REVISED PERFORMANCE MEASURES FOR ASSESSING INVESTMENT BENEFITS IN THE BACKLOG AND ENHANCED FORESTRY PROGRAM

Prepared for
FOREST RENEWAL B.C.

by
Ministry of Forests
Forest Practices Branch

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FOREST RENEWAL BC

Province of British Columbia

FOREST SERVICE BRITISH COLUMBIA

MINISTRY OF FORESTS

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3. Table of Contents

4. Introduction:

This paper describes refinements to the original performance measures paper (July 2, 1999) and explains how the performance measure values have changed in the updated spreadsheet (Performance Measure Calculator). The Performance Measure Calculator (PMC) is still used to quantify the volume and employment benefits from FRBC investments in the Backlog and Enhanced Forestry Program. This provincial spreadsheet, when localized, can be used to assist in determining the appropriate level of investment needed to meet your timber supply and employment objectives, as well as non-timber resource objectives for that management unit. Localization may be regional or by management unit based on available information. At this point in time the PMC is provincial in scope; one set of performance measures for the province. Each region uses the same calculator and inputs their rolled up regional RMP activity goals. Future regionalization of the calculator will be based on information available on a region by region basis.

The Performance measure values in the PMC provide the benefits from investment based on the amount of hectares treated by silvicultural activity. The benefits are increased merchantable volume available at harvest and employment, both short and long term.

This paper provides a provincial example of the benefits derived by FRBC's investment in the Backlog and Enhanced Forestry Programs for the fiscal year 2001/02. All data entries in the calculator are based on provincial numbers (regional roll-ups and provincial averages). Each performance measure is also defined. When the PMC is localized to the regional or management unit level, some of these measures will change in value to reflect more localized information. Such information may include better estimates of potential volume gains by species for specific treatments, increased potential mean annual increment (mai) gains from backlog planting, and different person days/ha by activity to reflect local labour availability, experience and conditions.

Appendix 1 contains the revised Performance Measure Calculator (PMC).

5. Performance Measures for Forest Renewal B.C. - Provincial Investments for 2001/02

Purpose:

The purpose of the performance measure calculator is to provide an interim process for quantifying the potential gains due to FRBC investments at the stand and forest level. In the longer term the Incremental Silviculture Strategy process will provide a more detailed platform for demonstrating the benefits from FRBC investments.

The performance measures contained in the Performance Measure Calculator (PMC) collectively, provide a flexible tool that produces output benefits from a pre-determined level of silviculture investment at the forest estate level. The example in this document demonstrates the benefits derived at the provincial level from FRBC investments in the Backlog and Enhanced Forestry Programs for the fiscal year 2001/02.

Introduction:

The PMC provides an example of a Provincial summary, by performance measure, of the benefits of Forest Renewal BC Investments in the Backlog and Enhanced Forestry Program for the 2001/02 fiscal year. The PMC reflects the benefits from investment on a provincial scale based on a predetermined level of hectares by silvicultural activity. The level of activity includes both supporting the base case timber supply (TSR1) merchantable volume plus any additional merchantable volumes generated from the Backlog and Enhanced Forestry Programs.

This example is based on a certain set of assumptions. The performance measures illustrate the benefits derived for the five specific performance measure categories used in Table 1, and the 9 specific silvicultural activities in the Backlog and Enhanced Forestry Program.

The five performance measurement categories used in Table 1 are:

- Timber supply (Stand and Forest Level)
- Wood Value
- Wildlife - Habitat Supply
- Range – Domestic Forage
- Employment

The specific categories of silviculture expenditures in the Backlog and Enhanced Forestry Program of Forest Renewal BC are:

- Tree Improvement
- Nursery production of seedlings
- Silviculture Surveys
- Site preparation
- Backlog planting
- Brushing
- Spacing
- Pruning
- Fertilization

The definitions of the specific treatment activities are in Appendix 1.

6. Table Layout and Definitions of Performance Measures

Table Layout

The Performance Measure Calculator contains 24 performance measures. Not all measures are directly used in the determination of benefits derived from a certain level of input investment. It doesn't mean, however, that they are not important. Infact, the majority of measures are qualifiers to assist in determining allocations of limited funds to those activities that will achieve your management unit objectives. For example, in "Wildlife - Habitat Supply" or "Range - Domestic Forage", none of these measures determine volume response to treatment or amount of employment that is generated through FRBC investments.

Each activity has a "planned treatment area" that drives the spreadsheet. The utility of this spreadsheet is to input the hectares needed by silvicultural activity that will achieve the objectives of your management unit. Based on "treatment costs/ha" by activity the amount of annual budget can be then be generated. Conversely, knowing the allocation of funds for your management unit you can work backwards through the spreadsheet to determine the optimum mix of hectares to treat by activity that will most closely target your management unit objectives.

In the July 2, 1999 report, the "**planned treatment area**" hectare values for all activities other than Tree Improvement came from MOF Annual Report *(1998/99).* The Tree Improvement hectare value was derived based on the assumption that 35% of the seedlings are from Class A seed (Source: *Dale Draper, Director, Tree Improvement Branch).* In 1998/99 188,458 hectares were planted (MOF Annual Report - Forest Practices Branch). Assuming an even distribution of genetically improved stock over all hectares:

188,458 ha X 0.35 = 65,950 ha of genetically improved stock was planted in 1998/99.

For 2000/01 and 2001/02, the "**planned treatment area**" hectare values for all activities other than Tree Improvement came from Regional Resource Management Plan (RMP) roll-ups. For 2000/01 and 2001/02 approximately 165,000 (MOF – Forest Practices Branch) will be planted. A recent update for Tree Improvement Branch sets the percentage of A class seed at 37%. The hectares planted with A class seed therefore are:

165,000 ha X 0.37 = 61,050 ha of genetically improved stock will be planted in 2000/01 and 2001/02.

Treatment cost ($/ha) – regions should insert the average (reported) activity cost by activity for their region into the PMC.

Administration, Planning and Layout - for administration, planning and layout it is assumed that 1 person is required per $250,000 of treatment dollars. The value per person is $70,000.

The amount of employment per hectare is 0.24 person days/ha.

This figure is arrived at by : operating dollars/$250,000 per FTE = FTE's
Then FTE's / total area treated = person days/ha

The five performance measurement categories used in the PMC each have specific sub-component performance measures that are defined in Appendix 1. Sources and assumptions for the values appearing in the PMC for each performance measure are footnoted at the bottom of the PMC.

Definitions of Performance Measures

1.0 Timber Supply Stand level

1.1 % that is included in the current TSR base case

- what is the percentage of this silvicultural activity that increases merchantable volume is included in the TSR base case assumptions. Remember, each TSR base case is different. Each TSR base case will have it's own set of assumptions.

Example: In the Performance Measure Calculator 93% of all spacing is already included in the TSR base case assumptions. This means that 93% of all spacing is currently directed at maintaining or improving the timber supply.

Activity:

Tree improvement

- it is assumed that 20% of tree improvement is currently included in the TSR1 base case

Spacing

- it is assumed that 93% of spacing is currently included in the TSR1 base case

Pruning

- it is assumed that 5% of pruning is currently included in the TSR1 base case

Fertilization

- it is assumed that 5% of fertilization is currently included in the TSR1 base case. Source: MOF *Forest Practices Branch review of TSR 1.*

1.2 what is the volume/ha gain (m^3/ha/yr)

- for each silvicultural activity the PMC provides the best estimate of the merchantable volume gain on a per hectare basis per year. This volume gain is based on the predominant commercial species in the province (coast and interior).

Activity:

Tree Improvement

- *in the previous Performance Measure Calculator (PMC) , a 10% increase in volume was assumed due to outplanting of A class seed. It was also assumed an average increase of 0.39 m^3/ha/yr (provincial average based on 70% interior @ 0.23 cu. m/ha/yr increase and 30% coastal @ 0.77 cu. m/ha/yr increase).*

Note: In the revised Performance Measure Calculator, this activity no longer contributes to the volume gain due to silvicultural activities. The gains are reported separately.

Revised TIPSY (Version 3.0) runs were made to update the performance measure for Tree Improvement.

TIPSY 3.0 Runs	Site Index	Stems/ha	OAFs	Genetic Gain	MAI m^3/ha/yr
Coastal Fdc	30 m	4444 sph	N/A	0%	10.18
Coastal Fdc	30 m	4444 sph	N/A	10%	10.95
					0.77
50:50 Pli/Sx	20 m	5500 sph	N/A	0%	5.53
50:50 Pli/Sx	20 m	5500 sph	N/A	10%	5.74
					0.21

From the last column in the table above, the revised performance measure for Tree Improvement is 0.38 m^3/ha/yr (provincial average based on 70% interior @ 0.21 cu. m/ha/yr increase and 30% coastal @ 0.77 cu. m/ha/yr increase). The TIPSY output tables for these runs are in Appendix 2.

Silviculture Surveys

- *In the previous PMC it was assumed that 33% of all silviculture surveys collect detailed information on stocking status, site productivity and/or operational adjustment factors for yield. This proportion value was used in the calculation in performance measure 1.3 - "What is the total merchantable volume increment in 65 years".*
-

Note: The gains attributed to Silviculture Surveys have been re-apportioned to the appropriate activities that generate the gains; namely, backlog planting and brushing. The mai gain from Silviculture Surveys is now 0.0 cu. m/ha/yr.

Backlog planting

- Source: *(ISIS).* ISIS indicates that on TSAs the average site index of backlog NSR is 17.7m @ breast height 50 years. The average stocking on these areas is 374 well spaced trees/ha. Planting is assumed to increase stocking by 990 well spaced sph to 1364 well spaced stems/ha. Using TIPSY (Version 3.0) for the interior, the estimated incremental merchantable volume per hectare gain/year due to backlog planting on TSAs is 2.93 m^3/ha/yr. The NSR Stand had an mai of 1.85 cu. m/ha/yr at 80 years. The fill-planted stand had an mai of 4.78 at 80 years. The difference was 2.93 cu. m/ha/per year. Appendix 2 contains the TIPSY runs comparing the differences in mai of the NSR and fill-planted stands at 80 years. This is comparable to the work done by Smith (1988) FRDA Report 043. It must be noted that the majority of the gain comes from the interior where most of the backlog planting (particularly Prince George) is occuring.

  The volume gain from backlog planting = **2.93 cu. m/ha/yr**

Site Preparation

The shaded area in the table demonstrates that site preparation and backlog planting are integral treatments. For successful plantations on many of these backlog sites it is imperative to carry out site preparation. No volume gain was attributed to site preparation. The combination volume gains from site preparation and planting are included in the backlog planting column.

The volume gain from site preparation **= 0.0 cu. m/ha/yr**

Brushing

- It was assumed that brushing would be used to ensure 1) survival of existing plantations, 2) achievement of full growth potential of sites. Secondly, it was assumed that where manual brushing is done to achieve desired control of vegetation that up to 3 treatments would be required.. Thirdly, it was assumed that if brushing is not done 15% of plantations will fail and 85% of target plantations would have a 10% increase in unstocked ground. Depending on site index, species, and current stocking level the cost guidelines for backlog impeded stands predict gains of up to 1.4 m3/ha/yr in herbaceous complexes, 2.4 m3/ha/yr in tall shrub complexes and up to 5.3 m3/ha/yr in deciduous complexes. The estimated overall gain due to brushing target stands is 1.0 m^3/ha/yr. For manual brushing the estimated gain per treatment is 0.33 m3/ha/yr based on the assumption that 3 treatments are required. Where single entry conifer release by manual treatment occurs the 1.0 m3/ha/yr should be used.

By better defining the amount of brushing by complex the backlog cost guidelines can be used to more accurately predict the actual response to brushing at the management unit level.

The weighted average annual volume gain resulting from the amount of chemical and manual brushing carried on in the province is:

(mai gain/yr manual brushing X 1 year X percentage manual/yr) + (main gain/yr chemical X 1 year X percentage chemical/year) = mai gain/year from manual and chemical brushing activities
(0.33 cu. m/ha/yr x 1 year x 0.87) + (1.0 cu. m/ha/yr x 1 year x 0.12) **= 0.41 cu. m/ha/yr**

The volume gain from brushing = **0.41 cu. m/ha/yr**

Fertilization

- It was assumed that the average gain due to fertilization is 30 m^3/ha/yr on the coast and 20 m^3/ha/yr per application in the interior. A second assumption is that 60% of the fertilization is done on the coast and 40% done in the interior. Each management unit may vary in response based on available localized information and species.

  The weighted mai gain is (30/65 X .6) + (20/65 X .4) = .277+.123 = 0.40 cu. m/ha/yr

  The volume gain from fertilization = **0.40 cu. m/ha/yr**

Spacing

- The previous spreadsheet had a 0.0 cu. m/ha/yr volume gain from spacing. Runs for 5 commercial species (coast and interior) were made using TIPSY (Version 3.0). The runs are included in Appendix 2. The weighted average volume gain (12.5 plus 17.5 cm utilization levels) for the five species was 0.25 cu. m/ha/yr.

The volume gain from spacing = **0.25 cu. m/ha/yr**

1.3 what is the total volume increment in 65 years (m3)

- this value results from multiplying the merchantable volume/ha/year value (performance measure 1.2) by the number of hectares treated by that activity. This number is then multiplied by 65 years to attain the volume gain at harvest. There are assumptions that were made in original spreadsheet that are the same in this revised PMC. For example, for performance measure 1.3 this table uses a specific baseline rotation age of 80 years (treatment at age 15 years; 65 years post-treatment growth). It is the 65 years of growth projection (using TIPSY for lodgepole pine treated versus not treated) that gives us the projected volume difference. In this example one specific rotation age was used.

Forest Level Measures

1.4 Impact on timber supply at the forest level

- what is the percent impact by silvicultural activity on the overall timber supply merchantable volume at the forest level. The examples used in the PMC were taken directly from Management Plans (TFL and TSA). This information can only be determined by forest

level analyses. This information will become available as more Silviculture Strategies (e.g. Strathcona TSA) become available.

Activity:

Tree improvement

- a range is estimated to be 3-9%. Sources are a potential 3% gain in merchantable volume from tree improvement is assumed at the forest level in TFL 33. A 9% potential gain in merchantable volume from tree improvement is illustrated at the forest level in TFL 37.

Backlog planting

- An estimate of 0-5% potential increase in specific interdecadal wood flow is assumed at the forest level from backlog planting. The increase is attributable to more productive forest land base added to the net productive land base for the management unit. Source: MOF Forest Practices Branch.

Brushing

- A potential range from 0-9.4% increase in merchantable volume is assumed at the forest level from brushing. This is attributable to reduced brush competition and the trees growing at their potential until crown closure.

Source: *Deloitte Touche (1992) illustrates a potential 9.4% merchantable volume increase.*

Spacing

- A increase of 0-10% merchantable volume may be achieved at the forest level from spacing. This may mean a 0% increase in volume at the stand level but up to a 10% increase in available volume at the forest level depending upon unique features in the management unit you are working with. The amount of forest level impact from spacing on merchantable volume depends on the age class distribution within your management unit, number of hectare available for treatment, the species, the management objectives, and the growth and yield information available. Source: *TFL 24 illustrates a potential increase in merchantable volume by up to 10%.* ***Note:*** *In certain cases spacing may have a negative impact on TSA merchantable volumes and timber supply due to the objectives (e.g. Grizzly Bear habitat with very low stocking densities) the spacing is trying to achieve.*

Fertilizing

- A range from 2-13% increase in merchantable volume is assumed at the forest level from fertilizing.

Source: *Fraser TSA incorporates an increase in LRSY of 3%*

Source: *Timberline (1997) illustrates a potential 2-13% interdecadal wood supply improvement for the Arrowsmith & Kootenay Lake TSAs.*

Source: *TFL 5 illustrates a potential of an 8% mid & long term increase due to spacing & fertilizing appropriate stands.*

1.5 operability - reduced years to achieve TSR objectives

- each specific activity will have a different impact on available merchantable volume at harvest or operability (the time frame when stands become harvestable). The numbers expressed by activity relate to earlier operability; that is, to be able to enter stands at younger ages to harvest.

- it must be remembered that shorter rotation lengths may not be cumulative for combined treatments. Analyses would be required to determine cumulative effects.

Activity:

Tree improvement

- it is assumed that tree improvement will shorten rotation lengths by 5 -10 years. This is mainly due to superior genetic qualities to grow faster and produce more volume.

Nursery production

- it is assumed that nursery production will shorten rotation lengths by 1 - 3 years. This is attributed to larger stock type and better root development to minimize outplanting shock.

Site Prep/planting

- it is assumed that site preparation and planting will shorten rotation lengths by 5 - 20 years on backlog sites *(cannot separate these two treatment impacts as planting and site preparation are required on some backlog sites to get these sites back into production)*

Brushing

- it is assumed that brushing will shorten rotation lengths by 5 years

Spacing

- it is assumed that spacing will not increase stand volume but will shorten rotation lengths by 5 - 30 years. This is a result of achieving desired or minimum merchantable volume and piece sizes sooner. Source: FRDA Reports 014, 041 and 099, Nawitka Resource Consultants. Source: MOF Forest Practices Branch - Spacing Compendium (currently being compiled). Source: TIPSY

Fertilizing

- it is assumed that fertilization will shorten rotations by 5 - 10 years due to the extra volume. Source: FRDA Reports 054, 099, 266. Source: MOF Forest Practices Branch - Fertilization Compendium (currently being compiled)

2.0 Wood Value

2.1 Impact on wood value

- what is the impact of each silvicultural activity on wood value; is there a positive (+), negative (-), or neutral (0) impact on the wood value. Research is currently underway with the commercial species in B.C. to quantify the impacts of silvicultural activities on wood quality.

Spacing

- several factors contribute to value gains from spacing. These are all related to the retention of higher valued commercial species during the activity of spacing and the impact of a modest diameter distribution shift to larger, more uniform piece size at rotation. Reduced harvest, transporting, and milling costs, increased lumber recovery, increased product recovery and volume, and increased product diversity result from larger piece size due to spacing. Some potential gains attributable to spacing are included in an issues paper in Appendix 3.

Pruning

- the minimum value gain from pruning using 20 years of published data from Madisson's Lumber Reporter (clear versus not-clear dimensional material 2x4's and 2x6's) was 3.5 times. This translates to an minimum increase in stand value of 40%. The value of the wood being produced in a pruned stand is at least 40% higher value than wood growing in a non-pruned stand. *(Forest Practices Branch, unpublished report, 2001).*

Fertilization

- it was assumed that there is no value gain or loss from fertilizating. There is only a volume gain available at harvest.

2.2 proportion of area with this as primary objective

- what proportion of the hectares to be treated has wood value as the primary objective. This performance measure is directly related to 1.1 and may result in significant overlap. Collectively, 1.1 and 2.2 may add up to more than 100%.

Activity:

Spacing

- it is assumed that 100% of the hectares treated have wood value as the primary objective.

Pruning

- it is assumed that 87% of the hectares treated have wood value as the primary objective. Source: MOF Forest Practices Branch. Pruning is assumed to be 95% incremental to current base case TSR 1.

2.3 is this currently a part of the TSR base case assumptions

- is wood value currently considered by activity in the TSR base case assumptions? The primary objective of TSR 1 and TSR 2 is volume and not value. TSR 2 may look at value but volume is still the mandate. Each TSA will have to dealt with separately concerning wood value.

2.4 % that is incremental to the current TSR base case

- what percentage of the hectares treated by activity for wood value as the primary objective are incremental to the current TSR base case. This question must be dealt with on an individual management unit basis.

2.5 what improvement in total value at harvest (%)

- for each activity what improvement in wood value at the stand level is estimated at harvest. Benefits are estimated at the same harvest age comparing a treated versus non-treated stand.

Activity:

Spacing

- it is assumed that there will be a 7 - 15% increase in wood value (expressed as the increased amount of lumber products extracted from 1 cu. m of wood) at harvest from spacing This wood value increase was based on the percent increase in stems above 30 cm DBH in the stand (stand and stock tables) comparing TIPSY runs with and without spacing. Lumber Recovery Factor, defined as the amount of lumber products that can be extracted out of 1 cu. m of wood, increases dramatically as stem diameter increases from 15-30 cm. Lumber recovery flattens out beyond 30 cm. Even though there may not be an increase in the cu. m of standing volume per hectare, the amount of actual products extracted per cu. m of that standing volume has increased. Therefore, a value shift due to increased lumber recovery. Getting more output from the same input. Source: *(MOF Forest Practices Branch/TIPSY, Issues Paper in Appendix 3).*

Pruning

- it is assumed that there will be a minimum of a 40% increase in wood value from pruning at harvest. A quick review of the past 20 years of actual prices from Madison's Lumber Reporter clearly demonstrate a minimum of a 3.5 times increase in value per 1000 board feet of clear wood over it's knotty counterpart. The value was based on clear versus non-clear 2x4's and 2x6's, the lowest valued clear dimensional material. Recently, 4x4 clear spruce has hit the market. Instead of $340/Mfbm from SPF it sold for $2600/Mfbm. Source: *(Douglas-fir Task Force Report; MOF Forest Practices Branch unpublished paper on Clear wood, 2001; FORINTEK; Nawitka Report (Hyslop, 1992), Pruning Compendium research findings)*

Fertilization

- it is assumed that there will be a 0% increase or loss in wood value at harvest from fertilization. Source: *(MOF Forest Practices Branch)*

3.0 Wildlife - Habitat Supply

FRBC felt it important to include habitat supply as one of the performance measures. MELP will be tasked to provide input information to be included in TSR analyses.

At this point in time the performance measures in this section do not directly contribute to the volume gain or employment generation calculations. They do, however, provide feedback on priorities of silvicultural activities that meet multiple resource objectives. (e.g. in the allocation of limited funds).

3.1 Planned area for specific wildlife forage or winter range creation (hectares)

- how many hectares are proposed for treatment, by silvicultural activity, that are targeted specifically at creating, maintaining or increasing wildlife forage or for the creation of winter range, old growth enhancement, or restoration of riparian areas.

3.2 Wildlife species for which wildlife forage or winter range improved

- identify the wildlife species or group of species that the specific silvicultural activity has improved their wildlife forage or winter range. Wildlife code names may be entered at a future date to save space.

3.3 % of total treatment area which incorporates specific forest objectives for habitat/biodiversity

- what is the percentage of the total activity area planned for treatment that will actually be treated, by silvicultural activity, that incorporates specific forest objectives for habitat/biodiversity. This information should be in the Stand Management Prescription, and related to other plans (e.g. FDPs, LUPs, etc).

4.0 Range - Domestic Forage

- FRBC felt it also important to include Range - Domestic Forage in the performance measures package. It has been kept separate from "Wildlife - Habitat Supply as their objectives may be in conflict. It is important to specify if activities are specifically for "Wildlife - Habitat Supply" or "Range Domestic Forage".

4.1 % impact on transitional range available for domestic forage

- what is the percentage impact, by silvicultural activity, on the hectares of transitional range (grass seeded cut-over areas used for grazing) available annually for domestic forage.

4.2 impact on maintaining transitional range for domestic forage

- how many years can the use of transitional range for domestic forage be extended if treated, by silvicultural activity

4.3 % impact on amount of domestic forage available for grazing

- what is the percentage impact of treatment, by silvicultural activity, on the amount of domestic forage available for grazing

5.0 Employment

5.1 short term employment (person days/ha)

-is the amount of time required by one person to complete one hectare of a silvicultural activity. The source for this information is from the 3rd quarter FRBC IMS report March 29, 1999. Use the most recent short term employment figures available from last years FRBC Annual Reports.

5.2 total employment (person days/year)

- is the total planned treatment area (ha) times the short term employment factor (person days/ha) for that treatment. The units are person days/year.

5.3 total full time equivalent positions

- is the total number of person days/year divided by 180 working days/year. The assumption was made to use *180 days/year for 1 FTE* taken from *BC Stats: Outputs of Forest renewal BC Programs (1997-98)*

5.4 proportion that is first nations

- the proportion of the activity that is carried out by first nations crews. Source for this figure comes from *BC Stats: Outputs of Forest Renewal BC Programs (1997-98).* Forest Practices Branch assumption was made that first nations crews are working mainly on backlog planting and enhanced forestry program activities. *This information can be fine-tuned by Regions.*

5.5 proportion that is displaced forest workers

- the proportion of the activity that is carried out by displaced forest workers. The estimates in Table 1 are the best estimates available. FRBC Regional Directors may desire collection of more reliable estimates of displaced forest worker employment by activity.

Assumption: *Table 1 figures for displaced forestry workers is assumed to be 20% for backlog planting and the enhanced forestry program activities; 1% for surveys. This information may be fine-tuned Regions.*

5.6 proportion that is regular contractors/employees

- the proportion of the activity that is carried out by regular contractors/employees. The estimates in Table 1 are the best estimates available. FRBC Regional Directors may direct collection of more reliable estimates of regular contractor/employee employment by activity.

Assumption: *All percentage values in are Table 1 figures for this performance measure are best estimates to date. This information may be fine-tuned by Regions.*

5.7 Direct Long Term Employment – DLTE

- is long term (permanent) employment directly in the forest industry resulting from harvesting the total volume increment in 65 years (performance measure 1.3 – cell M22). The direct employment factor used was 1.31 direct jobs per 1000 cu. m of wood harvested. The source for this multiplier is *"Just The Facts, 1996"* and *"Economics and Trade Branch"*

Direct Long Term Employment was calculated as follows:

DLTE = 5,458,538 cu. m x 1.31/ 1000 cu. m per job = 7151 direct jobs

DLTE breakdown by activity (e.g. for spacing) was calculated as follows:

DLTE per activity = DLTE x (total employment by activity/ overall employment total - all activities)
e.g. Spacing DLTE for spacing = 7151 x (74,519/290,130) = 1837 jobs

5.8 Total Long Term Employment – TDLTE

- is total long term (permanent) employment directly in the forest industry and those jobs created that are indirectly related to the forest industry. These jobs are a result of harvesting the total volume increment in 65 years (performance measure 1.3 – cell M22). The total (direct plus indirect) employment factor used was 2.5 direct jobs per 1000 cu. m of wood harvested: The source of this multiplier is *"Just The Facts, 1996"*.

Total Direct Long Term Employment was calculated as follows:

TDLTE = 5,458,538 cu. m x 2.5/ 1000 cu. m per job = 13,646 direct jobs

TDLTE breakdown by activity (e.g. for spacing) was calculated as follows:

TDLTE per activity = TDLTE x (total employment by activity/ overall employment total - all activities)

e.g. Spacing TDLTE for spacing = 13,646 x (74,519/290,130) = 3505 jobs

6. APPENDIX 1: Revised Performance Measures Calculator

Performance Measures Calculator: **<insert here>**

Definitions of Backlog and Enhanced Silviculture Activities

1. Tree improvement - the genetic improvement of preferred commercial tree species through first and second generation provenance studies from plus tree orchard stock.

2. Nurseries production of seedlings - production of preferred species and stock types in private nurseries.

3. Silviculture surveys - stocking, site productivity and OAF type surveys

4. Site preparation - preparing sites to promote natural regeneration and/or facilitate planting, and control vegetation.

5. Backlog planting - restocking backlog NSR areas with seedlings.

6. Brushing - controlling competing vegetation to ensure survival of seedlings and realization of site potential by planted and natural regenerated trees on site.

7. Spacing - thinning dense stands to prevent growth limitations caused by overcrowding, and to leave target stand densities that will achieve specific stand and forest level objectives.

8. Pruning - pruning is the removal of live branches on a tree up to a specified lift height in managed stands to increase the stem wood quality and stand value.

9. Fertilizing - fertilizing is the addition of site limiting nutrients to increase tree and stand volume through a temporarily increase in site productivity.

8. APPENDIX 2: TIPSY (Version 3) runs

Coastal Douglas-fir (Site Index 30 m; planted 4444 sph; 0% Gain)

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AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Planted                            DELAY   : 0 years (Regeneration)
DENSITY : 4444   trees/ha                            : Plant 1 year old stock

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
100% Coastal Douglas-fir, site curve *Bruce (1981)
      TOP HEIGHT (m @ BH AGE 50)   :  30.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09
```

	Volume (m3/ha) and MAI				All Trees 0.0+				250 Prime 12.5+		
Age (yr)	Top Ht (m)	Gross 0.0+	Merch 12.5+	MAI	Merch 17.5+	MAI	BA (m2)	DBHg (cm)	TREES (#/ha)	CC (%)	M Vol (/ha)	DBHg (cm)	LC (%)
0.0	0.0	0	0	0.00	0	0.00	0	0.0	4444	0	0	0.0	0
10.0	2.9	3	0	0.00	0	0.00	0	1.2	4253	47	0	0.0	0
20.0	10.3	78	14	0.70	0	0.00	19	7.7	3970	98	8	14.0	68
30.0	17.1	238	156	5.20	76	2.53	37	11.5	3542	100	54	20.5	55
40.0	22.6	390	307	7.68	247	6.18	49	15.6	2558	100	120	27.1	47
50.0	27.2	544	455	9.10	404	8.08	59	19.2	2020	100	211	33.5	42
60.0	30.9	693	594	9.90	548	9.13	66	22.6	1650	100	314	38.8	40
70.0	34.1	819	709	10.13	670	9.57	72	25.6	1399	100	409	42.7	38
80.0	36.7	937	814	10.18	784	9.80	77	28.5	1206	100	502	46.1	37
90.0	39.0	1042	905	10.06	881	9.79	81	31.1	1065	100	590	49.0	35
100.0	41.1	1135	980	9.80	963	9.63	83	33.8	932	100	670	51.2	34

MAXIMUM MEAN ANNUAL INCREMENT TABLE

Max MAI (m3/ha)	Age (yr)	Volume (m3/ha)	Utilization Standards	
10.18	80.0	814	Merchantable	12.5+
9.80	80.0	784	Merchantable	17.5+

Coastal Douglas-fir (Site Index 30 m; planted 4444 sph; 10% Gain)

```
AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Planted                            DELAY   : 0 years (Regeneration)
DENSITY : 4444   trees/ha                            : Plant 1 year old stock

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
100% Coastal Douglas-fir, site curve *Bruce (1981)
      Genetic Worth: 10.0%, selection age 12.0
      TOP HEIGHT (m @ BH AGE 50)   :  Actual       31.54 (improved stock)
                                   :  Base         30.00 (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09
          |     Volume (m3/ha) and MAI      |    All Trees 0.0+   |250 Prime 12.5+
        Top|---------------------------------|---------------------|--------------
 Age    Ht |  Gross|   Merch    |   Merch    | BA   DBHg  TREES  CC|M Vol  DBHg  LC
 (yr)   (m)|   0.0+|12.5+   MAI |17.5+   MAI |(m2)  (cm)  (#/ha)(%)|(/ha)  (cm) (%)
-------------------------------------------------------------------------------------
  0.0   0.0       0     0   0.00     0   0.00    0   0.0   4444   0     0   0.0   0
 10.0   3.2       4     0   0.00     0   0.00    1   1.7   4237  51     0   0.0   0
 20.0  11.1      96    22   1.10     0   0.00   21   8.3   3952  99    13  14.4  68
 30.0  18.2     271   190   6.33   110   3.67   40  12.3   3380 100    65  22.0  53
 40.0  24.0     430   344   8.60   288   7.20   52  16.6   2379 100   140  28.8  46
 50.0  28.7     604   512  10.24   462   9.24   62  20.5   1864 100   252  35.7  41
 60.0  32.5     752   650  10.83   606  10.10   69  24.0   1524 100   357  40.7  39
 70.0  35.6     887   771  11.01   737  10.53   75  27.3   1280 100   461  44.7  37
 80.0  38.3    1007   876  10.95   850  10.62   79  30.2   1112 100   561  48.0  35
 90.0  40.6    1112   962  10.69   943  10.48   83  33.1    965 100   650  50.7  34
100.0  42.5    1204  1038  10.38  1025  10.25   85  35.9    841 100   730  52.8  34
-------------------------------------------------------------------------------------

         MAXIMUM MEAN ANNUAL INCREMENT TABLE

Max MAI     Age     Volume    Utilization
(m3/ha)     (yr)    (m3/ha)   Standards
--------------------------------------------------
  11.01     70.0      771     Merchantable   12.5+
  10.62     80.0      850     Merchantable   17.5+
--------------------------------------------------
```

50:50 Pli/Sx (Site Index 20 m; planted 4444 sph; 0% Gain)

```
AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Planted                            DELAY   : 0 years (Regeneration)
DENSITY : 4444   trees/ha                            : Plant 1 year old stock

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
 60% Lodgepole Pine, site curve *Nigh (1999)
      TOP HEIGHT (m @ BH AGE 50)   :  20.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24d 99-NOV

 40% White Spruce, site curve *Goudie (1984) (plantation)
      TOP HEIGHT (m @ BH AGE 50)   :  19.59  (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09
```

	Volume (m3/ha) and MAI					All Trees 0.0+				250 Prime 12.5+		
Age (yr)	Top Ht (m)	Gross 0.0+	Merch 12.5+	MAI	Merch 17.5+	MAI	BA (m2)	DBHg (cm)	TREES (#/ha)	CC (%)	M Vol (/ha)	DBHg (cm)	LC (%)
0.0	0.0	0	0	0.00	0	0.00	0	0.1	4440	1	0	0.0	0
10.0	2.5	3	0	0.00	0	0.00	1	1.8	4225	50	0	0.0	0
20.0	6.8	35	2	0.10	0	0.00	11	5.9	3963	82	0	0.0	0
30.0	11.1	110	47	1.57	10	0.33	25	9.2	3698	98	19	16.0	60
40.0	14.9	216	143	3.58	69	1.73	38	12.1	3277	100	48	20.5	51
50.0	18.1	315	242	4.84	162	3.24	46	14.6	2755	100	80	23.9	45
60.0	20.7	401	324	5.40	252	4.20	50	17.0	2219	100	112	26.5	42
70.0	22.9	474	390	5.57	330	4.71	52	19.3	1775	100	142	28.5	39
80.0	24.6	537	442	5.53	396	4.95	53	21.2	1486	100	171	30.2	38
90.0	26.1	589	480	5.33	446	4.96	53	22.8	1303	100	195	31.5	37
100.0	27.4	634	506	5.06	482	4.82	53	24.2	1155	100	217	32.6	36

MAXIMUM MEAN ANNUAL INCREMENT TABLE

Max MAI (m3/ha)	Age (yr)	Volume (m3/ha)	Utilization Standards	
5.57	70.0	390	Merchantable	12.5+
4.96	90.0	446	Merchantable	17.5+

50:50 Pli/Sx (Site Index 20 m; planted 4444 sph; 10% Gain)

```
AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Planted                            DELAY   : 0 years (Regeneration)
DENSITY : 4444   trees/ha                            : Plant 1 year old stock

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
 50% Lodgepole Pine, site curve *Nigh (1999)
      Genetic Worth: 10.0%, selection age 10.0
      TOP HEIGHT (m @ BH AGE 50)   :  Actual       21.06 (improved stock)
                                   :  Base         20.00 (site index)
      TABLE SOURCE                 :  TASS v2.05.24d 99-NOV

 50% White Spruce, site curve *Goudie (1984) (plantation)
      TOP HEIGHT (m @ BH AGE 50)   :  19.59  (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09
```

	Volume (m3/ha) and MAI				All Trees 0.0+				250 Prime 12.5+		
Age (yr)	Top Ht (m)	Gross 0.0+	Merch 12.5+	MAI	Merch 17.5+	MAI	BA (m2)	DBHg (cm)	TREES (#/ha)	CC (%)	M Vol (/ha)	DBHg (cm)	LC (%)
0.0	0.0	0	0	0.00	0	0.00	0	0.1	4441	1	0	0.0	0
10.0	2.5	4	0	0.00	0	0.00	1	1.8	4226	46	0	0.0	0
20.0	6.7	36	4	0.20	0	0.00	11	5.8	3966	78	0	0.0	0
30.0	11.2	113	54	1.80	15	0.50	25	9.3	3660	98	21	16.2	59
40.0	15.1	223	149	3.72	79	1.98	38	12.3	3240	100	51	20.7	50
50.0	18.4	326	251	5.02	172	3.44	47	14.7	2744	100	84	24.3	45
60.0	21.1	415	339	5.65	268	4.47	51	17.3	2182	100	117	26.9	41
70.0	23.4	490	403	5.76	345	4.93	52	19.7	1718	100	149	29.0	39
80.0	25.2	561	459	5.74	416	5.20	54	21.7	1453	100	181	30.9	37
90.0	26.8	616	497	5.52	466	5.18	54	23.4	1256	100	207	32.3	36
100.0	28.1	662	522	5.22	501	5.01	54	24.9	1098	100	230	33.4	35

MAXIMUM MEAN ANNUAL INCREMENT TABLE

Max MAI (m3/ha)	Age (yr)	Volume (m3/ha)	Utilization Standards	
5.76	70.0	403	Merchantable	12.5+
5.20	80.0	416	Merchantable	17.5+

MAI difference: Backlog Planted stand versus NSR

- NSR Stand

```
AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Natural                            DELAY   : 2 years (Regeneration)
DENSITY : 374    trees/ha

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
 50% Lodgepole Pine, site curve *Nigh (1999)
      TOP HEIGHT (m @ BH AGE 50)   :  18.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24d 99-NOV

 50% White Spruce, site curve *Goudie (1984) (natural)
      TOP HEIGHT (m @ BH AGE 50)   :  18.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09
```

	Volume (m3/ha) and MAI				All Trees 0.0+				250 Prime 12.5+		
Age (yr)	Top Ht (m)	Gross 0.0+	Merch 12.5+	MAI	Merch 17.5+	MAI	BA (m2)	DBHg (cm)	TREES (#/ha)	CC (%)	M Vol (/ha)	DBHg (cm)	LC (%)
10.0	1.0	0	0	0.00	0	0.00	0	0.0	370	1	0	0.0	0
20.0	3.8	1	0	0.00	0	0.00	0	3.4	361	9	0	0.0	0
30.0	7.5	7	4	0.13	1	0.03	2	8.8	353	21	0	0.0	0
40.0	11.1	22	16	0.40	12	0.30	6	14.2	348	34	15	17.0	78
50.0	14.4	47	40	0.80	34	0.68	10	19.4	344	48	36	21.0	77
60.0	17.2	82	73	1.22	69	1.15	15	23.6	340	58	64	25.6	76
70.0	19.6	122	110	1.57	108	1.54	19	27.1	337	65	98	29.4	74
80.0	21.7	160	148	1.85	147	1.84	23	29.8	334	70	131	32.3	71
90.0	23.4	200	187	2.08	186	2.07	27	32.2	331	74	164	34.7	69
100.0	24.9	235	220	2.20	220	2.20	30	34.1	328	76	195	36.6	66

MAI difference: Backlog Planted stand versus NSR

- Backlog Planted

```
AGENCY  : MOF Research Branch                TIPSY Version 3.0b
PROJECT : Experimental                       SINDEX Version 1.14

REGEN.  : Planted                            DELAY   : 0 years (Regeneration)
DENSITY : 1364   trees/ha                            : Plant 1 year old stock

Operational Adjustment Factors: OAF1: 1.00   OAF2: 1.00   Combined OAF: 1.00

SPECIES
 50% Lodgepole Pine, site curve *Nigh (1999)
      TOP HEIGHT (m @ BH AGE 50)   :  18.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24d 99-NOV

 50% White Spruce, site curve *Goudie (1984) (plantation)
      TOP HEIGHT (m @ BH AGE 50)   :  18.00  (site index)
      TABLE SOURCE                 :  TASS v2.05.24b 97-OCT-09



Multiple Species option aggregates pure stands for forest-level planning.
It is NOT VALID for mixed-species SILVICULTURAL applications.
```

		Volume (m3/ha) and MAI					All Trees 0.0+				250 Prime 12.5+		
Age (yr)	Top Ht (m)	Gross 0.0+	Merch 12.5+	MAI	Merch 17.5+	MAI	BA (m2)	DBHg (cm)	TREES (#/ha)	CC (%)	M Vol (/ha)	DBHg (cm)	LC (%)
0.0	0.0	0	0	0.00	0	0.00	0	0.0	1363	0	0	0.0	0
10.0	2.0	0	0	0.00	0	0.00	0	1.3	1330	15	0	0.0	0
20.0	5.5	9	1	0.05	0	0.00	3	5.8	1286	49	0	0.0	0
30.0	9.4	42	22	0.73	6	0.20	12	11.0	1257	78	11	15.2	71
40.0	12.9	109	85	2.12	52	1.30	24	15.7	1244	95	35	20.4	66
50.0	16.0	194	169	3.38	136	2.72	35	18.9	1240	99	65	24.7	58
60.0	18.6	276	249	4.15	223	3.72	43	21.1	1236	100	96	27.8	50
70.0	20.8	346	318	4.54	296	4.23	49	22.6	1220	100	124	29.8	46
80.0	22.7	415	383	4.79	365	4.56	54	23.9	1195	100	153	31.7	43
90.0	24.3	470	435	4.83	420	4.67	57	25.1	1157	100	178	33.1	41
100.0	25.6	514	472	4.72	460	4.60	59	26.0	1112	100	199	34.1	39

MAI value for Spacing performance measure

In the first provincial performance measures table spacing had a 0.00 cu. m/ha value. The following table are extracted from a draft report "Volume Gains from Juvenile Spacing, 2001), demonstrates a modest 0.25 cu. m/ha/yr (about 16 cubic metres per hectare at age 80 years) volume gain based on several TIPSY runs for 5 species (Coastal Douglas-fir, coastal western hemlock, interior Lodgepole Pine, interior Douglas-fir and interior Spruce). The value above was calculated by finding the weighted average of volume gains by species for both the 12.5 and the 17.5 cm utilization levels. Tables 1a-e below show several runs by species and post spacing densities. The volume differences between spaced and un-spaced stands in these tables were used to derive the 0.25 cu. M/ha/yr value.

Table 1a:

Species	Spacing	Site	12.5+ cm (harvest at 80 yrs)			17.5+ cm (harvest at 80 yrs)		
Fdc	Density	Index	Vol	MAI	Vol diff	Vol	MAI	Vol diff.
Plant 4444	4444	30	625	8.33	0	597	7.96	0
Plant 4444	800	30	669	8.36	44	666	8.32	69
Plant 4444	600	30	602	8.03	-23	600	8.00	3

Table 1b:

Species	Spacing	Site	12.5+ cm (harvest at 80 yrs)			17.5+ cm (harvest at 80 yrs)		
Hw	Density	Index	Vol	MAI	Vol diff	Vol	MAI	Vol diff.
Natural 8000	8000	27.5	821	10.26	0	804	10.05	0
Natural 8000	1100	27.5	802	10.02	-19	798	9.98	-6
Natural 8000	1200	27.5	808	10.10	-13	804	10.05	0

Table 1c:

Species	Spacing	Site	12.5+ cm (harvest at 80 yrs)			17.5+ cm (harvest at 80 yrs)		
Pli	Density	Index	Vol	MAI	Vol diff	Vol	MAI	Vol diff.
Natural 10,000	10,000	20	340	4.25	0	303	3.79	0
Natural 10,000	1600	20	358	4.47	18	344	4.3	41
Natural	1800	20	357	4.46	17	342	4.28	39
Natural 10,000	2200	20	355	4.44	15	337	4.21	34

Table 1d:

Species	Spacing	Site	12.5+ cm (harvest at 80 yrs)			17.5+ cm (harvest at 80 yrs)		
Fdi	Density	Index	Vol	MAI	Vol diff	Vol	MAI	Vol diff.
Natural 8000	8000	20	269	3.36	0	229	2.86	0
Natural 8000	1600	20	272	3.4	3	244	3.05	15
Natural 8000	1800	20	270	3.38	1	241	3.01	12

Table 1e:

Species	Spacing	Site	12.5+ cm (harvest at 80 yrs)			17.5+ cm (harvest at 80 yrs)		
Sx	Density	Index	Vol	MAI	Vol diff	Vol	MAI	Vol diff.
Natural 8000	8000	20	350	4.38	0	306	3.83	0
Natural 8000	1600	20	364	4.55	14	343	4.29	37
Natrual 8000	1800	20	364	4.55	14	341	4.26	35
Natural 8000	2200	20	361	4.51	11	335	4.19	29

Spacing showed a small positive volume response to all species except for coastal western hemlock (spaced to 1100 sph at both utilization standards, and at the 12.5+ cm utilization stand spaced to 1200 sph) and coastal Douglas-fir spaced to 600 sph at a 12.5+ cm utilization. Decreases in merchantable volume at the stand level does not necessarily mean reductions in stand wood value. Spacing has a positive impact on stand value by eliminating the higher cost of harvesting small logs plus shifting the diameter distribution of the remaining crop trees upward due to more growing space available per crop tree. At this point in time value gains from spacing will be based on the difference in net harvest revenues. Further work will fine-tune value gains from spacing based on cost savings in harvesting, transporting, sorting and milling costs. Value gains will be based on increased lumber recovery from larger, more uniform piece sizes, more recoverable merchantable volume at harvest, and increased product diversity from larger logs.

9. APPENDIX 3: Issue Paper – Potential Value Gains from Spacing, Pruning and Fertilization

The bullets below are from a draft Issue Paper (30 pages). The paper details the potential value gains from each of the bullet items listed below. This Issue Paper represents the first attempt to isolate the impediments to quantifying the value gains from spacing, pruning and fertilization. This issue paper will be reviewed internally by Economics and Trades and Research Branches for input and future direction .

Introduction - Items that Affect Value

Based on current markets and manufacturing technologies, juvenile spacing, fertilization and pruning activities can affect stand value in the following ways:

- concentrating growth on higher-valued species, by removing lesser-valued species during spacing;
- reducing tree to truck logging cost, by decreasing the number of logs and increasing log size while retaining similar stand volume;
- reducing manufacturing cost, by higher throughput associated with more uniform log size;
- increasing lumber recovery (green LRF), by creating larger, more uniform log sizes;
- increasing lumber recovery in drying (dry LRF), by
    a) reducing the compression wood component by the removal of poorly formed stems (e.g., sweep, crook, forks) during spacing,
    b) reducing the proportion of juvenile wood through stand management practices; and
- increasing lumber value recovery, by
    a) increasing the proportion of larger dimension lumber as a result of larger log sizes,
    b) improving lumber strength, by reducing the proportions of compression and juvenile wood, and
    c) increasing the clear wood component (appearance) by pruning lower branches.

The current MoF methodology for estimating the value gains associated with each of these is detailed below. Where the methodology or information is deficient, a workaround methodology is documented if available. An example is also given. Information needs and suggested ways to improve methodology are then itemized.