sx	0.8			Bl	0.8	1200	700	600	7
SBSmc3/01	Pl	1.6	Sx	0.8			Bl	0.8	1200	700	600	7

Table 4: *2008 TSR3 Yield Assumptions for stands established after 1997 on Site Series 01 in the main BEC variants in the Vanderhoof FD.*

Site Series	Species Composition Spp1	Pct1	Spp2	Pct2	Spp3	Pct3	Spp4	Pct4	Initial Density	Regen Delay
ESSFmv1/01	Pl	72	Sw	25	Bl	3			1100	1
SBSdk/01	Pl	75	Sw	23	Bl	1	Fd	1	1100	1
SBSdw2/01	Pl	68	Sw	22	Fd	10			1200	1
SBSdw3/01	Pl	62	Sw	29	Fd	9			1200	1
SBSmc2/01	Pl	74	Sw	25	Bl	1			1100	1
SBSmc3/01	Pl	88	Sw	12					1100	1

of initial densities would result in reductions in yield. However, this could be compensated for by adjustments in estimates for other variables affecting managed stands.

For example, TSR3 regeneration delays are assumed to be one year (as compared to 2 to 6 years for TSR2). In addition, TSR3 used SIBEC estimates for site indices (as compared to inventory site indices for TSR2). As both of these revisions likely had a positive impact on yields, collectively they could have compensated for the reductions in yield from the use of lower initial densities. Regardless, TSR3 will reflect the net effect of the all of the changes in the managed stand assumptions.

Based on the limited field assessments completed on the blocks on which silviculture treatments had been completed under the RNI FSP (7 of 9 blocks inspected) had been partially to completely planted), planting is being done promptly after logging (i.e.: within 0 to 2 years after logging), with species mixes consistent with, and densities which are well higher than, TSR3 assumptions.[8]

RSI

Instead of a formal timber supply review, the chief forester based his most recent AAC determination on timber supply analysis in the 'Kamloops TSA Mountain Pine Beetle Horizontal Initiatives Project' (MFR, 2008a). The regeneration assumptions for this analysis were the same as those in TSR2 (2001). As a result, this section provides a comparison between the TSR2 and the stocking standards.

8 For more information on silviculture treatments on inspected blocks see Section 3.4

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Table 5: *Stocking Standards for Site Series 01 in the main BEC variants for the RSI FSP*

Site Series	Conifer Species		Well Spaced sph			
	Preferred	Acceptable	Target P+A	Min P+A	Min P	Max Regen Delay (years)
ESSFdc2/01	Pl, Se	Bl	1200	700	600	4
ESSFwc2/01	Bl, Se	Pl	1200	700	600	4
ICHmk1/01	Fd, Lw, Pl, Sx	Bl, Cw	1200	700	600	7
ICHmk2/01	Fd, Pl, Sx	Bl, Cw	1200	700	600	7
ICHmw2/01	Fd, Lw	Pl,Cw,Pw,Sx	1200	700	600	4
ICHmw3/01	Fd, Sx, Cw	Pl, Bl, Pw	1200	700	600	4
ICHvk1/01	Cw, Sx	Bl, Fd, Pw	1200	700	600	4
ICHwk1/01	Cw, Fd, Hw, Sx	Bl, Pw	1200	700	600	4
IDFdk2/01	Fd, Pl	Py, Sx	1000	500	400	7
IDFmw2/01	Fd, Pl	Cw, Sx, Bl	1200	700	600	7
IDFxh2/01	Fd, Py		1000	500	400	7
MSdm2/01	Pl, Sx, Fd	Bl	1200	700	600	7
SBSmm/01	Pl, Sx, Fd	Bl	1200	700	600	7

Table 6: *TSR2 Future MSYT assumptions for the relevant analysis units in the Kamloops TSA*[9].

AU	Description	Area	RD	Stems	sp1	%	sp2	%	sp3	%	sp4	%	sp5	%
103	Fir Wet <140 G/M	24,225	2	1,450	Fd	60	Pl	25	Sx	15				
104	Fir Wet >140 G/M	3,321	2	1,450	Fd	60	Pl	25	Sx	15				
105	Fir Wet <140 P/L	16,406	2	1,430	Pl	65	Fd	25	Sx	10				
106	Fir Wet >140 P/L	2,455	2	1,430	Pl	65	Fd	25	Sx	10				
107	Cedar <140 G/M	3,210	2	1,390	Sx	45	Cw	20	Fd	15	Pl	10	Hw	10
108	Cedar <140 P/L	1,257	2	1,320	Sx	30	Fd	30	Cw	20	Pl	10	Hw	10
109	Hemlock <140 G/M	1,155	2	1,400	Sx	40	Fd	30	Cw	10	Pl	10	Hw	10
110	Hemlock <140 P/L	989	2	1,360	Sx	40	Pl	25	Cw	15	Fd	10	Hw	10
111	Balsam <140 G/M	12,941	3	1,400	Se	80	Bl	20						
112	Balsam >140 G/M	530	3	1,400	Se	80	Bl	20						
113	Balsam <140 P/L	6,366	3	1,330	Se	60	Bl	25	Pl	15				
114	Balsam >140 P/L	1,607	3	1,330	Se	60	Bl	25	Pl	15				
115	Spruce <140 G/M	57,240	3	1,450	Sx	60	Bl	25	Pl	15				
116	Spruce >140 G/M	2,128	3	1,450	Sx	60	Bl	25	Pl	15				
117	Spruce <140 P/L	12,135	2	1,320	Sx	70	Bl	20	Pl	10				
118	Spruce >140 P/L	6,148	2	1,320	Sx	70	Bl	20	Pl	10				
119	Pine <140 G/M	63,488	2	1,560	Pl	80	Sx	10	Fd	10				
120	Pine >140 G/M	3,513	2	1,560	Pl	80	Sx	10	Fd	10				
121	Pine <140 P/L	38,592	2	1,480	Pl	90	Sx	10						
122	Pine >140 P/L	1,156	3	1,480	Pl	90	Sx	10						

9 OAF1 = 85% and OAF2 = 95% in all analysis units.

Table 5 shows the stocking standards for site series 01 for the primary BEC variants and

Table 6 summarizes the relevant TSR2 future MSYT assumptions for the Kamloops TSA. Linkages between TSR and the stocking standards are indirect because TSR AUs are based on inventory type group (species composition and site productivity) while the stocking standards are based on site series.

There are no major inconsistencies between the TSR2 regeneration assumptions and the stocking standards. The AU species compositions match up reasonably well with the preferred species in the stocking standards. TSR initial density assumptions of 1320 sph to 1560 sph are higher than the target density of 1200 sph from the stocking standards. Finally, the assumed TSR regeneration delays of 2 to 3 years are well within the stocking standards maximum regeneration delays of 4 to 7 years.

Based on the limited field assessments completed on the blocks on which silviculture treatments had been completed under the RSI FSP (6 of 10 blocks inspected had been planted and the rest of the inspected blocks were un-logged), planting is being done promptly after logging (i.e.: within 0 to 2 years after logging), with species mixes and densities consistent with TSR2 assumptions.[10]

RCO

Analysis unit-specific species composition assumptions for the MSYT were not available in the analysis report for TSR2 (completed in November, 2001). As a result comparison was done between TSR3 (completed in January, 2009) and the stocking standards (Table 7 and Table 8).

TSR3 used an elaborate system of AUs to model growth and yield. To reduce the complexity of these assumptions for the purpose of this comparison, the 10 analysis units with the greatest THLB area (representing 68% of the total THLB) were selected.

There are no major inconsistencies between the TSR3 regeneration assumptions and the stocking standards. The AU species compositions match up reasonably well with the preferred species from the stocking standards. For planted regimes the TSR3 establishment densities of 1000-1200 sph are higher than the target stocking standards and the assumed regeneration delays of 1 to 2 years are well within the stocking standards allowances. For natural regeneration regimes the TSR3 establishment density assumptions of 4000-5000 sph within 3 years of harvest are also consistent with the stocking standards.

Based on the limited field assessments completed on the blocks on which silviculture treatments had been completed under the RCO FSP (8 of 10 blocks inspected had been planted and one block was planned for planting and one block was planned for natural regeneration), planting is being done promptly after logging (i.e.: within 0 to 2 years after logging), with species mixes and densities consistent with TSR3 assumptions. Assuming the block planned for natural regeneration achieves the stocking standards, this management is also consistent with the TSR3 assumptions (about 45% of the area represented in Table 8 is expected to regenerate naturally).

Table 7: *Stocking Standards for Site Series 01 in the main BEC variants for the RCO FSP*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
CWHvm1/01	Cw	1.5	Hw	3.0	Ba	1.75			Ss	3.0	Yc	1.5	Fd	3.0	900	500	400	6
CWHvm2/01	Hw	2.5	Cw	1.5	Yc	1.5	Ba	1.75	Hm	1.0	Ss	3.0	Fd	2.25	900	500	400	6
MHmm1/01	Ba	0.6	Hm	1.0	Yc	1.0			Hw	1.0					900	500	400	7
MHmm2/01	Ba	0.6	Hm	1.0					Hw	1.0					900	500	400	7
CWHms2/01	Fd	2.25	Cw	1.0	Ba	0.75			Hw	1.0					900	500	400	3
CWHvh1/01	Cw	1.5	Hw	2.0	Yc	1.5			Pl	1.5	Ba	1.75	Ss	3.0	900	500	400	6
CWHws2/01	Ba	0.75	Bl	0.75	Cw	1.0	Hw	1.0	Sxs	0.75	Pl	2.0			900	500	400	6

10 For more information on silviculture treatments on inspected blocks see Section 3.4

Table 8: *TSR 3 Future MSYT assumptions for the 10 largest analysis units in the Kingcome TSA*

Future AU	Regime #	THLB Area (ha)	Analysis Unit Description	Planted/Natural	RegenDelay (yrs)	Regime %	Species 1	Species 1 %	Species 2	Species 2 %	Species 3	Species 3 %	Establishment Density (sph)	Genetic Gain Species 1
212	1	10,990	CW/CY-MED-EBM	P	1	85%	CW	80%	HW	20%			1000	3%
	2	1,939	CW/CY-MED-EBM	N	3	15%	HW	60%	CW	40%			4000	0%
213	1	26,456	CW/CY-POOR-EBM	P	2	65%	CW	80%	HW	20%			1000	3%
	2	14,245	CW/CY-POOR-EBM	N	3	35%	HW	60%	CW	40%			4000	0%
214	1	224	HWC/BA-GOOD-EBM	P	1	3%	CW	40%	HW	40%	BA	20%	1200	3%
	2	4,249	HWC/BA-GOOD-EBM	N	3	57%	HW	60%	BA	20%	CW	20%	5000	0%
	3	149	HWC/BA-GOOD-EBM	P	1	2%	CW	40%	HW	40%	BA	20%	1200	3%
	4	2,833	HWC/BA-GOOD-EBM	N	3	38%	HW	60%	BA	20%	CW	20%	5000	0%
215	1	1,364	HWC/BA-MED-EBM	P	1	18%	CW	40%	HW	40%	BA	20%	1200	3%
	2	3,183	HWC/BA-MED-EBM	N	3	42%	HW	60%	BA	20%	CW	20%	5000	0%
	3	909	HWC/BA-MED-EBM	P	1	12%	CW	40%	HW	40%	BA	20%	1200	3%
	4	2,122	HWC/BA-MED-EBM	N	3	28%	HW	60%	BA	20%	CW	20%	5000	0%
216	1	2,211	HWC/BA-POOR-EBM	P	1	18%	CW	40%	HW	40%	BA	20%	1200	3%
	2	5,158	HWC/BA-POOR-EBM	N	3	42%	HW	60%	BA	20%	CW	20%	5000	0%
	3	1,474	HWC/BA-POOR-EBM	P	1	12%	CW	40%	HW	40%	BA	20%	1200	3%
	4	3,439	HWC/BA-POOR-EBM	N	3	28%	HW	60%	BA	20%	CW	20%	5000	0%
263	1	7,728	CW/CY-MARG-EBM	P	2	65%	CW	80%	HW	20%			1000	3%
	2	4,161	CW/CY-MARG-EBM	N	3	35%	HW	60%	CW	40%			4000	0%
305	1	2,179	HWC/BA-MED	P	1	30%	CW	40%	HW	40%	BA	20%	1200	3%
	2	5,084	HWC/BA-MED	N	3	70%	HW	60%	BA	20%	CW	20%	5000	0%
311	1	6,803	CW/CY-GOOD-EBM	P	1	95%	CW	80%	HW	20%			1000	3%
	2	358	CW/CY-GOOD-EBM	N	3	5%	HW	60%	CW	40%			4000	0%
315	1	1,839	HWC/BA-MED-EBM	P	1	18%	CW	40%	HW	40%	BA	20%	1200	3%
	2	4,291	HWC/BA-MED-EBM	N	3	42%	HW	60%	BA	20%	CW	20%	5000	0%
	3	1,226	HWC/BA-MED-EBM	P	1	12%	CW	40%	HW	40%	BA	20%	1200	3%
	4	2,861	HWC/BA-MED-EBM	N	3	28%	HW	60%	BA	20%	CW	20%	5000	0%
613	1	4,555	CW/CY-POOR-EBM	P	2	65%	CW	80%	HW	20%			1000	3%
	2	2,453	CW/CY-POOR-EBM	N	4	35%	HW	60%	CW	40%			4000	0%

3.3 Accuracy of Stocking Standards in RESULTS

The minimum preferred and acceptable stocking densities were reversed in RESULTs for all of the Stocking Standard IDs represented in the blocks checked under the RSI FSP. This was likely due to a clerical error that occurred while transferring the FSP stocking standards into RESULTs. These errors mean that the RESULTs data is not as accurate as it could be. However, as the licensee is managing toward the correct standards from the FSP, the implications of this problem are minimal.

For the blocks reviewed under the RNI and RCO FSPs, the stocking standards listed in RESULTs were consistent with the FSP standards.

3.4 Block-level Implementation of FSP Stocking Standards

Most of the blocks that had been harvested were finished within the last year. As a result, limited silviculture treatments were observed. For all blocks, the licensees summarized the silviculture treatment regimes they expected to follow.

Following are the key observations and findings from the field inspections in each region[11]:

RNI

The 9 blocks selected for field inspection had all been logged. The blocks were in the SBSdk and SBSmc2. Block sizes ranged from 3 to 170 hectares with the average size being about 70 hectares.

All of the larger blocks (>70ha) were stratified into 2 Standards Units (SU) either because the block included two different BEC Subzone/Variants or because there were localized smaller wet areas (as opposed to the larger non-wet areas). In essence, stratification was based on differences in stocking standards although in most blocks the actual differences between the standards were minor.

The vast majority of the area inspected had a relative soil moisture regime (SMR) of 3 to 4 (i.e.: mesic within a scale of driest [0] to wettest [7] within the particular subzone/variant). In most cases the licensee foresters had stratified the localized wet areas reasonably accurately. For the inspected areas there was a greater range in soil nutrient regime (SNR), from B to D, with most of the sites being B to C (i.e.: where B is poor, C medium and D rich). Overall, most of the non-wet area was site series 01 with lesser

Table 9: *Stocking standards for the main non-wet to non-dry site series for the SBSdk*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
01	Pl	2.0	Sx	1.0	Fd	1.4									1200	700	600	7
03	Pl	2.0	Sx	1											1200	700	600	7
04	Pl	2.0	Sx	1	Fd	1.4									1200	700	600	7
05	Pl	2.0	Sx	1	Fd	1.4									1200	700	600	7
06	Pl	2.0	Sx	1	Fd	1.4									1200	700	600	4
07	Pl	1.4	Sx	0.8											1000	500	400	4
08	Pl	2.0	Sx	1											1200	700	600	4

Table 10: *Stocking standards for the main non-wet to non-dry site series for the SBSmc2*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
01	Pl	1.6	Sx	0.8											1200	700	600	7
03	Pl	1.6	Sx	0.8											1200	700	600	7
04	Pl	1.6	Sx	0.8											1200	700	600	4
05	Pl	1.6	Sx	0.8											1200	700	600	4
06	Pl	1.6	Sx	0.8											1200	700	600	4
08	Pl	1.6	Sx	0.8											1200	700	600	4
09	Pl	1.6	Sx	0.8											1200	700	600	4

11 See Appendix 1 for the lists of the blocks assessed in the field.

components of site series that were medium in moisture and poorer or richer in nutrients (site series 05 and 06 in the dk and site series 03 and 06 in the mc2). In most cases the licensee foresters generally acknowledged this range of site conditions in the Site Plans. Overall, given the generic stocking standards for the non-wet or non-dry sites (i.e.: similar target and minimum densities, suitable tree species and minimum free growing heights), there would be little benefit to be gained by further stratification and the appropriate stocking standards were being designated (from the list of approved standards) (Table 9 and Table 10).

All but two blocks had been planted (a few blocks had only been partially planted). All blocks had undergone roadside piling and some of the piles had been burnt. On wet sites, which occurred in localized areas of several blocks, mounding had been done prior to planting.

Planted target densities were 1400 to 1500 sph (200 to 300 sph above target stocking) and the species composition was about 60% to 70% pine with the rest being spruce on all blocks irrespective of site series. According to the licensee, this reforestation regime is predominant in most areas under this FSP. These reforestation treatments were consistent with achievement of the stocking standards.

The inspection of one block found a moderate level of pine advanced regeneration that was mostly infected with Lodgepole Pine Dwarf Mistletoe. The Site Plan did not recognize this forest health issue and the block had been planted with same species mix and density as the rest of the assessed blocks. Without mistletoe eradication, the future growth vigour, form, and value of the pine component of this stand could be jeopardized. There is still time for treatment to be carried out to deal with this issue.

For all but one Site Plan, Western Gall Rust and Commandra and Stalactiform Blister Rusts were listed as forest health concerns with expected damaged of 5% to 10%. For all of these blocks, the Site Plan recommends dealing with these forest health agents by reassessing at post harvest and planting high densities with a mix of spruce and pine.

Based on observations in nearby 20- to 40-year-old pine-leading stands in the SBSdk, the incidence of Western Gall Rust and Commandra and Stalactiform Blister Rusts (hard pine rusts) appeared to be much higher than noted in the adjacent Site Plans. Of the 5 Age Class 2 (20 to 40 years old) stands visited in the SBSdk, all consisted of >80% pine with overstory densities (dominant and co-dominant crown classes) estimated at 1000 to 1600 sph with an estimated 20 to 50% of the overstory trees with hard pine rust infections on the stem. In many cases, the stems infected with these pathogens had recently broken at the point of infection (likely due to snow loads and/or wind) and the trees had died (**Figure 2**). The incidence and severity of hard pine rusts in the SBSmc2 was much lower (based on observations from 3 age class 2 stands). However, there were other concerns in these stands.

Figure 2: *View of a 20 to 30 year old stand with common recent breakage of overstory trees infected with Western Gall Rust.*

In addition to the forest health concerns, many of the 20- to 40-year-old pine-leading stands assessed in the SBSmc2 and the SBSdk growing on medium to good sites (i.e.: Site Indices >18m) had common evidence of poor quality. The assessed stands had similar species compositions and densities as previously described. Many of the overstory stems had live crowns >40% and had common heavy branching, forks or crooks and poor taper. The prevalence of poor quality characteristics seemed to get worse as site quality increased and/or stand density decreased. It was not difficult to imagine that young stems with poor quality attributes would make poor quality sawlogs at rotation.

The potential significance of these forest health and quality concerns could be large.

First, pine with main stem hard rust infections are at risk of dying before rotation age. According to Woken et al.(2006) and Woods et al. (2000) there is limited-to-no data indicating how long trees with main stem hard pine rusts are likely to survive. However, several researchers have stated that main stem galls usually cause tree mortality (but not until 20 years following infection) (van der Kamp, 1988), main stem infections of Comandra blister rust are fatal (van der Kamp, 1994) and hard stem rusts can cause significant losses in young lodgepole pine stands (van der Kamp and Spence, 1987).

Second, there is evidence of widespread incidence of hard pine rust infections in portions of the northern and southern interior forest regions and the incidence of these diseases is growing. Based in part on forest health concerns, the Forest and Range Evaluation Program (FREP) recently completed an evaluation of free growing stands in the Lakes TSA (adjacent to the TSA where the RNI FSP was located) (Woods et al., 2008). This monitoring project found that pine-leading free growing stands (up to about 40 years old) had a hard pine rust incidence of over 20% and the incidence was significantly higher in 2005 than at the time of free growing declaration. As noted in the FREP report the increased incidence of hard pine rusts after free growing could be partially the result of improved recognition of forest pests and partially due to not picking up the disease incidence during the free growing survey. However, as is also noted, van der Kamp et al. (1997) have found that hard pine rust incidence does not peak until stand age 18 or older.

In the Cariboo, there have been similar recent findings about the incidences of disease in free growing pine-leading stands. As recipients under the Forests for Tomorrow (FFT) Program between 2007 and 2008, B. A. Blackwell and Associates Ltd. have completed more than 40,000 hectares of silviculture surveys in age class 2 stands in the Quesnel, Williams Lake and 100 Mile House TSAs that have been impacted by the mountain pine beetle (MPB). While the survey results have not been summarized based on forest health incidence (non-MPB), many of the stands had common incidences of hard pine rusts and/or lodgepole pine dwarf mistletoe (Davis, personal comm. 2009). As the landscape-level risk rating for Western Gall Rust for the whole SBS zone in the Cariboo TSAs is considered high, the risk rating for Commandra and Stalactiform Blister Rusts in SBSdw1, mc2 and mw is moderate to high (Forrex, 2003) and the qualitative disease incidence results from the FFT surveys are consistent with these risk assessments, managed pine stands in many parts of the Cariboo may be at risk.

Thirdly, many stands have been produced (and are still being established) according to the stocking standards (and subsequent juvenile spacing) that grow in conditions generally favourable for the proliferation of hard pine rust infections (and other diseases of pine). For the area represented by the RNI FSP, as summarized in recent TSRs and supported by the feedback from licensee foresters, the reforestation regime for many years has been to plant the majority of SBS sites with mostly pine at densities of 1400 to 1600 sph (in the last few years a consistent component of about 30% spruce has been used as a substitute for some pine). Stands assessed during this project, from newly planted to 40 years old, confirmed that species compositions are dominated by pine with densities of overstory pine of between 1000 to 1600 sph. Very little natural infill was observed in these stands. In most cases in the recently planted mixed species stands on non-wet sites, the spruce component is in a secondary crown class position (relative to the pine) and does not compete with the overstory trees. Figure 3 represents a generalized view of what a recently established mixed pine/spruce plantation could look like between about age 20 and 30 years with the pine in the overstory and the spruce in the understory. The significance of this scenario is that the pine trees are growing under more open conditions (relative to the pure pine stands) which may make them even more susceptible to infection from hard pine rusts and increase the proportion of the pine trees which will be killed by these diseases.

Figure 3: *Schematic showing generalized two layer crown class structure of mixed pine (overstory)/spruce plantations on non-wet sites in the SBS.*

There are potential impacts of these forest health concerns on TSR. Woods et al. (2000) found that volume losses in pine-dominated stands could be expected to be up to about 7% by culmination age. Estimated losses due to Western Gall Rust over a 20 year period in western Alberta were 15% (Bella and Navratil, 1988). However, the confidence intervals on these estimates were high and the researchers noted that the variables most linked to volume loss were lethality of the diseases (i.e.: the % of infected trees which are expected to die) and longevity (i.e.: length of time from infection to mortality).

The FREP monitoring of free growing stands in the Lakes TSA found a high incidence of hard pine rusts, but overall, the managed stands were found to be meeting timber supply projections (Woods et al. 2008). Based on this analysis, it is uncertain if changes in other assumptions or

modeling nuances (i.e.: using well spaced versus total trees) may have masked the potential negative impacts of these diseases on timber supply.

Endemic levels of forest health agents in stand-level modeling for TSR are typically manipulated through changes to OAFs. OAF1 reduces the theoretical yields in managed stands to account for dispersed areas of non-productive ground and imperfect inter-tree espacement. OAF2 reduces the yields due to factors such as forest health (the impact increases over time to age 100). Typically, MSYT assumptions for TSR use an OAF1 of 85% and an OAF2 of 95%. An OAF1 of 85% results in a 15% decrease in yield at all ages. An OAF2 of 95% increasingly reduces yields over time from 0% to 5% at 100 years. These assumptions are based on relatively healthy stands on typical sites and the effects at any age are additive. TSR3 for the Vanderhoof Forest District uses these default OAFs. In TIPSY, it is also possible to input user-specified OAFs. This process can be used to estimate the effects of disease-related mortality in pine stands.

A simplistic method of estimating the potential stand-level impacts of hard pine rusts on volume in the area under the RNI FSP is to assume that stems with main stem infections are going to die before rotation age. **Figure 4** compares TIPSY merchantable volume development for existing pure pine age class 2 managed stands grown using TSR2 assumptions (initial density of 1600 sph and normal OAFs) and a site index of 19.5m (from SIBEC) with the volume for stands that have 20% and 50% mortality[12] (species specific OAF2s with the maximum affect by the culmination age of 80 years). For the 20% mortality assumption the reduction in merchantable volumes ranges from about 15% at age 60 years to about 20% by 80 years, and for the 50% mortality assumption from about 37% at age 60 years to 50% by 80. As this situation is potentially applicable to a large area of age class 2 managed stands for the Vanderhoof Forest District (most of the SBS zone) and the post MPB mid-term timber supply relies on these stands, the TSR impacts of losses such as these could be serious.

Figure 5 shows a similar comparison for mixed pine and spruce stands (70% pine and 30% spruce established at 1450 sph with site index of 19.5m for pine and 19m for Spruce) that make up the majority of age class 1 free growing stands established under the RNI FSP. Assuming no growth loss for the spruce (due to shading from the dominant pine), the reduction in merchantable volumes associated with 20% mortality of pine ranges from about 12% at age 60 years to about 14% by 80 years, and for 50% mortality from about 29% at age 60 years to 36% by 80. If, as assumed in this analysis, the pine in these stands is equally likely to be infected with hard pine rusts as compared to the pure pine stands, the spruce component mitigates the potential losses to a degree.

Figure 4: *Volume impacts of different levels of pine disease related mortality in existing pure pine managed stands*

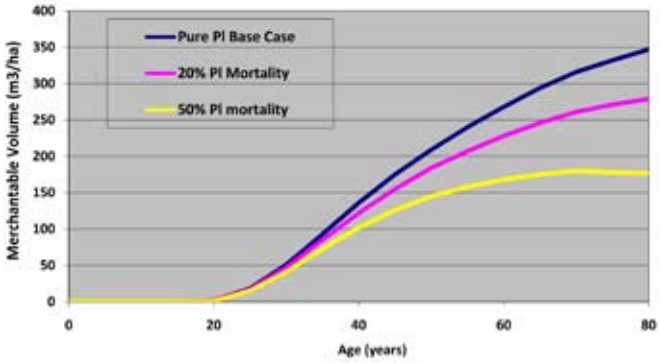


Figure 5: *Volume impacts of different levels of pine disease related mortality in existing mixed pine/spruce managed stands*

Pine often regenerates naturally at moderate to high densities following wildfire or logging. Typically resultant stands have stems with small live crowns and small branches. Thinning of these stands can reduce mortality from competition and maximize diameter growth on the residual stems. Planted stands of lower densities can result in similar stand conditions. In the early stages of stand development (until crown closure), lower density stands (based on low establishment densities or thinning) generally result in larger live crowns and larger branches.

12 These mortality levels were chosen to match worst and best case field estimates of main stem hard pine rust infections in age class 2 stands assessed under this project.

Based on observations from this project and the recent FFT surveys in the Cariboo, these conditions appear to be exacerbated on better quality sites. There are many forest health agents that affect young pine and are commonly found in managed pine stands in significant portions of the BC Interior. Based on observations from this project and the recent FFT surveys in the Cariboo, the incidence and severity of several of these forest health agents in immature stands appears to be inversely related to stand density. That is lower density stands in high hazard areas tend to have higher incidences and severity of disease. Management of pine leading stands to the current target stocking standards of 1200 to 1400 sph in high hazard areas appears to be producing stands which are at high risk to these forest health agents. When combined with concerns for wood quality from stems grown to meet the target stocking standards on medium to good sites, it is timely to do a more comprehensive review of the issues and the implications for stocking standards, future management and timber supply.

RSI

Logging had been completed on 6 of the 10 blocks selected for field inspection. The blocks were in the ICHmw3, wk1 and vk1 and were in terrain that varied from rolling hills to mountainous. Slopes and aspects were variable. Block sizes ranged from 4 to 29 hectares with the average size being about 15 hectares.

Most of the blocks consisted of one SU. Two blocks were stratified into 2 SUs based on differences in major site series. In essence, stratification was based on differences in stocking standards, although in one block the only difference between the SUs was the MITD. In the other block the likely impact of the differences between the standards was minor (pine changed from a preferred to acceptable species in a block planned for planting with cedar, fir and spruce at densities higher than the target standards).

Although the majority of the area inspected had a SMR of 3 to 4 (i.e.: mesic within a scale of driest [0] to wettest [7] within the particular subzone/variant) and SNR of B to C (i.e.: where B is poor, C medium and D rich), there was fair amount of ecological variability due to changes in aspect and slope positions. In most cases, the licensee forester classified the major site series correctly and acknowledged the range of site conditions in the Site Plans. For the majority of the blocks, given the broad range of site nutrient conditions covered by many of the main site series (e.g. in the wk1 sites series 01, 04 and 05 consist of sites with soil nutrient regimes of very poor or poor to rich or very rich) and generic stocking standards for the non-wet or dry sites (i.e. similar target and minimum densities and minimum free growing heights), there would be little benefit to be gained by further stratification and the appropriate stocking standards were being designated (from the list of approved standards) (Table 11 and Table 12). However, there were a few blocks where the site series were incorrectly identified, causing incorrect stocking standards to be applied. In all of these cases the differences between the applied and the correct standards related to a change in one or two species between preferred and acceptable. The likely impacts are minor as the blocks were planned to be planted with densities higher than the target standards with 2 or 3 species (of which at least 1 was preferred).

All logged blocks had undergone roadside piling and planting. Burning of roadside piles was planned. In one of the blocks, slash had been piled throughout the block and the piles were being burnt during the field inspection.

Table 11: *Stocking standards for the main non-wet to non-dry site series for the ICHmw3*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
01	Fd	1.4	Sx	1	Cw	1			Pl	2	Bl	1	Pw	2	1200	700	600	4
04	Fd	1.4	Pl	2					Cw	1	Pw	2	Sx/ Bl	1	1200	700	600	7
05	Fd	1.4	Sx	1	Cw	1			Pl	2	Bl	1	Pw	2	1200	700	600	7
06	Fd	1.4	Sx	1	Cw	1	Hw	1	Pl	2	Bl	1	Pw	2	1200	700	600	4
07	Fd	1.4	Sx	1	Cw	1			Pl	2	Bl/ Hw	1	Pw	2	1200	700	600	4

Table 12: *Stocking standards for the main non-wet to non-dry site series for the ICHwk1*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
01	Fd	1.4	Sx	1	Cw	1	Hw		Bl	1	Pw	2			1200	700	600	4
04	Fd	1.4	Sx	1	Cw	1			Hw	1	Pw	2			1200	700	600	4
05	Sx	1	Cw	1					Bl	1	Hw	1	Pw	2	1200	700	600	4

Planting target densities were 1200 to 1400 stems per hectare (sph) (200 sph above target stocking) and two to three species were mix planted in every block with species composition varying by site type. All planted western red cedar, irrespective of site quality, were fertilized at the time of planting.

Site Plans for some blocks noted the presence of Armillaria ostoyae root disease and specified that planting mixed species would be done to minimize the future impacts. In most cases the assessment of root disease and planned response were reasonable. However, in one un-logged block, both Armillaria ostoyae and Phellinus weirii were commonly observed. In this case, the amount and distribution of the root rots may make it difficult to achieve the stocking standards with only a mixed species planting strategy.

Adjacent to several blocks in the ICHvk1, where the reforestation plans call for mixed planting of cedar, spruce and a minor component of Douglas fir, there was evidence of moderate weevil attack on young spruce. The weevil hazard was not noted in the Site Plans. Depending on the proportion of spruce planted in this area, there is potential for impacts before and after free growing.

RCO

The 10 blocks selected for field inspection had all been logged. Three of the blocks were in the northern portion of the coast-interior transition zone (CWHms2) and the rest of the blocks were in the CWHvm1 or vh1. Block sizes ranged from 1 to 38 hectares with the average size being about 10 hectares. About half the bocks were logged by helicopter and the rest conventionally.

There was a fair amount of ecological variability due to changes in aspect, slope positions and parent materials. In most cases, the licensee foresters classified the major site series correctly and acknowledged the range of site conditions in the Site Plans.

Most of the blocks consisted of one SU. Two blocks were stratified into 2 SUs based on separating localized wet sites from non-wet sites. In essence, stratification was based on significant differences in stocking standards and was reasonably done.

Overall, given the relatively similar stocking standards for the non-wet to non-dry sites (i.e.: similar target and minimum densities, suitable tree species), little benefit would be gained by further stratification (Table 13).

Table 13: *Stocking standards for the main non-wet to non-dry site series for the CWHvm1*

	Preferred Species								Acceptable Species						Stocking			
Site Series	1	Ht	2	Ht	3	Ht	4	Ht	1	Ht	2	Ht	3	Ht	Target P&A	Min P&A	Min P	Regen Delay (yrs)
01	Cw	1.5	Hw	3	Ba	1.75			Ss	3	Yc	1.5	Fd	3	900	500	400	6
01s	Cw	1.5	Hw	3					Ba	1.75	Yc	1.5	Ss	3	900	500	400	6
05	Cw	1.5	Hw	3	Ba	1.75	Fd	3	Ss	3	Fd	3			900	500	400	3
06	Cw	1.5	Hw	3	Ba	1.75			Yc	1.5	Ss	3			900	500	400	6
06s	Cw	1.5	Hw	3					Ba	1.75	Yc	1.5	Ss	3	900	500	400	6
07	Cw	2	Hw	4	Ba	2.25			Ss	4	Fd	4			900	500	400	3

Eight of the 10 blocks inspected were planted. One block was planned for planting with Cw and one block where second growth hemlock and balsam was harvested is planned for natural regeneration.

Of the planted blocks, the three in the coast-interior transition zone were planted with mixed Fd and Cw. On the rest of the planted blocks Cw was used. Planting target densities were 800 to 1000 sph (100 sph below to 100 sph above target stocking).

The Site Plans did not contain any information on forest health. The licensee produces a separate Ecological Site Assessment for each block that included comments and plans for any forest health agents of significance. The licensee provided copies of these documents for two of the blocks and Hemlock Dwarf Mistletoe (DMH) was noted as a concern on both. The recommended treatments were to plant components of non-hemlock and, if necessary, slash infected residuals. As Cw made up most to all of the planted trees on the blocks where DMH was noted as a concern, the future risks of problems are low. No other forest health issues of significance were identified within, or in the vicinity of, the assessed blocks.

3.5 Opportunities for Improvement

Based on assessments and analysis carried out for this project in general, FSP stocking standards are being reasonably applied to cutblocks and basic silviculture is being done to achieve the stocking standards. Aside from the concerns for the health and quality of some pine plantations established consistent with the stocking standards, in most cases the managed stands will likely result in reasonable quality, resilient stands which will likely meet timber supply projections. The vast majority of the sites assessed from the RCO and RSI FSPs represent this positive situation. These findings are also consistent with the results of several Forest Practices Board audits and investigations of compliance with free growing requirements (FPB, 2003, 2005).

However, current stocking standards for most FSPs were, for the most part, developed over 30 years ago by the MFR, based on the objective of maximizing production of larger logs suitable for the manufacture of solid wood products. These standards pre-date the current MPB epidemic, concerns for global warming and the emergence of new non-solid wood markets. In addition to these changes, there have been improvements in knowledge about ecological site identification, site productivities and impacts of various management practices. As a result, it is timely to review stocking standards and ensure they will meet current objectives.

As part of a holistic review of stocking standards, there are opportunities for improvement that should be explored. Most of these improvements involve better linkages between the site limiting factors and site productivities associated with the regional ecological classification systems, the stocking standards and the cost/benefits of silviculture.

There should be an expectation that foresters set stocking standards that consider the cost/benefits of silviculture (amongst other things). This is true regardless of whether basic silviculture is considered a cost of harvesting or an investment in the next rotation.

As observed in this project, licensees are generally managing to target stocking densities. To achieve linkage between good stewardship of the regenerating forest and results, it is important that reforestation efforts are tied to achievement of the targets as opposed to the minimum standards (McWilliams, 2009). Therefore, it is important that target densities reflect the desired outcomes for the range of sites being managed.

However, as was observed in this project, target stocking densities for common sites are very uniform both within and between BEC variants. For these sites in the RNI and RSI, the targets are 1200 sph and for the RCO the target is 900 sph. However, within the ecological variability of these vast regions, there are some significant differences in site productivities. For example, for the CWHvm1 in the RCO, the site Index at 50 years (SI) for western red cedar (Cw) varies from 21m on a poor, slightly dry site to 28m on a rich, moist site (Klinka and Brisco, 2009). For the SBSdk, the SI for spruce varies from 15m to 21m for similar relative soil nutrient and moisture regimes (MFR, 2008). Everything else being equal, these changes in site productivity can have a significant effect on the cost/benefits of silviculture.

As a simplistic example of the impacts of differences in site quality for a coastal situation similar to sites inspected under the RCO FSP, Figure 6 and Figure 7 respectively compare the volume and financial results of planting the same density of western Cw on two different site qualities. The relatively poor site (SI23) represents a soil nutrient regime of poor with a soil moisture regime of fresh (within site series 01) and the good site (SI28) represents site series 05 in the CWHvm1 (Klinka and Brisco, 2009).

A similar example comparison is provided for sites inspected under the RSI FSP (Figure 8 and Figure 9). In this case, the sites are in the ICHvk1 and the relatively poor site represents a nutrient poor, mesic site (SI of 18m for Fd and Sx and 17m for Cw) and the rich site represents a nutrient rich, mesic site (SI of 24m for Fd and Sx and 21m for Cw)[13]. Based on the Field Guide for Site Identification and Interpretation for the Kamloops Forest Region (MFR, 1993) both of these sites are within site series 01 and therefore have the same stocking standards.

Figure 6: *Comparison of volume development for stands planted with 1000sph of Cw on two different sites in RCO*

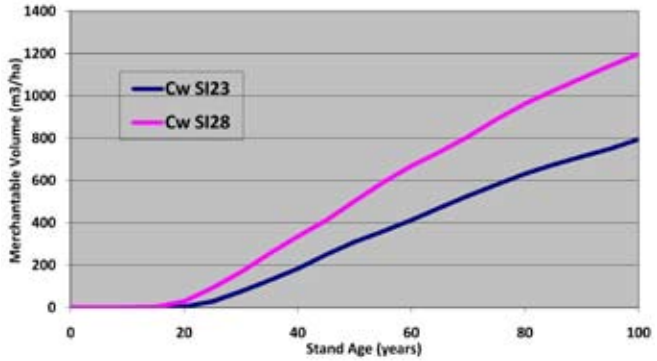
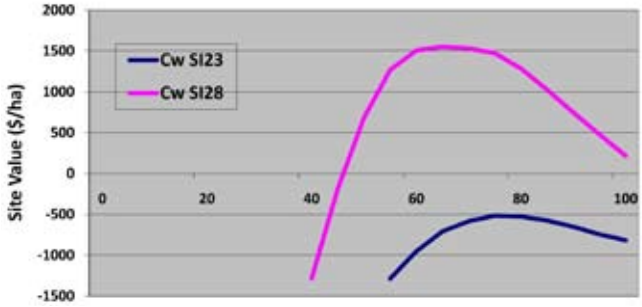


Figure 7: *Comparison of site value development (@2% discount rate) for stands planted with 1000sph of Cw on two different sites in RCO*



While there are other things to consider when setting target stocking densities (i.e.: desired product mixes, silvics of the different species and annual allowable cuts, ect.), the results from these simplistic comparisons indicate there may be opportunities to differentiate the target stocking standards based on site quality. This is an example of how stocking standards could evolve in the future to improve allocations of scarce resources. For example, this process could lead to higher target standards on medium to good sites and a corresponding reduction in standards on poorer sites.

Figure 8: *Comparison of volume development for stands planted with 1300sph of Cw, Fd and Sx (1/3 of each) on two different sites in RSI*

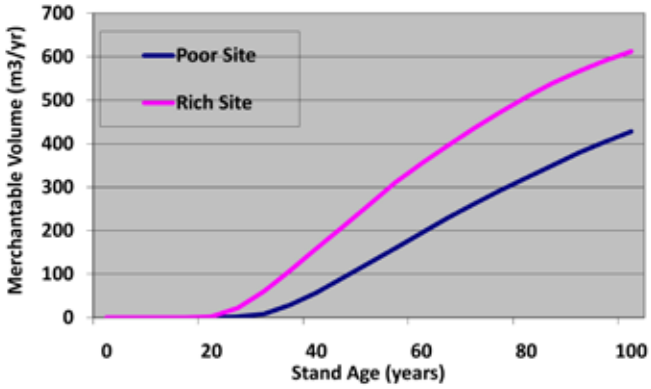
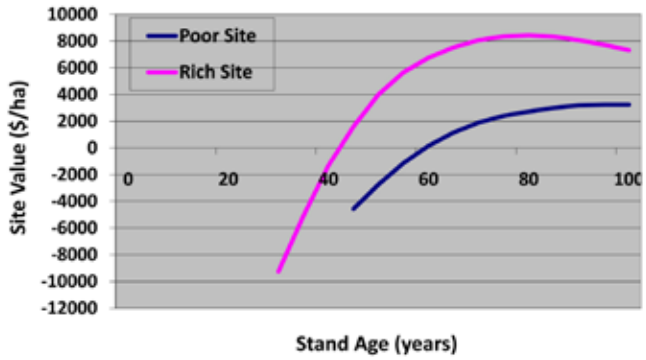


Figure 9: *Comparison of site value development (@2% discount rate) for stands planted with 1300sph of Cw, Fd and Sx (1/3 of each) on two different sites in RSI*



While it would be beneficial to pursue improvements to stocking standards and related systems, there are other components of the overall regulatory and policy framework that likely limit the potential for improvement.

Stocking standards are just one part of the system that influences basic regeneration performance. The other key components of the system are:

- The tenure system, (including free growing requirements), and
- The stumpage appraisal system.

No one part of the system can overcome the impacts associated with one or the other components (McWilliams, 2009). Until the interaction of all of the components provides an environment that encourages licensees to better overall reforestation performance, the majority of the opportunities for improvement may not be realized.

13 Site indices were estimated from managed stands adjacent to the assessed blocks.

4.0 CONCLUSIONS

Under this project, stocking standards for three FSPs were reviewed and compared against TSR assumptions. In addition, stocking standards in RESULTs for 15 blocks each from two of the FSPs and 9 blocks from the other FSP were checked against the FSP stocking standards. Finally, 10 logged to un-logged blocks each from two FSPs and 9 blocks from the other FSP were field checked for accuracy of the application of the stocking standards and consistency of silviculture treatments with the stocking standards. The key results were:

- Under FRPA, where FSP holders rolled over previously approved stocking standards, it was assumed that the standards were consistent with TSR. As the three sets of FSP stocking standards assessed in this project were largely grandfathered, previously approved standards, they were assumed to be consistent with the existing TSRs. Therefore, for these situations, the pertinent tests are whether TSR assumptions are consistent with the stocking standards and practices (actual and planned). This situation is similar to what existed pre-FRPA. Despite the flexibilities provided by FRPA to develop new stocking standards, these provisions were not used bythe three FSP holders.

  Depending on the FMU, for the three situations reviewed, there is a reasonable and improving linkage between stocking standards and TSR. The improvements are based on having separate TSR assumptions for existing managed stands versus future stands and on better linkages of TSR managed stand assumptions, the BEC system and reforestation results and plans. This is a good framework for future improvements in stocking standards.

  Of potential significance to short- to mid-term timber supply is having good estimates of the performance of stands regenerated based on the stocking standards. This information is also critical to assess whether the stocking standards are creating stands which meet the forest-level objectives and TSR assumptions or whether they should be changed. An extensive and intensive monitoring program would provide the required information.

- A transcription error occurred when transferring two components of the stocking standards for one FSP into RESULTs. These administrative errors will not likely lead to significant problems as the licensee is managing to the correct standards.

- Given the generic nature of the existing stocking standards, they are being reasonably applied to most logged areas. However, there is room for improvement in ecological site identification, stratification and the identification and consideration of landscape-level forest health factors that could impact regenerated stands after free growing when developing reforestation prescriptions.

- Silviculture treatments are consistent with achievement of the existing stocking standards.

- Overall, in the majority of areas assessed under this project, stocking standards have played, and are playing, a positive role in good overall reforestation results. However, there is significant concern for the future development of pine-leading stands established according to the stocking standards in the area represented by the RNI FSP inspections. The concerns relate to the impacts of the high incidence of hard pine stem rusts and/or the poor quality attributes of pine stands on medium to good sites grown to the densities targeted in the stocking standards. There should be considerable concern about this situation given the:

- Widespread use of pine established at similar densities in the interior,

- Widespread range and incidence of forest health agents which affect pine, and the uncertainty about the impacts of these health issues on future stand development, and

- The importance of existing managed and future stands to the mid-term timber supply in MPB impacted FMUs.

  Although monitoring projects in several of the areas, which are at high risk to forest health agents affecting pine, have confirmed that incidence levels are generally high, there is uncertainty about the future impacts. Better understanding of the potential impacts and, if needed, development of action plans to address the issues should be a top priority.

- For the most part, stocking standards have not changed significantly over the last 20 years. In light of the recent mountain pine beetle infestation, changes in technology that are forecast to influence utilization limits and desired forest products, and concerns for the impacts from climate change, it is timely to review many of the

current FSP stocking standards in the context of changing landscape-level objectives and assumptions about the future.

As part of a holistic review of stocking standards, there are opportunities for improvement that should be explored. Most of these improvements involve better linkages between the site limiting factors and site productivities associated with the regional ecological classification systems, the stocking standards and the cost/benefits of silviculture.

Given the interrelationship between stocking standards and the rest of the forest policy and regulatory system, improvements in stocking standards on their own can only have a limited effect on overall reforestation performance. Changes to other policy areas may need to be considered.

5.0 RECOMMENDATIONS

1) There is an immediate need to review TSR, stocking standards and reforestation practices in areas where immature pine leading stands are at high risk from forest health agents. The MFR should lead this process with the involvement of licensees.
2) There is the need for short and long term research on the impacts of forest health agents affecting immature pine. It is critical that monitoring is coupled with experimental work to understand the mechanisms behind the system changes.
3) There is a need for extensive and long-term monitoring of free growing stands throughout B.C. to ensure they are meeting timber supply projections and quality expectations.
4) General improvements to stocking standards should be pursued based on:
    - More differentiation of the standards that reflect changes in significant ecological and site limiting factors and are based on a cost/benefit framework. In some areas, an updated ecological site identification process may also be required.
    - The standards being more reflective of forest health issues that can impact stands from initiation to expected rotation.
    - The standards being more sensitive to wood quality.
    - Updated, specific, integrated regional objectives for timber (solid wood and fibre) and non-timber values (including carbon).

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APPENDIX I: