The Economic Feasibility of Commercial Thinning in Second Growth Forests on the British Columbia Coast

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ABSTRACT

This report is a detailed analysis of commercial thinning in second growth forests on the British Columbia coast. It provides insight into the possibility of a coastal forest products company, Western Forest Products, located in Gold River, British Columbia, to implement a commercial thinning treatment. Data from existing stands was inputted into TIPSY 4.2 to run a series of scenarios to attempt to clarify economic viability based on a series of input variables. It was found that given the inputted variables, commercial thinning is at this time not economically viable. Although, there is potential for future uses of a commercial thinning program, and is briefly evaluated throughout the report. The details in the methods section of this report would help allow someone who is interested in running TIPSY to further analyze this topic to easily set up comparable runs with their own input variables.

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i. INTRODUCTION

Over the last century, logging on the British Columbia Coast has grown at an accelerating rate from what it was in the early 1900's (BC Ministry of Forests, 2010). In 1910, the BC provincial Annual Allowable Cut (AAC) was around 1 million m^3. In 1987 and 2005 the ACC reached 90 million m^3. Those numbers represent total provincial cut levels. On average, the AAC for the coast is between 50-70% of that total cut (Ministry of Forests, 2011). The harvesting leads to a re-distribution of age class structures on the BC coast creating second growth forests. Many old growth forests that were harvested earlier in the century are now reaching volumes that are merchantable under today's market conditions. Second growth stands have been harvested on the BC coast since the 1990's but harvest rates have increased recently due in large part to an increase in demand from China for raw logs and dimensional lumber of a lower grade.

Following the BC forest industry's slow-down during the latter half of the 2000's, this demand from China has revitalized the industry and has caused many forest product companies to ramp up their production. Consequently, an increase of harvesting of second growth forests is beginning to occur. Second growth forests often have low costs due to their close proximity of wood from the forests to mills and sortyards, gentler terrain, and existing road networks that only need to be re-activated rather than requiring major road building costs (Henderson, 2011). Questions are beginning to arise over the practice of clearcut logging these second growth forests especially at younger ages of 40-60 years. Some argue that ecosystem based forestry science suggests that these forests should be left to regrow with only minor controlled thinnings until an age of 120 (Henderson, 2011).

Looking to the future of sustainably managing our forests, there may be a need to re-evaluate the management of these second growth forests. These younger forests differ from a biodiversity standpoint as they have higher tree densities, and lower variations in tree size and canopy structure than old growth (Lindh, 2004). When a stand is thinned it opens up the canopy, allowing for light to reach the understory and subsequently driving vegetation growth. It has been found that after thinning second growth, there is a significant increase in the amount of nitrogen fixing species of grasses sedges, and matted vines that can occur 7-23 years after the treatment (Lindh, 2004). These benefits can lead to a more diverse stand that promotes biodiversity and resembles select old growth characteristics.

This report is designed to look at the opportunities that a commercial thinning program may bring to a landowner or licensee. Commercial thinning, when implemented at the right time and in the right stand, is a valuable strategic management tool that may increase value and wood flow available within a forest estate (BC Ministry of Forests, 1999). Some more of the traditional objectives of Commercial Thinning are to:

1. obtain wood volume or revenues earlier than at final harvest;
2. improve the growth of residual trees;
3. improve the quality of the stand by removing dead, diseased, and deformed trees;
4. capture some of the production that would otherwise be lost to competition mortality;
5. obtain certain species and size classes for specialty products.

The focus of this report will be on Western Forest Products (WFP) Tree Farm License (TFL) and private lands in the Gold River area on the West Coast of Vancouver Island. This area is located within the Coastal Western Hemlock (CWH) Biogeoclimatic zone in the submontane very wet maritime (vm) subzone with pockets of dry maritime (dm). Data collected for this report has been made available by the Gold River operation and includes cruise data and production reports.

The main objective of this report was to determine whether it would be economically viable for WFP to commercially thin second growth stands now, at a volume equal to the total planned clearcut harvested second growth stands for the year 2011 but over a larger area. This was done by running a software program named Table Interpolation Program for Stand Yields (TIPSY), to obtain stand volumes and values for different commercial thinning scenarios. A cost analysis and operational feasibility assessment was also conducted to determine market values for harvested timber now and into future predicted markets. Furthermore, the feasibility of implementing a commercial thinning treatment on private versus public land was evaluated along with the effect a government assistance program and funding may have on the company's decision to implement a commercial thinning program.

ii. Background

Benefits of Commercial Thinning

Commercial thinning has many benefits including the improvement of stand quality, volume, and economic value. The main goal of commercial thinning is to increase flexibility in the timing and quantity of wood flow available at the forest estate level (BC Ministry of Forests, 1999). Commercial thinning can also be used to meet visual and adjacency constraints, and as a means to break up stands that are concentrated in similar seral stages and create a diverse age structure in areas where large areas are in similar age classes. Commercial thinning can help achieve overall forest health objectives and can also be used as a preventative measure such as "beetle proofing" a stand against such biological disturbance agents like the mountain pine beetle (Collins, 1996). It can also be used to meet other non-timber objectives, which can include forage for animals such as mule deer, by opening up the forest canopy allowing for increased forage on expected new vegetation growth (Serrouya, 2008).

Commercial Thinning in British Columbia

In the past, commercial thinning treatments have been implemented in BC, though only on a minor scale. From 1984 to 1993, an average of only 150 ha/year was commercially thinned. In 1994, as more research showed the benefits of commercial thinning, there was a substantial increase in treatments, to 1400 ha, and in 1995, 2100 ha were commercially thinned (Collins, 1996). Virtually all thinning has been on the coast and in most cases has been carried out on private land and Tree Farm Licenses.

Up to 1999, most of the research on commercial thinning was from Europe and eastern North America (BC Ministry of Forests, 1999). To date, there has been some but limited development and research on the subject in BC. This has occurred for a number of different reasons. The single most important being that commercial thinning was deemed unprofitable for major industry players due to declining log prices, especially in the low grade J and gang logs that typically are removed from a thinned stand. These grades account for about 60% of the total volume extracted from these stands (Collins, 1996). Thinning is a costly treatment that requires intensive planning, management and training. It is significantly more costly than conventional logging, and in order for a commercial thinning treatment to be implemented it has to have support from senior level management (Lambrick, 1996).

Methods for Commercial Thinning

Commercial thinning is a treatment that requires specialized machinery and high inputs of personnel training. There are two main types of harvesting, the first uses cable machinery such as yarders and skyline systems and the other ground based, which includes skidders and loaders (Lambrick, 1996). Falling can be completed by either hand-falling or with machines such as a single-grip harvester.

Ground based systems use prime-movers with wheels or tracks which need to be able to enter a stand from a road or work from designated trails (Lambrick, 1996). Trails require optimal soil conditions, flatter terrain and need to be positioned as to create limited site disturbance. An area can be permanently “degraded” by roads and other approved access by up to 7% (Lambrick, 1996). Use of ground based systems depends on terrain and soil conditions. Second growth stands that are at a prime age for commercial thinning (40-60 years) are often found in the lower, flatter sections of most of the valleys on the coast, and therefore ground based systems may be applicable in these cases. A push towards these ground based systems would lead to lower costs as they can be significantly less costly than cable thinning.

Thinning Intensity

Commercial thinning treatments aim to increase the growth of the residual trees in the stand by increasing the amount of growing space, but are restrained by other factors including site quality, species, age, and vigour (BC Ministry of Forests, 1999). A tree that is showing limited vigour due to stress or injury may not be able to realize the benefits of this increased growing space. Therefore, it is important to determine a thinning intensity that will provide results based on the stand management objectives. A heavy thinning may result in better residual tree growth, but overall volume in the stand will be lower. In low intensity thinnings residual trees fully utilize the available growing space, but individual tree growth may not be as high (BC Ministry of Forests, 1999). Land managers should use Stand Density Index (SDI) or Relative

Density Index (RDI) to rank stands for commercial thinning, where a desired residual stem count or residual basal area is based on normal basal area (BC Ministry of Forests, 1999).

Thinning Type

There are four types of thinning that are practiced in forestry applications. The four types of thinning are (BC Ministry of Forests, 1999):

Low thinning – removing lower crown class, leaving tallest trees

Crown thinning - removes some trees in the middle and upper crown classes to favour the best dominant and co-dominant trees.

Selection or high thinning – removes dominant and co-dominant trees to release trees in the lower crown classes

Systematic or geometric thinning – removes trees in a predetermined pattern such as rows. Crown class is disregarded in this case.

In order to determine which thinning type to use, one simple indicator would be to determine a thinning ratio based on the mean DBH of cut trees, and the mean stand DBH before thinning. This may not be the best descriptor of thinning types, as the most accurate would be to take measurements of diameter distributions before and after thinnings, along with determining residual density, basal area, and preferred tree characteristics for removal or retention. The type of treatment to be used comes down to management objectives of land managers. For example, if looking at reducing fire hazards within a stand, a low thinning would be most suitable as it would remove the intermediary trees that could act as ladder fuels moving the fire from the ground, up into the canopy (Interface Forestry, 2011). Economically, choosing a low thinning will not bring the volume and size of logs needed for sales, whereas a high thinning removes dominant, larger trees that could provide more value from the stand in the short term. The disadvantage to removing more dominant trees is that the trees left behind will take longer to reach merchantable values. In finding an optimal strategy it is necessary to balance short term and long-term goals.

Timing of Thinning

Commercial thinning is best suited for stands in an active height growth period and is completed before the peak mean annual increment (MAI) is reached. If thinning is carried out in an older stand, the trees growth will already be slow and there will be no response to the treatment. Any delays in thinning can result in a decline in release potential, higher risk of windthrow, and greater volume lost to natural mortality. Late thinnings can be done in stands that are considered windfirm, but must be tied to specific management objectives such as harvest of some volume from stands with adjacency constraints (BC Ministry of Forests, 1999).

Disadvantages of Commercial Thinning

There are few possible disadvantages to implementing a commercial thinning program. One of the biggest concerns is residual stand damage (BC Ministry of Forests, 1999). This often occurs if the timing of the thinning is not planned correctly, improper machinery is used, or equipment operators are careless with felled trees being transported through the stand. Post thinning, snow and wind damage can occur when the newly opened up stand can become susceptible to these elements. These can affect a stand in a way that will begin to negate the positive benefits of the commercial thinning.

Furthermore, if not done right, cumulative volume can be reduced when commercial thinning (Listar, 1999). For example if the wrong method is used, it may not provide the most optimal volume in the future. This falls in line with the economic risks that are inherent in commercial thinning. Before any type of commercial thinning program is implemented, a full analysis should be done to make sure that financial and management objectives are going to be met.

Training crews to perform a commercial thinning can also be a challenge to an operation. The added time to ensure that workers are more careful with their machinery, are aware of lower productivity expectations, and the general need for more skilled workers due to the nature of commercial thinning adds to the complexity of such treatments. A proper training program needs to be put in place in order to ensure efficiency and productivity.

Performing a commercial thinning treatment

Approvals

According to Policy 2.13 '*Commercial Thinning'* in the Resource Management Ministry policy manual (2007), any commercial thinning treatments will be considered to be part of the AAC. This allows for increased flexibility in timber flow, environmental considerations, and social values. The policy indicates that, ideally, commercial thinning will be planned and implemented within regional districts and included in regional five-year Forest & Range Resource programs and that district managers are in charge of making sure that opportunities to utilize commercial thinning are proactive when markets are good and management unit strategic objectives are met.

This policy manual was originally developed in October 1997, and predicted that 10-15% of BC's annual AAC would be from commercial thinning (BC Ministry of Forests, 1997). This has not occurred and commercial thinning is mostly non-existent across the province. Up to this point there is no current legislation specified just for commercial thinning, except for what is found in this manual that is over a decade old. Operations that look to start a commercial thinning treatment may be at odds with the process of how to implement a thinning program. According to the policy, a silviculture prescription is needed that contains details on residual stand conditions and stocking levels and maximum limitations on site disturbance. A post-harvest assessment must be done immediately after, followed by a free growing survey to ensure residual crop is free from stress factors such as blow down and snow break. Standard cutting permits and timber sale licenses will be used to authorize commercial thinning under the districts AAC. Stumpage will be incurred along with penalties for excessive removal of trees and excessive damage to residual trees or the site.

Jobs

Before implementing any commercial thinning program it needs to be decided whether the work is to be done by WFP employees or contractors. This will have to be decided upon based on what the company's objectives are in terms of what they want economically as well as in job creation and job diversity. As previously mentioned, one disadvantage of commercial thinning, is the high amount of training required in the beginning of the operation, leading to a lack in initial productivity. There will also have to be supervision from a manager or supervisor from within the company. This will ensure that crews will be kept on track and address any operational issues that are sure to arise during the beginning stages of the operation.

Harvesting System Selection

To begin, there is no one optimal system for commercial thinning. There are many variables that can occur within a stand or cutting permit that could pose challenges in a single system. In most cases the optimum system should be selected at the stand level (Lambrick, 1996). To keep this discussion basic, only two of the major systems will be outlined, cable thinning and ground based.

Cable thinning is advantageous when the following factors are present (Lambrick, 1996):

- Large cut tree average of .30 cubic meters average or better
- Heavy volume per hectare
- Steep, hummocky or wet terrain
- Fairly good access roads and yarding distances of less than 200 meters

Ground based thinning is advantageous when the following factors are present:

- Smaller tree average or future trend to cut smaller trees
- Lower volume per hectare
- Low Slope and soils with low risk to disturbance
- Desire to thin younger age classes
- Need for lighter entries to minimize windthrow risk
- Necessity to be able to recover blowdown cost effectively

In a study performed on Tree Farm License 39 near Port McNeil, BC it was found that the use of a ground-based loader for forwarding was about 60% lower in cost than for cable yarding (Clark, 1998). This was a commercial thinning experiment to determine costs and site disturbances using different equipment types. Also, the study determined that manual falling was more cost effective than mechanical falling.

iii. Methods

TIPSY

In order to analyze the general feasibility of commercial thinning, a series of scenarios were developed to test what the stand level outcomes would be with regards to volumes, economic values, and overall stand mortality. These scenarios were run through TIPSY modeling software and then evaluated based on their economic viability.

TIPSY 4.2 is a software program developed by the BC Ministry of Forests for predicting the yield of managed and natural stands (Di Lucca, 2002). TIPSY is calibrated using data from research plots and permanent sample plots in areas throughout the province. It is the only real source of data for managed stands in BC, and provides an approximation of what would happen in a particular managed stand.

One of the inherent limitations of TIPSY is the inability of the user to enter existing stand data and then have it extrapolate from that point into the future to see the future condition of the stand. Instead, all stands are grown from year zero based on user-input site index and initial stand density. This posed a problem for analysis in this report, as volumes of existing second growth stands were needed in order to compare future volumes if the current stand was thinned or if it was left to continue growing.

In order to make this comparison as realistic as possible, existing stand data that included volumes and area were needed. This data was obtained from WFP appraisal reports for second growth blocks E500-505 located in the lower Gold River Valley off of the Ucona Mainline (see appendix A). The blocks are not located right next to each other, but rather are all part of a larger cutting permit. These blocks are planned to be logged within the coming year and have an average age of 43 and 44 years. In order to more accurately evaluate WFP's operation as a whole, the data from this cutting permit was extrapolated to represent the entirety of all the second growth stands within the tenure that are of this age. To do this, a general approximation was made on species compositions of these second growth stands. This was found by dividing the volumes of each species in cutting permit E by the total volume of the permit.

<u>Example:</u>

Total Douglas-fir Volume = 44,633   Total Volume from Cutting Permit = 55,237

Douglas-fir percentage composition = 44,633/55,237 = 0.80 or 80%

Based on the cruise reports, there were four other species found within the permit, western red cedar, western hemlock, Sitka spruce and alder. Though all these species were present, the only two dominant ones were Douglas-fir (80%) and hemlock (20%), the others were negligible. At this point, another shortfall of the TIPSY software is its inability to run a mixed species stand for its commercial thinning model. Therefore, once again, simplification of the stands was made using a 100% Douglas-fir stand. This shouldn't pose much of an error since a high proportion of the permit is Douglas-fir, and from personal knowledge of the area a good percentage of second growth stands on the tenure are mostly Douglas-fir dominated.

Due to the fact that TIPSY cannot use existing stand data, a series of steps were taken to develop a base model that imitated the stand conditions from stands in cutting permit E. This was done by looking at the total volume/ha from the cutting permit (total volume (55,237m^3) / area (108.4 ha)), to get an average per hectare volume of 509 m^3. A base Tipsy model of 80% Douglas-fir and 20% coastal western hemlock was run, with the goal of finding a planting density and site index that would yield 509 m^3/ha at age 43. After changing the inputs around and creating different combinations for the variables, a planting density of 2000 and a site index of 33 for Douglas-fir and 31 for coastal western hemlock were the right inputs to produce the desired results.

Stand Description Inputs

TIPSY uses a variety of input variables that need to be correct in order for the most accurate results to be produced (Table 1); these include the forest region, district and biogeoclimatic zone. The WFP gold river operation is located in the Coast forest region and the Campbell River forest district in the Coastal Western Hemlock (CWH) biogeoclimatic zone. The average slope is also required, which in the area, according to cruise reports, is around 30%. The next step is to enter the species composition. Due to the fact that TIPSY can only run single species thinnings, a pure Douglas fir stand is used for all the scenarios, except for the base case which consisted of the 80-20 mix of Douglas-fir and western hemlock respectively. When inputting the species a site index is needed. The site indices chosen were approximations for the area as a whole given by one of the operations foresters at WFP (Nielsen, 2011-2012).

Table 1 - Input Variables into Stand Descriptions in TIPSY

Forest Region	Coast Forest Region
District	Campbell River
Biogeoclimatic zone	CWH
Slope	30%
Species Composition	80% Fd , 20% Hw
Site Index	33 for Fd and 31 for Hw
Planting Density	2000 SPH
Commercial Thinning (used for thinning scenarios)	To 400 sph @27 m Top height

When performing a commercial thinning simulation in TIPSY, there are a few input variables needed in order to run the model. The timing of the thinning treatments are determined by the model based on the top heights of the trees in the stand. The options are to thin at a height of 21, 27, or 33 meters. A residual density is then chosen to leave the post-thinned stand with a given number of stems greater than 12.5 cm dbh. A number of different scenarios were run based on different heights to attempt to achieve an age that resembles the current stand on cutting permit E. All thinnings performed to 400 sph at a top height of 27 meters, occurs at year 40.7 (which is the closest that could be extrapolated to 43 years).

Fertilization promotes residual tree vigour and growth, and can be simulated in TIPSY. The input variables for these include how many years after planting you want to perform the treatment, and the effectiveness of the fertilizer. The default effectiveness is 80%, and was used for all fertilization runs.

Economic Inputs

TIPSY has the option to include an economic analysis by generating an output that shows costs and potential sales data for logs. There are a number of variables needed in order to perform an economic and financial analysis of a stand in TIPSY (e.g. Table 2). This can be a useful tool in examining the economic and financial viability of your stand under various cost and price assumptions.

Table 2 - Input variable costs for TIPSY

Silviculture Costs	Site Prep	$100/ha
	Fertilization	$222/ha * Where applicable
Road Development	Road Reactivation	$625/ha

Tree to Truck	Harvesting	$30/m^3 for Clearcut $37.81/m^3 CT
Haul Cost	Haul Distance	$5.80/m^3
	Towing & Barging	*Would be lumped in with logs from rest of operation for harvest $2.20/m^3
Other Costs	Overhead	$1154/ha
	Other Harvest Costs	$0.25/m^3
Discount Assumptions	Discount rate	1.25
	Real Price Increase	3.10
	Real Cost Increase	0.56
	Real Increase Duration	25 years
	Analysis Base year	Year 41 @ commercial thinning age

Silviculture costs

Silviculture costs are relatively low, due to the lack of planting and regeneration needs for a commercial thinning stand. A value of $100 was chosen for site prep, as trails will need to be assessed, and soil pits dug to determine if rehabilitation would be required post-harvest. This silviculture cost would increase if it was determined that site rehabilitation would be needed. Free growing surveys that are required after two years would ideally be done in-house and would bare insignificant costs. The only real cost that applies to some of the models is fertilizing. For the coast region each treatment for fertilizing costs approximately $222, this is the default value given by TIPSY and is based on average costs during 2006.

Road Development

Second growth blocks already tend to have some remnants of an existing road network that were used during the first harvest. In most cases these roads can be re-activated, saving costs from having to rebuild a whole new road. However, these existing roads can be troublesome and certain sections of re-activation may be more expensive than others.

Based on approximations given by the head engineer at the WFP Gold River operation, the average cost to re-activate roads in second growth is around 12.50 per linear meter (Sommerfeld, 2011-2012). There is approximately 0.05 km of road per ha in cutting permit E and at a rate of approximately $12.50 per meter, the average cost per ha for road construction is $625.

Tree to Truck

The cost for the harvesting phase of the commercial thinning operation was derived from data from the UBC Malcolm Knapp Research Forest (MKRF) in Maple Ridge, BC, where an extensive commercial thinning operation is performed yearly. Delivered wood costs from these thinnings range from about \$30-35/m^3 for ground based short haul distance, up to \$55-60/m3 for cable thinning and longer haul distances (Lawson, 2011). Since the terrain where the second growth forests are located in Gold River, is similar to that at MKRF, and assuming cable and ground based logging are used in a 50-50 split, then the average cost would be around \$45/ m^3. The goal though at WFP is to minimize costs, so the models will be run with a lower cost. The overhead cable yarding option will be used at approximately \$30/m^3 and the addition of the default commercial thinning add-on amount of \$7.81/m^3 will be used in the runs with a thinning treatment.

Haul Costs

The average haul distance from the second growth blocks in Gold River is between 10-20 km. This commercial thinning operation would be on such a small scale that towing and barging costs would be lumped in with other harvested logs from the regular clearcutting operation. For final harvests, the default value of \$2.80/m^3 will be used for towing and barging.

Other costs

Overhead costs cover the administration and supervisory activities for the operation as a whole. Though commercial thinning doesn't remove as many trees as a clearcut operation, certain rules and regulations still need to be followed and therefore scaling, engineering, cruising, environmental protection, consulting fees and residue surveys still need to be performed. These are default values in TIPSY and were originally drawn from section 5.2 of the Coast Appraisal Manual. A stumpage rate of \$0.25/m^3 was used for the Douglas-fir in the Campbell River district (Province of British Columbia, 2007).

Market Analysis

Log prices from the log market report (Figure 1) put out by the ministry of forests, lands, and natural resource operations were used to calculate revenues (Timber Pricing Branch, 1990-2011).

Grade	Fd	Hembal
C	$135.34	
H	$128.30	$70.80
I	$72.41	$57.05
J	$58.15	$53.89
U	$44.75	$48.29
Y	$28.54	$45.76

Figure 1 - 3 Month Log Prices as of November 30,2011 (per m^3)

Discount Assumptions

A discount rate was used to convert future values into equivalent present values. As of January 12, 2012 the discount bank rate was 1.25 (Bank of Canada, 2012). This rate is pretty low and is expected to rise in the future. The volatility of this rate will effect results in terms of the economic benefits or shortfalls of a commercial thinning treatment.

The real price increase extrapolates what the future price of a product will be. The rate used for this input was the GDP growth rate from the World Factbook from the American Central Intelligence Agency (CIA) (2010) and is 3.10%. It is tough to put a real growth rate on Lumber prices, although based on the trend in log prices from 1990-2007 the percent increase per year on average is 3.10% (Timber Pricing Branch, 1990-2011). To demonstrate the variability in prices, Fir H-grade log prices was plotted (Figure 2).

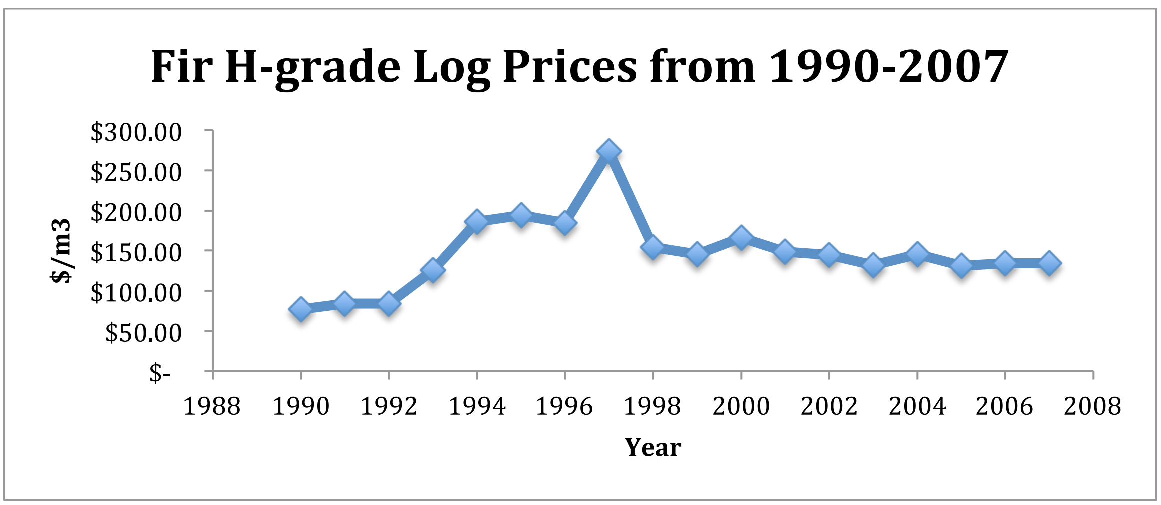

Figure 2-Fir H-grade Log Prices from 1990-2007

The anomaly here is that in 1997 prices shot right up and then back down again. Determining the real cost within the forest sector is difficult, due to variability of costs from year to year. For example, different types of harvesting, such as helicopter logging, can vary in price due to demand and such external factors as fuel prices. A simple indicator of cost change is to take the annual labor rate from the MOF Coastal Appraisal Manuals (2007) and get a percent change in the labor rate. This was calculated to be approximately 0.56% per year.

The analysis base year is the year that the commercial thinning takes place. From that point out net present value can be determined through the models. By doing this, the efficiency of the treatment can be analyzed to whether it is worth pursuing.

Scenarios

Each of the different scenarios (Table 3) was then run with each scenario's individual variables. Once these scenarios were run, different tables from TIPSY were created to show output data. For the purpose of this report two specific tables are used. The first is the stand yield table which displays the change in yield of the stand over time. This table will be used minimally, as the more relevant one is the economic analysis table, which shows the economic viability of each of the scenarios.

Table 3 - Description of Scenarios and tree to truck costs

Scenario 1	Base Case 80% Fd 20% Hw	$30.00/m^3
Scenario 2	Thinning at age 43 of current stand at rate of	$37.81/m^3
Scenario 3	Fertilizing After Commercial Thinning at age 43	$37.81/m^3
Scenario 4	Thinning on Private Land at age 43	$37.81/m^3
Scenario 5	Thinning with a reduced tree-to-truck cost	$36.81/m^3
Scenario 6	Thinning with an increased tree-to-truck	$45.00/m^3

Scenario 1: Base Case 80% Fd 20% Hw

20% western hemlock 80% Douglas-fir; Site index Fd 33 Hw 31

This is a run based on what the existing stand should look like if it was started from year zero. Meaning that the rest of the scenarios are based on this one to see what the effects of commercial thinning will have in comparison to the existing stand.

Scenario 2: Thinning at age 43 of current stand

100% Douglas-fir; Site index 33; Commercial thinning to 400 sph at average stand height of 27m

This was the model that would get the closest to 43 years of age for a thinning (the model shows 40.7 years). This would imitate what would happen if WFP decided to thin instead of harvest at this point in time. The point at which this becomes beneficial to perform (in an economic sense) is when the net present value of the thinned stand exceeds the unthinned stand.

Scenario 3: Fertilizing After Commercial Thinning

Fertilization at 41 and 51 years and have 80% effectiveness

These fertilization treatments would provide added growth potential to the thinned stand. The first treatment would be done immediately after the commercial thinning, and the second 10 years later in the same stand. The goal of these treatments is to see how the stand will incur increased value over time, even with the relatively high cost of thinning at $222 per hectare.

Fertilization in TIPSY is based on research plots from around BC. The plots were hand fertilized and claimed to have had a 100% effectiveness rate, but because most operations would choose to use an aerial application, an 80% effectiveness is recommended and was used for this scenario. Stands that have been recently thinned are good for fertilization treatments (Forest Practices Code, 1995), and therefore the timing of fertilization treatment was at age 41, immediately after the thinning. A second fertilizer application was scheduled at 51 years since it has been found that an optimal time to fertilize a stand is 10-15 years before harvest (Forest Practices Code, 1995), and this report is assuming a final harvest at 61 years of age.

Scenario 4: Thinning on Private Land

This scenario will be run with the same inputs except for stumpage which is non-existent on private land. Taxes are not taken into account in this report. WFP Gold River has a significant amount of private land in and around the area, a total of 741.6 ha (Nielsen, 2011-2012). Of that total, 149 ha are in the age class between 41-60 years, an age class that is appropriate for commercial thinning (Nielsen, 2011-2012).

Scenario 5: Thinning with a reduced tree-to-truck cost of 29.00/m^3

This is the low cost option. This scenario shows the implications of reducing the tree to truck cost to 29.00/m^3, (plus $7.81 commercial thinning cost) which is quite low for industry standards. In most cases this may be unrealistic but can show what can be attained if a lower cost can be acquired. It is only $1 less than the tree-to-truck costs of scenario 3 and 4, but this small adjustment was made to find the quickest point to reach a positive NPV after the thinning treatment.

Scenario 6: Thinning with a tree-to-truck of 45.00/m^3

This is based on what the cost associated with the Malcolm Knapp Research Forest in Maple Ridge estimates their commercial thinning to be around 45.00/m^3. This is a high estimate because most of the work at the research forest is contracted out, causing higher prices. WFP has the advantage of having some equipment and long standing relationships with logging contractors, hence can most likely incur a lower cost.

Due to the inability of TIPSY to run multi-species commercial thinning treatments, the thinning treatments are not exactly comparable to the base case which was run with an 80% Douglas-fir and 20% Western Hemlock mix. Therefore an alternate base case of 100% Douglas-fir was run to see how much of a difference there is between the two base cases (Scenario 1b).

iv. Results

Reading TIPSY Output Tables

The following column headers from the TIPSY tables are described and defined below:

TIPSY Age- Refers to the age since the stand initiating disturbance occurred, which in these second growth forests is the initial harvesting.

Top Height (m)- The average height of the 100 trees/ha of largest diameter at breast height.

Merchantable volume (Merch Vol.)- Total stand volume greater than 12.5cm DBH, measured in m^3/ha.

Harvest Revenue-All revenue accumulated to the final harvest age, this includes all commercial thinning treatments. This revenue will change if general real price increases change. This is measured in $/ha.

Tree-to-Truck- These costs cover landing and skid trail construction, felling, bucking, skidding, and loading of truck, plus any contractor overhead or profit. All costs are accumulated to this point, including commercial thinning. Measured in $/ha.

Haul Costs- Log transport from landing to the log dump. All costs including commercial thinning are accumulated and is measured in $/ha.

Average Revenue- Harvest revenue divided by the total merchantable volume 12.5+ cm at a selected harvest age. Measured in $\$/m^3$.

Conversion Cost- The sum of road development, tree-to-truck, haul, milling, overhead and other harvest costs divided by the merchantable volume 12.5+ cm at a selected harvest age. Silviculture and annual costs are not included. Measured in $\$/m^3$.

Net Present Value (NPV)- The sum of discounted revenues and costs (including silviculture and annual costs) incurred over a single rotation. Measured in $/ha.

Site Value-The sum of discounted revenues and costs (including silviculture and annual costs) from an infinite series of rotations of the same length. Also known as soil rent, bare land value and soil expectation values. Measured in $/ha.

SCENARIOS

Scenario 1: Base Case 80% Fd 20% Hw

The base case shows what would happen in the future if the stand stayed the same (Table 4). The inputs into TIPSY most likely vary from what WFP has calculated through their operational planning and financial assessments to determine the current value of the stand. Exact costs and log values from WFP were unavailable due to confidentiality agreements. Because of this, the analysis will be based on stand condition at year 41, which is when the commercial thinning treatment would theoretically be performed based on TIPSY.

Table 4 - Scenario 1 TIPSY Table

TIPSY Age (yr)	Top| Ht| (m)|	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
41	26.9	399	20480	12814	2314	51.33	49.31	806	1718
51	31.5	550	39952	18468	3387	72.63	48.12	11848	24374
61	35.5	682	69385	23874	4455	101.81	47.56	28557	52238
103	46.7	1046	160303	35490	7043	153.31	45.57	50623	68756

At age 41, the NPV of the cutting permit is $806/ha. The age in which the NPV is maximized is 103 years at a value of $50,623/ha.

Scenario 2: Thinning at age 41 of current stand

After the commercial thinning at age 40.7, the NPV is -$94/ha (Table 5). This negative NPV demonstrates that the commercial thinning did not produce a positive margin. At age 41, the NPV of the stand is $75/ha. The age in which the NPV is maximized is 109 years and has a value of $50,860/ha.

Table 5 - Scenario 2 TIPSY Table

TIPSY Age (yr)	Top| Ht| (m)|	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
-------	-------	--------	-----------	----------	---------	---------	------------	---------	----------
41	27.2	382	19687	13505	2220	51.48	51.28	75	-60
51	31.9	512	34703	17936	3099	67.76	50.25	7742	15864
61	35.8	641	59568	22707	4073	92.96	49.65	21147	38646
109	48.0	1103	175263	39239	7277	158.85	46.34	50860	67280
Commercial Thinning									
40.7	27								
40.7	27	378	19302	13360	2192	51.07	51.32	-94	-474
Commercial Thinning Harvest									
40.7	27	165	7394	6671	957	44.81			

When reading the above TIPSY output tables, the three commercial thinning lines show different results. The first set of lines is the stand immediately after it is thinned. The third line below the heading “Commercial Thinning Harvest” is what was taken out of the thinning treatment.

Scenario 3: Fertilizing After Commercial Thinning and at 51 years

The fertilization treatments proved to be somewhat effective (Table 6). It was effective in the sense that it adds about 10m^3 per year to the stand more than if unthinned. Economically the fertilization treatment caused the stand to have a NPV of -$925/ha immediately after the commercial thinning and -$986/ha at 41 years. Although this is significantly lower than scenario 1 or scenario 2, it does reach its maximum NPV of all the treatments at 106 years at a value of$50,714/ha. The fertilization treatment increased the m^3/ha by about 10 each year.

Table 6 - Scenario 3 TIPSY Table

TIPSY Age (yr)	Top| Ht| (m)|	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
-------	-------	--------	-----------	----------	---------	---------	------------	---------	----------
41	27.2	382	19688	13506	3063	51.48	53.48	-986	-2641
51	32.2	522	35580	18249	4362	68.1	52.32	6647	13595
61	36.3	660	62134	23323	5796	94.08	51.66	20851	38104
106	47.9	1100	174261	39085	10006	158.43	48.81	50747	67998
Commercial Thinning									
40.7	27								
40.7	27	378	19302	13360	3024	51.07	53.52	-925	-2508
Commercial Thinning Harvest									
40.7	27	165	7394	6671	1320	44.81			

Scenario 4: Thinning on Private Land

Private land proved to bring a higher NPV at 41 years of age of $129/ha (Table 7). Still, the NPV after the commercial thinning was negative at -$40/ha. Just like scenario 2 (the base case commercial thinning), the maximum NPV is at year 109 but has a higher value of $50,973/ha. It mirrors scenario 2 with the same rate of change in all aspects of the stand economically, but has a bit higher of a value due to the elimination of the stumpage fee that is attributed to stands on crown land.

Table 7 - Scenario 4 TIPSY Table

TIPSY Age (yr)	Top| Ht| (m)|	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
--------	------	--------	----------	-----------	---------	----------	----------	---------	-----------
41	27.2	382	19687	13505	2220	51.48	51.13	129	72
51	31.9	512	34703	17936	3099	67.76	50.07	7823	16032
61	35.8	641	59568	22707	4073	92.96	49.44	21250	38835
109	48	1103	175263	39239	7277	158.85	46.09	50973	67429
Commercial Thinning									
40.7	27								
40.7	27	378	19302	13360	2192	51.07	51.18	-40	-343
Commercial Thinning Harvest									
40.7	27	165	7394	6671	957	44.81			

Scenario 5: Thinning with a reduced tree-to-truck of 36.81/m³

If thinning costs can be reduced to $36.81/m³ an even higher NPV can be developed at $461/ha at age 41 (Table 8). The NPV after commercial thinning was also positive at $288/ha. At year 109 the maximum NPV is $51,483/ha.

Table 8 - Scenario 5 TIPSY Table

TIPSY Age (yr)	Top| Ht| (m)|	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
41	27.2	382	19687	13119	2220	51.48	50.26	461	879
51	31.9	512	34703	17396	3099	67.76	49.19	8235	16887
61	35.8	641	59568	21997	4073	92.96	48.54	21731	39718
109	48	1103	175263	37971	7277	158.85	45.19	51483	68104
Commercial Thinning									
40.7	27								
40.7	27	378	19302	12978	2192	51.07	50.31	288	461
Commercial Thinning Harvest									
40.7	27	165	7394	6504	957	44.81			

Scenario 6: Thinning with a tree-to-truck of 45.00/m^3

The NPV after the commercial thinning is quite low as expected at -$2402/ha, while the NPV increases just a little at age 41 to an NPV of -$2267/ha (Table 9). Maximum NPV is again attained at year 109 and has a value of $46,298/ha.

Table 9 - Scenario 6 TIPSY Table

TIPSY Age (yr)	Top Ht (m)	Merch Vol. (m3/ha)	Harvest Revenue ($/ha)	Tree-to-Truck ($/ha)	Haul Costs ($/ha)	Average Revenue ($/m3)	Conversion Cost ($/m3)	NPV ($/ha)	Site Value ($/ha)
41	27.2	382	19687	15853	2220	51.48	57.42	-2267	-5756
51	31.9	512	34703	21607	3099	67.76	57.42	4416	8971
61	35.8	641	59568	27994	4073	92.96	57.9	16871	30804
109	48	1103	175263	48983	7277	158.85	55.17	46298	61239
Commercial Thinning									
40.7	27								
40.7	27	378	19302	15668	2192	51.07	57.43	-2402	-6122
Commercial Thinning Harvest									
40.7	27	165	7394	7576	957	44.81			

Table 10 - NPV and volumes of each Scenario at current, 10, and 20 years

	NPV Immediately After CT at year 40.7 ($/ha)	Merch. Volume Immediately After CT at Year 40.7 (m^3/ha)	NPV Year 51	Merch. Volume Year 51	NPV Year 61	Merch. Volume Year 61
Scenario 1	$806	399	$11848	550	$28557	682
Scenario 2	$-94	378	$7742	512	$21147	641
Scenario 3	$-925	378	$6647	522	$20851	660
Scenario 4	$-40	378	$7823	512	$21250	641
Scenario 5	$288	378	$8235	512	$21731	641
Scenario 6	$-2402	378	$4416	512	$16871	641

Table 10 above compares the different scenarios based on NPV and merchantable volume in the first 20 years. The NPV includes the value of the commercial thinning. The Merchantable volume does not.

Scenario 1b – 100% Douglas-fir Base Case

This is not considered a scenario, but was used to show the difference between 100% Douglas-fir and a 80-20 fir-hemlock mix and whether the commercial thinning is overestimating or underestimating volumes. The following table (11) shows the comparison between Scenario 1 and the 100% Douglas-fir base case:

Table 11 - Comparison between Scenario 1 and 100% Douglas-fir base case

	NPV	
Age	**80-20 Base Case**	**100% Fd**
41	806	501
51	11848	11065
61	28557	27038

As seen above, the 100% Douglas-fir run has lower NPV at all ages. This means that all the thinning scenarios are undervalued based on the original stand conditions of 80% Douglas-fir and 20% Western Hemlock.

Graphs

The following graphs show the comparison of NPV over time between the six different scenarios (figures 3 and 4).

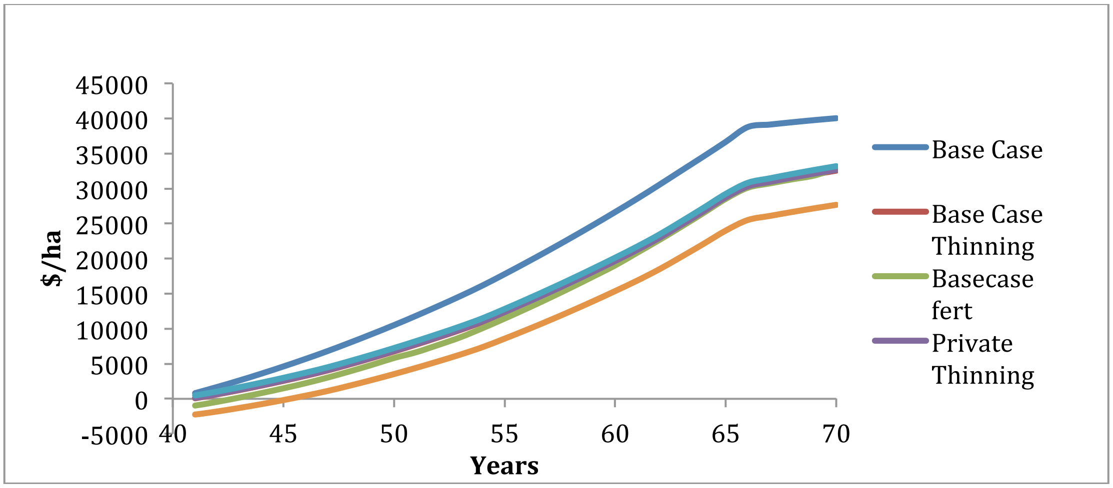

Figure 3 - Net Present Value from Years 40-70

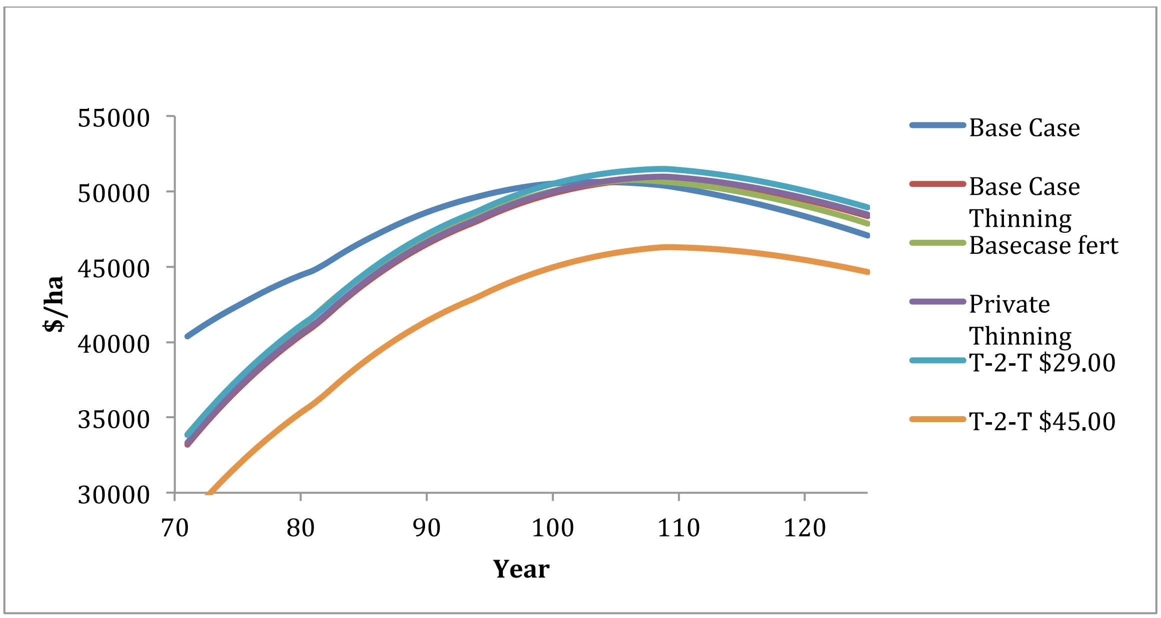

Figure 4 - NPV from years 70 to 125

Figure 5 shows the site value of the stand and how it changes from year 40 to 125. What is interesting is the spike and high rate of increase to about year 65 in each scenario, then the rate abruptly begins to increase at a decreasing rate then it spikes again at around year 70. This occurs in most all the scenarios, and was beyond the scope of the report to determine the cause.

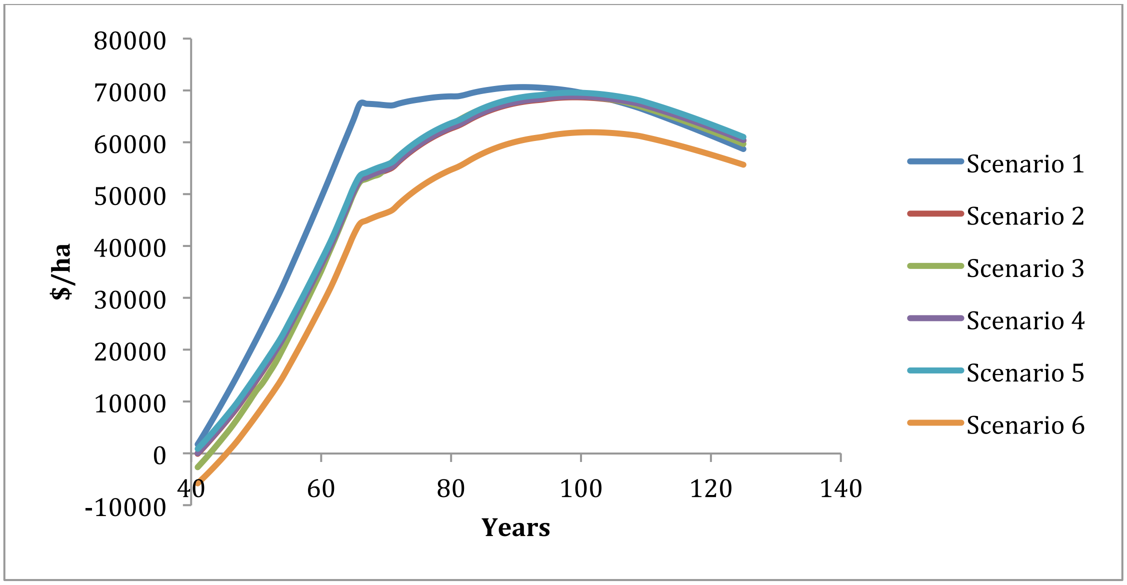

Figure 5 - Site Value from years 40-125

V. DISCUSSION

COMPARING SCENARIOS

In order for a commercial thinning treatment to be a viable option, the NPV needs to be higher than what the original stands NPV would be at any given year. This means that if you commercially thinned today would that increase the value of the stand into the future, compared to if it had not been commercially thinned. As seen in Table 12 the highest NPV in 20 years is from Scenario 1, which is to clearcut all of cutting permit E right now. This proves, based on all the scenarios, that commercial thinning would not be a viable option. This of course is based on the variables that were used to enter into TIPSY and are only as accurate as they are portrayed in the model and are only an approximation of what actually occurs.

**Values in the following tables are calculated based on the per ha value in the table multiplied by the area of cutting permit E of 108.4ha. This gives an approximation of the total value of the stand at a given time.*

Table 12 - NPV of each Scenario at current, 10, and 20 years

	Immediately After CT at year 40.7	Year 51	Year 61
Scenario 1	$87,370.40	$1,284,323.20	$3,095,578.80

Scenario 2	-$8,130.00	$839,232.80	$2,292,334.80
Scenario 3	-$106,882.40	$720,534.80	$2,260,248.40
Scenario 4	$13,983.60	$848,013.20	$2,303,500.00
Scenario 5	$49,972.40	$892,674.00	$2,355,640.40
Scenario 6	-$245,742.80	$478,694.40	$1,828,816.40

Scenario 1 may show the highest NPV in 20 years but when looking at the maximum NPV of the stand, Scenarios 4 (private land) and 5 (low-cost harvesting) are the highest (Table 13). Although, these scenarios reach maximum NPV at year 109 rather than 103, meaning a wait of an extra six years would be required. In reality, not many operations would wait that long to harvest a stand that they had already assessed for harvest at around 40-45 years of age.

Table 13 - Year of and Value of Maximum NPV

	Year of Max NPV	Maximum NPV
Scenario 1	103	$5,487,533
Scenario 2	109	$5,513,224.00
Scenario 3	106	$5,500,974.80
Scenario 4	109	$5,525,473
Scenario 5	109	$5,580,757.20
Scenario 6	109	$5,018,703.20

The site value of each of the scenarios (Table 14) shows much the same results, except that the maximum site value is reached earlier for most scenarios and occurs between years 91-101. TIPSY doesn't go into great detail about what site value means other than its definition that it is *the sum of discounted revenues and costs (including silviculture and annual costs) from an infinite series of rotations of the same length. Also known as soil rent, bare land value and soil expectation values.*

Table 14 - Maximum Site Values

	Year of Max Site Value	Maximum Site Value
Scenario 1	91	$ 7,660,411.20
Scenario 2	99	$ 7,447,513.60
Scenario 3	98	$ 7,477,323.60
Scenario 4	99	$ 7,465,182.80

Scenario 5	99	$	7,543,881.20
Scenario 6	101	$	6,716,464.00

There is another way to look at commercial thinning from an economic stand point, and this may be what is of interest to a company such as WFP. If there is somehow a way to attain a profit from a commercial thinning to gain some revenue, then you will be getting more value from your stand later on in the future as well. For example in Scenario 1 (Base case- no thinning), If WFP were to clearcut all 108.4 ha of cutting permit E they would attain a NPV of $87,370.40. Then, if a net revenue of say $10,000 were to be obtained from a commercial thinning treatment instead of logging the area, you would be getting $10,000 (This is a random value used for demonstration purposes and does not reflect a TIPSY output) plus the NPV of the stand when its final clearcut harvest 20 years down the road is $2,303,500.00 (See table 8, Scenario 4, for best approximation). That is a total NPV of $2,313,500.00, which is $2,226,129.60 more than if the whole stand had been clearcut at age 41. Most companies would look at these numbers and downplay them, as it would involve waiting 20 years down the road for a final harvest. With the current tenure system renewal at 20 years for Timber Supply Areas (TSAs) and 25 years for Tree Farm Licenses, (TFLs) (Ministry of Forests, lands and Natural Resource Operations, 2012) some companies may not have the land they are currently operable on, into the future. This makes investing in a commercial thinning treatment a bit of a risk. Without a government incentive to do so, it is a tough sell.

Private land does provide a different perspective when looking at commercial thinning. With private land, there is incentive to invest in your land, and commercial thinning can create that investment if proven economical. Commercial thinning also allows you to respond to niche markets or changes in market trends. This is made even increasingly easier on Private land as permits and other administrative aspects are not as strict or as intensive as on public lands, allowing land owners to respond quicker. The Malcolm Knapp Research forest is a prime example of this as they use commercial thinning to respond to market conditions. Many forestry companies in the Pacific Northwestern States like Oregon and Washington have also used commercial thinning in the past as a means to meet such economic goals.

These scenarios are only a select few, and there are many other scenarios that could be modeled. For example, changes in variables like log prices or real costs could alter results either favorably or unfavorably. These changes would only be assumptions and uncalculated and would only provide a scenario that risks whether or not that change will actually occur. There is a place for these types of assumptions though in forest level planning, and should be included.

It should be noted that there is more to commercial thinning than just economics; it can also have non-timber values and social implications as well. By implementing a thinning, a stand may develop higher levels of biodiversity leading to a stand that resembles the preceding old growth. This creates not only a healthier forest but can also provide value to members of society who put importance on those characteristics. Commercial thinning is also more labor intensive and thus requires more jobs, this could benefit a small community that has been hit hard by the recent downturns in the industry. It can help in terms of visual objectives or even recreation. Commercial thinning is similar to a partial cut in that trees still remain standing within the forest, rather than a large clearcut. This allows for a more visually appealing appearance to most members of the general public, and makes commercial thinning an attractive option to use near urban areas.

Knowledge Gaps

The most obvious knowledge gap in this report, and its attempt to determine the effects of a commercial thinning treatment, is the TIPSY software. Since the software is only updated every few years it can’t always be consistently accurate. It is also software, meaning that it is only as good as the programming that has been put into it and does not account for every aspect of a managed stand. Again, the biggest shortfall of TIPSY is its inability to perform a commercial thinning treatment on a mixed species stand. This hindered results for this report, as the existing stands are not 100% pure stands. By being able to input commercial thinning treatments into mixed species stands, these stands could be more accurately modeled. TIPSY is also using default values from 2006 and may need to be updated to current data, especially on costs and revenues variables.

There also exists a knowledge gap between researchers, government, and industry. This is evident in many aspects of forestry, but could be especially true in regards to commercial thinning. A lot of work was done in the late 1990's to try and promote commercial thinning and its benefits. Most of this work was government led, but yet still no legislation was made, nor did any companies in the industry take action. By narrowing this knowledge gap, once again, commercial thinning may be able to be a viable option for landowners or licensees on their lands.

RISKS AND ASSUMPTIONS

Due to the nature of the report, and some confidentiality from WFP, there were some limitations, risks and assumptions that were.

RISKS

- Limited by the notion that not all costs are necessarily accurate. Some are an approximation based on data attained from resources from WFP.
- Had to extrapolate cruise data from cutting permit E into TIPSY, which may not have created the exact same stand conditions. Therefore, resulting data will not be completely accurate but rather an approximation of the stand in question.
- TIPSY cannot perform mixed species commercial thinnings, therefore a 100% Douglas-fir stand was used for the scenarios requiring a thinning. Since the original stands on cutting permit E are an Douglas-fir and western hemlock mix, the actual values may be skewed due to the fact that the 20% of hemlock was considered as Douglas-fir.
- TIPSY grades some H logs as I logs. The H grade requires a minimum 5 annual growth rings per cm. This creates problems within TIPSY. TIPSY can't translate this information across the range of site indexes and thus the distribution of volume between grades H and I may be incorrect.
- General price increases and cost increases were very general due to lack of conclusive numbers found through research. Therefore, may not show the most accurate portrayal. Especially since they are never constant numbers and change over time.
- Models are models, and by no mean can extrapolate exactly what is going to happen into the future, but only can give a glimpse into the future of what may happen based on previous findings.

Assumptions

- Kept a baseline of no silviculture costs to keep costs constant. Since this wasn't a changing variable it didn't make a difference in final results.
- Variables used in TIPSY are only either approximations or defaults used by the TIPSY software.
- Tree-to-Truck costs are based on a rough estimate provided by Paul Lawson from the Malcolm Knapp Research Forest
- Overhead costs were based on TIPSY defaults as the true cost was not available from WFP
- It was assumed that in some cases, because commercial thinning would be on a small scale, that logs would be lumped in with the barging costs with other logs from across the operation.
- Overhead cable yarding was used as the default harvesting type in TIPSY, but may not be the actual method used.

Decision Making for Implementing a Commercial Thinning Treatment

If a commercial thinning treatment is calculated to be a valuable asset to the company, there is a series of steps that need to be taken in order to implement a program. In the case of WFP, their biggest concern is to determine whether the volume would come from "bonus" or "normal" AAC. Once that is determined, is the return on capital employed margin worth it, and is the project going to be margin positive? Also, considering the idea that the thinnings may provide access to otherwise constrained volumes (example: visuals or biodiversity objectives) needs to be addressed to see if there is added value elsewhere. Lastly, someone would have to present an economic and financial analysis to prove to upper-level management, that the project would be viable (McGourlick, 2011). A good example of a project that was brought forward for implementation was a poling program developed from within the WFP Gold River operation.

vi. Conclusions

Ultimately the goal is to minimize costs and maximize net revenue when looking at implementing a commercial thinning treatment, but can also be to protect stand value and biodiversity. This presents a challenge due to the complexity of such a program, and would require significant resources in research, labour, equipment, management, and training. There just has not been enough focus on the subject in the recent past to really be able to draw any conclusions on whether or not it is economically viable or not. Currently, according to the results of this report, it is not viable. This is not to say that in the future this will be the case, and that eventually commercial thinning may find its way into forest management on the BC coast.

RECOMMENDATIONS

The BC government and forest service should look into how commercial thinning could fit into forest management plans. This would most likely require legislation that would promote commercial thinning, much like the forest service has used for fertilization in the past (Nielsen, 2011-2012). A program like Forest Renewal BC may be a good idea in generating further analysis on this complex subject. There is a knowledge gap on the subject of commercial thinning, mostly spanning from the late 90's to the present. A new government or industry initiative should be made to re-evaluate commercial thinning as a viable option on the landbase.

This was a general report that made some assumptions that may not have been as accurate as they could have been. Though it does give a good understanding of the challenges presented with a commercial thinning treatment, and gives a general idea of what would happen given rough current inputs and predicted futures. The topic of commercial thinning hasn't really been addressed since the late 1990's, and it may be time to consider looking into re-addressing its advantages and uses in a sustainable forest management plan.

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APPENDICES

APPENDIX I: CRUISE REPORT E500-E505

APPENDIX I: CRUISE REPORT E500-E505

*** FOR MPS PURPOSES *** APPSM- 1 , p5

Appraisal Summary Report

Average Line Method	Grades: Cruiser Called Alpha	FIZ: B	08-Jul-2011 03:30:03PM
WESTERN FOREST PRODUCTS INC.	Cruiser Est Decay	PSYU: Quadra	Filename: WPG-2011-03-E500toE504.cop
Licence Number: TFL 19 CP: PLM	Cruiser Est Waste	Region: 1 - Coastal	Compiled by: TECO NRG
Project: 2011-03	CGNF Breakage Table	District: 5 - Campbell River	Cruised by: KERLEY & ASSOCIATES
Location : Gold River	No Of Blocks : 5		Version: 2011.00 TNRG build 5782

Utilization Levels:	Minimum DBH	Top Diameter	Stump Height
Mature Blocks: (cm)	17.5	15.0	30
Immature Blocks:(cm)	12.0	10.0	30

Standard Log Length:(m) 13.00

Net Area: [All Treatment Units : 108.4]

All Method Summary

Cruiser Call Variable Length Grades %

Species Code	Description	C	H	I	J	U	Y	Net Volume (m3) All	Live	DP	Net Volume / ha All	Live	DP
CE	Cedar					77	23	408	408	0	3.761	3.761	0.000
FI	Doug-Fir	5	2	1	84	8		44633	43634	999	411.741	402.525	9.216
HE	Hemlock		1	2	79	17	1	9108	9108	0	84.024	84.024	0.000
SP	Spruce				74	14	12	710	710	0	6.553	6.553	0.000
AL	Alder					90	10	378	378	0	3.490	3.490	0.000
	Total							55237	54238	999	509.568	500.352	9.216

Harvesting Method Summaries

Harvest Method	Net Volume	Net Vol /10m Log	Net Vol /Hectare	Hem+ Bal%	Partial Cut%	Slope%	Down Tree%	Heavy Fire%
CC	55237	0.42	509.568	16		30	0	0
Conventional Methods	55237	0.42	509.568	16		30	0	0
All Methods	55237	0.42	509.568	16			0	0

Cutting Authority

95% Confidence Interval	9.5
Plots/Ha	0.9
Cruised Trees/Plot	4.9
Net 2nd Growth-Conifer %	100.0
Net 2nd Growth-Conifer (m3)	54859
Net Immature by Block %	500:100% 501:100% 502:100% 503:100% 504: 91%
Non Heli Select Conifer (m3/ha)	506.08
Heli Select Total (decimal)	0.00
Heli+Skyline Total (decimal)	0.00
Piece Size - Conifer (m3/10m log)	0.42

Plots: 95 # <= 5yrs: 95 # > 5yrs: 0 # > 10yrs: 0 # no date: 0

FLAGS: Full Volumes, Normal Cruise, All Trees Compiled, Measure Plots Only, Damage,

*** FOR MPS PURPOSES *** AHV- 1 , p6

All Method Summary

Average Line Method	Grades: Cruiser Called Alpha	FIZ: B	08-Jul-2011 03:30:03PM
WESTERN FOREST PRODUCTS INC.	Cruiser Est Decay	PSYU: Quadra	Filename: WPG-2011-03-E500toE504.ccp
Licence Number: TFL 19 CP: PLM	Cruiser Est Waste	Region: 1 - Coastal	Compiled by: TECO NRG
Project: 2011-03	CGNF Breakage Table	District: 5 - Campbell River	Cruised by: KERLEY & ASSOCIATES
			Version: 2011.00 TNRG build 5782

[All Treatment Units : 108.4]

		Total	Conifer	F	C	H	S	D
Utilisation Limits								
Min DBH	cm (I)			12.0	12.0	12.0	12.0	12.0
Stump Ht	cm (I)			30.0	30.0	30.0	30.0	30.0
Top Dia	cm (I)			10.0	10.0	10.0	10.0	10.0
Log Len	m			13.0	13.0	13.0	13.0	13.0
Volume and Size Data								
Gross Merchantable	m3	57606	57085	46254	424	9582	824	522
Net Merchantable	m3	55237	54859	44633	408	9108	710	378
Net Merch - All	m3/ha	509.568	506.078	411.741	3.761	84.024	6.553	3.490
Net Merch - Live	m3/ha	500.352	496.862	402.525	3.761	84.024	6.553	3.490
Net Merch - DP	m3/ha	9.216	9.216	9.216				
Decay	%	1	1	1	2	2	0	
Waste(billing)	%	1	1	1		1	13	31
Total Cull (DWB)	%	4	4	4	4	5	14	27
Net Merch Vol/Tree	m3	0.73	0.75	0.91	0.17	0.44	0.63	0.22
Avg 13.0 m Log Net	m3	0.42	0.42	0.46	0.17	0.32	0.44	0.16
Useless Dead/Living	%	1	1		23			
Net Second Growth	%		100.0	100.0	100.0	100.0	100.0	
All Burn Volume	%							
Heavy Fire Volume	%							
Blowdown Volume	%	0	0	1				
Insect Volume	%							

Cruiser Call Variable Length Grades %

		Total	Conifer	F	C	H	S	D
#3 Peeler	C	4	4	5				
#2 Sawlog	H	2	2	2		1		
#3 Sawlog	I	1	1	1		2		
#4 Sawlog	J	82	82	84		79	74	
#5 Utility	U	10	10	8	77	17	14	90
#7 Chipper	Y	1	1		23	1	12	10

*** 1 tree(s) changed to tree class 6:because only log was less then 3.00 m ***
FLAGS: Full Volumes, Normal Cruise, All Trees Compiled, Measure Plots Only, Damage,

*** FOR MPS PURPOSES *** HV- 1 , p7

Harvest Method Summary

Average Line Method	Grades: Cruiser Called Alpha	FIZ: B	08-Jul-2011 03:30:03PM
WESTERN FOREST PRODUCTS INC.	Cruiser Est Decay	PSYU: Quadra	Filename: WPG-2011-03-E500toE504.cop
Licence Number: TFL 19 CP: PLM	Cruiser Est Waste	Region: 1 - Coastal	Compiled by: TECO NRG
Project: 2011-03	CGNF Breakage Table	District: 5 - Campbell River	Cruised by: KERLEY & ASSOCIATES
			Version: 2011.00 TNRG build 5782

Harvest Method : CC - Cable - Clearcut [All Treatment Units : 108.4]

		Total	Conifer	F	C	H	S	D
Utilisation Limits								
Min DBH	cm (I)			12.0	12.0	12.0	12.0	12.0
Stump Ht	cm (I)			30.0	30.0	30.0	30.0	30.0
Top Dia	cm (I)			10.0	10.0	10.0	10.0	10.0
Log Len	m			13.0	13.0	13.0	13.0	13.0
Volume and Size Data								
Gross Merchantable	m3	57606	57085	46254	424	9582	824	522
Net Merchantable	m3	55237	54859	44633	408	9108	710	378
Net Merch - All	m3/ha	509.568	506.078	411.741	3.761	84.024	6.553	3.490
Net Merch - Live	m3/ha	500.352	496.862	402.525	3.761	84.024	6.553	3.490
Net Merch - DP	m3/ha	9.216	9.216	9.216				
Decay	%	1	1	1	2	2	0	
Waste(billing)	%	1	1	1		1	13	31
Total Cull (DWB)	%	4	4	4	4	5	14	27
Net Merch Vol/Tree	m3	0.73	0.75	0.91	0.17	0.44	0.63	0.22
Avg 13.0 m Log Net	m3	0.42	0.42	0.46	0.17	0.32	0.44	0.16
Useless Dead/Living	%	1	1		23			
Net Second Growth	%		100.0	100.0	100.0	100.0	100.0	
All Burn Volume	%							
Heavy Fire Volume	%							
Blowdown Volume	%	0	0	1				
Insect Volume	%							
% Average Slope		30						

Cruiser Call Variable Length Grades %

		Total	Conifer	F	C	H	S	D
#3 Peeler	C	4	4	5				
#2 Sawlog	H	2	2	2		1		
#3 Sawlog	I	1	1	1		2		
#4 Sawlog	J	82	82	84		79	74	
#5 Utility	U	10	10	8	77	17	14	90
#7 Chipper	Y	1	1		23	1	12	10

*** 1 tree(s) changed to tree class 6:because only log was less then 3.00 m ***
FLAGS: Full Volumes, Normal Cruise, All Trees Compiled, Measure Plots Only, Damage,

*** FOR MPS PURPOSES *** CP- 1 , p8

Cutting Permit Summary

Average Line Method
WESTERN FOREST PRODUCTS INC.
Lioenoe Number: TFL 19 CP: PLM
Projeot: 2011-03

Grades: Cruiser Called Alpha
Cruiser Est Deoay
Cruiser Est Waste
CGNF Breakage Table

FIZ: B
PSYU: Quadra
Region: 1 - Coastal
Distriot: 5 - Campbell River

08-Jul-2011 03:30:03PM
Filename: WPG-2011-03-E500toE504.oop
Compiled by: TECO NRG
Cruised by: KERLEY & ASSOCIATES
Version: 2011.00 TNRG build 5782

Net Area: [A : 108.4]
Gross Area: [Grand Total : 108.4]

		Total	Conifer	F	C	H	S	D
Utilisation Limits								
Min DBH	om (I)			12.0	12.0	12.0	12.0	12.0
Stump Ht	om (I)			30.0	30.0	30.0	30.0	30.0
Top Dia	om (I)			10.0	10.0	10.0	10.0	10.0
Log Len	m			13.0	13.0	13.0	13.0	13.0
Volume and Size Data								
Gross Merohantable	m3	57606	57085	46254	424	9582	824	522
Net Merohantable	m3	55237	54859	44633	408	9108	710	378
Net Meroh - All	m3/ha	510	506	412	4	84	7	3
Distribution	%	100	99	81	1	16	1	1
Deoay	%	1	1	1	2	2	0	
Waste	%	1	1	1		1	12	22
Waste(billing)	%	1	1	1		1	13	31
Breakage	%	2	2	2	2	2	2	5
Total Cull (DWB)	%	4	4	4	4	5	14	27
Stems/Ha (Live & DP)		695.1	679.0	454.2	22.5	191.8	10.5	16.1
Avg DBH (Live & DP)	om	31.7	32.0	34.9	20.4	24.7	34.4	21.6
Snags/Ha		6.7	6.7		6.7			
Avg Snag DBH	om	12.8	12.8		12.8			
Gross Meroh Vol/Tree	m3	0.76	0.78	0.94	0.17	0.46	0.73	0.30
Net Meroh Vol/Tree	m3	0.73	0.75	0.91	0.17	0.44	0.63	0.22
Avg Weight Total Ht	m	29.8	29.9	31.0	15.1	26.1	22.1	22.1
Avg Weight Meroh Ht	m	24.7	24.8	26.0	9.9	20.2	17.6	16.1
Avg 13.0 m Log Net	m3	0.42	0.42	0.46	0.17	0.32	0.44	0.16
Avg 13.0 m Log Gross	m3	0.43	0.43	0.47	0.17	0.33	0.50	0.21
Avg # of 13.0 m Logs/Tree		1.80	1.80	2.02	1.00	1.42	1.44	1.46
Net Immature	%	99.3	100.0	100.0	100.0	100.0	100.0	
Net 2nd Growth	%		100.0					
Average Slope	%	30						
Cruiser Call Variable Length Grades %								
#3 Peeler	C	4	4	5				
#2 Sawlog	H	2	2	2		1		
#3 Sawlog	I	1	1	1		2		
#4 Sawlog	J	82	82	84		79	74	
#5 Utility	U	10	10	8	77	17	14	90
#7 Chipper	Y	1	1		23	1	12	10
Statistical Summary								
Coeff. of Variation	%	46.8	46.9	61.8	433.2	165.3	668.4	703.2
Two Standard Error	%	9.5	9.5	12.6	88.0	33.6	135.8	142.9
Number and Type of Plots		MP = 95						
Number of Potential Trees		463						
Plots/Ha		0.9						
Cruised Trees/Plot		4.9						

*** 1 tree(s) ohanged to tree olass 6:beoause only log was less then 3.00 m ***
FLAGS: Full Volumes, Normal Cruise, All Trees Compiled, Measure Plots Only, Damage,