# Stand Density Management in the Cariboo:

# Recommendations for a

# Management by Objectives Approach for

# Post Harvest Naturally Regenerated Pine Stands

Ver. 3.1

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# Table of Contents

# Table of Contents

# Table of Contents

# 1 Executive Summary

## Purpose and Scope:

The current maximum density silviculture regulation compels licensees and the BCTSP to conduct juvenile spacing operations on stands where density is greater than 10,000 countable stems per hectare. Initiating spacing in these stands based on a “one size fits all” rule was deemed to be inappropriate and potentially wasteful of silviculture funds. A joint agency and licensee *Cariboo Stand Density Management Advisory Committee* was formed in 2002 to make recommendations on density regimes in the 100 Mile House, Williams Lake and Quesnel Timber Supply Areas. The committee’s objectives were to:

1. Develop an approximation of the Desired Future Forest for managed stands from a timber product viewpoint while recognizing non-timber values.

2. Develop initial recommendations for moving to a “Management by Objective” regime for managed stands.

3. Develop Decision Support Tools to assist forest planners, managers and decision makers with evaluating the implications of silvicultural guidelines at the stand and forest estate levels.

4. Recommend specific stand density management regimes for managed natural regenerated lodgepole pine stands reflecting objectives 1), 2) and 3)

5. Consider the analytical framework of the Chief Forester’s “Guidelines for Developing Stand Density Management Regimes” in order to achieve these objectives.

6. Develop a decision framework that extends beyond the modeling perspective suggested by the Chief Forester’s Guidelines.

## Methods:

The Chief Forester’s process requires linking and assessing the effects of density management from biological, economic and forest estate levels. Due to diverse opinion on the ability to conduct meaningful economic projections it was decided to develop product objectives with a range of future values and assess these estimates at the estate level against volume (AAC), silviculture costs and product outturns by varying scenarios over a 250 year horizon. Deep economic analysis was not conducted in part due to results of other groups (Weyerhaeuser, Economics and Trade Branch, Research Branch) studies indicating that, for similar stand types, the economic justification of spacing will only likely be viable on high quality sites with low spacing costs. A literature index was compiled, in conjunction with the appendices, that included key research document findings for timber and non-timber values. Biotic factors (insect, disease, competing vegetation, etc.) were documented and an apparent link to the forest estate level provided via aggregated stand types. Habitat and wildlife requirements were also documented by basic stand types. The TIPSY stand level model provided output for numerous attributes and the attributes or factors were summarized in tables in varying formats. Two estate models were used to test scenarios and utilized TIPSY stand projections. TIPSY output was summarized in a fashion (Mean Annual Increment and Mean Annual Lumber Value) to assist with determining inflection points were value declines across a range of attributes by varying initial densities. The information assembled and modeled for this report was subjectively weighted and decided as modeling alone is incapable of leading to a conclusive density recommendation. Final density recommendations were tested for each TSA using the model (FSSIM) and data used for the TSR 2 base case in order to measure the impact to AAC.

## Results and Conclusions:

The densities in this table were applied to the forest estate model runs.

| Natural Regen.Pine Stands Site Index | TIPSY Initial Density | TIPSY Density @ 15 Years | **Recommended Acceptable Density @ 15 Years (total trees)** |
|---|---|---|---|
| 7 | 30000 | 27297 | 25000 |
| 8 | 30000 | 27010 | 25000 |
| 9 | 30000 | 26668 | 25000 |
| 10 | 30000 | 26280 | 25000 |
| 11 | 30000 | 25915 | 25000 |
| 12 | 30000 | 25539 | 25000 |
| 13 | 30000 | 25134 | 25000 |
| 14 | 30000 | 24710 | 25000 |
| 15 | 20000 | 16595 | 15000 |
| 16 | 20000 | 16314 | 15000 |
| 17 | 10000 | 8896 | 10000 |
| 18 | 10000 | 8830 | 10000 |
| 19 | 10000 | 8755 | 10000 |
| 20+ | 10000 | 8672 | 10000 |

Density control was applied across a range of site indices driven by impact to AAC, product outturns and silviculture cost**.** The impact to the TSR 2 base case AAC (pre MPB uplift) of implementing the recommended pine density strategies is almost inconsequential. The effect on AAC is non-existent for 100 years or more in each TSA before a very slight decline of about one percent is imposed. Product objectives were also achieved as well as reducing silviculture expenditures. The impacts to non-timber values and threats from biotic risk factors are documented in the report and are not an issue in these pine stands.

**Conclusion:**

Implementation of the Recommended Acceptable Densities from the above table in the 100 Mile House, Williams Lake and Quesnel TSA's ensures that the licensee short term obligatory risk is adequately and fairly balanced against the crown's long term obligatory risk. The current density regulation has no advantage to the crown over the recommended regimes. In fact spacing in some of the stand types in question may be harmful to stand development. Implementation of the recommendations would result in some stands (20%?) still being spaced. World timber supplies have increased from plantations, recycling and improved recovery factors. Cost minimization is the only real way for today's forest managers to ensure the Cariboo's continued place in commodity markets. Moving to these pine regimes will assist that effort without impacting other objectives.

**Recommendations:**

Core recommendations of this report are:

- Consider implementing the recommended acceptable density regimes for post harvest naturally regenerated pine stands. A process to review the results and make further recommendations on the selected numbers should be considered using formal Decision Analysis or Multi Criteria Analysis techniques involving agency and licensee stakeholders.

- Since the procedure for measuring countable height directly effects prescriptions, costs and stand outcomes; localized countable height guidelines and procedures for specific stand types must be developed for agency approval and implementation. During the 2005 field season various countable height methods should be tested and tracked by site series, age, site index, etc. Results from this assessment can be used to determine countable height procedures recommended by stand class. This process should be developed in conjunction with the Forest Practices Branch with support from the Chief Forester.

# 2 Introduction

## 2.1 Impetus for this Initiative

The original impetus for this report stemmed from concern among the major licensees' in the 100 Mile House, Williams Lake and Quesnel TSA's that regulatory requirements were compelling them to undertake what they thought were, in many instances, needless and costly juvenile spacing operations. Most of these obligations are the result of the current maximum density silviculture regulation applicable to Lodgepole pine stands.

Given this concern, and the magnitude of the dollars involved (please refer to Appendix E for the cost estimate), licensees and Ministry personnel resolved in 2002 to form the *Cariboo Stand Density Management Advisory Committee*. The committee's mandate is to assist the Regional Manager in pursuing the Chief Forester's February 15, 1999 policy and procedures for developing site-specific stand density management regimes tailored to Cariboo stands. Previous efforts to resolve the issue of maximum density had not lead to a satisfactory conclusion with government. Therefore, it was decided that resolution of the issue would only occur through implementation of the Chief Forester's *"Guidelines for Developing Stand Density Management Regimes".* This process requires linking and assessing the effects of density management from the biological, economic and forest estate levels. Therefore, resolution of the initial issue, applicable to stands where the maximum density rule is administered, requires a much broader perspective and assessment that considers a wide range of issues. The government's New Era goals, including the commitment to sound science-driven forest management that is also economically viable, provides an appropriate provincial policy backdrop for this initiative.

The implementation of professional reliance among the greater forestry community in general, and professional foresters in particular, lends additional impetus to the need for technically sound bases for whatever stand density management regimes are ultimately adopted in the Cariboo. Recent changes to regulatory requirements regarding maximum density countable height criteria and the *Chief Forest Transitional Stocking Requirements* alleviated obligations somewhat but do not address the issues as described in the *"Guidelines for Developing Stand Density Management Regimes".* Developing a "Management by Objectives" approach, where actions are linked to consequences, for a management unit is required as opposed to adopting the generic transitional or default standards.

Under pending regulatory change the District Manager will be the statutory decision maker. Therefore, licensees and BCTSP planners will have to seek regulatory variance under the Forest Stewardship Plan. The Forest Stewardship Plan is the main approval document that will govern forest management practices and takes direction from the objectives defined for the management unit. Variance from default standards will require "evidentiary information" for the District Manager. Therefore, resolution of the complex and multi-level stand density management issue will likely require “evidentiary information” similar to the Chief Forester’s Guidelines.

## 2.2 Chronology of Events and Reports Relevant To This Initiative

| | |
|---|---|
| February 1999: | "*Chief Forester Policy on Stand Density Management* " is issued. (see Appendix A) |
| March 2001: | Joint "*Request for Proposal*" released to solicit scientific rationale for determining Lodgepole Pine maximum density values in three southern forest regions. (see Appendix B) |
| October 2001: | *"Juvenile Spacing, Stand Volume, Piece Size & Value"* presentation released by Ken Mitchell and Jim Goudie of Ministry of Forests, Research Branch. (see Appendix C) |
| December 2001: | Mitchell and Goudie respond to Ministry of Forests' personnel's comments on their presentation *"Juvenile Spacing, Stand Volume, Piece Size & Value".* (see Appendix D) |
| December 2001: | Cariboo Major Licensees identify their maximum density spacing obligation. (see Appendix E) |
| March 2002: | "*Maximum Density and Countable Heights in Lodgepole Pine*", by Sterling Wood Group Inc. (see Appendix F) |
| May 2002 | Ministry of Forests' peer review report of the *"Maximum Density and Countable Heights in Lodgepole Pine*" paper is released by Ken Mitchell, Jim Goudie and Dave Coffey. (see Appendix G) |
| August 2002: | Cariboo Lumber Manufacturers' Association requests of the Cariboo Forest Region the sanctioning of its *"A Recommended Approach to Optimizing Density Management at the Stand and Forest Estate Levels in the Quesnel, Williams Lake, and 100 Mile House Timber Supply Areas*". (see Appendix H) |
| Summer 2002: | Cariboo Major Licensees survey a representative sample (58 blocks) of their maximum density liable stands. Report "Maximum Density Issue: Reconnaissance Level Survey Results" (see Appendix I) issued. |
| October 2002: | The joint *Cariboo Stand Density Management Advisory Committee* is formed. (see Appendix J) |
| November 2002: | Cariboo Forest Region sanctions the Committee's proposed approach to optimizing stand density management. (see Appendix K) |
| November 2002: | *Draft Chief Forester Stocking Requirements* released. (see Appendix L) |
| March 2003: | "*Stand Density Management: Economic Background Report*" produced for the Timber Enhancement Strategy Committee and the Cariboo Stand Density Management Advisory Committee. (see Appendix M) |

March 2003: *"Optimization and Economic Modeling Report, Stand Density Management in the Cariboo: A Management by Objectives Approach"* report produced for the Timber Enhancement Strategy Committee and the Cariboo Stand Density Management Advisory Committee. This report provided the foundation for this report. Therefore, the March 2003 report is not included in the appendices.

March 2004 Draft version "Stand Density Management in the Cariboo: Recommendations for a Management by Objectives for Post Harvest Regenerated Pine Stands" submitted to NRIN

May 2004 Cariboo Stand Density Management Advisory Committee outlines process, results and proposed recommendations in meeting with the Regional Executive Director and staff

October 2004 Cariboo Stand Density Management Advisory Committee hosts a field tour of typical Post Harvest Regenerated pine stands in the Chilcotin with the Regional Executive Director and staff

# 3 Objectives

The key objective of this paper is to provide a compilation of background information needed by decision makers to establish site-specific stand density management prescriptions. A decision framework to determine stand density management for Cariboo management unit objectives is required, rather than relying upon the legislated provincial level requirements and default stocking standards. This paper focuses on developing timber product objectives, while recognizing non-timber objectives and values, and is written in pursuit of the Chief Forester's policy and procedures for developing site-specific stand density management prescriptions. It addresses the three key elements of the Chief Forester's policy:

1. The biological responses of stands to treatment.
2. The economic implications of the treatment.
3. The forest-level effects of the treatment.

This paper also builds upon the recommendations of the *Type 2 Forest Level Silviculture Analysis Report for the Williams Lake Timber Supply Area* for the former Cariboo-Chilcotin Land Use Plan (CCLUP) Timber Enhancement Strategy Committee (TESC).

Specific objectives adopted by the committee were to:

7. Develop an approximation of the Desired Future Forest for managed stands from a timber product viewpoint while recognizing non-timber values.
8. Develop initial recommendations for moving to a "Management by Objective" regime for managed stands.
9. Develop Decision Support Tools to assist forest planners, managers and decision makers with evaluating the implications of silvicultural guidelines at the stand and forest estate levels.
10. Recommend specific stand density management regimes for managed natural regenerated lodgepole pine stands reflecting objectives 1), 2) and 3)
11. Consider the analytical framework of the "*Chief Forester's Policy on Stand Density Management* " in order to achieve these objectives.
12. Develop a decision framework that extends beyond the modeling perspective suggested by the Chief Forester's Guidelines.

# 4 Background

## 4.1 "New Era" Goals

Provincial government's New Era goals relevant to this initiative include:

- "Examine opportunities to modernise current regulatory regime to focus on outcome based regulating." *(Ministry of Forests)*
- "Optimise the financial return from the use of Crown land and water resources consistent with the province's land use and water policy objectives." *(MSRM)*
- "Increase the Allowable Annual Cut over time through scientific forest management, proper planning and incentives to promote enhanced silviculture."

It is expected that this paper will assist decision makers in the pursuit of general New Era undertakings to manage forests in accordance with sound science and sound economics.

## 4.2 Cariboo-Chilcotin Land Use Plan (CCLUP) Objectives

The founding principles of the CCLUP are:

- Community security/stability
- Economic (industrial) certainty/security
- Environmental sustainability

The over-arching objective of the land use plan is to "…ensure a healthy and productive land base and a strong and growing economy – not only for ourselves, but for generations to come." At the next level down, the objectives of the land use plan are to ensure:

- Access to resources
- Sustainable resource utilisation
- Maintenance of environmental qualities and values
- Integration of resource uses and values.

A key and innovative aspect of the plan is the adoption of a wide array of resource targets as objectives, each with an accompanying strategy for targets achievement. The plan also stated: "The areas available for conventional harvest are most suitable for timber enhancement activities."

## 4.3 Provincial Level Silviculture Objectives

The provincial incremental silviculture strategy is based on the following guiding principles (from Ministry of Forests' *"Strategy at a Glance"):*

- "Because the distant future cannot be foretold, the best and only course of action in managing the timber resource is that which minimizes risk and maintains options."
- "British Columbia's forests are important locally, provincially, nationally and globally and should be managed in this context."
- "Each generation of British Columbians becomes the steward of the province's forest resources and has a moral obligation to preserve this heritage for future generations."

The provincial incremental silviculture strategy also specifies working targets of increasing volume and maintaining or enhancing the quality of future wood supplies. Specific working targets are to:

- "Minimize the anticipated interim reduction in timber supply so that provincial annual harvests of at least 65 million $m^3$ during this period."
- "Create a long term timber supply capable of supporting a steady long term provincial harvest level of at least 75 million $m^3$."
- *"Over the long term, maintain the production of premium quality logs at or above 10% of total harvest."*

The major silviculture strategies outlined in the Ministry's incremental silviculture strategy are:

- "Increase the use of alternative silvicultural systems and commercial thinning."
- "Achieve earlier green-up of harvested areas."
- "Increase regenerated stand volumes by 20%."
- "Eliminate all pre-1982 good and medium site backlog NSR and all 1982 to 1987 backlog NSR."
- "Initiate a long rotation quality management program for stands where harvesting must be delayed."
- "Other silvicultural and non-silvicultural strategies must also be implemented to achieve working targets."

The strategy also notes "Regional and Management Unit strategies must be developed, (and) followed by programs and plans to implement them."

This report can thus be viewed as an initial part of the development of an appropriate silviculture strategy for the Cariboo in pursuit of the provincial incremental silviculture strategy, in the context of the present government's New Era goals. Unfortunately none of the strategies documented above explicitly consider or reference product objectives or cost issues.

In October 1987, government introduced the requirement that silviculture prescriptions must specify a "maximum density" for regenerating lodgepole pine and drybelt Douglas-fir stands. The underlying principle was that excessively dense re-stocking of sites following disturbance could reduce merchantable volume or lengthen the time to a viable harvest consistent with the target stocking standard. Spacing treatments to reduce the number of trees below a "maximum density" would constitute a basic spacing obligation for licensees and, therefore, would not be dependent on government's silviculture budget. The default maximum density is currently set at 10,000 coniferous stems per hectare for all silviculture prescriptions. The “evidentiary information or path” government used to assess and determine that the maximum density number for broad regulatory use at the provincial level should be 10,000 stems per hectare is not visible. It appears to be the result of a committee driven decision.

## 4.4 Regional Level Silviculture Objectives

At present there are no region-specific silviculture objectives applicable to Crown lands in the Cariboo Forest Region; however, there are some stated product objectives for the Tree Farm Licenses in the region. For reference purposes, below are typical regional silviculture objectives gleaned from a review of all Management Units’ strategies that was undertaken during the research phase of work for Appendix M to this paper.

Typical Regional Level Silviculture Objectives (not Cariboo-specific):

- Initiate a long rotation quality management program for stands where harvesting must be delayed. Ensure a long-term sustainable harvest that approximates the current harvest value and volume levels, and that produces a diversified mix of products necessary to create and maintain sustainable forest employment.
- Balance treatments that enhance growth and yield with those that increase the value of the wood produced.
- Utilize incremental silviculture treatments to contribute to sustainable management of non-timber values at the landscape level.

These objectives lack specificity required for interpretation and action by practitioners.

## 4.5 Summary of Chief Forester AAC Issues for Cariboo TSA's

Table 1 is provided to illustrate that very few silvicultural factors are recognized as issues in the Chief Forester's recent AAC determinations. Nevertheless, resolution of the issues identified may have a future impact on recommended stand density regimes.

**Table 1 - Summary of Chief Forester AAC Determination Issues by TSA**

| TSR 1 | TSR 2 | 100 Mile House | Williams Lake | Quesnel |
|---|---|---|---|---|
| | * | *Mature inventory volume issues: overestimation in current inventory (16%); Complete a Vegetation Resource Inventory for the TSA; in particular to improve the forest cover attributes* | *Mature volume issues: overestimation in current inventory (15%). Adjustment incorporated in analysis. Pending VRI/NVAF implementation will directly adjust inventory.* | *Mature volume issues: overestimation in current inventory (11%)* |
| | * | Mature inventory age issues: Fully review the concern that the forest inventory may overestimate forest ages (as indicated by the 1999 inventory audit) and hence affect assumptions regarding the achievement of the seral stage distribution for landscape-level biodiversity | | |
| | * | | *Continued performance in low volume stands: Monitor Economic viability esp. in western supply blocks, economic viability harvest performance in stands <100m³/ha* | |
| | * | | *Western Supply Blocks: investigate increased AAC opportunity particularly with respect to operability* | |
| | * | *Site productivity estimates (PEM, SIA/SIBEC)* | *Site productivity estimates (PEM, SIA/SIBEC)* | *Site productivity estimates (PEM, SIA/SIBEC)* |
| | * | | *MPB issues: monitor condition of new infestation and older infestation and apprise Chief Forester of condition,* | *MPB issues: "shelf life, monitoring, timber supply, CCLUP, fire hazard, watershed management compromised…* |
| | * | *NDT evaluation /seral stage retention* | | *OGMA's* |

| TSR 1 | TSR 2 | 100 Mile House | Williams Lake | Quesnel |
|---|---|---|---|---|
| * | * | | | *Landscape Unit planning: complete objectives, Verify stand age/seral stage classes in landscape units/BEC areas with identified concerns* |
| | * | *Rotation ages and minimum harvest criteria* | | Cut block adjacency |
| | * | *PFT and PA 16 PFT: definitions and locations* | | |
| * | | | | *PFT and PA PFT: definitions and locations* |
| | * | | Monitor and report any new information wit respect to First Nation rights and title that may effect timber supply | |
| | * | *Caribou: Review the amount of salvage harvesting permitted in the no-harvest caribou zone* | | *Caribou: Monitor caribou habitat management so that any changes in practices can be incorporated into the next analysis* |
| * | * | *Roads, trails & landings: net down method and ingress* | | |
| * | | | *Roads, trails & landings: net down method and ingress* | |
| | * | *MDWR: Review the data for the mule deer strategies during the course of developing sub-regional planning guidelines* | | *MDWR: Monitor mule deer management so that any changes in practices can be incorporated into the next analysis* |
| | * | *WT's and WTP's: Review the objectives for stand-level biodiversity and track the amount of area and volume required for wildlife trees or patch retention in the field to resolve any overlap with other constraints applied in the next timber supply analysis* | | |
| | * | | *Visual quality objectives: monitor influence from Sub-Regional Planning* | |
| | * | | *NSR records reconciliation with ISIS and inventory files* | |
| | | | *Review regeneration assumptions in the ICH zone* | |
| * | * | | | *Backlog NSR* |
| | * | | | *Operability: steep slopes* |

| TSR 1 | TSR 2 | 100 Mile House | Williams Lake | Quesnel |
|---|---|---|---|---|
| * | * | *Operability* | | |
| | * | *OAF's:* | | |
| | * | Utilization standards | | |
| * | * | *Riparian management zones, fish habitat* | | |
| * | | | *Riparian management zones, fish habitat* | |
| * | | *Unsalvaged losses* | *Unsalvaged losses* | |
| * | | *ESA's, terrain stability* | *ESA's, terrain stability* | |
| * | | | | *Stand conversion opportunities* |
| * | | | | *Deciduous availability (leading and incremental)* |
| * | | | | *Deciduous and mixed stands succession* |
| * | | *OGSI* | *OGSI* | *OGSI* |

## 4.6 Timber Supply Area (TSA) Level Silviculture Objectives

### 4.6.1 100 Mile House TSA Silviculture Objectives

In November of 1998 the *Timber Investments Strategy Committee* produced a report, based on TSR I Base Case assumptions, to review a number of opportunities to improve the available timber supply in this Timber Supply Area through the application of silviculture treatments. The report identified the critical period for developing the harvest rate as being in the period 130 to 150 years into the future. Scenario analysis concluded that any treatments that make stands available earlier, or provide more volume from managed stands, would improve the annual harvest level predicted for the Base Case. Objectives focused on improving the AAC through application of the Allowable Cut Effect (ACE) without consideration for timber product output.

## 4.6.2 Quesnel TSA Silviculture Objectives

In November of 1998 the *Timber Investments Strategy Committee* produced a report, based on TSR I Base Case assumptions plus any then available TSR II Base Case data that served as a source document in advance of the completion of TSR II for this Timber Supply Area. The report summarizes simulations of timber supply volume impacts arising from various strategies and/or stand level silviculture treatments. It concluded that the biggest impact accrued to the OGSI adjustments (+12%), with significant impacts also arising from the planting of genetically improved seedlings (even-flow response range of 5% to 9%), and the application of fertilizer when undertaken in combination with stand density management treatments (even-flow increases of 8% or 10%, assuming 15m$^3$/ha. or 40 m$^3$/ha. responses). Objectives focused on improving the AAC through application of the Allowable Cut Effect (ACE) without consideration for timber product output. Readers of this report are encouraged to consider the major differences in costs associated with the modeled management scenarios.

## 4.6.3 Williams Lake TSA Silviculture Objectives

In January of 1999, the Timber Investments Strategy Committee released its report on stand treatment analysis in the Crown forest component of the Williams Lake Timber Supply Area. It used TSR I Base Case assumptions, supplemented by the incorporation of additional scenarios for evaluation. It segregated its analysis into two parts - the Main TSA and the Three Western Supply Blocks.

This report identified the critical period for achieving the harvest rate as being 130 to 150 years into the future for the Main TSA, and 160 to 200 years into the future for the Three Western Supply Blocks. As was the case in the 100 Mile House TSA, scenario analysis for that report concluded that any treatments that make stands available earlier, or provide more volume from managed stands, would improve the annual harvest level predicted for the Base Case.

In 2000 the Williams Lake TSA Timber Enhancement Strategy Committee undertook a study to assess the impact of various incremental silviculture scenarios, driven by the desire to address the near-term timber supply reduction predicted in TSR I. The preface to the report stated that “Historically timber quality objectives in the Williams Lake TSA have not focused on identification of the premium saw log component of the inventory profile. Instead the focus has traditionally centred on identifying the “lower end” of the timber profile from a “Problem Forest Type (PFT)” or “Opportunity Wood” perspective. In spite of the absence of pulp mills in the TSA, the major licensees have demonstrated substantial harvesting performance down to 65 m3 per hectare. The 1992 20Year Availability Assessment Report determined there were insufficient sources of timber from the “traditional” saw log land base. Therefore, the PFT land base was accessed in order to stabilize the short term harvest level in the main TSA and to help offset the pending medium term short fall identified in the TSR 1 Analysis Report. The definition of the PFT land base was revised in the TSR ll Data Package to reflect current performance levels. Local sawmill capacity has evolved to efficiently process the lower spectrum of the inventory profile.

From a fibre supply perspective, local proponents of this exercise felt that identification of saw log and premium log quality objectives was not required at this time. Instead, resolution of other opportunities (eg. CCLUP, land base classification and genetic gain issues) was felt to be more pressing. Timber quality objectives will be assessed under a separate initiative". As with the other TSA's, objectives focused on improving the AAC through application of the Allowable Cut Effect (ACE) without consideration for timber product output.

The Type 2 Forest Level Silviculture Analysis Report for the Williams Lake Timber Supply Area dated May of 2000, was based upon TSR II Base Case assumptions. It concluded that juvenile spacing did not have any significant impact on long-term harvest levels, other than possibly offering some mitigation of timber harvest scheduling concerns. The volume growth curves were found to be "only slightly different" under the three different spacing densities of 1200, 1800 and 2800 stems per hectare, underscoring the importance of optimizing stand density management regimes, to ensure that scarce dollars are wisely invested.

That analysis found the most significant timber supply benefits, from a volume perspective, accruing to correct determination of the timber harvesting land base, and site indices (SIBEC and OGSI), followed by the use of genetically improved seedlings. The report also noted the importance of determining the true potential of enhancement opportunities, in the context of CCLUP, at the sub-regional and landscape unit levels.

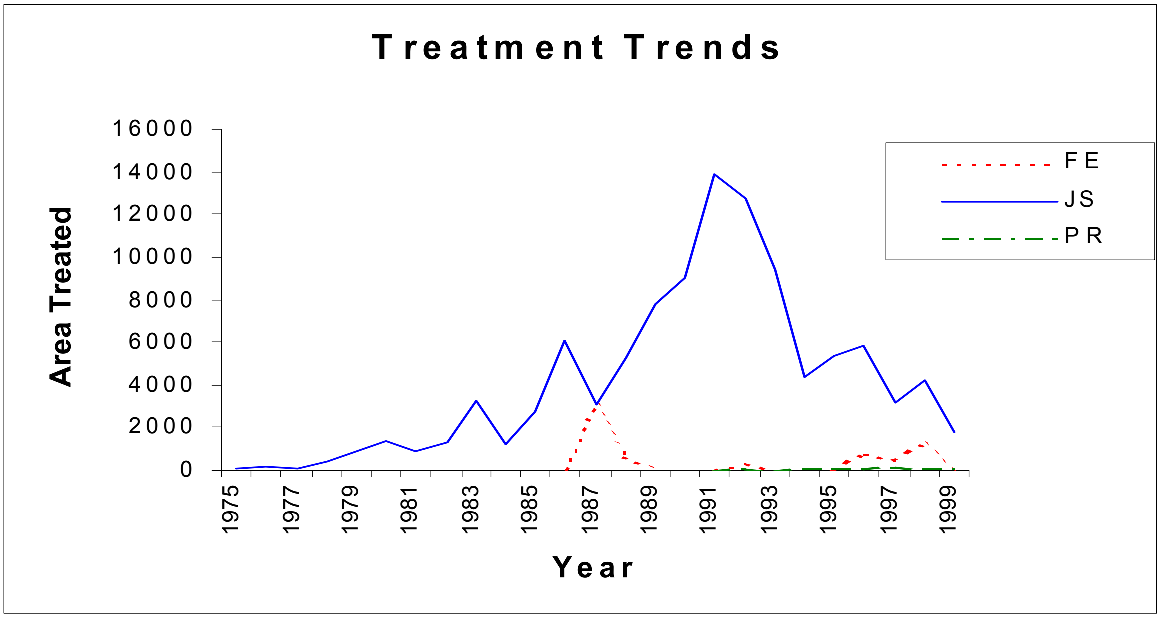
The report indicated that the prime benefits of juvenile spacing would likely accrue to the achievement of other resource values, primarily, with some wood quality enhancement potential as well as rendering partial cutting operations more efficient, and possibly facilitating subsequent commercial thinning operations.

The report also documented the high cost of the juvenile spacing and Lodgepole pine rehabilitation silviculture strategy options, particularly in comparison to the three major drivers of timber supply improvement; namely, THLB, SIBEC and OGSI. Lastly, the report stressed the importance of undertaking partial cutting yield analysis using the true mean annual increment in Cariboo partial cut managed stands.

### 4.6.4 Williams Lake TSA Silviculture Activities

The area treated incrementally, according to March 2000 ISIS data, was listed as being 93.5% juvenile spacing, 5.8% fertilization, and 0.6% pruning. The data also show a dramatic reduction in juvenile spacing activity since its peak in 1991 as illustrated in Figure 1. The peak in spacing activity primarily targeted mistletoe infested residual trees in harvested blocks. Recent spacing has been largely driven by the maximum density rule.

**Figure 1. Treatment Trends in the Williams Lake TSA**




Silviculture treatments are costly as indicated in Figure 2 on the following page.

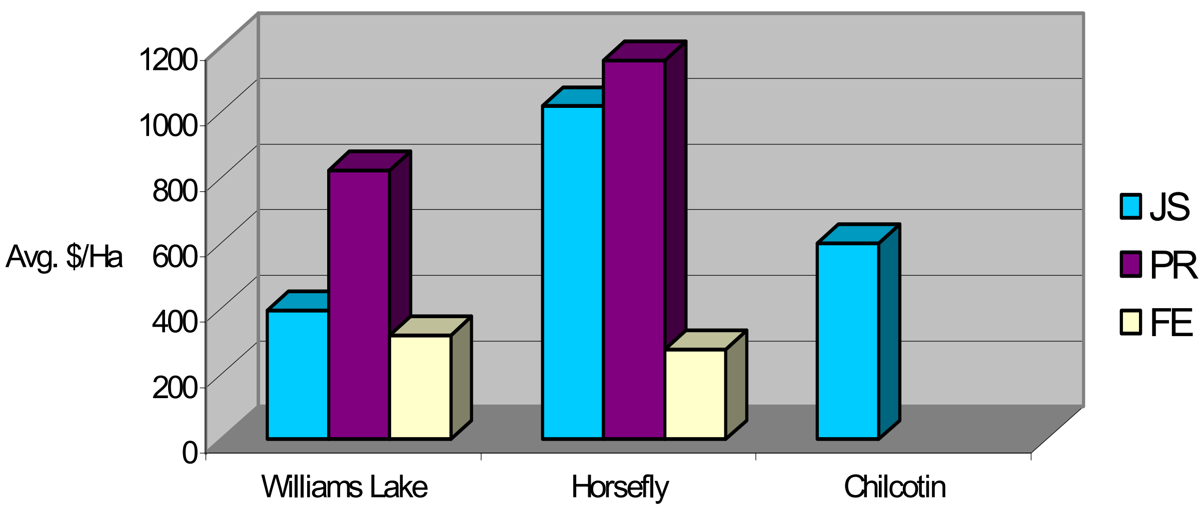



**Figure 2. Average Treatment Costs**

# 5 Information Sources

In addition to the events and reports identified in Section 2.2, an informal literature review provided information on specific issues related to stand density management. The full literature review is contained in the accompanying report entitled “Literature Index, Book 1”. A summary table is presented below.

Table 2

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Discussion of Wood Quality Attributes and Their Practical Implications | Forintek Canada Corp. | L Joxsa, G Middleton | Discussion on importance of approximately 30 wood quality attributes | "rapid early growth results in a large core of juvenile wood, larger live crown, larger knots and higher stem taper…affecting wood properties. ….specific prescription will depend on the desired end product" | 1 |
| Wood Quality: Its Definition, Impact & Implications for Value-Added Timber Management & End Uses | Forintek Canada Corp. | S Zhang | Discussion on importance of approximately 27 wood quality attributes | perception of wood quality varies between foresters, manufacturers and customers | 2 |
| Lodgepole Pine Product Yields Related to Differences in Stand Density | Forintek Canada Corp. | G Middleton, L Jozsa, L Palka, B Munro and P Sen | Destructive sampling of 220 trees at 700, 1100 & 1900 stems/hectare | LRF generally lowest for a given dia. in the 700 s/ha. Yields of select structural lumber increased as stand density increased. Wide dimension lumber from open grown trees generally failed to meet in-grade specifications for Modulus of Rupture and Modulus of Elasticity | 3 |
| Damage to residual Trees from a Commercial Thinning of Small Diameter Mixed Conifer Stands in Northeastern Washington | Yale School of Forestry and Environmental Studies | A. Camp | | Wounding reduction dependent upon system, density and season | 4 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Lodgepole Pine Development After Early Spacing in the Blue Mountains of Oregon | Pacific Northwest Research Station, USDA | P. Cochran & W. Dahms | Response of growth, mortality and crown cover over 27 year period from 5 levels of spacing on dense natural PL | Greatest cubic volume produced at 6 ft. spacing - wider spacings produced similar fbm volum. Crown widths increased as density widened. | 5 |
| Severely Repressed Lodgepole Pine Responds to Thinning and Fertilization: 19 Year Results | Weldwood of Canada Ltd (Hinton) | C Farnden & L Herring | observations over a 19 year period | best treatments gained 3 m in top height and 8 m in site index | 6a |
| Stand-Tending and rehabilitation Treatment Options for 36 Year Old Height Repressed Pl | BC MOF | T. Newsome, J. Parry | | Fertilization increased annual height growth significantly. Thinning alone produced diameter growth response but no height response. | 6b |
| Thinning Lodgepole Pine in Southeastern B.C.: 46 Year Results | BC MOF | W Johnstone | observations over a 46 year period | Response to treatment substantial in relative terms but not in absolute terms. As thinning intensity increased, individual tree volume increased but total stand volume decreased. Response to MPB attack supports theory that heavy thinning may assist in beetle proofing. | 6c |
| A Summary of Early Results from Recent Pl Thinning experiments in the BC Interior | BC MOF | W Johnstone, F van Thienen | 10 to 20 year observation periods | "trials are as yet too young to provide definitive answers on the optimum thinning regimes for Pl". Trends: see p. 58 & 59 of report | 7 |
| RPF Forum, July/August 1998, Real cost of enhanced forestry | | A. Baliisky, A. Rynsburger, C. Hoffart | | most 'intensive silviculture' activities in lodgepole pine stands are unnecessary from a timber or fiber supply perspective, are generally outlandishly economically inefficient, and are probably reducing the quantity and quality of the gross merchantable fiber yield on some of the most productive forest land in the northern interior of British Columbia | 8 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Spatial and Temporal Response of Vegetation to Silvicultural Practices in IDF Forests | ? | D Miege, D Lloyd, A Arsenault | lichens and bryophytes may be more sensitive indicators of environmental change than vascular plants | herbs and shrubs in greater abundance in large canopy gaps/cutblocks than in smaller gaps, species diversity is not greater; lichen and moss less abundant in cut blocks | 9 |
| Product Parameter Based Decision Support System for Jack Pine | Forestry Research Partnership, Forintek | T Zhang | | Developing SDMD's for product targets | 10 |
| A Retrospective Study of the Impact of Juvenile Spacing on Pl Yield | Babine EFMPP | L McCulloch | | Accuracy of TASS predictions inconclusive due to past spacing treatments | 11 |
| Validation of an Early Stand height Growth Model for PL on the Babine EFMPP | Babine EFMPP | R Vassov | objective: to validate accuracy of site index models in the Lakes TSA | Green-up heights reached two years less than predicted | 12 |
| Clumpy Spacing Juvenile Spacing Douglas Fir into Clumps to Imitate Natural Stand Structure | MOF | H Armleder | | Clumpy spacing advocated in MDWR areas | 13 |
| Fourteen-year growth response of young lodgepole pine to repeated fertilization | | B Kishchuk, G Weetman, R Brockley, C Prescott | | confirms existence of nutrient limitations other than N | 14 |
| Effects of Stand Density Management on Forest Insects & Diseases | NRC | L Safranyik | | Though thinning may have other negative impacts it can reduce pest incidence by removing of infested trees | 15 |
| Self Pruning of PL | Centre for Enhanced Forest Management, U of A | C. Prots, V. Lieffers & U. Silins | | Self pruning of lower branches is a mechanism to conserve water, reserving it for upper and better illuminated branches. | 16 |
| Effects of Thinning on Stem Form | ? 1932 | Meyer, Behre | | No significant change in stem form resulted from thinning | 17 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Effect of Silviculture on the Yield & Quality of Veneers | Southern Research Station, USDA | L Groom, R Newbold, J Guldin | As structural grades of plywood continue to be replaced by OSB, the economics associated with veneer production will change to favour higher grades and lower the value of lower grades thus affecting silviculture returns | Veneer from natural regeneration yielded best quality and highest financial ROR. | 18 |
| Effects of Stand Density (Spacing) on Wood Quality | OMNR, Northeast Science & Technology | A Willcocks, W Bell | Reference to 1988 Ballard & Long report concluding "initial density should be based on the largest acceptable knot size for a particular product" | Questions belief that significant quality differences accrue from small changes in spacing regimes | 19 |
| 31 Year Progress Report for the Chilco Creek Installation, Vanderhoof Forest District (E.P. 660) | MOF, Prince George Region | D Coopersmith, B Rogers, V Sit | Long term (1967+) plantation study examining influence of espacement on growth performance of white spruce, douglas fir and lodgepole pine | Densities not sufficient to induce natural pruning. Fir suffered from repeated frost damage | 20 |
| MPB: Spacing to Access Fibre & Improve Stand Growth & Value; Spacing to Maintain Habitat & Visual Quality Objectives; Spacing to Reduce Stand Susceptibility | CFS | | | Commercial thinning in ageing Pl proved economic. | 21 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Soil Biodiversity, Extension Note # 13 | MOF | B Chapman, M Kranabetter | | Retention of varying scale island remnants required | 22 |
| Guidelines for Maintaining Biodiversity During Juvenile Spacing | FRDA | A Park, L McCulloch | specific guidelines, App. 2 | Retain 5 - 10 >40 cm. dia. snags/ha. | 23 |
| Guidelines for Maintaining Biodiversity During Juvenile Spacing | FRDA | A Park, L McCulloch | specific guidelines, App. 2 | Retain 5 - 10 >40 cm. dia. snags/ha.; retain >40 cm. CWD | 23 |
| Goshawk and Raptor Inventory in the Cariboo, 1996 | MOELP | Beak Pacific Ltd. | | Goshawks have a narrow range of tolerance for tree densities (500 - 820 trees/ha), | 24 |
| Using Individual Tree Selection Silviculture to Restore Northern Goshawk Habitat: Lessons from a Southwestern Study | | Wayne Shepperd, Lance Asherin & Carlton Edminster | Study examined stocking ranges in small groups or clumps and affect on habitat. | Range of Vertical Stand Structure through time recommended over the landscape. | 24 |
| Old Growth Structural Attributes in Managed Forests: Is There a Vision? | Applied Mammal Research Institute | T. Sullivan, D. Sullivan & P. Lindgren | To test hypothesis that spacing will enhance species diversity of herb, shrub and tree layers and small mammal richness | Greater crown volumes exhibited in low & medium density stands. CWD levels similar in all stands. Richness and diversity of herbs, shrubs and trees similar in thinned stands. Structural diversity of all vegetation highest in low density thinned stands. Abundance of voles highest in old growth. Abundance of mice similar in all stands. Abundance of weasels higher in low density stands. | 25 |
| Spacing to Increase Diversity Within Stands | BC MOF, Forest Practices Branch | A Powelson, P Martin | Definition of "large tree" will vary by ecosystem. Stand Density Management Diagram used to illustrate concept | Widely spacing a stand can accelerate diameter (but not height) growth and development of some of the attributes of large trees | 26 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Spacing to Increase Diversity Within Stands | BC MOF, Forest Practices Branch | A Powelson, P Martin | Large crowns and long crowns enhance structural diversity - provide large diameter branches for nesting/perching and development of plant and animal communities | Wide spacing enhances production of longer, wider crowns with larger branches | 26 |
| Spacing to Increase Diversity Within Stands | BC MOF, Forest Practices Branch | A Powelson, P Martin | "Clean" logging leaves few dead standing trees and minimal CWD | Mortality within regenerated stand required to produce CWD/snags. Spacing delays mortality and reduces mortality volumes | 26 |
| Spacing to Increase Diversity Within Stands | BC MOF, Forest Practices Branch | A Powelson, P Martin | | Wide spacing promotes the development of a layered canopy. | 26 |
| Spacing to Increase Diversity Within Stands | BC MOF, Forest Practices Branch | A Powelson, P Martin | | Spacing can increase stand spatial diversity | 26 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases density | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases canopy closure | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases diameter growth | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases mortality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases habitat quality | 27 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing decreases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing has no affect on habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing has no affect on habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing has no affect on habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases habitat quality | 27 |
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | | Spacing increases habitat quality | 27 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Stand Tending Impacts on Environmental Indicators | ESSA Technologies Ltd. | J Greenough, W Kurz | stand density management involves trading off an increase in one environmental value against a decrease in another | No one treatment should be uniformly applied across the entire landscape | 27 |
| Recruiting Caribou Habitat Using Silviculture treatments | MOELP | L Waters, R Delong | Revelstoke area | Create open forests with large trees and complex structure; increase amount of lichen in later seral stage forests | 28 |
| Silviculture Guidelines and Practices for Maintaining or Recrutting Key Habitat Objectives | MWLAP, Biodiversity Branch | Manning, Cooper & Assoc. | see Development Type Assumptions, Habitat | | 29 |
| Effect of wind on newly thinned "doghair" PL | Centre for Enhanced Forest Management, U of A | X. Liu, R. Man, V. Lieffers & U. Silins | | Thinning should be done early in "doghair" stands | 30 |
| Repeated fertilization of Pl produced shorter, stouter trees with large lower branches and poorly formed upper crowns | Centre for Enhanced Forest Management, U of A | I Amponsah, V Lieffers, P Comeau, R Brockley | | Annual fertilization resulted in shorter and stouter trees with larger branches than the control | 31 |
| Loss of growth efficiency in stagnant overstocked Pl stands | Centre for Enhanced Forest Management, U of A | D Reid, V Lieffers, U Silins | | overly dense stands on poor sites thin too slowly when left unmanaged | 32 |
| Is the plumbing faulty in doghair Pl trees | Centre for Enhanced Forest Management, U of A | D Reid, V Lieffers, U Silins | | overly dense stands on poor sites result in a decline in the ability of the stem to conduct water to the crown | 33 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| A Brief Literature Review of the Status of Early Stand Density Management in Other Forest Industrialized Countries | FPB | | Cites benefits of stand density mgt. From other jurisdictions | Simulation models…can only provide crude estimates of merchantable volume, piece size & distribution by dia. Class at any predetermined rotation. Financial analyses based on output of these models is at best questionable. | 34 |
| A World Review of Strategic Silviculture Planning Processes that have Potential for Application in BC | FRDA (Report 223) | | | Concluded: extend range of species/silv practices in SYLVER, develop standard price/cost assumptions for silv planners, use timber supply models more, develop a global supply/demand model | 35 |
| Opportunities for Using Forest Level Planning & Silviculture to Enhance Forestry in the Future | | G Baskerville | | fundamental need to establish a functional link between forest level planning and stand level silv. To evaluate use of silv. As a tactical tool ("act stand, think forest") | 36 |
| Forest Level Effects of Stand Density Treatments | Cortex Consultants Inc. | J Tanz | | silv. Activities cannot be planned based on stand-level objectives alone | 37 |
| Incremental Silviculture Strategy for BC | FPB | R Winter | | Guiding Principle: "only course of action is that which minimizes risk and maintains options" (from gov't. perspective) | 38 |
| Incremental Silviculture Strategy for BC - Working Paper 1: Project Information, List of References; Working Paper 2: Concepts of Straegy & Planning, Proposed Framework; Working Paper 4: Proposed Log Quality framework, Timber Supply & Demand | FPB | LP Atherton & Assoc. | | "projecting real log prices…is fruitless". "maintain options by creating a diversified portfolio of forest stands appears to be the best choice…- the greatest reason for this choice is it reduces risk" | 39 |
| Strategic Silviculture Planning Initiatives in BC | FPB | R Winter | | Silv. Strategies for TSA/TFL's. focused on timber supply, quality and habitat | 40 |

| Title | Organization | Author(s) | Comment | Conclusion | Index |
|---|---|---|---|---|---|
| Silviculture Funding for Sustainable Forest Management: Principles & Policies for the Next Decade | Western Silviculture Contractors Assoc. | Policy Committee, WSCA | | | 41 |
| The Effect of the Silviculture Survey Parameters on the Free Growing Decision Probabilities & Projected Volume at Rotation | Research Branch, MOF | W Bergerud | | Lower Confidence Limit Decision Rule minimizes the crown's risk | 42 |
| Linking Regeneration Standards to Growth & Yield & Forest Management Objectives | Alberta Minister of Sustainable Resource Development | Alberta Reforestation Standards Science Council | | see Executive Summary p.1 | 42 |

## 5.1 Biotic Information

The TIPSY model provides stand level output of a range of biotic factors. Using TIPSY as an analytical tool the March 2002 Sterling Wood Group report, "Maximum Density and Countable Heights in Lodgepole Pine" (see Appendix F), concluded there is very little difference in the average diameter of stands over a wide range of initial stocking densities at typical culmination ages, owing to natural stand convergence, so long as the stands are not stagnant. To quote the report:

"…in overcrowded stands, as development proceeds and average plant size increases, stand density will converge to the same level, irrespective of differences in initial stand density. These principles lead us to expect that, for any selected average tree volume to be reached in some feasible rotation, many dense stands across a wide range of initial densities will converge, without thinning treatments, to that selected stage of stand development. Using Ministry of Forests' stand model TIPSY 3.0, this project has confirmed that expectation."

The report recommended that the highest density at age 15 which will converge to the highest stand structure without spacing should be labeled the "Acceptable Density". It also recommended acceptable density levels, by site index classes, for the Cariboo Kamloops and Nelson Regions, and recommended that countable height be changed from 20% to 50% immediately, and that additional field studies be undertaken to see if it could be further increased.

The subsequent Ministry of Forests' peer review (see Appendix G) of the Sterling Wood Group report stated that:

- "Maximum density should be based on a decision process that incorporates management objectives supported by an analysis of standing volume, product value and economic return." and
- "The maximum density proposed by the consultant, and the current standard of 10,000 trees, are unreasonable because they enforce juvenile spacing at any cost without regard to future gains or losses incurred by the treatment." and
- "This "one size fits all" approach to management is administratively convenient. However, it does not consider costs, benefits and management objectives. There is an urgent need for a more comprehensive and cost-effective process that will help foresters implement results-based silviculture."

The peer review report then recommended implementation of the Chief Forester's policy and guidelines for developing site-specific stand density management prescriptions (see Appendix A) – a course that the *Cariboo Stand Density Management Advisory Committee* had decided to undertake some months ago as outlined in Appendix H. The peer review also recommended consideration should be given to the following:

- Examine the trade-offs incurred when managing to maximize volume production versus economic return.
- Compare the impact of alternative management objectives on the rotation age, merchantable volume and net present value realized from each option.

The peer review report concluded by noting the economic risk posed to silviculture investments by the long time period between investment and its fruition. To quote the report: "Foresters could consider….in light of the magnitude of the expected benefits, and the risk that the benefits may not be realized at harvest. For example, will the market place of the future recognize the benefits of small gains in piece size considering the increasing role of engineered wood products and substitutes?" The report ended by quoting Reid Carter[1], as follows: "Value comes from differentiating the products not the resource. It takes too long to differentiate the resource once you know what the market wants."

In summary, the peer review emphasized the importance of economic factors and considerations in most appropriately managing stand density, including assessing investment risk and projecting forest product market demands into the future – a theme discussed in sections 5.2 and 6.1 of this report.

With TIPSY providing stand level information, it was nonetheless recognized that further stand level data or information sources were required for assessment of biotic risk factors. In addition to the information summarized for the previously referenced literature review, three main sources provided further information on biotic risk factors:

[1] forest products analyst with National Bank Financial

- Stand Establishment Decision Aids (SEDA) available online from the Forest Research Extenship Partnership (FORREX) at http://www.forrex.org/projects/2002/seda/homepage.asp and provided in Appendix W of this report. SEDA provides a summary of biotic risk factors and recommended treatment guidelines for vegetation competition, diseases and insects.
- Provincial Rare Natural Plant Risk Associations available from the BC Conservation Data Centre
- Silviculture Guidelines and Practices for Maintaining or Recruiting Key Habitat Objectives (Manning, Cooper & Assoc., June 2002) provided by the Ministry of Water, Land and Air Protection (MWL&P)

## 5.2 Economics and Forest Products Outlook

In early 2003, the former *Timber Enhancement Strategy Committee* commissioned a report to provide information to begin the process of reviewing economic factors relevant to developing appropriate, site-specific stand density management prescriptions the Cariboo Forest Region. The key findings of the *"Stand Density Management: Economic Background"* report (see Appendix M) are as follows:

- Industry has a history of strong adaptability to whatever forest resource is most readily available, at low cost.
- Log value is not simply a function of log size. The high value of the lumber yield from many small diameter logs illustrates this point.
- The proliferation of, and strong market inroads made by, Engineered Wood Products as a higher performance, lower installed cost replacement for solid sawn lumber products essentially caps the price of solid sawn lumber products.
- Sawn lumber is vulnerable to substitution by other wood and non-wood and hybrid products, should sawn lumber prices (or log costs) increase significantly. Even if lumber's price remains acceptable, on average, over time, its high price volatility has contributed greatly to user acceptance of, and continued use of, Engineered Wood Products and other substitute products.
- Assigning the most appropriate stand density management regimes to Cariboo ecosystems will almost certainly derive from a determination of the most economical achievement of whatever forest products are most readily produced by each forest ecosystem, cognizant of the themes noted above.

The report concluded as follows:

“The history and trends discussed in this paper imply that prudent strategies for forestland management are those that take advantage of the natural fibre characteristics of the sites being managed, and work in concert with those characteristics. For example, a strategy might call for small diameter, dense stands to be grown on the Chilcotin Plateau. Objectives could include yielding logs with dense and very stiff wood, to maximize its quality and potential value, while growing and managing for larger sized logs only where that is biologically facile, and relatively less costly to do – on ecosystems with richer sites. This would improve the chances of a positive return on the capital invested for long periods to produce larger logs for specialty or niche lumber markets, and log home building, far into the future.”

“The replacement, in the USA, of lost large and wide lumber production and softwood plywood production, by Engineered Wood Products[16] is an example of the kinds of trends (and economic forces at play) that must be kept in mind by forest managers while developing forest product targets and associated stand management prescriptions.” “Given the strong, and increasing, inroads being made by Engineered Wood Products, and the industry’s history of adapting to whatever resource is most readily available (cost and ready supply), coupled with the impossibility of knowing in any detail what market opportunities will be in two or three decades, or a century or more, it appears that the most prudent approaches are those that:

Minimize costs incurred in developing future stands

Exploit each site’s natural fibre and growth characteristics to cost-effectively maximize potential future stand and log quality

Retain future product options until harvest time”

As part of the report a product survey of the Cariboo mills provided the results in Table 3. The table illustrates the general market trend to narrow width lumber is also applicable to the Cariboo mills.

Table 3: (values in %)

| **Year** | **Lumber** | **Plywood** | **Product Total** | **Up to 6”** | **8”** | **10”** | **Other** | **Lumber Total** | **Specialty** | **MSR[2]** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 85 | 15 | 100 | 69 | 11 | 20 | 0 | 100 | 0 | 0 |
| 1992 | 93 | 7 | 100 | 79 | 6 | 14 | 1 | 100 | 1 | 10 |
| 2002 | 94 | 6 | 100 | 85 | 6 | 8 | 1 | 100 | 2 | 12 |

[2] MSR understated, some mills MSR production not available

The recent Industry Canada report *"Technology Roadmap: Lumber and Value-Added Wood Products" (June 2003*)[3] reaffirms one of the key findings of the *"Stand Density Management: Economic Background"* report. Industry Canada's report states "The Canadian lumber industry clearly sees itself evolving towards more remanufacturing, with engineered wood products and appearance wood products being perceived as growth sectors in an industry intent on increasing its client focus as a means of delivering value. Technical innovation is likely to play an even greater role in these fast-evolving sectors, for which market opportunities are extremely varied, and the need for flexibility more critical yet than in the primary sectors. Progress will generally mean increasing attention to, and integration with, clients' manufacturing processes and end-user preferences. Design is singled out as the most potent link between the lumber industry and its new clients, as well as the key to enhanced product value."

A report on the North American outlook for engineered wood and non-wood products, that are used as direct substitutes for lumber, reiterates the key findings of the *"Stand Density Management: Economic Background"*. The report states that increasing volumes of wood and non-wood substitutes are displacing conventional, sawn structural and appearance grade lumber products at a slow but very steady rate. "These substitutes," explained Russell Taylor, Publisher of *WOOD Markets* and author of the report, "include a variety of engineered wood products but also includes an assortment of non-wood items (e.g., vinyl sidings, mouldings and windows; plastic lumber and decking; and steel)." Collectively, these substitutes represent a volume equivalent to over 10% of all wood products consumption in North America, or more than 7 billion bf in 1999 (Table 4). "More convincing," said Taylor, "is that these substitutes have collectively been growing at the astounding rate of almost 20% per year since 1992 – a rate that pales to anything in the solid wood business."
What is almost unbelievable to the lumber trade is that an increasing number of end-users and consumers are willing to pay substantially more for engineered or specialty non-wood products over lumber. "For example," said Taylor, "a spectrum of end-users will pay a 50% premium for plastic decking lumber over the price for some of the highest quality knotty cedar or twice the price for treated pine decking." Why? One simple premise is the reason: these substitute products can deliver the quality, value, performance and reliability that the end-user wants – and paying a higher price than wood is becoming a trend in some product lines!
These same end-users are choosing substitutes over lumber partly as a lack of confidence with wood or in response to the strong promotion that substitutes are able to generate. As well, problems with variable lumber quality and volatile prices have caused builders to switch to the largest group of lumber substitutes, engineered wood products (mainly I-joists, laminated veneer lumber, glue-laminated beams and finger-jointed studs). About 70% of lumber substitutes are actually wood-based or engineered products with the balance an assortment of non-wood products.

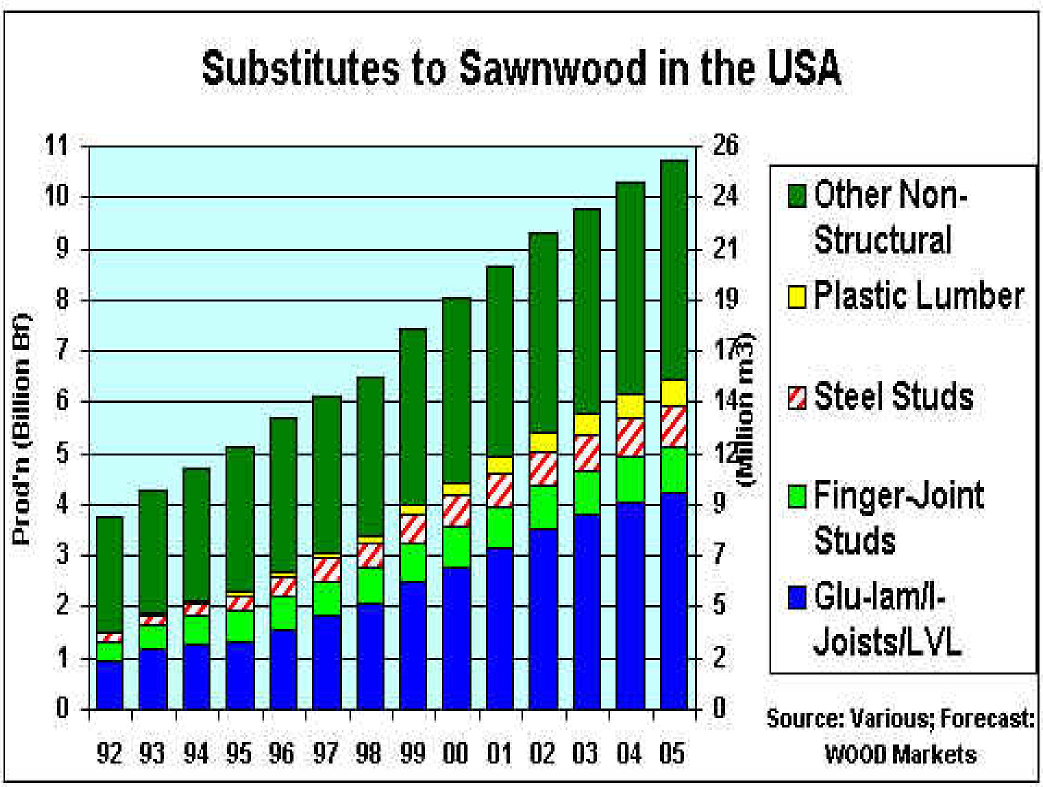
[3] available on line at http://strategis.ic.gc.ca/epic/internet/infi-if.nsf/vwGeneratedInterE/fb01315e.html

"This variety of lumber substitutes is growing at the pace of over 500 million bf per year – about the equivalent production of three large sawmills," said Taylor. However, this incremental volume will likely give lumber producers some additional trouble since an oversupply of lumber is expected to lower sawmill output throughout North America over the next few years.

"Steel studs used in residential house construction still remain the largest threat to solid sawn and engineered lumber," said Taylor, "even though the actual use of steel to-date is still very small." "This is contrast to vinyl siding," commented Taylor, "which over the last 20 years has achieved a 50% share of the siding market with a product that is now the lowest priced product on the market. Two other substitutes, fibre-cement siding and OSB, have another 10% each, while wood siding has sunk to about 8% from close to a 50% share in the late 1970s."

Substitute products are forecast to increase in quantity while a variety of new composite products designed "with the consumer in mind" are expected to enter the market on a steady basis. The onslaught of substitute products will continue to be driven by an older and wealthier consumer that wants products that offers consistent performance, little to no maintenance, and are backed up by warranties ranging from ten to 50 years. Conventional lumber's fit into a more discerning market environment will mean that some commodity products will need to be improved, re-positioned, or be priced even lower to remain good value over a variety of specialty products or substitutes. At the current rate of growth, substitutes will continue to put extra pressure on lumber's dominant (but fragile) market position and its current over-capacity, making price advances even more difficult for lumber."

Table 4:



A report issued by the US Forest Service, entitled *"An Analysis of the Timber Situation in the United States: 1952-2050"*[4], projects that sawtimber prices will increase negligibly in the future and, echoing the projections above, estimates that lumber and plywood will be in less demand. The report reached two main conclusions:

- Softwood sawtimber prices are projected to increase over the next 50 years, but at a rate (0.6 percent per year) considerably below that of the past 50 years (1.9 percent per year)
- With lumber and plywood composing a decreasing share of total forest product output, virtually all of the projected increase in U.S. harvest is in non-sawtimber trees—trees used for OSB or paper and paperboard.

The Executive Summary from the document states:

"For more than a century, the United States has developed periodic national assessments of future supply and demand prospects for timber that have helped shape perceptions of resource trends and needs for new or modified forest policies.

Since 1952, U.S. timber harvest has risen by nearly 67 percent, accompanied by growing timber inventories on both public and private lands but a decline in the critical private timberland base. Projections to 2050 in the fifth RPA timber assessment show the forest products sector continuing to change, with U.S. timber harvest expanding by an additional 24 percent to meet increased consumption needs. As a result of steady improvement in growth and productivity on U.S. forest lands, this harvest increment can be accommodated by continued expansion in inventory despite decreasing area in the private timberland base.

[4] from General Technical Report PNW-GTR-560, An Analysis of the Timber Situation in the United States: 1952-2050, A Technical Document Supporting the 2000 USDA Forest Service RPA Assessment, Richard W. Haynes, Technical Coordinator. Full document available on line at http://www.fs.fed.us/pnw/pubs/gtr560/

Projections to 2050 show the forest products sector changing and expanding to meet a 40-percent increase in U.S. consumption of forest products by 2050. The rate of increase is less than one-third the annual rate of increase over the last 33 years owing, in part, to declining use of paper and paperboard per dollar of gross domestic product, and projected relatively stable housing starts. Increasing consumption needs would be met by:
(1) an increase in U.S. timber harvest of 23 percent,
(2) an increase in log, chip, and product imports of 85 percent, and
(3) an increase in use of recovered paper of 85 percent.
With a near-term economic recession, U.S. roundwood harvest is projected to decrease in the short term, then increase. The proportion of total roundwood needed for domestic product consumption that comes from domestic timber harvest decreases from 80 to 73 percent by 2050. The remainder is provided by harvest in other countries. Per capita U.S. wood and paper product consumption will remain just under three-quarters of a ton per person per year while per capita U.S. timber harvest will decline. Consumption shifts toward pulp and paper products from a 27-percent share in 2000 to a 37-percent share by 2050.

The share of composites increases from 3 to 7 percent. Oriented strandboard (OSB) production displaces softwood plywood, further eroding the importance of solid wood products. Hardwood lumber production grows more slowly than softwood lumber production. Softwood lumber imports from Canada rise in the near term, and after 2015, softwood lumber production increasingly expands largely in the South and, to a limited degree, the Pacific Northwest. Pulp, paper, and paperboard production increases most in the South, mainly in the South-Central region.

Relatively stable forest product prices are expected over the next five decades. Softwood sawtimber prices are projected to increase over the next 50 years, but at a rate (0.6 percent per year) considerably below that of the past 50 years (1.9 percent per year). Market-based adjustments on private timberlands plus increased imports help meet expected increases in U.S. consumption. Despite generally rising prices, stumpage markets in the West will continue to be weak for small-diameter logs. Hardwood pulpwood prices will remain relatively low but will increase at the end of the projection period with increasing limitations on availability of harvestable hardwoods on non-industrial private timberlands in the South. Softwood pulpwood prices will remain at or below recent depressed levels, then rise at the end of the projection. Prices for softwood and hardwood lumber will increase at about the same pace as for sawtimber. The increase rate for softwood lumber is less than for the last 50 years. Prices for oriented strandboard increase faster than for softwood plywood but remain less than the softwood plywood price. Prices for nonstructural panels and for paper and paperboard remain relatively stable through 2050.

In the period to 2050, annual U.S. timber harvest is projected to increase 24 percent to 22.4 billion cubic feet. Softwood harvest is projected to increase to 13.7 billion cubic feet and hardwoods to 8.8 billion cubic feet. In addition, the consumption of hardwood agrifiber grows to about 0.1 billion cubic feet. With lumber and plywood composing a decreasing share of total forest product output, virtually all of the projected increase in U.S. harvest is in non-sawtimber trees—trees used for OSB or paper and paperboard. The overall share of harvest from non-sawtimber will increase from 44 percent in 2000 to 66 percent by 2050. The share of total harvest from non-industrial private land will increase from 61 to 63 percent. Softwood timber inventories will increase by 53 percent, mostly on public timberlands. Hardwood inventories, almost entirely in private forests, will increase by 27 percent. Inventory changes expected for softwoods are similar across regions, but there are differences for hardwoods for which there is a decrease in the South.

Over the next 50 years, the species composition is projected to remain comparable to current conditions with the exception that in the South, upland hardwood acres decrease while planted pine acres increase. For the most part, age structure of forests will shift toward a greater proportion of acres in sawtimber with the exception of decreasing sawtimber acres for private hardwood timberland in the South and for private softwood timberland in the West, although in the West, the sawtimber proportion will increase after 2020.

Most (80 percent in 1997) of timber harvest takes place in the Eastern United States. Most of the expected increase in harvest will come from managed stands primarily in the South. By 2050, about 60 percent of the softwood timber harvest from private timberlands will come from plantations (both in the South and the Pacific Northwest West) that occupy about 30 percent of the softwood timberland area and less than 20 percent of the total timberland area.

The proportion of the roundwood harvest consumed in the United States for wood pulp is expected to remain relatively constant at 30 percent; wood pulp capacity is projected to increase modestly by 26 percent after 2010 as paper recycling rates stabilize. Use of softwood pulpwood from pine plantations, and use of recycled fiber are expected to increase.

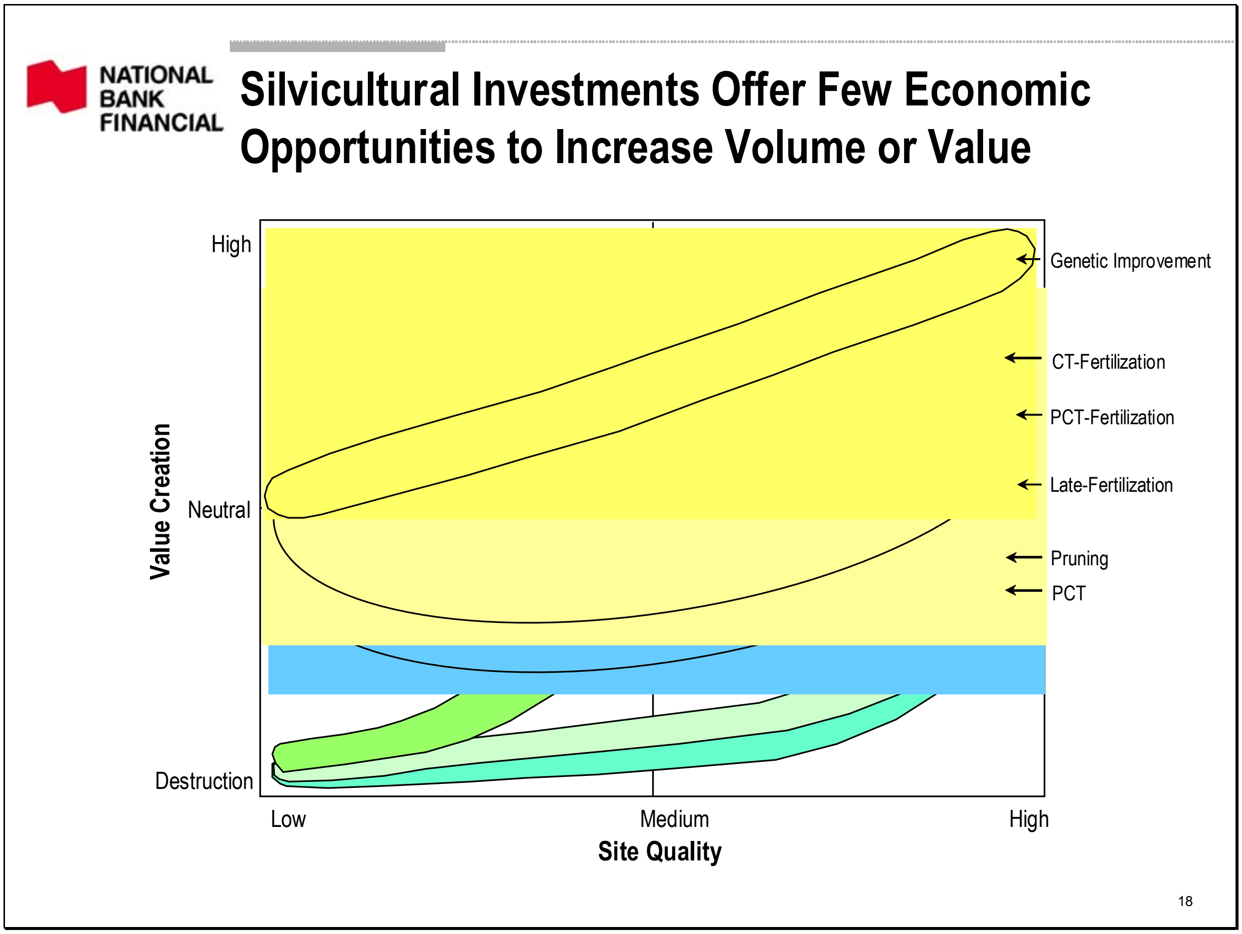
Canada is expected to provide the primary source of imports (over 75 percent), but imports from other sources also are expected to increase. Canada will provide roughly 30 percent of U.S. softwood lumber consumption over the next 50 years, but imports from other countries (Eastern Europe, the Nordic countries, Southern Hemisphere countries) are expected to increase to 15 percent of U.S. softwood lumber consumption. Canada currently provides 80 percent of U.S. paper and paperboard imports, which amount to 14 percent of U.S. paper and paperboard consumption. Other countries provide imports for 3 percent of consumption.

Canadian share of U.S. consumption will increase in the near term to 17 percent then decline to 12 percent by 2050. Other countries' share will increase from 3 to 10 percent of consumption. Imports from Canada of paper and paperboard are projected to continue increasing; imports from Canada of printing and writing paper increase in the near term, then level off; and imports from Canada of newsprint decline. United States imports of printing and writing paper will come increasingly from Europe and Asia. Canadian exports of higher valued printing and writing paper will increase."

The USFS report projects that the long term outlook may be for a very slight rise in real prices. However, in the shorter term the range of price fluctuations are significant, as evidenced from the chart in Appendix V. The chart shows that lumber prices fluctuated from below $200.00 US to $500.00 US from 1990 to 2003. This historic lumber price fluctuation is likely to remain a major factor in the lumber supply chain.

Reid Carter's 2003 presentation to the Association of BC Professional Foresters Annual General Meeting (see Appendix X) offered similar conclusions in that forest products are now a commodity product competing in an oversupplied global market and that "cost minimization is the most suitable strategy" for BC. Mr. Carter's presentation concludes that opportunities for silviculture, from a market based perspective, to increase stand value or volume are very limited as illustrated in Figure 3.

Figure 3.




## 5.3 Forest and Stand Level Data and Models

Forest level data sets and FSSIM models developed by the former CCLUP TESC provided the foundation for estate modelling for individual TSA's. The data sets and models were made available from a 2002/03 fiscal year TESC project (FIRS #1018017) which provided documentation and models for the 100 Mile House, Williams Lake and Quesnel TSA's. The models provided were calculated to within 1% of the AAC in the TSR 2 Analysis Reports.

A Woodstock forest estate model was utilized to test initial scenarios.

# 6 Issues Identification

As stated in the introduction, the original impetus for this project stemmed from a licensee wide concern that current regulatory obligations[5] were likely forcing unnecessary and costly silvicultural treatments. These treatments are mandated without consideration of future losses or gains. The current obligations were assessed as a financial liability in the $15 million range[6] as shown in Appendix E. In recognition of the issue, the Ministry of Forests responded with the Regional Manager providing a letter of support in November 2002 (copy in Appendix K) as well as District Managers indicating willingness to delay obligatory treatments while the *Cariboo Stand Density Management Advisory Committee* work is in progress. There is a risk associated with deferment from the licensee's perspective. Stands may be held under licensee obligation for a longer period of time and may be more susceptible to fire outbreak during that period. Additionally the accounting liability issue to licensees and BCTSP is not resolved – merely delayed.

Timber product outcomes from implementation of the current Silvicultural Stocking Standards beyond the stand level have never been tested. It is simply assumed that managing to these standards will provide the required forest of the future. It is not known if the treatments and costs associated with the maximum density regulation and the current Silvicultural Stocking Standards are necessary or appropriate at the Management Unit level from an AAC perspective or are cost effective.

One silviculturist stated "We field practitioners would love to use the Guidelines for Stand Density management as recommended but the first step in using them is to clearly articulate forest product objectives and we don't have those in most management units. Until we get them we will continue to manage toward the generic "middle ground" where densities are somewhere in the 2,000 to 10.000 s.p.h. range at free growing age."[7]

Further issues, by category, are discussed on the following pages.

[5] From Silviculture Practices Regulation: "if a silviculture prescription for an area was approved before April 1, 1994, the person who is required to establish a free growing stand under the prescription must, if the density of lodgepole pine or drybelt Douglas-fir trees per hectare exceeds 10 000 or another number specified by the regional manager under subsection (3), carry out a spacing treatment on the area before the end of the free growing assessment period to reduce the number of trees"

[6] As of December 2001

[7] Bruce Pamplin, MOF, Maximum Density Presentation: Counterpoints from MOF Staff

## 6.1 Economic Issues

In summarizing economic principles the “Chief Forester Policy on Stand Density Management “ states “because of the usually lengthy time period between density management treatments and final harvest, current utilisation limits, product values, timber market conditions and harvesting costs may not be useful”. Nevertheless the guidelines state that “stand-level economic analysis must be undertaken”. The document also states “key elements and variables in stand-level economic analyses include:

1. Stand models and data sets that are consistent with the biological concepts of timber production

2. Anticipated product (log, lumber or chip) values at the time of harvest, including any anticipated future real price increases (these values and prices should be based on estimates of future product markets)

3. Harvest costs anticipated at the time of future harvest, 30 to 80 years hence

4. Silviculture treatment costs, if comparing rotations of different length

5. Selection of an appropriate social discount rate

6. A sensitivity analysis of silviculture options”

Additional economic issues to consider include the following:

1. Investment risk over the period from initial silviculture treatment until ultimate forest harvest.

2. Uncertainty of market demand for particular forest products in the future, particularly given the time frame within which forest products run their life cycle from invention to obsolescence – typically in less than a Cariboo rotation period (plywood, for example).

3. Uncertainty and ability to predict future product prices.

4. Certainty that forest products manufacturers will continue to adapt to changing forest resource attributes, to reduce costs, and to add economic value to lower cost logs.

5. The powerful imperative of the forest industry to minimize its costs at every opportunity. Industry must avert needless expenditures and reduce costs at every opportunity. Industry must ensure that any discretionary costs incurred are only those that increase value (benefit minus cost) sufficiently to cover the carrying costs over the full investment period. This is also consistent with the government's New Era goals and approaches.

In a report commissioned by the Ministry of Forests entitled *"Incremental Silviculture Strategy for BC"*[8], L.P. Atherton & Associates concluded:

- "On the balance of probabilities, and given that timber is found to be generally price inelastic, it would *appear* that global real log prices are likely to rise over time[9], probably later rather than sooner. Predicting with any reliability the rate and timing of price increases, and differentials between grades and sizes is virtually impossible."
- "…projecting real log prices over the length of BC rotations, that is from 40 to 100 years and longer, is fruitless"

This view on prediction has been reiterated in presentations by the Forest Practices Branch.

[8] Working Paper 4: Proposed Log Quality Framework, Timber Supply and Demand, Feb 1999

[9] 0.6% per year as estimated by a recent USFS projection (see section 5.2)

## 6.2 Management Issues

Clark Binkley, the former Dean of the Faculty of Forestry at the University of British Columbia, stated that "Gordon Baskerville[10] likens forest management to building a house. You, the owner, know what you want from the house -- how many people it can sleep, how many people can sit in the dining room, how many cars in the garage,…An architect designs the house within the constraints of the building code. In forestry, the Forest Practices Code takes the place of the building code, and the forester the role of the architect. The one difference is there is no owner to articulate a clear, manageable objective for the forest. For this reason …there is no *forest* management in BC, just a string of stand management practices that may or may not add to a coherent overall design."[11] Moving from this current framework of stand management practices to an overall design approach requires identification and implementation of management objectives.

Strategic management issues to consider, when moving to objectives based management, include the following:

- Whether to adopt a strategy that targets specific forest products.
- Whether to adopt a strategy of keeping future forest product options open.
- Whether to adopt a strategy of minimizing costs "carried" by the managed stands.
- Whether to adopt a strategy of maximizing the future value of managed stands, based upon what we know today of market and forest product trends over time.
- Whether particular investment risk management strategies should be implemented in concert with any stand density management investments, in order to minimize the long-term risk posed by natural hazards to those investments.

[10] Dr. Gordon Baskerville is a professional forester registered in New Brunswick. He is retired from professorships in forestry at the University of New Brunswick and the University of British Columbia. Gordon has had a distinguished career in forest management spanning the continent since receiving his PhD from Yale. His research and management experience includes tenures with the Canadian Forest Service, New Brunswick Department of Natural Resources, UNB, and UBC. Most recently, Gordon chaired the Dept. of Forest Resources Management at UBC. He has been an active participant in the ongoing Canadian forest policy debate.

[11] excerpt from a presentation at the Private Forest Landowners Association AGM, June 5, 1998

- Whether there are any imperatives from the Cariboo-Chilcotin Land Use Plan, sustainability initiatives, biodiversity concerns and certification schemes that warrant consideration in assigning stand density management prescriptions in the Cariboo Forest Region. The one obvious aspect of the land use plan is the objective of managing Mule Deer Winter Ranges. In some ranges, there is need to improve range habitat by removing some of the overly dense stands; however, there is currently little prospect of economically harvesting these stands, at least at the present time.

- Whether timber and non-timber values and factors can be assessed and with availability of appropriate decision tools.

- Whether there are any serious economic risks of missed future opportunity inherent in adopting particular stand density management regimes.

- Whether there are any significant forest estate level implications associated with the various stand density management regimes that might be pursued.

## 6.3 Biologic Issues

Biologic issues to consider in designing stand density management regimes in the Cariboo include the following:

- Determining the stand density level above which stands would stagnate or suffer a significant decline in the identified target values.

- Determining the stand density level below which site occupancy is unacceptably low. (Note: Definition of what constitutes “unacceptably low” is itself a management issue.)

- Identification and assessment of the biotic factors influencing stand density development

## 6.4 Technical Issues

Technical issues arising include the following:

- Countable height criteria.

- Countable height methodology by stand type.

- Stocking survey methodology, including Minimum Inter-tree Distance. In particular, how to identify and capture in surveys, those trees and only those trees that will likely be competitors at crown closure.

- Determining the level of silviculture needed to ensure that site occupancy in developing stands is reasonably complete or meets standards under a "due diligence" concept.

## 6.5 Information Issues

Studies conducted by Forintek have concluded that a "comprehensive knowledge of the characteristics of any material is essential to its best utilization[12]". This conclusion would also translate into a requirement for knowledge of the characteristics of non-timber values. Based on information contained in the above referenced Forintek report, and other documents sourced in the research for this project, quantified knowledge of the following wood quality attributes and factors associated with various stand density conditions is ideally required:

- Mean wood density (specific gravity)
- Density variation (relative density)
- Log taper
- Dimensional stability
- Mechanical properties
- Current and future market requirements
- Current and future product financial values
- Lumber output by product (sawlog, chip)
- Lumber recovery
- Lumber grade
- Fibril angle
- Log volume
- Compression wood
- Knots

[12] "Discussion of Wood Quality Attributes and Their Practical Implications" by L.A. Joxsa and G.R. Middleton, Forintek Canada Corp.

- Log straightness
- Juvenile/mature wood distribution
- Age (tree or stand)
- Grain
- Machinability
- Rings
- Wood engineering properties
- Fibre length
- Bark
- Heartwood/sapwood
- Extractives
- Decay
- Growth stresses
- Moisture content
- Durability
- Wood permeability
- Aesthetic characteristics
- Finishing characteristics
- Fire resistance
- Coarse Woody Debris
- Snags
- Mortality
- Stand Density
- Live crown

- Crown closure
- Height
- Area (basal area)
- Seral stage
- Stand connectivity
- Habitat
- Life forms (guilds) within Natural Range of Variation
- Canopy layers (vertical structure) over time
- Future harvest and milling costs

Unfortunately many of these factors or attributes are not quantified or available for decision analysis.

## 6.6 Decision Tool Issues

Evaluating the effect of stand density assumptions and treatment costs on future yields requires use of a stand level model in conjunction with a forest estate model. At the estate level, the TSR 2 process used the timber supply model FSSIM for the Cariboo TSAs. FSSIM is a simulation model with the ability to approximate spatial harvest restrictions. Although suited for strategic level analysis it lacks optimization, cost tracking or economic analysis capability. Woodstock is a more flexible forest estate modeling system that can be linked directly to spatial planning software. There is not a need to conduct spatial level analysis for the stand density issue or to assess the spatial impact of current and revised stocking levels on AAC. However, moving beyond the capabilities of FSSIM to a model with cost tracking and economic analytic features is required. As well, an optimization component is desirable as it precludes the requirement to iteratively simulate runs. The ability to demonstrate the effect of stand level management variables[13] on forest estate objectives (AAC target, investment required, timber product targets, etc.) is necessary and is fundamental to the strategy of this initiative.

The stand level tools applicable to the stand density issue developed by the MOF are considered world class. These include TASS, Tipsy, TIPSY Economist and SYLVER.

[13] at least at the aggregated stand level

Computer modelling and analysis are essential to providing context and perspective to the issue, but due to risk and uncertainty in the projections should not be the only decision tool. There are numerous factors that are not measured in estate level or stand level decision tools (introducing uncertainty) or that are quantified but with an unexpected or unknown range of variation (introducing risk). Currently, forest managers are unable to predict stand developmental pathways for a given density treatment, due principally to the lack of managed stand response data as stands near rotation and corresponding integration of such data into operational decision-support tools. Furthermore, stand-level density management decisions must address the inversely related objectives of simultaneously maximizing merchantable volume, products, and value per unit area as well as, when appropriate, individual tree size. Other objectives including biodiversity and social values must also be balanced against risks such as insects, disease and fire.

This leads to the common problem of how to ensure good decisions. In this era of certification, sustainability and results based accountability a transparent methodology is required to ensure critical decisions are balanced. Therefore, a formal Decision Analysis methodology, providing structure, repeatability and displaying an "evidentiary path" is required for decision makers.

Multi Criteria Analysis[14] (MCA) is a decision making tool developed for complex multi-criteria problems that include quantitative and/or qualitative aspects of the problem in the decision making process. MCA is used to compare and rank alternative options or courses of action, taking into account and evaluating their known or likely consequences. MCA can help evaluate the relative importance of identified criteria and reflect their importance in the decision making process. Working with criteria with different dimensions MCA allows for consideration of criteria that are difficult to measure or where quantitative data is minimal. Reaching consensus in a multi-stakeholder arena or where differing opinions are expressed can be very difficult – especially when multiple criteria are involved. Team members don't have to agree on the relative importance of the criteria or the rankings. Each individual can enter their own judgments based on identified criteria. Formal decision analysis is particularly helpful when choices are complicated by difficult tradeoffs and by uncertainty about the consequences of management actions.

Good decisions require sound technical information, informed value judgments, and a structured decision process to integrate them. Structured decision making involves:

- Clearly defining the problem and the decision to be made
- Setting clear objectives and measures of performance
- Developing a range of creative alternatives
- Evaluating the performance of the alternatives and identifying key trade-offs

[14] explanation condensed from Wageningen University, Holland

- Assessing risk and uncertainty
- Understanding the values of the people and organizations affected by the decision and the importance they assign to different kinds of outcomes
- Making explicit and transparent choices

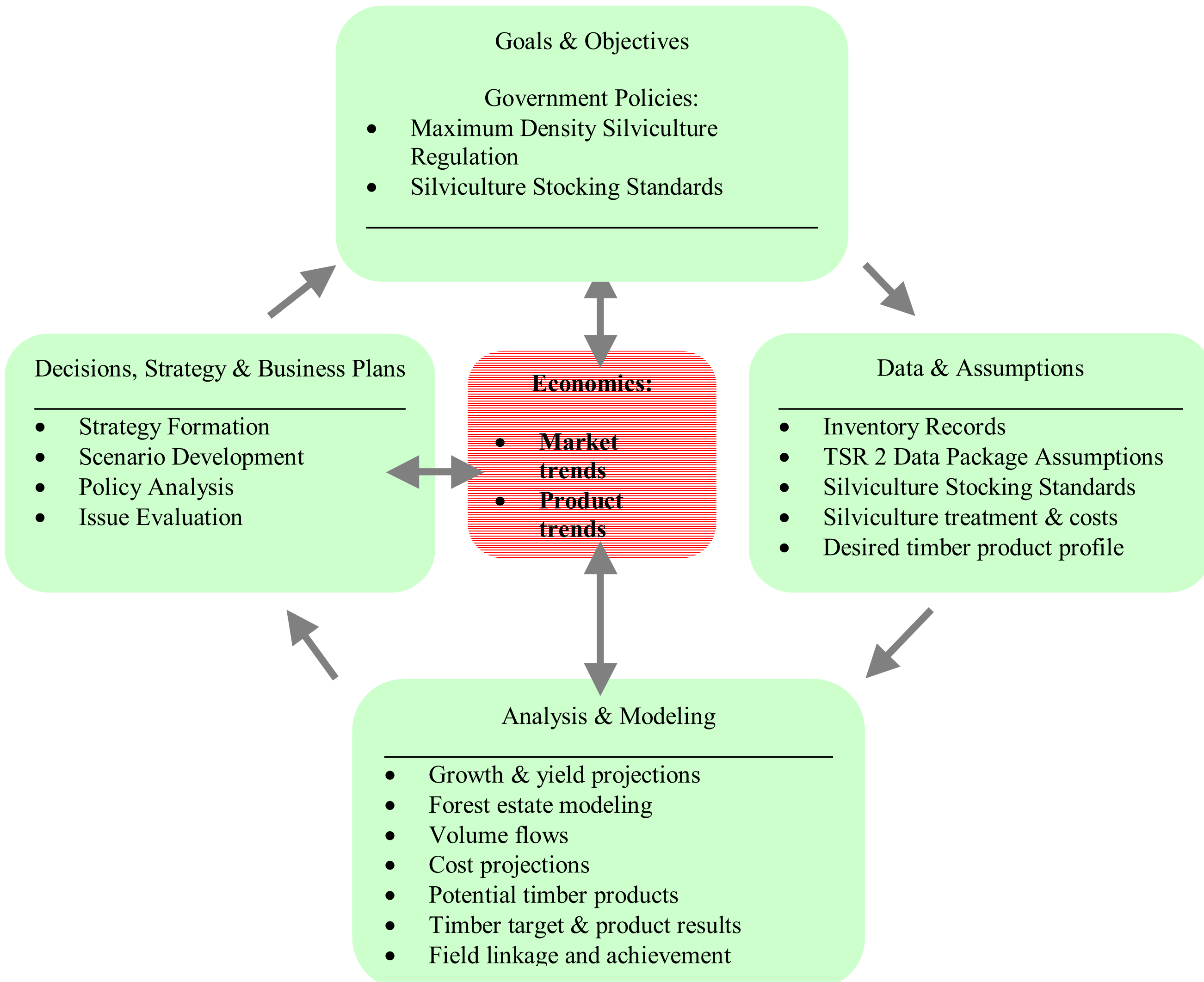
A summary of Multi Criteria Analysis theory and application is provided in Appendix U.

# 7 Strategy

The ability to measure the effect of varying stocking standards with associated varying treatment costs, at the estate level, on future timber availability and product profiles is required. However, simply illustrating the future product profiles is insufficient. Developing a product profile objective or target is also required and should be viewed as an initial step in creating the Desired Future Forest. This can be considered the Desired Future Forest - Timber Objectives. The Desired Future Forest condition is driven by the CCLUP, SRMP, sustainability and certification requirements in conjunction with economic and timber objectives. It was agreed to create a modeling environment and tools that would allow iterative assessment of varying stand density regimes. As well, the ability to link aggregated stand types at the silviculturalist operational level and illustrate estate level impacts from varying density control regimes is required. Modeling the outcomes of changing stand level strategies and having the results within a short time period was also a parameter. This strategy would allow the committee to “test and select” various scenarios. Recommended scenario(s), with density regimes, can then be presented to decision makers. In order to minimize modeling costs a pilot area was chosen within the Williams Lake TSA. A pilot area approach was deemed most practical as the objective is not to calculate an AAC for the TSA’s but to assess the implications of revised density strategies on AAC, product profiles and treatment costs to achieve the AAC and product profiles. The pilot area must be representative of the three TSA’s on the basis of site, species, ecosystem and silviculture treatment regimes. Core management objectives and associated density regimes can then be tested at the full TSA level using the FSSIM estate model with the appropriate TSR data and assumptions. The pilot area can be used to test numerous scenarios. When agreement is reached on a viable scenario it can be tested at the TSA level, for TSR type implications, using FSSIM. The pilot area utilized the Woodstock model for scenario testing. The selected scenario was then modeled using FSSIM with the appropriate TSR 2 assumptions for each TSA with the exception of the density regime to be tested.

The strategy allows for an iterative approach where scenarios and assumptions can be tested as illustrated in Chart A on the following page.

Chart A



Goals & Objectives
Government Policies:
Maximum Density Silviculture Regulation
Silviculture Stocking Standards
Decisions, Strategy & Business Plans
Strategy Formation
Scenario Development
Policy Analysis
Issue Evaluation
Economics:
Market trends
Product trends
Data & Assumptions
Inventory Records
TSR 2 Data Package Assumptions
Silviculture Stocking Standards
Silviculture treatment & costs
Desired timber product profile
Analysis & Modeling
Growth & yield projections
Forest estate modeling
Volume flows
Cost projections
Potential timber products
Timber target & product results
Field linkage and achievement

## 7.1 Decision Tools

Ideally data and modeling projection capability would be available to support the elements and factors identified as contributing to assessment of stand density regimes. This should include an estimation of the range of variability in the projections. This capability should extend from the tree to the stand to the forest estate level. Components of estimated stand level projections are available from TIPSY with estate models able to assist with assessment at the forest level. Recognizing that the full range of factors is currently not available for assessment by these tools requires the use of a third tool as discussed in Section 6.6 on decision tool issues.

It has been amply demonstrated that science based data is inadequate to address the issue of optimum stand density. Nevertheless decision makers must be provided with information on the consequences of alternative solutions to complex and expensive problems. The real issue becomes what is the level of acceptable risk. Can decision tools provide decision makers with a compelling reason to support density management and if so at what density levels? The level of acceptable risk will vary by proponent (eg. the crown vs industry). Incorporating Multi-Criteria Analysis is advocated to assist decision makers and introduces a third tool at the "issue evaluation" stage in the chart on the previous page. It can be used as a feedback mechanism to analysis and modeling. It provides a method to evaluate the relative importance of determining factors in the absence of agreed absolute factors.

## 7.2 Product Objectives

In preparation for moving toward "Management by Objectives" a review of forest product output and lumber profiles was conducted for the major licensee mills operating in the Cariboo region over the past twenty years. The objective of the study was three fold:

1) Determine what may be expected to constitute "high value forest products" in the future

2) Chart product output trends from Cariboo mills over the last twenty years (see Table 5 below).

3) Research and reference likely market trends

Table 5 on the following page provides a summary of the product outturn.

Table 5 (values in %)

| Year | Specialty | MSR | Up to 6” | 8” | 10” | Other | Lumber Total | Plywood | Logs Total |
|---|---|---|---|---|---|---|---|---|---|
| 1982 | 0 | 0 | 69 | 11 | 20 | 0 | 85 | 15 | 100 |
| 1992 | 1 | 10 | 79 | 6 | 14 | 1 | 93 | 7 | 100 |
| 2002 | 2 | 12 | 85 | 6 | 8 | 1 | 94 | 6 | 100 |

Based on this trend evident in Table 5, the conclusions iterated on page 14 of the *“Stand Density Management:: Economic Background Report”* (see Appendix M) and the stand level economic analysis as referenced in “Economics of Pre-Commercial and Commercial Thinning” (see Appendix N) the future timber objectives outlined in Table 6 below are recommended:

Table 6: Desired Future Forest, Estate Level Timber Product Targets

| Product: | Lumber | Plywood, Premium | Product Total | Up to 6” | 8” | 10” | Other | Lumber Total | Specialty | MSR15 |
|---|---|---|---|---|---|---|---|---|---|---|
| Target %: | 94 | 6 | 100 | 85 | 6 | 8 | 1 | 100 | 2 | 12 |

As referenced in the original work plan for this project, determining the correct balance in the planned portfolio for the Desired Future Forest is the question. The above table provides a target strategy based on market trends to date. A conservative approach to targets is used by adopting the 2002 profile. The trend of a continuing transition to an increasing component of smaller dimensional lumber and reconstituted wood products was held to 2002 levels. Targets can be modified to accommodate a different view and modeled to illustrate impacts.

Objectives focusing on timber product outcomes are applied and modeled at the estate level using the MOF’s TSR II assumptions and data. By default this approach ensures the integrated management objectives and the Cariboo-Chilcotin Land Use Plan[16], as interpreted in the Chief Forester’s AAC Rationale for Williams Lake TSA, are represented.

## 7.3 Product Value

Future timber values were not modeled for net present value in this exercise since, as previously referenced and adopted, it is impossible to predict and fruitless to do so. However, for comparative and reference purposes the selling price values in Table 7 were modeled using TIPSY projections from two perspectives:

- Culmination of Mean Annual Increment (volume) with value expressed in \$/hectare/year using the value ranges from Table 7

[15] MSR understated, some mills MSR production not available

[16] With reference to the MOF’s TSR 2 Analysis the Chief Forester’s rationale document stated: “…I am confident that the currently discernible implications of the CCLUP have been incorporated in the analysis as faithfully as is currently practicable for my consideration in this determination.”

- Culmination of Mean Annual Lumber Value ($ value) with value expressed in $/hectare/year using the value ranges from Table 7

Table 7

| | *Product ($/mfbm)* | | | | |
|---|---|---|---|---|---|
| *Value Range* | 2 X 4 | 2 X 6 | 2 X 8 | 2 X10 | Chips |
| *Low* | $150 | $250 | $250 | $350 | $50 |
| *Medium* | $250 | $350 | $350 | $450 | $75 |
| *High* | $350 | $450 | $450 | $550 | $100 |

The value ranges adopted for Table 7 were estimated from analysis of the range in variation of lumber prices over a 20 year period as demonstrated from data collected by *Random Lengths* in Table 8 and supported by the chart in Appendix V.

Table 8. Examples of price fluctuations -1980 to 2003. Prices are $/ 1000 board feet

| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Yearly Avg** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1980** | 230 | 236 | 207 | 168 | 190 | 215 | 221 | 214 | 195 | 199 | 213 | 204 | **208** |
| **1981** | 204 | 201 | 205 | 226 | 217 | 214 | 218 | 198 | 179 | 169 | 169 | 182 | **199** |
| **1982** | 175 | 169 | 177 | 177 | 175 | 188 | 182 | 169 | 164 | 166 | 187 | 201 | **178** |
| **1983** | 236 | 232 | 239 | 241 | 268 | 270 | 250 | 210 | 196 | 208 | 205 | 224 | **232** |
| **1984** | 224 | 239 | 244 | 225 | 202 | 195 | 190 | 196 | 184 | 184 | 192 | 204 | **207** |
| **1985** | 201 | 202 | 192 | 201 | 234 | 233 | 214 | 192 | 196 | 190 | 186 | 193 | **203** |
| **1986** | 199 | 200 | 236 | 244 | 230 | 212 | 210 | 221 | 223 | 212 | 219 | 212 | **218** |
| **1987** | 226 | 246 | 246 | 245 | 238 | 258 | 257 | 258 | 257 | 232 | 224 | 235 | **244** |
| **1988** | 239 | 248 | 244 | 247 | 236 | 248 | 249 | 219 | 220 | 221 | 230 | 233 | **236** |
| **1989** | 247 | 247 | 245 | 243 | 243 | 250 | 256 | 235 | 235 | 237 | 223 | 229 | **241** |
| **1990** | 232 | 245 | 248 | 261 | 247 | 243 | 237 | 220 | 214 | 203 | 202 | 206 | **230** |
| **1991** | 205 | 206 | 219 | 234 | 255 | 297 | 256 | 226 | 225 | 224 | 240 | 244 | **236** |
| **1992** | 266 | 305 | 325 | 309 | 293 | 269 | 258 | 269 | 278 | 261 | 290 | 319 | **287** |
| **1993** | 368 | 449 | 490 | 422 | 333 | 312 | 296 | 341 | 370 | 399 | 453 | 499 | **394** |
| **1994** | 491 | 476 | 459 | 377 | 416 | 404 | 390 | 396 | 363 | 382 | 402 | 370 | **411** |
| **1995** | 381 | 383 | 360 | 336 | 317 | 292 | 331 | 327 | 345 | 320 | 324 | 332 | **337** |
| **1996** | 329 | 346 | 353 | 366 | 416 | 409 | 402 | 442 | 443 | 421 | 459 | 428 | **401** |
| **1997** | 436 | 444 | 433 | 457 | 444 | 427 | 429 | 413 | 393 | 378 | 379 | 369 | **417** |
| **1998** | 359 | 375 | 369 | 369 | 331 | 332 | 345 | 355 | 326 | 332 | 340 | 350 | **349** |
| **1999** | 373 | 386 | 393 | 395 | 421 | 459 | 480 | 404 | 388 | 357 | 385 | 384 | **402** |
| **2000** | 387 | 385 | 381 | 354 | 326 | 331 | 304 | 287 | 291 | 277 | 283 | 271 | **323** |
| **2001** | 265 | 285 | 301 | 324 | 402 | 365 | 324 | 334 | 309 | 275 | 284 | 277 | **312** |
| **2002** | 297 | 317 | 339 | 325 | 313 | 302 | 309 | 292 | 279 | 274 | 265 | 271 | **299** |
| **2003** | 278 | 295 | 277 | | | | | | | | | | |

## 7.4 Non-Timber Values and Factors

Non-timber or non-commodity outputs under sustainable forest management philosophies must be recognized and managed. It was decided to adopt a strategy to proactively seek and determine these factors and provide a linkage to the aggregated stand level and to the estate level.

## 7.5 Strategy Summary

- Maintain the current AAC within each TSA at the TSR 2 level (pre MPB uplift)
- Achieve the Desired Future Forest, Estate Level Timber Product Targets identified in Table 6, Section 7.2
- Apply a conservative approach in allocating assumptions
- Minimize the silviculture treatment costs incurred in developing future stands
- Provide silviculture the benefit of the doubt as to the cost effectiveness of treatments in maintaining AAC through the ACE
- Diversify stand portfolios to plan for uncertainty and risk in future financial and biological predictions
- Exploit each site's natural fibre and growth characteristics to cost-effectively maximize potential future stand and log quality
- Retain future product options until harvest
- Develop an iterative modeling regime
- Provide a transparent link between stand and forest levels
- Demonstrate consideration for biotic factors related to timber and non-timber values
- Given the level of uncertainty in predicting future product values, harvest costs and application of an appropriate discount rate; economic modeling will not form part of the decision tool suite. However, silviculture costs and a range of product values will be tracked to provide an indication of cost and benefit.
- In the absence of appropriate data, and the variation associated with model projections, apply professional judgment in the context of risk assessment
- Develop the appropriate decision tools and decision framework capable of assessing and balancing technical data with professional judgment

# 8 Strategy Options Adopted

## 8.1 Stand Level

Documentation of tree and stand level factors influencing stand development and the management/decision cycle as depicted in chart A is necessary. Provision of an apparent linkage, where possible, to the estate level is also necessary. The linkage between stand level and estate level is maintained in the Development Type summary tables (MS Excel format) provided in Appendix R.

## 8.2 Estate Level

A number of alternative strategy options have been modeled to demonstrate the range of possible stand outcomes and associated forest product yields that would accrue to each option. The intent is to gain insight into the future stands' yield in terms of volume, potential product quality and associated silviculture treatment costs. It is expected that the analysis of these options will assist decision-making on a Cariboo strategy for stand density management regimes. Two strategies for estate modeling are applied:

- Development of a pilot area applicable to scenarios 1, 2, 3, 4, 4b and 5 in order to minimize modeling costs and provide a recommended modeling regime for each of the TSA's. The Woodstock estate software model was used in the pilot area.

- Modeling of the recommended stand density regimes for each of the 100 Mile House, Williams Lake and Quesnel TSA's using FSSIM.

### 8.2.1 Scenario 1: Status Quo

This option is analyzed to identify the attributes of the future forest, and the forest products it could yield, at harvest age, that ensues from following the current regulatory requirements associated treatment costs. This provides a base line reference for the AAC target using TSR 2 assumptions while imposing the Chief Forester Transitional Stocking Guidelines (Dec. 2002). A minimum harvest target volume of 65 $m^3$/ha is imposed to reflect the Williams Lake TSR 2 assumption.

### 8.2.2 Scenario 2: Modified Status Quo (100 $m^3$/ha.)

This scenario is the same as the Status Quo scenario except that a minimum harvest volume of 100 $m^3$ per hectare is assumed. This scenario is provided to assess the impact of raising the minimum harvest level from the current management level of 65 $m^3$/ha.

### 8.2.3 Scenario 3: Minimum Silviculture Cost

This option is analyzed to identify the attributes of the future forest, and the forest products it could yield, at harvest age, that would ensue from pursuing a least cost silviculture management regime. Stocking densities and treatments are minimized. It is provided as a reference point to illustrate silvicultural and economic benefits and effects.

### 8.2.4 Scenario 4a: Desired Future Forest, Timber Objectives

This scenario builds on the Minimum Silviculture Cost scenario by targeting the product profile identified in the strategy and the AAC identified in Scenario 1. In this initial timber objective scenario the effect of brushing is “turned on” to ensure that the stands achieve minimum stocking levels and then modeled to measure the product output and AAC objectives.

### 8.2.5 Scenario 4b: Desired Future Forest, Timber Objectives

This scenario is the same as Scenario 4a except that it assumes that both planting and brushing are undertaken in order to ensure that the stands achieve the levels required to recapture the AAC lost to reduced silviculture.

### 8.2.6 Scenario 5: Desired Future Forest, Revised Maximum Density for Pine Stands

Based on scenario 4b, this scenario reflects the impact of modified stand density regimes for pure pine Development Types 42, 45, 53 and 54 as identified in Appendix R (highlighted in green).

Table 9. Summary of Estate Level Modeling Scenarios

| Scenario | Area | Forest Estate Model |
|---|---|---|
| 1 | Pilot | Woodstock |
| 2 | Pilot | Woodstock |
| 3 | Pilot | Woodstock |
| 4 | Pilot | Woodstock |
| 4b | Pilot | Woodstock |
| 5 | Pilot | Woodstock |
| 5 | 100 Mile House TSA | FSSIM |
| 5 | Williams Lake TSA | FSSIM |
| 5 | Quesnel TSA | FSSIM |

# 9 Analysis Methodology, Inputs and Assumptions

## 9.1 Forest Estate Level: Data Sets

The data sets used by the former CCLUP Timber Enhancement Strategy Committee provided the foundation for this exercise. Please refer to Appendix P for a description of the source database used for the pilot area Woodstock modeling. The data sets used for FSSIM modeling at the TSA level for the 100 Mile House, Williams Lake and Quesnel TSA's were created under FIRS #1018017 (2002/03 fiscal year).

## 9.2 Selection of a Pilot Area

This analysis projects timber harvest flow and lumber profile from managed stands, over time, under various stand density management regimes for a representative sample area of the Cariboo region. The timber supply analyst involved with this project indicated that the modeling software required for the project, and scenarios developed, would be too complex to run efficiently over an area as large as the Williams Lake TSA. Hence it became essential to establish a pilot area representative of the three TSA's. The pilot area was selected on the basis of site, species, ecosystem and silviculture treatment regimes, to ensure that the full range of variability in the TSAs was represented in the pilot area. Data base queries generated a report which resulted in the selection of 11 representative Landscape Units for the pilot area with a THLB area of 367,311 hectares. Table 10 shows the selected Landscape Units.

Table 10.

| **Landscape Unit** | **Gross Productive Area (ha)** | **THLB (ha)** |
|---|---:|---:|
| Beaver Valley | 45,510 | 35,473 |
| Beece Creek | 15,275 | 8,658 |
| Black Creek | 44,250 | 41,570 |
| Cheshi Stikelan | 14,517 | 9,362 |
| Gaspard | 73,958 | 61,175 |
| Horsefly | 59,787 | 46,369 |
| Lower Cariboo | 38,967 | 28,811 |
| Nazko | 74,910 | 68,845 |
| Riske | 38,246 | 31,104 |
| Upper Dean | 29,485 | 25,876 |
| Westbranch | 19,040 | 10,067 |
| Total | 453,944 | 367,311 |

With only 24,000 hectares of unique site/type stands in the 100 Mile House TSA not already represented in the Williams Lake and Quesnel TSAs it was decided to adopt the Williams lake TSA as the basis for this report. Williams Lake is also a sound choice as the assumptions and constraints used in TSR 2 are very complex and are indicative of the complexity required in future analyses. FIA funding to proceed with the analysis in Williams Lake was received in January, 2003. FIA funding approval to provide analysis in the Quesnel TSA was received in mid-February, 2003; however, there was insufficient time left in the fiscal year for the current contractor to start and complete the project. There was also insufficient time to seek and tender the project to other contractors. There is a limited availability of consultants in B.C. with the necessary analytical skills and software required for this type of project. Therefore, the funding was declined for the Quesnel TSA. This increased the importance of the need for the pilot area to be representative.

Please refer to Appendix O (Tables 1 through 5) for further data comparing the pilot area with the three TSA's. Table 1 compares the gross productive forest area (GPF) and timber harvesting land base (THLB) in the whole TSA to that of the pilot study area. It shows that in terms of combination of BEC, leading species, and site productivity, over 99% of the Williams Lake THLB (2,442,162 of the total 2,459,555 ha.) is represented in the pilot study area. All the combinations that do not appear in the 11 landscape units each have a THLB area that is less than 4,000 ha (Table 2). Chart B on the following page illustrates the range of site indices and BEC combinations in the pilot study area.

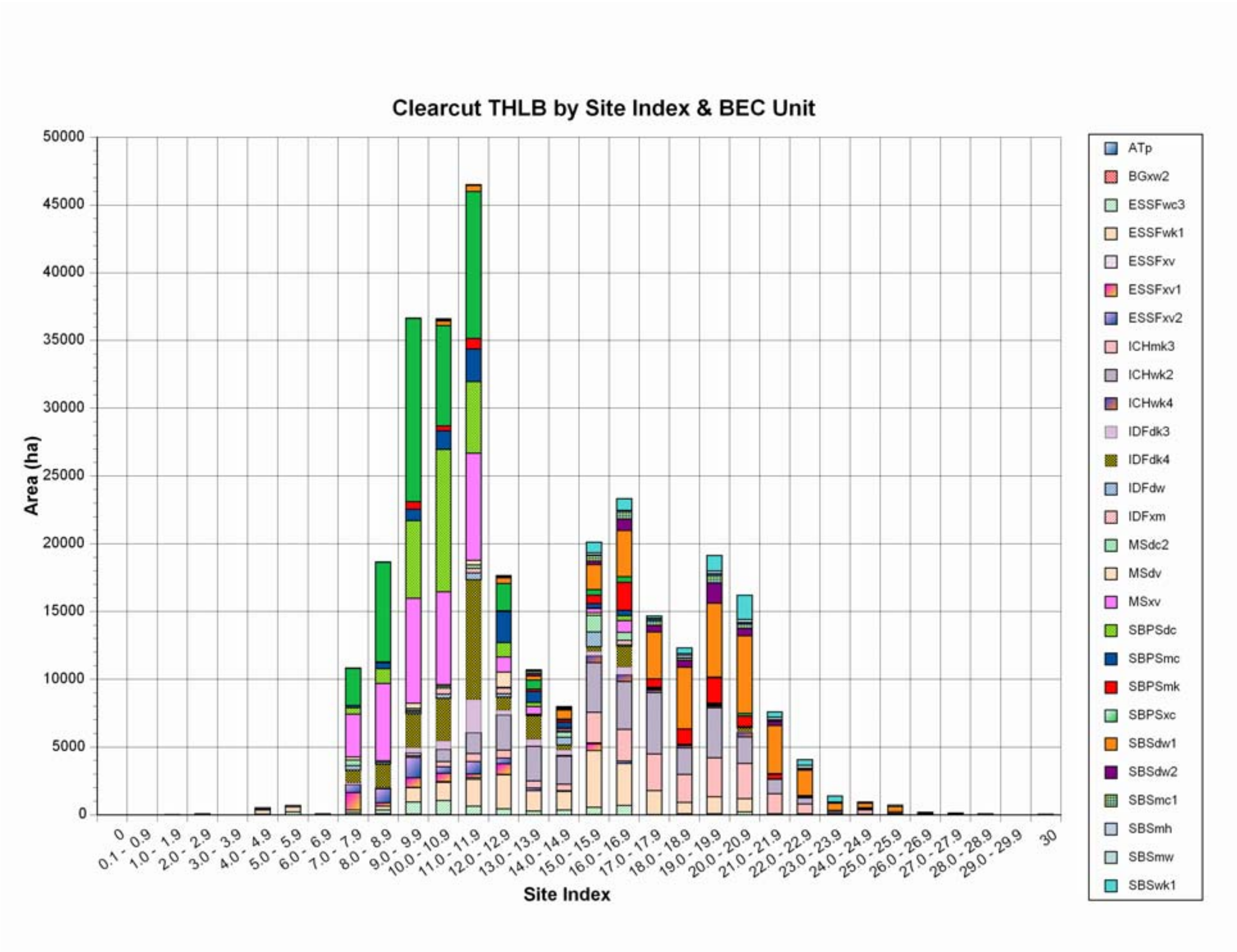



**Chart B – Pilot Area: Clearcut THLB by Site Index & BEC Unit**

## 9.3 Land Base Inventory - Pilot Area

The Timber Harvesting Land Base (THLB) was obtained by net down the total land base according to the land use and management assumptions defined in the TSR II data package for Williams Lake. Table 3 of Appendix O summarizes the THLB net-down process of the pilot study area. The THLB includes all area available for timber extraction, even those subject to constraints such as selection harvesting and visual quality requirements. Within the pilot area THLB, about 16% (59,453 ha.) is designated as selection harvesting stands; however, as discussed in Section 9.6, selection harvesting areas are excluded from the modeling exercise for the pilot area reports.

## 9.4 Land Base Inventory – TSA's

FSSIM model runs were conducted on the individual three TSA's using the land base assumptions specific to each TSA from TSR 2 as documented in the Data Packages.

## 9.5 Forest Estate Model Description

### 9.5.1 Woodstock

Woodstock 3.0 is a forest estate modeling program produced by *Remsoft Inc*. Use of the Woodstock model is sanctioned by the Ministry of Forests. Woodstock was selected for use in this project in order to generate linear programming matrices and complete harvest simulations. *Mosek 2.0*, a linear programming solver by MOSEK ApS in Denmark, was used to solve the optimization matrices as Woodstock can only create the matrices, but not solve them.

The Woodstock program is extremely flexible, and is readily tailored to the user's analysis needs. A key aspect is its ability to optimize, rather than simply simulate timber harvest flows. Therefore, every scenario modeled has the advantage of the model automatically optimizing the harvest level. Another key aspect is the economic modeling component. It also can be used to determine the effects of natural disturbances on timber supplies. Woodstock software is forward compatible, so there is no fear of losing present analysis investments to future programming updates. The latter feature is important as the model should be used in the future to test impacts on altering stand densities. For example, if a licensee is considering a change in management prescription that effects density or species choice then the impact on future yields at the estate level can be modeled quite easily. This strategy may be important in the future in order to provide "evidentiary information" to a District Manager for reasons outlined in the introduction.

### 9.5.2 FSSIM

FSSIM is a forest estate model developed by the MOF and is in common use throughout B.C. Information on the model is provided on-line at

http://www.for.gov.bc.ca/ftp/HTS/external/!publish/FSSIM/

## 9.6 Estate Modeling Inputs and Assumptions

### 9.6.1 Woodstock

Please refer to Appendix P for a description of the source database used for the Woodstock modeling undertaken in the Pilot area in the production of this report. The inputs and assumptions were adopted from the Williams Lake TSA TSR II Data Package (August 1999) except for the following:

- The analysis was completed on a pilot study area rather than the whole TSA, as previously described.
- Selection harvesting stands (i.e., Dry-belt fir stands, Mule Deer Winter Range Douglas fir leading stands and Caribou selection harvesting stands) were

excluded from harvesting as the density issue is not relevant in these stands. Additionally, post-selection harvested stands are not converted into managed stands; therefore, TIPSY could not generate lumber yield curves for them.

- Regeneration assumptions used in the analysis are specific to biogeoclimatic variant and site productivity and reflect the current stocking targets in this TSA for Scenario 1 and 2. Scenarios 3, 4a, 4b and 5 test the effects of revised densities and associated treatment costs. The regeneration assumptions and silviculture costs for each scenario are documented in Appendix R.
- No-harvest rules were assigned and the linear programming solver selected harvest areas to achieve the maximum even-flow harvest. (In the TSR II process, the long-standing “relative oldest first” harvest rule was used; however, for this analysis that rule was considered inappropriate, and artificially limiting. Also, the current MPB epidemic is a sound biological reason why forest managers may well decide that “relative oldest first” is inappropriate from a modern stewardship perspective.)

### 9.6.2 FSSIM

Inputs and assumptions for the FSSIM runs are documented in the report for FIRS project #1018017. With the closure of the Cariboo Region office and accompanying staff reduction this project catalogued and documented the process, assumptions, data and results for TSR 2 for the 100 Mile House, Williams Lake and Quesnel TSA’s. The FSSIM models used by the former TESC were also catalogued. The Scenario 5 modeling conducted in FSSIM applied TSR 2 assumptions with the exception of revised stand density regimes for pure Pine stands.

## 9.7 Timber Yield

### 9.7.1 Woodstock (Volume and Lumber)

The Batch VDYP model was used to create yield curves for unmanaged stands and the Batch TIPSY model was used to create timber volume and lumber yield curves for managed stands. To capture the variability in the TSA in biogeoclimatic zones, stand types, and site productivity, a volume and lumber width yield table was created for each unique combination of biogeoclimatic variant, stand type and site productivity class. Appendix S contains the yield curves and lumber output for the scenarios analyzed for this paper. 9,107 Development Types were created. Development Types are unique combinations of species, site, BEC, and other attributes. Development Types are similar to, but not the same as, Analysis Units in the FSSIM model. Approximately 500 growth curves are linked to the Development Types. Development types were aggregated to the limits of the inventory data into 75 strata as represented in the Development type summary table in Appendix R.

### 9.7.2 FSSIM (Volume)

The FSSIM models developed under the former TESC for TSR 2 support and analysis were utilized as previously described. Scenario 5 incorporated an adjustment for pure pine density management.

## 9.8 Management Practices

### 9.8.1 Woodstock

The Williams Lake TSA TSR 2 Data Package (refer to Appendix Q) details the management practices modeled in the estate level analyses conducted for this paper. Exceptions have been noted in Section 9.6.1.

#### 9.8.1.1 Development Type or Aggregated Stand Level Practices

An eleven page summary of regeneration regimes and silvicultural cost estimates developed for the scenarios modeled under Woodstock in the Pilot area. is contained in Appendix R. The assumptions for 75 Development Types are listed in an MS Excel file (sheet labeled Silv. assumptions & Cost). Assumptions are listed for:

- Scenario 1: Silviculture regimes and treatment costs associated with managing to the Transitional Stocking Guidelines.
- .Scenario 4b: Modified Scenario 1 regeneration assumptions – minimal treatments deemed necessary to achieve AAC and product objectives.

- 2nd Approximation: The current practices, costs and assumptions as developed in a two day workshop with local silviculture practitioners. Represents compliance to current regulations such as the maximum density rule.
- 3rd Approximation: The current practices, costs and assumptions with the exception that the stand density assumptions for four pine Development Types (42, 45, 53 and 54) were revised to reflect the recommendations in table 35. As well, regimes for non-pine stands were adjusted to more accurately reflect current practices as captured in the workshops held with local practitioners.

Assumptions used in Scenarios 2, 3 and 4a are not listed as they were used to develop the interim modeling results to assess impacts of changing silviculture regimes using the Pilot area land base. Interim regimes were determined to be not acceptable to the committee's requirements and the strategies stated in section 7.5.

The regeneration assumptions listed represent and illustrate the varying views and opinions, at the stand level, of potentially appropriate regimes. They were modeled in Woodstock to provide an indicator as to what may be acceptable regimes. Confirmation was needed at the TSA level as to impact on AAC volumes.

### 9.8.2 FSSIM

Management practices modeled in FSSIM for each TSA were as reported in the Data Packages for TSR 2 and confirmed in discussions with Forest Analysis Branch staff. Scenario 5 incorporated an adjustment for pure pine density management. Development types (equivalent to Analysis Units in FSSIM) were used in the model runs for the 100 Mile House, Williams Lake and Quesnel TSA's. Assumptions and yield projections were modified for the equivalent units to Development Types 42, 45, 53 and 54. No further revisions were made to the base case TSR 2 model as the requirement for this run was to measure the impact on AAC in revising the pine regimes.

## 9.9 Desired Future Forest

### 9.9.1 Timber Objectives

As identified in the strategy the following timber objectives are targeted in this exercise.

Table 11. Desired Future Forest, Estate Level Timber Product Target

| Product: | Lumber | Plywood, Premium | Product Total | Up to 6" | 8" | 10" | Other | Lumber Total | Specialty | MSR[17] |
|---|---|---|---|---|---|---|---|---|---|---|
| Target %: | 94 | 6 | 100 | 85 | 6 | 8 | 1 | 100 | 2 | 12 |

[17] MSR understated, some mills MSR production not available

The objective is to maintain the current AAC with adoption of current product profile outcomes as the product objective for the Desired Future Forest while minimizing silvicultural investments.

### 9.9.2 Non-Timber Values

Management of non-timber values, from a habitat, red listed species, competition, insect or disease perspective, is documented in the tables below. These are identified as biotic risk factors and recommendations are summarized by the Development Types crated for the Pilot area which, as previously stated, represent 99% of the areas found in the Williams Lake TSA and a similar ratio in the Quesnel and 100 Mile House TSA's.

Factors identified were taken from the *Silvicultural Guidelines and Practices: Maintaining or Recruiting Key Habitat Objectives (June 2002 MWLAP).* A copy of the report is in Appendix Z.

Biotic risk factors specific to insects, competition and disease were interpreted from FORREDX Stand Establishment Decision Aids[18] (SEDA) documents. The SEDA reference sheet (eg. D1) in table 12 is provided in Appendix W.

Factors for provincial rare natural plant risk associations were also documented by development type. Plant risk associations were sourced from the BC Conservation Data Centre. Biotic risk factors were assessed from the perspective of stand density control and its positive or negative impact on non-timber values. These tables were developed at the development type level (where possible) to provide assistance in determining if silvicultural practices, specifically stand density, are required to enhance non-timber values or to recognize if stand density management for timber values is detrimental to non-timber values. They are relevant to recommendations in this report for Development Types numbers 42, 45, 53 and 54 and summarized in Tables 12 through 19.

[18] The SEDA documents are available on-line at http://www.forrex.org/projects/2002/seda/homepage.asp.

Table 12. Biotic Risk Factors, SEDA

| Pilot Area Table 12 | Biotic Risk Factors: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | FORREX SEDA Reference (Stand Establishment Decision Aid) - March 10, 2003) | | | | | | | |
| | Competing Vegetation | | | Disease | Insect | Thinning Issues (with SEDA reference page) | | |
| Development Type # | Zone with High Hazard | Site Series with High Hazard | Site Series with Moderate Hazard | Subzone with High, Mod-High & Moderate Hazard | Subzone with High, Mod-High or Moderate Hazard | Avoid Thinning | Thinning Recommended | Neutral |
| 1 | | | | | | | | |
| 2 | | 3 | 2, 3 | M-H | | D1 | | C6, C7 |
| 3 | | 3 | 2, 3 | M-H | | D1 | | C6, C7 |
| 4 | | 3 | 2, 3 | M-H | | D1 | | C6, C7 |
| 5 | | 4,5,6,7 | 3, 7 | M | | D1 | | C3,C4,C5,C6,C7,C8 |
| 6 | | 4,5,6,7 | 3, 7 | M | | D1 | | C3,C4,C5,C6,C7,C8 |
| 7 | | 4,5,6,7 | 3, 7 | M | | D1 | | C3,C4,C5,C6,C7,C8 |
| 8 | | | | | | | | |
| 9 | | | | M | | D6 | | |
| 10 | | | | M | | D6 | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | 6,7 | 4,5,7 | M, M-H, H | M-H, H | D1, D2, D7, D8, I2 | | C1,C5,C7,C8,D4,I1 |
| 15 | | 6,7 | 4,5,7 | M, M-H, H | M-H, H | D1, D2, D7, D8, I2 | | C1,C5,C7,C8,D4,I1 |
| 16 | | 6,7 | 4,5,7 | M, M-H, H | M-H, H | D1, D2, D7, D8, I2 | | C1,C5,C7,C8,D4,I1 |
| 17 | | 6,7,8 | 5,6 | M, M-H, H | M-H, H | D1, D2, D8, I2 | | C1,C5,C7,C8,I1 |
| 18 | | 6,7,8 | 5,6 | M, M-H, H | M-H, H | D1, D2, D8, I2 | | C1,C5,C7,C8,I1 |
| 19 | | 6,7,8 | 5,6 | M, M-H, H | M-H, H | D1, D2, D8, I2 | | C1,C5,C7,C8,I1 |
| 20 | | 6,7,8 | 6 | M-H, H | M-H, H | D2, D7, I2 | | C1,C5,C7,C8,I1 |

| Pilot Area Table 12 | Biotic Risk Factors: | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | FORREX SEDA Reference (Stand Establishment Decision Aid) - March 10, 2003) | | | | | | | |
| | Competing Vegetation | | | Disease | Insect | Thinning Issues (with SEDA reference page) | | |
| Development Type # | Zone with High Hazard | Site Series with High Hazard | Site Series with Moderate Hazard | Subzone with High, Mod-High & Moderate Hazard | Subzone with High, Mod-High or Moderate Hazard | Avoid Thinning | Thinning Recommended | Neutral |
| 21 | | 6,7,8 | 6 | M-H, H | M-H, H | D2, D7, I2 | | C1,C5,C7,C8,I1 |
| 22 | | 6,7,8 | 6 | M-H, H | M-H, H | D2, D7, I2 | | C1,C5,C7,C8,I1 |
| 23 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 24 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 25 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 26 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 27 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 28 | | | | M-H, H | | D2, D6, D7 | D4 | D5 |
| 29 | | | | H | | D7 | D4 | |
| 30 | | | | H | | D7 | D4 | |
| 31 | | | | H | | D7 | D4 | |
| 32 | | | | H | | D7 | D4 | |
| 33 | | | | H | | D7 | D4 | |
| 34 | | | | H | | D7 | D4 | |
| 35 | | | | | | | | |
| 36 | | | | | | | | |
| 37 | | | | | | | | |
| 38 | | | | | | | | |
| 39 | | | | | | | | |
| 40 | | | | | | | | |
| 41 | | | | | | | | |
| 42 | | | | | | | | |
| 43 | | | | M, M-H, H | | D7, D8 | D3, D4 | D5 |
| 44 | | | | M, M-H, H | | D7, D8 | D3, D4 | D5 |
| 45 | | | | M, M-H, H | | D7, D8 | D3, D4 | D5 |
| 46 | | | | H | | D7, D8 | D4 | D5 |
| 47 | | | | H | | D7, D8 | D4 | D5 |
| 48 | | | | H | | D7, D8 | D4 | D5 |
| 49 | | | | M, M-H, H | | D7, D8 | | D3, D4, D5 |

| Pilot Area Table 12 | Biotic Risk Factors: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | FORREX SEDA Reference (Stand Establishment Decision Aid) - March 10, 2003) | | | | | | | |
| | Competing Vegetation | | | Disease | Insect | Thinning Issues (with SEDA reference page) | | |
| Development Type # | Zone with High Hazard | Site Series with High Hazard | Site Series with Moderate Hazard | Subzone with High, Mod-High & Moderate Hazard | Subzone with High, Mod-High or Moderate Hazard | Avoid Thinning | Thinning Recommended | Neutral |
| 50 | | | | M, M-H, H | | D7, D8 | | D3, D4, D5 |
| 51 | | | | M, M-H, H | | D7, D8 | | D3, D4, D5 |
| 52 | | | | M-H, M, H | | D6 | D3, D4 | D5 |
| 53 | | | | M-H, M, H | | D6 | D3, D4 | D5 |
| 54 | | | | M-H, M, H | | D6 | D3, D4 | D5 |
| 55 | | | 8 | M, H | M, H | D6, D7, D8, I2 | | C1, D3, D4, D5, I1 |
| 56 | | | 8 | M, H | M, H | D6, D7, D8, I2 | | C1, D3, D4, D5, I1 |
| 57 | | | 8 | M, H | M, H | D6, D7, D8, I2 | | C1, D3, D4, D5, I1 |
| 58 | | | 9 | M, H | M | D6, D7, D8, I2 | | C1, D4, D5, I1 |
| 59 | | | 9 | M, H | M | D6, D7, D8, I2 | | C1, D4, D5, I1 |
| 60 | | | 9 | M, H | M | D6, D7, D8, I2 | | C1, D4, D5, I1 |
| 61 | | | | M, H | M, M-H | D1, D7, I2 | | D4, D5, I1 |
| 62 | | | | M, H | M, M-H | D1, D7, I2 | | D4, D5, I1 |
| 63 | | | | M, H | M, M-H | D1, D7, I2 | | D4, D5, I1 |
| 64 | | | 6,8 | M,H | M, M-H | D1, D7, D8, I2 | | C8, D3, D4, D5, I1 |
| 65 | | | 6,8 | M,H | M, M-H | D1, D7, D8, I2 | D3, D4 | C8, D5, I1 |
| 66 | | | 6,8 | M,H | M, M-H | D1, D7, D8, I2 | D3, D4 | C8, D5, I1 |

| Pilot Area Table 12 | Biotic Risk Factors: | | | | | | |
|---|---|---|---|---|---|---|---|
| | FORREX SEDA Reference (Stand Establishment Decision Aid) - March 10, 2003) | | | | | | |
| | Competing Vegetation | | | Disease | Insect | Thinning Issues (with SEDA reference page) | |
| Development Type # | Zone with High Hazard | Site Series with High Hazard | Site Series with Moderate Hazard | Subzone with High, Mod-High & Moderate Hazard | Subzone with High, Mod-High or Moderate Hazard | Avoid Thinning | Thinning Recommended | Neutral |
| 67 | * | 5,7 | 6, 7, 8 | H | M | D7, I2 | D4 | C1, C5, D5 |
| 68 | * | 5,7 | 6, 7, 8 | H | M | D7, I2 | D4 | C1, C5, D5 |
| 69 | * | 5,7 | 6, 7, 8 | H | M | D7, I2 | D4 | C1, C5, D5 |
| 70 | | 7,8,13 | 6, 8 | M, M-H, H | H | D7, D8, I1, I2 | D4 | C1, C5, C8, D3, D5 |
| 71 | | 7,8,13 | 6, 8 | M, M-H, H | H | D7, D8, I1, I2 | D4 | C1, C5, C8, D3, D5 |
| 72 | | 7,8,13 | 6, 8 | M, M-H, H | H | D7, D8, I1, I2 | D4 | C1, C5, C8, D3, D5 |
| 73 | | 7,8,9,10 | 7, 8 | M, H | M | D1, D7, I2 | D4 | C5, C7, C8, D5 |
| 74 | | 7,8,9,10 | 7, 8 | M, H | M | D1, D7, I2 | D4 | C5, C7, C8, D5 |
| 75 | | 7,8,9,10 | 7, 8 | M, H | M | D1, D7, I2 | D4 | C5, C7, C8, D5 |

Table 13. Biotic Risk Factors, Habitat

| Pilot Area Table 13 | Biotic Risk Factors: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Silviculture Guidelines & Practices Maintaining or Recruiting Key Habitat Objectives MWLAP Jun 2002 | | | | | | | | | |
| | NSZR: No Specific Zonal Recommendations; **HSHZ**: High Suitability Habitat Zone | | | | | | | | | |
| Development Type # | CWD | WTP | RMA | Landscape Level | Primary Cavity Excavators | Northern Goshawk | Black-tailed Deer & Roosevelt Elk | MDWR (even aged stands) | Mtn. Caribou | Grizzly Bear |
| 1 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 2 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 3 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 4 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 5 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 6 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 7 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 8 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 9 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 10 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 11 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 12 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 13 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 14 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 15 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 16 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 17 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 18 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 19 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 20 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 21 | NSZR | NSZR | NSZ | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |

| Pilot Area Table 13 | Biotic Risk Factors: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Silviculture Guidelines & Practices Maintaining or Recruiting Key Habitat Objectives MWLAP Jun 2002 | | | | | | | | | |
| | NSZR: No Specific Zonal Recommendations; **HSHZ**: High Suitability Habitat Zone | | | | | | | | | |
| Development Type # | CWD | WTP | RMA | Landscape Level | Primary Cavity Excavators | Northern Goshawk | Black-tailed Deer & Roosevelt Elk | MDWR (even aged stands) | Mtn. Caribou | Grizzly Bear |
| | | | R | | | | | | | |
| 22 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | **HSHZ** | **HSHZ** |
| 23 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 24 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 25 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 26 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 27 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 28 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | **HSHZ** | N.A. | **HSHZ** | NSZR | NSZR |
| 29 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 30 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 31 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 32 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 33 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 34 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 35 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 36 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 37 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 38 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 39 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 40 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 41 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 42 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |

| Pilot Area Table 13 | Biotic Risk Factors: Silviculture Guidelines & Practices Maintaining or Recruiting Key Habitat Objectives MWLAP Jun 2002<br>NSZR: No Specific Zonal Recommendations; **HSHZ**: High Suitability Habitat Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Development Type # | CWD | WTP | RMA | Landscape Level | Primary Cavity Excavators | Northern Goshawk | Black-tailed Deer & Roosevelt Elk | MDWR (even aged stands) | Mtn. Caribou | Grizzly Bear |
| 43 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 44 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 45 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 46 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 47 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 48 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 49 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 50 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 51 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | NSZR |
| 52 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 53 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 54 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 55 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 56 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 57 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 58 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 59 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 60 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 61 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 62 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 63 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 64 | NSZR | NSZR | NSZ | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |

| Pilot Area Table 13 | Biotic Risk Factors: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Silviculture Guidelines & Practices Maintaining or Recruiting Key Habitat Objectives MWLAP Jun 2002 | | | | | | | | | |
| | NSZR: No Specific Zonal Recommendations; **HSHZ**: High Suitability Habitat Zone | | | | | | | | | |
| Development Type # | CWD | WTP | RMA | Landscape Level | Primary Cavity Excavators | Northern Goshawk | Black-tailed Deer & Roosevelt Elk | MDWR (even aged stands) | Mtn. Caribou | Grizzly Bear |
| | | | R | | | | | | | |
| 65 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 66 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 67 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 68 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 69 | NSZR | NSZR | NSZR | NSZR | **HSHZ** | NSZR | N.A. | **HSHZ** | NSZR | NSZR |
| 70 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 71 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 72 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | NSZR |
| 73 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 74 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| 75 | NSZR | NSZR | NSZR | NSZR | NSZR | NSZR | N.A. | NSZR | NSZR | **HSHZ** |
| | | | | | | max. density in HHSZ for goshawk: 4,000 | | max. density in HHSZ for mule deer: 5,000 | max. density in HHSZ for mtn. caribou: 5,000 or less | max. density in HHSZ for grizzly bear: 4,000 |

Table 14. Biotic Risk Factors, Rare Plant Associations

| Pilot Area Table 14 | Biotic Risk Factors: | | |
|---|---|---|---|
| | Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 1 | | *bluebunch wheatgrass - junegrass; sand dropseed - needle & thread grass;* | Spreading needlegrass |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| 20 | | | |
| 21 | | | |
| 22 | | | |
| 23 | *saltgrass - alkaligrass* | *bluebunch wheatgrass - junegrass; douglas fir / common juniper / kinnikinnick; arrowgrass marsh;* | awned sedge fen - marsh; slender sedge/drepanocladus moss; buckbean - slender sedge; hybrid white spruce / prickly rose / sarsaparills; hybrid white spruce/prickly rose/sedge; douglas fir / pinegrass - showy aster; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheargrass - needlegrass; tall willow / sartwell's sedge; bullrush marsh; |

| Pilot Area Table 14 | Biotic Risk Factors: Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
|---|---|---|---|
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 24 | saltgrass - alkaligrass | bluebunch wheatgrass - junegrass; douglas fir / common juniper / kinnikinnick; arrowgrass marsh; | awned sedge fen - marsh; slender sedge/drepanocladus moss; buckbean - slender sedge; hybrid white spruce / prickly rose / sarsaparills; hybrid white spruce/prickly rose/sedge; douglas fir / pinegrass - showy aster; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheargrass - needlegrass; tall willow / sartwell's sedge; bullrush marsh; |
| 25 | *saltgrass - alkaligrass* | *bluebunch wheatgrass - junegrass; douglas fir / common juniper / kinnikinnick; arrowgrass marsh;* | awned sedge fen - marsh; slender sedge/drepanocladus moss; buckbean - slender sedge; hybrid white spruce / prickly rose / sarsaparills; hybrid white spruce/prickly rose/sedge; douglas fir / pinegrass - showy aster; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheargrass - needlegrass; tall willow / sartwell's sedge; bullrush marsh; |
| 26 | | *douglas fir / common juniper / penstemon;* | spreading needlegrass; hybrid white spruce/feathermoss - brachythecium; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheatgrass - pinegrass; |
| 27 | | douglas fir / common juniper / penstemon; | spreading needlegrass; hybrid white spruce/feathermoss - brachythecium; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheatgrass - pinegrass; |

| Pilot Area Table 14 | Biotic Risk Factors: Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
|---|---|---|---|
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 28 | | *douglas fir / common juniper / penstemon;* | spreading needlegrass; hybrid white spruce/feathermoss - brachythecium; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; douglas fir / bluebunch wheatgrass - pinegrass; |
| 29 | | | |
| 30 | | | |
| 31 | | | |
| 32 | | *pacific sagebrush/ short-awned porcupine grass; baltic rush - silverweed; hybrid white spruce - twinberry - coltsfoot; trembling aspen / spreading needlegrass - old man's whickers; bluebunch wheatgrass - balsamroot; bluebunch wheatgrass - junegrass; douglas fir / common juniper / penstemon; douglas fir/ common juniper / cladonia; douglas fir / prickly rose / sarsaparilla; sand dropseed - needle & thread grass;* | spreading needlegrass; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; |
| 33 | | pacific sagebrush/ short-awned porcupine grass; baltic rush - silverweed; hybrid white spruce - twinberry - coltsfoot; trembling aspen / spreading needlegrass - old man's whickers; bluebunch wheatgrass - balsamroot; bluebunch wheatgrass - junegrass; douglas fir / common juniper / penstemon; douglas fir/ common juniper / cladonia; douglas fir / prickly rose / sarsaparilla; sand dropseed - needle & thread grass; | spreading needlegrass; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; |

| Pilot Area Table 14 | Biotic Risk Factors: Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
|---|---|---|---|
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 34 | | *pacific sagebrush/ short-awned porcupine grass; baltic rush - silverweed; hybrid white spruce - twinberry - coltsfoot; trembling aspen / spreading needlegrass - old man's whickers; bluebunch wheatgrass - balsamroot; bluebunch wheatgrass - junegrass; douglas fir / common juniper / penstemon; douglas fir/ common juniper / cladonia; douglas fir / prickly rose / sarsaparilla; sand dropseed - needle & thread grass;* | spreading needlegrass; douglas fir / rocky mountain juniper - pasture sage; douglas fir / feathermoss - stepmoss; |
| 35 | | | |
| 36 | | | |
| 37 | | | |
| 38 | | | |
| 39 | | | |
| 40 | | lodgepole pine / trapper's tea / crowberry; | lodgepole pine / altai fescue / stereocaulon; |
| 41 | | lodgepole pine / trapper's tea / crowberry; | lodgepole pine / altai fescue / stereocaulon; |
| 42 | | lodgepole pine / trapper's tea / crowberry; | lodgepole pine / altai fescue / stereocaulon; |
| 43 | | | bullrush marsh |
| 44 | | | bullrush marsh |
| 45 | | | bullrush marsh |
| 46 | | | bullrush marsh |
| 47 | | | bullrush marsh |
| 48 | | | bullrush marsh |
| 49 | | | lodgepole pine - cladonia - haircap moss; douglas fir / pinegrass - showy aster; |
| 50 | | | lodgepole pine - cladonia - haircap moss; douglas fir / pinegrass - showy aster; |
| 51 | | | lodgepole pine - cladonia - haircap moss; douglas fir / pinegrass - showy aster; |
| 52 | *saltgrass - alkaligrass* | | northern mannagrass fen; labrador tea/sphagnun; bullrush marsh |

| Pilot Area Table 14 | Biotic Risk Factors: Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
|---|---|---|---|
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 53 | *saltgrass - alkaligrass* | | northern mannagrass fen; labrador tea/sphagnun; bullrush marsh |
| 54 | *saltgrass - alkaligrass* | | northern mannagrass fen; labrador tea/sphagnun; bullrush marsh |
| 55 | | | hybrid white spruce - twinberry - coltsfoot; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; |
| 56 | | | hybrid white spruce - twinberry - coltsfoot; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; |
| 57 | | | hybrid white spruce - twinberry - coltsfoot; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; |
| 58 | *hybrid white spruce / coral lichens* | | douglas fir - lodgepole pine / cladonia; douglas fir / pinegrass - showy aster; |
| 59 | *hybrid white spruce / coral lichens* | | douglas fir - lodgepole pine / cladonia; douglas fir / pinegrass - showy aster; |
| 60 | *hybrid white spruce / coral lichens* | | douglas fir - lodgepole pine / cladonia; douglas fir / pinegrass - showy aster; |
| 61 | | *hybrid white spruce/devil's club/step moss* | douglas fir / pinegrass - showy aster; |
| 62 | | *hybrid white spruce/devil's club/step moss* | douglas fir / pinegrass - showy aster; |
| 63 | | *hybrid white spruce/devil's club/step moss* | douglas fir / pinegrass - showy aster; |
| 64 | | | |
| 65 | | | |
| 66 | | | |
| 67 | | *hybrid white spruce/ostrich fern;* | hybrid white spruce/paper birch - devil's club; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; douglas fir / douglas maple / step moss; |

| Pilot Area Table 14 | Biotic Risk Factors: Provincial Rare Natural Plant Risk Associations, BC Conservation Data Centre (*red listed*, blue listed) | | |
|---|---|---|---|
| Development Type # | S1 (Critically Imperiled) | S2 (Imperiled) | S3 (Vulnerable) |
| 68 | | *hybrid white spruce/ostrich fern;* | hybrid white spruce/paper birch - devil's club; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; douglas fir / douglas maple / step moss; |
| 69 | | *hybrid white spruce/ostrich fern;* | hybrid white spruce/paper birch - devil's club; hybrid white spruce - douglas fir / thimbleberry; douglas fir - lodgepole pine / cladonia; douglas fir / douglas maple / step moss; |
| 70 | | | |
| 71 | | | |
| 72 | | | |
| 73 | | | |
| 74 | | | |
| 75 | | | |

Information required to link red listed species is not available at the development type level. Instead it is presented by District.

Table 15. Biotic Risk Factors, Red Listed Vertebrates

| | | |
|---|---|---|
| **Red Listed Vertebrates** | | from BC Species & Ecosystem Explorer MSRM & MWL&P |
| Table 15 | | from Managing Identified Wildlife: Procedures and Measures |
| | | http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp |
| | | http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/other/wild/index.htm |
| **District** | **Species** | **Silviculture Factors** |
| 100 Mile House | American avocet | |
| Chilcotin | American white pelican | Do not harvest or salvage during breeding season |
| Quesnel | American white pelican | |
| 100 Mile House | Badger | |
| Chilcotin | Badger | |
| Williams Lake | Badger | |
| 100 Mile House | Brewer's sparrow | Limited thinning of dense (>50% foliar cover) stands of sagebrush may be appropriate as long as the primary objective is the improvement of nesting habitat. Grazing should be carried out in a manner that will not lead to crown breakage, but is sufficiently intensive to maintain the desired density of sage, and prevent succession to climax bunchgrass. Protect large sagebrush during weed control operations. Maintain clumps of large (>1 m tall) sage. |
| Williams Lake | Brewer's sparrow | |
| 100 Mile House | Caribou | Mountain caribou see Recruiting Caribou Habitat Using Silviculture Treatments, 2001 |
| Horsefly | Caribou | |
| Quesnel | Caribou | |
| Chilcotin | Common pika | |
| Quesnel | Common pika | |
| 100 Mile House | Fisher | To provide denning and resting habitat within the harvested landbase, wildlife tree patch requirements should exceed Code requirements in that wildlife tree patches should be 2 ha or greater. Large diameter spruce (>40 cm dbh), cottonwood (>75 cm dbh) or fir in decay classes 2 and 3 are preferred. Select trees with cavities, broom rust or witches broom.Maintain natural levels, decay and size characteristics and dispersion of coarse woody debris.Maintain windfirm mature cover within riparian management zones (i.e., at least 30% canopy closure). |
| Chilcotin | Fisher | |
| Horsefly | Fisher | |
| Quesnel | Fisher | |
| Williams Lake | Fisher | |
| Williams Lake | Pallid bat | |
| Williams Lake | Peregrine falcon | |
| 100 Mile House | Prairie falcon | Reduce likelihood of secondary impacts from insecticides |
| Chilcotin | Prairie falcon | |
| Horsefly | Prairie falcon | |
| Williams Lake | Prairie falcon | |
| 100 Mile House | Swainson's hawk | |
| Chilcotin | Swainson's hawk | |

| Red Listed Vertebrates | | from BC Species & Ecosystem Explorer MSRM & MWL&P |
|---|---|---|
| Table 15 | | from Managing Identified Wildlife: Procedures and Measures |
| | | http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp |
| | | http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/other/wild/index.htm |
| **District** | **Species** | **Silviculture Factors** |
| Williams Lake | Swainson's hawk | |
| Williams Lake | Upland sandpiper | |
| Williams Lake | Western grebe | |
| 100 Mile House | White sturgeon | |
| Quesnel | White sturgeon | |
| Williams Lake | White sturgeon | |
| Williams Lake | Yellow breasted chat | Maintain riparian thicket habitat for breeding & foraging |

## Table 16. Biotic Risk Factors, Red Listed Amphibians

**Red Listed Amphibians** from BC Species & Ecosystem Explorer MSRM & MWL&P @ http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp

| District | Species |
|---|---|
| 100 Mile House | No matches |
| Chilcotin | No matches |
| Quesnel | No matches |
| Williams Lake | No matches |
| Horsefly | No matches |

## Table 17. Biotic Risk Factors, Red Listed Reptiles

**Red Listed Reptiles** from BC Species & Ecosystem Explorer MSRM & MWL&P @ http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp

| District | Species |
|---|---|
| 100 Mile House | No matches |
| Chilcotin | No matches |
| Quesnel | No matches |
| Williams Lake | No matches |
| Horsefly | No matches |

## Table 18. Biotic Risk Factors, Butterflies

**Red Listed Butterflies** from BC Species & Ecosystem Explorer MSRM & MWL&P @ http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp

| District | Species |
|---|---|
| 100 Mile House | No matches |
| Chilcotin | No matches |
| Quesnel | No matches |
| Williams Lake | No matches |
| Horsefly | No matches |

Table 19. Biotic Risk Factors, Red Listed Dragonflies & Damselflies

**Red Listed Dragonflies & Damselflies** from BC Species & Ecosystem Explorer MSRM & MWL&P @ http://srmapps.gov.bc.ca/apps/eswp/jsp/search.jsp

| District | Species | Silviculture Factors |
|---|---|---|
| 100 Mile House | Familiar bluet | N.A. |
| Chilcotin | No matches | |
| Quesnel | No matches | |
| Williams Lake | No matches | |
| Horsefly | No matches | |

## 9.10 Determination of Decision Elements

The factors or decision elements that are required for the decision making process must be determined and, ideally, quantified. The main sources used for this exercise are:

- "Discussion of Wood Quality Attributes and Their Practical Implications", Forintek Canada Corp. (Section 1, Literature Index, Book 1)
- "Wood Quality: Its Definition, Impact and Implications for Value Added Timber Management and End uses", Forintek Canada Corp. (Section 2, Literature Index, Book 1)
- "Silviculture Guidelines and Practices for Maintaining or Recruiting Key Habitat Objectives", Biodiversity Branch, MWAP (Section 29, Literature Index, Book 1 and referenced by Development Types in Table 13 in this document)
- TASS/TIPSY yield model output – summarized in this report in Tables 21 through 34.

Other sources were used and can be found in the Literature Index accompanying the hardcopy version of this report.

The factors were identified and subjectively ranked by the author of this report for importance according to a review of the literature cited. Timber elements were ranked numerically. Non-timber elements were ranked alphabetically. Many of the factors required do not have quantifiable data. A summary is presented in Table 20.

TABLE 20.

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| 1, 21 | 3.1 | 1 | Mean wood density (specific gravity) | density uniformity | weight per unit volume | indicator of end use stability |
| 1, 21 | 3.2 | 1 | Density variation (relative density) | density uniformity | weight per unit volume | indicator of end use stability |
| 1, 30 | p. 30 | 1 | Wood density (specific gravity) | Lumber: Stiffness, strength; Pulp: High density valued | Density not necessarily an indicator of strength or stiffness | Average density in a heavily thinned stand was only 5% lower than control but stiffness and strength of lumber decreased significantly |
| 1, 30 | p. 24 | 2 | Log taper | diameter | length | Lumber yield recovery decreases significantly with increasing taper |
| 1, 30 | p. 31 | 3 | Dimensional stability | Shrinking, swelling, warping = high wastage level | | wood density |
| 1, 30 | p. 32 | 4 | Mechanical properties | Strength, stiffness | Machine Stress Rated (MSR) | Governed by end use |
| 5 (TASS/TIPSY) | | 5 | Lumber | 2 x 4 | | |
| 5 (TASS/TIPSY) | | 5 | Lumber | 2 x 6 | | |
| 5 (TASS/TIPSY) | | 5 | Lumber | 2 x 8 | | |
| 5 (TASS/TIPSY) | | 5 | Lumber | 2 x 10 | | |
| 5 (TASS/TIPSY) | | 5 | Lumber | All | | |
| 5 (TASS/TIPSY) | | 6 | Lumber Recovery | Board feet/m3 | | |
| 5 (TASS/TIPSY) | | 7 | Grade H | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade I | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade J | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade U | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade X | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade Y | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade All | 10 cm. Top | m3 per hectare | |
| 5 (TASS/TIPSY) | | 7 | Grade Chips | | BDU/hectare | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| 1, 21 | 3.6 | 9 | Fibril angle | | | large fibril angles in juvenile wood correlate to lower strength and stiffness where no appreciable difference in density |
| 1, 30 | p. 23 | 10 | Log volume | diameter | length | Lumber yield increases significantly up to 20 cm. Dia; then less significantly to 30 cm. Where it levels off |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (7.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (12.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (17.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (22.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (27.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (32.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Gross (0) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Total (0) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (7.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (12.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (17.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (22.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (27.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | MAI (32.5) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 12.5+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 15+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 20+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 25+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 30+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 35+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable | m3 per hectare | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| | | | | (dia. class 40+) | | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 45+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 50+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 55+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 60+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 65+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 70+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 75+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 80+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 85+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 90+) | m3 per hectare | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 12.5+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 15+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 20+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 25+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 30+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 35+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 40+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 45+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 50+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 55+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 60+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 65+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 70+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 75+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 80+) | Volume per tree | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 85+) | Volume per tree | |
| 5 (TASS/TIPSY) | | 10 | Volume | Merchantable (dia. class 90+) | Volume per tree | |
| 1, 21 | 3.7 | 11 | Compression wood | lowers strength; increases shrinkage and warping | related to increased tree lean and vigour | avoid density control that introduces tall and slender trees |
| 1, 21 | 3.8 | 12 | Knots | structural lumber defect due to strength reduction from grain deviation | knot size and frequency | spacing will increase knot size and potentially lower value, but may be offset by increased log diameter and resulting wider lumber widths which permit larger knots - likely variable by species, site & treatment(s) |
| 1, 30 | p. 24 | 13 | Log straightness | sweep | crook | |
| 1, 30 | p. 26 | 14 | Reaction (compression) wood | Longitudinal shrinkage | large fibril angle, lower cellulose content; reduction in suitability for solid and fibre products | Thinning is associated with formation of compression wood |
| 1, 30 | p. 26 | 15 | Knots | Mechanical properties | Visual downgrading | Size and location |
| 1, 21 | 3.3 | 16 | Juvenile/mature wood distribution | | | density stabilizes in Pl at age 40 |
| 1, 30 | p. 27 | 16 | Juvenile wood | Strength, stiffness reduced by higher % of juvenile wood | | |
| 1, 30 | p. 25 | 17 | Age | Juvenile wood content | | High juvenile content decreases dimensional stability and strength |
| 5 (TASS/TIPSY) | | 17 | Age | Age | | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| 1, 21 | 3.9 | 18 | Grain | | | weak relationship between relative density and ring width in Pl (Forintek, Book 1, Sect. 21) |
| 1, 30 | p. 27 | 18 | Grain | grain angle reduces lumber strength significantly | | rapid growth may increase grain coarseness - however, appears to be related to juvenile/mature wood formation |
| 1, 30 | p. 33 | 19 | Machinability | | | |
| 1, 30 | p. 29 | 20 | Rings | ring width grading rules | effects wood ensity and mechanical properties | width of ring, earlywood, latewood; transition earlywood to latewood |
| 1, 30 | p. 34 | 21 | Wood engineering properties | Fastening, gluing characteristics | Density, moisture content, grain angle | |
| 1, 21 | 3.5 | 22 | Fibre length | longer fibres make stronger paper sheets | | fibre length is a function of age at vertical height levels |
| 1, 30 | p. 25 | 23 | Bark | % of log volume (7 to 18%) | | Debarking cost, fibre loss, content in pulp |
| 1, 30 | p. 28 | 24 | Heartwood/sapwood | End use specific | extractives, moisture content, | Manage rotation age to control ratios - minimize heartwood as costly to dry although sapwood contains much more moisture |
| 1, 21 | 3.4 | 24 | heartwood/sapwood distribution | | | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| 1, 21 | 3.10 | 25 | Extractives | High content lowers adhesive bond | | Affects pulp yield, higher bleaching costs, low content preferred by panel industry, |
| 1, 30 | p. 25 | 26 | Decay | Volume loss | heartwoo/sapwood | Generally increases with age (60 year plus?) |
| 1, 30 | p. 27 | 27 | Growth stresses | Cracks, ring shake, brittle heartwood…; | Warping | Ring shake in hemlock, true firs |
| 1, 30 | p. 30 | 28 | Moisture content | costs: transportation, manufacturing, drying | debarking | |
| 1, 30 | p. 32 | 29 | Durability | Decay resistance | | Second growth may offer diminished durability |
| 1, 30 | p. 32 | 30 | Wood permeability | | | |
| 1, 30 | p. 33 | 31 | Aesthetic characteristics | | | |
| 1, 30 | p. 33 | 32 | Finishing characteristics | | | |
| 1, 30 | p. 33 | 33 | Fire resistance | | | |
| 1, 42 | 1.2 | A | Wildlife Tree Patches | | | |
| 1, 42 | 1.1 | A | Coarse Woody Debris | | | |
| 1, 42 | 1.10 | A | Vertebrate - Grizzly bear | Forage | Cover | |
| 1, 42 | 1.3 | A | Riparian Mgt. Areas | | | |
| 1, 42 | 1.4 | A | Seral stage | | | |
| 1, 42 | 1.4 | A | Connectivity | | | |
| 1, 42 | 1.5 | A | Vertebrate - cavity excavators | Dead/dying (snags) | | |
| 1, 42 | 1.6 | A | Vertebrate - Northern Goshawk | Stand density | | |
| 1, 42 | 1.7 | A | Vertebrate - Coastal black tailed deer | Winter range | | |
| 1, 42 | 1.7 | A | Vertebrate - Roosevelt elk | Winter range | | |
| 1, 42 | 1.8 | A | Vertebrate - Mule deer | Winter range | | |
| 1, 42 | 1.9 | A | Vertebrate - Mountain caribou | Winter range | | |
| 5 (TASS/TIPSY) | | A | Coarse Woody | DBH class: 5 | stems per | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| | | | Debris | | hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 10 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 15 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 20 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 25 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 30 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 35 | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: All | stems per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 5 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 10 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 15 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 20 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 25 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 30 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: 35 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | Coarse Woody Debris | DBH class: All | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 5 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 10 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 15 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 20 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 25 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: 30 | m3 per hectare | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less | DBH class: 35 | m3 per hectare | |

| Source (Literature Index: Book, Tab, section or page) | | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|---|
| | | | decay) | | | |
| 5 (TASS/TIPSY) | | A | CWD (cumulative volume less decay) | DBH class: All | m3 per hectare | |
| Bunnell | | A | Hardwood | | | |
| Bunnell | | A | Brush | | | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 5 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 15 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 25 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 35 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 45 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 55 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: 65 | stems per hectare | |
| 5 (TASS/TIPSY) | | B | Snags | DBH class: All | stems per hectare | |
| Bunnell | | B | Life forms (guilds) within NRV | | | |
| Bunnell | | B | Patch size | | | |
| Bunnell | | B | Canopy layers (vertical structure) | | | |
| Bunnell | | B | Edge effect | | | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: mean height | metre | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: Volume | m3 per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: Basal Area | m2 per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (5) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (15) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (25) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (35) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (45) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (55) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (65) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic: DBH (All) | stems per hectare | |
| 5 (TASS/TIPSY) | | C | Mortality | Periodic (All) | cm. | |
| 5 (TASS/TIPSY) | | D | Stand Density | No. of trees dia class (0) | stems per hectare | |

| Source (Literature Index: Book, Tab, section or page) | Table 20: Ranking | Decision Element | Value Factor 1 | Value Factor 2 | Critical Element |
|---|---|---|---|---|---|
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (5) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (10) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (15) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (20) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (25) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (30) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (35) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (40) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (45) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (50) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (55) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (60) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (65) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (70) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (75) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (80) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (85) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (90) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Stand Density | No. of trees dia class (All) | stems per hectare | |
| 5 (TASS/TIPSY) | D | Area | BA (0.0 Utilization) | m2 per hectare | |
| 5 (TASS/TIPSY) | E | Live crown | 250 Prime (12.5 Utilization) | % | |
| 5 (TASS/TIPSY) | E | Crown closure | All trees (0.0 Utilization) | % | |
| 5 (TASS/TIPSY) | F | Height | Top height | metres | |

The primary source for quantifiable data is from TIPSY. Output for all factors projected by TIPSY from the above table were generated by development type for pine stands and a range of initial densities. This output is provided in a separate book with the hardcopy version of the report.

TIPSY pine site index tables, presented below in tables 21 - 34, were generated for Mean Annual Increment (MAI) and Mean Annual Lumber Value (MAVL) across a range of initial densities. Value is expressed based on the assumptions developed for the three ranges (low, medium and high) across product types as shown in Table 7. The prime factors considered in the tables include:

- Initial stand density
- Rotation age
- Product value ($/ha./year)
- Lumber Recovery Factor (LRF)
- MAI ($m^3$/ha./year)
- Lumber (BF/ha.)
- Merchantable volume ($m^3$/ha.)

Rate of change is expressed as a percentage in relation to the preceding value (reading left to right). Other values such as CWD, snags, live crown %, volume by diameter class, etc. are portrayed in similar tables in the TIPSY output book available through the committee.

These TIPSY output summary tables place the prime factors into value categories from the perspective of culmination of MAI, or a volume perspective, and culmination of MALV, or a value perspective. The intent of this summary is to be able to quantify inflection points where values start to decline based on varying stand density. The tables are presented by site index.

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Table 21. Site Index 7 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 190 | 180 | 190 | 190 | 190 | 200 | 220 | 230 |
| low value | 9607 | 10023 | 10261 | 9953 | 9644 | 9425 | 8420 | 7362 |
| Rate of Change | | 4% | 2% | -3% | -3% | -2% | -11% | -13% |
| medium value | 15973 | 16666 | 17034 | 16546 | 16034 | 15671 | 14008 | 12262 |
| Rate of Change | | 4% | 2% | -3% | -3% | -2% | -11% | -12% |
| high value | 22339 | 23309 | 23808 | 23140 | 22424 | 21916 | 19595 | 17162 |
| Rate of Change | | 4% | 2% | -3% | -3% | -2% | -11% | -12% |
| LRF | 148 | 164 | 167 | 169 | 169 | 171 | 171 | 171 |
| Rate of Change | | 11% | 2% | 1% | 0% | 1% | 0% | 0% |
| MAI | 0.43 | 0.41 | 0.41 | 0.39 | 0.38 | 0.37 | 0.33 | 0.29 |
| Rate of Change | | -5% | 0% | -5% | -3% | -3% | -11% | -12% |
| Lumber (all) (bf/ha.) | 12092 | 11954 | 12865 | 12523 | 12136 | 12487 | 12288 | 11267 |
| Rate of Change | | -1% | 8% | -3% | -3% | 3% | -2% | -8% |
| Merch volume (m3/ha.) | 82 | 73 | 77 | 74 | 72 | 73 | 72 | 66 |
| Rate of Change | | -11% | 5% | -4% | -3% | 1% | -1% | -8% |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 230 | 220 | 220 | 210 | 210 | 210 | 220 | 240 |
| low value | 9952 | 10493 | 10432 | 10068 | 9828 | 9453 | 8420 | 7458 |
| Rate of Change | | 5% | -1% | -3% | -2% | -4% | -11% | -11% |
| MAI | 0.41 | 0.4 | 0.4 | 0.39 | 0.38 | 0.37 | 0.33 | 0.29 |
| Rate of Change | | -2% | 0% | -3% | -3% | -3% | -11% | -12% |
| LRF | 158 | 171 | 172 | 171 | 172 | 170 | 171 | 173 |
| Rate of Change | | 8% | 1% | -1% | 1% | -1% | 1% | 1% |
| Lumber (all) | 15007 | 15053 | 14970 | 13871 | 13572 | 13095 | 12288 | 11906 |
| Rate of Change | | 0% | -1% | -7% | -2% | -4% | -6% | -3% |
| | | | | | | | | |
| Rotation Age | 230 | 220 | 210 | 210 | 200 | 210 | 220 | 240 |
| medium value | 16479 | 17338 | 17252 | 16675 | 16318 | 15691 | 14008 | 12421 |
| Rate of Change | | 5% | 0% | -3% | -2% | -4% | -11% | -11% |
| MAI | 0.41 | 0.4 | 0.4 | 0.39 | 0.38 | 0.37 | 0.33 | 0.29 |
| Rate of Change | | -2% | 0% | -3% | -3% | -3% | -11% | -12% |
| LRF | 158 | 171 | 171 | 171 | 171 | 170 | 171 | 173 |
| Rate of Change | | 8% | 0% | 0% | 0% | -1% | 1% | 1% |
| Lumber (all) | 15007 | 15053 | 14328 | 13871 | 12981 | 13095 | 12288 | 11906 |
| Rate of Change | | 0% | -5% | -3% | -6% | 1% | -6% | -3% |
| | | | | | | | | |
| Rotation Age | 220 | 220 | 210 | 210 | 200 | 210 | 220 | 240 |
| high value | 23008 | 24183 | 24077 | 23283 | 22811 | 21929 | 19595 | 17383 |
| Rate of Change | | 5% | 0% | -3% | -2% | -4% | -11% | -11% |
| LRF | 158 | 171 | 171 | 171 | 171 | 170 | 171 | 173 |
| Rate of Change | | 8% | 0% | 0% | 0% | -1% | 1% | 1% |
| MAI | 0.41 | 0.4 | 0.4 | 0.39 | 0.38 | 0.37 | 0.33 | 0.29 |
| Rate of Change | | -2% | 0% | -3% | -3% | -3% | -11% | -12% |
| Lumber (all) | 14368 | 15053 | 14328 | 13871 | 12981 | 13095 | 12288 | 11906 |
| Rate of Change | | 5% | -5% | -3% | -6% | 1% | -6% | -3% |

Table 22. Site Index 8 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 160 | 180 | 160 | 170 | 170 | 170 | 180 | 200 |
| low value | 13699 | 15096 | 14410 | 14206 | 13709 | 13135 | 11690 | 10441 |
| Rate of Change | | 10% | -5% | -1% | -3% | -4% | -11% | -11% |
| medium value | 22725 | 24898 | 23850 | 23486 | 22687 | 21763 | 19398 | 17322 |
| Rate of Change | | 10% | -4% | -2% | -3% | -4% | -11% | -11% |
| high value | 31750 | 34700 | 33290 | 32766 | 31665 | 30390 | 27106 | 24202 |
| Rate of Change | | 9% | -4% | -2% | -3% | -4% | -11% | -11% |
| LRF | 154 | 171 | 170 | 170 | 170 | 171 | 169 | 170 |
| Rate of Change | | 11% | -1% | 0% | 0% | 1% | -1% | 1% |
| MAI | 0.59 | 0.57 | 0.56 | 0.55 | 0.53 | 0.51 | 0.46 | 0.41 |
| Rate of Change | | -3% | -2% | -2% | -4% | -4% | -10% | -11% |
| Lumber (all) (bf/ha.) | 14436 | 17636 | 15099 | 15771 | 15257 | 14663 | 13870 | 13757 |
| Rate of Change | | 22% | -14% | 4% | -3% | -4% | -5% | -1% |
| Merch volume (m3/ha.) | 94 | 103 | 89 | 93 | 90 | 86 | 82 | 81 |
| Rate of Change | | 10% | -14% | 4% | -3% | -4% | -5% | -1% |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 200 | 200 | 190 | 190 | 190 | 200 | 200 | 200 |
| low value | 14556 | 15210 | 15025 | 14462 | 13937 | 13391 | 11822 | 10441 |
| Rate of Change | | 4% | -1% | -4% | -4% | -4% | -12% | -12% |
| MAI | 0.58 | 0.56 | 0.56 | 0.55 | 0.53 | 0.5 | 0.45 | 0.41 |
| Rate of Change | | -3% | 0% | -2% | -4% | -6% | -10% | -9% |
| LRF | 162 | 175 | 173 | 171 | 172 | 172 | 171 | 170 |
| Rate of Change | | 8% | -1% | -1% | 1% | 0% | -1% | -1% |
| Lumber (all) | 18978 | 19634 | 18472 | 17802 | 17184 | 17355 | 15428 | 13757 |
| Rate of Change | | 3% | -6% | -4% | -3% | 1% | -11% | -11% |
| | | | | | | | | |
| Rotation Age | 200 | 190 | 190 | 190 | 190 | 190 | 200 | 200 |
| medium value | 24047 | 25036 | 24751 | 23834 | 22984 | 22096 | 19538 | 17322 |
| Rate of Change | | 4% | -1% | -4% | -4% | -4% | -12% | -11% |
| MAI | 0.58 | 0.57 | 0.56 | 0.55 | 0.53 | 0.51 | 0.45 | 0.41 |
| Rate of Change | | -2% | -2% | -2% | -4% | -4% | -12% | -9% |
| LRF | 162 | 173 | 173 | 171 | 172 | 171 | 171 | 170 |
| Rate of Change | | 7% | 0% | -1% | 1% | -1% | 0% | -1% |
| Lumber (all) | 18978 | 18687 | 18472 | 17802 | 17184 | 16541 | 15428 | 13757 |
| Rate of Change | | -2% | -1% | -4% | -3% | -4% | -7% | -11% |
| | | | | | | | | |
| Rotation Age | 200 | 190 | 190 | 190 | 190 | 190 | 200 | 190 |
| high value | 33539 | 34875 | 34477 | 33207 | 32031 | 30804 | 27255 | 24214 |
| Rate of Change | | 4% | -1% | -4% | -4% | -4% | -12% | -11% |
| LRF | 162 | 173 | 173 | 171 | 172 | 171 | 171 | 173 |
| Rate of Change | | 7% | 0% | -1% | 1% | -1% | 0% | 1% |
| MAI | 0.58 | 0.57 | 0.56 | 0.55 | 0.53 | 0.51 | 0.45 | 0.4 |
| Rate of Change | | -2% | -2% | -2% | -4% | -4% | -12% | -11% |
| Lumber (all) | 18978 | 18687 | 18472 | 17802 | 17184 | 16541 | 15428 | 13111 |
| Rate of Change | | -2% | -1% | -4% | -3% | -4% | -7% | -15% |

| Table 23. Site Index 9 | Value expressed in $/ha./yr. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 160 | 160 | 180 | 190 | 170 | 170 | 190 | 200 |
| low value | 27629 | 28864 | 30141 | 28942 | 26561 | 25666 | 23201 | 20841 |
| Rate of Change | | 4% | 4% | -4% | -8% | -3% | -10% | -10% |
| medium value | 45556 | 47382 | 49006 | 47051 | 43665 | 42216 | 38140 | 34274 |
| Rate of Change | | 4% | 3% | -4% | -7% | -3% | -10% | -10% |
| high value | 63483 | 65899 | 67870 | 65160 | 60769 | 58767 | 53078 | 47708 |
| Rate of Change | | 4% | 3% | -4% | -7% | -3% | -10% | -10% |
| LRF | 165 | 176 | 179 | 176 | 171 | 171 | 168 | 167 |
| Rate of Change | | 7% | 2% | -2% | -3% | 0% | -2% | -1% |
| MAI | 1.09 | 1.05 | 1.06 | 1.03 | 1 | 0.97 | 0.89 | 0.81 |
| Rate of Change | | -4% | 1% | -3% | -3% | -3% | -8% | -9% |
| Lumber (all) (bf/ha.) | 28674 | 29617 | 33945 | 34397 | 29069 | 28128 | 28375 | 26860 |
| Rate of Change | | 3% | 15% | 1% | -15% | -3% | 1% | -5% |
| Merch volume (m3/ha.) | 174 | 168 | 190 | 195 | 170 | 165 | 169 | 161 |
| Rate of Change | | -3% | 13% | 3% | -13% | -3% | 2% | -5% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 210 | 210 | 210 | 210 | 210 | 210 | 230 | 240 |
| low value | 30195 | 31506 | 30769 | 29195 | 27879 | 26901 | 23852 | 21138 |
| Rate of Change | | 4% | -2% | -5% | -5% | -4% | -11% | -11% |
| MAI | 1.05 | 1.02 | 1.02 | 1 | 0.99 | 0.96 | 0.87 | 0.8 |
| Rate of Change | | -3% | 0% | -2% | -1% | -3% | -9% | -8% |
| LRF | 179 | 188 | 184 | 180 | 176 | 176 | 173 | 168 |
| Rate of Change | | 5% | -2% | -2% | -2% | 0% | -2% | -3% |
| Lumber (all) | 39462 | 40196 | 39485 | 37815 | 36402 | 35275 | 34351 | 32007 |
| Rate of Change | | 2% | -2% | -4% | -4% | -3% | -3% | -7% |
| | | | | | | | | |
| Rotation Age | 200 | 200 | 200 | 200 | 200 | 210 | 220 | 230 |
| medium value | 49003 | 50705 | 49656 | 47246 | 45239 | 43703 | 38858 | 34509 |
| Rate of Change | | 3% | -2% | -5% | -4% | -3% | -11% | -11% |
| MAI | 1.06 | 1.03 | 1.03 | 1.01 | 1 | 0.96 | 0.87 | 0.8 |
| Rate of Change | | -3% | 0% | -2% | -1% | -4% | -9% | -8% |
| LRF | 178 | 187 | 183 | 179 | 175 | 176 | 173 | 167 |
| Rate of Change | | 5% | -2% | -2% | -2% | 1% | -2% | -3% |
| Lumber (all) | 37709 | 38476 | 37813 | 36187 | 34819 | 35275 | 33026 | 30800 |
| Rate of Change | | 2% | -2% | -4% | -4% | 1% | -6% | -7% |
| | | | | | | | | |
| Rotation Age | 200 | 200 | 200 | 200 | 200 | 210 | 220 | 230 |
| high value | 67863 | 69950 | 68568 | 65344 | 62654 | 60505 | 53874 | 47904 |
| Rate of Change | | 3% | -2% | -5% | -4% | -3% | -11% | -11% |
| LRF | 178 | 187 | 183 | 179 | 175 | 176 | 173 | 167 |
| Rate of Change | | 5% | -2% | -2% | -2% | 1% | -2% | -3% |
| MAI | 1.06 | 1.03 | 1.03 | 1.01 | 1 | 0.96 | 0.87 | 0.8 |
| Rate of Change | | -3% | 0% | -2% | -1% | -4% | -9% | -8% |
| Lumber (all) | 37709 | 38476 | 37813 | 36187 | 34819 | 35275 | 33026 | 30800 |
| Rate of Change | | 2% | -2% | -4% | -4% | 1% | -6% | -7% |

Table 24. Site Index 10 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 140 | 140 | 150 | 150 | 160 | 150 | 160 | 170 |
| low value | 35915 | 37501 | 38120 | 35941 | 35088 | 32701 | 29209 | 26044 |
| Rate of Change | | 4% | 2% | -6% | -2% | -7% | -11% | -11% |
| medium value | 58841 | 61054 | 61801 | 58492 | 57025 | 53509 | 47891 | 42763 |
| Rate of Change | | 4% | 1% | -5% | -3% | -6% | -10% | -11% |
| high value | 81768 | 84606 | 85482 | 81042 | 78962 | 74316 | 66573 | 59483 |
| Rate of Change | | 3% | 1% | -5% | -3% | -6% | -10% | -11% |
| LRF | 170 | 180 | 180 | 177 | 175 | 172 | 170 | 165 |
| Rate of Change | | 6% | 0% | -2% | -1% | -2% | -1% | -3% |
| MAI | 1.35 | 1.31 | 1.31 | 1.27 | 1.26 | 1.21 | 1.1 | 1.01 |
| Rate of Change | | -3% | 0% | -3% | -1% | -4% | -9% | -8% |
| Lumber (all) (bf/ha.) | 32088 | 32964 | 35511 | 33816 | 35089 | 31203 | 29882 | 28415 |
| Rate of Change | | 3% | 8% | -5% | 4% | -11% | -4% | -5% |
| Merch volume (m3/ha.) | 189 | 183 | 197 | 191 | 201 | 181 | 176 | 172 |
| Rate of Change | | -3% | 8% | -3% | 5% | -10% | -3% | -2% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 200 | 200 | 200 | 210 | 220 | 220 | 200 | 210 |
| low value | 39800 | 41558 | 40406 | 38054 | 36050 | 34595 | 30649 | 27201 |
| Rate of Change | | 4% | -3% | -6% | -5% | -4% | -11% | -11% |
| MAI | 1.27 | 1.24 | 1.24 | 1.2 | 1.16 | 1.13 | 1.08 | 0.99 |
| Rate of Change | | -2% | 0% | -3% | -3% | -3% | -4% | -8% |
| LRF | 189 | 200 | 195 | 191 | 188 | 185 | 175 | 171 |
| Rate of Change | | 6% | -3% | -2% | -2% | -2% | -5% | -2% |
| Lumber (all) | 48057 | 49341 | 48301 | 48025 | 47915 | 46108 | 37894 | 35563 |
| Rate of Change | | 3% | -2% | -1% | 0% | -4% | -18% | -6% |
| | | | | | | | | |
| Rotation Age | 200 | 200 | 200 | 210 | 210 | 180 | 190 | 200 |
| medium value | 63834 | 66235 | 64563 | 60929 | 57874 | 55677 | 49676 | 44198 |
| Rate of Change | | 4% | -3% | -6% | -5% | -4% | -11% | -11% |
| MAI | 1.27 | 1.24 | 1.24 | 1.2 | 1.18 | 1.19 | 1.09 | 1 |
| Rate of Change | | -2% | 0% | -3% | -2% | 1% | -8% | -8% |
| LRF | 189 | 200 | 195 | 191 | 186 | 178 | 174 | 170 |
| Rate of Change | | 6% | -3% | -2% | -3% | -4% | -2% | -2% |
| Lumber (all) | 48057 | 49341 | 48301 | 48025 | 45863 | 38260 | 36184 | 34026 |
| Rate of Change | | 3% | -2% | -1% | -5% | -17% | -5% | -6% |
| | | | | | | | | |
| Rotation Age | 190 | 200 | 200 | 210 | 210 | 180 | 190 | 200 |
| high value | 87932 | 90913 | 88720 | 83804 | 79719 | 76939 | 68726 | 61216 |
| Rate of Change | | 3% | -2% | -6% | -5% | -3% | -11% | -11% |
| LRF | 187 | 200 | 195 | 191 | 186 | 178 | 174 | 170 |
| Rate of Change | | 7% | -3% | -2% | -3% | -4% | -2% | -2% |
| MAI | 1.29 | 1.24 | 1.24 | 1.2 | 1.18 | 1.19 | 1.09 | 1 |
| Rate of Change | | -4% | 0% | -3% | -2% | 1% | -8% | -8% |
| Lumber (all) | 45851 | 49341 | 48301 | 48025 | 45863 | 38260 | 36184 | 34026 |
| Rate of Change | | 8% | -2% | -1% | -5% | -17% | -5% | -6% |

Table 25. Site Index 11 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 130 | 140 | 140 | 140 | 130 | 140 | 140 | 150 |
| low value | 46334 | 49833 | 48432 | 45748 | 42098 | 41729 | 36214 | 32595 |
| Rate of Change | | 8% | -3% | -6% | -8% | -1% | -13% | -10% |
| medium value | 75326 | 79915 | 77862 | 73821 | 68502 | 67687 | 59123 | 53256 |
| Rate of Change | | 6% | -3% | -5% | -7% | -1% | -13% | -10% |
| high value | 104317 | 109997 | 107293 | 101895 | 94906 | 93645 | 82032 | 73918 |
| Rate of Change | | 5% | -2% | -5% | -7% | -1% | -12% | -10% |
| LRF | 178 | 189 | 186 | 180 | 174 | 176 | 172 | 168 |
| Rate of Change | | 6% | -2% | -3% | -3% | 1% | -2% | -2% |
| MAI | 1.63 | 1.59 | 1.59 | 1.56 | 1.52 | 1.48 | 1.34 | 1.23 |
| Rate of Change | | -2% | 0% | -2% | -3% | -3% | -9% | -8% |
| Lumber (all) (bf/ha.) | 37679 | 42103 | 41191 | 39292 | 34316 | 36331 | 32064 | 30984 |
| Rate of Change | | 12% | -2% | -5% | -13% | 6% | -12% | -3% |
| Merch volume (m3/ha.) | 212 | 223 | 222 | 218 | 197 | 207 | 187 | 184 |
| Rate of Change | | 5% | 0% | -2% | -10% | 5% | -10% | -2% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 180 | 180 | 180 | 180 | 190 | 190 | 210 | 220 |
| low value | 50779 | 53059 | 51634 | 48801 | 46323 | 44560 | 39139 | 34405 |
| Rate of Change | | 4% | -3% | -5% | -5% | -4% | -12% | -12% |
| MAI | 1.54 | 1.5 | 1.5 | 1.48 | 1.43 | 1.39 | 1.24 | 1.14 |
| Rate of Change | | -3% | 0% | -1% | -3% | -3% | -11% | -8% |
| LRF | 192 | 208 | 204 | 196 | 195 | 192 | 189 | 183 |
| Rate of Change | | 8% | -2% | -4% | -1% | -2% | -2% | -3% |
| Lumber (all) | 54172 | 56074 | 54971 | 52431 | 52806 | 50905 | 49430 | 45728 |
| Rate of Change | | 4% | -2% | -5% | 1% | -4% | -3% | -7% |
| | | | | | | | | |
| Rotation Age | 170 | 170 | 180 | 180 | 190 | 190 | 200 | 220 |
| medium value | 81009 | 84231 | 82181 | 77936 | 74123 | 71358 | 62717 | 55196 |
| Rate of Change | | 4% | -2% | -5% | -5% | -4% | -12% | -12% |
| MAI | 1.56 | 1.54 | 1.5 | 1.48 | 1.43 | 1.39 | 1.27 | 1.14 |
| Rate of Change | | -1% | -3% | -1% | -3% | -3% | -9% | -10% |
| LRF | 194 | 203 | 204 | 196 | 195 | 192 | 186 | 183 |
| Rate of Change | | 5% | 0% | -4% | -1% | -2% | -3% | -2% |
| Lumber (all) | 51486 | 53117 | 54971 | 52431 | 52806 | 50905 | 47222 | 45728 |
| Rate of Change | | 3% | 3% | -5% | 1% | -4% | -7% | -3% |
| | | | | | | | | |
| Rotation Age | 170 | 170 | 180 | 180 | 190 | 190 | 200 | 180 |
| high value | 111302 | 115484 | 112727 | 107072 | 101922 | 98156 | 86334 | 76083 |
| Rate of Change | | 4% | -2% | -5% | -5% | -4% | -12% | -12% |
| LRF | 194 | 203 | 204 | 196 | 195 | 192 | 186 | 174 |
| Rate of Change | | 5% | 0% | -4% | -1% | -2% | -3% | -6% |
| MAI | 1.56 | 1.54 | 1.5 | 1.48 | 1.43 | 1.39 | 1.27 | 1.21 |
| Rate of Change | | -1% | -3% | -1% | -3% | -3% | -9% | -5% |
| Lumber (all) | 51486 | 53117 | 54971 | 52431 | 52806 | 50905 | 47222 | 37849 |
| Rate of Change | | 3% | 3% | -5% | 1% | -4% | -7% | -20% |

| Table 26. Site Index 12 | Value expressed in $/ha./yr. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 110 | 110 | 120 | 120 | 120 | 120 | 130 | 130 |
| low value | 41261 | 43061 | 43641 | 40920 | 38777 | 37083 | 33174 | 28772 |
| Rate of Change | | 4% | 1% | -6% | -5% | -4% | -11% | -13% |
| medium value | 67098 | 69432 | 70074 | 65970 | 62731 | 60109 | 53808 | 46941 |
| Rate of Change | | 3% | 1% | -6% | -5% | -4% | -10% | -13% |
| high value | 92935 | 95803 | 96506 | 91019 | 86686 | 83134 | 74443 | 65110 |
| Rate of Change | | 3% | 1% | -6% | -5% | -4% | -10% | -13% |
| LRF | 175 | 186 | 187 | 181 | 176 | 176 | 174 | 169 |
| Rate of Change | | 6% | 1% | -3% | -3% | 0% | -1% | -3% |
| MAI | 1.47 | 1.42 | 1.42 | 1.38 | 1.36 | 1.31 | 1.18 | 1.08 |
| Rate of Change | | -3% | 0% | -3% | -1% | -4% | -10% | -8% |
| Lumber (all) (bf/ha.) | 28413 | 28999 | 31710 | 30049 | 28737 | 27622 | 26817 | 23613 |
| Rate of Change | | 2% | 9% | -5% | -4% | -4% | -3% | -12% |
| Merch volume (m3/ha.) | 162 | 156 | 170 | 166 | 163 | 157 | 154 | 140 |
| Rate of Change | | -4% | 9% | -2% | -2% | -4% | -2% | -9% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 150 | 150 | 150 | 150 | 160 | 160 | 160 | 170 |
| low value | 45394 | 47437 | 46166 | 43328 | 41000 | 39267 | 34218 | 29747 |
| Rate of Change | | 5% | -3% | -6% | -5% | -4% | -13% | -13% |
| MAI | 1.36 | 1.33 | 1.33 | 1.3 | 1.24 | 1.21 | 1.12 | 1.01 |
| Rate of Change | | -2% | 0% | -2% | -5% | -2% | -7% | -10% |
| LRF | 197 | 209 | 204 | 199 | 197 | 194 | 184 | 179 |
| Rate of Change | | 6% | -2% | -2% | -1% | -2% | -5% | -3% |
| Lumber (all) | 40215 | 41692 | 40876 | 38732 | 39257 | 37678 | 33118 | 30739 |
| Rate of Change | | 4% | -2% | -5% | 1% | -4% | -12% | -7% |
| | | | | | | | | |
| Rotation Age | 140 | 150 | 150 | 150 | 150 | 160 | 160 | 160 |
| medium value | 72261 | 75239 | 73422 | 69156 | 65613 | 62821 | 54922 | 48018 |
| Rate of Change | | 4% | -2% | -6% | -5% | -4% | -13% | -13% |
| MAI | 1.4 | 1.33 | 1.33 | 1.3 | 1.27 | 1.21 | 1.12 | 1.06 |
| Rate of Change | | -5% | 0% | -2% | -2% | -5% | -7% | -5% |
| LRF | 193 | 209 | 204 | 199 | 194 | 194 | 184 | 173 |
| Rate of Change | | 8% | -2% | -2% | -3% | 0% | -5% | -6% |
| Lumber (all) | 37810 | 41692 | 40876 | 38732 | 36956 | 37678 | 33118 | 27505 |
| Rate of Change | | 10% | -2% | -5% | -5% | 2% | -12% | -17% |
| | | | | | | | | |
| Rotation Age | 140 | 150 | 150 | 150 | 150 | 150 | 160 | 150 |
| high value | 99274 | 103040 | 100678 | 94984 | 90256 | 86419 | 75626 | 66359 |
| Rate of Change | | 4% | -2% | -6% | -5% | -4% | -12% | -12% |
| LRF | 193 | 209 | 204 | 199 | 194 | 189 | 184 | 173 |
| Rate of Change | | 8% | -2% | -2% | -3% | -3% | -3% | -6% |
| MAI | 1.4 | 1.33 | 1.33 | 1.3 | 1.27 | 1.25 | 1.12 | 1.06 |
| Rate of Change | | -5% | 0% | -2% | -2% | -2% | -10% | -5% |
| Lumber (all) | 37810 | 41692 | 40876 | 38732 | 36956 | 35427 | 33118 | 27505 |
| Rate of Change | | 10% | -2% | -5% | -5% | -4% | -7% | -17% |

| Table 27. Site Index 13 | Value expressed in $/ha./yr. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 100 | 110 | 110 | 120 | 130 |
| low value | 50120 | 52295 | 50744 | 47542 | 46939 | 45085 | 40455 | 36048 |
| Rate of Change | | 4% | -3% | -6% | -1% | -4% | -10% | -11% |
| medium value | 81235 | 83960 | 81676 | 76837 | 75645 | 72774 | 65329 | 58268 |
| Rate of Change | | 3% | -3% | -6% | -2% | -4% | -10% | -11% |
| high value | 112350 | 115624 | 112608 | 106132 | 104350 | 100464 | 90202 | 80489 |
| Rate of Change | | 3% | -3% | -6% | -2% | -4% | -10% | -11% |
| LRF | 180 | 188 | 184 | 180 | 180 | 178 | 176 | 174 |
| Rate of Change | | 4% | -2% | -2% | 0% | -1% | -1% | -1% |
| MAI | 1.73 | 1.68 | 1.68 | 1.63 | 1.6 | 1.55 | 1.42 | 1.28 |
| Rate of Change | | -3% | 0% | -3% | -2% | -3% | -8% | -10% |
| Lumber (all) (bf/ha.) | 31107 | 31655 | 30924 | 29287 | 31567 | 30450 | 29838 | 28878 |
| Rate of Change | | 2% | -2% | -5% | 8% | -4% | -2% | -3% |
| Merch volume (m3/ha.) | 1.73 | 1.68 | 1.68 | 1.63 | 1.6 | 1.55 | 1.42 | 1.28 |
| Rate of Change | | -3% | 0% | -3% | -2% | -3% | -8% | -10% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 130 | 130 | 130 | 140 | 140 | 150 | 150 | 160 |
| low value | 56174 | 58718 | 57090 | 54025 | 51038 | 49116 | 42932 | 37535 |
| Rate of Change | | 5% | -3% | -5% | -6% | -4% | -13% | -13% |
| MAI | 1.66 | 1.62 | 1.62 | 1.54 | 1.51 | 1.43 | 1.32 | 1.19 |
| Rate of Change | | -2% | 0% | -5% | -2% | -5% | -8% | -10% |
| LRF | 199 | 212 | 208 | 207 | 201 | 205 | 194 | 188 |
| Rate of Change | | 7% | -2% | 0% | -3% | 2% | -5% | -3% |
| Lumber (all) | 42898 | 44581 | 43676 | 44689 | 42608 | 43798 | 38491 | 35887 |
| Rate of Change | | 4% | -2% | 2% | -5% | 3% | -12% | -7% |
| | | | | | | | | |
| Rotation Age | 130 | 130 | 130 | 140 | 140 | 140 | 150 | 150 |
| medium value | 89179 | 93020 | 90695 | 85953 | 81479 | 78352 | 68598 | 59969 |
| Rate of Change | | 4% | -2% | -5% | -5% | -4% | -12% | -13% |
| MAI | 1.66 | 1.62 | 1.62 | 1.54 | 1.51 | 1.47 | 1.32 | 1.19 |
| Rate of Change | | -2% | 0% | -5% | -2% | -3% | -10% | -10% |
| LRF | 199 | 212 | 208 | 207 | 201 | 199 | 194 | 188 |
| Rate of Change | | 7% | -2% | 0% | -3% | -1% | -3% | -3% |
| Lumber (all) | 42898 | 44581 | 43676 | 44689 | 42608 | 41016 | 38491 | 35887 |
| Rate of Change | | 4% | -2% | 2% | -5% | -4% | -6% | -7% |
| | | | | | | | | |
| Rotation Age | 130 | 130 | 130 | 140 | 140 | 140 | 150 | 150 |
| high value | 122184 | 127322 | 124300 | 117881 | 111920 | 107656 | 94265 | 82403 |
| Rate of Change | | 4% | -2% | -5% | -5% | -4% | -12% | -13% |
| LRF | 199 | 212 | 208 | 207 | 201 | 199 | 194 | 188 |
| Rate of Change | | 7% | -2% | 0% | -3% | -1% | -3% | -3% |
| MAI | 1.66 | 1.62 | 1.62 | 1.54 | 1.51 | 1.47 | 1.32 | 1.19 |
| Rate of Change | | -2% | 0% | -5% | -2% | -3% | -10% | -10% |
| Lumber (all) | 42898 | 44581 | 43676 | 44689 | 42608 | 41016 | 38491 | 35887 |
| Rate of Change | | 4% | -2% | 2% | -5% | -4% | -6% | -7% |

Table 28. Site Index 14 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 110 | 110 | 110 | 120 | 120 |
| low value | 83851 | 87579 | 84781 | 84014 | 79067 | 75475 | 68213 | 58267 |
| Rate of Change | | 4% | -3% | -1% | -6% | -5% | -10% | -15% |
| medium value | 134123 | 139359 | 135277 | 134003 | 126553 | 120925 | 109261 | 93795 |
| Rate of Change | | 4% | -3% | -1% | -6% | -4% | -10% | -14% |
| high value | 184395 | 191139 | 185773 | 183991 | 174038 | 166375 | 150309 | 129323 |
| Rate of Change | | 4% | -3% | -1% | -5% | -4% | -10% | -14% |
| LRF | 192 | 203 | 198 | 200 | 194 | 191 | 189 | 178 |
| Rate of Change | | 6% | -2% | 1% | -3% | -2% | -1% | -6% |
| MAI | 2.62 | 2.55 | 2.55 | 2.5 | 2.45 | 2.38 | 2.17 | 2 |
| Rate of Change | | -3% | 0% | -2% | -2% | -3% | -9% | -8% |
| Lumber (all) (bf/ha.) | 50260 | 51767 | 50484 | 54975 | 52223 | 49982 | 49246 | 42623 |
| Rate of Change | | 3% | -2% | 9% | -5% | -4% | -1% | -13% |
| Merch volume (m3/ha.) | 262 | 255 | 255 | 275 | 269 | 262 | 260 | 240 |
| Rate of Change | | -3% | 0% | 8% | -2% | -3% | -1% | -8% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 140 | 130 | 130 | 130 | 140 | 140 | 150 | 160 |
| low value | 92836 | 94855 | 92417 | 87582 | 83359 | 80574 | 71818 | 64156 |
| Rate of Change | | 2% | -3% | -5% | -5% | -3% | -11% | -11% |
| MAI | 2.51 | 2.52 | 2.51 | 2.45 | 2.36 | 2.29 | 2.07 | 1.89 |
| Rate of Change | | 0% | 0% | -2% | -4% | -3% | -10% | -9% |
| LRF | 210 | 216 | 213 | 209 | 206 | 206 | 204 | 199 |
| Rate of Change | | 3% | -1% | -2% | -1% | 0% | -1% | -2% |
| Lumber (all) | 73860 | 70645 | 69358 | 66462 | 68270 | 66208 | 63336 | 60194 |
| Rate of Change | | -4% | -2% | -4% | 3% | -3% | -4% | -5% |
| | | | | | | | | |
| Rotation Age | 130 | 130 | 130 | 130 | 130 | 130 | 140 | 150 |
| medium value | 145703 | 149210 | 145781 | 138716 | 132489 | 127931 | 114276 | 101931 |
| Rate of Change | | 2% | -2% | -5% | -4% | -3% | -11% | -11% |
| MAI | 2.55 | 2.52 | 2.51 | 2.45 | 2.39 | 2.32 | 2.11 | 1.93 |
| Rate of Change | | -1% | 0% | -2% | -2% | -3% | -9% | -9% |
| LRF | 208 | 216 | 213 | 209 | 206 | 205 | 202 | 196 |
| Rate of Change | | 4% | -1% | -2% | -1% | 0% | -1% | -3% |
| Lumber (all) | 68998 | 70645 | 69358 | 66462 | 63928 | 61875 | 59529 | 56738 |
| Rate of Change | | 2% | -2% | -4% | -4% | -3% | -4% | -5% |
| | | | | | | | | |
| Rotation Age | 130 | 130 | 130 | 130 | 130 | 130 | 140 | 150 |
| high value | 198789 | 203565 | 199145 | 189850 | 181674 | 175538 | 156806 | 139765 |
| Rate of Change | | 2% | -2% | -5% | -4% | -3% | -11% | -11% |
| LRF | 208 | 216 | 213 | 209 | 206 | 205 | 202 | 196 |
| Rate of Change | | 4% | -1% | -2% | -1% | 0% | -1% | -3% |
| MAI | 2.55 | 2.52 | 2.51 | 2.45 | 2.39 | 2.32 | 2.11 | 1.93 |
| Rate of Change | | -1% | 0% | -2% | -2% | -3% | -9% | -9% |
| Lumber (all) | 68998 | 70645 | 69358 | 66462 | 63928 | 61875 | 59529 | 56738 |
| Rate of Change | | 2% | -2% | -4% | -4% | -3% | -4% | -5% |

Table 29. Site Index 15 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 100 | 100 | 90 | 100 | 100 | 90 | 100 | 110 |
| low value | 79208 | 82527 | 75772 | 75373 | 70858 | 62173 | 57468 | 52285 |
| Rate of Change | | 4% | -8% | -1% | -6% | -12% | -8% | -9% |
| medium value | 125470 | 130535 | 120780 | 120048 | 113255 | 100006 | 92310 | 83877 |
| Rate of Change | | 4% | -7% | -1% | -6% | -12% | -8% | -9% |
| high value | 171732 | 178543 | 165789 | 164724 | 155653 | 137838 | 127153 | 115468 |
| Rate of Change | | 4% | -7% | -1% | -6% | -11% | -8% | -9% |
| LRF | 200 | 213 | 199 | 203 | 198 | 182 | 183 | 182 |
| Rate of Change | | 7% | -7% | 2% | -2% | -8% | 1% | -1% |
| MAI | 2.31 | 2.25 | 2.27 | 2.2 | 2.14 | 2.08 | 1.9 | 1.74 |
| Rate of Change | | -3% | 1% | -3% | -3% | -3% | -9% | -8% |
| Lumber (all) (bf/ha.) | 46253 | 47998 | 40497 | 44665 | 42389 | 34040 | 34833 | 34742 |
| Rate of Change | | 4% | -16% | 10% | -5% | -20% | 2% | 0% |
| Merch volume (m3/ha.) | 231 | 225 | 204 | 220 | 214 | 187 | 190 | 191 |
| Rate of Change | | -3% | -9% | 8% | -3% | -13% | 2% | 1% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 120 | 110 | 110 | 110 | 120 | 120 | 120 | 120 |
| low value | 82020 | 83584 | 81313 | 76977 | 73087 | 70460 | 62640 | 55674 |
| Rate of Change | | 2% | -3% | -5% | -5% | -4% | -11% | -11% |
| MAI | 2.21 | 2.22 | 2.2 | 2.16 | 2.06 | 2.01 | 1.84 | 1.67 |
| Rate of Change | | 0% | -1% | -2% | -5% | -2% | -8% | -9% |
| LRF | 211 | 216 | 214 | 208 | 208 | 206 | 202 | 197 |
| Rate of Change | | 2% | -1% | -3% | 0% | -1% | -2% | -2% |
| Lumber (all) | 55882 | 52769 | 51742 | 49543 | 51292 | 49627 | 44561 | 42658 |
| Rate of Change | | -6% | -2% | -4% | 4% | -3% | -10% | -4% |
| | | | | | | | | |
| Rotation Age | 120 | 110 | 110 | 110 | 110 | 110 | 120 | 130 |
| medium value | 128598 | 131566 | 128362 | 122026 | 116329 | 112098 | 99780 | 88496 |
| Rate of Change | | 2% | -2% | -5% | -5% | -4% | -11% | -11% |
| MAI | 2.21 | 2.22 | 2.2 | 2.16 | 2.11 | 2.05 | 1.84 | 1.67 |
| Rate of Change | | 0% | -1% | -2% | -2% | -3% | -10% | -9% |
| LRF | 211 | 216 | 214 | 208 | 205 | 203 | 202 | 197 |
| Rate of Change | | 2% | -1% | -3% | -1% | -1% | 0% | -2% |
| Lumber (all) | 55882 | 52769 | 51742 | 49543 | 47581 | 45966 | 44561 | 42658 |
| Rate of Change | | -6% | -2% | -4% | -4% | -3% | -3% | -4% |
| | | | | | | | | |
| Rotation Age | 120 | 110 | 110 | 110 | 110 | 110 | 120 | 130 |
| high value | 175176 | 179549 | 175411 | 167075 | 159593 | 153895 | 136921 | 121318 |
| Rate of Change | | 2% | -2% | -5% | -4% | -4% | -11% | -11% |
| LRF | 211 | 216 | 214 | 208 | 205 | 203 | 202 | 197 |
| Rate of Change | | 2% | -1% | -3% | -1% | -1% | 0% | -2% |
| MAI | 2.21 | 2.22 | 2.2 | 2.16 | 2.11 | 2.05 | 1.84 | 1.67 |
| Rate of Change | | 0% | -1% | -2% | -2% | -3% | -10% | -9% |
| Lumber (all) | 55882 | 52769 | 51742 | 49543 | 47581 | 45966 | 44561 | 42658 |
| Rate of Change | | -6% | -2% | -4% | -4% | -3% | -3% | -4% |

Table 30. Site Index 16 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 90 | 90 | 90 | 90 | 90 | 90 | 100 | 100 |
| low value | 91734 | 95242 | 92619 | 86914 | 81760 | 77939 | 71286 | 61180 |
| Rate of Change | | 4% | -3% | -6% | -6% | -5% | -9% | -14% |
| medium value | 145104 | 150474 | 146791 | 138349 | 130604 | 124611 | 113773 | 97947 |
| Rate of Change | | 4% | -2% | -6% | -6% | -5% | -9% | -14% |
| high value | 198473 | 205707 | 200962 | 189784 | 179449 | 171283 | 156260 | 134717 |
| Rate of Change | | 4% | -2% | -6% | -5% | -5% | -9% | -14% |
| LRF | 201 | 214 | 210 | 205 | 200 | 196 | 196 | 186 |
| Rate of Change | | 6% | -2% | -2% | -2% | -2% | 0% | -5% |
| MAI | 2.66 | 2.58 | 2.58 | 2.51 | 2.44 | 2.38 | 2.17 | 1.98 |
| Rate of Change | | -3% | 0% | -3% | -3% | -2% | -9% | -9% |
| Lumber (all) (bf/ha.) | 48022 | 49696 | 48743 | 46283 | 43951 | 41996 | 42476 | 36758 |
| Rate of Change | | 3% | -2% | -5% | -5% | -4% | 1% | -13% |
| Merch volume (m3/ha.) | 239 | 232 | 232 | 226 | 220 | 214 | 217 | 198 |
| Rate of Change | | -3% | 0% | -3% | -3% | -3% | 1% | -9% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 120 |
| low value | 96642 | 97913 | 95154 | 90020 | 85626 | 82563 | 73325 | 65414 |
| Rate of Change | | 1% | -3% | -5% | -5% | -4% | -11% | -11% |
| MAI | 2.55 | 2.52 | 2.5 | 2.45 | 2.39 | 2.33 | 2.13 | 1.91 |
| Rate of Change | | -1% | -1% | -2% | -2% | -3% | -9% | -10% |
| LRF | 214 | 219 | 217 | 212 | 208 | 207 | 203 | 201 |
| Rate of Change | | 2% | -1% | -2% | -2% | 0% | -2% | -1% |
| Lumber (all) | 59885 | 60747 | 59571 | 56947 | 54716 | 52938 | 47499 | 45937 |
| Rate of Change | | 1% | -2% | -4% | -4% | -3% | -10% | -3% |
| | | | | | | | | |
| Rotation Age | 110 | 100 | 100 | 110 | 110 | 110 | 110 | 120 |
| medium value | 151094 | 153217 | 149552 | 141799 | 135377 | 130699 | 116515 | 103704 |
| Rate of Change | | 1% | -2% | -5% | -5% | -3% | -11% | -11% |
| MAI | 2.55 | 2.58 | 2.56 | 2.45 | 2.39 | 2.33 | 2.13 | 1.91 |
| Rate of Change | | 1% | -1% | -4% | -2% | -3% | -9% | -10% |
| LRF | 214 | 216 | 213 | 212 | 208 | 207 | 203 | 201 |
| Rate of Change | | 1% | -1% | 0% | -2% | 0% | -2% | -1% |
| Lumber (all) | 59885 | 55695 | 54626 | 56947 | 54716 | 52938 | 47499 | 45937 |
| Rate of Change | | -7% | -2% | 4% | -4% | -3% | -10% | -3% |
| | | | | | | | | |
| Rotation Age | 110 | 100 | 100 | 100 | 100 | 110 | 110 | 120 |
| high value | 205546 | 208925 | 204190 | 193903 | 185145 | 178835 | 159705 | 141993 |
| Rate of Change | | 2% | -2% | -5% | -5% | -3% | -11% | -11% |
| LRF | 214 | 216 | 213 | 210 | 206 | 207 | 203 | 201 |
| Rate of Change | | 1% | -1% | -1% | -2% | 0% | -2% | -1% |
| MAI | 2.55 | 2.58 | 2.56 | 2.48 | 2.43 | 2.33 | 2.13 | 1.91 |
| Rate of Change | | 1% | -1% | -3% | -2% | -4% | -9% | -10% |
| Lumber (all) | 59885 | 55695 | 54626 | 52146 | 50050 | 52938 | 47499 | 45937 |
| Rate of Change | | -7% | -2% | -5% | -4% | 6% | -10% | -3% |

Table 31. Site Index 17 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 90 | 90 | 80 | 80 | 90 | 90 | 90 | 90 |
| low value | 109834 | 111858 | 104199 | 97595 | 97098 | 93338 | 81208 | 69398 |
| Rate of Change | | 2% | -7% | -6% | -1% | -4% | -13% | -15% |
| medium value | 172403 | 175634 | 165224 | 155396 | 154156 | 148411 | 129561 | 111063 |
| Rate of Change | | 2% | -6% | -6% | -1% | -4% | -13% | -14% |
| high value | 234971 | 239410 | 226249 | 213196 | 211214 | 203484 | 177914 | 152729 |
| Rate of Change | | 2% | -5% | -6% | -1% | -4% | -13% | -14% |
| LRF | 209 | 217 | 210 | 205 | 206 | 205 | 198 | 187 |
| Rate of Change | | 4% | -3% | -2% | 0% | 0% | -3% | -6% |
| MAI | 2.99 | 2.93 | 2.91 | 2.83 | 2.77 | 2.69 | 2.44 | 2.23 |
| Rate of Change | | -2% | -1% | -3% | -2% | -3% | -9% | -9% |
| Lumber (all) (bf/ha.) | 56299 | 57384 | 48809 | 46232 | 51341 | 49556 | 43508 | 37491 |
| Rate of Change | | 2% | -15% | -5% | 11% | -3% | -12% | -14% |
| Merch volume (m3/ha.) | 269 | 264 | 233 | 226 | 249 | 242 | 220 | 201 |
| Rate of Change | | -2% | -12% | -3% | 10% | -3% | -9% | -9% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 100 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| low value | 112180 | 114886 | 111390 | 104925 | 99141 | 95446 | 84931 | 75600 |
| Rate of Change | | 2% | -3% | -6% | -6% | -4% | -11% | -11% |
| MAI | 2.89 | 2.75 | 2.74 | 2.68 | 2.64 | 2.58 | 2.38 | 2.19 |
| Rate of Change | | -5% | 0% | -2% | -1% | -2% | -8% | -8% |
| LRF | 217 | 230 | 225 | 220 | 214 | 212 | 207 | 201 |
| Rate of Change | | 6% | -2% | -2% | -3% | -1% | -2% | -3% |
| Lumber (all) | 62774 | 69300 | 67805 | 64775 | 62062 | 60127 | 54118 | 48428 |
| Rate of Change | | 10% | -2% | -4% | -4% | -3% | -10% | -11% |
| | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 110 | 100 | 100 | 110 | 110 |
| medium value | 174967 | 177898 | 173137 | 163823 | 155983 | 150588 | 134138 | 119635 |
| Rate of Change | | 2% | -3% | -5% | -5% | -3% | -11% | -11% |
| MAI | 2.89 | 2.87 | 2.86 | 2.68 | 2.74 | 2.66 | 2.38 | 2.19 |
| Rate of Change | | -1% | 0% | -6% | 2% | -3% | -11% | -8% |
| LRF | 217 | 222 | 218 | 220 | 209 | 208 | 207 | 201 |
| Rate of Change | | 2% | -2% | 1% | -5% | 0% | 0% | -3% |
| Lumber (all) | 62774 | 63795 | 62459 | 64775 | 57171 | 55308 | 54118 | 48428 |
| Rate of Change | | 2% | -2% | 4% | -12% | -3% | -2% | -11% |
| | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 110 |
| high value | 237755 | 241707 | 235609 | 223493 | 213165 | 205907 | 183456 | 163669 |
| Rate of Change | | 2% | -3% | -5% | -5% | -3% | -11% | -11% |
| LRF | 217 | 222 | 218 | 213 | 209 | 208 | 205 | 201 |
| Rate of Change | | 2% | -2% | -2% | -2% | 0% | -1% | -2% |
| MAI | 2.89 | 2.87 | 2.86 | 2.8 | 2.74 | 2.66 | 2.42 | 2.19 |
| Rate of Change | | -1% | 0% | -2% | -2% | -3% | -9% | -10% |
| Lumber (all) | 62774 | 63795 | 62459 | 59660 | 57171 | 55308 | 49511 | 48428 |
| Rate of Change | | 2% | -2% | -4% | -4% | -3% | -10% | -2% |

Table 32. Site Index 18 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 80 | 80 | 80 | 80 | 80 | 80 | 90 | 90 |
| low value | 123308 | 125743 | 122134 | 118757 | 108639 | 104298 | 95612 | 84072 |
| Rate of Change | | 2% | -3% | -3% | -9% | -4% | -8% | -12% |
| medium value | 193651 | 197518 | 192393 | 186623 | 172608 | 165977 | 151649 | 133640 |
| Rate of Change | | 2% | -3% | -3% | -8% | -4% | -9% | -12% |
| high value | 263994 | 269294 | 262652 | 254489 | 236576 | 227655 | 207687 | 183208 |
| Rate of Change | | 2% | -2% | -3% | -7% | -4% | -9% | -12% |
| LRF | 210 | 218 | 213 | 214 | 206 | 205 | 203 | 197 |
| Rate of Change | | 4% | -2% | 0% | -4% | 0% | -1% | -3% |
| MAI | 3.35 | 3.3 | 3.3 | 3.18 | 3.11 | 3.01 | 2.76 | 2.52 |
| Rate of Change | | -1% | 0% | -4% | -2% | -3% | -8% | -9% |
| Lumber (all) (bf/ha.) | 56263 | 57407 | 56195 | 61068 | 51165 | 49333 | 50424 | 44601 |
| Rate of Change | | 2% | -2% | 9% | -16% | -4% | 2% | -12% |
| Merch volume (m3/ha.) | 268 | 264 | 264 | 286 | 249 | 241 | 248 | 227 |
| Rate of Change | | -1% | 0% | 8% | -13% | -3% | 3% | -8% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 110 | 100 | 100 | 100 | 100 | 110 | 110 | 110 |
| low value | 129441 | 132997 | 128800 | 121144 | 114395 | 110232 | 97386 | 86655 |
| Rate of Change | | 3% | -3% | -6% | -6% | -4% | -12% | -11% |
| MAI | 3.03 | 3.14 | 3.12 | 3.05 | 2.98 | 2.8 | 2.62 | 2.45 |
| Rate of Change | | 4% | -1% | -2% | -2% | -6% | -6% | -6% |
| LRF | 230 | 231 | 227 | 222 | 217 | 220 | 212 | 203 |
| Rate of Change | | 0% | -2% | -2% | -2% | 1% | -4% | -4% |
| Lumber (all) | 76410 | 72471 | 70833 | 67569 | 64690 | 67768 | 60971 | 54779 |
| Rate of Change | | -5% | -2% | -5% | -4% | 5% | -10% | -10% |
| | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| medium value | 200221 | 205482 | 199646 | 188726 | 179097 | 172716 | 153431 | 136686 |
| Rate of Change | | 3% | -3% | -5% | -5% | -4% | -11% | -11% |
| MAI | 3.17 | 3.14 | 3.12 | 3.05 | 2.98 | 2.93 | 2.71 | 2.5 |
| Rate of Change | | -1% | -1% | -2% | -2% | -2% | -8% | -8% |
| LRF | 224 | 231 | 227 | 222 | 217 | 214 | 207 | 201 |
| Rate of Change | | 3% | -2% | -2% | -2% | -1% | -3% | -3% |
| Lumber (all) | 70910 | 72471 | 70833 | 67569 | 64690 | 62633 | 56168 | 50209 |
| Rate of Change | | 2% | -2% | -5% | -4% | -3% | -10% | -11% |
| | | | | | | | | |
| Rotation Age | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| high value | 271503 | 277967 | 270493 | 256309 | 243799 | 235362 | 209611 | 186907 |
| Rate of Change | | 2% | -3% | -5% | -5% | -3% | -11% | -11% |
| LRF | 218 | 231 | 227 | 222 | 217 | 214 | 207 | 201 |
| Rate of Change | | 6% | -2% | -2% | -2% | -1% | -3% | -3% |
| MAI | 3.29 | 3.14 | 3.12 | 3.05 | 2.98 | 2.93 | 2.71 | 2.5 |
| Rate of Change | | -5% | -1% | -2% | -2% | -2% | -8% | -8% |
| Lumber (all) | 64437 | 72471 | 70833 | 67569 | 64690 | 62633 | 56168 | 50209 |
| Rate of Change | | 12% | -2% | -5% | -4% | -3% | -10% | -11% |

Table 33. Site Index 19 Value expressed in $/ha./yr.

| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
|---|---|---|---|---|---|---|---|---|
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 70 | 80 | 80 | 80 | 80 | 80 | 90 | 80 |
| low value | 134101 | 146549 | 141954 | 132600 | 125666 | 120838 | 109766 | 92123 |
| Rate of Change | | 9% | -3% | -7% | -5% | -4% | -9% | -16% |
| medium value | 211122 | 228441 | 222035 | 208601 | 198432 | 191063 | 173146 | 146615 |
| Rate of Change | | 8% | -3% | -6% | -5% | -4% | -9% | -15% |
| high value | 288142 | 310333 | 302116 | 284601 | 271198 | 261289 | 236526 | 201108 |
| Rate of Change | | 8% | -3% | -6% | -5% | -4% | -9% | -15% |
| LRF | 207 | 223 | 219 | 213 | 209 | 207 | 207 | 195 |
| Rate of Change | | 8% | -2% | -3% | -2% | -1% | 0% | -6% |
| MAI | 3.71 | 3.67 | 3.66 | 3.56 | 3.49 | 3.39 | 3.07 | 2.79 |
| Rate of Change | | -1% | 0% | -3% | -2% | -3% | -9% | -9% |
| Lumber (all) (bf/ha.) | 53903 | 65500 | 64052 | 60789 | 58202 | 56168 | 57031 | 43584 |
| Rate of Change | | 22% | -2% | -5% | -4% | -3% | 2% | -24% |
| Merch volume (m3/ha.) | 260 | 294 | 293 | 285 | 279 | 271 | 276 | 223 |
| Rate of Change | | 13% | 0% | -3% | -2% | -3% | 2% | -19% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 110 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| low value | 150148 | 153371 | 148421 | 139009 | 131245 | 126330 | 111315 | 98473 |
| Rate of Change | | 2% | -3% | -6% | -6% | -4% | -12% | -12% |
| MAI | 3.29 | 3.38 | 3.38 | 3.3 | 3.23 | 3.17 | 2.96 | 2.78 |
| Rate of Change | | 3% | 0% | -2% | -2% | -2% | -7% | -6% |
| LRF | 237 | 240 | 235 | 230 | 225 | 222 | 213 | 203 |
| Rate of Change | | 1% | -2% | -2% | -2% | -1% | -4% | -5% |
| Lumber (all) | 85684 | 81092 | 79348 | 75724 | 72602 | 70281 | 63081 | 56482 |
| Rate of Change | | -5% | -2% | -5% | -4% | -3% | -10% | -10% |
| | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| medium value | 229685 | 234478 | 227784 | 214746 | 203860 | 196626 | 174408 | 154966 |
| Rate of Change | | 2% | -3% | -6% | -5% | -4% | -11% | -11% |
| MAI | 3.43 | 3.38 | 3.38 | 3.3 | 3.23 | 3.17 | 2.96 | 2.78 |
| Rate of Change | | -1% | 0% | -2% | -2% | -2% | -7% | -6% |
| LRF | 232 | 240 | 235 | 230 | 225 | 222 | 213 | 203 |
| Rate of Change | | 3% | -2% | -2% | -2% | -1% | -4% | -5% |
| Lumber (all) | 79703 | 81092 | 79348 | 75724 | 72602 | 70281 | 63081 | 56482 |
| Rate of Change | | 2% | -2% | -5% | -4% | -3% | -10% | -10% |
| | | | | | | | | |
| Rotation Age | 100 | 90 | 90 | 90 | 90 | 100 | 100 | 100 |
| high value | 309403 | 316900 | 308420 | 291176 | 276783 | 266921 | 237502 | 211460 |
| Rate of Change | | 2% | -3% | -6% | -5% | -4% | -11% | -11% |
| LRF | 232 | 233 | 228 | 222 | 217 | 222 | 213 | 203 |
| Rate of Change | | 0% | -2% | -3% | -2% | 2% | -4% | -5% |
| MAI | 3.43 | 3.54 | 3.54 | 3.46 | 3.38 | 3.17 | 2.96 | 2.78 |
| Rate of Change | | 3% | 0% | -2% | -2% | -6% | -7% | -6% |
| Lumber (all) | 79703 | 74272 | 72603 | 69021 | 66040 | 70281 | 63081 | 56482 |
| Rate of Change | | -7% | -2% | -5% | -4% | 6% | -10% | -10% |

| Table 34. Site Index 20 | Value expressed in $/ha./yr. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Initial Density | 5000 | 10000 | 20000 | 30000 | 40000 | 50000 | 100000 | 200000 |
| **Culmination of MAI** | | | | | | | | |
| Rotation Age | 70 | 70 | 70 | 70 | 70 | 80 | 80 | 90 |
| low value | 157341 | 159284 | 154359 | 145130 | 136966 | 138999 | 121623 | 110586 |
| Rate of Change | | 1% | -3% | -6% | -6% | 1% | -13% | -9% |
| medium value | 246114 | 249302 | 242360 | 228772 | 216787 | 218278 | 192038 | 174031 |
| Rate of Change | | 1% | -3% | -6% | -5% | 1% | -12% | -9% |
| high value | 334888 | 339319 | 330361 | 312414 | 296608 | 297556 | 262454 | 237476 |
| Rate of Change | | 1% | -3% | -5% | -5% | 0% | -12% | -10% |
| LRF | 214 | 220 | 215 | 212 | 208 | 213 | 206 | 204 |
| Rate of Change | | 3% | -2% | -1% | -2% | 2% | -3% | -1% |
| MAI | 4.16 | 4.09 | 4.09 | 3.94 | 3.84 | 3.72 | 3.42 | 3.11 |
| Rate of Change | | -2% | 0% | -4% | -3% | -3% | -8% | -9% |
| Lumber (all) (bf/ha.) | 62128 | 62998 | 61588 | 58537 | 55864 | 63411 | 56322 | 57089 |
| Rate of Change | | 1% | -2% | -5% | -5% | 14% | -11% | 1% |
| Merch volume (m3/ha.) | 291 | 286 | 286 | 276 | 269 | 298 | 274 | 280 |
| Rate of Change | | -2% | 0% | -3% | -3% | 11% | -8% | 2% |
| | | | | | | | | |
| **Culmination of MALV** | | | | | | | | |
| Rotation Age | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| low value | 173062 | 175088 | 169336 | 158947 | 149803 | 144067 | 126514 | 111705 |
| Rate of Change | | 1% | -3% | -6% | -6% | -4% | -12% | -12% |
| MAI | 3.74 | 3.67 | 3.67 | 3.55 | 3.48 | 3.4 | 3.18 | 2.99 |
| Rate of Change | | -2% | 0% | -3% | -2% | -2% | -6% | -6% |
| LRF | 238 | 245 | 240 | 237 | 231 | 230 | 221 | 211 |
| Rate of Change | | 3% | -2% | -1% | -3% | 0% | -4% | -5% |
| Lumber (all) | 89115 | 89957 | 87980 | 84032 | 80536 | 78100 | 70341 | 63051 |
| Rate of Change | | 1% | -2% | -4% | -4% | -3% | -10% | -10% |
| | | | | | | | | |
| Rotation Age | 100 | 90 | 90 | 90 | 90 | 90 | 100 | 100 |
| medium value | 262192 | 266971 | 259083 | 244109 | 231086 | 222696 | 196868 | 174770 |
| Rate of Change | | 2% | -3% | -6% | -5% | -4% | -12% | -11% |
| MAI | 3.74 | 3.86 | 3.82 | 3.73 | 3.67 | 3.58 | 3.18 | 2.99 |
| Rate of Change | | 3% | -1% | -2% | -2% | -2% | -11% | -6% |
| LRF | 238 | 239 | 236 | 230 | 224 | 222 | 221 | 211 |
| Rate of Change | | 0% | -1% | -3% | -3% | -1% | 0% | -5% |
| Lumber (all) | 89115 | 82919 | 81068 | 77321 | 74000 | 71582 | 70341 | 63051 |
| Rate of Change | | -7% | -2% | -5% | -4% | -3% | -2% | -10% |
| | | | | | | | | |
| Rotation Age | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 100 |
| high value | 352448 | 359121 | 349174 | 330036 | 313323 | 302247 | 267518 | 237834 |
| Rate of Change | | 2% | -3% | -5% | -5% | -4% | -11% | -11% |
| LRF | 233 | 239 | 236 | 230 | 224 | 222 | 213 | 211 |
| Rate of Change | | 3% | -1% | -3% | -3% | -1% | -4% | -1% |
| MAI | 3.89 | 3.86 | 3.82 | 3.73 | 3.67 | 3.58 | 3.33 | 2.99 |
| Rate of Change | | -1% | -1% | -2% | -2% | -2% | -7% | -10% |
| Lumber (all) | 81571 | 82919 | 81068 | 77321 | 74000 | 71582 | 63937 | 63051 |
| Rate of Change | | 2% | -2% | -5% | -4% | -3% | -11% | -1% |

# 10 Results and Discussion

## 10.1 Pilot Area (Woodstock Model)

The intent of scenario development and analysis using the Pilot area approach was to provide context and perspective on potential outcomes at the forest estate level. Outcomes include maximum even flow harvest level, silviculture costs and product outturns. Use of the Woodstock model allowed measurement of the outcomes while use of the representative Pilot area was adopted to minimize modeling costs.

The tables below summarize the results for the scenarios analyzed, during the sixth and tenth decades, and for all twenty-five decades cumulatively. Please refer to Appendix S for the detailed data and output from the Woodstock model. Decision-makers may want to review the various decades for interest's sake; however, the comparative results between scenarios are the most relevant for decision-making. Summations for any given decade are also available, although they are not included in this report. Results for decade six are presented as this is when significant areas of managed stands come on stream in the harvest cue. By decade ten the majority of harvest is streaming from managed stands.

**Table 36: Pilot Area Analysis Results for the Sixth Decade**

| Scenario | Maximum Even-flow Harvest Level ($m^3$) | Silviculture Cost $/ha. | Narrow Lumber % | Medium Lumber % | Wide Lumber % |
|---|---|---|---|---|---|
| 1 | 6,405,513 | | 90.6 | 2.5 | 6.9 |
| Cost | $3.50 / $m^3$ MEHL | $641 / ha. | | | |
| 2 | 6,250,455 | | 89.9 | 2.7 | 7.4 |
| Cost | $3.52 / $m^3$ MEHL | $644 / ha. | | | |
| 3 | 5,933,605 | | 97.7 | 0.7 | 1.6 |
| Cost | $1.59 / $m^3$ MEHL | $289 / ha. | | | |
| 4a | 6,184,669 | | 91.7 | 2.3 | 6.1 |
| Cost | $2.22 / $m^3$ MEHL | $385 / ha. | | | |
| 4b | 6,249,563 | | 91.3 | 2.4 | 6.4 |
| Cost | $2.15 / $m^3$ MEHL | $381 / ha. | | | |
| 5 | 6,129,570 | | 91.4 | 2.4 | 6.2 |
| Cost | $2.28 / $m^3$ MEHL | $398 / ha. | | | |

## Table 37: Analysis Results for the Tenth Decade

| Scenario | Maximum Even-flow Harvest Level ($m^3$) | Silviculture Cost $/ha. | Narrow Lumber % | Medium Lumber % | Wide Lumber % |
|---|---|---|---|---|---|
| 1 | 6,405,513 | | 86.0 | 3.6 | 10.4 |
| Cost | $3.99 / $m^3$ MEHL | $1,288 / ha. | | | |
| 2 | 6,250,455 | | 85.7 | 3.6 | 10.7 |
| Cost | $3.89 / $m^3$ MEHL | $1,166 / ha. | | | |
| 3 | 5,933,605 | | 78.0 | 3.6 | 18.3 |
| Cost | $2.79 / $m^3$ MEHL | $700 / ha. | | | |
| 4a | 6,184,669 | | 85.2 | 3.7 | 11.1 |
| Cost | $2.95 / $m^3$ MEHL | $849 / ha. | | | |
| 4b | 6,249,563 | | 86.0 | 3.6 | 10.4 |
| Cost | $3.28 / $m^3$ MEHL | $986 / ha. | | | |
| 5 | 6,129,570 | | 86.0 | 3.6 | 10.4 |
| | $3.48 / $m^3$ MEHL | $1,037 / ha. | | | |

## Table 38: Analysis Results for All Decades (Cumulatively)

| Scenario | Maximum Even-flow Harvest Level ($m^3$) | Silviculture Cost $/ha. | Narrow Lumber % | Medium Lumber % | Wide Lumber % |
|---|---|---|---|---|---|
| 1 | 6,405,513 | | 91.6 | 2.3 | 6.1 |
| Cost | $4.90 / $m^3$ MEHL | $980 / ha. | | | |
| 2 | 6,250,455 | | 91.8 | 2.2 | 5.9 |
| Cost | $4.85 / $m^3$ MEHL | $1,023 / ha. | | | |
| 3 | 5,933,605 | | 85.7 | 2.8 | 11.6 |
| Cost | $2.92 / $m^3$ MEHL | $559 / ha. | | | |
| 4 | 6,184,669 | | 91.9 | 2.2 | 5.9 |
| Cost | $3.40 / $m^3$ MEHL | $660 / ha. | | | |
| 4b | 6,249,563 | | 92.2 | 2.2 | 5.6 |
| Cost | $3.59 / $m^3$ MEHL | $699 / ha. | | | |
| 5 | 6,129,570 | | 92.0 | 2.2 | 5.8 |
| Cost | $3.81 / $m^3$ MEHL | $736 / ha. | | | |

### 10.1.1 Harvest Flow Implications

Scenario 1 yields the greatest Maximum Even-flow Harvest Level (MEHL), while the Minimum Cost scenario yields the lowest MEHL. Scenario 2 was judged to most accurately represent the harvest level outcome of the TSA over the short time (excluding MPB uplifts). Therefore, scenario 4b used the scenario 2 harvest level as a target to ascertain which silvicultural treatments were deemed necessary to recapture the harvest lost to reduced silviculture in scenarios 3 and 4a. Scenario 5 indicates a 2% reduction in harvest flow compared to scenario 4b. This is attributable to the revised pine density regimes. Refer to the FSSIM results in section 10.2 for further discussion on the reduced harvest level. The Woodstock modeling was utilized to gain insight into potential. The FSSIM runs were designed to test the impact of revised pine density regimes against the currently accepted management practices and assumptions as documented in the TSR 2 process and accepted by the Chief Forester.

### 10.1.2 Silviculture Cost Implications

The Status Quo (Scenario 1) results in the greatest incurred costs. As expected the Minimum Cost (Scenario 3) results in the lowest costs for all three periods. Scenarios 4a and 4b are intermediate in their cost implications. An exception is Scenario 2 which incurs slightly higher costs per hectare than the Status Quo scenario. This is to be expected as the minimum harvest volume in this scenario was raised to 100 $m^3$/ha. Scenario 5 incurs slightly higher silviculture cost structure than scenario 4b, primarily due to regimes for non-pine stands being adjusted to more accurately represent actual practice in conjunction with natural pine regeneration moving to revised assumed densities. Therefore, costs between the scenarios are not directly comparable but are relatively comparable.

### 10.1.3 Lumber Implications

The Minimum Cost scenario yields a significantly larger percentage of wide lumber in its lumber yield profile in the tenth decade and cumulative runs, owing to its wider spaced stands. Overall fluctuations in lumber output are minimal. However, scenario 3 does illustrate that silviculture has an impact on volume but may a have mimimal or adverse affect on lumber output. This scenario raises questions as to the quality of that wider lumber (faster grown and more open grown trees yielding weaker wood, and failing to meet in grade strength properties – refer to Appendix M,). When density treatments are eliminated in lower site index naturally regenerated pine stands there is insignificant affect, at the estate level, on product profiles.

### 10.1.4 Value per Management Dollar Expended

Scenario 3 provides the greatest benefit per dollar expended. However, if this option is not acceptable to decision-makers on Crown land, then the intermediate management regimes, as illustrated by Scenarios 4a and 4b, provide much of the cost benefit of Scenario 3 (66% and 76% of that of Scenario 3), and virtually the same wide lumber percentages, but with very little MEHL downside.

## 10.2 TSA Level

The impact of revised stand density regimes for natural pine regeneration, as documented in Appendix R under Development Types 42, 45, 53 and 54, on AAC was tested using the FSSIM model and replicates all other assumptions as documented in the TSR 2 process. Results, by TSA, are presented in tabular format in the following four sections.

## 10.2.1 100 Mile TSA (FSSIM Model), Scenario 5

Table 39.
Harvest flow in the 100 Mile House TSA
(Scenario 5 assumptions for Pl regeneration regimes)

| Period (Decade) | TSR II Basecase | After PL density modified | Changes | |
|---|---|---|---|---|
| | Harvest volume (m3/year)* | Harvest volume (m3/year)* | Volume change (m3/year)* | % change |
| 1 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 2 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 3 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 4 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 5 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 6 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 7 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 8 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 9 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 10 | 1,335,000 | 1,335,000 | 0 | 0.00% |
| 11 | 1,209,000 | 1,209,000 | 0 | 0.00% |
| 12 | 1,209,000 | 1,200,000 | -9,000 | -0.74% |
| 13 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 14 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 15 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 16 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 17 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 18 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 19 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 20 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 21 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 22 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 23 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 24 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |
| 25 | 1,154,000 | 1,141,000 | -13,000 | -1.13% |

* Round to thousand ('000)

## 10.2.2 Williams Lake TSA, Main (FSSIM Model), Scenario 5

Table 40.
Harvest flow in the Williams Lake, Main TSA
(Scenario 5 assumptions for Pl regeneration regimes)

| Period (Decade) | TSR II Basecase | After PL density modified | Changes | |
|---|---|---|---|---|
| | Harvest volume (m3/year)* | Harvest volume (m3/year)* | Volume change (m3/year)* | % change |
| 1 | 2,780,000 | 2,780,000 | 0 | 0.00% |
| 2 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 3 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 4 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 5 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 6 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 7 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 8 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 9 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 10 | 2,458,000 | 2,458,000 | 0 | 0.00% |
| 11 | 2,458,000 | 2,468,000 | 15,000 | 0.61% |
| 12 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 13 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 14 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 15 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 16 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 17 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 18 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 19 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 20 | 2,458,000 | 2,468,000 | 15,000 | 0.59% |
| 21 | 2,458,000 | 2,468,000 | 15,000 | 0.59% |
| 22 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 23 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 24 | 2,458,000 | 2,467,000 | 15,000 | 0.59% |
| 25 | 2,458,000 | 2,467,000 | 15,000 | 0.61% |

* Round to thousand ('000)

### 10.2.3 Williams Lake TSA, Western Supply Blocks (FSSIM Model), Scenario 5

Table 41.
Harvest flow in the Williams Lake, Western Supply Blocks TSA
(Scenario 5 assumptions for Pl regeneration regimes)

| Period (Decade) | TSR II Basecase | After PL density modified | Changes | |
|---|---|---|---|---|
| | Harvest volume (m3/year)* | Harvest volume (m3/year)* | Volume change (m3/year)* | % change |
| 1 | 672,500 | 672,500 | 0 | 0.00% |
| 2 | 564,000 | 564,000 | 0 | 0.00% |
| 3 | 564,000 | 564,000 | 0 | 0.00% |
| 4 | 564,000 | 564,000 | 0 | 0.00% |
| 5 | 564,000 | 564,000 | 0 | 0.00% |
| 6 | 564,000 | 564,000 | 0 | 0.00% |
| 7 | 564,000 | 564,000 | 0 | 0.00% |
| 8 | 564,000 | 564,000 | 0 | 0.00% |
| 9 | 564,000 | 564,000 | 0 | 0.00% |
| 10 | 564,000 | 564,000 | 0 | 0.00% |
| 11 | 564,000 | 568,000 | 4,000 | 0.71% |
| 12 | 564,000 | 568,000 | 4,000 | 0.71% |
| 13 | 564,000 | 568,000 | 4,000 | 0.71% |
| 14 | 564,000 | 568,000 | 4,000 | 0.71% |
| 15 | 564,000 | 568,000 | 4,000 | 0.71% |
| 16 | 564,000 | 568,000 | 4,000 | 0.71% |
| 17 | 564,000 | 568,000 | 4,000 | 0.71% |
| 18 | 564,000 | 568,000 | 4,000 | 0.71% |
| 19 | 564,000 | 568,000 | 4,000 | 0.71% |
| 20 | 564,000 | 568,000 | 4,000 | 0.71% |
| 21 | 564,000 | 568,000 | 4,000 | 0.71% |
| 22 | 564,000 | 568,000 | 4,000 | 0.71% |
| 23 | 564,000 | 568,000 | 4,000 | 0.71% |
| 24 | 564,000 | 568,000 | 4,000 | 0.71% |
| 25 | 564,000 | 568,000 | 4,000 | 0.71% |

* Round to thousand ('000)

### 10.2.4 Quesnel TSA (FSSIM Model), Scenario 5

Table 42.
Harvest flow in the Quesnel TSA
(Scenario 5 assumptions for Pl regeneration regimes)

| Period (Decade) | TSR II Basecase | After PL density modified | Changes | |
|---|---|---|---|---|
| | Harvest volume (m3/year)* | Harvest volume (m3/year)* | Volume change (m3/year)* | % change |
| 1 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 2 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 3 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 4 | 2,340,000 | 2,340,000 | 0 | 0.00% |
| 5 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 6 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 7 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 8 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 9 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 10 | 2,339,000 | 2,339,000 | 0 | 0.00% |
| 11 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 12 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 13 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 14 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 15 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 16 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 17 | 2,339,000 | 2,348,000 | 14,000 | 0.60% |
| 18 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 19 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 20 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 21 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 22 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 23 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 24 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |
| 25 | 2,119,000 | 2,127,000 | 13,000 | 0.61% |

* Round to thousand ('000)

Tables 39, 40, 41 and 42 indicate that the impact to the TSR 2 base case AAC (pre MPB uplift) of revising pine density strategies is almost inconsequential. The effect on AAC is non-existent for 100 years or more in each TSA before a very slight decline of about one percent is imposed.

# 11 Conclusions

The current regulatory driven maximum density rule of 10,000 stems per hectare is unwarranted for application in the 100 Mile House, Williams Lake and Quesnel TSA's in post harvest naturally regenerated pine stands. Implementation of the revised density regimes as modeled in this report achieves the multiple objectives identified. These objectives include:

- maintaining the TSR 2 AAC levels
- achieving the Desired Future Forest product profile targets
- accounting for potential adverse biotic factors (disease, insects, competing vegetation)
- accounting for management of non-timber values
- achieving the above objectives while minimizing silvicultural investment
- fairly balancing risk and uncertainty to the crown and licensees

In spite of the complex analytical approach involved in this project, determination of appropriate density numbers was ascertained from professional judgment based on analysis and knowledge of the compiled documents and modeling reports. The decision tools (TIPSY, Woodstock, FSSIM) employed were very useful but were inadequate to support reaching a conclusion as to the appropriate densities.

# 12 Recommendations

In conjunction with the TIPSY output for ranked factors expressed in the MAI and MAVL tables and assessing TIPSY output for non-timber values, knowledge of the impact to the AAC by TSA, estate modeling conducted in the Pilot area, reviewing documents in the appendices and the literature index and reviewing the principles of stand density management dynamics; a first approximation of a range of recommended acceptable densities by Site Index was determined as summarized in Table 35. It is proposed that the Recommended Acceptable Densities apply to post harvest naturally regenerated pine stands in the 100 Mile House, Williams Lake and Quesnel TSA's and be implemented across a range of site indices.

It is felt that, on average, the selected densities adequately and fairly balance the long term (through rotation) obligatory risk of the crown and licensees short term (approximately up to 15 years) obligatory risk in these stands. Elements and measures of risk are discussed in a Research Branch report contained in Appendix Y.

## 12.1 Recommended Stand Density Regimes

Table 35

| Natural Regen. Pine Stands Site Index | TIPSY Initial Density | TIPSY Density @ 15 Years | **Recommended Acceptable Density @ 15 Years (total trees)** | Current MOF Maximum Density (countable trees) | 2002 Sterling Wood Group Report[19], Recommended Acceptable Density @ 15 Years |
|---|---|---|---|---|---|
| 7 | 30000 | 27297 | 25000 | 10000 | 25000 |
| 8 | 30000 | 27010 | 25000 | 10000 | 25000 |
| 9 | 30000 | 26668 | 25000 | 10000 | 25000 |
| 10 | 30000 | 26280 | 25000 | 10000 | 25000 |
| 11 | 30000 | 25915 | 25000 | 10000 | 25000 |
| 12 | 30000 | 25539 | 25000 | 10000 | 25000 |
| 13 | 30000 | 25134 | 25000 | 10000 | 25000 |
| 14 | 30000 | 24710 | 25000 | 10000 | 25000 |
| 15 | 20000 | 16595 | 15000 | 10000 | 16000 |
| 16 | 20000 | 16314 | 15000 | 10000 | 16000 |
| 17 | 10000 | 8896 | 10000 | 10000 | 16000 |
| 18 | 10000 | 8830 | 10000 | 10000 | 16000 |
| 19 | 10000 | 8755 | 10000 | 10000 | 16000 |
| 20+ | 10000 | 8672 | 10000 | 10000 | 11000 |

[19] Sterling Wood Group recommendations included to provide context as they were based on biological response theories and assessment of TIPSY output

## 12.2 Recommended Implementation

- Consider implementing the recommended acceptable density regimes for post harvest naturally regenerated pine stands. A process to review the results and make further recommendations on the selected numbers should be considered using formal Decision Analysis or Multi Criteria Analysis[20] techniques involving agency and licensee stakeholders.

- Stands that exceed the acceptable density should be spaced unless there are specific site issues that are apparent such as biotic risk factors or concern over meeting product objectives. In such cases, silviculturists should employ the economic component of TIPSY as part of the determination process for the Forest Stewardship Plan to assess the viability of thinning and other treatment regimes. A range of financial values, similar to Table 7 in this report, should be used in the assessment to consider risk around future pricing and other uncertainties.

- Monitoring protocols should move away from the individual cut block level to a broader level such as licensee, operating area, district or a series of contiguous landscape units. However, objectives must be set for the selected unit(s) prior to designing a monitoring scheme. Desired Future Forest objectives could be set under Forest Stewardship Plans.

- Stand density control objectives may result in conflict as timber optimization may or may not suggest thinning but habitat management may suggest encouragement of clumps or open stands. A timber/habitat stand density plan should be managed at the management unit level, as discussed above. For example, a Landscape Unit plan may recommend thinning be applied to small portions of certain cut blocks and encourage development of “clumps” in portions of the same block within the unit.

- Since the procedure for measuring countable height directly effects prescriptions, costs and stand outcomes; localized countable height guidelines and procedures for specific stand types must be developed for agency approval and implementation. During the 2005 field season various countable height methods should be tested and tracked by site series, age, site index, etc. Results from this assessment can be used to determine countable height procedures recommended by stand class. This process should be developed in conjunction with the Forest Practices Branch.

[20] See Appendix U for further information on MCA

# 13 List of Appendices

App. A: Chief Forester Policy on Stand Density Management

App. B: ILMA's RFP for Stand Density

App. C: Juvenile Spacing, Stand Volume, Piece Size & Value; MOF Research Br. 2001

App. D: MOF Staff response to App. 3

App. E: Summary of Cariboo Major Licensee Maximum Density Obligation, 2001

App. F: Maximum Density and Countable Heights, Sterling-Wood Group, 2002 (report for ILMA)

App. G: Research Branch Review of Maximum Density and Countable Heights, Sterling-Wood Group, 2002

App. H: CLMA Request Sanctioning Proposed Process to Regional Manager, 2002

App. I: Maximum Density Survey Results and Presentation, 2002

App. J: Structure of Cariboo Stand Density Management Advisory Committee, 2002

App. K: Regional Manager Letter of Support to Committee, 2002

App. L: Chief Forester Draft Transitional Stocking Requirements, 2002

App. M: Stand Density Management Economic Background Report, 2003

App. N: Economics of Pre-Commercial and Commercial Thinning, Economics & Trade Branch

App. O: Pilot Area Description

App. P: Pilot Area, Woodstock Data Base Structure

App. Q: Williams Lake TSA TSR 2 Data Package, 1999

App. R: Pilot Area Development Type Assumptions

App. S: Pilot Area, Woodstock Output

App. T: Yield Curves

App. U: Multi-Criteria Analysis Description

App. V: Trade Policy and Lumber Prices

App. W: SEDA

App. X: Perspectives on the Forest Industry, R. Carter, 2003

App. Y: Effect of Silviculture Survey Parameters on the Free-Growing Decision Probabilities and Projected Volume at Rotation

App. Z: Silviculture Guidelines and Practices for Maintaining or Recruiting Key Habitat Objectives