

Nadina 2013 Draft Stocking Standards Rationale

Released January 2014

Introduction

The Nadina District consists of the Lakes and Morice Timber Supply Areas (TSAs). The Lakes TSA features predominantly fire-origin pine stands, with the Morice featuring a more diverse mix of pine and spruce stands. Pine was historically planted on mesic and drier sites, with spruce on moist, low-lying areas. Mixed plantations were uncommon until approximately 2001, when licensees began planting a mix of pine and genetically-improved spruce. Warm winters and moist summers contributed to the peak of the mountain pine beetle epidemic in 2005, and these changes in climate also contributed to increased forest health issues - specifically stem rusts - in both TSAs. These changes have led forest professionals to consider the importance of landscape level species diversity, increased initial stand establishment densities, and subsequent changes to stocking standards to maintain or enhance a commercially valuable supply of timber.

On November 12, 2013, the Nadina District Manager forwarded Draft Nadina Stocking Standards with an accompanying memo to licensees for consideration in their next Forest Stewardship Plan (FSP) or FSP extension. This rationale has been prepared in support of the proposed Draft 2013 Nadina Stocking Standards.

History of Stocking Standards

Stocking standards were first introduced in British Columbia in the 1940s. The concept of the “well-spaced tree” was introduced in 1987, when licensees became responsible for reforestation costs, and basic silviculture funding was provided through the stumpage system. More recently, the *Forest and Range Practices Act* (FRPA) and its regulations took effect on January 31, 2004. One of the government’s objectives under FRPA was to “*reduce the complexity and prescriptive nature of the Forest Practices Code. FRPA was intended to reduce administrative and operational costs for both the industry and government while continuing to maintain high levels of environmental stewardship, public confidence and a strong compliance and enforcement regime. FRPA was meant to enable, not mandate, flexibility and innovation in determining approaches to forest practices.*”¹

In October 2006, the Forest Practices Branch developed a reference guide for the evaluation of stocking standards under FRPA². The document was intended to provide overview guidance to Ministry of Forests and Range staff in reviewing and approving stocking standards under FRPA, as well as assist licensee staff or consultants who are preparing FSPs and associated stocking standards. In this document, the Forest Practices Branch stated that “The guide [*Reference Guide to FDP Stocking Standards*] provides a baseline of knowledge for FSP developers and reviewers – however it is not to be blindly accepted as the final word on this topic.”³

¹ Ministry of Forests and Range, Forest Practices Branch. 2006. “An Overview Reference for The Evaluation of Stocking Standards under FRPA”. October 2006, pg. 3, accessed November 27, 2013,

<http://www.for.gov.bc.ca/ftp/hfp/external/publish/FSP%20stocking%20standards/FSPstkstdsGuide.pdf>.

² Ibid.

³ Ibid, pg 7.

Default stocking standards were originally developed to assist woodlot owners in preparation of woodlot license plans. Although FRPA was intended to enable flexibility and innovation, the majority of licensees proposed standards very similar, with some variations, to those in the reference guide (which were developed under the Forest Practices Code regime). These reference guides were not developed for this purpose, as they were presented for information only, and were meant to be customized by the licensees for development of stocking standards within their individual FSPs. The guidebooks do specify that it is prudent to increase target and minimum stocking standards where local experience or conditions indicate higher levels of random mortality. Practitioners were encouraged to consider forest health concerns for specific species and site combinations, and to consult with local forest health specialists for information.

The Establishment to Free Growing Guidebook⁴ under the heading “Selecting Appropriate Stocking Levels” provides a synopsis of the objectives and assumptions that were used to develop the current target and minimums now included in the reference guide. The target density of 1200 stems per hectare (sph) was selected through a consideration not just of volume, but of piece size and value. The minimum of 700 sph was typically set at a point approximately 80% of the volume produced by a stand at target density⁵.

Forest Planning and Practices Regulation (FPPR) Sections 16, 44, 45, and 26, as well as Schedule 1 (6), specify the conditions and factors that must be considered when a professional is developing or approving stocking standards. The challenge is to determine whether stocking standards meet the tests in FPPR Section 26 (3) or, if not, whether the standards proposed are “reasonable” having regard to the future supply of timber under Section 26 (5). The original reference guides were based on extensive ecological and growth and yield plot data filtered through expert opinion. They did not take into account climate change; however, the footnotes were updated in 2010 with forest health information. Land Management Handbook 50⁶ discusses the silviculture survey system used by the B.C. Ministry of Forests to assess stands for free-growing status, and examines survey parameters and potential impact on volume at rotation.

Provincial and Local Circumstances

Rust occurrence and severity

Forest health surveys in the Nadina have shown that between 1995 and 2011, the level of high rust incidence in plantations has increased by 29%. Recent forest health surveys show that rusts are present in 99% of the sampled plantations. About 41% of these have high incidence (>20%) of rust (see Figure 1.0). Western gall rust and comandra blister rust are the most prevalent diseases. There appears to be no pattern of distribution, and therefore the past strategies to manage pine according to areas of higher or lesser risk

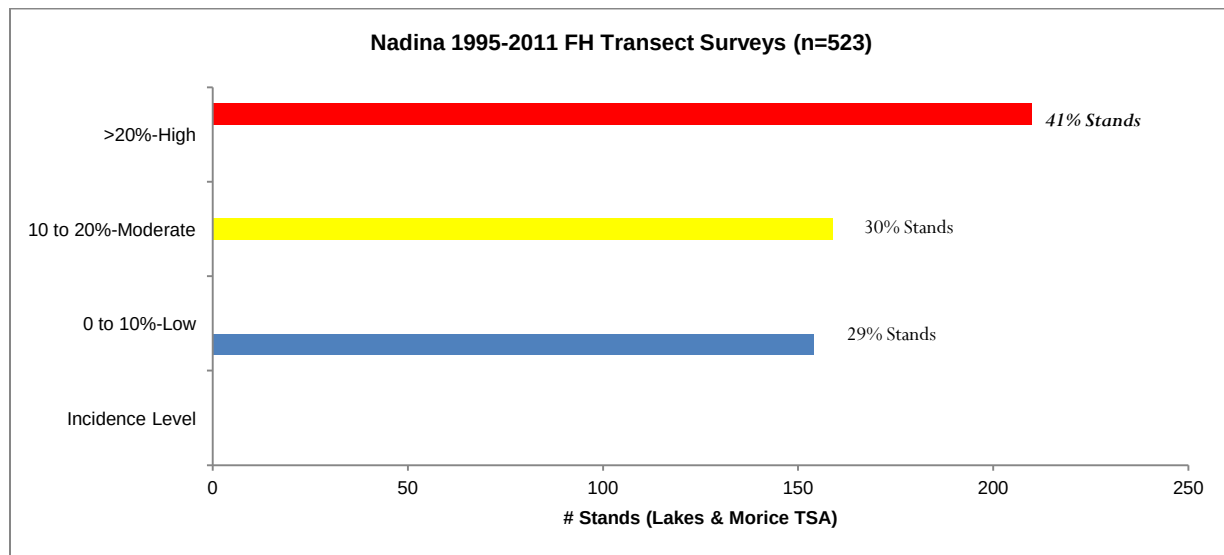
⁴ B.C. Ministry of Forests. 2000. Establishment to Free Growing Guidebook. Prince George Forest Region. Rev. ed., Version 2.2. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook, accessed November 28, 2013, <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/FREE/EFG-PG-print.pdf>.

⁵ Bergerud, W.A. 2002. The effect of the silviculture survey parameters on the free-growing decision probabilities and projected volume at rotation. Res. Br., B.C. Min. For., Victoria, B.C. Land Management Handbook No. 50, accessed November 28, 2013, <http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh50.pdf>, pg. 21.

⁶ Ibid.

of infection is no longer valid⁷. In studying the southern interior of British Columbia, Mather et al found that “over one-quarter of lodgepole pine plantations have substandard stocking levels soon after being declared free-growing as a result of insect, disease and abiotic damage...”⁸ In studying forest health and climate change in British Columbia, Woods et al⁹ state that “Changes in climatic conditions that result in warmer and wetter late springs and summers will likely increase the risk of damage in most areas that already suffer losses to rusts.”

Figure 1.0 Nadina 1995-2011 Forest Health Transect Survey Results



Stand Development Monitoring (SDM) Results

The high rust incidence found in forest health surveys is mirrored in results from Nadina District Stand Development Monitoring (SDM) assessments¹⁰ where a total of 80% of the sampled stands had rust. Other forest health factors included abiotic deformities and vegetative competition. SDM assessments are indicating that in the 11 years – on average – between a free growing declaration and the SDM sampling, the healthy well-spaced (WS) density decreased by an average of 15% (<1% to 42%). Preliminary results of the 2013 SDM surveys (15 samples) show a similar trend of high rust incidence and decreased well-spaced density between free growing declaration and SDM sampling.

Well-spaced density in TIPSy versus SDM

Figure 2.0 shows projected changes in well-spaced density over a 90-year rotation for typical lodgepole pine plantations, based on initial planting densities covering a range from 1000-2000 stems per hectare in

⁷ Forest Health Strategy - Nadina District 2013-2014, Appendix 1&2 – Lakes/Morice TSA Rust Occurrence Maps, pgs. 37-38, accessed November 28, 2013, http://www.for.gov.bc.ca/ftp/DND/external!/publish/Forest_Health/.

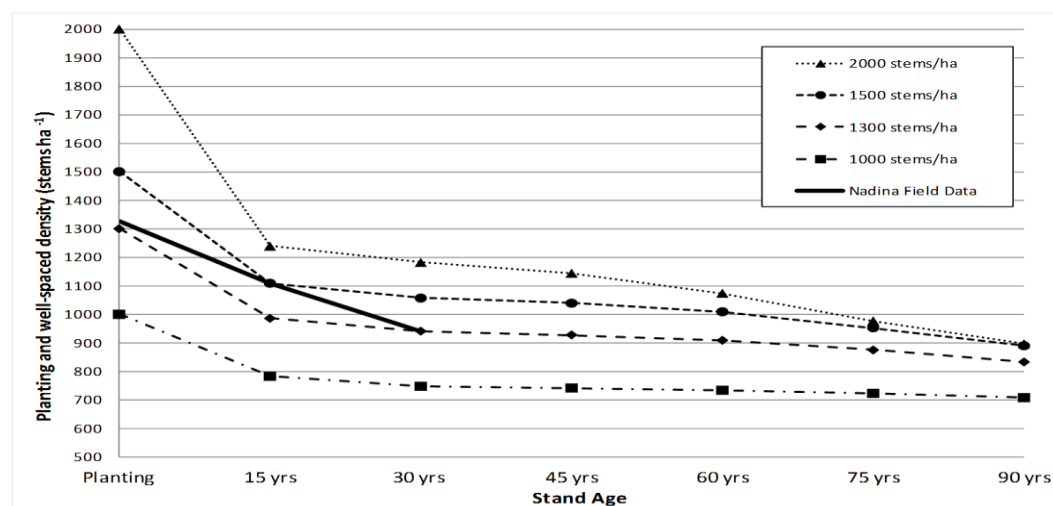
⁸ Mather, Simard, Heineman and Sachs. 2010. Decline of planted lodgepole pine in the southern interior of British Columbia. *The Forestry Chronicle*, Vol 86 No. 4:484-497.

⁹ Woods, et al. 2010, “Forest Health and climate change: A British Columbia perspective,” *The Forestry Chronicle*, July/August 2010, Vol. 86, No. 4 (2010), accessed November 29, 2013, http://www.fs.fed.us/rm/pubs/rmrs_gtr292/2010_woods.pdf.

¹⁰ 2012 Nadina District FREP Summary: Timber (Stand Development Monitoring), accessed November 29, 2013, http://www.for.gov.bc.ca/ftp/DND/external!/publish/Forest_Health/.

the Nadina Forest District. The graph shows projected changes based on the growth and yield application Table Interpolation Program for Stand Yields (TIPSY) (version 4.2).

Figure 2.0¹¹ Projected changes in well-spaced density based on TIPSY compared to field data



Current timber supply projections for the Nadina District assume an initial planting density of 1500 stems per hectare. According to TIPSY projections with this initial planting density, well-spaced densities should vary by approximately 18% between year 15 and year 90, and 30 year old stands should have well-spaced densities of about 1050 stems per hectare. TIPSY projections for typical pine-leading stands also show that well-spaced densities after year 15 tends to be relatively stable, regardless of the initial planting densities.

SDM results from 31 randomly selected managed stands (graphed as a solid line on Figure 2.0) show that the sampled stands are, in general, following the trajectory projected by TIPSY for a stand established at 1300 sph. If forest health or other factors continue to impact the stands, resulting in a continuation of the same trajectory, the well-spaced densities will fall below TIPSY projections. Projections of ongoing climate change, coupled with its influence of forest disturbance agent behavior, will likely produce an increasingly significant downward pressure on healthy, well-spaced densities over time. Higher initial planting densities provide a buffer in the event that endemic forest health or other stand dynamics further reduce stocking levels.

Density versus Wood Quality and Value

SDM assessments are also showing that about 96% of the sample stands are below 1200 sph (see Figure 3.0), the target density stated in the Establishment to Free Growing guidebook. According to the guidebook, the target density of 1200 sph was selected through a consideration not just of volume, but of piece size and value, and the conifer species selection and stocking tables were developed for the primary

¹¹ Forest Health Strategy - Nadina District 2013-2014, pg. 7, accessed November 28, 2013, http://www.for.gov.bc.ca/ftp/DND/external/publish/Forest_Health/2013_DND_Forest%20Health%20Strategy.pdf.

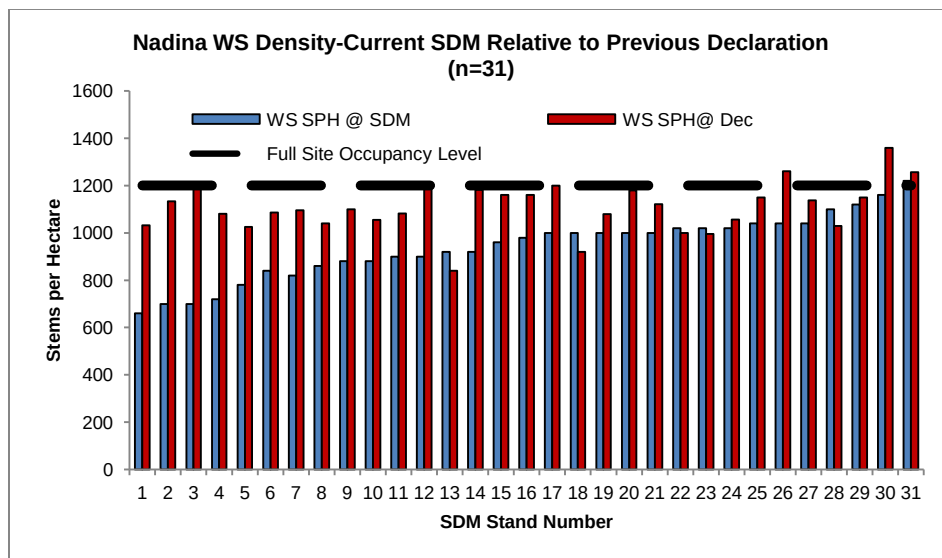
management objective of sawlog production under an even-aged system¹². The conifer stocking guidelines assume that sawlogs are the primary product objective, and considered the trade-off between piece size, value and maximum volume production.¹³

Dymond reports that 84% of BC annual timber harvest goes to lumber mills, 8% to plywood and veneer mills, 5% to chip/pulp mills and 3% to panel/ medium density fibre board mills. Of the volume that goes to the lumber mills, approximately 47% ends up as lumber. From the scaled harvest plus bark, approximately one-third goes to lumber, one-third to bioenergy, and one-third to pulp, paper and other products.¹⁴ Through Government's 'Beyond the Beetle: A Mid-Term Timber Supply Action Plan', there is a commitment to "engage industry in a review of stocking standards to ensure future stands are resilient to climate change and have the potential to optimize fibre production in the future."¹⁵

Figure 3.0 shows the Nadina SDM results relative to the previous declaration:

- The average planting density on the stands sampled for SDM was 1325 sph. The mean age of these stands at the time of the survey was 26 (stands planted mid- to late-1980s).
- The average well-spaced density of 942 sph is 22% below 1200 sph (generally accepted as "full site occupancy level" of healthy well-spaced stems), and 81 % of the stands were equal to or below 1200 well-spaced sph at declaration.
- Well-spaced density is forecast in TIPSY to decline over the rotation but slowly after age 15, and remain relatively stable after that time.
- The average number of years between the free growing declaration and the SDM sampling is 11.

Figure 3.0 Nadina 2010-2012 Stand Development Monitoring Results



¹² B.C. Ministry of Forests. 2000. Establishment to Free Growing Guidebook. Prince George Forest Region. Rev. ed., Version 2.2. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook, accessed November 28, 2013, <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/FREE/EFG-PG-print.pdf>, pg 4.

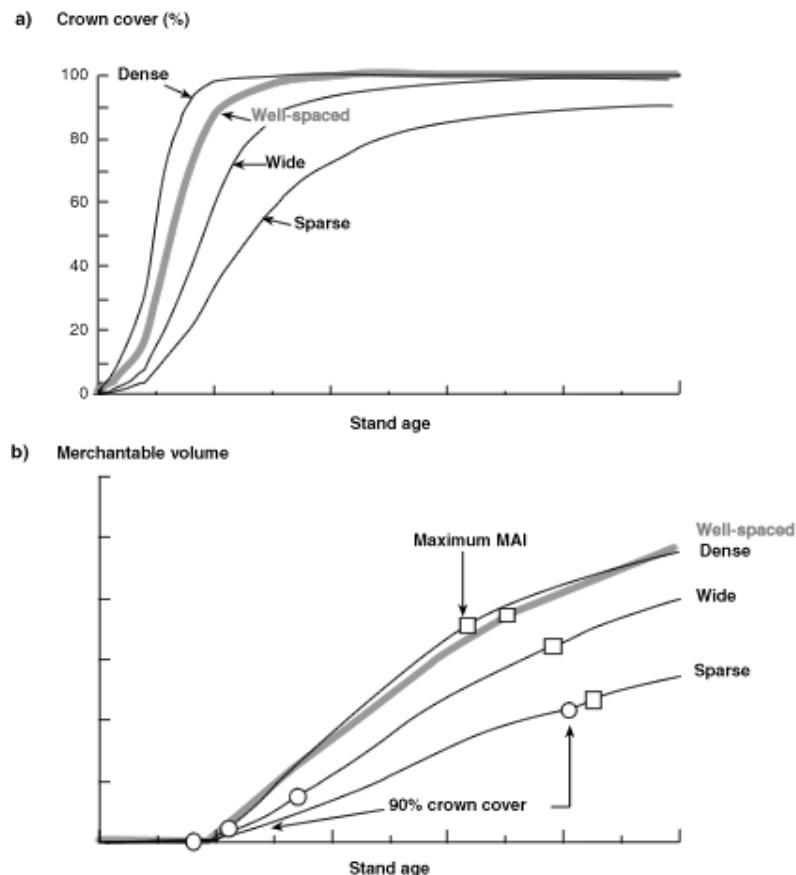
¹³ Ibid, pg. 15.

¹⁴ Dymond, Caren C. 2012. Our Log's Story from Truck to Product. Prov. B.C., Victoria, B.C. Extension Note 107, accessed December 19, 2013, <http://www.for.gov.bc.ca/hfd/pubs/Docs/En/En107.pdf>

¹⁵ Prov. B.C., Victoria, B.C. Beyond the Beetle: A Mid-Term Timber Supply Action Plan, accessed December 20, 2013, http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/mid-term-timber-supply-project/MTTS-Action-Plan-201210.pdf

Since 1940, plantation espacement in BC has ranged from two metres (2500 sph) to four metres (625 sph). The guidelines for developing stand density management regimes published by the Forest Practices Branch state, “Full site occupancy is achieved quickly if the establishment density is moderately high and the spatial distribution of trees is uniform. Uniformity increases in importance as establishment density decreases. Site occupation by tree crowns [Figure 4a] and merchantable volume [Figure 4b] decline in response to decreasing establishment density. Any clumping of the same number of stems will reduce the stand yield even further...Note that it is the unoccupied growing space or "holes" in the stand canopy that reduce timber yield - not the clumpiness itself. Low density stands produce less volume initially because there are too few trees to exploit the available growing space. The rate of stand growth improves after crown closure.”¹⁶ Ralph Winter states that a minimum inter-tree distance (MITD) of 2.0 metres has been specified as extensive analysis showed that by dropping the MITD from 2.0 to 1.6 metres was the equivalent of reducing the target stocking standard by 200 well-spaced stems per hectare.¹⁷ Bergerud also concludes, “Accepting a lower value for the MITD is equivalent to reducing the MSS and allowing strata with lower potential volumes a greater chance to be declared free-growing.”¹⁸

Figure 4. Espacement affects a) site utilization and b) volume production



¹⁶ Guidelines for Developing Stand Density Management Regimes. 1999. Forest Practices Branch, BC Ministry of Forests, accessed December 19, 2013, <http://www.for.gov.bc.ca/hfp/publications/00083/sdm-18.htm>

¹⁷ Personal communication with Dawn Stronstad, Nadina Stewardship Forester, December 2013.

¹⁸ Bergerud, W.A. 2002. The effect of the silviculture survey parameters on the free-growing decision probabilities and projected volume at rotation. Res. Br., B.C. Min. For., Victoria, B.C. Land Management Handbook No. 50, accessed November 28, 2013, <http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh50.pdf>, pg. 21.

Young Stand Monitoring (YSM) Results

Fifty ground Young Stand Monitoring (YSM) ground plots were established in the Morice TSA in 2012 to monitor young stands. The primary focus of YSM is to check the accuracy of the growth and yield assumptions and predictions of key timber attributes in young stands for timber supply review in a management unit. The YSM plots include an assessment of damage agents and severity on individual trees, to assess forest health. By basal area, 36% of the trees had no damage, and 31% had damage by unknown agents. The majority of the remaining damage was due to disease (19%)¹⁹.

Guidance on Species Diversity at the Landscape Level

On September 24, 2009, the Chief Forester issued a memo entitled Guidance on Tree Species Composition at the Stand and Landscape Level,²⁰ in which he stated how vulnerable single species stands can be to pest infestation. The memo provided guidance to professionals and tenure holders on how to address the potential risks to immediate and long-term forest health associated with species selection decisions. On June 11, 2012, Jim Sutherland, Deputy Chief Forester, issued a memo regarding the issuance and use of TSA Tree Species Monitoring Reports,²¹ in which he stated “Species diversity is a very important consideration in forest management in British Columbia and is a fundamental climate change adaptation strategy.” Tree species monitoring reports are available to allow professionals or tenure holders to plan their planting and stand management activities, as well as monitor their own diversity trends.²²

Guidance on Forest Health Factors

On June 21, 2012, Jim Sutherland, Director of Resource Practices Branch/Deputy Chief Forester, issued a memo²³ to provide guidance related to adjudicating FPPR Section 26 requirements that stocking standards address both immediate and long-term forest health issues. It was noted that the transition to mid-term TSA harvest levels is highly dependent on yield curves and regeneration delays used in the TSR analysis, and that it is increasingly important that the stocking standards in FSPs are aligned with the assumptions in the TSR. The importance of accounting for new or existing information related to forest health hazards and risks was also highlighted. The Deputy Chief Forester emphasized the expectation that prescribing foresters will consider local forest health information in developing and assessing stocking standards and species choices to determine if their decisions will reduce losses to these factors in managed stands now

¹⁹Ministry of Forests, Lands and Natural Resource Operations, Forest Analysis and Inventory Branch, September 2, 2013, Young Stand Monitoring in the Morice TSA: Plot Establishment Report, accessed November 29, 2013, http://www.for.gov.bc.ca/hfs/vri/monitoring/downloads/Morice_TSA_Young_Stand_Monitoring.PDF

²⁰Snetsinger, J. 2009. “Guidance on Tree Species Composition at the Stand and Landscape Level”, Ministry of Forests and Range, Forest Stewardship Division Memo, September 29, 2009, accessed November 27, 2013, <http://www.for.gov.bc.ca/hfp/silviculture/TreeSpeciesSelection/Chief%20Forester%20Guidance%20on%20Tree%20Species%20Composition.pdf>

²¹ Sutherland, J. 2012. “Issuance and Use of TSA Tree Species Monitoring Reports”, Ministry of Forests, Lands and Natural Resource Operations, Resource Practices Branch Memo, June 11, 2012, accessed November 27, 2013, http://www.for.gov.bc.ca/hfp/sof/species/TSA%20Species%20Report%20Memo%20JD%20e_signature_Weaver%20120607.pdf

²² Ministry of Forests, Lands and Natural Resource Operations, Species Monitoring Reports – 2012, accessed November 22, 2013, <http://www.for.gov.bc.ca/hfp/sof/species%20monitoring%20reports.htm>.

²³ Sutherland, J. 2012. “Guidance for assessing FSP stocking standards alignment with addressing immediate and long-term forest health issues”, Ministry of Forests, lands and Natural Resource Operations, Deputy Chief Forester Memo, June 21, 2012, accessed November 27, 2013, <https://www.for.gov.bc.ca/hfp/silviculture/Guidance%20for%20assessing%20FSP%20stocking%20standards%20June%202012.pdf>.

and in the future. Additional guidance, including general information, forest health strategies, and forest health decision aids, can be found on the government webpage.²⁴

Guidance on Climate Change

On April 2, 2013, Assistant Deputy Minister (ADM) Tom Ethier issued a memo²⁵ stating that the impacts of climate change need to be addressed as part of the long-term forest health test by those preparing Forest Stewardship Plans and those reviewing plans submitted for approval or extension. He encouraged licensees to “develop timely and responsive climate change adaptation strategies”²⁶. The ADM noted that climate adaptation strategies may include increased deployment of ‘non-conventional species’, and that increasing establishment density to account for risk of seedling mortality of these ‘non-conventional species’ may be the best option for managing risk and uncertainty. The ADM also highlighted the “flexibility that exists within the current legislative framework to enable innovative approaches to stocking standards establishment consistent with climate change adaptation strategies and approaches, and to address potential risks associated with innovative reforestation practices.”²⁷

Forest Health Impacts on Maintaining/Enhancing an Economically Valuable Supply of Timber

Section 26 of the *FPPR* indicates that one of the key tests for the Minister (or DDM) to use when evaluating stocking standards is whether the proposed stocking standards address long-term forest health issues to a density that is consistent with maintaining or enhancing an economically valuable supply of commercial timber. *TSR and forest management assumptions incorporate a normal or average level of mortality beyond free growing.* Forest health factors such as hard pine stem rusts reduce the total and well-spaced density of stands, and also create voids.

Virtually all TSRs in the province are based on Table Interpolation Program for Stand Yields (TIPSY). TIPSY forecasts a stable timber flow, provided the well-spaced (WS) density is above 1000 stems per hectare (sph). TIPSY also forecasts that the vast majority of tree mortality that a managed stand will suffer takes place prior to age 15, regardless of the initial planting densities. After age 15, WS densities are forecast by TIPSY to be relatively stable.

Current timber supply projections for the Nadina District assume an initial planting density of 1500 stems per hectare. According to TIPSY projections with this initial planting density, well-spaced densities should vary by approximately 18% between year 15 and year 90, and 30 year old stands should have well-spaced densities of about 1050 stems per hectares.

In contrast, SDM results show that well spaced densities have declined by 15% since their free-growing declaration or designation, and are on average 10% below the forecast density of 1050 sph at age 30. The decline in density is not yet a crisis, but given the recent decline in planting densities and the increasing

²⁴ Ministry of Forests, Lands and Natural Resource Operations, Forest Health webpage, accessed November 21, 2013, <http://www.for.gov.bc.ca/hfp/health/index.htm>.

²⁵ Ethier, T. 2013. “Consideration of Climate Change When Addressing Long-Term Forest Health in Stocking Standards”, Ministry of Forests, Lands and Natural Resource Operations, Resource Stewardship Division Memo, accessed November 21, 2013, <http://www.for.gov.bc.ca/HFP/silviculture/Consideration%20of%20Climate%20Change%20Memo.pdf>.

²⁶ Ibid, pg.1

²⁷ Ibid, pgs 2,3

trend in forest disease and insect impacts in juvenile managed stands, it appears likely that managed stands are not following the trajectory projected by TIPSy.

Rust

Strategies to Address Rust

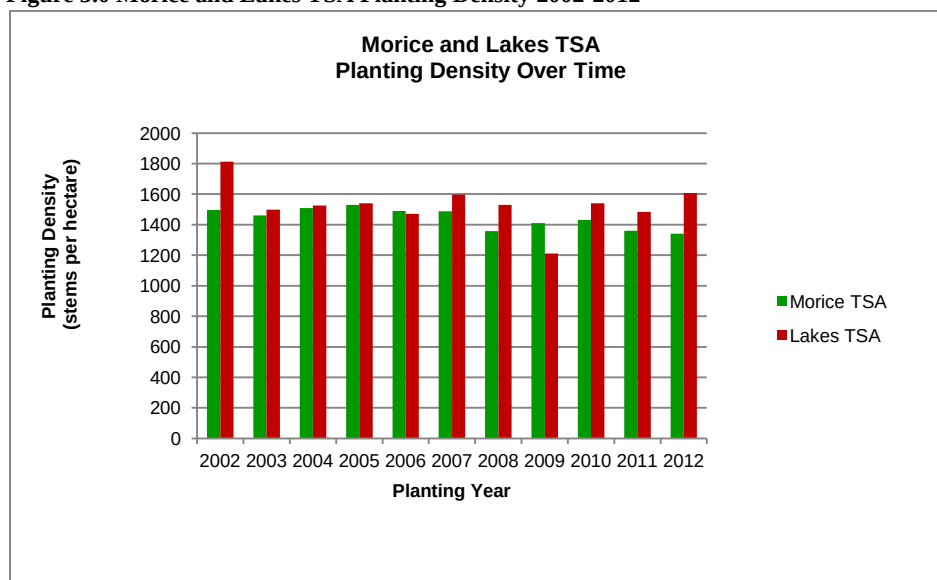
Updated annually since 1999, Forest Health Strategies as early as 2003 listed hard pine rusts as a significant forest health factor in both TSAs. Maximizing species diversity through planting of non-host species and initial planting densities of 2200-2400 sph have historically been recommended management tactics to address increasing levels of rust. On August 1, 2013, the Nadina District 2013-2014 Forest Health Strategy²⁸ was released. Strategies to reduce the impact of pine stem rusts include avoiding reforestation with 100% pine, increase planting densities to 2200-2500 stems per hectare in pine leading plantations (at least 50% pine), and planting non-host species where these species are ecologically acceptable. The Pine Stem Rust Management Guidebook also suggests alternate species establishment and increased target stocking to compensate for future mortality²⁹.

Planting Density Over Time

The average planting density in both the Lakes and Morice TSAs has decreased by approximately 12% over the last 10 years:

- Lakes: averaged 1813 sph in 2002, and 1607 sph in 2012
 - Morice: averaged 1496 sph in 2002, and 1342 sph in 2012)
- (see Figure 5.0)

Figure 5.0 Morice and Lakes TSA Planting Density 2002-2012



²⁸ Forest Health Strategy - Nadina District 2013-2014, accessed November 28, 2013,

http://www.for.gov.bc.ca/ftp/DND/external/publish/Forest_Health/2013_DND_Forest%20Health%20Strategy.pdf

²⁹ Pine Stem Rust Management Guidebook, Government of British Columbia, accessed December 5, 2013,

<http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/pinestem/pine1.htm#tmrs>

Spruce planting has increased in both TSAs over the last 10 years, but the density of the spruce plantations has decreased (see Figures 6.0 and 7.0). Current (decreasing) planting densities are not sufficient to keep up with TSR forecasts, given the decreases in managed stand densities post free-growing.

Figure 6.0 Morice TSA Planting Density 2002-2012

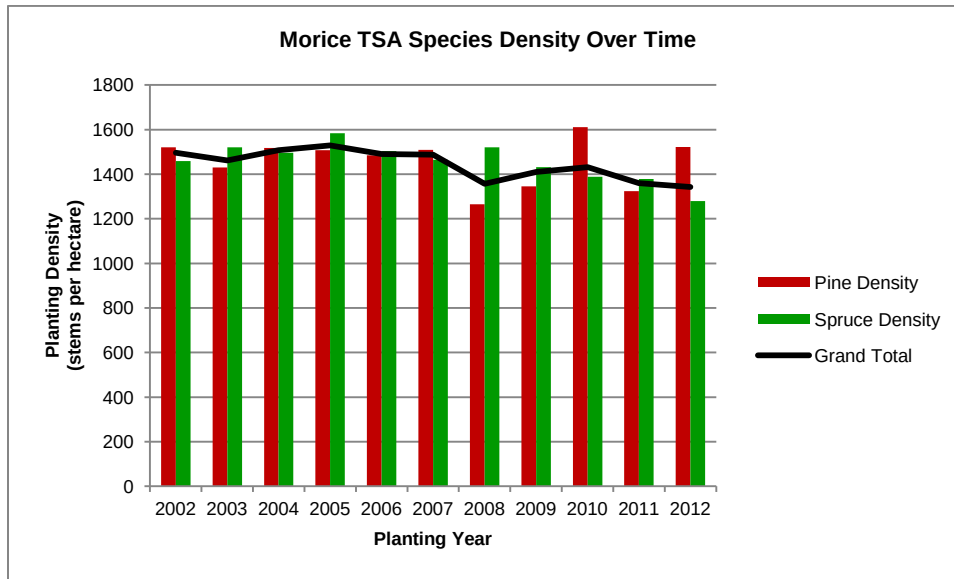
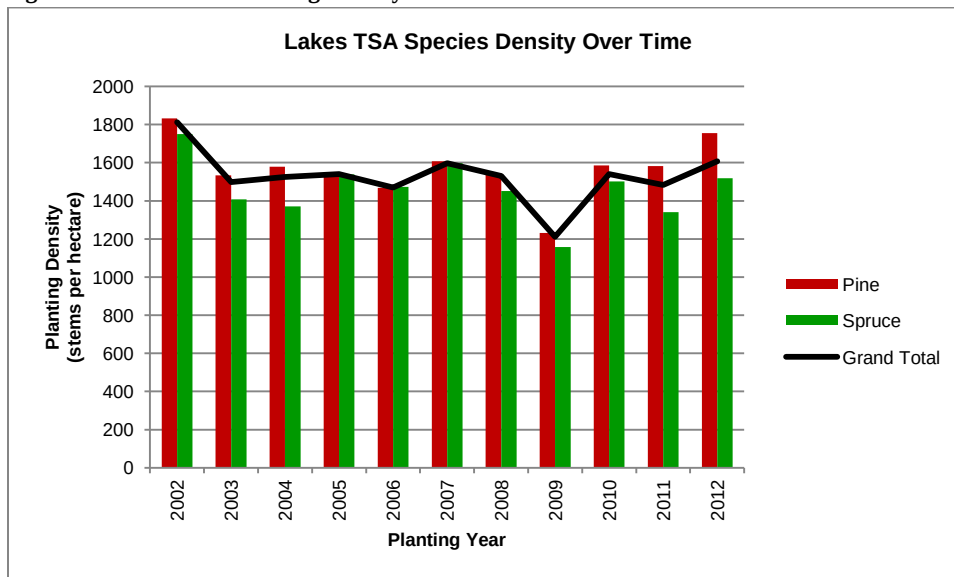


Figure 7.0 Lakes TSA Planting Density 2002-2012



Current planting practices in the Nadina have not followed the recommendations found in the Forest Health Strategy. Planting densities have decreased to well below recommended strategic levels.

Increased Stocking Densities Where Pine Constitutes >50% of Stocking

To recognize the additional costs associated with increased planting densities (while still seeking optimum seedling establishment) the proposed stocking and free growing densities were chosen. The decision to increase planting density for stands where pine constitutes > 50% of stocking has been made due to the elevated risk of loss associated with pine as compared to other coniferous species in the area. The SBSdk 01, for example, is an ecological unit that is prone to high losses from rusts, particularly comandra blister rust. The density targets have come from this realization, coupled with recognition of the stand densities required to maximize future volume productivity (see Figure 8.0³⁰ and Table 1.0).

Figure 8.0 Seedling density and volume prediction relationships

(PMV is the proportion of maximum future volume per hectare predicted from the observed understorey density)

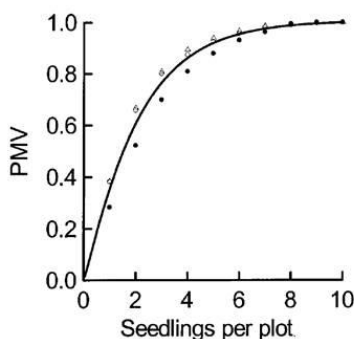


Figure 2. Seedling density and volume production relationships for plantation Douglas-fir on site index 19 m (open circle), lodgepole pine on site index 17 m (solid circle), and interior spruce on site index 21 m (triangle) predicted by the stand growth model TIPSy. PMV is proportion of maximum volume. Seedling plot size is 0.005 ha. Solid line is the fitted relationship (Equation 2).

Table 1.0 Example of site series with increased target and minimum stems per hectare when pine is >50%:

	BEC zone and site series	Preferred Species and (Free Growing Height)	Regeneration			
			Acceptable Species (and Height)	Target (sph)	Minimum Stocking (sph)	Minimum preferred (sph)
>50% Pli	SBSdk 01	Sx(1.0), Pli(2.0), Fdi(1.4), Lw(2.0)		2000	1600	1600
	SBSdk 01	Sx(1.0), Pli(2.0), Fdi(1.4), Lw(2.0)		1600	1400	1400
PREVIOUS	SBSdk 01	Pli(2.0), Sx(1.0)	Fdi(1.4)	1200	700	600

The Pine Stem Rust Management Guidebook (1996)³¹ states “A high stand density provides a buffer against rust-caused tree mortality”, as well as listing alternative species establishment and increased target stocking as treatment methods for hard pine stem rusts. In reference to comandra blister rust, Johnson (1986) states “Other than retaining more trees than stocking guides recommend, no practical control measures are available to suppress the rust in young stands. Increased stocking will, over time, be offset

³⁰ Martin, P. et al. 2005. “A New Basis for Understorey Stocking Standards for Partially Harvested Stands in British Columbia Interior”, *West. J. Appl. For.* 20(1):5-12, accessed November 21, 2013, <http://afrf.forestry.ubc.ca/files/2012/03/WJAF-2015-12.pdf> pg 7.

³¹ Pine Stem Rust Management Guidebook, British Columbia Ministry of Forests, accessed December 5, 2013, <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/PINESTEM/pine1.htm#tmhp>.

by rust-caused mortality. In marginally stocked stands, the disease may cause significant losses.”³² Stock et al (2005)³³ also suggest increasing stocking density to offset rust-caused mortality, as well as regenerating with non-host species. “Denser stands appear to have less incidence of comandra blister rust; denser stands reduce the occurrence of alternate hosts and increase the self-pruning lower branches.”³⁴

Upon further examination of Figure 2.0 (page 4), the trajectory that the Nadina SDM stands are following does not parallel the projections for stand density that TIPSy models. If an assumption is made that the desired stand at year 30 has at least the number of stems that a stand established at 1500-1600 sph would have in TIPSy - and the stand follows the same trajectory from 15 to age 30 in terms of healthy well spaced trees as the SDM data indicates - an initial density of 2000 sph (subject to endemic forest health and stand dynamics) would result in slightly more than 1200 well-spaced trees at 15, and just under 1100 at year 30. If the impact of forest health issues is less, the resultant stand at free growing is the desired target 1200 sph at free growing. If forest health issues are a factor, the level of stocking is reasonable - one that produces the predicted yield for a stand with 1100 sph at free growing.

The recommended increases in initial planting densities are a result of the realization of increasing losses to forest health agents in pine stands and the fundamental principle of managing the provincial forest resource to maximize benefits and opportunities for both present and future generations. Greater than 50% pine, particularly at regeneration delay, indicates that on a site with that stocking standard, the species being actively managed as a “future crop” is pine.

Increased non-host species

Species choices have come from a combination of modelling efforts that have shown increasingly favourable conditions for larch and Douglas-fir in the Central Interior, and the increasing body of evidence that suggests losses to lodgepole pine (in particular) are rising and are beyond what was considered in our growth and yield forecasts. See Table 1.0 above for an example of non-host species (larch) incorporated into the stocking standards.

The modelling efforts conducted by G. Rehfeldt (US Forest service ret.) and Barry Jaquish (Ministry of Forest, Lands and Natural Resource Operations, Kalamalka Research Station) resulted in the expanded range for western larch³⁵. The same process is underway for interior Douglas-fir, and is expected to be ready for publication in six to eight months. LePage³⁶'s research examining operational field plantations of both Douglas-fir and larch in the Nadina, Skeena, and Kalum Forest Districts shows that the species have the potential to perform well in areas that are well outside the existing and expanded range. In

³² Johnson, D. “Comandra Bliser Rust”, U.S. Department of Agriculture, Forest Service, Forest Insect & Disease Leaflet 62, June, 1986, accessed December 5, 2013, <http://www.na.fs.fed.us/spfo/pubs/fidls/comandra/comandrafidl.htm>.

³³ Stock, A., M. Duthie-Holt, S. Walsh, J. Turner, and K. Swift. 2005. Southern Interior Forest Region: Forest health Stand Establishment Decision Aids. *BC Journal of Ecosystems and Management* 6(1):55–73, accessed December 6, 2013, http://www.forrex.org/sites/default/files/pages/files/vol6_no1_art6.pdf

³⁴ Ibid, pg.60

³⁵ Rehfeldt, G. and Jaquish, B. 2010. “Ecological impacts and management strategies for western larch in the face of climate-change”, *Mitig Adapt Strateg Glob Change* (2010) 15:283-306, accessed November 27, 2013, doi: 10.1007/s11027-010-9217-2, http://www.fs.fed.us/rm/pubs_other/mrs_2010_rehfeldt_g001.pdf

³⁶ Phil LePage, Research Silviculturist, Ministry of Forests, Lands and Natural Resource Operations, Skeena Region

addition, there has been extensive climate modelling efforts by Wang et al. (2012)³⁷ and DeLong et al. (2010, 2012)³⁸ that show the climate shifting to more suitable regimes for both species in many areas of the Nadina. It takes a considerable length of time for conifers to mature, and the climate will continue to change. Climate modelling has provided guidance to move forward with expanded ranges for both Douglas-fir and larch in the Nadina District.

Climate Change

Climate Change Forecasts for the Nadina

According to Price and Daust (2011)⁴⁰, the climate in the Nadina is expected to get warmer and wetter, on an annual basis, with temperature and precipitation in winter increasing more than in summer. Projected future climate envelopes for the SBS in the Nadina Forest District range from mostly SBS to mostly ICH-IDF or IDF-ICH, depending on climate scenario projection.⁴¹ The health of British Columbia's forests is being influenced by climate change, and is most pronounced in young managed stands.⁴² Current climate change forecasts indicate that pine may not be a reliable crop species in the future. Spruce reliability may also change on those site series that may get drier as a result of climate change. Resilient ecosystems that can adapt to climate change require species diversity at the landscape level. Currently, the proportion of planted species on the landscape in the Nadina District differs from the natural stands at the landscape level.

In February 2012, the Ministry of Forests, Lands and Natural Resource Operations issued a memo announcing the release of "B.C.'s Forest Stewardship Action Plan for Climate Change Adaptation"⁴³. The plan states, "climate change is already affecting BC's forests and communities through changes to dynamics of insects and fire. Adapting BC's forest practices to a changing climate is both an immediate imperative and long term proposition that must begin now."⁴⁴ The Action Plan aims to reduce risks,

³⁷ Wang, T., Campbell, E.M., O'Neill, G.A., Aitken, S.N., 2012. "Projecting future distributions of ecosystem climate niches: uncertainties and management applications". *Forest Ecology and Management*, in press, accessed December 3, 2013, <http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/Wangfinalreport.pdf> and Wang et al, 2011, "ClimateWNA – High-Resolution Spatial Climate Data for Western North America", *Journal of Applied Meteorology and Climatology*, 51:16-29, doi: 10.1175/JAMC-D-11-043.1, accessed December 3, 2013, http://www.ualberta.ca/~ahamann/publications/pdfs/Wang_et_al_2012b.pdf

³⁸ DeLong, S.C., H. Griesbauer, W. Mackenzie, and V. Foord. 2010. Corroboration of Biogeoclimatic Ecosystem Classification climate zonation by spatially modelled climate data. *BC Journal of Ecosystems and Management* 10(3):49–64, accessed December 3, 2013, http://www.for.gov.bc.ca/hre/becweb/Downloads/Downloads_ClimateChange/Delong%20et%20al%202010%20%20BEC%20climate.pdf

³⁹ ClimateWNA-High-Resolution Spatial Climate Data for Western North America, 2012, *Journal of Applied Meteorology and Climatology*, February 18, 2012, accessed December 3, 2013, <http://technews.tmcnet.com/news/2012/02/18/6129556.htm>.

⁴⁰ Daust, D. and Price, K. 2011. "Projected Climate Change Impacts in the Nadina Forests District, Bulkley Valley Research Centre Project 2009-12, accessed December 3, 2013, http://bvcentre.ca/files/research_reports/Nadina_CC_Impacts.pdf.

⁴¹ Price, K. and Daust, D. "Forested Ecosystems", Ministry of Forests, Lands and Natural Resource Operations, Adapting BC's Natural Resource Management to Climate Change, accessed December 3, 2013, [http://www.for.gov.bc.ca/HFP/future_forests/council/2e_VA_Forested_Ecosystems_final\(Aug30\).pdf](http://www.for.gov.bc.ca/HFP/future_forests/council/2e_VA_Forested_Ecosystems_final(Aug30).pdf)

⁴² Alex Woods (2011) "Is the health of British Columbia's forests being influenced by climate change? If so, was this predictable?", *Canadian Journal of Plant Pathology*, 33:2, 117-126, doi: 10.1080/07060661.2011.563908, accessed November 21, 2013, <http://www.tandfonline.com/doi/pdf/10.1080/07060661.2011.563908>.

⁴³ Snetsinger, J. and Peterson, J.D. 2012. Ministry of Forests, Lands and Natural Resource Operations Memo, "Forest Stewardship Action Plan for Climate Change Adaptation", accessed November 22, 2013, <http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/Announcement.pdf>.

⁴⁴ Ministry of Forests, Lands and Natural Resource Operations, 2012, "Forest Stewardship Action Plan for Climate Change Adaptation", Issue 1 February 2012, Two page summary, accessed December 3, 2013, http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/Action_Plan_two-page_summary_Feb_27_final.pdf.

capture opportunities, and improve the ability of BC forests to withstand the full amplitude of climate change and variability.

The goals of the plan are to foster resilient forests, maintain future options and benefits, and build adaptive capacity. The webpage includes tools for adapting BC's forest management, climate change strategies and information on Future Forest Ecosystems Scientific Council (FFESC), and the FFESC project reports. Nadina District forest practitioners can use these tools to view and download maps showing areas of expansion for orchard seed use, as well as stay abreast of amendments to the Chief Forester's Standards for Seed Use.

Assisted Migration of Larch and Douglas-fir

On June 3, 2010, the *Chief Forester's Standards for Seed Use* was amended to expand the seed transfer limits of western larch (*Larix occidentalis*) beyond its contemporary species range.⁴⁵ On December 15, 2010, the Chief Forester published a memo giving guidance for the incorporation of western larch into FSP and Woodlot License Plan (WLP) stocking standards in areas of assisted range and population expansion.⁴⁶ The Chief Forester stated "the goal is to increase species diversity as a climate change adaptation strategy as a means to increase ecosystem resilience and address potential future forest health and productivity impacts that may occur in these areas,"⁴⁷ and added that the range expansion was intended, in part, to address potential long-term forest health associated with a changing climate and the uncertainty it brings. Guidance was provided with regard to meeting the requirements of FPPR Sections 26 (3) and (4), as well as key silviculture considerations when considering the use of larch in new areas.

Douglas-fir was modelled by Nitschke in 2010 to have significant increases in suitability in the SBSdk, SBSmc2 and SBSwk3 biogeoclimatic zones⁴⁸. The study suggested that Douglas-fir could become a more frequent species as its ability to regenerate and establish increases across the Central Interior Study Region under climate change⁴⁹, but suggested a degree of caution should be exercised in some ecosystems due to the persistence of growing season frosts (avoid planting in cold air drainage areas and frost hollows). In an operational off-site species plantation assessment project, LePage and McCulloch found "field data for Douglas-fir and western larch plantations, some up to 50 years old, indicate that not only can these species survive in non-optimal climates, but also that they have the potential to grow at rates that are as good as or better than the local species," and went on to comment that "the use of both species may help mitigate the anticipated impacts of climate change on our forest resources."⁵⁰ LePage also notes "the predicted BEC climate shifts indicate that Lw and Fdi will be ecologically acceptable in

⁴⁵ Ministry of Forests, Lands and Natural Resource Operations, Amendments to the Standards – June 2010, "Assisted Range and Population Expansion of Western Larch for Use as a Climate Change Adaptation Strategy in British Columbia", accessed December 4, 2013, <http://www.for.gov.bc.ca/code/cfstandards/amendmentJun10.htm>.

⁴⁶ Snetsinger, J. 2010. "Guidance for the incorporation of western larch into Forest Stewardship Plan and Woodlot License Plan stocking standards in areas of assisted range and population expansion", Ministry of Forests, Mines and Lands, Stewardship Division Memo, December 15, 2010, accessed November 27, 2013, <https://www.for.gov.bc.ca/hfp/silviculture/Signed%20125986%20Guidance%20memo.pdf>.

⁴⁷ Ibid, pg 1

⁴⁸ Nitschke, C.R. 2010. Regeneration vulnerability assessment for dominant tree species throughout the central interior of British Columbia. British Columbia Future Forest Ecosystem Scientific Council Technical Report A2. Future Forest Ecosystem Scientific Council, British Columbia, Canada, accessed December 4, 2013, http://www.for.gov.bc.ca/ftp/hfp/external/publish/web/ffesc/reports/FFESC-Technical-Report_ProjectA2_Nitschke.pdf.

⁴⁹ Ibid, pgs. 54-55

⁵⁰ LePage, P. and McCulloch, L. 2010. Assessment of Off-Site Tree Plantations in the Northwest Interior of British Columbia – Project Summary, Forest Genetics Council of British Columbia, Genecology and Seed Transfer Program, accessed December 4, 2013, http://www.fgcouncil.bc.ca/Off-Site_Species_Assessment_Final_Report_Opt.pdf.

significant areas of the SBS by 2050 - climate will be like SBSdw3 and IDFmw2 over ~20% of the old SBSdk subzone. By 2080, over 56% of the old SBSdk will have climate like the IDF⁵¹.

Incorporation of Climate Change in the Draft Stocking Standards

One of the main issues, regardless of whether a species can be established today, is whether it will be suitable - not maladapted - in the future. The climate change considerations are at a biogeoclimatic subzone and variant level, thus the recommended species options are at this level. The site series recommendations are based on the silvics of the species and research done regarding where the species can be successfully regenerated. The new stocking standards are potentially climatically suitable at the subzone level, and suitable in terms of silvics at the sites series level.

The tree species selection tool⁵² was one of the methods utilized to choose stocking levels in the draft 2013 Nadina Stocking Standards, as well as climate and drought risk-based projections. Within this tool, the Stand Level Drought Risk Assessment Tool⁵³ was used to assess projected changes in available soil moisture at the site level and based on Prism downscale climate modeling in the ClimateWNE⁵⁴. Both Douglas-fir and larch are considered acceptable in the proposed stocking standards table in the SBSwk3 01 site series, as the climate models show these species will become more suitable in terms of climate and can be established now on sites other than just the 03 sites series.

Modeled climate change variable projections along the drought risk tool were used in developing new stocking standards for the SBSwk3 (see Table 2.0). According to the models, by 2020 approximately 30% of the SBSwk3 unit for zonal sites will move towards a warmer SBS climate analogue where Douglas-fir and larch could be 'acceptable' on suitable sites. By 2080, about 25% of the SBSwk3 is projected to have an Interior Douglas-fir (IDF)/Interior Cedar Hemlock (ICH)-like climate analogue, supporting both Douglas-fir and larch on suitable zonal sites. Frost free days, which are a major limiting factor for both Douglas-fir and larch, are also projected to increase by 2080, which favors the expanded use of both species in the SBSwk3⁵⁵. Current reference guide footnotes related to frost still apply, but lower slope positions should always be avoided.

⁵¹ Personal communication with Dawn Stronstad, Nadina Stewardship Forester, November 2013.

⁵² Ministry of Forests Lands and Natural Resource Operations, Future Forest Ecosystems Initiative, Tree Species Selection Project, Tree Species Selection Tool, accessed December 5, 2013, <http://www.for.gov.bc.ca/hfp/silviculture/TSS/TSS.htm>.

⁵³ DeLong, S.C, H. Griesbauer, and C. R. Nitschke. 2012. Risk Analysis and Decision Support Tool, Future Forest Ecosystem Scientific Council, Final Report, accessed December 4, 2013, http://www.for.gov.bc.ca/hfp/future_forests/council/#completed-projects. (To download or run Stand Level Drought Risk Assessment tool see http://www.for.gov.bc.ca/hfp/silviculture/TSS/Drought_Risk.html on the Tree Species Selection Tool website <http://www.for.gov.bc.ca/hfp/silviculture/TSS/tss.htm>)

⁵⁴ Wang, T., E.M. Campbell, G.A. O'Neill, S.N. Aitken (2012). Projecting future distributions of ecosystem climate niches: Uncertainties and management applications. *For. Ecol. Manage.* 279:128-140, accessed December 4, 2013, <http://www.sciencedirect.com/science/article/pii/S0378112712003118>. (For further information on ClimateWNA (Western North America) Prism downscaling model see <http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/> ; to run the web version of ClimateWNA see <http://climatemodels.forestry.ubc.ca/climatewna/>).

⁵⁵ Ibid

Table 2.0 Example of incorporation of Douglas-fir and Larch into stocking standards

	BEC zone and site series	<i>Regeneration</i>					<i>Free Growing</i>		
		Preferred Species and (Free Growing Height)	Acceptable Species (and Height)	Target (sph)	Minimum Stocking (sph)	Minimum preferred (sph)	Target (sph)	Minimum Stocking (sph)	Minimum preferred (sph)
>50% Pli	SBSwk3 01	Sx(1.0), Pli(2.0)	Bl(1.0), Fdi(1.4), Lw(2.0)	2000	1600	1400	1600	1200	1000
	SBSwk3 01	Sx(1.0), Pli(2.0)	Bl(1.0), Fdi(1.4), Lw(2.0)	1600	1200	1000	1400	800	700
PREVIOUS	SBSwk3 01	Pli(2.0), Sx(1.0)	Bl(1.0)	1200	700	600	1200	700	600

Species Diversity at the Landscape Level

Forest and Range Evaluation Program (FREP) Report#14 was published in 2008. This report shows that approximately 27% of the forest in the Northern Interior Forest Region was classified as monoculture before any harvesting occurred, and that there was no significant change in the amount of area that is classified as monoculture when areas have achieved their free growing obligations. Since 1987, however, the amount of monoculture at free growing had increased by about 9%. The report recommended that FSPs and reforestation strategies be aligned with the management unit objectives for timber value, volume, habitat, forest health and resilience.

The Tree Species Selection Tool⁵⁶ was updated at the end of July 2013. This tool is designed to provide forest practitioners with the best available science-based tree species selection related information for a given geographical area. Users can search for/identify tree species that are ecologically suitable, understand historical species composition of the ecological unit, have access to available information about a range of ecological risk factors, and view available information relevant to management objectives/values for evaluating the list of ecologically suitable species. It should be noted that ecological suitability is only one of the legislated tests for stocking standards.

Type IV Silviculture Strategies

In July 2012, the Lakes TSA Type IV Silviculture Strategy was initiated, followed by the Morice TSA in November 2012. Ministry of Forests, Lands and Natural Resource Operations' staff (local and Victoria), other government and industry stakeholders, and other professionals were invited to participate. Workshops were held to gather feedback and professional opinion regarding current forest management, related issues, and future opportunities in the TSAs. The purpose of the Type IV strategy is to establish targets for timber quantity, quality, and non-timber values, and identify potential strategies to achieve them. The silviculture strategies also were initiated to address the growing concern over species deployment within the environment of climate change. In addressing risks from forest health, fire and climate change, the silviculture strategy sets direction for species selection, harvesting, and incremental silviculture priorities. Nadina licensees and practitioners were invited to participate in the process and provide feedback on numerous occasions.

⁵⁶ Ministry of Forests, Lands and Natural Resource Operations, Future Forest Ecosystems Initiative, Tree Species Selection Tool, accessed December 6, 2013, <http://www.for.gov.bc.ca/hfp/silviculture/TSS/tss.htm>.

Consideration of Species Diversity at the Landscape Level

On September 24, 2009, the Chief Forester issued a memo entitled Guidance on Tree Species Composition at the Stand and Landscape Level,⁵⁷ in which he stated that reforesting areas with a dominant single species can increase the risk of reduced yield due to forest health impacts. He went on to state that a reduction in species diversity and resiliency of our managed stands may have implications regarding the future options from our forests. “Managing for diversity is meant to reduce the forest health risks to future timber supply by providing a diversity of species should one or more become susceptible to pests or other damaging agents....I encourage you to use the best science available, including emerging information on climate change and species suitability, to develop and adapt stocking standards at scales ranging from cutblocks through to a watershed or landscape unit or to a management unit (TSA or TFL).”⁵⁸

The draft 2013 Nadina Stocking Standards address diversity on the landscape level by incorporating additional species. Pine and balsam have been retained as preferred and/or acceptable on site series as they were historically. Douglas-fir and larch have been added as preferred and/or acceptable on numerous sites series. See Table 3.0 below showing the addition of both Douglas-fir and larch into the preferred species for the SBSmc2 01 BEC zone and site series.

Table 3.0 Example of diversification of species in the stocking standards

	BEC zone and site series	<i>Regeneration</i>					<i>Free Growing</i>		
		Preferred Species and (Free Growing Height)	Acceptable Species (and Height)	Target (sph)	Minimum Stocking (sph)	Minimum preferred (sph)	Target (sph)	Minimum Stocking (sph)	Minimum preferred (sph)
>50% Pli	SBSmc2 01	Pli(1.6) Sx(.8)Fdi(1.4) Lw(2.0)	Bl(0.8)	2000	1600	1400	1600	1200	1000
	SBSmc2 01	Pli(1.6) Sx(.8)Fdi(1.4) Lw(2.0)	Bl(0.8)	1600	1400	1200	1400	800	700
PREVIOUS	SBSmc2 01	Pl(1.6),Sx(0.8)	Bl(0.8)	1200	700	600	1200	700	600

Maintenance or Enhancement of Commercially Valuable Supply of Timber

Timber Supply Forecasts Showing Forest Health Impacts

Mid-term harvest is dependent on three factors:

1. Remaining live stands
2. Shelf-life
3. Managed stand performance

⁵⁷ Snetsinger, J. Chief Forester Memo, British Columbia Ministry of Forests and Range. “Guidance on Tree Species Composition at the Stand and Landscape Level”, September 24, 2009, accessed November 27, 2013, <http://www.for.gov.bc.ca/hfp/silviculture/TreeSpeciesSelection/Chief%20Forester%20Guidance%20on%20Tree%20Species%20Composition.pdf>

⁵⁸ Ibid, pg.2

As shown on the graphs below (Figures 9.0 and 10.0), managed stands will be significantly contributing to harvest levels within 20 to 40 years:

Figure 9.0 Contribution of Natural and Managed Stands to Harvest Forecast for the Morice TSA
(Adapted from Type IV Silviculture Strategy: Draft Modelling and Analysis Report – Morice TSA, Forest Ecosystem Solutions, Ltd.)

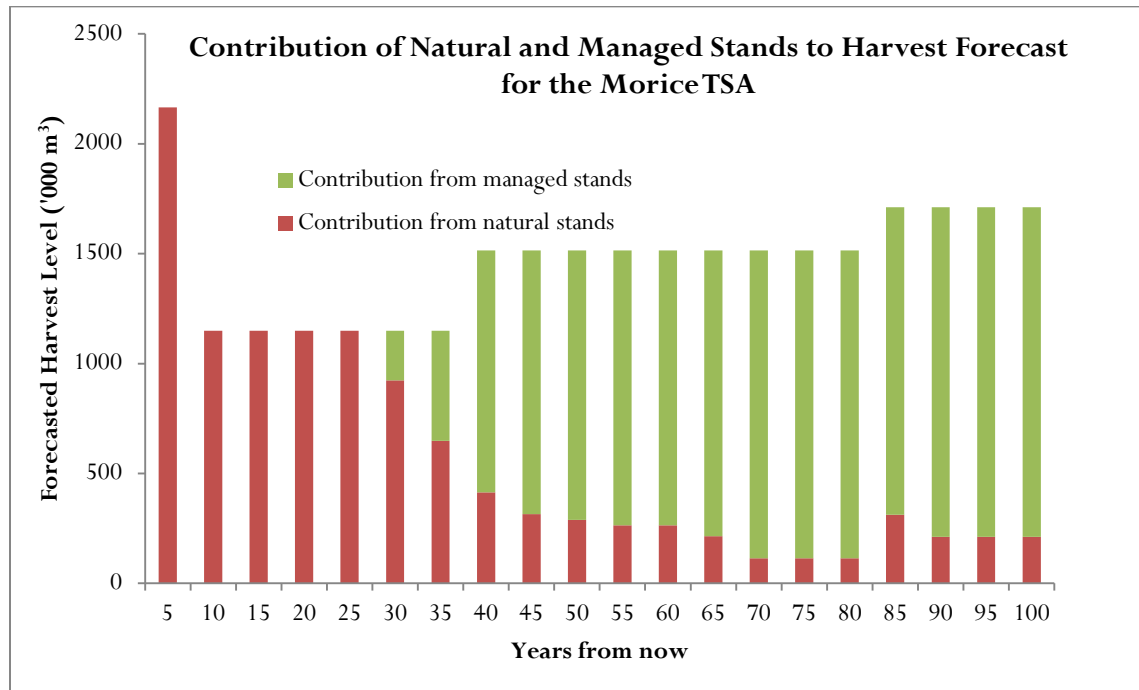
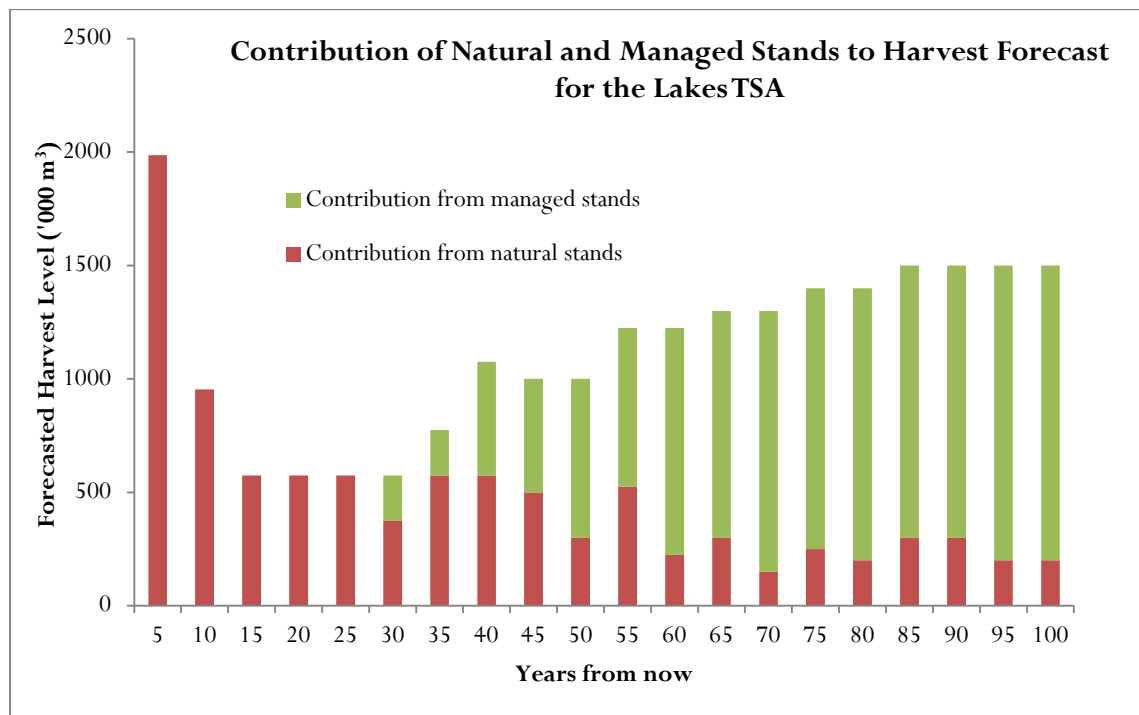


Figure 10.0 Contribution of Natural and Managed Stands to Harvest Forecast for the Lakes TSA
(Adapted from Type IV Silviculture Strategy: Draft Modelling and Analysis Report – Lakes TSA, Forsite Consultants Ltd.)



If managed stands are affected by forest health factors, growth and yield will be impacted and this will in turn impact harvest forecast. Analyses are currently being conducted to quantify these impacts.

Stand Density and Wood Quality

Tree quality is defined by characteristics such as log diameters, branch diameter and distribution, stem taper and straightness. Silviculture decisions can strongly affect the characteristics defining tree quality. Lower stocking density may increase piece size; however, the resulting increase in crown length will produce large diameter branches, as well as increase both bole taper and the proportion of juvenile wood⁵⁹. Damaging agents play a major role in the development of young stands, and can prevent stands from achieving their potential production. A three-quarter inch knot in logs with a six inch top can place the log into the lowest grade of lumber⁶⁰. Johnstone and Thienen (2011)⁶¹ studied the effects of plantation density on the growth and yield of lodgepole pine, and found that both stand basal area and stand volume increased with plantation density up to 2000 stems per hectare and then declined slightly.

Damaging agents create voids which reduce the stand density and affect the quality of the remaining stems. Trees with wide spacing (created by voids) have larger crowns – a “wolfish” appearance - and are slower to self-prune. They may also have lower wood quality due to larger branches and knot size⁶². Stocking density affects both knot size and the amount of juvenile wood. Stocking standards must be based on achieving an acceptable end result. Density is important to yields, quality, and resiliency.

Effect of Declining Species Densities on Timber Supply

Future stand yields are dependent on species, initial density (including spatial distribution), regeneration method, site index and silvicultural treatments. Planting density in both the Lakes and Morice TSAs has declined by approximately 12% in the last 10 years. Although the amount of spruce planted has increased between 2002 and 2012, the density of spruce plantations has decreased from 1574 sph to 1333 sph. Seedlings derived from seed with genetic gains (A-class seed) will outperform natural ingress, so relying on ingress to fill voids in managed stands may not be a reasonable assumption. Forest health impacts turn regular plantation tree distribution into clumped with voids created by the loss of large trees. Voids in managed stands result in decreased timber supply, both in terms of quantity and quality. Mather et al state that substandard stocking levels are “cause for concern because of the potential for broad-scale reductions in forest yield relative to projections”⁶³ and suggest that practitioners consider increasing the planting density to allow for damage losses.

In an Association of BC Forest Professionals commissioned paper to review the effect of BC’s current stocking standards on forest stewardship, J & E McWilliams (2009) state the following: “To illustrate the impact of spatial distribution on future yield projections, consider a site index 20 m lodgepole pine stand with initially 1,000 trees per hectare. A TASS [Tree and Stand Simulator] projection of this stand,

⁵⁹Province of British Columbia, Forest Practices Branch. 1999. “Guidelines for Developing Stand Density Management Regimes”, January, 1999, accessed December 3, 2013, <http://www.for.gov.bc.ca/hfp/publications/00083/sdm-25.htm>.

⁶⁰ Jeff McWilliams, Nadina FSP Stocking Standards Information Session September 17, 2013

⁶¹ Johnstone, W.D. and van Thienen, F.J. March 2011. The Effects of Plantation Density on the Growth and Yield of Lodgepole Pine: 20-year Results. Ministry of Forests and Range, Forest Science Program. Extension Note 102, accessed December 5, 2013, <http://www.for.gov.bc.ca/hfd/pubs/Docs/En/En102.pdf>.

⁶² Ballard, L. A. and Long, J.N. 1988. “The influence of stand density on log quality of lodgepole pine”. *Can. J. For. Res.* 18: 911-916.

⁶³ Mather, Simard, Heineman and Sachs. 2010. Decline of planted lodgepole pine in the southern interior of British Columbia. *The Forestry Chronicle* Vol 86 No. 4, pg. 495.

assuming it was a plantation, will result in approximately 300 m³/ha at age 75. In contrast, changing the spatial distribution to clumped, reduces the volume projection to approximately 200 m³/ha. In TASS, future volume is a function of the occupied growing space, which is defined by the total number of trees and their spatial distribution.⁶⁴

Proposal to Increase Target and Minimum Stocking Standards

The increase to both target and minimum stocking standards is based on:

- 1) Increase in occurrence and severity of rusts
 - the level of high rust incidence in plantations increased by 29% between 1995 and 2011
 - rusts are present in 99% of sample plantations
 - about 41% of sample plantations have high incidence (>20%) rust
 - rust demonstrates a ubiquitous nature throughout the landscape, nullifying the option of risk-rating
- 2) Free growing densities and the mortality that is occurring beyond free growing
 - 80% of 2010-2012 SDM assessment samples had rust (not all sampled strata were pine)
 - SDM surveys show that about 96% of the sample stands are not fully occupied, starting with an average planting density of 1325 sph
 - the average well-spaced density of 942 sph is 22% below full site occupancy level, and is consistent with the density of a stand aged 90 years in the TIPSy model
 - 2013 SDM surveys (15 stands) show similar results
 - YSM data is showing similar results, with 19% of trees damaged by disease
- 3) Decreasing planting densities in the Nadina District
 - the Lakes TSA decreased from an average of 1813 sph in 2002 to 1607 sph in 2012
 - the Morice TSA decreased from an average of 1496 sph in 2002 to 1342 sph in 2012
 - planting of spruce has increased in both TSAs over the last 10 years, but the density of spruce plantations has decreased by 15%
 - these densities are higher than the planting densities of the SDM samples (however, they are well below the recommended densities to address rust)
- 4) The need to maintain or enhance a commercially valuable supply of timber
 - increased mortality, combined with a reduction in stocking levels, is creating a downward pressure on timber supply
 - future yields depend on stand establishment practices

Proposal to Include Both a Regeneration and Free Growing Standard

The risks associated with potential failure to meet minimum free-growing densities are reduced if higher initial densities are established at the time of stand establishment. Addressing below-minimum stocking levels post-free growing is expensive and difficult. The volume reductions related to stands with densities well below full site occupancy affects both the quality and quantity of timber produced in these managed

⁶⁴ McWilliams, J. and E. A Review and Analysis of the Effect of BC's Current Stocking Standards on Forest Stewardship. April 2009. Association of BC Forest Professionals, Commissioned Paper, pg 23, accessed November 27, 2013, http://www.abcfp.ca/publications_forms/publications/documents/Stocking_Standards.pdf

stands. Higher initial densities can offset the risks associated with forest health factors and climate change. In studying the influence of espacement on the growth and development of a lodgepole pine plantation, Johnstone and Pollack (1990)⁶⁵ recommended higher plantation stocking levels for lodgepole pine, suggesting a minimum planting density of at least 1600 stems per hectare. Pollack et al (1992)⁶⁶ studied white spruce espacement, concluding a plantation density range of 1300-1600 stems per hectare was optimal.

FPPR Sections 44 and 16 require that stocking standards be specified for both the regeneration and free growing milestone. Section 44 (1) states (underline added by authors):

“A person who has an obligation to establish a free growing stand must establish, for areas that have been identified under section 16 (1) [stocking standards] as areas to which this section will apply, a stand that

(a) meets the applicable stocking standards set out in the forest stewardship plan for the area, by the applicable regeneration date specified for the area, and

(b) meets the applicable stocking standards and free growing height set out in the forest stewardship plan for the area by a free growing date that is no more than 20 years from the commencement date, unless the minister permits a later free growing date.”⁶⁷

FPPR Section 16 (3) states (underline added):

“A person required to prepare a forest stewardship plan must ensure that the plan specifies, for each of the situations or circumstances specified under subsection (1) where

(a) section 44 (1) (a) will apply, the regeneration date and stocking standards,

(b) section 44 (1) (b) will apply, the free growing height and stocking standards...”⁶⁸

The draft Nadina Stocking Standards provide guidance/recommendation for both milestones, as standards for both milestones are FRPA requirements. The reference guide is a ‘code era’ document; requirements were different, and thus only free growing densities are provided. Current forest management assumptions in completed TSRs have regeneration assumptions that speak to initial densities, and all regeneration delays are assumed to be 2 years. The TSR assumptions do not speak to free growing densities. Free growing is an administrative milestone, while regeneration delay is a biological and administrative milestone. The draft standards actually provide additional leniency when it comes to regeneration delay, as no natural regeneration is included in the current TSRs.

The forest management assumptions have initial densities of 1500 sph and 1400 sph (Morice Data package 2013 – 1500 in the actual last complete TSR). A standard that allows as few as 700 sph to be

⁶⁵ Johnstone, W.D., and Pollack, J.C. 1990. “The influence of espacement on the growth and development of a lodgepole pine plantation.” *Canadian Journal of Forest Research*. **20**: 1631-1639.

⁶⁶ Pollack, J.C. et al. 1992. The influence of Initial Espacement on the Growth of a 32-year-old White spruce Plantation. British Columbia Ministry of Forests Research Note 111, accessed December 5, 2013, <http://www.for.gov.bc.ca/hfd/pubs/Docs/Mr/Rn/Rn111.pdf>.

⁶⁷ FPPR Section 44 (1), accessed December 5, 2013, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/14_2004#section44.

⁶⁸ Ibid, Section 16 (3), accessed December 5, 2013.

established is clearly inconsistent with those assumptions and maintaining and enhancing the supply of timber. The draft Nadina regeneration delay densities were set at a level more reflective of TSR assumptions.

Given the forest health issues within the district, the proposed pine leading stocking standards have increased the regeneration densities to account for the expected higher level of mortality. This increase is proposed to ensure that similar levels of site occupancy are achieved and maintained as are assumed by TIPSy modelling, in order to maintain the supply of economically valuable timber.

Review Process

When Nadina District licensees requested FSP extensions in 2011, the DDM determined that the proposed stocking standards (i.e., the ‘default’ used for more than 20 years) did not adequately ensure that the regenerated areas would be stocked with ecologically suitable species that address long-term forest health issues to a density that is consistent with maintaining or enhancing the economically valuable supply of commercial timber. In August 2013, the District Manager provided a list of references to Nadina licensees to assist in FSP preparation, citing that the current default stocking standards required updating.

A Stocking Standards Information Meeting was held on September 17, 2013 with licensees, district staff, and regional and provincial forest health experts. Licensees were notified that draft stocking standards would be forwarded for review. The 2013 draft Nadina Stocking Standards were sent to licensees for review on November 8, 2013. The draft stocking standards were developed with input from Regional forest pathologists and ecologists, the Provincial Silviculture Operations Specialist, the Research Silviculturalist and Research Scientist, the Provincial Stand Management Officer, the Manager of Harvesting and Silviculture Practices, as well as district staff. A technical discussion session to address feedback and comments received regarding the 2013 draft stocking standards is proposed for late January 2014.

Conclusion

Forest health and stand development monitoring surveys, as well as young stand monitoring results, show an increase in the amount and severity of forest health impacts on young stands in the Nadina Forest District. This fact, coupled with decreasing planting densities in the last 10 years, is resulting in post-free growing stand densities that are well below full site occupancy. Climate change modelling suggests that the species being deployed over the landscape may not be suitable in the future. Diversifying species on the landscape will address risks to future timber supplies. Decreasing stocking levels in managed stands are resulting in voids that will severely impact the quality and quantity of timber produced, and thus compromise the production of an economically valuable supply of timber. Timber supply modelling does not take into account the level of mortality that is occurring in young stands in the Nadina post free growing, and is therefore not consistent with the current timber supply review or related timber supply projections.

Forest professionals have an obligation to consider all relevant information and best science when proposing stocking standards for forest stewardship plans. “Forest Stewardship is the responsible use of

forest resources based on the application of an ecological understanding at the stand, forest and landscape levels which maintains and protects ecosystem function, integrity and resilience. It is based upon an ethical responsibility to the land and people for current and future generations... Stewardship ensures that current management strategies are intended to create benefits for both the present and future generations.”⁶⁹ Decisions made today will impact future generations. The draft Nadina Stocking Standards propose an increase in target and minimum stocking standards, as well as increased species diversity on the landscape, to ensure that future managed stands in the Nadina District are well-stocked with ecologically suitable species that address immediate and long-term forest health issues to a density or basal area that is consistent with maintaining or enhancing an economically valuable supply of commercial timber, and is consistent with the timber supply analysis.

Elements of the approval tests have been addressed

Section 26 of the FPPR describes the key tests for the Minister (or DDM) to use when evaluating stocking standards. These approval tests have been met with the draft 2013 Nadina Stocking Standards.

1) Initial High Level Test

There are no obvious errors or omissions in the draft stocking standards.

2) Ecological Suitability Test

Section 26 (3) (a) states the standards must result in an area being stocked with ecologically suitable species. Published literature, research and data was examined and cited regarding species acceptability. Climate change modelling was utilized to support expanded use of both larch and Douglas-fir in the draft standards.

3) Forest Health Test

Section 26 (3) (a) states that the stocking standards must address immediate and long-term forest health issues on the area. Credible data from rust transect surveys, stand development monitoring, and young stand monitoring all indicate that forest health is having a significant impact on stands post free growing. Planting density in both the Morice and Lakes TSAs has been decreasing over the last 10 years. The draft stocking standards took into consideration the increase in rust occurrence and severity in the Nadina, decreasing planting densities and climate change information. Increased stocking and free growing densities are proposed, as well as increased species diversity to address the immediate and long-term forest health issues in the Nadina. The changes proposed in the draft stocking standards reduce the health risk posed to the maintenance of a commercially valuable timber supply.

4) Economically Valuable Supply of Commercial Timber Test

Although ensuring today's stocking standards are consistent with an economically valuable supply of timber in the future is challenging, maintenance or enhancement of a mix of species is considered a reasonable strategy. The draft stocking standards propose higher densities in >50% pine stands, increased target and minimum stocking levels and incorporating higher deployment of larch and Douglas-fir on numerous site series. Higher stocking levels are

⁶⁹ “Principles of Forest Stewardship”. Association of British Columbia Forest Professionals Report. May 2012, accessed November 29, 2013, http://www.abcfp.ca/publications_forms/publications/documents/Principles_of_Stewardship_2012.pdf.

proposed for stands composed of greater than 50% pine, as hard pine stem rusts are resulting in high loss of well-spaced stems. The losses resulting from stems rusts create voids which reduces the quantity and quality of the remaining stems.

5) Consistency with the Timber Supply Review Test.

Results from field-based studies have been presented with the draft stocking standards. Stand development monitoring results show that the trajectory of current post-free growing stands in the Nadina is inconsistent with the trajectory projected through TIPSy for future yields in the district. TIPSy forecasts that the vast majority of tree mortality that a managed stand will suffer takes place prior to age 15. The research completed in the Nadina does not support this assumption, with stand development and young stand monitoring showing significant losses to well-spaced trees post-free growing. The ecological condition of managed stands in the Nadina is not consistent with the assumptions for stand condition used in the timber supply analysis. Maintaining or enhancing the species mix will maintain future options for value and volume recovery. The proposed stocking standards will benefit the public, stakeholders and the province in reducing the risk associated with future timber supply projections.