CARIBOO REGION TISC

QUESNEL TIMBER SUPPLY AREA

STAND TREATMENTS ANALYSIS
TIMBER SUPPLY ANALYSIS REPORT

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EXECUTIVE SUMMARY

This report provides a review of potential impacts of various stand level treatments on forest level timber supply in the Quesnel Timber Supply Area. The information developed in this set of analyses is intended to assist the Chief Forester of B.C. in future allowable annual cut (AAC) determinations and provide direction to forest managers in prescribing future forest management treatments.

A base case for analysis was created in accordance with the Quesnel Timber Supply Review (TSR I) and any information available for the upcoming TSR II.

Simulated are the potential impacts of various strategies or stand level treatments on forest level timber supply using the MoF simulation model FSSIM:

- Old growth site index bias adjustments;
- Reduced regeneration delay through prompt site preparation and planting;
- Plant genetically improved stock;
- Stand density management;
- Juvenile spacing and fertilization;
- Eliminate backlog not satisfactorily regenerated (NSR) areas;
- Rehabilitate PFT;
- Rehabilitate roads and landings;
- Commercial thinning; and
- Commercial thin and fertilize;

Old growth site index has the largest impact on timber supply. Significant increases in timber supply are shown to be associated with genetic improvement, fertilization and stand density management.

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APPENDIX I – INFORMATION PACKAGE

1.0 INTRODUCTION

This is a report of timber supply analysis completed on behalf of the Cariboo Forest Region Timber Investments Strategy Committee (TISC). A review of potential impacts of various stand level treatments on forest level timber availability is underway for each of the three TSAs in the Cariboo Forest Region. This report provides results for the Quesnel TSA.

The information developed here is intended to assist the Chief Forester of B.C. in future allowable annual cut (AAC) determinations and provide direction to forest managers in prescribing future forest management treatments. It is not intended to provide a review of TSR I or anticipate TSR II. The project is intended to provide insight into timber supply impacts of various silvicultural stand treatments. Such impacts as are demonstrated should be considered incremental changes and the results are not to be interpreted as actual values.

Timber supply is the quantity of timber available for harvest over time. The methodology includes use of a forest-level simulation model which predicts the development of a forest over a 250-year planning horizon given a description of initial forest conditions, expected patterns of growth, and a set of rules related to harvesting and regenerating the forest. In addition, management assumptions related to non-timber forest resources are included in the analysis process.

Analysis will be undertaken using the MoF forest estate model FSSIM.

2.0 ESTABLISHING A BASE CASE

Determined by the Chief Forester in TSR I, the AAC for the Quesnel TSA is 2 340 000 m^3/year. The cut is partitioned. Of the total AAC, the sawlog timber supply is 1 965 500 m^3, problem forest types (PFTs) represent 300 000 m^3, and deciduous stands provide 40 000 m^3. For modeling purposes the unsalvaged losses of 24 500 m3/year are added to the harvest forecast.

To simulate the potential impacts of various stand level treatments on forest level timber supply using the MoF simulation model FSSIM, a base case was designed and is documented in Appendix I – Information Report.

Two approaches to harvest flow are used in the simulations presented. An even-flow of harvest volume over time facilitates comparisons between silviculture treatments. Uneven-flow scenarios are more indicative of realistic harvest flow requirements.

An even-flow analysis using only natural stand yields identified a minimum long-term harvest level was very similar to the AAC as set in TSR I. However, when managed stand yields are implemented for regenerated stands, the sawlog timber supply can rise 20% above the current AAC in an even-flow harvest scenario (see Figure 2.1). This harvesting level is selected as the base case in even-flow regime analyses presented in Section 3. Of this new harvest level (2 723 100 m3/year), the sawlog timber supply rises to 2 358 600 m3/year, and the other types are held at the TSR I levels.

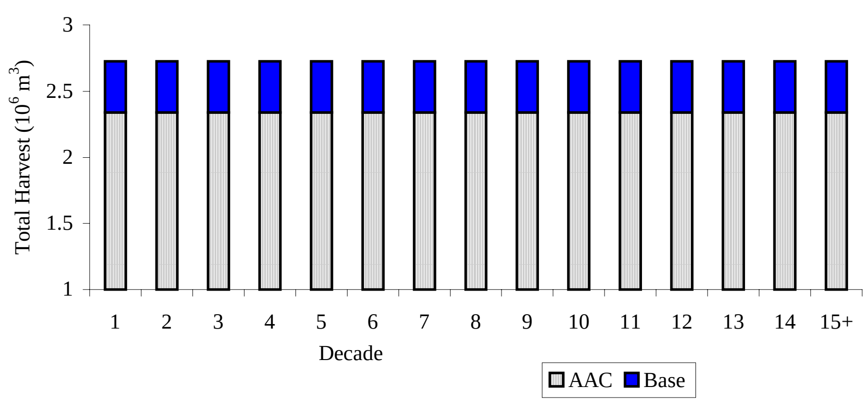

Figure 2.1 Even-flow base case harvest level

Given the current age class structure and the abundance of existing mature timber, uneven harvest flow scenarios are developed using the following principles:

- The initial harvesting level should be as high as possible;
- Reductions are limited to 10% per decade;

- There are only two logical time frames, short and long-term with a floating break point where the even-flow harvesting starts;
- No merchantable volume shortages are permitted within the planning horizon (25 decades); and
- The operable stock levels are stable in the long-term.

Using the long-term harvesting level identified in even-flow analysis, which includes the impact of managed stands, the short-term harvesting levels were raised to maximize short-term benefits. As a result the base case for uneven-flow harvest is determined (see Figure 2.2 and Table 2.1) as:

- An initial harvesting level that is 50% higher than the even-flow harvest level;
- Four decades of 10% reductions; and
- A stable long-term harvesting level the same as the even-flow base case (2 723 100 m^3/year).

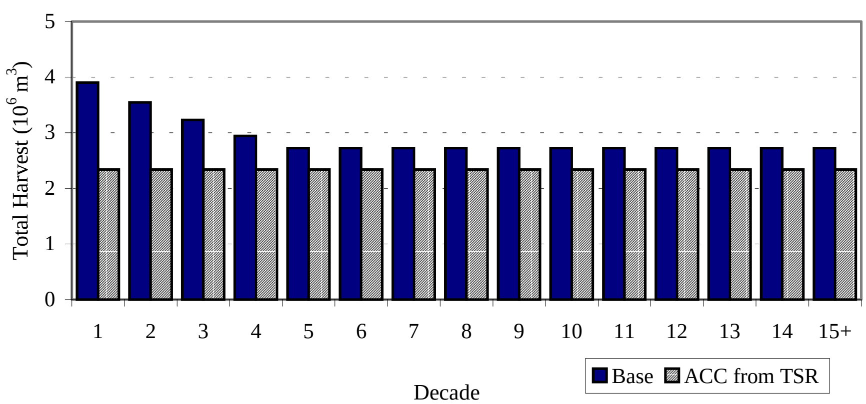

Figure 2.2 Uneven-flow base case harvest flow

Table 2.1 Base case harvest schedule (m3/year)

Decade	Total Annual Harvest
1	3 902 400
2	3 548 610
3	3 230 199
4	2 943 629
5	2 723 100
6	2 723 100
7	2 723 100
8	2 723 100
9+	2 723 100

Total and merchantable stock levels over time are presented in Figure 2.3.

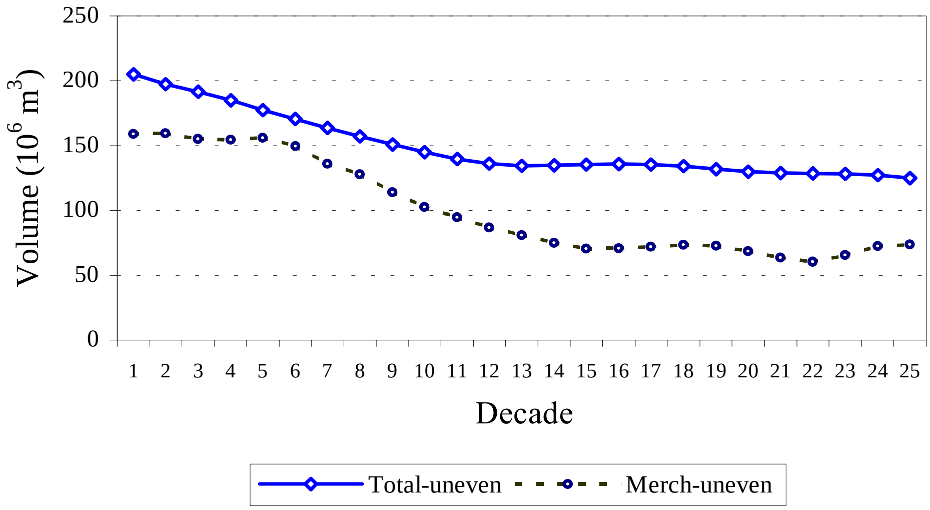

Figure 2.3 Uneven-flow base case total and merchantable stock levels

3.0 STRATEGIES AND TREATMENT REGIMES

The following regimes are modeled:

- Old growth site index bias adjustments;
- Reduced regeneration delay through prompt site preparation and planting;
- Planting genetically improved stock;
- Juvenile spacing;
- Juvenile spacing and fertilizing;
- Eliminate backlog NSR immediately;
- Rehabilitate PFT;
- Rehabilitate roads and landings;
- Commercial thinning; and
- Commercial thinning and fertilizing.

Sensitivity analysis approaches are used to estimate the potential effects of these treatments on both even-flow and uneven-flow scenarios. The benefit of each treatment is compared with the base case.

3.1 Old Growth Site Index Bias Adjustments

The site index for all existing stands over 140 years of age are adjusted by applying MoF standard old growth site index (OGSI) adjustment equations.[1] All analysis units (all species) representing stands greater than 140 years of age are adjusted when regenerated. The area involved is 218 000 ha or 24% of the total net area. New yield curves use the converted site index values. The conversion has an impact on timber supply by changing the yield curves, the minimum harvesting ages, and the green-up ages. In uneven-flow harvesting regime, OGSI adjustments raise sawlog timber supply by 10% in short-term and 5% in long-term (Figure 3.1a and Table 3.2)

[1] Nussbaum, A.F. Site index adjustments for old-growth stands based on paired plots. Res. Br., B.C. Min. For., Victoria B.C. Work Pap. 37/1998

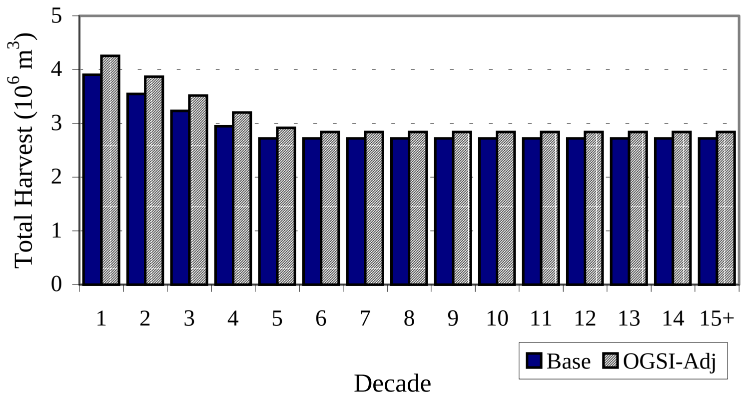

Figure 3.1a The impact of OGSI adjustments vs. base case (uneven-flow)

Table 3.1 Harvest schedule – OGSI adjustments

Decade	Total Annual Harvest (m^3)
1	4 256 190
2	3 867 021
3	3 516 769
4	3 201 542
5	2 917 838
6	2 841 030
7	2 841 030
8	2 841 030
9+	2 841 030

In even-flow harvest, OGSI adjustments raise sawlog timber supply by 12% in comparison to the even-flow base case. The new harvesting level is 3 006 132 m^3/year (Figure 3.1b)

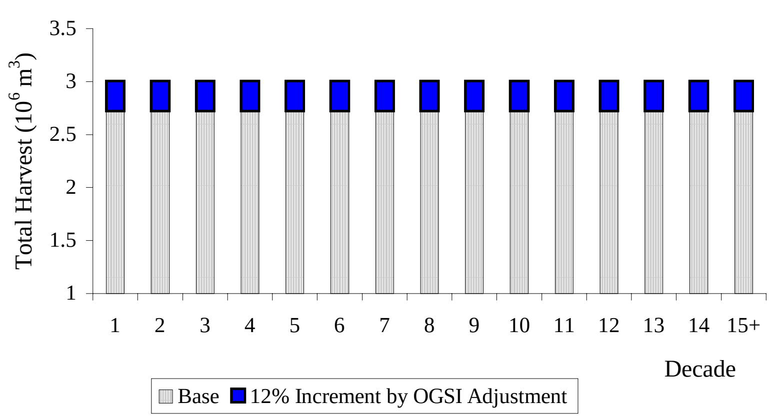

Figure 3.1b The impact of OGSI adjustments vs. base case (even-flow)

3.2 Reduce Regeneration Delay

Regeneration delay can be reduced through prompt site preparation and planting. If a decrease of 2 years can be achieved, sawlog timber supply is shown to increase by 5% in short-term and keep the long-term harvest rate unchanged in an uneven-flow analysis (Figure 3.2a and Table 3.2).

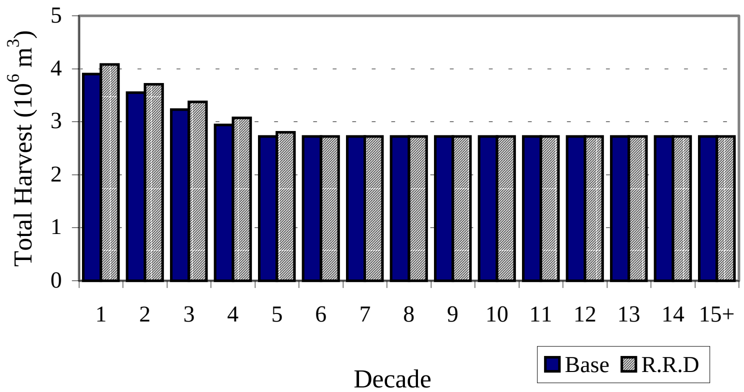

Figure 3.2a Uneven case - reduced regeneration delay (R.R.D.)

Table 3.2 Harvest schedule – reduced regeneration delay

Decade	Total Annual Harvest (m^3)
1	4 079 295
2	3 707 816
3	3 373 484
4	3 072 586
5	2 801 777
6	2 723 100
7	2 723 100
8	2 723 100
9+	2 723 100

In the even-flow case, this treatment raises timber supply to 2 793 858 m^3/year. That is a 3% increment over the base case (Figure 3.2b).

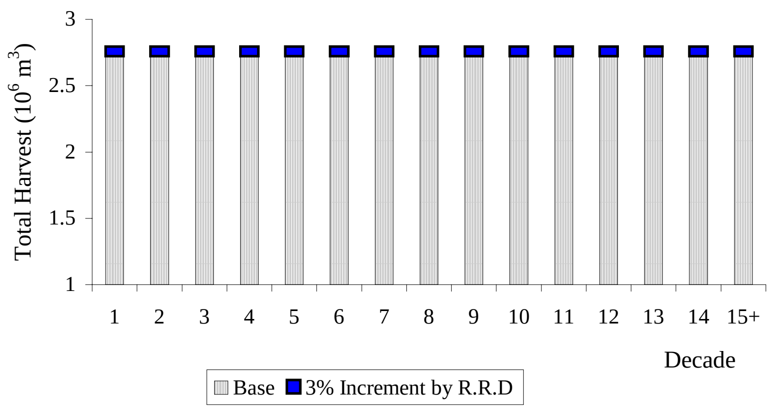

Figure 3.2b Even-flow case - reduced regeneration delay (R.R.D)

3.3 Plant Genetically Improved Stock

Only pine and spruce stands are candidates for planting with genetically improved stock. Genetic improvement is simulated by site index adjustments. In a sensitivity approach, three levels of site index adjustment (3%, 5%, and 7%) are applied to represent a range of expectations for stand level impacts. Forest level impacts are driven by recalculated yield curves, green-up constraints, and minimum harvesting ages.

In uneven-flow simulation, results indicate that a 3% increase in site index translates into a 10% timber supply increase in the short-term. For the moderate adjustment case (5%) a 15% timber supply increase in short-term can be achieved. Using a 7% increase in site index a 15% timber supply increase in short-term can be achieved along with a 4% increase in long-term (Figure 3.3a and Table 3.3).

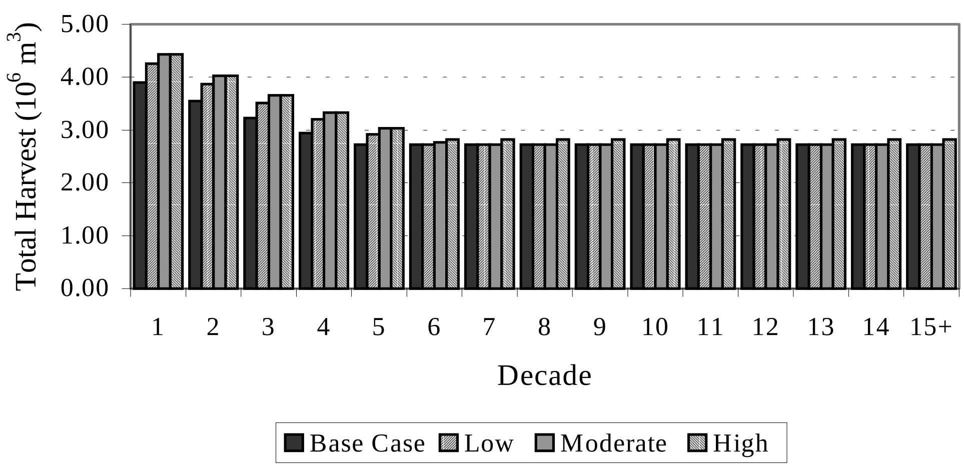

Figure 3.3a Uneven-flow harvest with genetic improvement scenarios

Table 3.3 Harvest schedule (m3/year) – genetic improvement

Decade	Harvest - Low Response (SI increased 3%)	Harvest - Moderate Response (SI increased 5%)	Harvest - High Response (SI increased 7%)
1	4 256 190	4 433 085	4 433 085
2	3 867 021	4 026 227	4 026 227
3	3 516 769	3 660 054	3 660 054
4	3 201 542	3 330 498	3 330 498
5	2 917 838	3 033 899	3 033 899
6	2 723 100	2 766 959	2 817 444
7	2 723 100	2 723 100	2 817 444
8	2 723 100	2 723 100	2 817 444
9+	2 723 100	2 723 100	2 817 444

In even-flow analysis, this treatment raises timber supply according to the response levels. There is a 5% timber supply increase associated with the low response; 7% timber supply increase with a moderate response; and a 9% timber supply increase in high response (Figure 3.3b and Table 3.4).

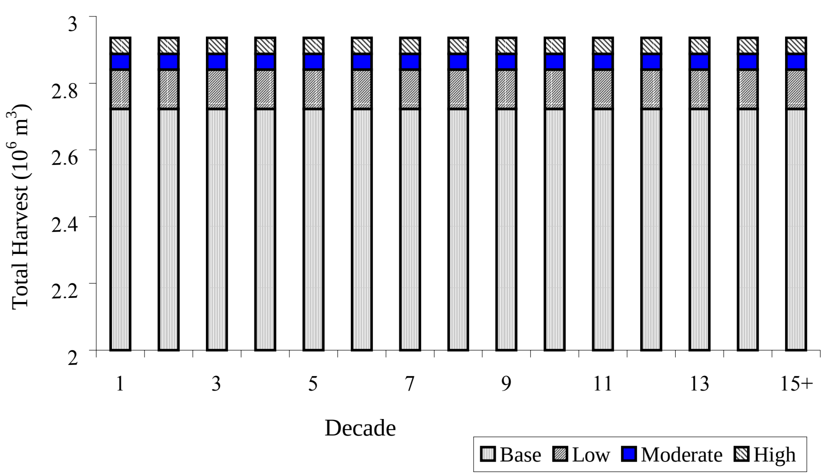

Figure 3.3b Even-flow harvest with genetic improvement scenarios

Table 3.4 Harvest schedule (m3/year) – genetic improvement (even-flow)

Decade	Harvest - Low Response	Harvest - Moderate Response	Harvest - High Response
All	2 841 030	2 888 202	2 935 374

3.4 Stand Density Management

Stand density is managed through juvenile spacing. This treatment is applied to all regenerating stands. The initial density is set to 4 444 stems/ha to reflect planting plus volunteer trees. This ensures that sufficient stems are available to thin. Three treatment levels for density are designed (1 200 stems/ha, 2 400 stems/ha, and 3 600 stems/ha) for both even-flow and uneven-flow harvesting regimes. The stands have different responses for each level of treatment. The best forest level results are associated with spacing the stand to 2 400 stems/ha. In uneven-flow approach timber harvest increases by 14% in the short-term. If spacing to 3 600 stems/ha, only a 5% increase in the short-term is possible. When spacing density to 1 200 stems/ha a 10% increase in short-term can be achieved (Figure 3.4a and Table 3.5).

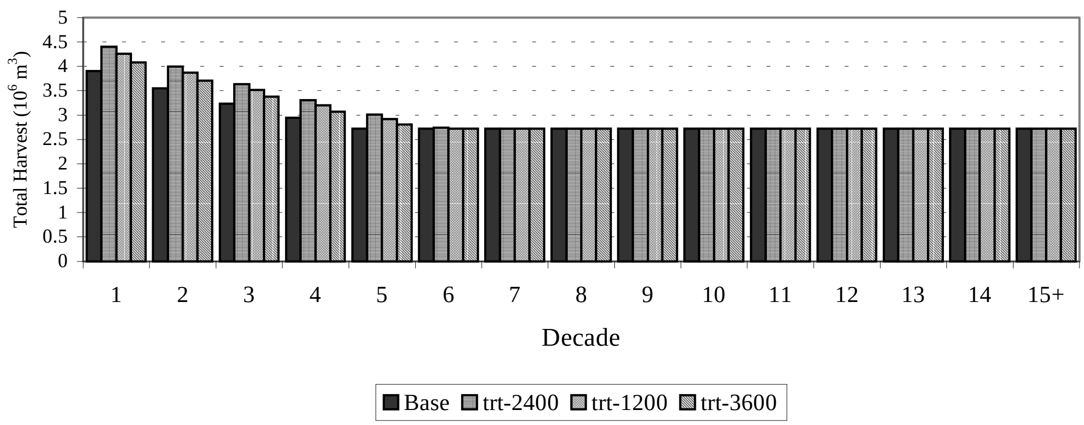

Figure 3.4a The response of uneven harvest flow to juvenile spacing

Table 3.5 Uneven-flow harvest schedule (m3/year) – juvenile spacing

Decade	Harvest - Spacing to 3600	Harvest - Spacing to 2400	Harvest - Spacing to 1200
1	4 079 295	4 397 706	4 256 190
2	3 707 816	3 994 385	3 867 021
3	3 373 484	3 631 397	3 516 769
4	3 072 586	3 304 707	3 201 542
5	2 801 777	3 010 686	2 917 838
6	2 723 100	2 746 068	2 723 100
7	2 723 100	2 723 100	2 723 100
8	2 723 100	2 723 100	2 723 100
9+	2 723 100	2 723 100	2 723 100

In an even-flow scenario, spacing to 2 400 stems/ha increases the timber harvest level by 7% within the planning horizon. If spacing to 3 600 stems/ha, only a 3% increase is achieved. When spacing density to 1 200 stems/ha a 6% increase can be achieved (Figure 3.4b and Table 3.6).

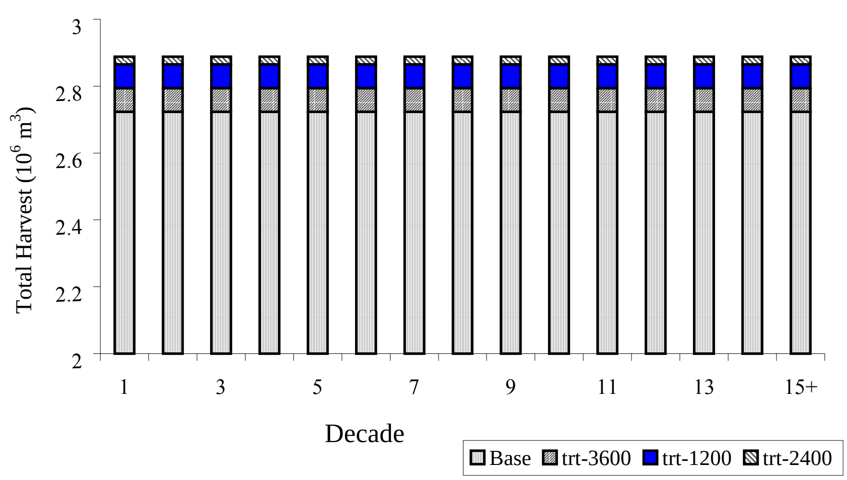

Figure 3.4b The response of even harvest flow to juvenile spacing

Table 3.6 Even-flow harvest schedule – juvenile spacing

Treatment levels	Total Annual Harvest (m^3)
Base case	2 723 100
Space to 1200	2 864 600
Space to 2400	2 888 200
Space to 3600	2 793 800

3.5 Fertilizing Pine

This scenario assumes that only pine leading managed stands will be fertilized. Candidates include all stands in good and intermediate sites. These are site class 1 or 2 as defined in Section 4.1 of the Information Package (see Appendix I). Including approximately 133 000 ha of problem forest types, about 550 000 ha may be candidate for this treatment over the duration of the analysis period.

Operational fertilization will not be undertaken without appropriate stand density management. For this reason all regenerating stands are modeled from an initial density of 4 444 stems/ha and spaced to 2 400 stems/ha. Fertilization is assumed to be applied to pine stands during spacing and repeatedly throughout the life of the stand. The response to fertilizing is set to an increase of 15 m^3/ha and this is maintained through the life of the stand. A second analysis used an increase of 40 m^3/ha.

Impacts of the fertilization treatment alone can be inferred by comparison to the spacing sensitivity. For this reason, for this analysis, the base case was redefined as the harvest flow of the 2 400 stem stand density management analysis. Compared in this way, in an uneven-flow system, fertilizing is shown to increase timber supply by 1% and 5% in the short-term given the 15 and 40 m^3/ha assumptions respectively. Impacts may be higher if spruce and other managed stands were included in the fertilization program.

The impact from the combined treatment can be deduced by comparing with the base case. Total harvest levels are 15% and 20% higher in the short-term and keep the long-term unchanged in this scenario (Figure 3.5a and Table 3.7).

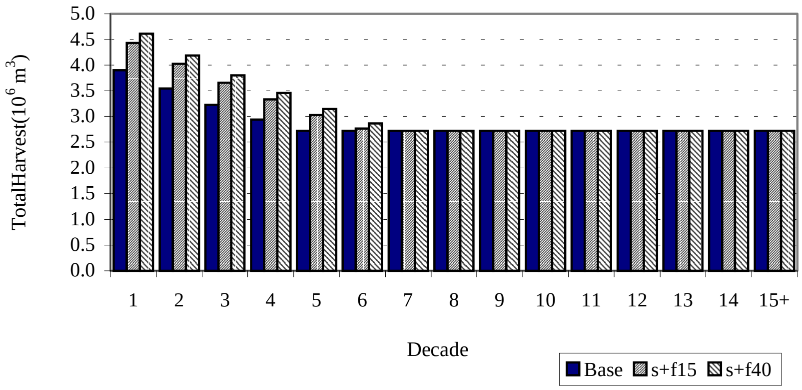

Figure 3.5a Harvest flow with pine fertilization

Table 3.7 Harvest schedule – fertilization of pine

Decade	Total Annual Harvest (m^3) ($15m^3$/ha assumption)	Total Annual Harvest (m^3) ($40m^3$/ha assumption)
1	4 433 085	4 609 980
2	4 026 227	4 185 432
3	3 660 054	3 803 339
4	3 330 498	3 459 455
5	3 033 899	3 149 959
6	2 766 959	2 871 413
7	2 723 100	2 723 100
8	2 723 100	2 723 100
9+	2 723 100	2 723 100

In the even-flow harvest approach, the two levels of fertilization impact $15m^3$ and $40m^3$ increase harvest 1% and 3% over the base case and the effect of the complete treatment is an 8% and 10% increment respectively. This raises the annual harvest level to 2 911 788 m^3/year and 2 958 960 m^3/year. (Figure 3.5b).

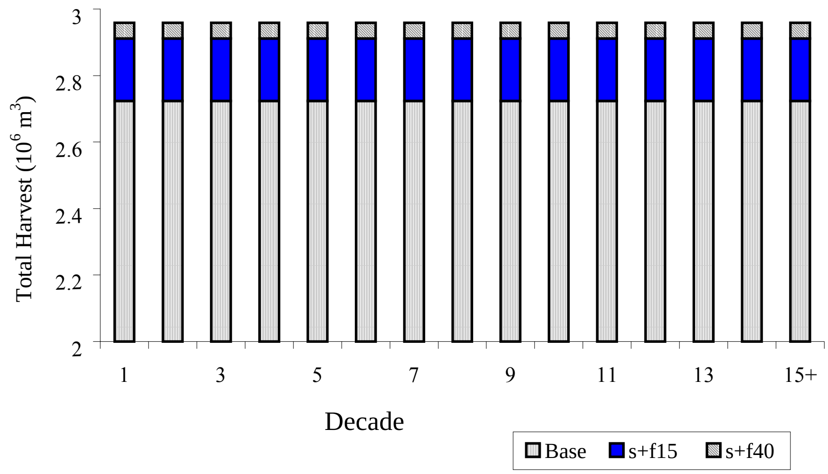

Figure 3.5b Even-flow harvesting level - fertilization of pine

3.6 Eliminate Backlog NSR

Areas classified as backlog not satisfactorily regenerated (NSR) areas are regenerated immediately in this scenario. The response in uneven-flow regime is a 4% increase of timber supply in the short-term (Figure 3.6a).

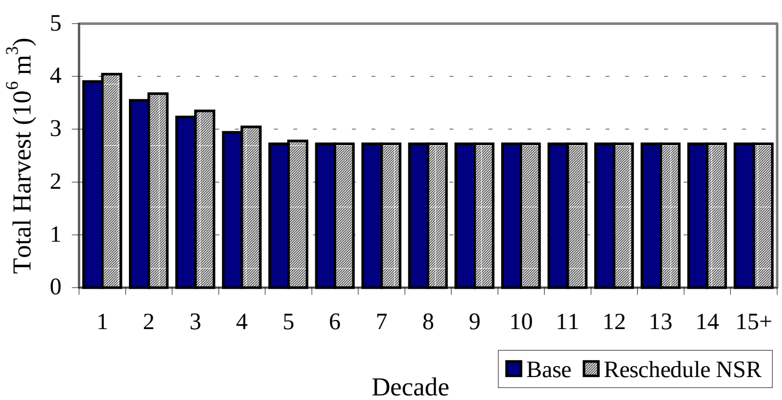

Figure 3.6a Uneven-flow harvest - eliminating backlog NSR

Table 3.8 Harvest Schedule – Reschedule NSR

Decade	Total Annual Harvest (m^3)
1	4 043 916
2	3 675 974
3	3 344 827
4	3 046 794
5	2 778 565
6	2 723 100
7	2 723 100
8	2 723 100
9+	2 723 100

The response for this scenario in even-flow regime is a 2% increase in timber supply—an increase in harvesting level to 2 770 272 m^3/year (Figure 3.6b).

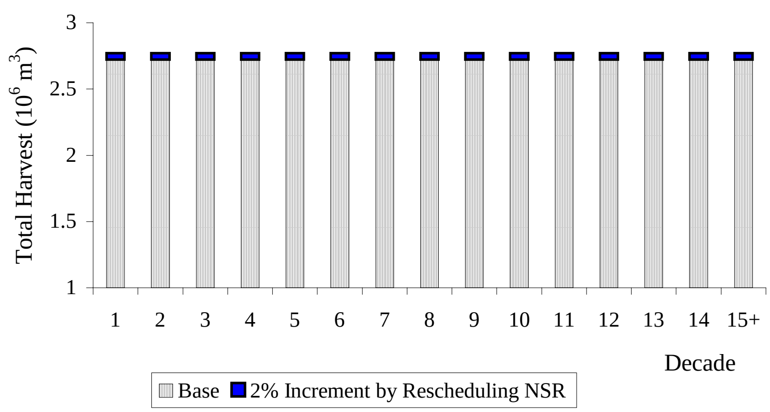

Figure 3.6b Even-flow harvest flow eliminating backlog NSR.

3.7 Rehabilitate Problem Forest Types (PFTs)

Rehabilitation of PFTs is modeled by removing limits to the area harvested and making the harvest of PFTs the priority. This forces the transition from PFT to managed stands to happen as early as possible. All PFT stands are assumed to regenerate to pine after harvesting. In uneven regime, this scenario can increase timber supply by 5% in short-term (Figure 3.7a and Table 3.9).

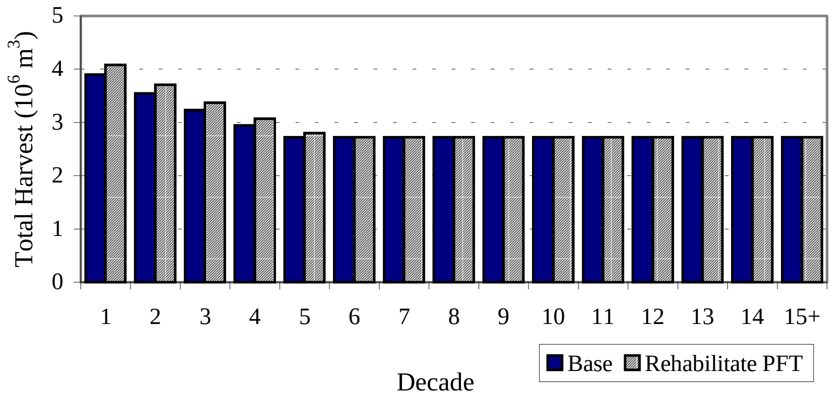

Figure 3.7a The impact of rehabilitating PFTs

Table 3.9 Harvest schedule – rehabilitate PFTs

Decade	Total Annual Harvest (m^3)
1	4 079 295
2	3 707 816
3	3 373 484
4	3 072 586
5	2 801 777
6	2 723 100
7	2 723 100
8	2 723 100
9+	2 723 100

In an even-flow regime, this scenario can increase timber supply by 3% and increase harvesting level to 2 793 858 m^3/year (Figure 3.7b).

In both the even and uneven-flow scenarios, total harvest increases are relatively small. Hidden within the total harvest is a change in the balance between PFT and sawlog harvests with the sawlog proportion increasing with time.

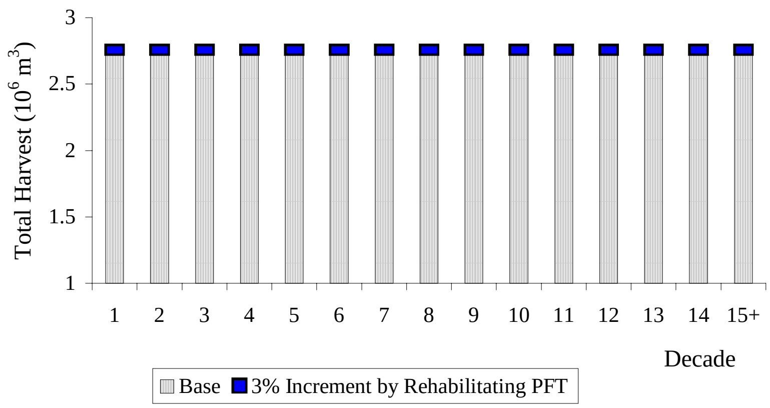

Figure 3.7b Even-flow - the impact of rehabilitating PFTs

3.8 Rehabilitate Roads and Landings

If current and future road reductions are cut in half, the harvesting level in the short-term can increase by 9% in uneven-flow analysis (Figure 3.8a and Table 3.10).

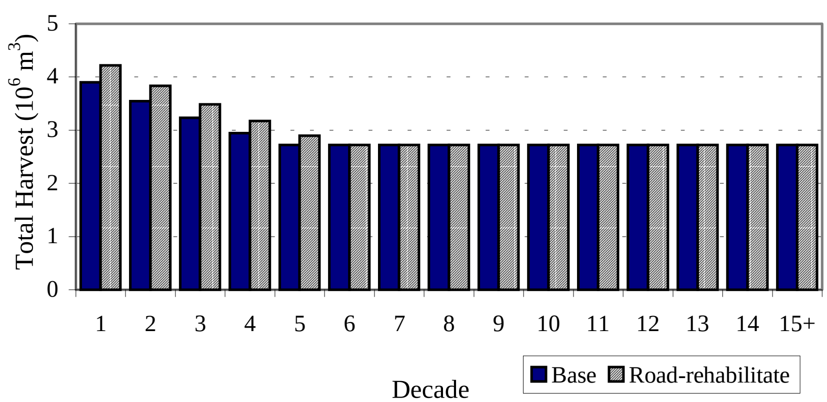

Figure 3.8a Uneven-flow - rehabilitating 50% of roads and landings

Table 3.10 Harvest schedule – rehabilitate roads and landings

Decade	Annual Total Harvest (m^3)
1	4 220 811
2	3 835 180
3	3 488 112
4	3 175 751
5	2 894 626
6	2 723 100
7	2 723 100
8	2 723 100
9+	2 723 100

If this management assumption is applied in the even-flow system, the harvesting level will increase by 3% to 2 793 858 m^3/year (Figure 3.8b).

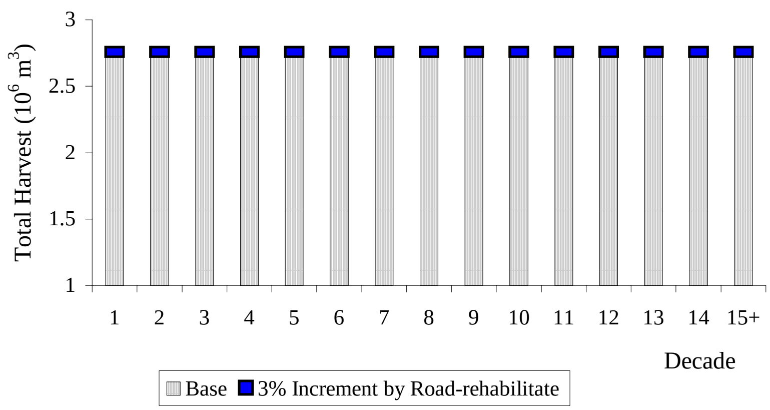

Figure 3.8b Even-flow - rehabilitating 50% of roads and landings

3.9 Commercial Thinning

This is a commercial thinning only regime. Thinning is assumed to remove 30% of the volume from 40 to 60 year old natural and managed stands. Thinning candidates are pine and Douglas-fir on good and medium sites. Stands in this category at the beginning of the analysis represent 19 541 ha or 2.17% of the total net land base.

The base for comparison of results will be our base case modified to include thinning to 2 400 stems (the best results were achieved at this density). Yields after thinning were assumed to exhibit a 5% accumulated volume increase. Final harvests are delayed for a minimum of 20 years post thinning.

For an uneven regime, another 5% increment of timber supply in the short-term can be achieved from commercial thinning (Figure 3.9a and Table 3.11). Key to achieving the increased harvest levels is leaving the commercially thinned stands long enough to realize the higher volume levels.

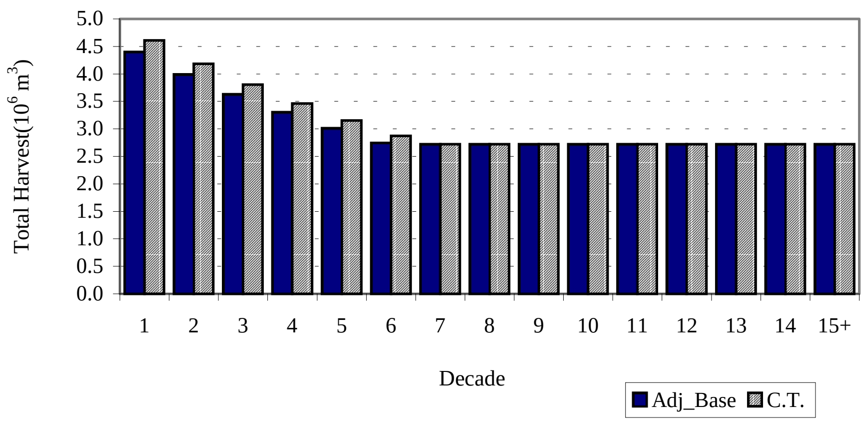

Figure 3.9a Uneven-flow - Comparison of base case vs. commercial thinning

Table 3.11 Harvest schedule – commercial thinning

Decade	Total Annual Harvest (m^3)
1	4 609 980
2	4 185 432
3	3 803 339
4	3 459 455
5	3 149 959
6	2 871 413
7	2 723 100
8	2 723 100
9+	2 723 100

In an even-flow regime, the net benefit from commercial thinning is a 1% increment in timber supply which increases to 2 911 788 m^3/year (Figure 3.9b).

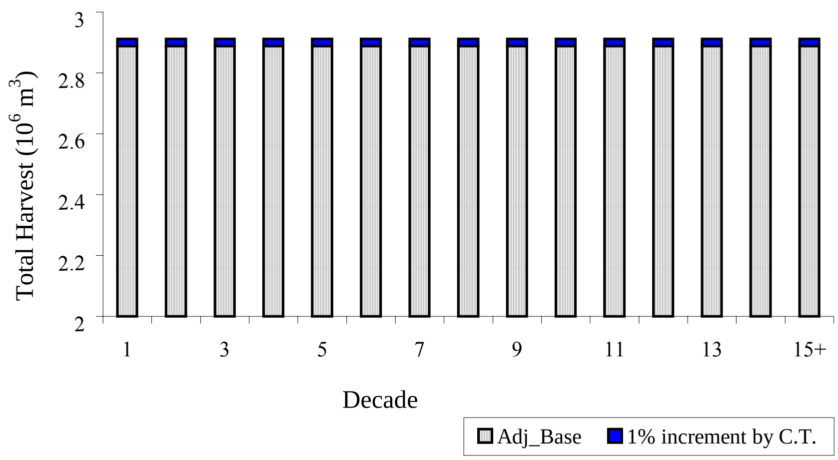

Figure 3.9b Even-flow - comparison of base case vs. commercial thinning

3.10 Commercial Thinning and Fertilizing

The same commercial thinning methodology as modeled in the preceding analysis is used here. The candidate stands are pine and Douglas-fir on good and medium sites. The fertilization is applied during thinning. The response to fertilizing is set to 15 m^3/ha (and 40 m^3/ha). In the uneven-flow scenario, benefits in the short-term are 7% (and 10%) (Figure 3.10a and Table 3.12).

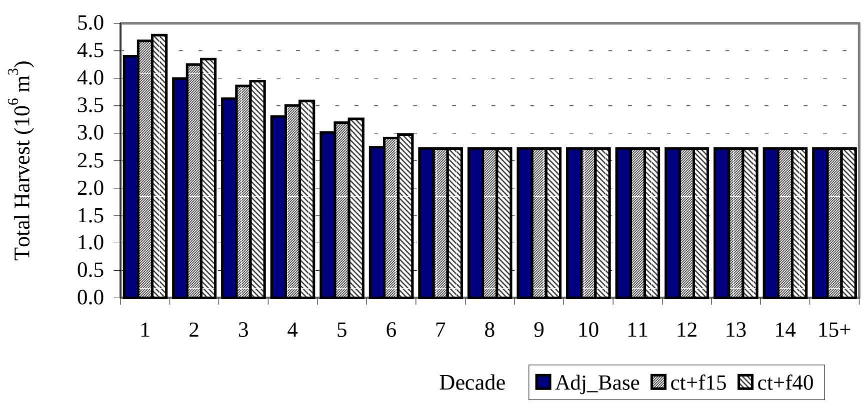

Figure 3.10a Uneven-flow - commercial thinning and fertilizing

Table 3.12 Harvest schedule – commercial thinning and fertilizing

Decade	Total Annual Harvest (m^3) ($15m^3$/ha assumption)	Total Annual Harvest (m^3) ($40m^3$/ha assumption)
1	4 680 738	4 786 875
2	4 249 114	4 344 638
3	3 860 653	3 946 624
4	3 511 038	3 588 411
5	3 196 384	3 266 020
6	2 913 195	2 975 868
7	2 723 100	2 723 100
8	2 723 100	2 723 100
9+	2 723 100	2 723 100

When applying this scenario to even-flow harvesting regime, 15 and 40 m^3/ha respectively, the timber supply can increase 2% and 3% within the planning horizon and the annual harvesting level rises to 2 935 374 and 2 958 960 m^3/year (Figure 3.10b).

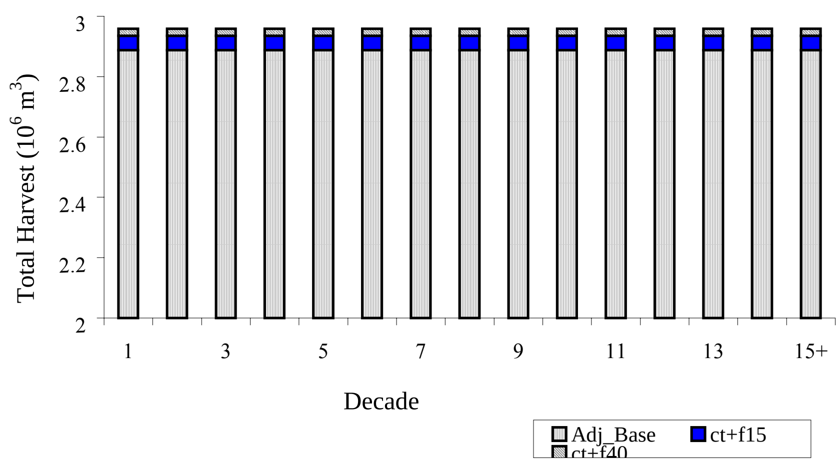

Figure 3.10b Even-flow - commercial thinning and fertilizing

4.0 SUMMARY

Table 4.1 provides a summary of impacts associated with the treatments modeled. Harvest levels shown are total harvest net of unsalvaged losses. Increases expressed as a percent represent an increase in the conifer sawlog partition of the cut.

Table 4.1 Summary of impacts associated with treatments

Scenario	**Even-flow**		**Uneven-flow**			
	Total Harvest (000 m^3/year)	**% above base case (sawlog harvest)**	**Short-term**		**Long-term**	
			Total Harvest (000 m^3/year)	**% above base case (sawlog harvest)**	**Total Harvest (000 m^3/year)**	**% above base case (sawlog harvest)**
Current AAC	n/a	n/a	2 340	n/a	n/a	n/a
Base case	2 723	n/a	3 902	n/a	2 723	n/a
Old growth site index	3 006	12%	4 256	10%	2 841	5%
Reduce regeneration delay	2 794	3%	4 079	5%	2 723	0%
Genetic improvement						
low (3%)	2 841	5%	4 256	10%	2 723	0%
moderate (5%)	2 888	7%	4 433	15%	2 723	0%
high (7%)	2 935	9%	4 433	15%	2 817	4%
Density Management						
3600 stems	2 794	3%	4 079	5%	2 723	0%
2400 stems	2 888	7%	4 398	14%	2 723	0%
1200 stems	2 865	6%	4 256	10%	2 723	0%
Fertilization						
redefined base case	2 888	n/a	4 398	n/a	2 723	n/a
15 m^3/ha increase	2 912	8%	4 433	5%	2 723	0%
40 m^3/ha increase	2 959	10%	4 610	10%	2 723	0%
NSR backlog	2 770	2%	4 044	4%	2 723	0%
PFT rehabilitation	2 794	3%	4 079	5%	2 723	0%
rehabilitate roads and landings	2 794	3%	4 221	9%	2 723	0%
Commercial thinning						
redefined base case	2 888	n/a	4 398	n/a	2 723	0%
commercial thinning	2 912	1%	4 610	5%	2 723	0%
Commercial thinning and fertilization						
redefined base case	2 888	n/a	4 398	n/a	2 723	n/a
15 m^3/ha increase	2 935	2%	4 681	7%	2 723	0%
40 m^3/ha increase	2 959	3%	4 786	10%	2 723	0%