



Cortex Consultants

Fertilization Strategy and Tactical Plan: Quesnel Timber Supply Area

Version 1

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prepared for: **Quesnel TSA Strategic Forest Analysis Steering
Committee**
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1 Introduction

The BC Forests for Tomorrow initiative is a provincial strategy to improve long-term timber supply through the re-establishment of forests that would otherwise remain non- or under-productive. The program includes the planning, development, and operations necessary to rehabilitate and reforest areas affected by: the Mountain Pine Beetle and wildfire; pre-existing areas classed as Not Satisfactorily Restocked; and, potentially, other areas that would otherwise not be re-forested (MoFR, 2005).

A potential method of improving timber supply is to enhance the growth of forest stands through fertilization. Forest fertilization has recently been approved in principle as a Mountain Pine Beetle (MPB) mitigation treatment.

The Quesnel Timber Supply Area (TSA) is a prime candidate area for mitigation since it is one of the areas most heavily impacted by the MPB. Significant short- to mid-term timber supply impacts have been forecast (MoF, 2004).

1.1 Project Objective

The objective of this project is to develop a tactical level fertilization strategy for the Quesnel TSA. The tactical strategy will provide the rationale for a five-year fertilization scheme and will spatially identify potential candidate stands. Candidate stands will require field reconnaissance in 2006 to confirm the proposed treatment. The field reconnaissance will be conducted under a separate operational-level project implementation led by West Fraser Mills Ltd. in Quesnel. It is expected that the TSA implementation will be coordinated with TFL and other proposed fertilization schemes to maximize efficiencies and minimize costs. The objectives of the fertilization strategy are:

- to mitigate short and mid-term timber supply impacts through strategically focused fertilization activities,
- to add merchantable volume to existing age class 1-4 stands to ensure that they can be operable sooner and mitigate mid-term timber supply impacts,
- to modify age class imbalances and help redistribute timber flow and availability,
- to help reduce the depth and duration of reduced timber supply,
- to help reduce the community and regional economic impacts due to the MPB infestation,
- to carry out investments in crown land to support both short and mid term employment, and
- to be an important complement to the FFT strategic investments which primarily focus on improving mid- to long-term impacts.

2 Methods

2.1 Developing an Initial Candidate Stand List

Fertilization candidate stands were selected from the resultant used for the Quesnel Type II silviculture analysis. Key selection criteria were the primary species, inventory site index, and inventory age class. Stands from the total productive forest were included in the selection set. In a second step, additional polygons were removed from the first selection set using refined criteria. Table 1 list the criteria used in the analysis.

Table 1. Criteria for identifying candidate areas for fertilization.

Criteria #	Criteria	Criteria Notes
1	Leading species >80% F or S, wet belt or transition (submesic, and mesic)	
1	F or S mixed > 60%, wet belt or transition (submesic, subhygric and mesic)	
2	Site Index > 16 (current inventory based)	
3	Priority age class: 5 then 4 then 3 then 2	Age class 5=81 to 100 yrs Age class 4=61 to 80 yrs Age class 3=41 to 60 yrs Age class 2=21 to 40 yrs
4	Avoid rare ecosystems: SBSmw/00, MSxv/05, MSxv/02, SBSmw/03, SBSmk/02, SBSwk1/03	
5	Avoid ungulate management areas	
6	Avoid high snow loading areas	
7	Avoid blocks with a high proportion of RMA, RRZ	Used only RRZ as selection criteria.
8	Avoid ESA's	
9	Avoid OGMA's	
n/a	Avoid proposed CLA's (Conservation Legacy Areas)	Final CLA's not available for the analysis. This selection criteria was not used.
10	< 100 km. to mills	110 km was used to represent Quesnel city limits.
11	Target stands within 2 km. of existing roads	This was completed using orthophotos during visual selection process.
12	Slopes < 40%	All slopes in the final analysis area were < 40% slope.

2.2 Establishing Stand Priorities with Orthophotos

Candidate stands were selected from the resultant using criteria 1-9. A coverage developed from this selection set was plotted on orthophotos, which were subsequently reviewed visually to select candidate stands using selection criteria 10, 11 and 12. Polygons were ranked as 1 (good

candidate and requires immediate inspection), 2 (medium candidate and inspection can be completed in 2007 and beyond), and 3 (poor candidate not requiring inspection).

2.3 Estimating Yields for Interim Candidate Stand Types

Following photo assessment, batchTIPSY and TIPSY were used to update inventory volumes, predict harvest volume, and produce economic value estimates. Brockley (pers. com.) suggested that batchTIPSY may underestimate fertilization effectiveness and/or unduly increase compensation for competition, so yields were estimated with both systems.

2.3.1 batchTIPSY

Two yield tables per polygon were produced: no fertilization and fertilization. Fertilization age is inventory age.

For stands aged >40 years natural regeneration is assumed. All other assumptions are based on TSR 2 documentation.

Stands aged ≤ 40 are assumed planted and used all other TSR 2 assumptions.

For Douglas-fir polygons all BEC zone are assumed to be ICH. This assumption is applied because TIPSY does not show gains for all other interior BEC zones.

Table 2 lists the assumptions used for the batchTIPSY runs.

The harvest age is estimated by finding the minimum age when the polygon reaches 140 m³/ha. Minimum harvest age is calculated as the age when polygon volume is ≥ 140 m³/ha. If the minimum harvest age is less than the fertilization age the minimum harvest age is fertilization age + 10. If the minimum harvest age is below the inventory age, then harvest age is inventory age + 10. Volume and revenue estimates are based on the volume harvested at the harvest age.

The total volume benefit from fertilization is calculated as the harvest volume from the fertilized yield table **minus** harvest volume from the non-fertilized yield table.

2.3.2 TIPSY

Fertilization analysis units are specified based on primary species, secondary species, BEC label, and inventory age. It was assumed that all secondary species for Douglas-fir are spruce (Brockly, pers. comm. and all secondary species in spruce polygons were ignored. The fertilization effectiveness was assumed to be 100% in consideration of the OAF1 and OAF2 values of 85% and 95% respectively. Table 3 lists the TIPSY assumptions.

Minimum harvest age is calculated as fertilization age + 10 or the age when polygon volume is ≥ 140 m³/ha. If the minimum harvest age is less than the fertilization age the minimum harvest age is fertilization age + 10. If the minimum harvest age is below the inventory age, the harvest age is inventory age + 10. Volume and revenue estimates are based on the volume harvested at the harvest age.

The total volume benefit from fertilization is calculated as: harvest volume from the fertilized yield table **minus** harvest volume from the non-fertilized yield table.

Table 2. batchTIPSY assumptions used in the fertilization analysis.

Primary Species	Inventory Age	Regen Method	Regen Delay	Expected Species	% Composition	Initial Density	BEC	Fert Age	OAF 1	OAF 2
Fdi	> 40	Natural	2	Inventory Species 1 and Species 2	Inventory Species 1 % and Species 2 %	2300	ICH	Inventory Age	15	5
Fdi	<= 40	Plant	2	Inventory Species 1 and Species 2	Inventory Species 1 % and Species 2 %	2300	ICH	Inventory Age	15	5
S	> 40	Natural	2	Inventory Species 1 and Species 2	Inventory Species 1 % and Species 2 %	3000	Inventory BEC	Inventory Age	15	5
S	<= 40	Plant	2	Inventory Species 1 and Species 2	Inventory Species 1 % and Species 2 %	3000	Inventory BEC	Inventory Age	15	5

Table 3. TIPSy assumptions used in the fertilization analysis.

Fert Au	Species 1	Species 2	% Composition	Site Index Break	Inv. Age	Initial Density	BEC	Weighted Site Index	Regen Method	Fert Age	Area (ha)
100	FD		100	>=18.6	> 40	2300	ICH	20.5	Natural	72	1,440
101	FD		100	16-18.5	> 40	2300	ICH	16.7	Natural	72	2,532
200	FD		100	>=18.6	<= 40	2300	ICH	20.4	Planted	28	119
201	FD		100	16-18.5	<= 40	2300	ICH	16.9	Planted	31	1,286
300	FD	S	82/18	>=18.6	> 40	2300	ICH	21.8	Natural	75	255
301	FD	S	83/17	16-18.5	> 40	2300	ICH	17.2	Natural	68	172
400	FD	S	80/20	>=18.6	<= 40	2300	ICH	20.9	Planted	32	84
401	FD	S	83/17	16-18.5	<= 40	2300	ICH	17.0	Planted	29	553
500	S		100	>= 17.1	> 40	3000	IDF	20.8	Natural	70	18
501	S		100	>= 17.1	> 40	3000	MS	25.0	Natural	52	5
502	S		100	>= 17.1	> 40	3000	SBPS	19.2	Natural	64	547
503	S		100	>= 17.1	> 40	3000	SBS	20.7	Natural	78	402
511	S		100	16-17	> 40	3000	MS	16.0	Natural	50	10
512	S		100	16-17	> 40	3000	SBPS	16.4	Natural	64	799
513	S		100	16-17	> 40	3000	SBS	16.6	Natural	83	241
601	S		100	>= 17.1	<= 40	3000	MS	19.0	Planted	22	2
602	S		100	>= 17.1	<= 40	3000	SBPS	20.8	Planted	31	65
603	S		100	>= 17.1	<= 40	3000	SBS	19.0	Planted	24	42
611	S		100	16-17	<= 40	3000	MS	16.0	Planted	38	89
612	S		100	16-17	<= 40	3000	SBPS	16.0	Planted	29	58
613	S		100	16-17	<= 40	3000	SBS	16.0	Planted	32	53

2.4 Determination of Return on Investment

Revenue estimates were derived for dimension lumber volumes outputs from the batchTIPSY and TIPSY runs. Three different price levels were used in the analysis: low, medium, and high. The price levels are based on assessment of data prices from the last 20 years and U.S.F.S. projections¹ (Winkle, pers. comm.). Also utilized are the default prices for TIPSY which are based on 2001 data.

Table 4 lists the dimensions used and the price assumptions for the analysis.

Table 4. Dimensions and prices used in the fertilization analysis.

Value Cycle	Species	Lumber (\$/MBF)				Chips (\$/BDU)
		2x4	2x6	2x8	2x10	
Low						
	Interior Douglas-fir	173	300	298	426	50
	White spruce	150	250	250	350	50
Medium						
	Interior Douglas-fir	289	420	417	547	75
	White spruce	250	350	350	450	75
High						
	Interior Douglas-fir	404	541	536	669	100
	White spruce	350	450	450	550	100
TIPSY Default						
	Interior Douglas-fir	498	507	511	625	110
	White spruce	431	422	429	514	110

Fertilization costs are estimated at \$350/ha, and includes the cost of purchase and application. Application costs are expected to average \$180.00/ha.

Revenue gain from fertilization is calculated as harvest revenue from fertilized yield table minus harvest revenue from non-fertilized yield table.

Net revenue from fertilization is calculated as revenue gain from fertilization **minus** fertilization cost.

¹ From Section 5.2 Economics and Forest Products Outlook, Stand Density Management in the Cariboo: Recommendations for a Management by Objectives Approach. (P. Winkle, Jan. 2005)

Return on investment (ROI) from fertilization at medium cycle prices is calculated as:

$$((\text{revGain} / (\text{disc_factor} ^ \text{harv_year})) - \text{fert_cost}) / \text{fert_cost} * 100$$

2.5 Selection and Prioritization of Candidate Stands

The final selection and prioritization is based on proximity of polygons, stand size, harvest year, and ROI grouping. The final selection further stratifies the candidate stands selected through the photo assessment.

2.6 Additional Database and GIS Query Definitions

Another set of selection queries was specified that select polygons based on species, age, site index, and proximity to Quesnel (Table 5). All selection criteria except proximity to Quesnel were completed aspatially. This selection set is then linked to a resultant and polygons were selected based on proximity criteria. A portable database has been created showing the results of the queries.

Table 5. Additional database and GIS queries for the fertilization analysis.

Query	Species 1	Species 2	Age (yrs)	Site Index (m)	Dist* (km)
A1	F		60 - 80	18+	<100
A2	S		60 - 80	18+	<100
A3	F		60 - 80	15 -18	<100
A4	S		60 - 80	15- 18	<100
A5	F	S	60 - 80	18+	<100
A6	S	F	60 - 80	18+	<100
A7	F	S	60 - 80	15 -18	<100
A8	S	F	60 - 80	15- 18	<100
A9	F		60 - 80	18+	100 - 200
A10	S		60 - 80	18+	100 - 200
A11	F		60 - 80	15 -18	100 - 200
A12	S		60 - 80	15- 18	100 - 200
A13	F	S	60 - 80	18+	100 - 200
A14	S	F	60 - 80	18+	100 - 200
A15	F	S	60 - 80	15 -18	100 - 200
A16	S	F	60 - 80	15- 18	100 - 200
A17	F		40 - 60	18+	<100
A18	S		40 - 60	18+	<100
A19	F		40 - 60	15 -18	<100
A20	S		40 - 60	15- 18	<100
A21	F	S	40 - 60	18+	<100

Query	Species 1	Species 2	Age (yrs)	Site Index (m)	Dist* (km)
A22	S	F	40 - 60	18+	<100
A23	F	S	40 - 60	15 -18	<100
A24	S	F	40 - 60	15- 18	<100
A25	F		40 - 60	18+	100 - 200
A26	S		40 - 60	18+	100 - 200
A27	F		40 - 60	15 -18	100 - 200
A28	S		40 - 60	15- 18	100 - 200
A29	F	S	40 - 60	18+	100 - 200
A30	S	F	40 - 60	18+	100 - 200
A31	F	S	40 - 60	15 -18	100 - 200
A32	S	F	40 - 60	15- 18	100 - 200
A33	F		15 - 40	18+	<100
A34	S		15 - 40	18+	<100
A35	F	S	15 - 40	18+	<100
A36	S	F	15 - 40	18+	<100
A37	F		15 - 40	18+	100 - 200
A38	S		15 - 40	18+	100 - 200
A39	F	S	15 - 40	18+	100 - 200
A40	S	F	15 - 40	18+	100 - 200
B1	F	PI	60 - 80	18+	<100
B2	S	PI	60 - 80	18+	<100
B3	F	PI	60 - 80	15 -18	<100
B4	S	PI	60 - 80	15- 18	<100
B5	F	PI	60 - 80	18+	100 - 200
B6	S	PI	60 - 80	18+	100 - 200
B7	F	PI	60 - 80	15 -18	100 - 200
B8	S	PI	60 - 80	15- 18	100 - 200
B9	F	PI	40 - 60	18+	<100
B10	S	PI	40 - 60	18+	<100
B11	F	PI	40 - 60	15 -18	<100
B12	S	PI	40 - 60	15- 18	<100
B13	F	PI	40 - 60	18+	100 - 200
B14	S	PI	40 - 60	18+	100 - 200
B15	F	PI	40 - 60	15 -18	100 - 200
B16	S	PI	40 - 60	15- 18	100 - 200
B17	F	PI	15 -40	18+	<100
B18	S	PI	15 -40	18+	<100
B19	F	PI	15 -40	18+	100 - 200
B20	S	PI	15 -40	18+	100 - 200

3 Results

3.1 Interim Candidates

The photo assessment identified 6,101 ha as candidate type 1 (good). Of this 6,101 ha, 641 ha are classified as Woodlot ownership, leaving a total area classified as interim candidates of 5,460 ha. Table 6 provides the area summary by candidate classification.

Table 6. Area by fertilization candidate type.

Candidate #	Candidate Type	Land Base Classification	Area
1	Good	Productive – Crown	5,460
1	Good	Productive – Woodlot	641
		Total	6,101
2	Medium	Productive – Crown	1,787
2	Medium	Productive – Woodlot	135
		Total	1,922
3	Poor	Productive – Crown	717
3	Poor	Productive – Woodlot	30
		Total	747

The majority of good candidate stands are located south west of Quesnel. Figures 1-3 show the location of initial candidate stands.

Initial Candidates

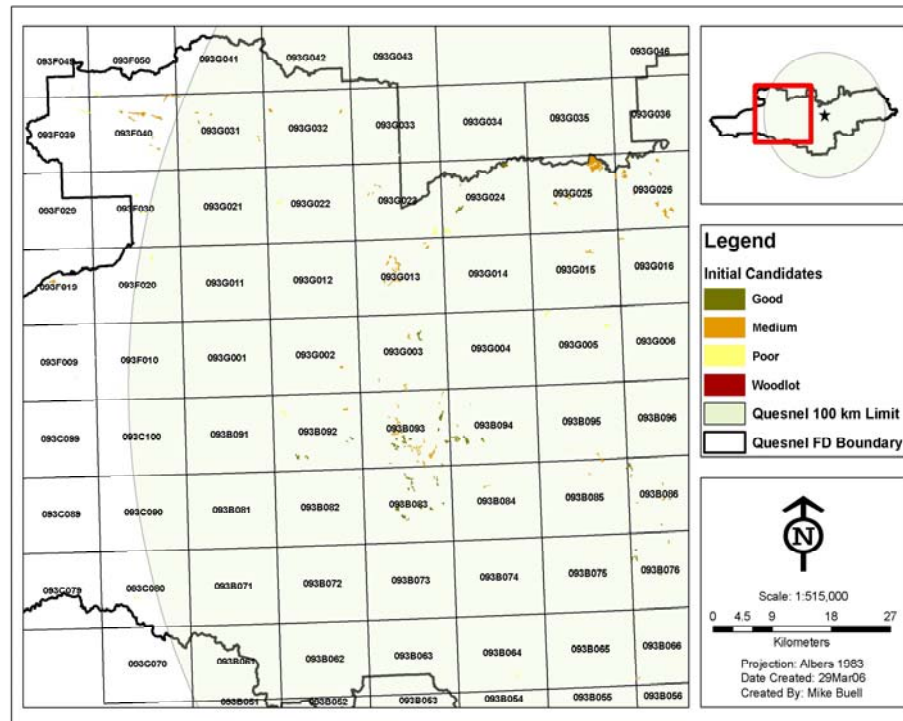
- Good
- Medium
- Poor
- Woodlot
- Quesnel 100 km Limit
- Quesnel FD Boundary

Scale: 1:365,000

0 3 6 12 18
Kilometers

Projection: Albers 1983
Date Created: 29Mar06
Created By: Mike Buell

Figure 3. Initial candidate stands, W Quesnel Forest District.



2.1 Yield Estimates for Initial Candidates

After considering the yield tables obtained from the batchTIPSY and TIPSY analyses, it was decided that the data from the TIPSY run would be used as TIPSY allowed the control of fertilization effectiveness (set to 100%). Table 7 shows the average m³/ha and percent gain by fertilization analysis unit. Several analysis units were excluded since they were classified as medium or poor in the photo assessment or were classified as woodlots.

Table 7. Average volume and percent gain for fertilization analysis.

Fert Au	Average Yield Gain (m³/ha)	Average % Gain	Area (ha)
100	10.0	3	1,194
101	10.7	6	1,570
200	14.0	9	95
201	12.0	8	1,068
300	8.0	2	208
301	12.9	8	94
400	14.0	9	78
401	13.0	8	253
502	15.4	5	130
503	8.5	2	245
512	15.6	9	390
513	16.0	5	121
613	12.0	7	13
Total			5,460

Note: Fert Au definitions are found in Table 3

Table 8 shows the expected year when the fertilization stand will be harvested. The table shows the expected harvest area and gain in harvest volume from fertilized stands.

Table 8. Expected harvest area and volume gain from fertilized stands.

Year	Area Harvested (ha)	Harvest Volume Gain (m³)
2016	2,262	33,424
2021	188	1,334
2026	492	8,165
2031	62	650
2036	534	8,115
2041	398	4,112
2046	672	8,121
2051	580	6,427
2056	204	1,642
2061	66	912
Total	5,460	72,902

3.3 Cost Benefit Analysis for Initial Candidates

The cost benefit analysis shows expected returns from fertilization. The 2% ROI is achieved depending on cycle price and the default TIPSy prices. Table 9 shows the area by ROI class for all price cycles and TIPSy prices.

Table 9. Area by ROI class.

ROI @2% Class (%)	VALUES			
	Low	Medium	High	TIPSy
>=300	-	5	474	459
>=200	-	636	2,179	2,115
>=100	1,018	2,148	1,625	1,633
>2	3,843	2,671	1,182	1,252
<=2	598	-	-	-
Total	5,460	5,460	5,460	5,460

3.4 Selection and Prioritization of Candidate Stands

The selection and prioritization of candidate stands is based on proximity, stand size, harvest year, and ROI grouping. Stands less than 2 ha in size are removed along with stands where the harvest year is greater than 2050. Prioritization is then based on harvest year and ROI grouping.

To fill in the fertilization candidates for years 2007 and 2009, initial candidates classified as 2 (medium) are included. These stands are coded as priority 3 and 4. A summary of the selected stands by priority group is provided in Tables 10, 11 and 12.

Table 10. Selected stands, priority group 1.

PRIORITY GROUP	POLYGON GROUP #	ROI GROUP	ROI @ 2%	EARLIEST HARVEST YEAR	HA
1	1	2	>=200%	2016	15
1	2	2	>=200%	2016	11
1	3	2	>=200%	2016	23
1	4	2	>=200%	2016	47
1	5	2	>=200%	2016	53
1	5	3	>=100%	2026	52
1	6	1	>=300%	2016	5
1	6	2	>=200%	2016	101
1	6	3	>=100%	2021	4
1	7	3	>=100%	2026	43
1	8	2	>=200%	2016	28
1	8	3	>=100%	2026	5
1	9	3	>=100%	2026	19

1	10	3	>=100%	2016	93
1	10	3	>=100%	2026	78
1	10	4	>2%	2016	23
1	11	3	>=100%	2016	109
1	12	2	>=200%	2016	22
1	12	3	>=100%	2016	47
1	12	4	>2%	2016	16
1	13	3	>=100%	2016	48
1	13	3	>=100%	2021	25
1	13	3	>=100%	2026	8
1	13	4	>2%	2016	6
1	14	2	>=200%	2016	18
1	14	3	>=100%	2016	559
1	14	3	>=100%	2026	33
1	15	2	>=200%	2016	100
1	15	3	>=100%	2016	264
1	15	3	>=100%	2026	77
1	16	2	>=200%	2016	19
1	16	3	>=100%	2016	61
1	16	3	>=100%	2026	6
1	16	4	>2%	2016	54
1	16	4	>2%	2021	53
1	17	3	>=100%	2016	163
1	17	3	>=100%	2026	6
1	17	4	>2%	2021	46
1	18	2	>=200%	2016	32
1	18	3	>=100%	2016	83
1	18	3	>=100%	2026	15
1	19	2	>=200%	2016	62
1	19	3	>=100%	2026	85
1	19	3	>=100%	2016	34
1	19	3	>=100%	2021	12
1	19	4	>2%	2016	35
1	20	3	>=100%	2026	41
1	20	3	>=100%	2021	31
1	21	2	>=200%	2016	74
1	21	3	>=100%	2026	25
1	21	3	>=100%	2021	14
1	21	4	>2%	2016	2
1	22	2	>=200%	2016	2
1	23	2	>=200%	2016	20
1	24	2	>=200%	2016	9
1	24	3	>=100%	2016	19
1	24	4	>2%	2016	4
				Total ha	2,940

Table 11. Selected stands, priority group 2

PRIORITY GROUP	POLYGON GROUP #	ROI GROUP	ROI @ 2%	EARLIEST HARVEST YEAR	HA
2	4	3	>=100%	2036	15
2	5	3	>=100%	2036	9
2	14	4	>2%	2031	10
2	14	4	>2%	2046	7
2	15	3	>=100%	2036	19
2	15	4	>2%	2036	316
2	15	4	>2%	2046	57
2	15	4	>2%	2041	43
2	16	4	>2%	2046	72
2	16	4	>2%	2041	22
2	16	4	>2%	2031	8
2	17	3	>=100%	2036	2
2	17	4	>2%	2036	140
2	17	4	>2%	2046	29
2	17	4	>2%	2041	23
2	18	3	>=100%	2031	15
2	18	4	>2%	2046	442
2	18	4	>2%	2041	147
2	18	4	>2%	2036	6
2	19	4	>2%	2041	115
2	19	4	>2%	2031	3
2	20	3	>=100%	2031	21
2	20	4	>2%	2046	4
2	21	4	>2%	2046	52
2	21	4	>2%	2041	39
2	21	4	>2%	2031	6
2	21	4	>2%	2036	5
2	22	3	>=100%	2036	6
2	22	4	>2%	2036	13
2	22	4	>2%	2041	10
2	24	4	>2%	2046	9
Total ha:					1,663

Table 12. Selected stands, priority group 3

PRIORITY GROUP	POLYGON GROUP #	ROI GROUP	ROI @ 2%	EARLIEST HARVEST YEAR	HA
3	1	1	>=300%	2016	16
3	1	2	>=200%	2016	109
3	1	3	>=100%	2016	5
3	1	4	>2%	2016	8
3	2	2	>=200%	2016	24
3	3	1	>=300%	2016	8
3	3	2	>=200%	2016	61
3	4	2	>=200%	2016	12
3	4	3	>=100%	2016	9
3	5	2	>=200%	2016	84

3	5	3	>=100%	2016	86
3	5	4	>2%	2016	12
3	6	2	>=200%	2016	22
3	7	2	>=200%	2016	3
3	7	4	>2%	2016	5
3	8	3	>=100%	2016	84
3	8	4	>2%	2016	5
3	9	2	>=200%	2016	6
3	9	3	>=100%	2016	9
3	9	4	>2%	2016	11
3	11	2	>=200%	2016	12
3	12	2	>=200%	2016	8
3	13	2	>=200%	2016	9
3	14	2	>=200%	2016	25
3	15	3	>=100%	2016	11
3	16	2	>=200%	2016	12
3	17	2	>=200%	2016	5
3	17	3	>=100%	2016	27
3	18	3	>=100%	2016	14
3	18	4	>2%	2016	12
3	19	2	>=200%	2016	11
3	19	3	>=100%	2016	5
3	19	4	>2%	2016	22
3	20	3	>=100%	2016	3
3	20	4	>2%	2016	8
3	21	3	>=100%	2016	29
3	24	2	>=200%	2016	10
3	25	1	>=300%	2016	2
3	25	2	>=200%	2016	121
3	28	2	>=200%	2016	12
3	28	3	>=100%	2016	28
3	29	2	>=200%	2016	32
3	29	3	>=100%	2016	13
3	30	2	>=200%	2016	30
Total ha:					1,043

Table 13 Selected stands, priority group 4

PRIORITY GROUP	POLYGON GROUP #	ROI GROUP	ROI @ 2%	EARLIEST HARVEST YEAR	HA
4	1	3	>=100%	2031	7
4	1	4	>2%	2031	3
4	2	3	>=100%	2036	9
4	3	3	>=100%	2026	19
4	7	4	>2%	2036	23
4	9	4	>2%	2031	33
4	10	4	>2%	2041	5
4	11	3	>=100%	2026	7
4	11	3	>=100%	2036	3
4	12	3	>=100%	2026	6

4	14	3	>=100%	2036	14
4	15	3	>=100%	2036	23
4	17	3	>=100%	2026	6
4	17	4	>2%	2036	28
4	17	4	>2%	2041	2
4	18	4	>2%	2036	4
4	18	4	>2%	2046	21
4	19	3	>=100%	2026	7
4	19	3	>=100%	2036	5
4	19	4	>2%	2021	6
4	19	4	>2%	2041	5
4	19	4	>2%	2046	25
4	20	3	>=100%	2021	4
4	20	4	>2%	2031	8
4	22	3	>=100%	2026	28
4	23	3	>=100%	2031	11
4	23	4	>2%	2036	10
4	24	3	>=100%	2036	13
4	25	4	>2%	2036	4
4	29	3	>=100%	2021	4
4	29	4	>2%	2041	6
4	30	4	>2%	2046	19
4	31	3	>=100%	2036	4
					372

Table 14 shows the final area by fertilization year and prioritization for the candidate stands.

Table 14. Area by fertilization year and priority class.

Year	Priority Group	Area (ha)	Comments
2006	1	2,940	1) Develop operational program for fall 2006 treatment 2) Initiate monitoring program
2007	2	1,663	1) Develop operational program for fall 2007 treatment
2008	3 & 4	1,415	1) Develop operational program for fall 2008 treatment
2009			1) Assess monitoring response from 2006 S & F treatments. 2) Based on monitoring response results develop tactical recommendations for further F & S stand treatment
2010			1) Develop operational F & S treatment program based on 2009 tactical recommendations. 2) Assess potential to apply second treatment to 2006 stands. 3) Consider starting a Pine fertilization program depending upon MPB and other forest health conditions.
Total		6,018	

Figures 4 to 6 shows the location of the prioritized candidates in relation to Quesnel.

Figure 4. Prioritized candidate stands, NE Quesnel Forest District.

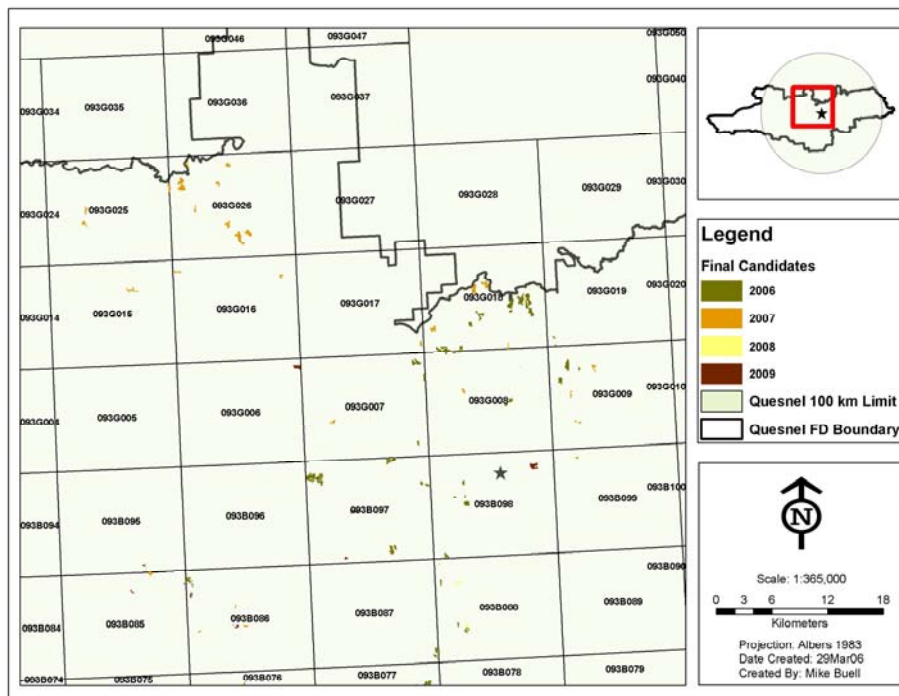


Figure 5. Prioritized candidate stands, SE Quesnel Forest District.

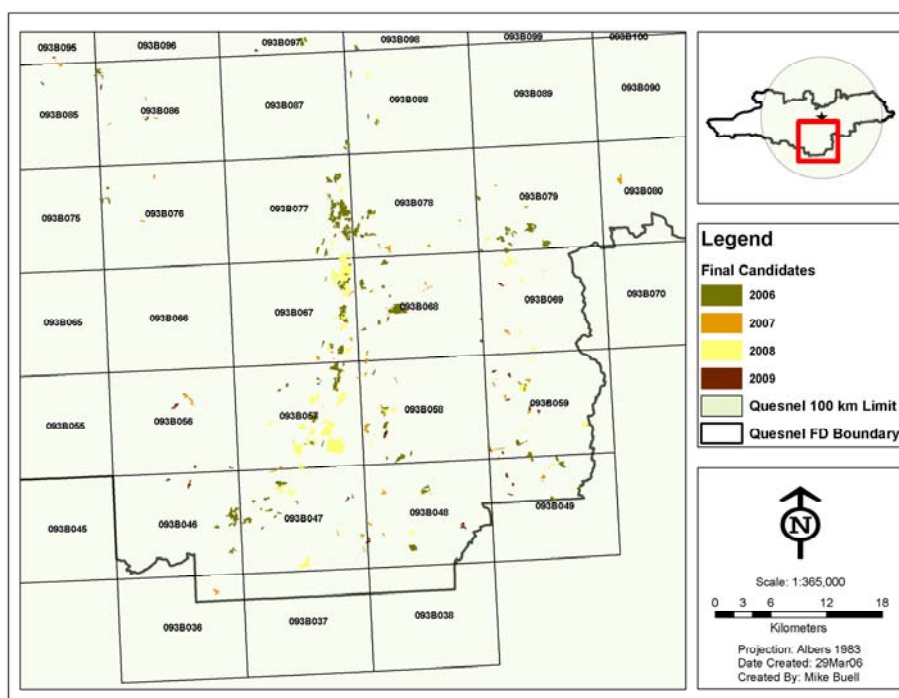
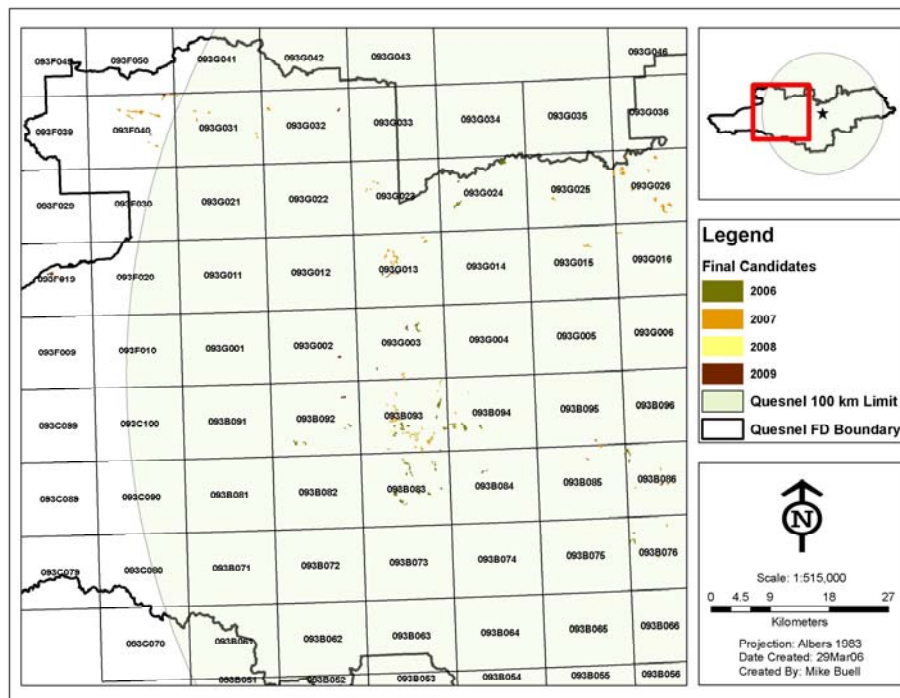


Figure 6. Prioritized candidate stands, W Quesnel Forest District.



4 Growth Monitoring

4.1 Growth Monitoring Scheme, Option 1

The growth monitoring scheme described in this section is drawn largely from Hawkins (2005).

Due to the large amount of area that can be fertilized and the full cost of application a growth monitoring program is required to evaluate the growth of treated stands. Control plots (untreated) will be established that have the same ecological attributes as the treated stands.

The monitoring approach is to install a small number of plots in each treated area and partner control area. Five randomly selected plots of 100 ha or less and at an intensity of five percent, to a maximum of 10 plots for stands greater than 100 ha will be installed. This protocol will be used in both treated and control areas, and assumes, as indicated in the guidelines, that the treated areas are relatively large.

The approach will be as follows:

1. select a point of commencement (POC) from stands in the final candidate resultant
2. grid with plots located every 100m is overlaid on the stand and is numbered sequentially
3. plot is selected if 100 m from any polygon border
4. random number list is generated for each stand – total random numbers = number of grid positions
5. if stand is < 100 ha first five sample points on random number list will be selected
6. if stand is ≥ 100 ha select plots if more than 100 m from a stand boundary
7. repeat process for the control area

The approach used in this analysis is the following:

1. overlay grid of 100m points onto the interim candidates
2. if stand does not have the minimum 5 plots then no plots are selected
3. for stands that will have minimum 5 plots use random number generator to find the number of plots needed – between minimum 5 and maximum 10
4. exclude points that are within 100m of stand boundary
5. randomly select points within stands using random number generator based on point id

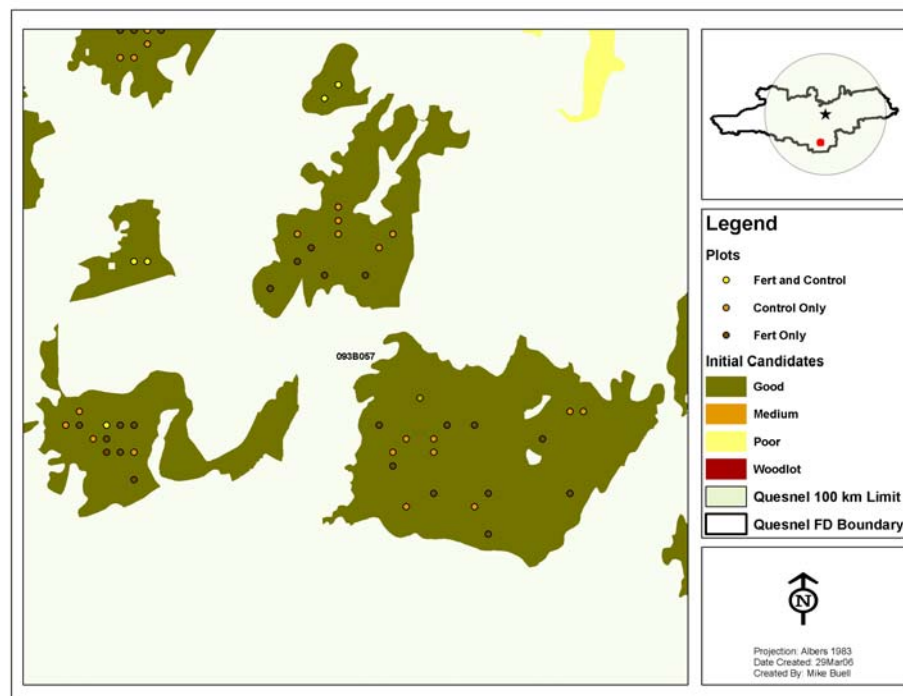
repeat process for control points

The results of the growth monitoring exercise show that 643 plots are required to support the fertilization program. Of the 643 plots, 168 had control and fertilization plots that overlap. Table 15 shows the number of control and fertilization plots required to support the program and Figure 7 provides a illustration of the results from the growth monitoring exercise.

Table 15. Total plots required to support the Quesnel fertilization program.

Plot Type	Number of plots
Control only	240
Fertilization only	235
Control and fertilization combined	168
Total	643

Figure 7. Close-up of a selected plot, SE Quesnel Forest District.



4.2 Growth Monitoring Scheme, Option 2

Quantification of expected responses to treatment is primarily based on TIPSy yield predictions. As there is an unknown measure of uncertainty inherent in all projections, an “effectiveness” monitoring program is required to know if growth and yield patterns over time are emerging as projected by the models. Therefore, an alternative approach to monitoring as defined in option 1, is to establish plots in the population of treated stands and re-measure the plots over time to verify the growth of the treated stands against TIPSy projections for similarly treated stands. If significant differences are noted between actual and predicted growth then further research would be required to determine the reason for the difference. Such an approach would require between 20 and 30 installations, preferably before treatment occurs.

5 Discussion

The tactical strategy is based on inventory estimates and TIPSy yield projections with an assessment using orthophotos. Therefore, due to potential inventory inaccuracies, stands will have to be ground and/or aerial truthed for fertilization suitability under the next level to develop an operational assessment plan. The tiered approach adopted for the tactical plan will make substitution of candidate stands in an operational assessment relatively straightforward.

Similarly, the operational treatment plan resulting from the operational assessment can easily be adjusted to allow for varying budget schedules.

Fertilizer treatment of the 6,000 hectares identified in this tactical plan will increase timber supply by 81,000 m³ or more in the medium term – a time when a severe deficit in timber supply is forecast. The actual volume gain depends, in part, on when a stand is harvested and on the accuracy of TIPSy projections. Gains of this nature are needed to contribute to the future harvest portfolio in MPB devastated areas.

6 Recommendations

1. A five-year schedule of fertilization treatments is listed in Table 16.

Table 16. Recommended fertilization treatment and activities by year and priority group.

Year	Priority Group	Area (ha)	Comments
2006			1) Develop operational assessment and treatment programs for fall 2006 treatment
	1	2,940	2) Design and initiate monitoring program
2007	2	1,663	1) Develop operational program for fall 2007 treatment
2008	3 & 4	1,415	1) Develop operational program for fall 2008 treatment
2009			1) Assess monitoring response from 2006 S & F treatments. 2) Based on monitoring response results develop tactical recommendations for further F & S stand treatment
2010			1) Develop operational F & S treatment program based on 2009 tactical recommendations. 2) Assess potential to apply second treatment to high response 2006 stands. 3) Consider initiating a Pine fertilization program depending upon MPB and other forest health conditions.
Total		6,018	

2. Conduct foliar analysis on select treated and untreated stands to determine potential formulation requirements (adjust for urea, ammonium nitrate and sulphur)
3. Select approximately 1,000 hectares, from the highest response older Fir and Spruce immature stands, for subsequent intensive repeated fertilizer applications and monitor

results to determine potential responses applicable to similar stand types in the Southern and Northern Interior Forest Regions

4. Select approximately 1,000 hectares from younger Fir and Spruce immature stands, for intensive repeated fertilizer application in conjunction with optimized pre-commercial thinning and monitor results to determine potential responses applicable to similar stand types in the Southern and Northern Interior Forest Regions
5. The operational plan must be verified with MOFR regional entomologists to assess the risk and value of the proposed fertilizer treatments in relation to any known or potential forest health issues
6. The operational plan must be verified with MOFR regional and local biologists to assess the potential for inclusion of treatment in any adjacent Ungulate Winter Ranges
7. A First Nations consultation process should be initiated as early as possible

References

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