Management Options for Balsam Intermediate Utilization Stands on TFL 52

Prepared for

West Fraser Mills Ltd.
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Executive Summary

Approximately 11,000 ha of TFL 52 are currently classified as Balsam IU stands. These stands are the legacy of partial cutting to Intermediate Utilization standards that took place in the spruce-subalpine fir forests during the1950s and 1960s. The Balsam IU name reflects the treatment history and the fact that most of the residual trees were subalpine fir.

The stocking and quality of the Balsam IU stands have been a concern for over thirty years. The yields predicted for Balsam IU stands in timber supply analysis reflect the widely held assumption that these stands have lower than average stocking and reduced growth. The Chief Forester of BC has instructed West Fraser to develop treatment options, determine yield implications and submit a treatment plan as part of the 5-year silviculture plan. Starting in 1995, a large number of sample plots were established on TFL 52 to collect the basic data needed to evaluate potential treatment options. This report documents the analysis and interpretation of those data.

A classification of stand structure was developed to assess the current stocking and growth potential of Balsam IU stands. The main conclusions of the analysis are:

- 47% of the area is clearly well stocked, has good growth potential and requires no further treatment.
- 22% of the area has at least minimum stocking and probably requires no further treatment.
- 20% of the area appears to have poor stocking and may require treatment. Additional field checks are needed to confirm the status of these stands.
- 8% of the area has enough merchantable volume to be harvested now.
- 3% of the area has broadleaf stands composed of birch, aspen and cottonwood. These stands may have more value for wildlife habitat and biodiversity than for timber.

Overall, only about 20% of the area may potentially require any treatment.

The lack of information on current and past growth rates is a major limitation of the data assembled for this study. Additional data collection may be needed to provide credible evidence that many of these stands are growing faster than the predictions currently used in timber supply analysis.

Mary Lester, Craig Mistal and Earl Spielman on the edge of a Balsam IU stand [Type F7] in the Willow geographic area.

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 HISTORICAL BACKGROUND

In the 1950s and 1960s, a considerable portion of the spruce-subalpine fir forests in the Kamloops, Cariboo and Prince George forest regions were partially cut to intermediate utilization standards. These areas became known as "Balsam IU" stands, reflecting the treatment history and the fact that most of the residual trees were subalpine fir. Diameter-limit and seed block cuttings removed mature spruce and left stands that were highly variable in the density, size distribution and spatial arrangement of trees. The network of skid trails also contributed to the spatial heterogeneity (Fraser, 1977).

In the 1970s, forest managers became concerned about the stocking and quality of the Balsam IU stands. A number of studies (Gasson, 1976; Ivanco, 1976; Herring, 1977) examined the quality and growth potential of the large residuals and the small advance regeneration in some limited areas. They found that many of the largest residuals[1] had sustained damage in the logging operations and were generally of poor quality. The small advance regeneration[2] was usually in good condition and showed signs of growth release following logging. It was also noted that new regeneration of subalpine fir, white spruce, lodgepole pine, Douglas-fir and paper birch had become established since logging (Herring and McMinn, 1980; Ivanco, 1976; Fraser, 1977).

This information was used to develop a survey for the Balsam IU stands (McNaughton and Fraser, 1978). Treatment options—summarized by Herring and Vyse (1977)—included fill-planting, spacing, brushing, and complete rehabilitation by logging and planting. The surveys, however, were never implemented on the large scale originally envisioned. As a result, very few of the Balsam IU stands were treated.

1.2 PROJECT BACKGROUND

There are approximately 11,000 ha of Balsam IU stands within TFL 52. In Management Plan No. 2, West Fraser made a commitment to apply appropriate treatments to these stands. The Chief Forester of BC accepted that commitment and required West Fraser to develop treatment options, determine yield implications and "submit a treatment plan for approval as part of its 5-year silviculture plan" (Ministry of Forests, 1996). Starting in 1995, a large number of sample plots were established in the Balsam IU stands on TFL 52 to collect the basic data needed to evaluate potential treatment options. In 1999, J.S. Thrower and Associates were contracted to analyze the data, develop decision criteria for alternative treatment options, and classify Balsam IU stands with respect to stand structure and associated treatment options.

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1 Trees larger than 15 cm stump diameter.
2 Less than 3 m tall.

1.3 Project Overview and Objectives

The project was conducted in phases outlined below:

1. Several of the Balsam IU stands were visited in a preliminary field reconnaissance before commencement of any analysis.
2. Data collected by the different sampling contractors was assembled, edited, linked and compiled. An earlier report (J.S. Thrower and Associates, 2000) documented the editing and linking of the data sets.
3. A stand structure classification scheme was developed and used to design decision diagrams for assigning treatment options.
4. Field visits were made to selected stands in each of the major stand structure categories to assess the accuracy and applicability of the stand structure classification. Following the field trip, we made minor revisions to the benchmarks that separate the stand structure categories.
5. Decision diagrams and silvicultural interpretations were revised to reflect changes to the stand structure classification, and the final report was prepared.

1.4 Terms of Reference

J.S. Thrower and Associates were contracted to edit, link and analyze the survey data, develop feasible treatment options, and classify Balsam IU stands with respect to those treatment options. This report documents the development of the stand structure classification and decision diagrams. The J.S.Thrower project team for these phases of the project was composed of Ian Cameron, MF, R.P.F., Mary Lester, R.P.F. and Craig Mistal, MPM. The coordinator for West Fraser was Earl Spielman, R.P.F.

2. DATA

2.1 Overview

All inventory polygons designated as Balsam IU types in TFL 52 were identified and selected for sampling. The areas covered by the Balsam IU polygons were then divided into 15 survey units. Contracts for field sampling were awarded to three contractors: Timberline Forest Inventory Consultants (TFIC), Keen Forestry (KEEN) and CIMCO. Survey units were subsequently aggregated into nine geographic areas (Table 1). Field sampling started in 1995 and continued through 1998.

All plot locations were determined systematically, but data collection methods varied between contractors and from year to year. Two concentric plots were established at each sample location: one for measurement of large trees and one for small trees. The large-tree plots were either a 0.01 ha fixed-radius plot or a variable-radius (prism) plot. There were also two plot designs for sampling small trees. If the large tree plot was a fixed-area plot, then the small tree plot was also a fixed radius plot (0.001 ha—0.005 ha). Surveyors measured all trees that were taller than 1.3 m but less than the minimum DBH of the associated large-tree plot. Alternatively, if the large tree plot was a prism plot, then the small tree plot was a conventional 0.005 ha silviculture survey plot. Measurements on silviculture plots were limited to stem counts by species (total and well-spaced), while height and DBH data were collected only on 'representative' trees. All data were checked and edited, and UTM coordinates were assigned to each plot. Complete details of sampling methods are described in the progress report (J.S. Thrower and Associates, 2000).

Table 1. Cross-reference of survey units, contractors and geographic areas.

Survey Unit	Geographic Area	Contractor	Year
1	Cottonwood West	TFIC	1995
2	Antler North	KEEN	1995
3	Kruger	KEEN	1995
4	Antler South	TFIC	1996
5	Willow	CIMCO	1996
6	Cottonwood West	CIMCO	1998
7	Willow	CIMCO	1998
8	Abhau	TFIC	1998
9	Sovereign	CIMCO	1998
10	Sovereign	CIMCO	1998
11	Willow	TFIC	1998
12	Antler South	TFIC	1998
13	Slough	TFIC	1998
14	Ketcham	TFIC	1998
15	Antler North	TFIC	1998

2.2 Compilation

Data were compiled separately for each plot. Variables calculated in the summaries included:

1. Gross merchantable volume (m^3/ha).
2. Top height (m).
3. Basal area (m^2/ha).
4. Stem Count (trees/ha).

5. Quadratic-mean diameter (cm).
6. Stand and stock tables by species and 5 cm diameter classes.

Data from individual plots were then used to produce summaries for each forest cover polygon, which, in turn, were used for the classification of stand structure.

2.3 SITE QUALITY

Most of the trees in Balsam IU stands are not suitable for site index because of early suppression. Site quality estimates were therefore derived from the Terrestrial Ecosystem Map (TEM) and the relationships between site series and site index (J.S. Thrower and Associates, 2000a). For each polygon we calculated a weighted potential site index for lodgepole pine based on the proportions of site series identified in the TEM. Polygons were then assigned to site classes, as defined in Table 2.

Table 2. Definition of site classes.

Site Class	Site Index Range
High	>23 m
Good	19.6 m –23.0 m
Medium	15.5 m – 19.6 m
Poor	<15.5 m

3. TREATMENT OPTIONS

The potential treatment options described below were developed in discussions with West Fraser staff at the beginning of the project. Some of the treatments resemble options originally described by Herring and Vyse (1977).

Table 3. Description of treatment options.

Option	Description
Harvesting	Stands with sufficient merchantable volume could be harvested and replaced with more productive plantations.
Rehabilitation	Stands with patchy stocking or with significant portions occupied by broadleaf shrubs or trees could be converted to plantations of conifers or mixtures of broadleaves and conifers.
Fill-Planting	Stands with significant unoccupied growing space could be fill-planted to increase future yields.
Juvenile Spacing	Dense stands of small trees could be spaced to lower densities to provide more growing space for crop trees.
Brushing	Brushing could reduce competition to conifers in stands with a large component of broadleaved trees and shrubs.
Commercial Thinning	Well stocked stands with trees of commercial size could be candidates for commercial thinning or other forms of partial cutting.

The first of these options—harvesting—is applicable to stands that have already accumulated sufficient volume to permit a viable harvesting operation. West Fraser staff consider Balsam IU stands with at least 200 m^3/ha as stands that could be harvested now or in the near future. These stands are categorized as *Current Harvest Potential* and represent approximately 8% of the 11,000 ha of Balsam IU stands. The other treatment options apply to stands regarded as *Future Harvest Potential.*

4. CURRENT HARVEST POTENTIAL

As noted earlier, stands with more than 200 m^3/ha were classified as *Current Harvest Potential.* Despite the higher volume, these stands will probably have low growth potential, especially if composed mostly of large residuals. Within *Current Harvest Potential*, we identified six different stand types based on additional volume and species criteria (Figure 1, Table 4). Stands with more than 150 m^3/ha in trees 25 cm and larger are well suited for harvesting now. The proportion of subalpine fir was another decision criterion. Stands with a high component of subalpine fir may have higher incidence of rot and lower merchantable yield.

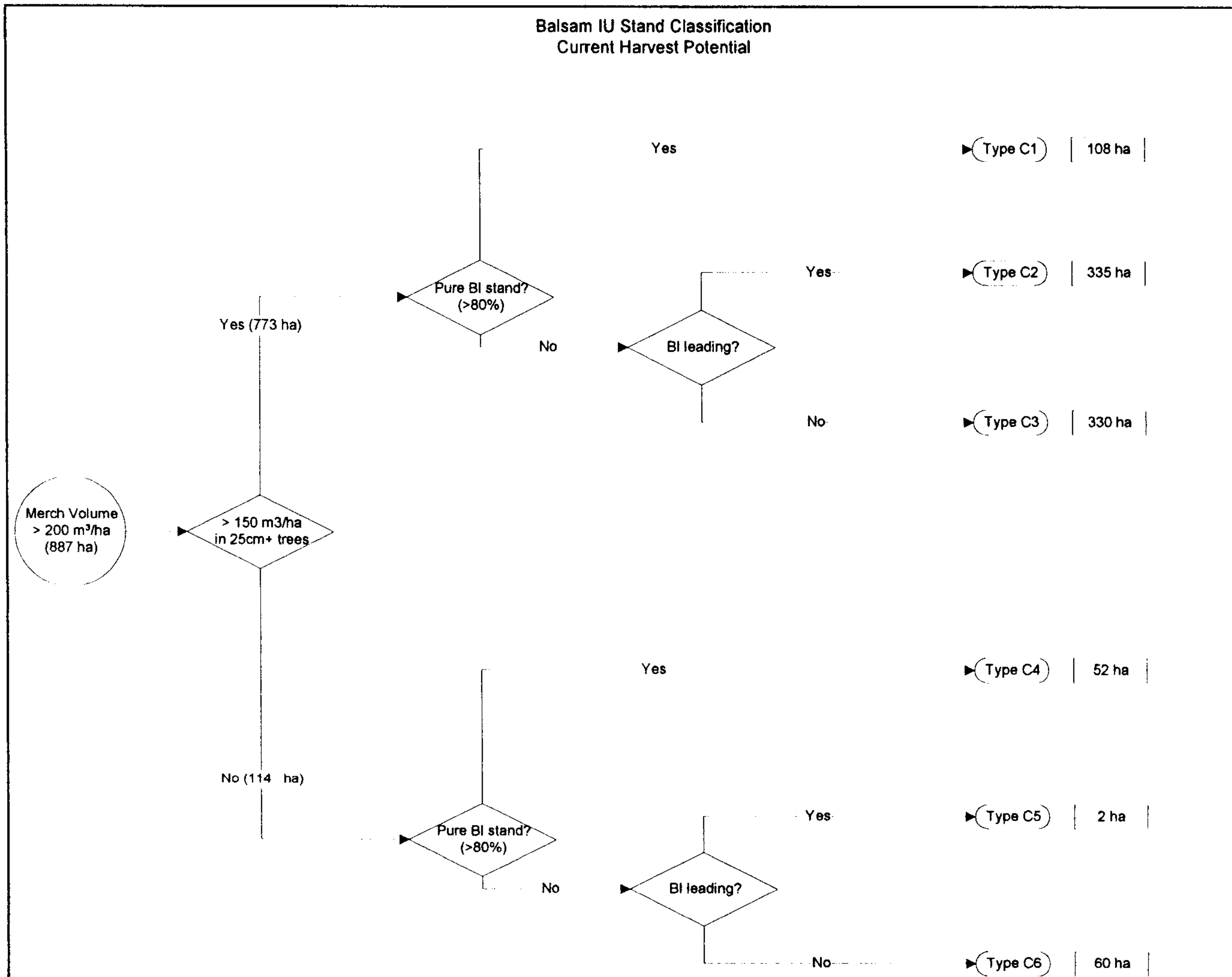

Figure 1. Decision diagram for *Current Harvest Potential.*

Table 4. Description of stand types for *Current Harvest Potential.*

Stand Type	Area (ha)	Description
C1	108	Pure Bl stands with more than 150 m³/ha over 25 cm DBH,
C2	335	Bl leading stands with more than 150 m³/ha over 25 cm DBH
C3	330	Stands not leading in Bl with over 150 m³/ha over 25 cm DBH
C4	52	Pure Bl stands with less than 150 m³/ha over 25 cm DBH
C5	2	Bl leading stands with less than 150 m³/ha over 25 cm DBH
C6	60	Stands not leading in Bl with less than 150 m³/ha over 25 cm DBH
Total:	***887***	

4.1 Site Quality

The distribution of site classes within *Current Harvest Potential* varies by stand type (Figure 2). In particular, types C2 and C3 have a very high proportion of good site, which may affect their priority for harvest.

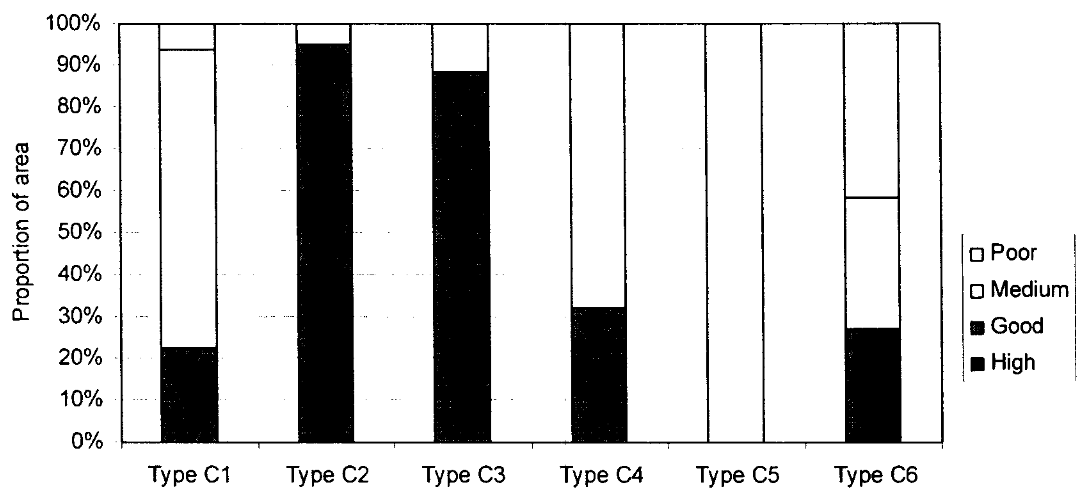

Figure 2. Site quality distribution by stand type for *Current Harvest Potential.*

4.2 Treatment Priorities

The priorities for harvesting stands within the *Current Harvest Potential* category will depend on the factors described below.

- The size of the polygon.
- The proximity of the polygon to other merchantable IU stands or current harvesting operations.
- The productive potential of the site. The most productive stands should be given a higher priority for harvest. Types C2 and C3, in particular, have a high proportion of good site.

- The size of the trees – where the stocking of the stand includes a high proportion of sub-merchantable stems, the stand should be given a lower priority for harvest
- The species composition of the stand. Stands with a high proportion of subalpine fir should be given a high priority for harvest, particularly on the best sites.
- The contribution of the stand to wildlife and biodiversity values in each landscape unit.
- The contribution of the stand to other values such as trapping or recreation.
- The location of the stand. It may be more advantageous to harvest stands growing on better sites closer to town even though the present appraisal system accounts for distance from a manufacturing centre.

5. FUTURE HARVEST POTENTIAL

5.1 Stand Structure Components

It is generally recognized that Balsam IU stands exist in a range of stand structures. These structures can be described by the species composition and distribution of three basic components:

1. Large residuals left standing at the time of logging.
2. Trees that developed from the small advance regeneration present at the time of logging.
3. New regeneration that has became established since logging.

Although these components are best described by their size or age at the time of logging, this information was not available for each tree. There was at least one tree cored for age in each plot, but the relationship between age and size is too variable to be used for reliable estimation of ages for the other trees (See Appendix I –Age-DBH Relationships). In the absence of complete age information, we have chosen to use diameter to divide the trees into structural categories.

Table 5. Definition of components of stand structure.

Component	Description
RESIDUAL	Pl and Fd: DBH >=35 cm Other species: DBH >=30 cm
IMMATURE	Pl and Fd: 12.5 cm <= DBH < 35 cm Other species: 12.5 cm <= DBH < 30 cm
SUBMERCHANTABLE	All species: DBH < 12.5 cm

The RESIDUAL component likely represents the large residual trees left after logging and some of the larger advance regeneration. It was our intention to exclude any post-logging regeneration from this category. The 30 cm and 35 cm DBH benchmarks were derived from an analysis of DBH distributions predicted by TIPSY and from observations made during our field examinations. These benchmarks are slightly larger than the largest of the new regeneration trees that we aged and measured. The RESIDUAL component corresponds to the trees most likely to have damage and associated decay from the logging operation. For silvicultural interpretations and treatment recommendations, we have assumed that the RESIDUAL component will have negligible growth in the future and will not contribute to the future harvest.

The IMMATURE component is likely composed of trees that were either small advance regeneration at the time of logging or new regeneration that has become established since logging. The data set does not contain any information about the growth rates of these trees. However, Ivanco (1976) and Gasson (1976) noted that the smaller advance regeneration was in good condition when they did their studies. The vast majority of IMMATURE trees we observed and cored during our field examination were growing very well. In the silviculture interpretations and treatment recommendations, we have assumed the trees in the IMMATURE component are viable crop trees that will contribute to a future harvest.

The SUBMERCHANTABLE component is composed mostly of trees that have become established since logging. As noted earlier, we cannot reliably distinguish between advance regeneration and post-harvest regeneration in the dataset. The age data we do have suggest that nearly all the SUBMERCHANTABLE trees are post-harvest regeneration.

5.2 Stand Structure Classification

The stand structure classification was based on the various combinations of RESIDUAL, IMMATURE and SUBMERCHANTABLE components found in the dataset. The rationale for the benchmarks used to divide the stands into different categories is outlined below.

5.2.1 Density of Overstory

The potential of SUBMERCHANTABLE trees to become merchantable depends largely on the density of the overstory canopy, if one is present. In some stands, the canopy may be sufficiently dense to affect the growth of the SUBMERCHANTABLE trees. Based on our field examinations, we have set this level at 20 m^2/ha of basal area. In the silviculture interpretations and treatment recommendations, we have disregarded the contribution of the SUBMERCHANTABLE component to either current stocking or a future harvest whenever the combined basal area of the RESIDUAL and IMMATURE components exceeds 20 m^2/ha.

5.2.2 Stocking

Many of the Balsam IU stands are not fully stocked. For this report, the definition of full stocking depended on the density of the overstory. If there was more than 20 m^2/ha of basal area in RESIDUAL and IMMATURE stems, then stands with more than 800 stems/ha larger than

12.5 cm DBH were considered fully stocked. None of the SUBMERCHANTABLE stems would count towards stocking. Alternatively, if there was less than 20 m^2/ha of basal area in RESIDUAL and IMMATURE stems, then stands were considered fully stocked if they had 800 stems/ha IMMATURE or some combination of IMMATURE and SUBMERCHANTABLE that exceeded 1200 stems/ha. Both of these measures are conservative relative to the stocking standards for seedlings when we consider the size of the trees in the Balsam IU stands. Although this definition includes RESIDUALS in the assessment of stocking, this is of no practical consequence because the density of RESIDUALS is generally low.

5.2.3 *Density of RESIDUALS*

The basal area of RESIDUAL trees ranges from zero to approximately 15 m^2/ha. Stands with more of the large residuals should probably be treated sooner than similar stands. with fewer residuals. Based on our field examinations, we have set the benchmark for residuals at 10 m^2/ha.

5.2.4 *Broadleaf Composition*

Broadleaf tree species such as paper birch, black cottonwood and trembling aspen are presently not considered commercial species in TFL 52. Stands dominated by broadleaf species, although relatively rare, may have important values for wildlife and biodiversity. In the classification, stands with more than 50% of their volume in broadleaf species are identified as broadleaf stands.

5.3 Site Quality

Over 75% of the *Future Harvest Potential* stands are growing on Good or High sites (Figure 3). The distribution of site quality does not vary much between the stand structure types.

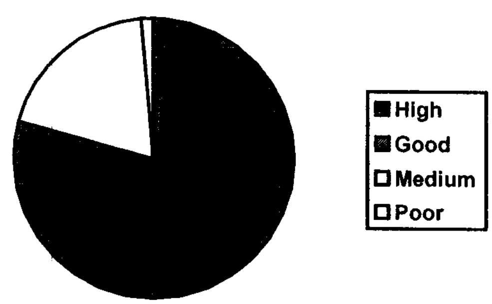

Figure 3. Site quality distribution of *Future Harvest Potential.*

5.4 Stand Structure Types

The decision diagram for *Future Harvest Potential* is shown in Figure 4 and descriptions of the stand structure types are summarized in Table 6. In the summary table, the stand types with good stocking are shaded green, those with lesser stocking are shaded grey and those with a major broadleaf component are shaded yellow.

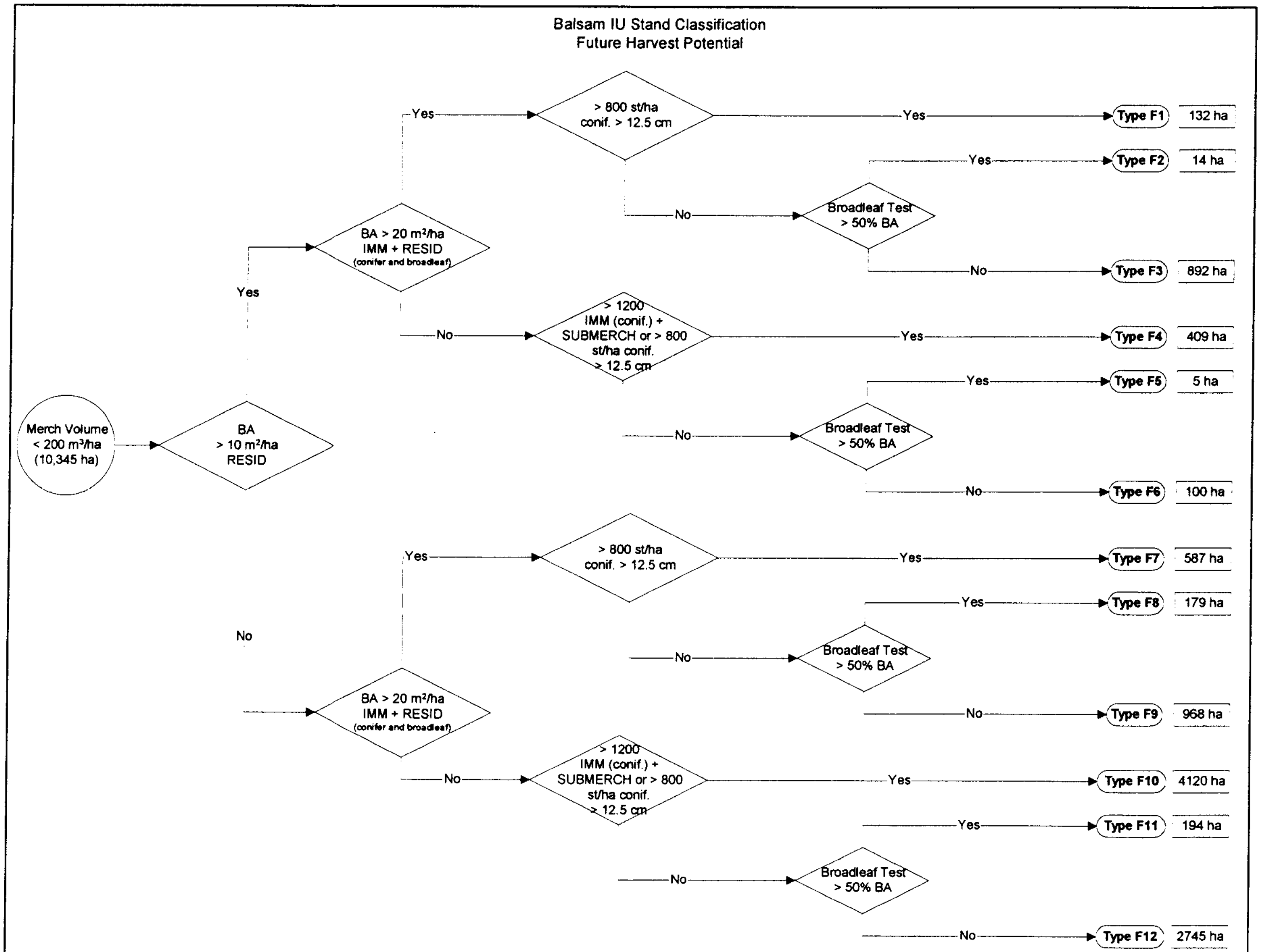

Figure 4. Decision diagram for *Future Harvest Potential.*

Table 6. Description and silviculture options for *Future Harvest Potential* stands.

Type	Area (ha)	Description	Next Harvest	Recommended Silviculture Options
[redacted]				
F2	14	Moderate RESIDUAL component, and low stocking of conifers larger than 12.5 cm DBH. Broadleaf species comprise more than 50% of the basal area. Overstory is too dense for adequate growth of SUBMERCH component	Broadleaf species and a some conifers from the IMMATURE component plus any RESIDUALS of adequate quality.	a) No treatment. These few stands may be of higher value for biodiversity, wildlife or visual quality than for timber. b) Rehabilitation (harvest and plant). High broadleaf composition may lead to brush and broadleaf problems in regenerated stand.
F3	892	Moderate RESIDUAL component, and low stocking of conifers larger than 12.5 cm DBH. Broadleaf species comprise less than 50% of the basal area. Overstory is too dense for adequate growth of SUBMERCH component.	IMMATURE component plus any RESIDUALS of adequate quality.	No treatment or rehabilitation (Similar to F2). With lower composition of broadleaves, it may make the rehabilitation option more attractive than the no treatment option.
[redacted]				
F5	5	Moderate RESIDUAL component, with low stocking of conifers in combined IMMATURE and SUBMERCH components. Broadleaf species comprise more than 50% of basal area.	RESIDUALS, depending on quality	No treatment or rehabilitation (Similar to F2). May have high value for wildlife and biodiversity because of broadleaf component. Very small area in this category.
F6	100	Moderate RESIDUAL component, with low stocking of conifers in combined IMMATURE and SUBMERCH components. Broadleaf species comprise less than 50% of basal area.	IMMATURE and SUBMERCH components plus any RESIDUALS of adequate quality	Check stocking. If conifer stocking is adequate, then no treatment may be best option. Higher conifer stocking than F5 but still marginal.
[redacted]				

Type	Area (ha)	Description	Next Harvest	Recommended Silviculture Options
F8	179	Low or absent RESIDUAL component, and adequate stocking of conifers larger than 12.5 cm DBH. Overstory is too dense for adequate growth of SUBMERCH component. Broadleaf species comprise more than 50% of the basal area.	IMMATURE component, but may be mostly broadleaves.	Similar to F2 without residuals: a) No treatment. These few stands may be of higher value for biodiversity, wildlife or visual quality than for timber. b) Rehabilitation. High broadleaf composition may lead to brush and broadleaf problems in regenerated stand.
F9	968	Low or absent RESIDUAL component, and low stocking of conifers larger than 12.5 cm DBH. However, overstory is still too dense for adequate growth of SUBMERCH component. Broadleaf species comprise less than 50% of the basal area.	IMMATURE component	Check stocking. If conifer stocking is adequate, then no treatment may be best option. Higher harvest priority than stands with better stocking. Similar to F8 but lower deciduous content.
[redacted]				
F11	194	Low or absent RESIDUAL component and low stocking of conifers. Broadleaf species comprise more than 50% of the basal area.	IMMATURE and SUBMERCH components, but may be mostly broadleaves.	a) No treatment. These few stands may be of higher value for biodiversity, wildlife or visual quality than for timber. b) Rehabilitation. High broadleaf composition may lead to brush and broadleaf problems in regenerated stands. c) Similar to F2, F5 and F8: stocking is low and deciduous content is high.
F12	2,745	Low or absent RESIDUAL component and low stocking of conifers. Broadleaf species comprise less than 50% of the basal area.	IMM and SUBMERCH	Check stocking. Combined IMMATURE and SUBMERCH may be adequate stocking. Large area in this category. Determine whether rehabilitation is an option. Similar to F11 but lower deciduous content.
Total:	***10,345***			

5.5 Analysis

The structure classes for stands with *Future Harvest Potential* can be grouped into three categories (Table 1). Those classified as Good Stocking are clearly well stocked and are unlikely to need further treatment before the next harvest. The broadleaf dominated stands have inadequate stocking of conifers, but they may have high value for biodiversity or as wildlife habitat.

Stands with Sub-Optimal Stocking make up about 45% of the stands *Future Harvest Potential.* Closer inspection of the three largest types—F3, F9 and F12—shows that although the stands may not be fully stocked, many have more than minimal stocking (Type F6 accounts for only 100 ha).

Table 7. Stocking categories for *Future Harvest Potential* stands.

Stocking Category	Types	Area	% Area
Good Stocking	F1, F4, F7, F10	5,248	51
Sub-Optimal Stocking	F3, F6, F9, F12	4,705	45
Broadleaf Dominated	F2, F5, F8, F11	392	4
Total		*10,345*	*100*

In Types F3 (892 ha) and F9 (968 ha), the overstory is sufficiently dense to restrict the growth of trees in the SUBMERCHANTABLE component. The trees most likely to contribute to a future harvest, therefore, are those in the IMMATURE component. A cumulative area distribution for types F3 and F9 (Figure 5) shows that approximately 30% of F3 and 60% of F9 have densities between 420/ha and 800/ha[3]. We consider stands in this range to have adequate stocking.

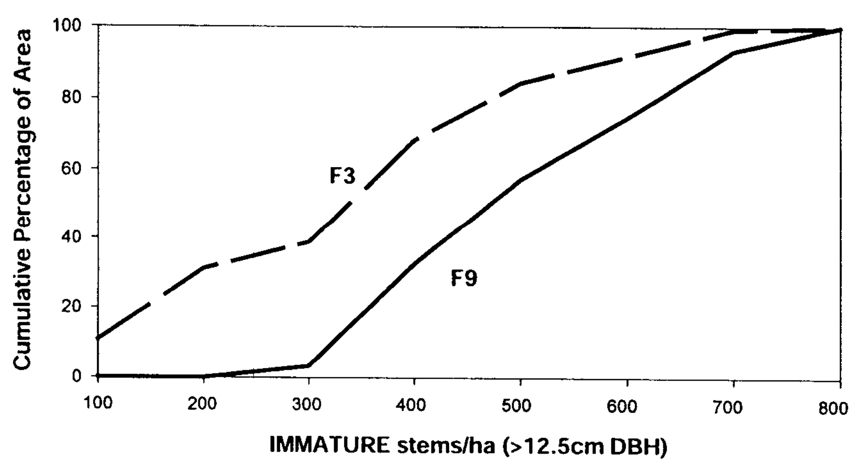

Figure 5. Cumulative area distribution for types F3 and F9.

[3] The lower limit—420/ha—is the Not Satisfactorily Restocked threshold for backlog stands (Ministry of Forests, 2000).

Type F12 does not have the same overstory restriction as Types F3 and F9, so the SUBMERCHANTABLE layer does contribute to stocking in these stands. The cumulative area distribution for F12 (Figure 6) shows that about 30% of the area exceeds 800 stems/ha. In this case, however, the 800 stems/ha are a combination of SUBMERCHANTABLE and IMMATURE components. We consider these stands, therefore, adequately stocked rather than fully stocked. An additional 30% of the F!2 stands lie between 420 and 800 stems/ha, and may be considered marginally stocked.

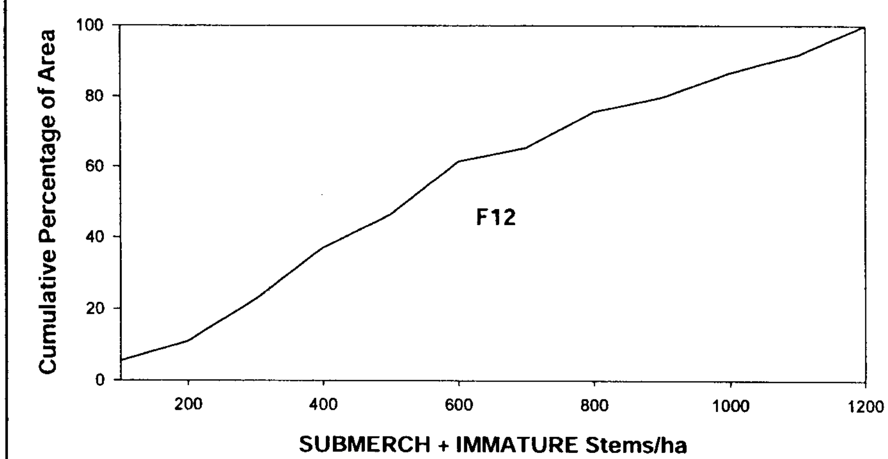

Figure 6. Cumulative area distribution for F12.

If these assumptions about stocking are approximately correct, then the resulting distribution of area by stocking class will be that shown in Table 8. The area of *Current Harvest Potential* is included to provide a complete overview of the area surveyed for this study.

Table 8. Area summary by stocking class.

Stocking Class	ha	%
Current Harvest Potential	887	8
Good Stocking	5,248	47
Adequate Stocking	1,535	14
Marginal Stocking	961	9
Unsatisfactory Stocking	2,209	20
Broadleaf Dominated	392	3
Total	*11,232*	*100*

Limitations in the data (See 7 Data Limitations), however, cause us to be circumspect about the SUBMERCHANTABLE stem counts. Consequently, we have less confidence in those parts of the classification that depend on small differences in the density of SUBMERCHANTABLE stems. With respect to the stocking classes (Table 8), we are reasonably confident that stands with good stocking are correctly identified. We have less confidence about the distinctions between adequate, marginal and unsatisfactory stocking. Further field work would be required to ensure those stands are correctly classified.

6. GROWTH AND YIELD IMPLICATIONS

The priority for harvest or treatment of individual stands will depend, in part, on the growth and yield implications of the alternatives. For most of the stands classified as *Future Harvest Potential*, the major decisions will revolve around the sequence in which these stands should be harvested and regenerated to more productive stands. Establishing that sequence requires some assessment of how the current stands are growing and a comparison with the predicted growth of the plantations that might replace them.

6.1 Predicting Future Growth

In the absence of growth models specifically applicable to Balsam IU stands, we have estimated their growth with yields from TIPSY (Version 3) for white spruce, using the input parameters listed in Table 9, and the resulting yield curves are displayed in Figure 7. The growth of stand types designated as *Good Stocking* (Table 8) were approximated in TIPSY by natural stands established at 1200 stems/ha. All forms of Sub-Optimal stocking types (i.e., adequate, marginal or unsatisfactory) were designated as *Poor Stocking* and projected in TIPSY as natural stands established at 420 stems/ha. The alternative management scenario—a regenerated stand—involves cutting the existing stand and establishing a spruce plantation with 1600 stems/ha. The site index used for the TIPSY runs—21 m—is approximately the area-weighted average of potential site index for spruce.

Table 9. TIPSY input parameters.

	Good Stocking	Poor Stocking	Regenerated
Stand Types	F1, F4, F7, F10	F3, F6, F9, F12	All
Area	5,248	4,705	
Site Index	21 m	21 m	21 m
Regeneration	Natural	Natural	Planted
Distribution	Random	Random	Regular
Initial Density	1200/ha	420/ha	1600/ha
OAF1 / OAF2	0.85/0.95	0.85/0.95	0.85/0.95

Additional assumptions are required to account for the volume accumulated in the 30 to 45 years since the IU logging. The age of the stands, however, is not a good indicator of either the current status of the stand or the number of years before the stand will become merchantable. Some stands classified here as *Poor Stocking* currently have up to 75 m^3/ha in merchantable volume, exclusive of RESIDUALS. Other stands classified as *Good Stocking* will be well stocked, but may have very little merchantable volume.

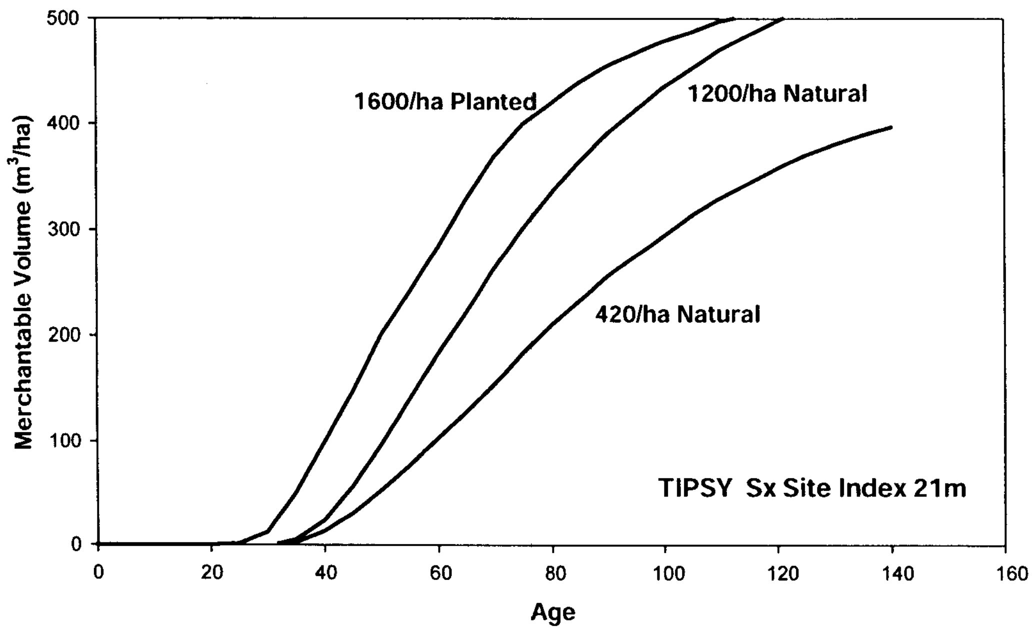

Figure 7. Spruce yield curves for natural and planted stands.

We have assumed that the current position of an existing stand on its associated yield curve (*Good Stocking* or *Poor Stocking*) is best characterized by the amount of merchantable volume in the IMMATURE stand component. This effectively ignores both the potential growth and competitive effects of any stems in the RESIDUAL component. The subsequent growth of the stand is then assumed to follow the associated yield curve. Stands assigned to the *Poor Stocking* curve are expected to grow more slowly than stands assigned to the *Good Stocking* curve. For example, it takes 40 years to grow from 100 m^3/ha to 400 m^3/ha on the *Good Stocking* curve, whereas it takes 80 years on the *Poor Stocking* curve (Figure 8).

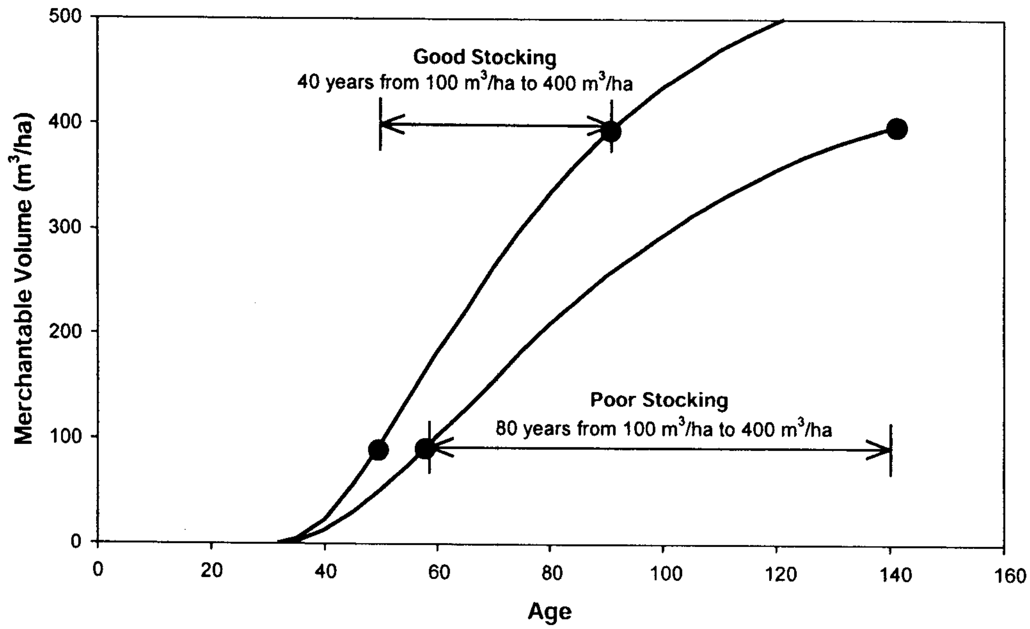

Figure 8. Estimating years to harvest.

6.2 Time to Next Harvest

The *Regenerated* yield curve (Figure 7) shows that plantations will attain 400 m^3/ha in about 75 years. This coincides with the culmination of mean annual increment and is one benchmark against which to compare the performance of the Balsam IU stands. Another benchmark is the minimum of 200 m^3/ha required for an economical harvesting operation.

The number of years to reach 200 m^3/ha and 400 m^3/ha (Table 10) was calculated for each polygon based on the yield curves assigned from the stand structure classification. Since plantations are predicted to grow to 400 m^3/ha in approximately 75 years, stands that will reach that target in less time have a low priority for treatment or conversion. Approximately 94% of the *Good Stocking* stands (4925 ha) fit into that category. Within the assumptions used for this analysis, all of the *Poor Stocking* stands (4708 ha) are potential candidates for replacement; only a few of these stands are predicted to reach minimum merchantability (200 m^3/ha) in the next 20 years.

The yield predictions used in this analysis probably underestimate the performance of many of the stands classified as *Poor Stocking*. More than half of the area in this category is occupied by stands better described as adequate or marginal stocking (Table 8). If we had better information about stands in adequate and marginal stocking classes, then it would be possible to assign these stands to a yield curve that is intermediate to the *Good* and *Poor* curves, rather than assigning them all the *Poor* yield curve.

Table 10. Area distribution by years to reach 200 m^3/ha or 400 m^3/ha.

Stand Type	Years to 200 m^3/ha 0-20 yrs (ha)	20-40 yrs (ha)	40+ yrs (ha)	Years to 400 m^3/ha 30-60 yrs (ha)	60-100 yrs (ha)
Good Stocking					
F1	132			132	
F4	252	88	69	340	69
F7	587			587	
F10	1,920	1,946	254	3,866	254
Total	*2,891*	*2,034*	*323*	*4,925*	*323*
Poor Stocking					
F3	85	786	21		892
F6	72	28			100
F9	160	808			968
F12	27	2,233	485		2,745
Total	*344*	*3,855*	*506*		*4,705*

7. DATA LIMITATIONS

There were a number of important limitations in the dataset used for this report. Those limitations influenced scope and depth of the analysis, and they must be considered in the interpretation of the results.

7.1 GROWTH RATES

There is no information on growth rates in the dataset. We do have the TEM and associated site index to describe the site potential, but no direct, quantitative evidence about growth rates. The stands we visited on our field trips were growing very well. In many cases, the stands looked more like regular second-growth stands than residual stands from partial cutting. It's possible that such stands might better be modelled with TIPSY than VDYP in timber supply analysis, but more information on growth rates would be needed to support that decision.

7.2 TREE AGES

There is limited information about tree ages, and the relationship between age and size is too weak to use size as a predictor of age. This means that we cannot distinguish among post-harvest regeneration, advance regeneration and older residuals with any certainty.

7.3 SURVEY METHODS FOR SMALL TREES

The use of two different survey methods for small trees created some problems. Where small fixed-area plots were used, there was good information for trees less than 12.5 cm DBH. Where silviculture plots were used as the small-tree plots, there was little information on the size of trees. On the other hand, the silviculture plots tallied the number of well-spaced trees, and many regulatory benchmarks are expressed as well-spaced stems per hectare. This information was not collected on the fixed-area plots. Minimum tree size also varied with survye method. On the small fixed-area plots, the smallest trees tallied were 1.3 m tall. In contrast, some trees shorter than 1.3 m were tallied on the silviculture plots. For this analysis, we used total stems per hectare as the benchmark for the SUBMERCHANTABLE component because it was the only small-tree measure of density that was consistent throughout the dataset.

7.4 Missing Data

The small-tree plots measured by CIMCO in the Willow were not keypunched and therefore not included in the dataset. This means that those polygons might be misclassifed because they appear in the dataset as polygons with no SUBMERCHANTABLE trees, when in fact they might have ample stocking in the SUBMERCHANTABLE component.

7.5 Sampling Error

The number of plots per polygon ranges between 1 and 32. Many of the smaller polygons contain only 1 or 2 plots. Although the plot statistics should be relatively unbiased, the sampling error will be higher with fewer plots. This means that some polygons may be placed in the wrong stand structure category. Our field check found one stand that was clearly misclassified because the plot statistics did not reflect the overall composition of the polygon (See 93B099 Polygon 194 Cottonwood West in Appendix II). To gain a better understanding of this potential impact, we compared plot statistics with information from the forest cover inventory. Species composition was selected for this comparison because it is one of the attributes that is estimated directly from photos in the inventory. We found there was generally good agreement between the two data sources when there were 4 or more plots in a polygon. Results for polygons with fewer plots were highly variable. This means that the reliability of the classification for any particular polygon increases with the number of plots established. It also means that it is necessary to check the stand with at least a walkthrough before scheduling treatments.

7.6 Misclassification of Balsam IU Stands

Another misclassification issue relates to the definition of Balsam IU stands selected for this study. Several of the stands we visited had clearly not been harvested under intermediate utilization and probably should not have been classified as Balsam IU stands. One indication is the absence of subalpine fir in the species composition in either the inventory label or the plot statistics. A review of the data suggests that 10% of the *Current Harvest Potential* and 15% of the *Future Harvest Potential* are probably not Balsam IU stands.

8. TREATMENT OPPORTUNITIES

This classification of the Balsam IU stands on TFL 52 gives the forest manager a reasonable degree of confidence in the ranking of stands for potential treatment. Those with the lowest stocking are obviously the best candidates for treatment. Polygons with a small number of plots need to be checked, and those on the highest quality sites should be given high priority.

The extent of field checks on the poorly stocked sties should be limited to identification of potential treatment areas for a five-year period. West Fraser probably has more to gain by correct classification of stands currently in the sub-optimal category. It is very likely that, with better information, many stands would move from the *Poor Stocking* curve to a *Good Stocking* curve, with associated positive effects on timber supply.

The main opportunities for treatment of these stands are rehabilitation of poorly stocked stands and harvesting of stands that currently exceed 200 m^3/ha. There are also come opportunities for commercial thinning, but only if required to fill in minor gaps if future timber supply.

Some foresters might view the stands with high stem counts as candidates for spacing, but these stands are not really overstocked; the stands are well differentiated with a wide variation in tree sizes. The prospect of exposing spruce stems to damage from the terminal weevil is a further reason to discount the spacing option.

We also do not recommend fill-planting in the stands with stocking gaps. It is probably better to either rehabilitate the stands now or harvest them as soon as they become merchantable.

9. RECOMMENDATIONS

1. Schedule field checks for stands identified as adequate, marginal or unsatisfactory stocking. Stands that actually have poor stocking should be included in a 5-year rehabilitation plan.
2. Confirm stocking levels and collect growth data on stands identified as *Good Stocking.* The existing growth predictions for these stands probably underestimate actual growth.
3. Examine the wood quality issues associated with the large residual stems in stands with *Current Harvest Potential.* Knowing the economic value of that wood will help determine the priority of these stands for harvest.
4. Assess the value of the broadleaf for wildlife or biodiversity. These stands could be very difficult to convert to conifer production and may have higher value as wildlife habitat.

10. CONCLUDING REMARKS

Most of the area currently occupied by Balsam IU stands is potentially very productive, as indicated by the values of potential site index. The historical concern about these stands has been the amount of stocking and the quality of the stems. Three decades beyond the era of IU logging, more than half of the Balsam IU stands on TFL 52 are well-stocked with vigorous trees. Most of the remaining area—which is less well stocked—still exceeds the minimum requirements for satisfactory stocking.

From the present perspective, it may be fortuitous that many of the spacing and improvement cuttings planned in the 1970s were not applied on a large scale. The current stocking issues are more about under-stocking than over-stocking. The large residual stems left after logging are much less prominent now; the current stands are dominated by the new and advance regeneration that either became established or was released after logging. With some additional work on documenting the growth of these stands they may at last be recognized as viable contributors to the timber harvesting landbase.

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12. APPENDIX I – AGE-DBH RELATIONSHIPS

13. APPENDIX II – FIELD CHECKS OF STAND CLASSIFICATION

Following the development of the stand structure classification, several stands were visited September 19th and 20th, 2000 to check the classification. Participant in the field trip were Mary Lester, Ian Cameron and Craig Mistal (J.S. Thrower and Associates), and Earl Spielman (West Fraser). Polygons were chosen to include representatives of the major types within the *Future Harvest Potential* category. At each stop there was a visual assessment of the status of each stand component (RESIDUAL, IMMATURE and SUBMERCHANTABLE). In several stands we established either fixed-area plots or prism sweeps to assess the benchmarks used in the classification. Following the field trip, some of the benchmarks were revised to reflect the conditions we observed in the field. The following sections document the observations made at the various polygons visited on the field trip.

Table 11. Polygons visited.

Type	Polygons
F1	1
F3	4
F7	2
F8	1
F9	3
F10	5
F11	1
F12	3

13.1 93H013 POLYGON 206 ANTLER NORTH

Area:	36.1 ha
Species Composition:	$Bl_{55}Sx_{37}Pl_{8}$
Inventory Label:	$Bl_{70}Sx_{15}Pl_{10}At_{5}$
Volume:	111 m^3/ha
Basal area distribution:	3 m^2/ha residual, 18 m^2/ha immature, no broadleaf component
Conifer Stocking:	29 sph resid, 690 sph imm conif, 1000 sph understory, 500 WS
Stand Classification:	Type F9, site class G
# plots in polygon:	4

Notes:

- The immature stocking is high enough that the submerch layer should not count towards the stocking
- BA 25 m^2/ha from prism count
- This stand is classified as Type F9: it has low residual stocking, the BA of residual plus immature is just above the cutoff of 20 m^2/ha where the understory does not count towards the stocking but the total stocking of IMM + RESID is marginally below 800 stems/ha.

13.2 93H013 Polygon 405 Antler North

Area:	15.0 ha
Species Composition:	$Bl_{69}Sx_{31}$
Inventory Label:	$Bl_{65}Sx_{35}$
Volume:	132 m^3/ha
Basal area distribution:	15 m^2/ha residual, 6 m^2/ha immature, no broadleaf
Conifer Stocking:	166 sph resid, 181 sph imm conif
Stand Classification:	Type F3, site class G
# plots in polygon:	2

Notes:

- Volume is on the higher end of stands visited but there is still room for the immature component to grow before harvest.
- This stand is classified as Type F3: it has greater than 10 m2/ha of BA of residuals and >20 m2/ha of immature plus residual so the submerch stems do not count towards stocking.
- Although stocking is on the low end, this stand should be retained until immature stems are merchantable.

13.3 93H013 Polygon 595 Antler North

Area:	142.6 ha
Species Composition:	$Bl_{78}Sx_{21}At_1$
Inventory Label:	$Bl_{66}Sx_{33}At_1$
Volume:	94 m^3/ha
Basal area distribution:	5 m^2/ha residual, 13 m^2/ha immature, 1% of BA is broadleaf
Conifer Stocking:	56 sph resid, 491 sph imm conif, 73 sph understory, 36 WS
Broadleaf Stocking:	5 sph immature
Stand Classification:	Type F12, site class G
# plots in polygon:	11

Notes:

- Higher residual content than in most of the stands visited earlier.
- Based on field observations, stocking of residuals and immature is high enough that the submerchantable layer will not contribute to stocking.
- The quality of residual stems must be checked to determine how long to carry this stand.
- This stand is classified as Type F12: it has a low residual layer and low stocking of immature stems. The stand is just under the 20 m^2/ha BA of immature plus residual where submerch stems do not contribute to stocking.

13.4 93B099 POLYGON 194 COTTONWOOD WEST

Area:	41.9 ha
Species Composition:	$Pl_{57}Sx_{28}At_{10}Ep_{2}Fd_{2}Bl_{1}$
Inventory Label:	$At_{40}Pl_{27}Sx_{17}Ep_{15}Fd_{1}$
Volume:	19 m^3/ha
Basal area distribution:	0 m^2/ha residual, 5 m^2/ha immature, 12% of BA is deciduous
Conifer Stocking:	0 sph resid, 250 sph imm conif, 1100 sph understory, 550 WS
Broadleaf stocking:	0 sph immature, 200 sph understory
Stand Classification:	Type F10, site class G
# plots in polygon:	2

Notes:

- NSR with a high deciduous content, some understory coniferous stems.
- Skidoo trail through polygon
- Could be rehabilitated but it would be expensive to control the deciduous.
- It may be more important for recreation and wildlife.
- This stand is classified as Type F10, with no residuals, a low BA of conifers but adequate stocking of immature plus understory. The field tour showed a higher deciduous component than was identified in the plots: the inventory species label reflects this higher percentage of broadleaf species in the stand.
- This is probably not an IU stand.

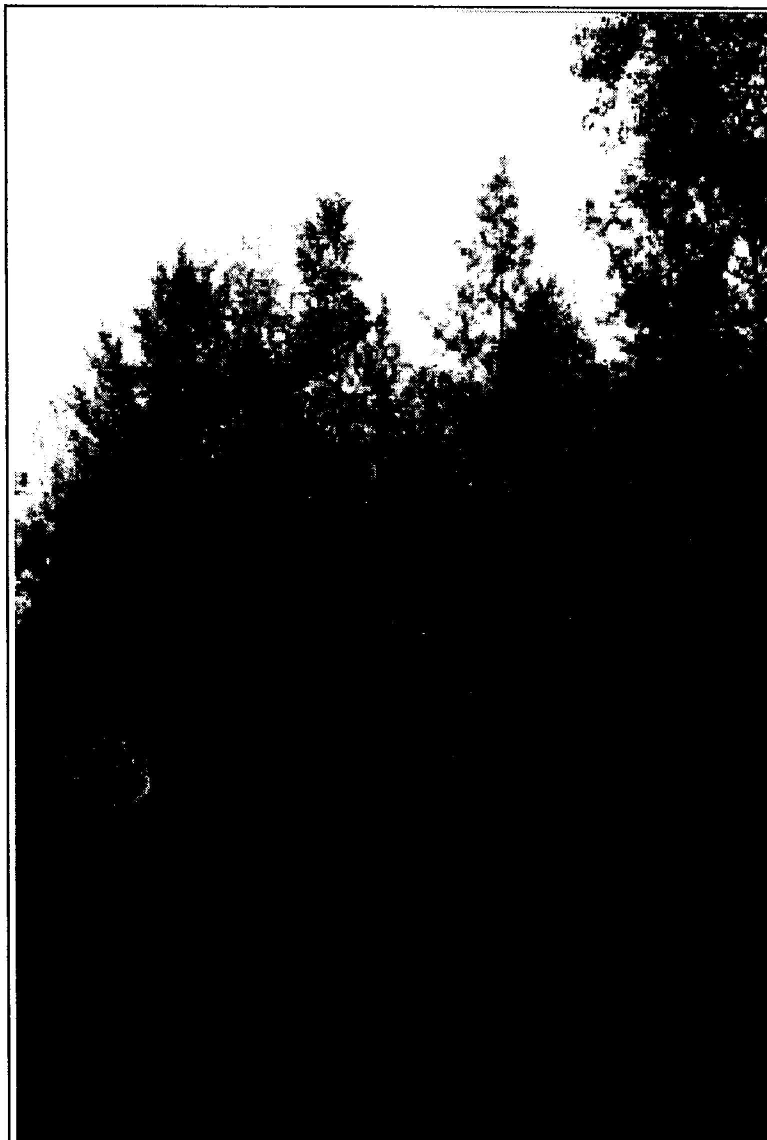

Figure 12. Broadleaf stand in Cottonwood West [B099 Polygon 194]

13.5 93B099 POLYGON 263 COTTONWOOD WEST

Area:	35.3 ha
Species Composition:	$At_{40}Ep_{31}Fd_{20}Sx_9$
Inventory Label:	$Fd_{60}At_{33}Ep_{10}Sx_7$
Volume:	9 m^3/ha
Basal area distribution:	0 m^2/ha residual, 4 m^2/ha immature, 69% of BA is deciduous
Conifer Stocking:	0 sph resid, 150 sph imm conif, 1250 sph understory, 625 WS
Broadleaf stocking:	75 sph immature, 2350 sph understory
Stand Classification:	Type F10, site class G, not IU
# plots in polygon:	4

Notes

- The portion of this stand adjacent to the 300 Road is a well-stocked immature Fdi plantation.
- Based on the species contribution and lack of residual layer, this stand should not be included as an IU stand.
- This stand is classified as Type F10: low residual volume, low basal area of immature plus residual but stocking in excess of 1200 stems/ha of immature plus submerch. The deciduous component of 2350 stems/ha under 12.5 cm should be checked for brushing opportunities.

13.6 93G009 POLYGON 176 COTTONWOOD WEST

Area:	16.8 ha
Species Composition:	$Sx_{46}Pl_{35}At_{10}Ac_8Ep_1$
Inventory Label:	$Sx_{51}Pl_{26}At_{14}Ac_6Ep_3$
Volume:	156 m^3/ha
Basal area distribution:	7 m^2/ha residual, 21 m^2/ha immature, 21 % of BA is broadleaf
Conifer Stocking:	75 sph resid, 450 imm conif, 100 understory, 50 WS understory
Broadleaf Stocking:	150 sph immature, 100 sph understory
Stand Classification:	Type F9, Site Class G, not IU
# plots in polygon:	4

Notes:

- Minor aspen component, no residual layer, consistent stocking.
- Even-aged immature stand, as above, should not be part of IU and should be modeled in TIPSY.
- Limby Pl due to low densities: 1,000 stems/ha > 12.5, 1,400 stems/ha total.
- Calculated BA for stand (from field tour): 38 total, Pl – 24 m^2/ha.

- Options for the stand include pruning to increase clear wood production or harvesting the stand in the near future because of large branch sizes.
- This stand is classified as Type F9: it has a low residual component, BA of immature plus residual over 20 m^2/ha but less than 800 stems/ha of coniferous over 12.5 cm diameter. It has a low broadleaf content.

13.7 93G009 POLYGON 228 COTTONWOOD WEST

Area:	17.3 ha
Species Composition:	$Sx_{81}At_{19}$
Inventory Label:	$Sx_{83}At_{13}Pl_4$
Volume:	132 m^3/ha
Basal area distribution:	3 m^2/ha residual, 30 m^2/ha immature, 16% of BA is broadleaf
Conifer Stocking:	50 sph resid, 850 imm conif, 1100 understory, 550 WS
Broadleaf Stocking:	300 sph immature
Stand Classification:	Type F7, Site Class G, not IU
# plots in polygon:	2

Notes:

- No residual layer – an even-aged stand, some Pl and Fd with spruce on wetter ground, very consistent stocking.
- A portion of the polygon has been spaced.
- This stand should not be included as an IU stand – it should be modeled using TIPSY.
- Max density 1300 stems/ha > 12.5 cm, 2800 stems/ha total.
- Largest spruce 28.6 cm.
- This stand could be pruned to increase clear wood production or should be harvested when the majority of the stems are merchantable due to large branch sizes.
- This stand is classified as Type F7: low BA of residuals, > 20 m^2/ha of immature stems, and >800 stems/ha of conifers greater than 12.5 cm diameter. It is a well-stocked immature stand.

13.8 93G009 Polygon 388 Cottonwood West

Area:	16.1 ha
Species Composition:	$Pl_{70}Fd_{22}Ac_4At_3Ep_1$
Inventory Label:	$At_{55}Pl_{33}Ac_9Ep_2Sx_1$
Volume:	45 m^3/ha
Basal area distribution:	4 m^2/ha residual, 7 m^2/ha immature, 11% of BA is broadleaf
Conifer Stocking:	25 sph resid, 375 sph imm conif, 1400 sph understory, 700 WS
Broadleaf Stocking:	1750 sph understory
Stand Classification:	Type F10, site class M, not IU
# plots in polygon	4

Notes:

- High deciduous (aspen, cottonwood, birch and willow), with minor conifers (Pl>Sx>Fd>Bl).
- Moose browse on Bl above snowline.
- Bear sign throughout polygon
- Beaver activity.
- Because of the high deciduous content, this would be a very expensive polygon to rehabilitate and may be of higher value as wildlife habitat.
- This stand is classified as Type F10: Low stocking of residuals, low BA of residual plus immature but adequate stocking of immature plus understory. The plots also show a low deciduous BA but 1,750 stems/ha of broadleaf stems under 12.5 cm. The inventory species label better reflects the high deciduous component which was seen in the field tour.

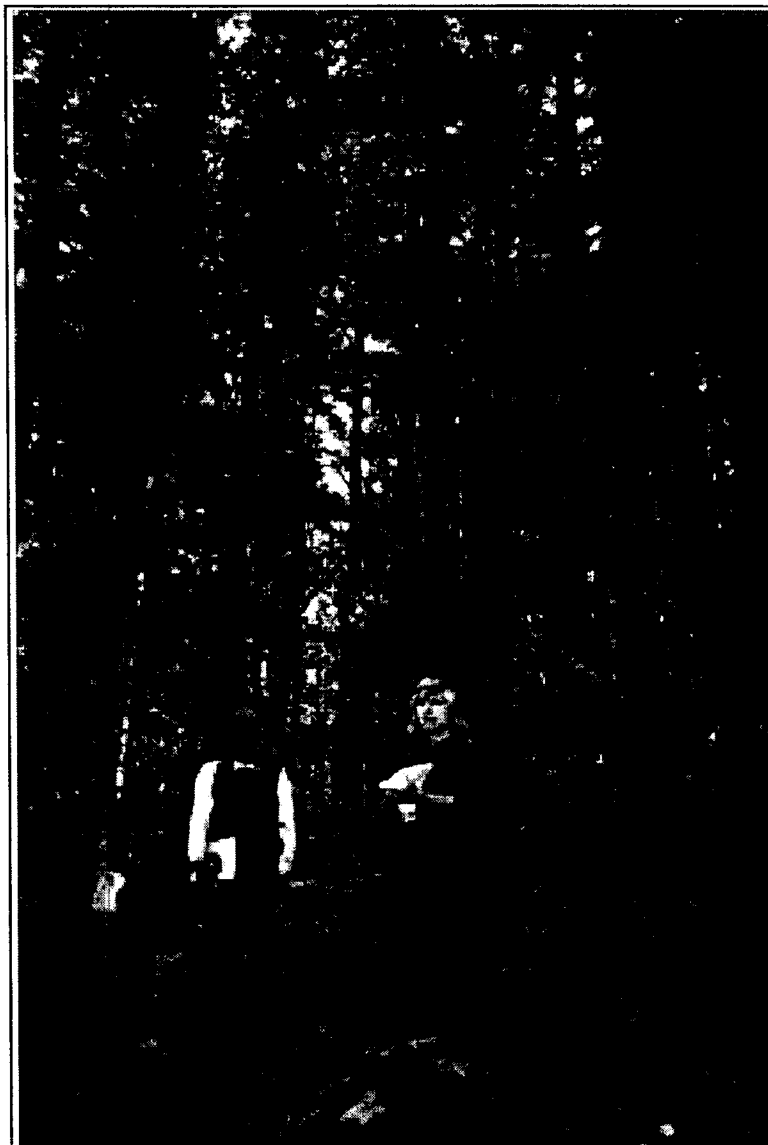

Figure 13. 93G009 Polygon 388 Cottonwood West

13.9 93G009 Polygon 412 Cottonwood West

Area:	16.7 ha
Species Composition:	$Pl_{52}At_{33}Ep_{15}$
Inventory Label:	$Pl_{70}At_{20}Sx_{10}$
Volume:	28 m^3/ha
Basal area distribution:	0 m^2/ha residual, 8 m^2/ha immature, 50 % of BA is broadleaf
Conifer Stocking:	0 sph resid, 226 imm conif, 0 understory, 0 WS
Broadleaf stocking:	225 sph immature
Stand classification:	Type F11 , Site Class G, not IU
# plots in polygon:	3

Notes:

- Less aspen than polygon 445.
- Pl age 30 BH, 38 total.
- Low density and similar management considerations to Polygon 445.
- This stand is classified as Type F11: low residual, low BA of immature plus residual, less than 800 stems/ha over 12.5 cm and less than 1200 sph of immature plus submerch. The stand has a broadleaf flag because 50% of the BA is aspen and birch in the cruise plots.

13.10 93G009 Polygon 445 Cottonwood West

Area:	6.3 ha
Species Composition:	$Pl_{38}Ep_{31}Ac_{29}$
Inventory Label:	$Pl_{80}At_{20}$
Volume:	61 m^3/ha
Basal area distribution:	8 m^2/ha residual (deciduous), 22 m^2/ha immature, 61% of BA is broadleaf
Conifer Stocking:	0 sph resid, 500 imm conif, 1400 understory, 700 WS
Broadleaf Stocking:	600 sph immature, 400 sph understory
Stand classification:	Type F8, Site Class P
# plots in polygon:	1

Notes:

- Stocking in this stand is low and there is a component of aspen. BA total - 36, BA coniferous over 12.5 cm - 24 m^2/ha.
- 2500 stems/ha total, 1300 stems/ha Pl and At > 12.5 cm, 1000 stems/ha Pl > 12.5.
- Low BA should put this stand in a high priority for harvest in about 15 years. Harvest and planting at higher densities would provide much better site occupancy.
- Site index appears to be better than poor but the eastern portion of the polygon may be wet.

- This stand is classified as Type F8: this category has a low BA of residuals but the BA of immature plus residuals is high enough that the understory stems are not counted towards stocking of the stand. It has less than 800 stems/ha of conifers over 12.5 cm and over 50% of the BA is deciduous. Compared to the field visit, the plot established in this type appears to overestimate the broadleaf component and underestimate the conifers. It may be more correctly classified as a type F7 with higher conifer stocking.

13.11 93G009 POLYGON 470 COTTONWOOD WEST

Area:	32.9 ha
Species Composition:	$Pl_{48}Sx_{36}Bl_{17}$
Inventory Label:	$Sx_{55}Bl_{25}Ep_{10}Pl_{8}Fd_{2}$
Volume:	148 m^3/ha
Basal area distribution:	11m^2/ha residual, 14 m^2/ha immature, no broadleaf component
Conifer Stocking:	150 sph resid, 700 sph imm conif, 600 sph understory, 300 WS
Broadleaf Stocking:	0
Stand Classification:	Type F1, site class P
# plots in polygon:	2

Notes:

- Drier site than 228 and 176 and trees are smaller because of the site.
- Some Fd.
- About 1000 stems/ha, similar to 176.
- Thrifty stand, no treatment is required.
- This stand is classified as Type F1: the residual component is greater than 10 m^2/ha, and the combined BA of residuals and immature is >20 m^2/ha so the understory stocking is not counted towards the stocking of the stand. Stocking of stems over 12.5 cm exceeds 800 stems/ha.

13.12 93G009 POLYGON 610 COTTONWOOD WEST

Area:	44.0 ha
Species Composition:	$Bl_{43}Ep_{27}Sx_{14}Pl_{10}Fd_{3}At_{3}$
Inventory Label:	$Bl_{39}Sx_{37}Ep_{14}At_{5}Pl_{3}Fd_{2}$
Volume:	152 m^3/ha
Basal area distribution:	17 m^2/ha residual, 15 m^2/ha immature, 27% of BA is broadleaf
Conifer Stocking:	133 sph resid, 483 sph imm conif, 1400 sph understory, 700 WS
Broadleaf Stocking:	217 sph immature, 267 sph understory
Stand Classification:	Type F3, site class G
# plots in polygon:	6

Notes:

- Higher residual volume than previous stands but immature stems are not merchantable.
- Vets are generally of poor quality with sweep and scars and may not contribute to volume at the next harvest.
- Leave the stand but it may be a higher priority for harvest than stands without vets because of the higher proportion of the site occupied by the vets.
- This stand is classified as Type F3: it has a residual component and BA of residual plus immature stems exceeds 20 m^2/ha. The stocking of immature stems is less than 800 sph and less than 50% of the BA is deciduous.

13.13 93G009 POLYGON 621 COTTONWOOD WEST

Area:	13.3 ha
Species Composition:	$Bl_{61}Sx_{16}Fd_{11}Pl_6Ep_5$
Inventory Label:	$Bl_{80}Sx_{13}Ep_5Pl_2$
Volume:	104 m^3/ha
Basal area distribution:	0 m^2/ha residual, 22 m^2/ha immature, 6% of BA is broadleaf
Conifer Stocking:	0 sph resid, 900 sph imm conif, 600 sph understory, 300 WS
Broadleaf Stocking:	200 sph understory
Stand Classification:	Type F7, site class G
# plots in polygon:	1

Notes:

- Minor deciduous content.
- Well-stocked stand of Bl, Fd, Sx with few residuals.
- Good growth on the immature component.
- Some sub-merch stems may become crop trees.
- This is an IU stand and the calculated volumes and species composition are based on low plot numbers.
- Leave until immature stems are merchantable.
- This stand is classified as Type F7: low residual component, IBA of residual plus immature stems exceeds 20 m^2/ha , but stocking of immature stems over 12.5 cm DBH exceeds 800.

13.14 93G009 Polygon 756 Cottonwood West

Area:	113.7 ha
Species Composition:	$Bl_{55}Pl_{18}Sx_{12}At_{11}Ep_{5}$
Inventory Label:	$Bl_{60}Sx_{20}Pl_{20}Ep_{8}At_{4}$
Volume:	88 m^3/ha
Basal area distribution:	3 m^2/ha residual, 14 m^2/ha immature, 15% of BA is broadleaf
Conifer Stocking:	40 sph resid, 476 sph imm conif, 627 sph understory, 314 WS
Broadleaf Stocking:	73 sph immature, 227 sph understory
Stand Classification:	Type F12, site class G
# plots in polygon:	22

Notes:

- Low residual volume but there is some volume over 35 cm.
- BA of immature stems is high enough that the sub merchantable stems will not contribute to the next crop.
- 900 stems/ha > 12.5 cm, 600 Bl > 12.5 cm.
- Stand is at the low end of stocking.
- Leave but place the stand fairly high in the harvest queue to increase site occupancy.
- This stand is classified as Type F12: the lowest category for stocking. It has a low residual volume, low BA of immature plus residual and low stocking of immature plus understory stems. Because of the large size of this polygon, its high site and the high number of plots in it, it should be checked to determine if the stand should be rehabilitated or scheduled for early harvest.

13.15 93H012 Polygon 811 Willow

Area:	49.8 ha
Species Composition:	$Bl_{88}Sx_{12}$
Inventory Label:	$Sx_{55}Bl_{45}$
Volume:	78 m^3/ha
Basal area distribution:	9 m^2/ha residual, 1 m^2/ha immature, no broadleaf
Conifer Stocking:	100 sph resid, 60 sph imm conif, silv. plots not entered
Stand Classification:	Type F12, site class M
# plots in polygon:	4

Notes:

- Stocking is mainly on the leave strips between the skid trails: trails are approximately 5 m in width with 13 m leave strips.
- Density in leave strips is approximately 1000 stems/ha.
- No residual layer, immature layer is growing well.

- Leave for now but should be a priority for harvest in the short term to increase site occupancy.
- This stand is classified as type F12: no residual layer and low numbers in immature and submerchantable stems. Addition of the information from the silviculture plots may show higher stocking and should move the polygon into a Type F10.

13.16 93H012 POLYGON 940 WILLOW

Area:	29.7 ha
Species Composition:	$Bl_{90}Sx_{10}$
Inventory Label:	$Bl_{65}Sx_{35}$
Volume:	157 m^3/ha
Basal area distribution:	20 m^2/ha residual, 4 m^2/ha immature, no broadleaf
Conifer Stocking:	200 sph resid, 200 sph imm conif, silv. plots not entered
Stand Classification:	Type F3, site class M
# plots in polygon:	2

Notes:

- Not a merchantable stand, residual component is low.
- Wide openings in the stand appear to be poorly stocked but the stand is not NSR.
- Further walkthroughs or a regeneration survey may be necessary to establish stocking in openings which from the orthophoto appear to be well-distributed across the polygon.
- Options: site prepare and plant openings, possibly brush control necessary OR leave and harvest when volumes are adequate and immature stems are merchantable OR if stocking is very low, rehabilitate and plant.
- This stand is classified as Type F3: the stocking of residuals and immature stems is high enough that the submerch layer does not count towards stocking.

13.17 93H012 POLYGON 1092 WILLOW

Area:	47.4 ha
Species Composition:	$Sx_{63}Bl_{37}$
Inventory Label:	$Bl_{76}Sx_{22}Pl_2Ep_1$
Volume:	133 m^3/ha
Basal area distribution:	17 m^2/ha residual, 3 m^2/ha immature, no deciduous
Conifer Stocking:	160 sph resid, 80 sph imm conif, silv. plots not entered
Stand Classification:	Type F3, site class M
# plots in polygon:	5

Notes:

- Overstory is very clumpy with openings large enough that larger stems in the submerch category will become crop trees.
- Some spruce weevil in the understory.
- Patches could be spaced but dominance has been expressed and the threat of increased spruce weevil suggests that no treatment may be a better option.
- This stand is classified as Type F3: high stocking of residual stems, and the stocking of immature plus residual is high enough that the submerch stems do not count towards stocking. Because of the clumpy nature of the larger stems, a portion of the submerch component perhaps should be counted towards stocking of the site.

13.18 93H023 Polygon 589 Ketcham

Area:	73.0 ha
Species Composition:	$Sx_{30}Pl_{30}Bl_{29}Ac_{10}$
Inventory Label:	$Sx_{57}Bl_{36}At_{7}$
Volume:	79 m^3/ha
Basal area distribution:	6 m^2/ha residual, 11 m^2/ha immature, 9% BA broadleaf
Conifer Stocking:	80 sph resid, 600 sph imm conif, 4500 stems/ha understory, 2250 WS
Broadleaf Stocking:	500 stems/ha understory
Stand Classification:	Type F10, site class G
# plots in polygon:	5

Notes:

- NW corner of the polygon has low coniferous stocking, is very brushy and should be typed as a separate unit.
- Remainder of the stand has a good immature layer and submerch stems that will contribute to the next crop.
- Leave.
- This stand is classified as Type F10: it has low residual stocking and a low enough BA of immature plus residual that understory stems will become crop trees in the future. It is well-stocked and has approximately 10% broadleaves.

13.19 93H023 Polygon 619 Ketcham

Area:	85.4 ha
Species Composition:	$Bl_{51}Sx_{49}$
Inventory Label:	$Bl_{68}Sx_{32}$
Volume:	143 m^3/ha
Basal area distribution:	10 m^2/ha residual, 12 m^2/ha immature, no broadleaf
Conifer Stocking:	100 sph resid, 417 sph imm conif, 3372 sph understory, 1686 WS
Stand Classification:	Type F9, site class G
# plots in polygon:	18

Notes:

- Similar to Antler Polygon 344 but the trees are slightly smaller.
- Submerch stems are too small to contribute to the next crop.
- This stand is classified as Type F9: it has a low residual component (but is right at the cutoff), and a high enough basal area of residual plus immature where the understory does not count towards the stocking. Although the classification puts this stand into a marginal or low stocking category, the field visit showed it to be well-stocked.

13.20 93H023 Polygon 708 Ketcham

Area:	44.7 ha
Species Composition:	$Bl_{61}Sx_{37}Pl_3$
Inventory Label:	$Bl_{52}Sx_{46}Pl_1Ac_1$
Volume:	84 m^3/ha
Basal area distribution:	4 m^2/ha residual, 9 m^2/ha immature, no deciduous
Conifer Stocking:	38 sph resid, 325 sph imm conif, 7025 sph understory, 3513 WS
Stand Classification:	Type F10, site class G
# plots in polygon:	8

Notes:

- This polygon is flat and appears to have low productivity perhaps due to cold, wet soils and a high water table.
- Understory mortality due to spruce budworm.
- Potential rehab but any treatment must consider the site limiting factors of cold, wet soils, frost, budworm and brush.
- This stand is classified as Type F10: it has a low residual component and a low BA of residual plus immature but is well-stocked with understory stems. There are no broadleaves present.