

Timber Supply Analysis  
For Management Plan #9 on TFL15  
January 2004

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“This plan is the start of a never ending fact-finding job which, as time progresses, will gradually bring details into sharper focus for more efficient selection of logging areas, for revision of inventory estimates, for intensification of planning and for a stronger basis of predicting growth and yield. From this may evolve revisions of the sustained yield estimated, refinements in procedure, modifications of cutting methods, etc., for incorporation in future working plans”

**Quote from:**

Initial Management Working Plan for the BC Interior Sawmills Limited Management License Reserve Area (TFL 35), December 1955

**Executive summary**

This report summarizes the results of a comprehensive series of timber supply analyses completed as a part of Weyerhaeuser Company Limited’s Management Plan 9 for TFL 15. The analyses form the basis for a recommended harvest level of 66,570m<sup>3</sup>/yr for the period July 29, 2004, to July 28, 2009. A Base Case, one recommended option and numerous sensitivity analyses were designed to demonstrate the relationship of current management practices and provincial policy to the stability of short, mid and long-term harvest levels.

**Introduction**

The Timber Supply Analysis (analysis) is a key component of Weyerhaeuser Company Limited’s (Weyerhaeuser) Management Plan 9 submission for Tree Farm License #15 (TFL 15). The analysis is characterized by several elements:

- Weyerhaeuser’s desire to maintain the current harvest level, as a result of continued investment, and commitment to our forestry programs
- Interpretation and incorporation of the Okanagan Shuswap Land and Resource Management Plan
- Development of a Recommended Option encompassing modified cutblock sizes and modified precommercial spacing regimes

The Timber Supply Analysis Information Package prepared for TFL15 contains relevant data, inventory summaries and management assumptions that document input data and modeling procedures. When Weyerhaeuser deviated from the Information Package, specific notation and rationalization is included in the analysis.

## General description of landbase

TFL 15 is located in the south central portion of the Province on the height of land between the Okanagan and Kettle valleys adjacent to OK Falls and Oliver. The total landbase is 46,411.4 hectares and extends approximately thirty-four (34) kilometers on a north south axis and is twenty-five (25) kilometers in width. There are seven Biogeoclimatic subzone variants on the TFL over an elevation range of approximately 500m to 2200m. The principal tree species on TFL 15 are Lodgepole Pine, Western Larch, Ponderosa Pine, Douglas Fir, Sub-Alpine Fir and Englelman Spruce. Figure 1 shows the distribution of leading species of the forested landbase. Continuous forest management since mid-1950 has created approximately 11,318 hectares of second growth. The current harvest level is set at 70,000 m<sup>3</sup>/yr.



Figure 1: Leading species distribution

## Management zones

Eight management zones identified in the Okanagan Shuswap fall within TFL15. Of these, five have an identified resource value that needs to be incorporated into the timber supply analysis. Four are built into this analysis and provide specific forest cover and/or disturbance and/or green-up requirements. These zones are the General Management Zone, the Mule Deer Winter Range RMZ<sup>1</sup>, the Big Horn Sheep RMZ and the Visual Landscape Management Zone. The resource values for the fifth zone (Elk Habitat Zone) are met by Mule Deer Winter Range RMZ requirements. Table 1 shows the gross and net areas for each zone.

<sup>1</sup> RMZ = Resource Management Zone

**Table 1: Management zone summary**

| Zone name                  | Area     |          | Comments   |
|----------------------------|----------|----------|--|
|                            | gross    | net      |  |
| General management zone    | 22,785.0 | 22,785.0 |  |
| Mule Deer Winter Range RMZ | 9,949.6  | 5,349.9  | 4,599.7 hectares overlaps with the visual management zone and will be managed in conjunction with respective visual forest cover objectives. 5,349.9 hectares will be managed using mule deer forest cover objectives. |
| Big Horn Sheep RMZ         | 20,733.1 | 10,909.9 | Defers to Mule Deer winter range objectives when overlap occurs  |
| Visual management zone     | 9,092.0  | 2,724.0  | 6,368 hectares overlaps with Mule Deer and Big Horn Sheep zones and will managed in conjunction with their respective forest cover objectives. 2,724.0 hectares will be managed using VQO forest cover objectives.     |
| Elk Habitat RMZ            | 7,005.4  | na       | No area outside Mule Deer or Big Horn zones. Defers to Mule Deer winter range objectives when overlap occurs.  |

### **Timber supply analysis methods**

The linear optimizing program WOODSTOCK was used to determine the harvest level and sensitivity analysis for TFL15. Land classification is accomplished by the use of development types. A development type is a specific group of stands based on developmental characteristics without differentiation for age. The combination of management zones, watersheds, land class and existing and future yield curves are combined into unique development classes.

In this formulation, silvicultural activities are specified outside the model in relationships between existing and future stands and WOODSTOCK was allowed to choose when to harvest given the minimum operability criteria supplied. Measuring management success was accomplished through the use of numerous outputs; specific criteria and indicators are identified in Table 2.

**Table 2: Criteria and Indicators**

| <b>Criteria</b>                                   | <b>Indicator</b>   |
|---|--|
| Timber Supply                                     | Harvest level  |
|   | Composition of projected harvest volume                                |
|   | Average volume per hectare and area harvested                          |
|   | Harvest age minus forest-level culmination age                         |
|   | Current, future and total growing stock                                |
|   | Age class distribution   |
| Visual quality objectives                         | Percent area below maximum disturbance and age criteria                |
| Maximum cutblock size and green-up                | Percent area below maximum age criteria                                |
| Snow interception cover in mule deer winter range | Percent snow interception area above a minimum age and height criteria |
| Snow interception cover in Sheep winter range     | Percent area above minimum height criteria                             |

Thresholds were identified for the indicators above while values for others were monitored for behaviour. WOODSTOCK was configured to maximize the total harvest across the planning horizon, subject to meeting the combination of specific thresholds for the indicators.

Actions within WOODSTOCK occur at single points in time and interpolation does not occur. The planning period used was ten years, so all actions and activities occur every ten years. Because of this, height-based indicators (e.g. green-up) were translated to age-based values. These values were calculated for specific zones/constraints using area-weighted height age relationships. The planning horizon used was 200 years.

### **General management zone**

This is the largest zone and is managed for timber production. Resource constraints were factored into WOODSTOCK as follows:

1. To model a green-up height of 2 meters and a three-pass harvesting sequence WOODSTOCK was constrained to maintain a maximum of 33% of the gross forested area less than one period (10 years).

### **Mule Deer Winter Range**

This is the third largest zone and is managed for timber production and to provide forest cover that is adequate to meet snow interception cover for the mule deer. The LRMP identified three snowpack zones in the LRMP area each with different resource constraints. Two of these snowpack zones occur within TFL15. To manage for Mule Deer Winter Range values a combination of larger assessment units and smaller planning cells were identified within the snowpack

zones. Ten Mule Deer Winter Range Assessment Units were identified and represent the area utilized by deer as winter range. Assessment unit size was targeted to be between 1,500 and 2,000 hectares. Some assessment units within TFL15 are small, as the units do not recognize tenure boundaries. Mule Deer Winter Range Planning Cells are subdivisions of assessment units and are to approximate the spatial distribution of forest cover attributes over the winter range. A total of 60 cells fall within TFL15 and are tracked in the analysis. Any individual assessment unit can have many planning cells in both snowpack zones. The development of the assessment units and planning cells and subsequent incorporation into operational planning is to help achieve “good distribution of forage and cover through out the mule deer winter range”. These resource constraints were factored into WOODSTOCK as follows:

1. To model the moderate snowpack zone forest cover requirements in the LRMP (“maintain 33% of the forested area in stands that are suitable for snow interception cover<sup>2</sup>) the following occurred:
  - Existing stands and regeneration strategies acceptable for snow interception (Douglas fir leading or component of appropriate age, except where noted) were identified and aggregated into a snow retention species group
  - Area-weighted snow interception retention requirements for each assessment unit were provided by the Ministry of Water, Land and Air Protection
  - WOODSTOCK was constrained to ensure that no less than the area-weighted snow retention requirements were achieved; 50% of which could be allocated to the non-timber harvesting landbase (nthlb). Table 3 shows the retention requirements for specific planning cell

**Table 3: Mule deer winter range planning cell thlb snow interception retention percents**

| Mule Deer Winter Range Planning Cell | Base Case retention | Sensitivity analysis |      |
|--------------------------------------|---------------------|----------------------|------|
|                                      |                     | +10%                 | -10% |
| 102                                  | 10                  | 20                   | 0    |
| 100                                  | 10                  | 20                   | 0    |
| 92                                   | 10                  | 20                   | 0    |
| 84                                   | 19.2                | 29.2                 | 9.2  |
| 78                                   | 11                  | 21                   | 1    |
| 73                                   | 10                  | 20                   | 0    |
| 70                                   | 20                  | 30                   | 10   |
| 69                                   | 10                  | 20                   | 0    |
| 65                                   | 10                  | 20                   | 0    |
| 58                                   | 10                  | 20                   | 0    |
| 55                                   | 10                  | 20                   | 0    |
| 54                                   | 20                  | 30                   | 10   |
| 49                                   | 13.1                | 23.1                 | 3.1  |

<sup>2</sup> Okanagan – Shuswap Land and Resource Management Plan, Polygon Specific Resource Management Zone, Wildlife, Mule Deer Winter Range RMZ, p 4-6

| Mule Deer Winter Range Planning Cell | Base Case retention | Sensitivity analysis |      |
|--------------------------------------|---------------------|----------------------|------|
|                                      |                     | +10%                 | -10% |
| 45                                   | 20                  | 30                   | 10   |
| 40                                   | 20                  | 30                   | 10   |
| 25                                   | 20                  | 30                   | 10   |

2. To model the low snowpack zone forest cover requirements in the LRMP (“maintain 15% of the forested area in stands that are suitable for snow interception cover<sup>3</sup>) the following occurred:
  - Existing stands and regeneration strategies acceptable for snow interception (Douglas fir leading or component of appropriate age, except where noted) were identified and aggregated into a snow retention group
  - The amount of the snow retention group was monitored for each specific cell
3. Adoption of the assessment unit and planning cell concept results in “good distribution” of forage and cover and as per the LRMP, block width restrictions<sup>4</sup> can be removed. To model the green-up height of 2 meters and a three-pass harvesting sequence WOODSTOCK was constrained to maintain a maximum of 33% of the gross forested area less than one period one (10 years in age).

### Big Horn Sheep RMZ

This is the second largest zone and is managed primarily for timber production and to provide forest cover that is adequate to meet the thermal, snow interception and security requirements for the sheep. Resource constraints were factored into WOODSTOCK as follows:

1. To model the green-up height of 2 meters and a three-pass harvesting sequence WOODSTOCK was constrained to maintain a maximum of 33% of the gross forested area less than one period (10 years in age).
2. To model the forest cover requirements in the LRMP (“maintain 33% of the stand to a height of 16.0 meters or greater and a crown closure class of 3 or greater<sup>5</sup>), WOODSTOCK was constrained to ensure that no less than 33% of the forested landbase was less than 60 years of age (the area weighted age to reach 16 meters).

### Visual landscape management zone

This is the fourth largest zone and is managed for timber production and to maintain the visual quality of the landscape. Visual quality is managed through the use of visual quality objectives, percent disturbance and green-up. Three main visual quality objectives were identified: Retention, Partial Retention

<sup>3</sup> Okanagan – Shuswap Land and Resource Management Plan, Polygon Specific Resource Management Zone, Wildlife, Mule Deer Winter Range RMZ, p 4-9

<sup>4</sup> Okanagan – Shuswap Land and Resource Management Plan, Polygon Specific Resource Management Zone, Wildlife, Mule Deer Winter Range RMZ, p 4-2

<sup>5</sup> Okanagan – Shuswap Land and Resource Management Plan, Polygon Specific Resource Management Zone, Wildlife, Bighorn Sheep RMZ, p 4-6

and Modification. Appendix 6 from the Okanagan Shuswap LRMP provides guidance on maximum percent disturbance and visually effective green-up for various silviculture regimes. A copy of this table is in Appendix 1. To model resource constraints the following three conditions<sup>6</sup> were incorporated into WOODSTOCK:

1. To model a visually effective green-up height of 3.0 meters and a maximum denudation area of 20% in the Partial Retention unit, WOODSTOCK was constrained to maintain no more than a maximum of 20% of the gross forested area less than 20 years in age.
2. To model a visually effective green-up height of 3.7 meters and a maximum harvest area of 11.3% below this height in the Retention unit, WOODSTOCK was constrained to maintain no more than a maximum of 11.3% of the gross forested area less than 20 years in age.
3. To model a visually effective green-up height of 3.0 meters and a maximum harvest area of 30% below this height in the Modification unit, WOODSTOCK was constrained to maintain no more than a maximum of 30% of the gross forested area less than 10 years in age.

### **Elk Habitat RMZ**

The Okanagan Shuswap LRMP states that the objectives and strategies identified for the Mule Deer Winter Range RMZ will generally provide adequate management direction for elk winter habitat. Given the distribution of cover and deployment of the assessment units and planning cells, the additional spatial requirement (30 to 50% of the snow interception cover to occur in 10-hectare patches) was not modeled.

### **Base Case**

The base case reflects Weyerhaeuser's current performance and includes:

- requirements from the Forest Practices Code (FPC) and Forest and Range Protection Act (FRPA)
- new growth and yield data
- current silvicultural practices
- current rehabilitation practice on all in-block roads and landings
- forest-cover, green-up and maximum allowable disturbance and cut block size limitations from the Okanagan Shuswap LRMP

There are no Wildlife Habitat Areas within TFL15, so the impact of the identified wildlife strategy was modeled as 0. Preliminary discussions have occurred regarding Whiteheaded Woodpecker WHA's, but work is still ongoing with the Recovery Team.

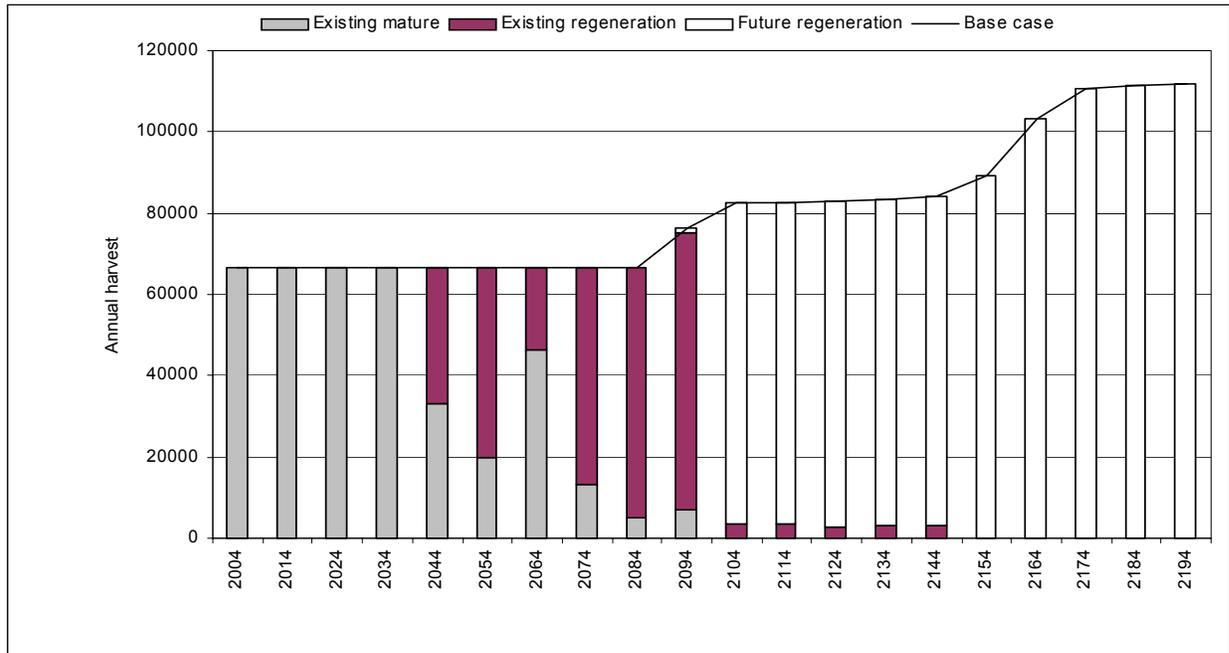
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<sup>6</sup> Defined in the Information Package

## Results

### Timber indicators

A maximum harvest level of 66,570 m<sup>3</sup>/yr is sustainable for the first 40 years, at which point harvest levels are forecasted to increase steadily to a long-term harvest level of 111,448 m<sup>3</sup>/yr. Figure 2 shows the contribution to the total harvest of three categories of wood; existing mature, existing regeneration and future regeneration. The transition from harvesting the existing mature to harvesting the existing and future regeneration (transition period) begins in 2044 and is essentially complete by 2074. The combined base case harvest flow is shown for reference and is repeated in all sensitivity analysis.



**Figure 2: Harvest composition of base case**

Variability around harvest flow was controlled in three distinct intervals to ensure that the resulting pattern was acceptable. This was required for two reasons:

- The objective function was to maximize harvest volume over the planning horizon
- A key component of the yield curves at older ages is that net volume is constant. That is volume loss through mortality equals volume gain through growth

Without flow control the combination of these two plus the age class structure and minimum operability limits create spikes of harvest followed by troughs, culminating in a significant harvest in the last few periods of the planning horizon.

In order to balance and redistribute the harvest, three control intervals (periods 1 to 4, 5 to 12 and 13 to 20) were developed and a “harvest flow interval control” was created (+/-15% around the average harvest in each interval). The harvest flow within the planning horizon had to be non-declining and had to meet a minimum merchantable growing stock volume in the last forty years. This combination had the effect of redistributing volume more evenly within each interval and creating the stepped pattern in Figure 2.

Wider harvest flow interval control ranges (up to +/- 30% was tested) created larger between-interval steps, delayed harvest later within each interval and increased the planning horizon volume toward the maximum. Smaller ranges (down to +/-5% was tested) created smaller between-interval steps, smoothed harvest (more even-flowish) within each interval and created a much larger difference between the planning horizon volume and the maximum. +/- 15% was used, as it more closely resembles the harvest flows achieved in parallel runs in COMPLAN and those in MP8.

A non-declining flow in periods 1 to 4 (first interval) was selected for all sensitivities to reflect Weyerhaeuser’s desire for a stable harvest flow in the short-term.

Minimum operability reflects a balance between harvest flow objectives, the impact of constraints on this flow and on-the-ground operability. On-the-ground operability is a balance between volume, piece size and diameter distribution and demand for various log products. Diameter information from VDYP and TIPSY was combined with professional judgement, special cruise and appraisal cruise data to bridge the combination of available model output (quadratic mean diameter, average diameter, and stand volume) and operational operability criteria and desired harvest flow. Table 4 outlines the minimum operability associated with the base case.

**Table 4: Minimum operability criteria**

| <b>Operational operability criteria</b>   | <b>Yield curve</b>  | <b>WOODSTOCK yield curve approximation</b> |
|---|---|--|
| Fd/Lw<br>>= 50% of the stems in a stand > 30cm dbh and a minimum volume 150m <sup>3</sup> /ha | 1, 2, 3, 5, 6, 8, 9 ,10,11, f1, f2, f5, f7                              | 150m <sup>3</sup> /ha minimum              |
|   | 1e2, 2e1, 3e1, 3e2, 6e1, 6e2, 7e1, 9e1, 11e2, f5nsr, f3                 | 175m <sup>3</sup> /ha minimum              |
|   | 2e2, 5e1, 5e2, 5e3, 6e3, 9e2, 9e3, 10e1, 10e2, 10e3, 11e1, f2nsr, f3nsr | 250m <sup>3</sup> /ha minimum              |

| <b>Operational operability criteria</b>  | <b>Yield curve</b>  | <b>WOODSTOCK yield curve approximation</b> |
|--|---|--|
| Ba leading<br>>= 50% of the stems in a stand > 30cm dbh and a minimum volume 200m <sup>3</sup> /ha<br>Sx leading<br>>= 50% of the stems in a stand > 25cm dbh and a minimum volume between 175 and 200m <sup>3</sup> /ha | 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 16e2, 17e2, 17e3, 19e1, 19e2, 20e2, 22e2, 22e3, 23e1, 23e2, 24e2  | 200m <sup>3</sup> /ha minimum              |
|  | 13e1, 13e2, 13e3, 14e1, 14e3  | 275m <sup>3</sup> /ha minimum              |
| Pl leading<br>>= 70% stems in a stand >5" butt and a 4" top and minimum volume 150m <sup>3</sup> /ha   | 26, 27, 28, 29, 30, 31, 32, 33, 34, 35  | 175m <sup>3</sup> /ha minimum              |
|  | 26e1, 26e2, 26e3, 27e1, 27e2, 27e3, 28e1, 28e2, 28e3, 30e1, 30e2, 30e3, 31e1, 31e2, 31e3, 32e1, 32e2, 32e3, 34e1, 34e2, 35e2, f4nsr, f8nsr, f9nsr, f4, f8, f9, f9h, f10, f10h, f11, f12, f13, f13h, f14, f14h, f15, f16 | 200m <sup>3</sup> /ha minimum              |
| Residual stands<br>>= 100 years age  | 2R, 3R, 7, 8R, 10R, 11R, 12, 18R, 25  | 100 years old minimum                      |
| SC4 stands<br>>= 70% stems in a stand >4" butt and a 3" top and minimum volume 100m <sup>3</sup> /ha   | 274, 284, 294, 324, 334, 354  | 140m <sup>3</sup> /ha minimum              |

The effects on average harvest volume per hectare, harvest area and average harvest age is shown in Figures 3 and 4. Annual peak harvest is 379 hectares in 2034 and corresponds to the low average volume per hectare of 176m<sup>3</sup>/ha. Average harvest age drops slightly below forest-level culmination age (99 years), twice in the planning horizon. Between 2044 and 2054 the average harvest age is 94, and between 2104 and 2134, the average harvest ages are 82, 88, 91 and 96 respectively.

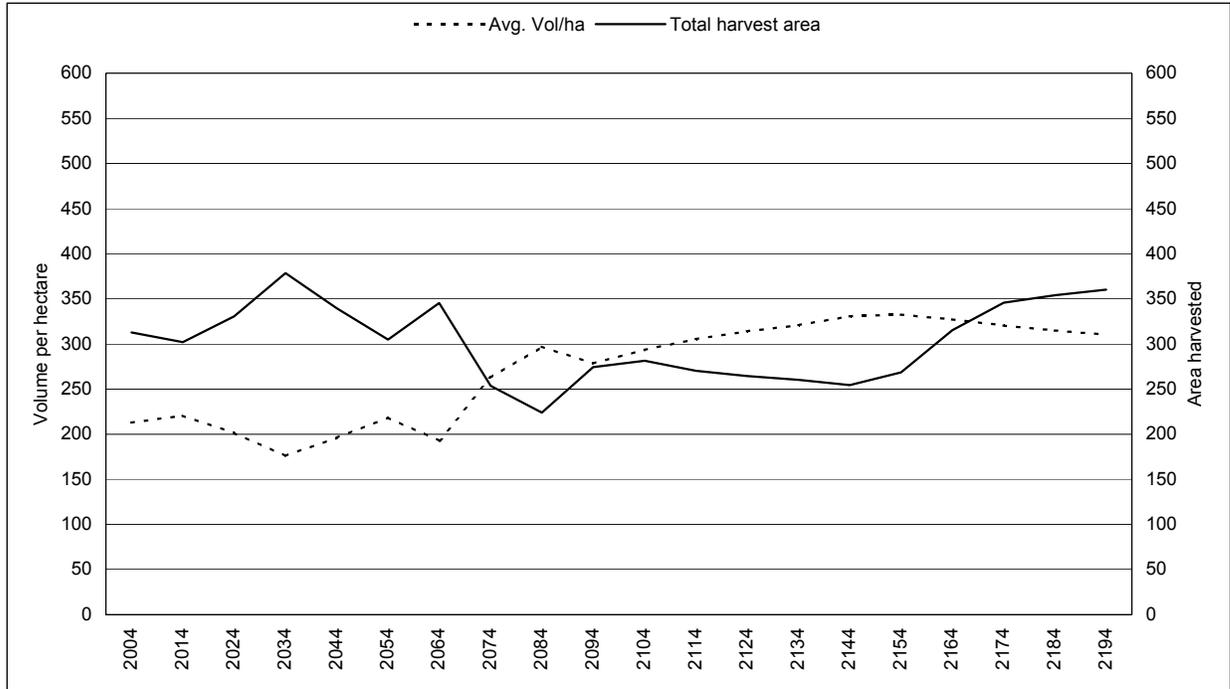


Figure 3: Average volume per hectare and area harvested

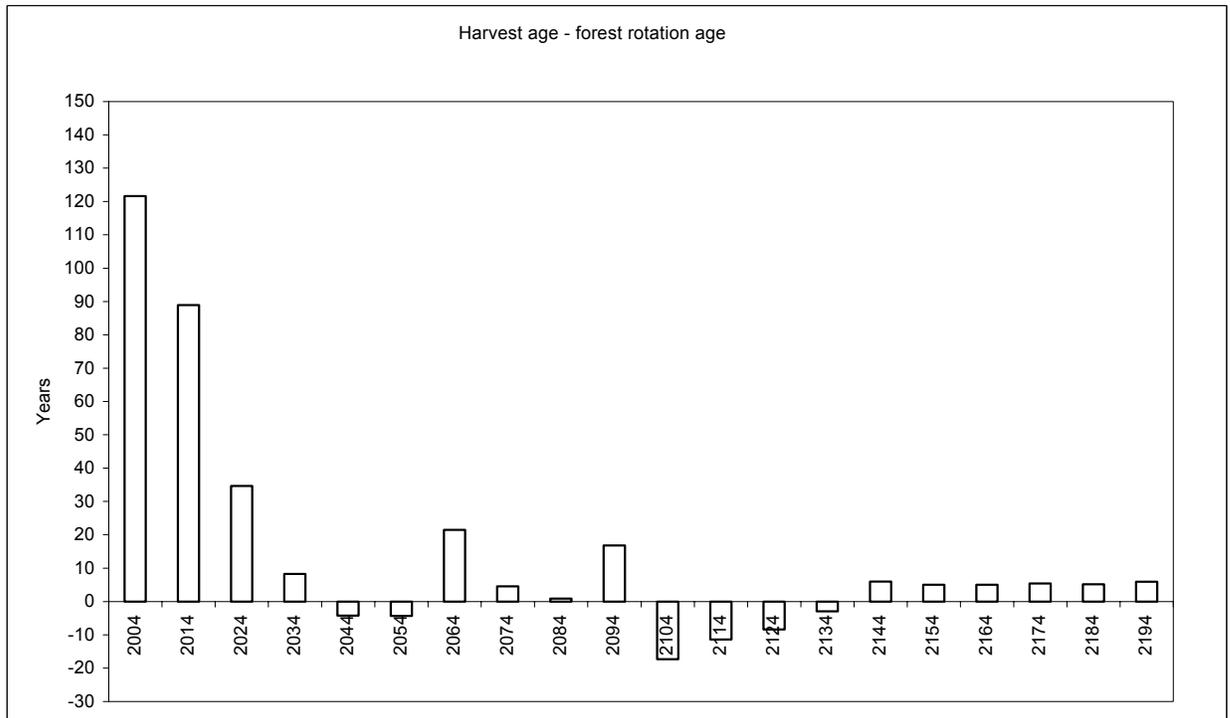
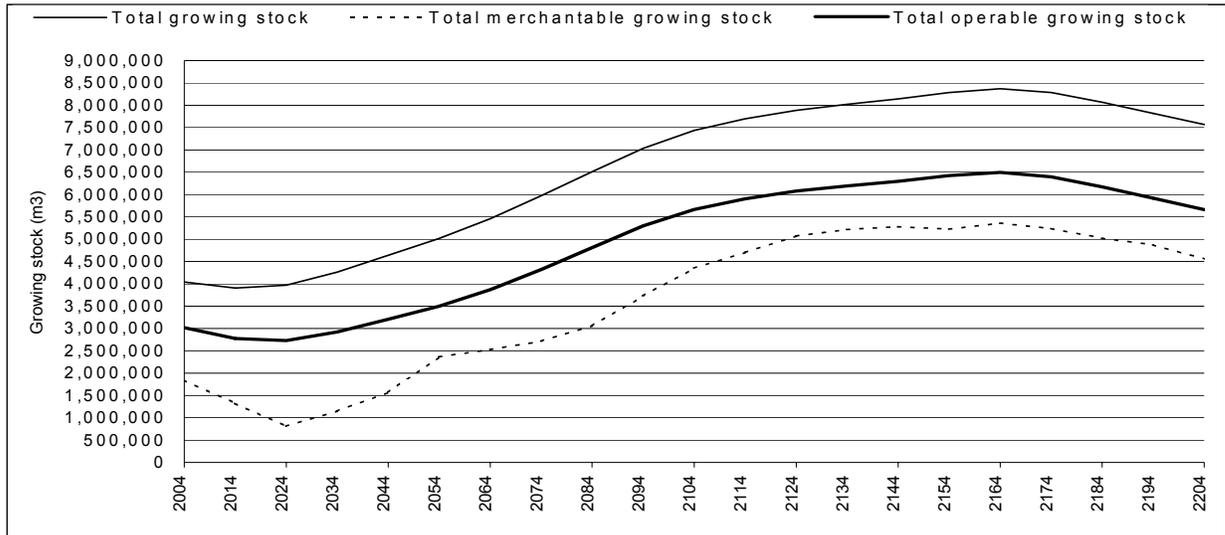


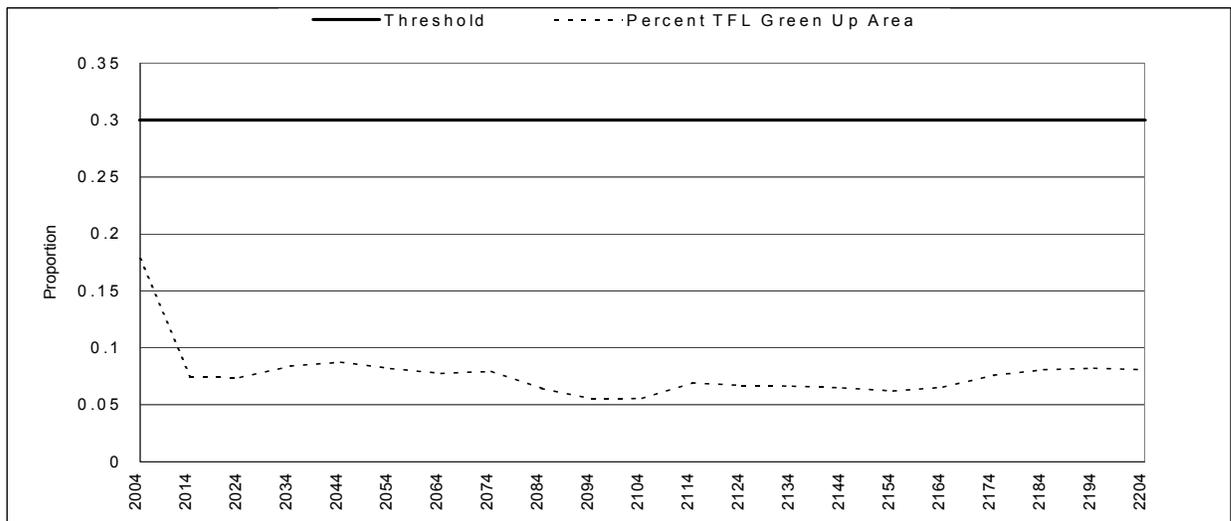
Figure 4: Average harvest age minus forest level culmination age

Total (all forested land), merchantable (above minimum operability) and operable (timber harvesting landbase) growing stock levels are shown in Figure 5. WOODSTOCK was constrained to maintain 3,200,000m<sup>3</sup> per period for the last 40 years in the planning horizon to ensure harvest flow stability beyond the planning horizon. This constraint is non-binding in the base case because of the harvest flow variability constraint discussed earlier.



**Figure 5: Growing stock**

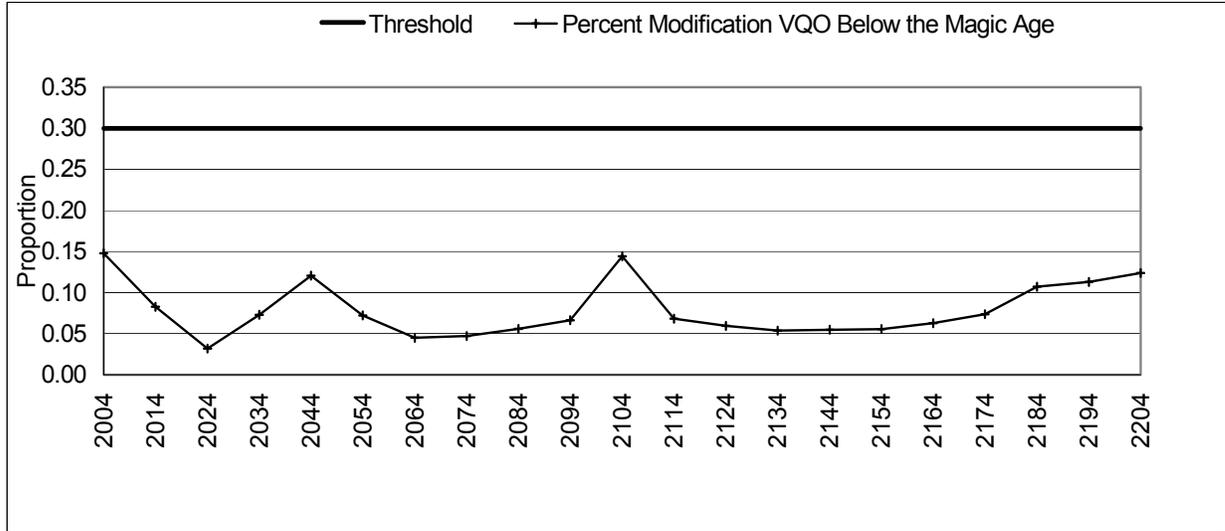
Figure 6 shows that green-up is not constraining at any point in the planning horizon.



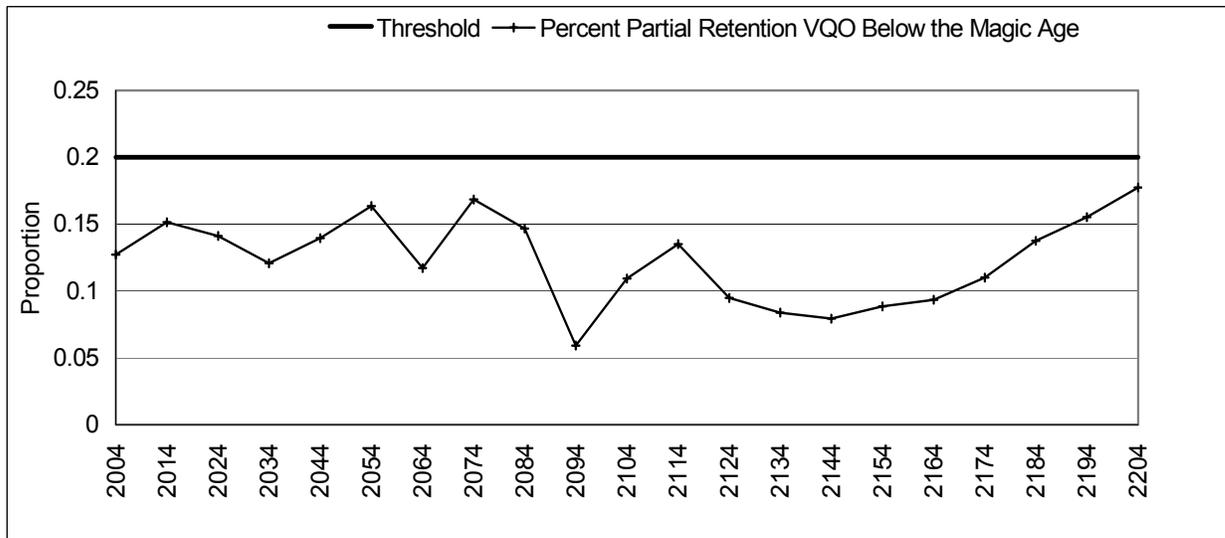
**Figure 6: Area below 2 meter green-up threshold**

**Visual landscape management indicators**

Green-up and harvest disturbance thresholds do not impact harvest levels for either the modification or partial retention visually sensitive areas. Figure 7 and 8 show the area below the threshold.

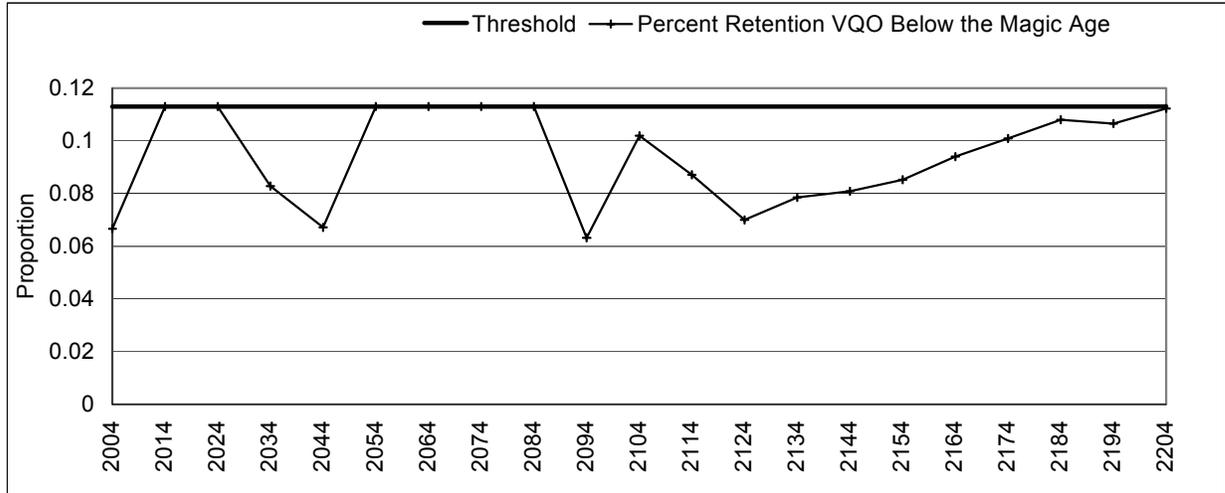


**Figure 7: Area below 3 meter green-up threshold**



**Figure 8: Area below 3 meter green-up threshold**

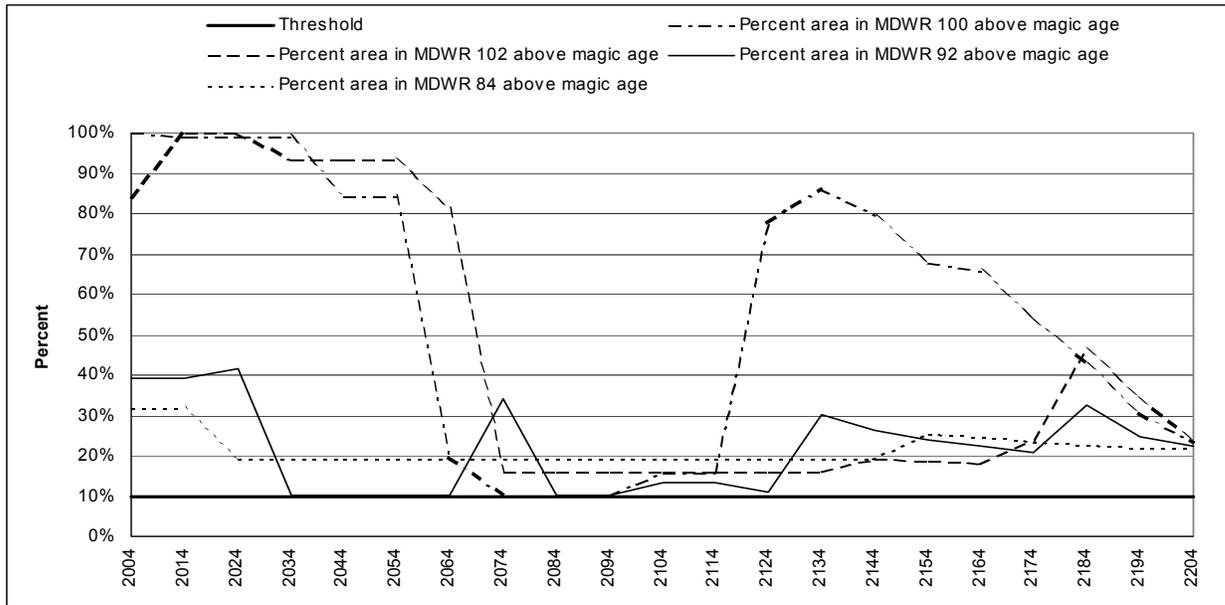
As shown in Figure 9, twice during the planning horizon, the 3.7 meter threshold limits harvest.



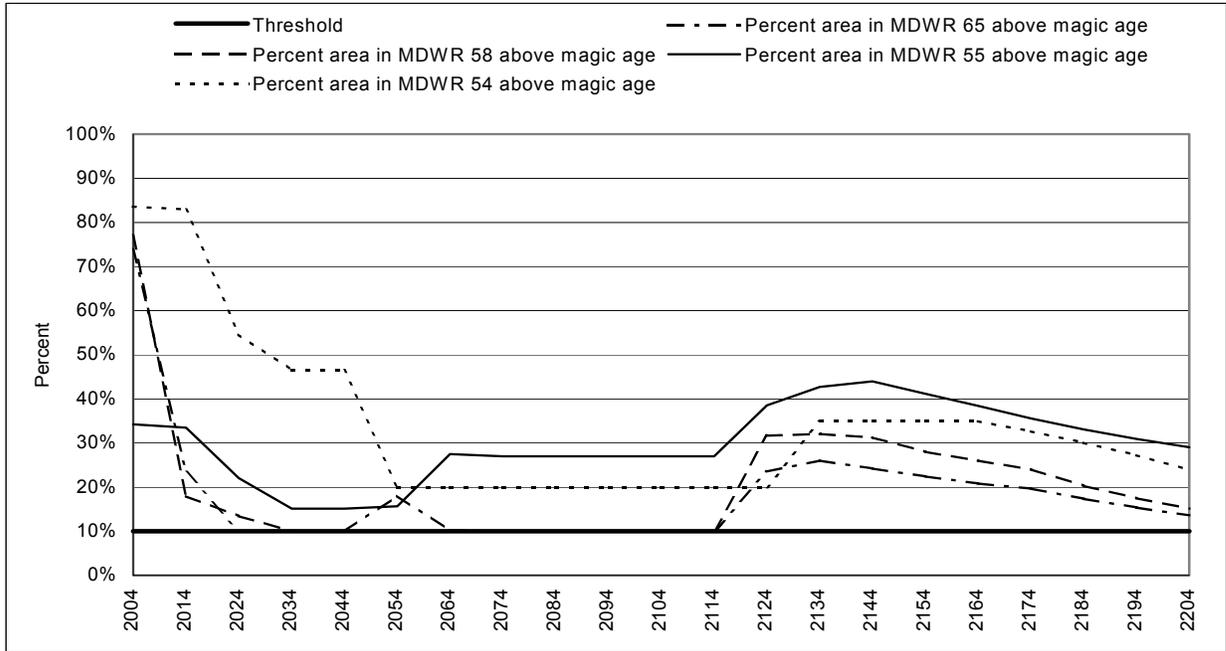
**Figure 9: Area below 3.7 meter green-up threshold**

**Mule deer winter range planning cell indicators**

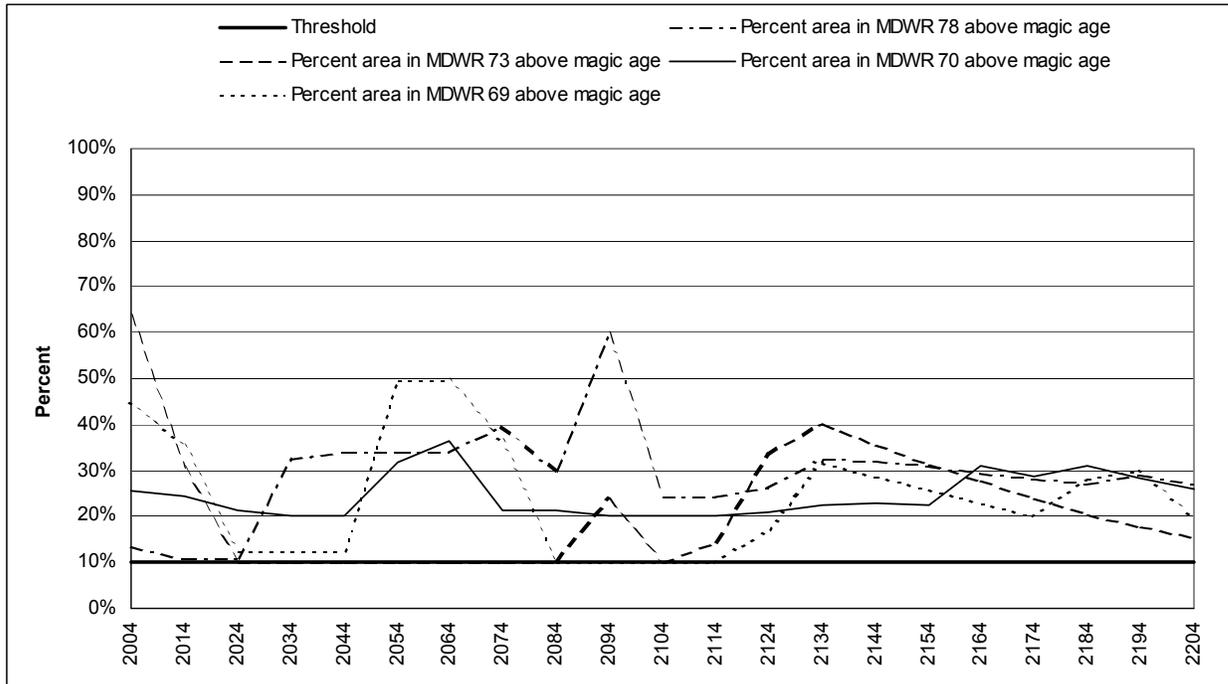
Figures 10 through 13 show the area of snow interception cover for sixteen specific planning cells. These cells were identified as requiring specific snow interception levels.



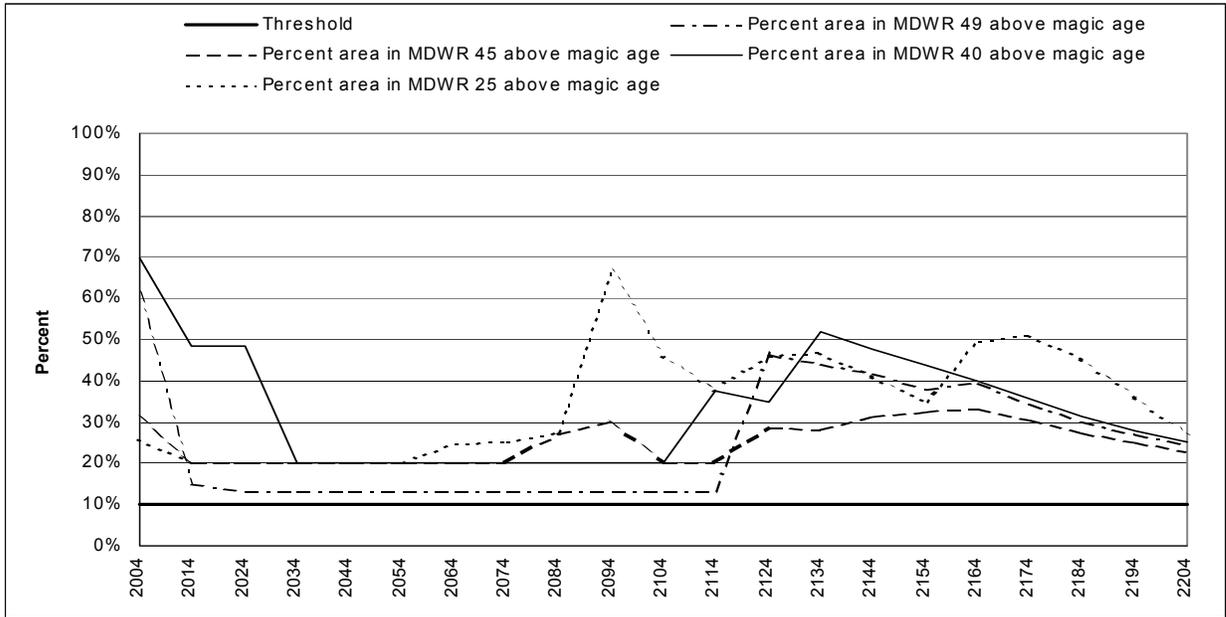
**Figure 10: Percent area above the snow interception threshold for cells 102, 100, 92, 84**



**Figure 11: Percent area above the snow interception threshold for cells 65, 58, 55, 54**



**Figure 12: Percent area above the snow interception threshold for cells 78, 73, 70, 69**

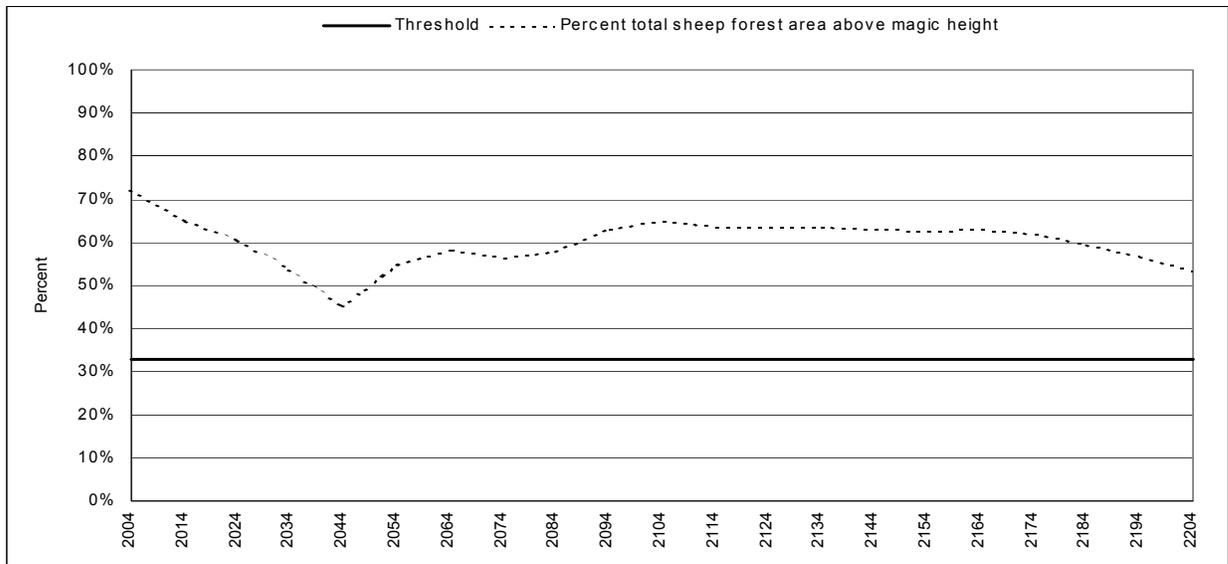


**Figure 13: Percent area above the snow interception threshold for cells 49, 45, 40, 25**

Six of the sixteen planning cells constrain harvest levels for various time frames. The timeframe of most constraint is 2024 to 2064, which corresponds to the transition period between existing mature and existing regeneration.

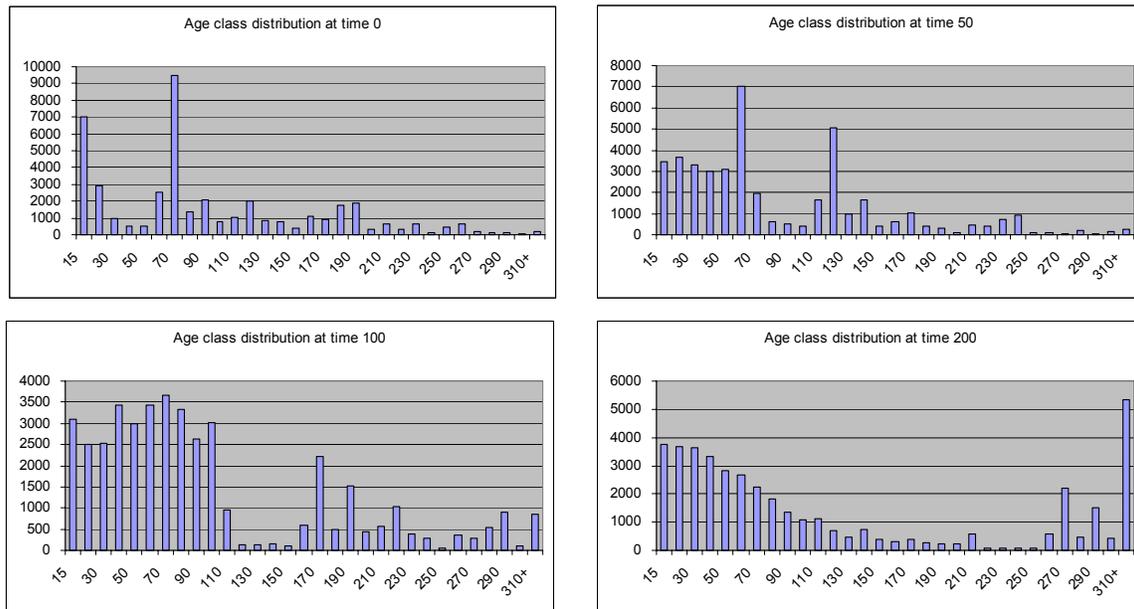
**Big Horn Sheep Habitat Indicators**

Snow interception thresholds are met throughout the planning horizon (Figure 14).



**Figure 14: Percent area above the snow interception threshold for Big horn sheep**

Age class distributions for time 0, 50, 100 and 200 are show in Figure 15.



**Figure 15: Age class distributions for time 0, 50, 100 and 200**

### Sensitivity Analysis

The degree of certainty with data, assumptions and procedures was measured through the sensitivity analyses outlined in Table 5 below. Two sensitivities identified in the Information Package were not examined. A non-declining flow would redistribute the 40 year cumulative volume of 2,662,800 m<sup>3</sup> (66,570m<sup>3</sup>/yr x 40), starting with a lower initial harvest, and periodic increases with no overall difference in cumulative volume and was not viewed as a preferred option. After additional review combined area and volume harvest control was not applicable either.

**Table 5: Sensitivity and harvest flow analyses descriptions**

| Change  | Rationale  |
|---|--|
| Maximum initial level harvest                 | Test stability of a maximum short-term harvest level constrained by a maximum +/-10% per decade change       |
| Forest cover constraints +/- 10%              | ± 10% in forest cover requirements for Mule deer winter range  |
| Regeneration volume +/- 10%                   | To determine the impact on the harvest forecast of reducing and increasing future regeneration volume by 10% |
| Green-up +/- 1m                               | Test the impact of changing green-up heights on harvest flow   |
| Minimum operability +/- 25 m <sup>3</sup> /ha | To test the sensitivity of the harvest flow to changes in minimum operability levels                         |
| Standing volume +/- 5%                        | To determine the impact on the harvest forecast of reducing and increasing standing mature volume by 5%      |

| Change                                     | Rationale  |
|--|--|
| Combined -5% volume, -25m <sup>3</sup> /ha | To demonstrate the impact of modeling artifacts on the -5% volume sensitivity  |
| Fd, Sx site index +/- 1m                   | To determine the impact on the harvest forecast of changing the regenerated site index values for Douglas fir and Spruce |
| Landbase +/- 10%                           | To test the stability of the harvest flow to changes in thlb   |
| Vas fire impacts                           | To examine the potential range of impacts from the Vas fire  |

### Maximum initial harvest

The maximum initial harvest that can be supported on TFL15 and meet a 10% per decade decline is 74,000 m<sup>3</sup>/yr. The 40-year cumulative harvest is slightly lower at 2,573,913 m<sup>3</sup> than the 2,662,800 m<sup>3</sup> in the base case. This reflects a modeling limitation and is not the result of the harvest flow policy. Figure 16 below shows the harvest flow relative to the base case. Trends in all the other indicators are similar with slight elevations in the first decade due to the 7,430m<sup>3</sup>/yr additional harvest.

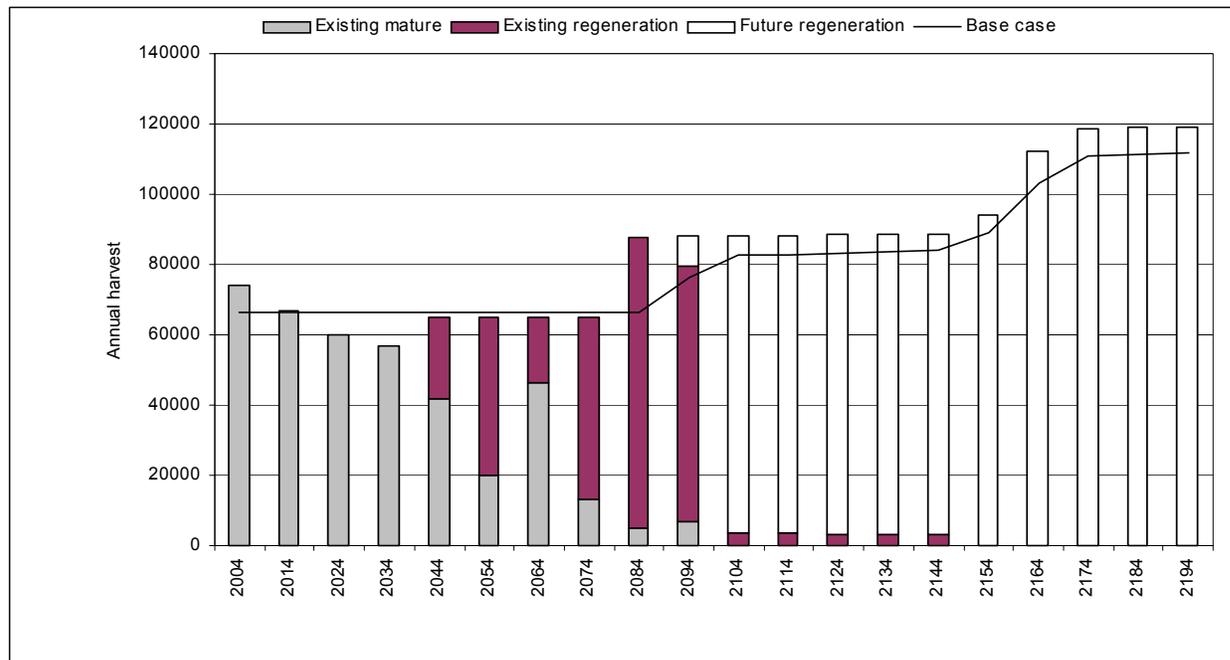


Figure 16: Harvest composition for maximum initial harvest flow

### Mule Deer Winter Range Planning Cell snow interception +/-10% thlb

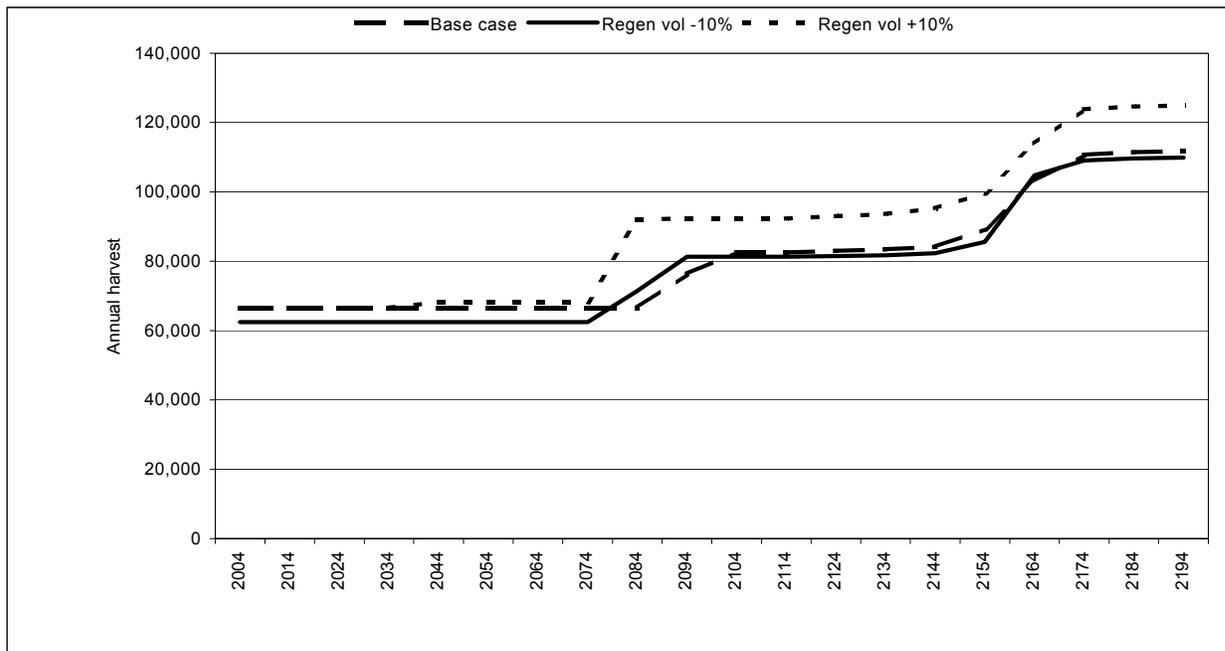
To meet the increased requirements specified in Table 3, harvest access in specific planning cells was prevented until the revised targets were met. There was a 0.8% decrease in harvest flow (66,000 m<sup>3</sup>/yr from 66,570 m<sup>3</sup>/yr) attributable to the increased retention levels. When the amount of snow interception cover was decreased by 10%, short-term harvest levels increased by

360 m<sup>3</sup>/yr to 66,930 m<sup>3</sup>/yr. Mid and long term levels were unchanged. There were no impacts for both cases in either mid or long-term harvest levels.

**Regeneration volume +/-10%**

The proportional scale in the WOODSTOCK regeneration yield file was inflated by 10% to test the sensitivity of the harvest flow to a positive uncertainty in regeneration volume. The impact on harvest flow was minimal in the short term because the majority of the increase occurs after decade 4, the pinch point in the harvest-planning horizon. The time to achieve minimum operability is reduced, however this occurs after decade 4 as well. Mid term and long term volumes are higher due to the percentage increase.

The proportional scale in the WOODSTOCK regeneration yield file was decreased by 10% to test the sensitivity of the harvest flow to a negative uncertainty in regeneration volume. The impact on short-term harvest flow was a decrease of 4,090m<sup>3</sup>/yr (66,570m<sup>3</sup>/yr to 62,480m<sup>3</sup>/yr). The effect of harvest flow interval control is shown in the -10% sensitivity in Figure 17. Intuitively the harvest volume from periods 5 to 20 should be less, however what this indicates is that there is surplus merchantable growing stock in the base case in periods 5 to 20 because the +/-15% flow control prevents some stands from being harvested in periods 5 to 20. In this sensitivity, the surplus merchantable growing stock is required to maximize harvest volume, and the impact of reduced site indices is masked somewhat. Mid term and long term volumes are not significantly different. Figure 17 shows the impact on harvest flow and composition for both runs.



**Figure 17: Harvest flow for +/-10% regeneration volume**

### Green-up heights +/-1m

The current green-up height of 2 meters was converted to an area-weighted age using the values in Table 28 of the Information Package. Because the area-weighted age is close to the period break within WOODSTOCK, green-up heights (modeled as ages) were varied +/- 1m. To model an increase in green-up height, the green-up threshold was increased to 3m (3 periods). To model the impact of reducing green-up heights from 2m to 1m, WOODSTOCK was run without any green-up constraints. This was done because the age equivalent of 1m is a finer resolution than the periods in WOODSTOCK. There was a slight change in long-term harvest flows, The impacts on harvest flow can be seen in Figure 18.

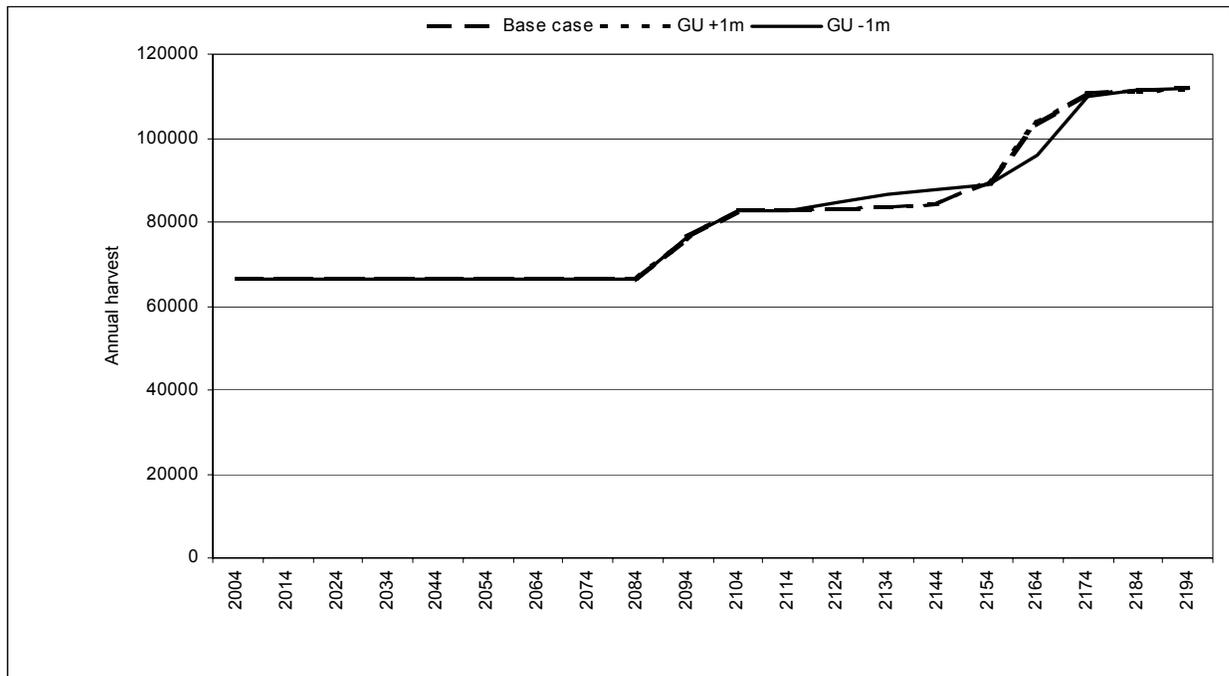


Figure 18: Harvest flow for +/-1m green-up

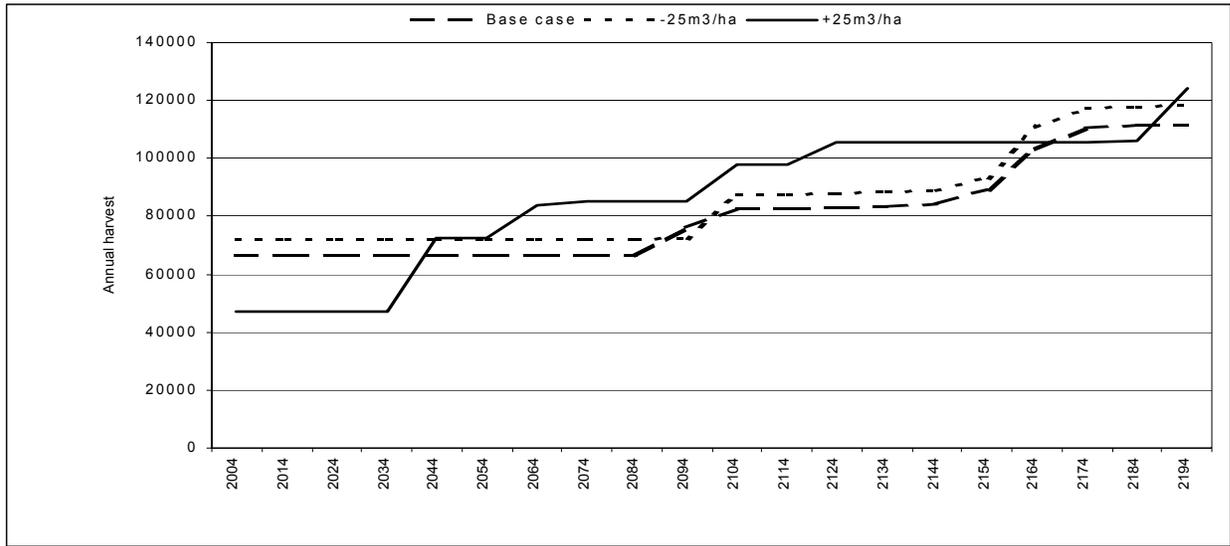
### Minimum operability +/-25m3/ha

Minimum operability is a combination of desired stand characteristics (volume, diameter distribution and piece size) and harvest flow objectives. As stated above diameter information from VDYP and TIPSY was combined with professional judgement, special cruise and appraisal cruise data and used to bridge the combination of available model output (quadratic mean diameter, average diameter, and stand volume) and operational operability criteria and desired harvest flow.

To model the impact of an increase in minimum operability criteria, 25 m3/ha was added to the existing "mature" stand operability thresholds in Table 4 which results in a 29% decline in short-term harvest (66,570 m3/yr to 47,090

m<sup>3</sup>/yr). The low growing stock point is higher as a result and additional mature volume is available for harvest during the transition period. Minimum operability for existing and future regeneration was not changed and when combined with the harvest flow variability constraint (+/- 15% of the average) mid and long-term harvest levels exceed the base case as a result.

To model the impact of a decrease in minimum operability criteria, 25 m<sup>3</sup>/ha were removed from the existing “mature” stand operability thresholds in Table 4. There is a 9.2% increase in short-term harvest (66,570 m<sup>3</sup>/yr to 72,120 m<sup>3</sup>/yr), and minor changes in the mid and long-term harvest levels. Figure 19 shows the harvest levels.



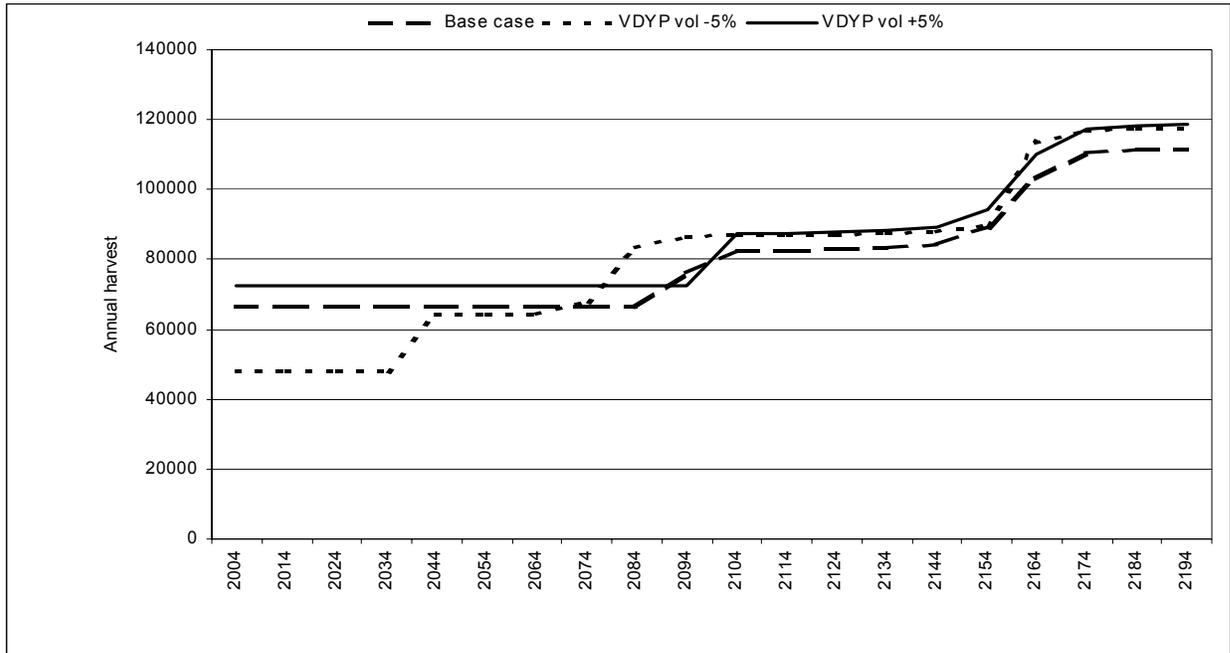
**Figure 19: Harvest composition for a +/-25m<sup>3</sup>/ha change in minimum operability**

**Standing volume +/-5%**

The proportional scale for VDYP yield curves in the WOODSTOCK yield file was increased by 5% to test the sensitivity of the harvest flow to a positive uncertainty in inventory volume. The short-term harvest level increased 8.7% to 72,370m<sup>3</sup>/yr, and was maintained until decade 8. The long-term harvest level is slightly above the base case. The proportional scale for VDYP yield curves in the WOODSTOCK yield file was decreased by 5% to test the sensitivity of the harvest flow to a negative uncertainty in inventory volume. The short-term harvest level decreased 27.6% to 48,150 m<sup>3</sup>/yr. Mid and long-term harvest levels are above the base case.

This trend occurs in both sensitivities because the same harvest flow variability constraint (+/- 15% of the average) that controls the long term harvest level (LTHL) in the base case is used to control LTHL in these sensitivities. The +5% sensitivity enters the control period for LTHL with a higher short-term harvest so the +/- 15% results in a larger LTHL. The -5% sensitivity enters the

control period for LTHL with a larger amount of regenerated growing stock in period 6 which creates a significant jump in mid-term harvest level, relative to the short-term. The same process then occurs as with the +5% sensitivity and LTHL control. In both cases the ratio of operable to merchantable growing stock is similar and neither is approaching the 3,200,000m<sup>3</sup> constraint. Figure 20 shows the harvest flows for both these sensitivities.



**Figure 20: Harvest flow for +/-5% VDYP volume gain**

**Combined standing volume -5%, minimum operability -25m<sup>3</sup>/ha**

The results from the +25m<sup>3</sup>/ha sensitivity (harvest level drops 29.3% to 47,090) and the -5% volume sensitivity (harvest level drops 27.6% to 48,150) on the surface allude to the notion that small changes in volume availability have much larger impacts on timber availability. Part of the explanation is the inter-relationship of several modeling artifacts.

Yields with WOODSTOCK are based on periods not years and are not assumed to occur at the beginning, the middle or end of any period. Both harvest entry and related yield calculations are user defined. In addition a period of 0 is not allowed, so when a stand is harvested it is transitioned to a yield curve with an age of period 1. The age classes in the inventory are converted to the same numeric value in WOODSTOCK but are considered to be periods. Yield curves from TIPSYP and VDYP are in 10 year age increments and the volume/age relationship at ages 10, 20, 30, 40, 50, 60 up to age 200 (TIPSYP) and 250 (VDYP) or sooner if the volume flat-lined were used as input into the yield file. The age classes within the database are shown in Table 6 below.

**Table 6: Age ranges, classes and WOODSTOCK periods**

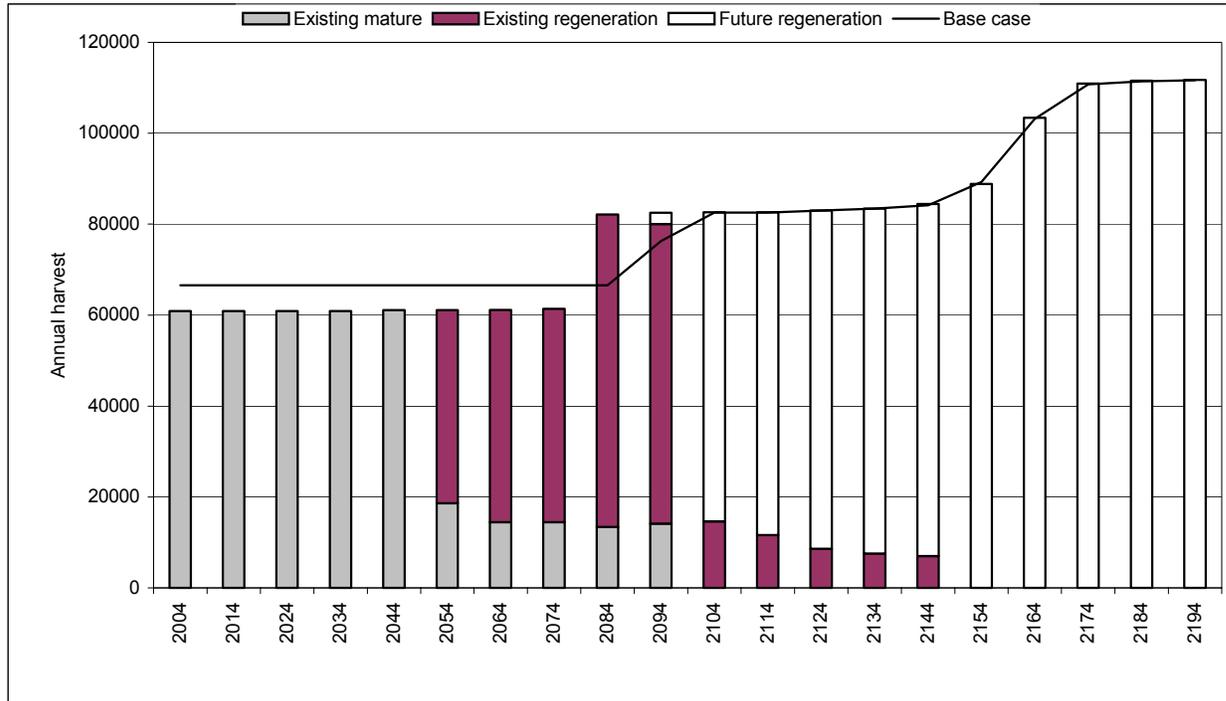
| Age range  | Age class | WOODSTOCK period age |
|--|-----------|----------------------|
| 0 to 15  | 1         | 1                    |
| 16 to 24   | 2         | 2                    |
| 25 to 34   | 3         | 3                    |
| 35 to 44   | 4         | 4                    |
| 46 to 54   | 5         | 5                    |
| ... in 10 year intervals up to age class 41 which is > 406 years |           |                      |

In application this means that age class 5 stands are between 46 and 54 in the inventory and are 5 periods old in WOODSTOCK. They have a yield value related to either TIPSY or VDYP at age 50. WOODSTOCK does not interpolate yields between periods, nor does it have “look-a-head” functionality similar to many simulation models. The minimum time unit in WOODSTOCK is 10 years so this means that a stand aged 46 in the inventory has the same yield as a stand aged 54, and that the yield is from the appropriate yield model at age 50. When WOODSTOCK develops the lp-matrix, yields for all merchantable stands (above minimum operability) within the operable window (first and last operable times) are created. The lp-solver chooses a specific yield point from the available yield points that contributes the most to maximizing the objective function, in this case total harvest over the planning horizon.

To illustrate the impact, the minimum operability for analysis unit 27 is 175 m<sup>3</sup>/ha, which occurs between period 9 and 10. Volumes at period 8, 9 and 10 are 136 (162m<sup>3</sup>/ha\*0.843), 160 (190m<sup>3</sup>/ha\*0.843) and 181 (215m<sup>3</sup>/ha\*0.843) respectively. The 0.843 is the proportional ratio accounting for VRI, roads, etc. A stand in age class 4 (predominant age class in AU27) at time 0 is operable in 6 periods (10 periods old) with a volume of 181. The additional 5% reduction in volume demonstrated in the sensitivity above, generates a volume at period 10 of 171 m<sup>3</sup>/ha, 10 m<sup>3</sup>/ha below the minimum operability and subsequently delays the harvest of this stand to period 11. In reality we would harvest the stand at 171 m<sup>3</sup>/ha as our minimum operability of 175 m<sup>3</sup>/ha is the best link to our diameter distribution operability criteria.

In subsequent WOODSTOCK runs the minimum operability of all pine strata was reduced to 170m<sup>3</sup>/ha (10m<sup>3</sup>/ha lower than the values below) and the impact was to increase harvest from the 48,150 to 52,490 m<sup>3</sup>/yr. Additional runs indicated that harvest levels continue to increase as minimum operability is lowered. At a minimum operability of 150m<sup>3</sup>/ha for the Pine stratum, the AAC was 56,000m<sup>3</sup>/yr, only a 16% reduction from 66,570m<sup>3</sup>/yr. What this is demonstrating is the inter-relationship of “blocky” yield curves, no interpolation of yield between periods in WOODSTOCK, and minimum operability thresholds occurring between the steps.

To illustrate this modeling artifact, another sensitivity was created that shows the impact of a -5% decrease in yield combined with a -25m<sup>3</sup>/ha decrease in operability. The -25m<sup>3</sup>/ha was used to illustrate the variability due to the combination of 10 year periods and no interpretation between periods. Decadal volume changes for most stands are +/-25m<sup>3</sup>/ha during the ages of interest on TFL15. Figure 21 shows that the combination of the two results in a harvest level of 60,900m<sup>3</sup>/yr, a drop of 8.5%, much more in-line with expectations.



**Figure 21: Harvest flow for -5% volume change combined with -25m<sup>3</sup>/ha minimum operability**

**Fd and Sw site indices +/-1m**

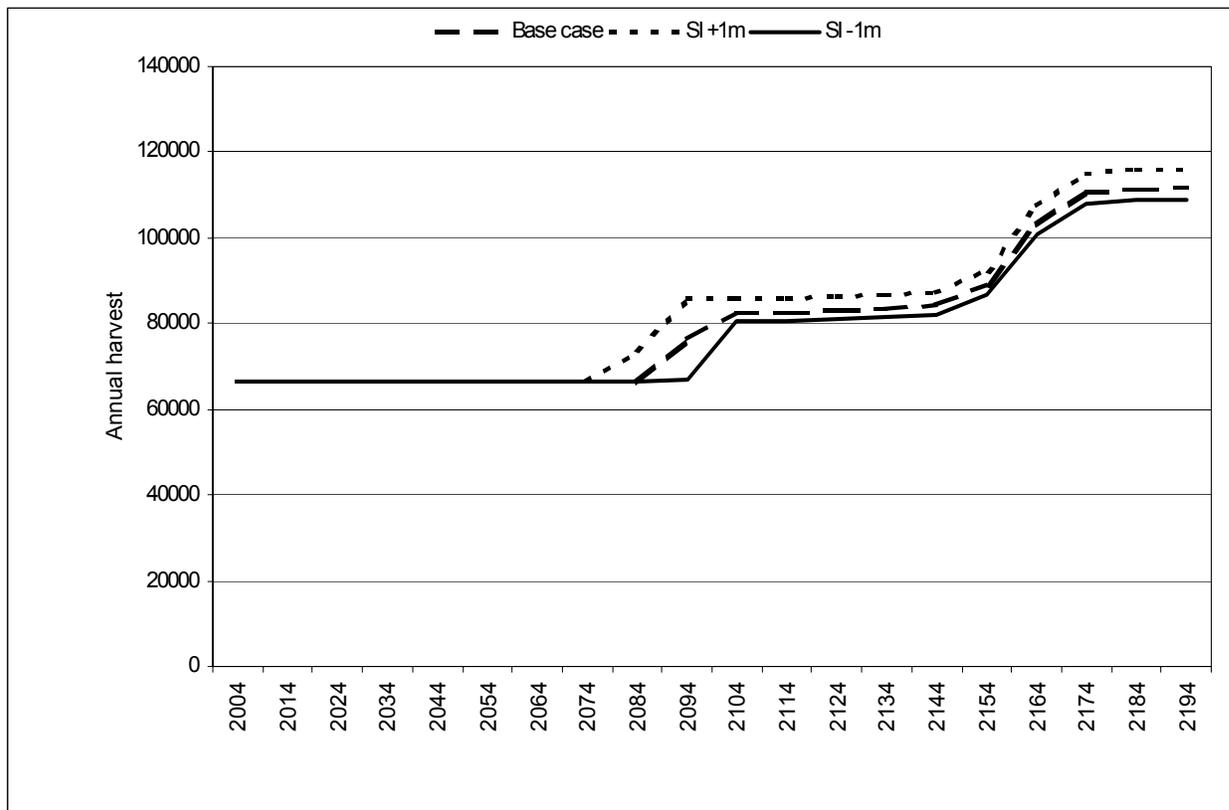
During development of site index values for Douglas fir and Spruce, some uncertainty was raised regarding the applicability of Provincial site index conversion equations to local conditions. To test the potential impact on harvest flow new yield curves were generated for all Douglas fir and spruce leading regeneration with site indices greater than 15m. Table 7 shows the base case and +/-1m site indices for the affected yield curves.

**Table 7: Base case site indices, and +/- 1m sensitivities**

| Yield curve  | Base case site index | +1m site index | -1m site index |
|--|----------------------|----------------|----------------|
| 2e2, 3e1, 3e2, 5e1, 5e3, 6e3, 7e1, 7e2, 9e1, 9e2, 10e1, 10e2, 13e2, 19e2 | 17                   | 18             | 16             |
| 5e2, 11e1, 19e1, 22e3, 23e1  | 19                   | 20             | 18             |
| 6e2, 17e2  | 16                   | 17             | 15             |

| Yield curve                 | Base case site index | +1m site index | -1m site index |
|-----------------------------|----------------------|----------------|----------------|
| 9e3, 13e3, 17e3, 22e2, 23e2 | 20                   | 21             | 19             |
| 10e3, 11e2, f3              | 18                   | 19             | 17             |

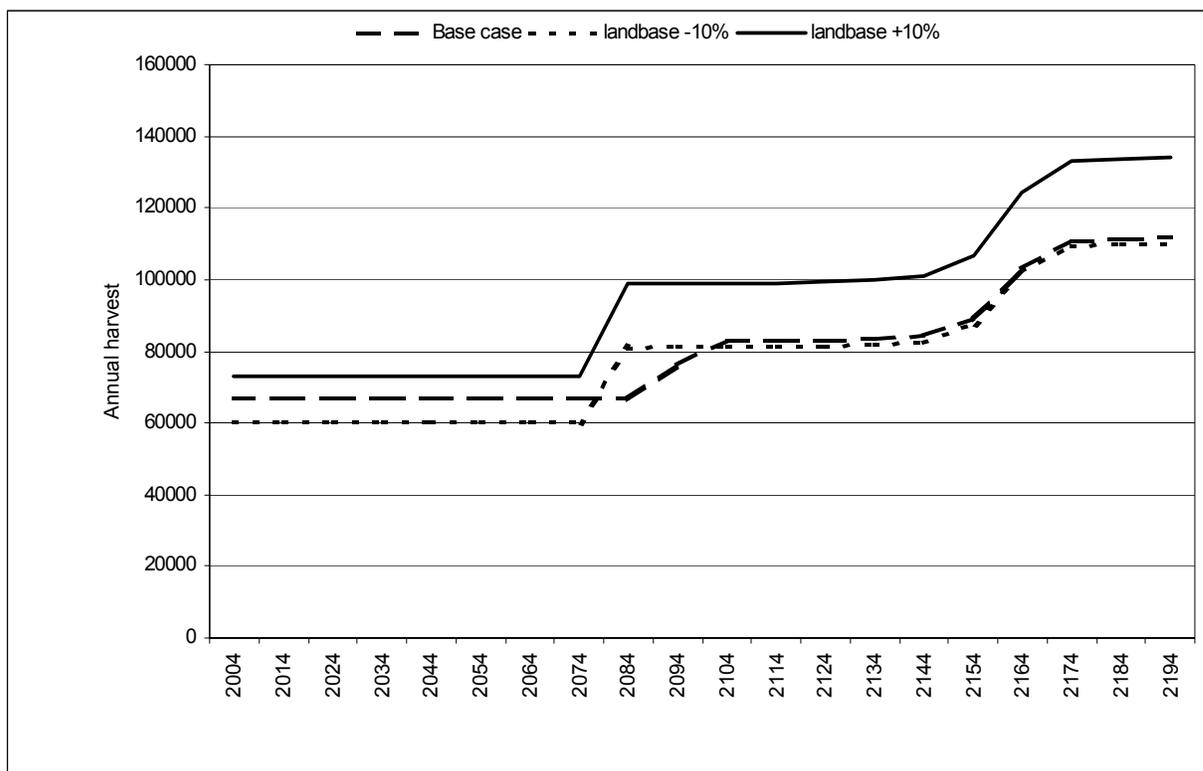
Dropping site index one meter decreased the short-term harvest level 110 m<sup>3</sup>/yr. Increasing site index 1m had no impact on short-term harvest level and increased mid and long-term harvest levels slightly. Figure 22 shows the harvest flows for both these sensitivities.



**Figure 22: Harvest flow for +/- site index**

**Landbase +/-10%**

Changes in landbase were factored into this analysis by increasing and decreasing the WOODSTOCK “areas” file by factors of 1.1 and 0.9. Reducing the area of all polygons to 90% (3,466.6 ha thlb reduction) decreased short-term harvest flow by 6,100 m<sup>3</sup>/yr or 9.2%. Mid term harvest flow decreases by 5.7% and long-term harvest declined by 5.5%. Increasing the area of all polygons to 110% increased short-term harvest flow 7,220 m<sup>3</sup>/yr (10.9%). Mid term harvest flow increased by 15.7% to 98,921 m<sup>3</sup>/yr and long-term harvest increased 17,927 m<sup>3</sup>/yr to 133,247 m<sup>3</sup>/yr. Figure 23 shows the harvest flow for both sensitivities.



**Figure 23: Harvest composition for a +/-10% change in total landbase**

**Vas fire**

The Vas Fire started on the afternoon of Aug 22, 2003 and as of October 28, 2003 the Ministry of Forests listed the approximate size to be 3,300 hectares. The fire perimeter of August 27, 2003 was used for this sensitivity analysis and approximately 2,204 hectares is within TFL15. Burn severity varied considerably from light under-burns to significant crown fires. All types of landbase are included within the perimeter from open range to regeneration and mature timber. Of note is that significant areas of regeneration and mature timber were intentional back-burned to control the spread. Table 8 shows the approximate area and volume distribution of landbase within the fire perimeter. The land classifications are identical to those identified in the Information Package.

**Table 8: Landbase classification within Vas fire perimeter**

| Classification             | Area (ha) | Volume m <sup>3</sup> |
|----------------------------|-----------|-----------------------|
| Area within fire perimeter | 2,204     | 184,638               |
| Deciduous                  | 7.9       | na                    |
| Marginally dry             | 461.1     | 52,185.5              |
| Non forest                 | 316.3     | 6,769                 |
| OGMA                       | 135.1     | 12,273.3              |
| PFT1                       | 169.1     | 6,463.9               |
| Terrain U                  | 4.9       | 567.4                 |

| Classification           | Area (ha) | Volume m <sup>3</sup> |
|--------------------------|-----------|-----------------------|
| WTP's                    | 0.58      | na                    |
| THLB                     | 1,109     | 106,377               |
| <b>within CP's</b>       |           |                       |
| Age <15                  | 109.9     | 380.2                 |
| Age 16 to 25             | 43.3      |                       |
| Age 26 to 35             | 113.1     |                       |
| Age 36 to 45             | 50.1      |                       |
| Age 45+                  | 395.2     | 39,249.5              |
| Total THLB within CP's   | 711.1     | 39,629.7              |
| <b>outside CP's</b>      |           |                       |
| Under active development | 92.3      | 24,627.3              |
| remainder                | 305.6     | 42,120                |
| Total THLB outside CP's  | 397.9     | 66,747.3              |

Mortality will be variable and not be evident until fall 2004 at the earliest. To bracket the potential impact on harvest flow, four sensitivity analyses were run with two mortality levels (20% thlb, 50% thlb) on regeneration ( $\leq 45$ ) and on regeneration and mature ( $> 45$ ) within the existing CP's.

Stands were assigned a random number between 0 and 1 and then through an iterative process, selected until approximately 20% or 50% of the total thlb area was identified. The regenerated areas and regenerated areas with mature were set to age 0, and grown along the existing curves.

Current harvest plans are focused on salvaging the burned timber outside existing CP's while meeting cover requirements for mule deer, sheep and visuals by identifying unburned forest. Current model constraints for mule deer winter range planning cell, sheep and visual requirements reflect the strategy on the ground.

The results of the sensitivity analyses are in Table 9. The original age class structure identifies those stands that were randomly selected and reset to age 0. The ranges of thlb destruction presented and current salvage plans indicate that there will be little impact of the Vas fire to the short-term harvest levels.

**Table 9: Vas fire sensitivity analysis summary**

| Scenario             | Total thlb area within fire | Target area | Actual area        | Original age class structure |      | Impact  |
|----------------------|-----------------------------|-------------|--------------------|------------------------------|------|---|
|                      |                             |             |                    | Age class                    | area |   |
| 20% regen            | 358                         | 71          | 70.5               | 1                            | 38.4 | No impact on harvest flow relative to base case |
|                      |                             |             |                    | 2                            | 8.2  |   |
|                      |                             |             |                    | 3                            | 17.4 |   |
|                      |                             |             |                    | 4                            | 6.4  |   |
| 50% regen            | 358                         | 179         | 178.0              | 1                            | 72.6 | No impact on harvest flow relative to base case |
|                      |                             |             |                    | 2                            | 32.0 |   |
|                      |                             |             |                    | 3                            | 49.3 |   |
|                      |                             |             |                    | 4                            | 24.1 |   |
| 20% regen and mature | 728                         | 145         | 70.5r<br>73.8m     | 5                            | 3.1  | Short-term harvest flow reduced to 66,357 m3/yr |
|                      |                             |             |                    | 6                            | 10.0 |   |
|                      |                             |             |                    | 7                            | 15.4 |   |
|                      |                             |             |                    | 8                            | 5.8  |   |
|                      |                             |             |                    | 9                            | 2.2  |   |
|                      |                             |             |                    | 10                           | 6.0  |   |
|                      |                             |             |                    | 11                           | 1.2  |   |
|                      |                             |             |                    | 13                           | 2.0  |   |
|                      |                             |             |                    | 17                           | 20.0 |   |
|                      |                             |             |                    | 20                           | 1.0  |   |
|                      |                             |             |                    | 27                           | 4.8  |   |
| 50% regen and mature | 728                         | 364         | 178r<br>185.7<br>m | 5                            | 10.0 | Short-term harvest flow reduced to 66,180m3/yr  |
|                      |                             |             |                    | 6                            | 23.8 |   |
|                      |                             |             |                    | 7                            | 41.0 |   |
|                      |                             |             |                    | 8                            | 34.9 |   |
|                      |                             |             |                    | 9                            | 5.0  |   |
|                      |                             |             |                    | 10                           | 13.1 |   |
|                      |                             |             |                    | 11                           | 5.0  |   |
|                      |                             |             |                    | 13                           | 2.0  |   |
|                      |                             |             |                    | 17                           | 23.6 |   |
|                      |                             |             |                    | 19                           | 2.3  |   |
|                      |                             |             |                    | 20                           | 1.0  |   |
|                      |                             |             |                    | 21                           | 6.6  |   |
|                      |                             |             |                    | 25                           | 0.2  |   |
| 27                   | 8.3                         |             |                    |                              |      |   |
| 31                   | 8.7                         |             |                    |                              |      |   |

### **Sensitivity analysis summary**

In summary, the sensitivity analyses indicate that a harvest level of 66,570m<sup>3</sup>/yr is relatively stable. The largest impact in short-term harvest level is attributable to changes in short-term operable volume and changes in thlb. The recently completed Okanagan Shuswap LRMP and associated Protected Area Strategy, incorporation of OGMA's, TEM and VRI data brings a great amount of certainty to the thlb definition. The -5% decrease in yield combined with a -25m<sup>3</sup>/ha decrease in operability sensitivity demonstrates the combined impact of several model artifacts on the -5% volume sensitivity. The harvest level of this sensitivity (60,900m<sup>3</sup>/yr) is more in-line with similar mature volume sensitivities of other units.

In addition the 20-year plan indicates that the more than the recommended harvest level of 66,570m<sup>3</sup>/yr can be laid out on the ground for the first twenty years. This provides additional certainty regarding standing volume estimates.

### **Option 1: Modified cutblock size and modified juvenile spacing regimes**

A series of analyses was used to help develop a modified cutblock size and juvenile spacing regime for TFL15. Performance and practices were identical to the base case except:

- new yield curves<sup>7</sup> for yield curves f4 and f10
- new greenup and disturbance thresholds to reflect the modified cutblock sizes

The new yield curves were generated from TASS managed stand yield tables that covered the range of site indices, establishment densities (15,000 – 35,000 trees / ha), and post-spacing densities common on TFL 15. The new curves are blended and reflect the area distribution of sites and ingress patterns on TFL15. A copy of the report is in Appendix 2.

The main conclusion of this work is that spacing will have either a neutral or negative impact on Weyerhaeuser's management objectives for TFL 15. This evidence demonstrates that spacing is not justified below at least 35,000 trees / ha, and in fact the stand density threshold is likely to be even higher.

Current regulations limit block size to 40 hectares and when combined with green-up requirement, a fragmented landscape results. Table 10 shows a recent patch size gap analysis for TFL15. The actual distribution does not reflect the variability in size suggested in the Biodiversity Guidebook. The shaded areas identify the gaps in the patch size distribution where there is insufficient area.

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<sup>7</sup> Impacts of Juvenile Spacing Lodgepole Pine Stands on TFL15. JS Thrower, October 30, 2003  
Weyerhaeuser TFL15 MP9  
Timber Supply Analysis

**Table 10: Patch size gap analysis**

| NDT | Patch size from BGB | Total area | With Douglas fir |                             |        | With out Douglas fir |                             |        |
|-----|---------------------|------------|------------------|-----------------------------|--------|----------------------|-----------------------------|--------|
|     |                     |            | Area             | Patch distribution % actual | target | Area                 | Patch distribution % actual | target |
| 3   | <40                 | 9,588      | 4,794            | 41                          | 20-30  | 4,794                | 41                          | 10-20  |
| 3   | 40-80               | 2,823      | 1,411            | 12                          | 25-40  | 1,411                | 26                          | 10-20  |
| 3   | 80-250              | 3,327      | 1,663            | 47                          | 30-50  | 1,663                |                             |        |
| 3   | 250-1000            | 5,939      | 2,969            |                             | na     | 2,969                | 33                          | 60-80  |
| 3   | 1000+               | 1,861      | 931              |                             |        | 931                  |                             |        |
| 4   | <40                 | 7,348      | 7,348            | 41                          | 30-40  |                      |                             |        |
| 4   | 40-80               | 3,199      | 3,199            | 18                          | 30-40  |                      |                             |        |
| 4   | 80-250              | 3,446      | 3,446            |                             |        |                      |                             |        |
| 4   | 250-1000            | 4,133      | 4,133            | 42                          | 20-30  |                      |                             |        |

Current research indicates that retention levels must vary and be coupled to a patch size strategy. This practice is reflected in the March 24, 1998 interim large cutblock strategy from the (then) Penticton Forest District, the May 25 1999 FPC bulletin on cutblock size and the recommendations from the (then) BC Environment Habitat Protection Branch Penticton Office regarding large cutblocks. To provide an assessment of the type and amount of retention on TFL15, 337 recent cut-blocks on TFL 15 for the period 1992-2003 were examined. The report is contained in Appendix 3.

The classification scheme was based on Tables 10, 16 and A5.1 of the Biodiversity Guidebook which describe Natural Disturbance Type (NDT) and define seral stage by age. Retention was identified as nil to low, medium, and medium to high and for early, mature and old seral stages.

This classification scheme gives a relative idea of the type, distribution and abundance of seral forest elements on harvested blocks. Weyerhaeuser's specific intent for the classification scheme was to create a qualitative system for assessing levels of retention by NDT rather than a quantitative system. Seral stage distribution within each retention category varies considerable and depends on stand structure, forest health and site specific conditions (small nthlb patches, steep pitches, rock, wet/dry). Table 11 shows the distribution by NDT.

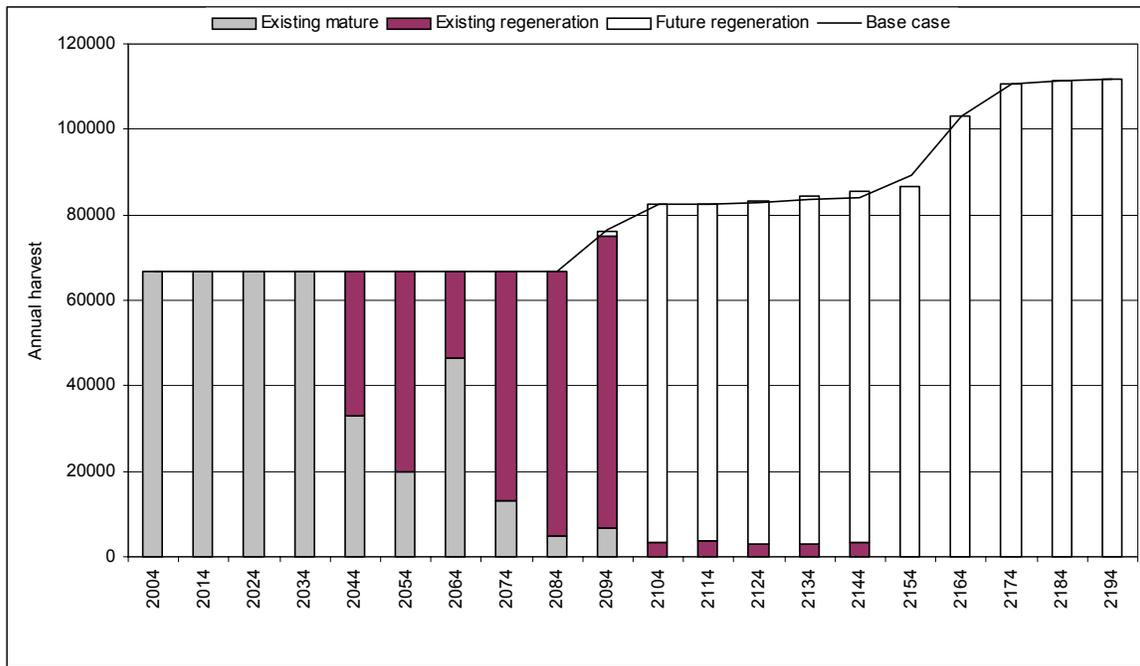
**Table 11: Retention levels by NDT**

| Retention Type | % NDT3 Area | % NDT4 Area |
|----------------|-------------|-------------|
| Nil to Low     | 25.3        | 3%          |
| Low to Medium  | 48.9        | 22%         |
| Medium to High | 25.8        | 75%         |

Current retention practice includes wildlife tree retention, maintenance of tree species and understory vegetation diversity, retention of coarse woody debris, natural shape and cutblock edge irregularity and forest cover retention in and around riparian zones. Combined with the current LRMP directed allotment of OGMA's, these practices meet the intent and fulfill the objectives and strategies in the "Ecosystem Management – Forests" of the LRMP and provide adequate retention associated with a Patch Size strategy.

**Results**

To model Option 1, the green-up and disturbance limits were turned off in WOODSTOCK and new yield curves without juvenile spacing were used for f4 and f10. There is no difference in harvest flow from the base case. A harvest level of 66,570 m<sup>3</sup>/yr is sustainable for the first 40 years, at which point harvest levels are forecasted to increase steadily to a long-term harvest level of 111,448 m<sup>3</sup>/yr. Figure 24 shows the harvest flow relative to the base case. There is a slight difference in harvest volume in the periods starting in 2094 and 2154. The behaviour of all the other indicators is unchanged from the base case as well.



**Figure 24: Harvest flow for recommended option**

**Recommendations**

Two management regimes were analyzed, current practice (base case) and Option 1. Option 1 meets all the indicators throughout the planning horizon, maintains the base case harvest level, introduces new silviculture regimes for Lodgepole pine based on the culmination of nearly a decade of work, and further

implements the Biodiversity Strategy referred to in the Draft MP9.

Weyerhaeuser recommends that the new harvest level be 66,750 m<sup>3</sup>/yr and that Option 1 practices are an integral component of delivering the volume and Biodiversity Strategy.

## **Appendix 1: Visual Quality Guidelines from the Okanagan Shuswap LRMP**



## **Appendix 2: Impacts of Juvenile Spacing Lodgepole Pine Stands on TFL15**



**Appendix 3: Classification of Retention Levels for 1992-2003 Cutblocks on  
TFL 15**