ECONOMIC WOOD AVAILABILITY AND PROFITABILITY OF SMALL-SCALE FORESTS IN WANGANUI DISTRICT

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Abstract

New Zealand wood availability forecasts indicate that increases in the future wood availability significantly relies on small-scale forest owners' resources. This 'small-scale' resource is poorly understood and comprises a large number of owners. It is questionable how many of these forests are established with consideration of the cost and practicality of harvesting. An improved understanding of the likelihood of this resource ever being harvested is important for understanding future wood supply.

The main objective of this study is to answer a fundamental question on how much small scale forest area is economic to harvest. The study aims to estimate the basic stumpage value of the forests at modelled costs and different log price levels, and to analyse the profitability of the small scale forests by looking at the historic rate of return, as well as the net present value (NPV) and internal rate of return on existing and future forest land. The emission trading scheme (ETS) was also taken into account during the analyses and the effects of the ETS on the profitability, optimum age and future wood availability were investigated.

The methodology developed for this study uses a forest growth model (Radiata Pine Calculator), Geographic Information Systems, the Visser harvest cost model, and Microsoft Excel. The growth model enables the analysis to be customised to a specific region of interest, while spatial characteristics such as slope and transportation distance of individual forests were taken into account by using GIS. The cost model allows the analysis to be customised to individual forests to some extent although a number of assumptions are made generalising the forests as whole. Developing the overall framework within Excel allows easy analysis of the results and changes to the underlying assumptions.

Harvesting and transportation costs are the main drivers in determining the profitability of small scale forests. A significant increase in log prices is required for the existing forests to obtain substantial profit from log production. At current log prices 90% of small-scale forests in the Wanganui District are economically available. The other 10% small blocks on steep sites, have negative stumpage revenues because of high harvesting costs.

Additional cashflows from entering the ETS have the potential to generate significant revenue for post-89 forests. However the substantial increases in optimal rotation age are likely to delay the increase in harvest volumes forecast from the small-scale estate.

CHAPTER 1 : INTRODUCTION

1.1. Wood availability

1.1.1. Wood Supply Forecasting Systems

The New Zealand Ministry of Agriculture and Forestry (MAF) prepares and publishes regional and national wood availability forecasts. The most recent forecasts were undertaken in 2006 to 2009 and are summarised in MAF (2010). The forecasts are based on plantation forest area data from the National Exotic Forest Description (NEFD) with yield tables generated for each wood supply region using data from large-scale (over 1000 ha) forest owners . The forecasts show the range of harvest volumes potentially available from the planted forest estate of both large and small scale forest growers according to five modelled scenarios as well as description of each region's forests, wood processing plants, infrastructure and identified opportunities and constraints.

The national wood availability forecasts display two clear phases to the increase in national radiata pine wood availability that are between 2009 and 2012, and 2015 and 2025 (Figure 1.1.1). In the first phase of the increase, the current available harvest level of 18 million m^3/year (year ended March 2009) will increase to around 24 million m^3/year. This increase mostly comes from the increasing harvest intentions of large scale owners. However, most of the second phase of the increase (up to 35 million m^3/year) comes from small scale forest growers who established forests during the 1990s. The report notes that the translation from the wood availability into harvesting levels and the timing of the harvest depend on market conditions and the owners' decisions.

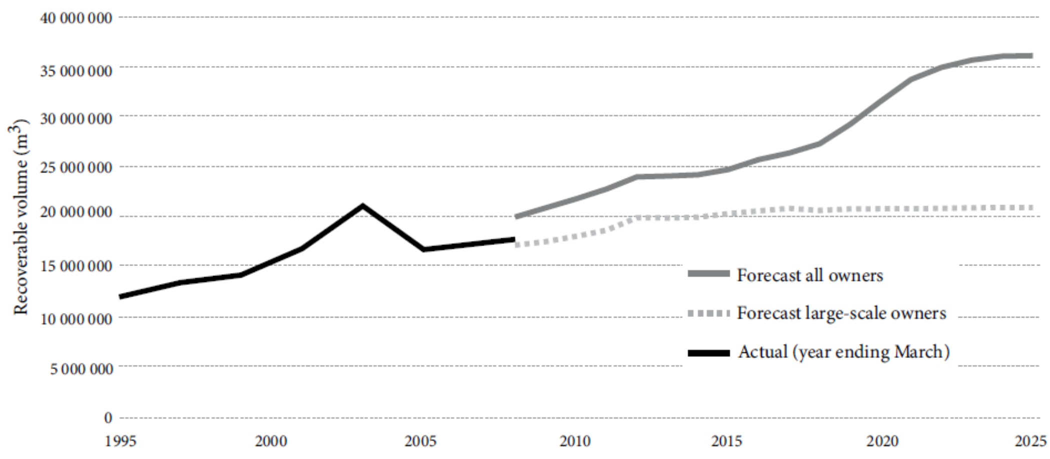

Figure 1.1.1. Historic harvest and Forecast Wood Availability of Radiata pine forest in New Zealand Source: Fig. 1.2 of MAF (2010)

The study area for this project, Wanganui District (237 339 ha), is one of 13 territorial authorities within the western Southern North Island (SNI) wood supply region (Figure 1.1.2). The Wanganui district contains over 30 000 ha of plantation forests, contributing 17% of 168 470 ha of plantation forests within SNI region according to the NEFD (MAF, 2009). The SNI region is notable for a large number of small scale owners. Although the 168 470 ha exotic forest area contributes only 9.4 % of the national total, the region has 21.7% of the nation’s forest owners, 85% of whom own less than 40 ha of forest (MAF 2009).

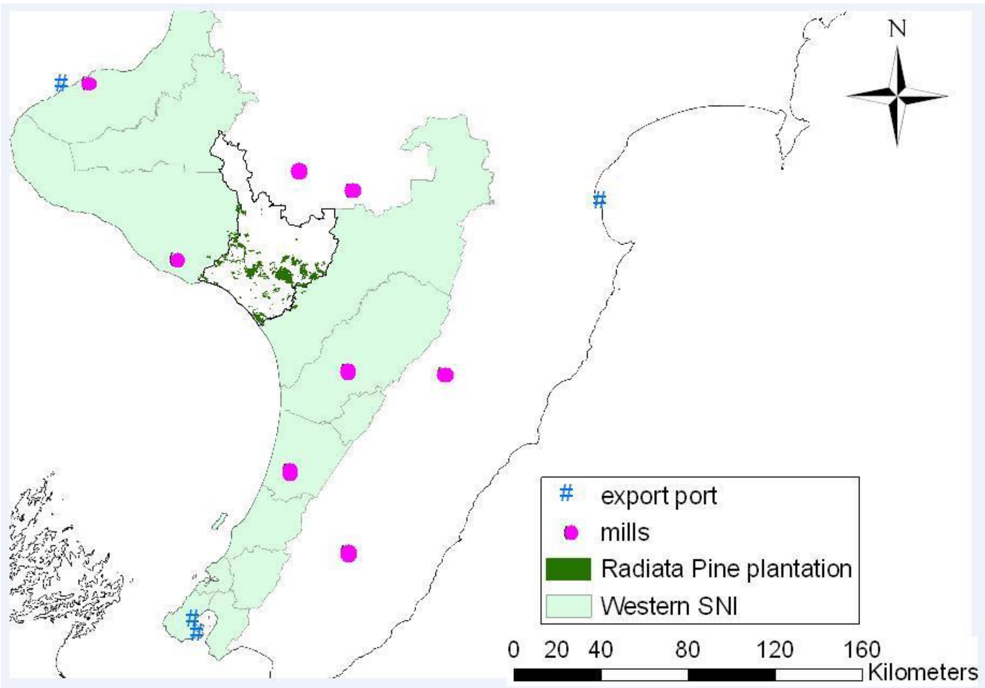

Figure 1.1.2 Wanganui District Study area: location of the forest, mills and ports outside the district

Scenarios 1 and 2 in the wood availability forecasts assume harvest age of 30 for all small scale forests (Figure 1.1.3). These two scenarios show the potential availability of mature forest in any given year and directly reflect the area of forest in each age class in the western SNI region. It is unlikely that the future harvesting would occur like this as these two scenarios show the potential magnitude of harvesting under favourable market conditions only.

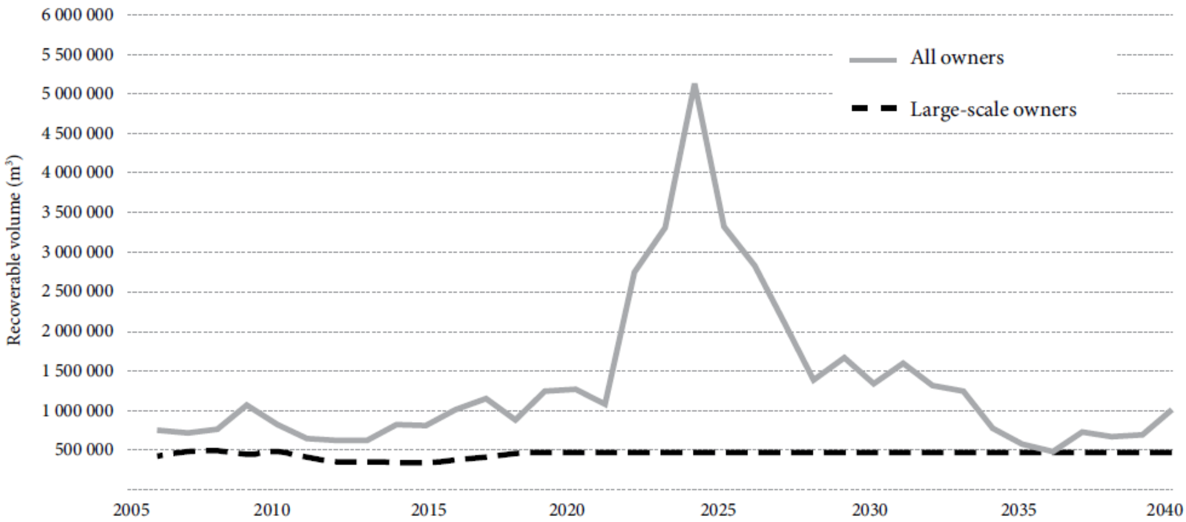

Figure 1.1.3 The Wood Availability for the western SNI region radiata pine Scenario 2: Large-scale owners Harvest at stated intentions, Small-scale owners Harvest at age 30

Source Fig 4.7 of MAF (2009)

Scenarios 3, 4, and 5 are based on yield regulation under which future harvesting is generally constrained to be non-declining. By this yield regulation, the logistical and market constraints are taken into account of harvesting volume forecasts. Scenario 4 results show that there will be a gradual increase in the regional wood availability between 2008 and 2013 despite a drop-off in the large-scale forest owners' harvest intentions. It also forecasts a dramatic increase in the wood availability from 2015 to 2020 due to the small scale forest resources established during the 1990s (Figure 1.1.4).

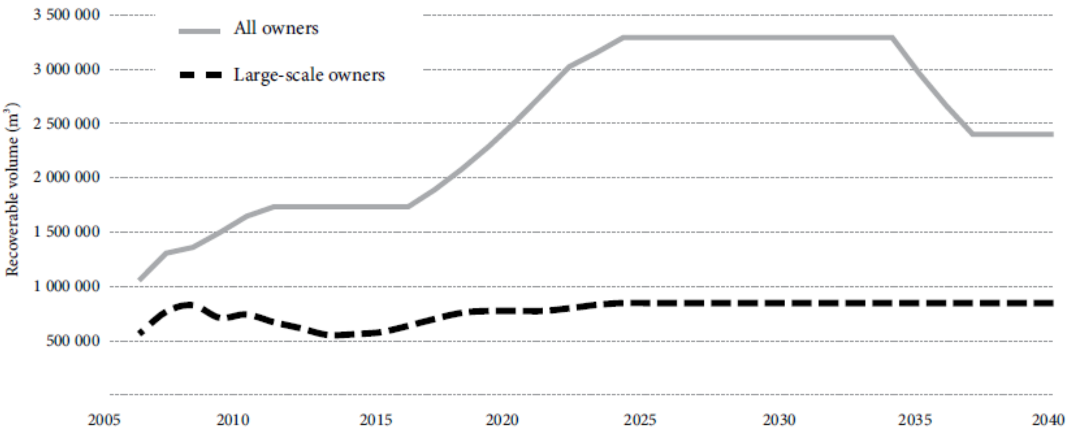

Figure 1.1.4. The Wood Availability for the western SNI region radiata pine Scenario 4: a split non-declining yield, with a target rotation age of 30 years. Source: Fig. 4.10 of MAF (2009).

While the forecasts indicate an increasing supply in the western SNI region, the report also notes that the actual wood supply from harvest volume at any given point in time will be determined largely by market conditions and other limiting factors such as wood processing capacity, harvesting and transport costs.

This limitation, however, seems to be present commonly in a global context. Similar to New Zealand, Australia's wood supply forecast is based on area of plantation and yield tables. Market factors are not taken into account (BRS, 2007; Ferguson et al., 2003). Ireland's forecast report of the roundwood production also recognizes the gap between the forecasted potential wood supply and actual supply from private sector due to lack of economic analysis in their study (Gallagher & O'Carroll, 2001). Wood supply prediction in Ontario, Canada, also identifies the need of incorporating economic analysis in forest planning so that the predicted wood supply would be differentiated based on cost (Sobze et al., 2006).

On the other hand, the HUGIN system in Sweden incorporates calculations of costs and revenue for timber production in forecasting the long term timber yields (Lind & Soderberg, 1994). The HUGIN system is designed for various analyses at regional and national level under different scenarios of silviculture and cutting levels. The system can be used to obtain growth and yield prediction through various calculations such as biomass, timber quality, costs and revenues, and effects of nature conservation (Lundstrom & Soderberg, 1996).

In addition to this, other decision-support systems have been developed in Sweden, such as the Forest Management Planning Package (FMPP) and the Forest Time Machine. These systems include projection models and make integrated analyses of forestry including economic calculations (Andersson et al.2005; Jonsson et al.1993).

1.1.2. Small Scale Forests

Small scale forests, often referred to non industrial private forest (NIPF) in other countries, contribute largely to the forestry sector in both the domestic and global context. Some 88% of planted forests are privately owned in New Zealand while 38% of the total plantation forest area belongs to private forest owners with under 10,000 ha (FOA, 2010). However, there is little information and research on the small scale forest owners in New Zealand.

NIPF accounts for about 59% of the total timberlands in the USA and contributes nearly 50% of US timber production. In the USA prior to 1980s, research on the NIPF focused on determinant factors for harvesting and reforestation decisions. In the last decade, researchers have studied a broader set of issues, shifting from the assumption of the maximum profit as landowners' objective to the landowners' non-market activities and interests (Amacher et al.2003; Binkley, 1981; Zhai & Harrison, 2000).

In European countries such as Finland, Sweden and Norway, 60-70% of forest land is privately owned, often with multiple goals compared to industrial plantations (Amacher, et al., 2003; Harrison et al. 2002). There are recent surveys available on small scale private forest owners' behaviour and objectives along with a development plan of methodology for forecast and modelling of the private forests (Andersson, et al., 2005; Ingemarson et al. 2006; Mac Siúrtáin et al. 2008).

1.1.3. Wood availability from the small-scale estate

New Zealand wood availability forecasts indicate that later this decade and heading into the 2020s wood availability from 'small-scale' owners could increase from 3 to 4 million m^3/year to 15 million m^3/year. This 'small-scale' resource is poorly understood and comprises a large number of owners, some of whom may have established forests without much consideration of the cost and practicality of harvesting.

An improved understanding of the likelihood of this resource ever being harvested is important for understanding future wood supply. A fundamental question to answer is how much forest area is not economic to harvest based on future log price scenarios and costs? Some of the key factors that will affect harvest profitability are:

- Log prices
- Forest yield – log quality and quantity
- Harvesting and transport costs – topography, roading costs, presence of existing roads, proximity to public roads
- Depth of local log market and the match between forest log quality and type of processing plants
- Distance to processing plants, export port
- Forest owner behaviour
- Carbon prices

1.2. Carbon Policy

1.2.1 International Policy Background

Since the first World Climate Conference held in Geneva in 1979, there have been many debates and contradictions about the anthropogenic influence on the global climate change. Nowadays the general consensus is that there is an enhanced greenhouse effect caused by the human-induced greenhouse gas emissions.

The United Nations Framework Convention on Climate Change ("UNFCCC") was passed at the World Climate Conference in 1992 and it came into force in 1994. Later in 1998, the Kyoto Protocol was signed by European Union (EU) and 37 industrialised countries (Annex I countries) including New Zealand in agreement to reduce the overall Annex I parties' GHG[1] emissions by at least 5 % below the 1990 levels, though there is considerable variation in the emission targets of different countries.

This international framework has resulted in the development of economic instruments that enable emission reduction at lower cost than traditional "command and control" environmental regulation. These market-based mechanisms can operate by placing a price on emissions

[1] Greenhouse gases listed in Annex A in the Kyoto Protocol: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Surphur hexafluoride (SF_6)

through a carbon tax or emission trading. With a carbon tax, the carbon price is determined by government and the market decides the quantity of emission reduction while with emission trading the carbon price is determined by the market.

The emission trading mechanism has been more widely adopted among the Annex I countries. Emissions trading sets a limit on the quantity of the emissions over a set period of time- “emissions cap”. Trading scheme participant firms or sectors are then permitted to buy and sell emission allowances in order to meet their emissions cap. The emission allowances (carbon dioxide equivalent (CO_2-e)) act like commodities in the carbon market where the price of CO_2-e (often referred to as the carbon price) is determined by the market demand relative to its supply.

Emissions trading schemes are in operation and being proposed around the world. The most well known example is found in European Union (EU ETS). The cap and trade scheme is the world’s first and largest mandatory trading scheme for CO_2 emissions. The EU ETS operates in 30 countries and is aimed at reducing total emissions so that the emissions in 2020 will be 21 % lower than in 2005.The EU ETS covers emissions from major installations in selected sectors, including energy, ferrous metals, mineral industry and pulp and paper. Recently, inclusion of the airline industry has been proposed and selected to be under EU ETS as well, but it will not take place until 2012 (MFE, 2011). Japan has a voluntary ETS (J-VETS) of which the first phase was launched in 2005, covering CO_2 combustion from participating companies. A mandatory cap and trade ETS scheme has launched in Tokyo on April 2010, targeting office and commercial buildings and factories while from April 2011 Saitama Prefecture will implement a mandatory ETS.

In the case of the United States, the climate change policies have been developed mainly at state and regional levels. Under the Global Warming Solutions Act of 200 Assembly Bill (AB 32), California State is required to reduce the GHG emissions to 1990 levels by 2020. A cap and trade scheme is to start in 2012 with an additional regulation that aims for 33 percent of electricity to be sourced from renewable energy by 2020. California is also the leading member of the Western Climate Initiative (WCI) participants of which are six Midwestern states and one Canadian province. WCI aims to reduce regional GHG emissions to 15 percent below 2004 levels by 2020.

The Regional Greenhouse Gas Initiative (RGGI) is another policy formed by 10 north-eastern and mid-Atlantic states. It is a mandatory cap and trade program that concerns only CO_2 reduction. It aims to reduce CO2 emissions from the power sector by 10 percent by 2018 however it is being criticized for over-allocating the emission cap (Capoor & Ambrosi, 2009; Linacre et al., 2011).

1.2.2. Domestic Policy and Market- NZETS

New Zealand ratified the Kyoto Protocol in 2002 committing it to reduce net greenhouse gas (GHG) emissions to the 1990 gross levels over the first commitment period (CP1) 2008- 2012. The emissions trading scheme (ETS) that passed into law in late 2008 under the Labour Government is an attempt to incentivise individual entities to help meet New Zealand's Kyoto Protocol obligations at minimum cost. Under the new National Government, the Climate Change Response (Moderated Emissions Trading) Amendment bill became enacted in 2009 which established an ETS that will cover all sectors and all gases by 2015 in such ways that moderates the impacts of ETS on domestic economies.[2]

Under the ETS, New Zealand businesses and individuals in included sectors (Table 1.2.1) are obliged to surrender eligible emission units to the Government according to their GHG emissions with a temporary arrangement during the transition phase from July 2010 to December 2012. The primary emission units are the New Zealand Units (NZU), which are issued by the Government. Some international emission units i.e. RMUs, ERUs, and CERs, can also be surrendered through the links with international carbon markets.

Forestry land is categorised into two types: pre-1990 forest land, and post-1989 forest land. The owners of forest planted before 1990 cannot earn NZUs but have to pay a liability (purchase units) for deforestation. However this will be partially compensated a free allocation by the Government of up to 60 units per hectare which can be also sold domestically or internationally. Owners of forest first planted after 1989 are eligible to enter the ETS to earn units for the carbon sequestered by the forest. However, they still have to pay the liability at the time of harvesting/deforestation or at any other time when carbon stocks decrease.

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[2] MFE. (2011). Climate change information New Zealand Retrieved June, 2011, from http://www.climatechange.govt.nz/emissions-trading-scheme/about/international-examples.html

Table 1.2.1 Emissions Trading Scheme Review by sectors[3]

<table>
<tr><th>Sector</th><th>Entry date</th><th>Transitional obligation until December 2012 (CP1)</th><th>Unit allocation terms</th></tr>
<tr><td>pre-1990 forest</td><td rowspan="2">1 January 2008</td><td rowspan="2">Fixed surrender price $NZ25/tonne</td><td>Allocation of 60 free units per hectare to pre-1990 forests (which may be sold internationally), otherwise units to be purchased for deforestation</td></tr>
<tr><td>post-1989 forest</td><td>Afforestation (carbon removal) earns units, otherwise units to be purchased for deforestation</td></tr>
<tr><td>Transport (Liquid fossil fuels)</td><td rowspan="4">1 July 2010</td><td rowspan="4">One emission unit for two tonnes emissions (50%) and fixed surrender price $NZ25/tonne</td><td rowspan="3">Units to be purchased</td></tr>
<tr><td>Stationary energy</td></tr>
<tr><td>Emission-intensive industrial processes that are not trade-exposed</td></tr>
<tr><td>Trade-exposed emission-intensive industrial processes</td><td>Free allocation on intensity/production basis phasing out from 2013 at 1.3% each year.</td></tr>
<tr><td>Non-organic Waste</td><td rowspan="2">1 July 2013</td><td rowspan="3">No obligation in CP1 except reporting from 1 January 2012.</td><td></td></tr>
<tr><td>Synthetic GHG manufacture/importation</td><td>Those exporting or destroying synthetic gases will earn units from 2013 (for removing carbon that would have otherwise occurred in NZ)</td></tr>
<tr><td>Agriculture</td><td>1 January 2015</td><td>Free allocation on intensity/production basis phasing out from 2016 at 1.3% each year.</td></tr>
<tr><td>Fishing</td><td></td><td></td><td>Free allocation</td></tr>
</table>

The linking of the New Zealand carbon market to the EU ETS through CERs makes New Zealand a price taker in the market; i.e. the price of NZUs is influenced by CER prices in Europe. Recently, the spot prices for NZUs have been sitting below NZ$20 due to downward pressure from economic conditions of Europe[4].

An improved understanding of the likelihood and timing of harvest of the small-scale owners' resource is important for understanding not only future wood supply but also future changes in planted forest carbon stocks. Forecasts of changes in carbon stocks are sensitive to the timing of

3 Source : http://www.climatechange.govt.nz/emissions-trading-scheme visited in June 2011

4 http://www.pointcarbon.com/polopoly_fs/1.1557515!CMANZ20110708.pdf

forecast harvesting of the post-1989 forests because the bulk of this resource was planted over a narrow range of years. For example, Manley and Maclaren (2009) show that New Zealand faces liabilities if the estate planted in the 1990s is harvested over a short-period of time. The ETS has the potential to have a major impact on forestry in New Zealand. For example, Maclaren et al. (2008) showed that the ETS could increase the profitability of forestry but that increasing carbon price would result in longer rotations.

1.3. Thesis Objectives

The main objectives of this study are:

1) To estimate the proportion of the small-scale owners' estate in Wanganui district that is economic to harvest at different log price levels.

2) To analyse the historical rate of return and optimum rotation age of existing forests.

3) To analyse the internal rate of return for new planting.

4) To analyse the effect of the ETS on the profitability, optimum rotation age and future wood availability.

1.4. Thesis Outline

To enable this analysis, 58 forests were selected as samples and the delivered cost for each forest was estimated to show what proportion of the forests is economically available to harvest. The study was based on the Wanganui district. The study looked at the profiles of the forests in the region. A harvesting cost model and financial analyses were then used on the sample forests to determine the proportion that is economic to harvest. The historical rate of return of the existing forests and the internal rate of return of new planting were then estimated. The impact of the ETS on internal rate of return and timing of harvest was also analysed.

The thesis is presented as follows:

- Chapter 2 provides a literature review of issues surrounding the estimation of small scale forests wood supply, delivered cost, and carbon forestry.
- Chapter 3 describes the methodology developed to estimate delivered costs, the proportion of forests economically available, and the effect of ETS.
- Chapter 4 presents the results and
- Chapter 5 summarises the main conclusions, implications for the future wood availability of the small scale forests in the area and generally in New Zealand and also presents key areas for further research.

CHAPTER 2 : LITERATURE REVIEW

2.1. Wood supply

New Zealand Wood Availability Forecasts use the latest NEFD data along with surveys on large scale owners for harvest intention and yield tables. Five scenarios are modelled for the analyses showing a range of potential ways the forests in each region could be harvested in the future. The first two scenarios unrealistically assume all the small scale forests to be harvested at age 30 years, simply showing the potential magnitude of mature forest in any given year while ignoring the variability of market conditions. The other three scenarios are based on yield regulation, assuming future harvesting to be non-declining in general. Although these partially take into account logistical and market constraints, log prices and other determinant market factors for harvesting are ignored in the analyses (MAF, 2010). Consequently, there may be a gap between the forecast and the actual future wood supply.

The timber supply curve in a given region and time period refer to harvest volumes that owners would sell at different stumpage prices. The regional stumpage supply curve is derived from individual forest owners who have different reservation prices below which they won't sell stumpage. Therefore, the most accurate estimation of actual timber supply should be derived from three levels of analysis on (a) potential availability of the forest resources; (b) profitability of the timber production on the forest; (c) the forest owners' behaviours and objectives (intention to harvest).

While small-scale forests are considered to be a significant source of timber in the future, their contribution to the future wood supply remains questionable. In United States, many small-scale forestlands tend to be on poorer sites and further from market, producing lower harvest volume per hectare (Klemperer, 2003, p. p.390). Also, they are not as intensely managed as large scale forests due to number of physical, social, and economic reasons (Adams et al., 1992; Kurtz et al., 1993; Alig and Adams, 1995; Arano & Munn, 2006).

In general, there are two types of studies on small scale forests as timber suppliers: (1) Assessment of available quantity and quality i.e. inventory (Grogan et al., 2001; Phillips et al., 2009), and (2) Predicting forest harvesting decisions based on the owner's objectives and behaviour, using a logit approach (Pukkala et al., 2003, Vokoun et al., 2006, Favada et al., 2007, Dhakal et al., 2008, Putten & Jennings, 2010).

Both Grogan et al. (2001) and Phillips et al. (2009) present research projects on small forest assessment. Grogan et al. (2001) aims to quantify the average NIPF parcel of east Texas through field inventory on and to monitor the availability and condition of the forest resources in the long term.

In Ireland, a forecasting project team was formed to develop a national GIS based model on geospatial forecasts of roundwood production from private sector forests 2009-2028. Site, management and productivity attributes were added to the available spatial dataset which contained age and species information of the private forests so that the forecast generated is geographically referenced (Phillip et al., 2009). However the accessibility of the forests (i.e. road network), economic and market factors were not included in this forecast.

The rationale behind the gap between wood availability and wood supply of small scale forests varies case by case across the world. Although dominated by small-scale forestland owners and enterprises, Japanese forestry heavily relies on imported wood (80%). This is due to low timber price and high cost of production caused by fragmented ownership, steep terrain, rapid weed growth, and high labour cost (Ota, 2001).

At the other end of spectrum, 85% of the total forest area in Europe is considered extractable without any legal, technical or economic restrictions on wood production. In Finland 62% of the total forest area is owned by family forest owners and contributes the majority of domestic wood supply. As these forests are often family commodities, the wood supply in Finland highly depends on the owners' objectives (Pukkala 2003).

Pukkala et al. (2003) demonstrated a new prediction method of the future timber supply in a 4900 ha of private forest area in Finland. The study used a utility maximising approach so that the management plan of each forest would be based on distribution of the importance of forest management goals - economic security, timber sales, recreation, and nature values. The results of this study were rather straight-forward: as the owners put more importance on non-monetary values, the future timber supply would be lower. Profitability of the forests does not appear as a major concern. This could be due to the fact that the small-scale forests' management activities are subsidised by the state and the industrial demand is continuous.[5]

The management decisions on small-scale forests depend on different factors such as market drivers, policy variables, owner characteristics and plot/resource conditions (Beach et al., 2005; Dhakal et al., 2008). Beach et al. (2005) reviewed a number of empirical economic studies which had examined the relationship between small-scale forest harvesting and the driving factors (market drivers, policy variables, owner characteristics and plot/resource conditions). Through this systematic review they found that the market drivers are the least likely of the four factors to significantly influence the forest harvesting decisions for individual forests. However, the studies were predominantly based on data from the Southern US, and they did not provide information on the magnitude of the effect.

Dhakal et al. (2008), on the other hand, found the landowner's expectation of increasing log prices was one of the important determinant factors in the landowners' planting decisions in a study based on 4 regions in South Island, New Zealand. In New Zealand, a large amount of wood supply comes from industrial large-scale owners regardless of the growing amount of small-scale forest resources. The small-scale forests are often referred to as "farm forests" as they occupy land on farms. The investment in forestry is often considered as a supplement to the investor's income rather than as primary income source (Bawden 2000). These forests are often on marginal land areas that are less productive than other agricultural lands such as dairy and crop farming.

2.2. Wood Supply Function

Cost at harvest varies across a region, depending on the forest condition (e.g. age and volume) and site characteristics (e.g. slope and location). The variable delivered cost at harvest (i.e. the cost of harvesting and transportation to the mill) can be used as an indication of the supply function.

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[5] Finnish Forest Association (n.d.) Retrieved July, 2011, from http://www.forest.fi/smyforest/foresteng.nsf/allbyid/2D2F0A3436947427C2256F25003E59EF?Opendocument

Delivered cost model is often used in studies on biofuel forest resources. There are a number of studies that have assessed available biofuel forest resources in a given region and the cost of delivering forest biofuel resources to a bioenergy plant (i.e. delivered cost). (Nord-Larsen & Talbot, 2004, Robertson & Manley, 2006, Moller & Nielsen, 2007, Rorstad et al. 2010).
GIS is often used in these studies as a crucial tool to evaluate biomass supply and estimate the transport costs (Robertson & Manley, 2006, Moller & Nielsen, 2004, Rorstad et al. 2010). The determinants of transport costs such as site characteristics and distance between forests and plants are obtained through GIS.

Robertston & Manley (2006) and Moller & Nielsen (2004) considered other cost factors such as chipping and processing independently from location. Robertson & Manley (2006) estimated biomass fuel availability from forest (chiplogs, landing residues and cutover residues), and sawmills (sawdust, bark, and chips) in the Canterbury region by incorporating yield table development., survey, and existing inventory data. For delivery cost, they obtained information on: collection, chipping, and screening costs for forest biomass streams, and opportunity costs for the chiplogs and sawmill streams. Transport costs were estimated using GIS network analysis.

Rorstad et al. (2010) estimated the supply of harvest residues of 500 NIPF by combining GIS and forest modelling with environmental and economic constraints. The GIS-based information was used to calculate total hauling costs which vary substantially between stands. Unlike the other studies that assumed costs except for transportation are more or less constant (Nord-Larsen & Talbot, 2004, Robertson & Manley, 2006), Rorstad et al. (2010) took account of stand characteristics such as terrain, capturing the variability of "in-forest" costs which determine the level and shape of the supply function. Basis supply functions were plotted as accumulated biomass of the harvest residues against the calculated harvest costs. It was noted that these functions give the amount of harvest residues that is profitable to "harvest" given the road side price of harvest residues, assuming profit maximising objectives.

2.3. Profitability and the effect of the ETS

For forest investment analysis, the discount cashflow (DCF) approach is often used, with net present value (NPV) and internal rate of return (IRR) used as indicators of the financial returns from forestry. Manley (2010) surveyed 14 forest valuers on their method of market valuation, the input variables (discount rate, log price, cost) and other related information. The estimated IRRs ranged from 1% to 7% (for pre-tax cashflows), which was typically less than the discount rate used, which ranged from 7.1 to 10.7%. Evison (2008b) calculated IRRs of commercial forestry land-use and of agricultural land uses. The IRR of forestry was calculated to be 2.71% for a typical pruned log regime. This study indicated that commercial forestry gives an intermediate return which sits between other landuses offering high returns, such as dairy and arable cropping, and those offering low returns, including sheep and beef farming. Neilson (2010) estimated the pre-tax IRR of a pruned sawlog regime to be 4.4% in 2009. The study also found that there has been a decreasing trend in IRR for radiata pine plantation forest- from 11.60% in 1992.

Maclaren et al. (2008) found that without carbon cashflow, forestry struggles to pay realistic land prices on good sites, while it could not be justified on poor sites unless extremely low discount rates are used. Land Expectation Value (LEV) was employed as an index of profitability and forestry projects with different regimes and species were analysed and compared. The study found that with a land price of $3000/ha an 8% rate of return could be achieved for radiata pine clearwood, framing, plant-and-leave regimes at carbon prices (per tonne CO_2) of $13.08, $11.70, and $9.55 respectively. The optimum rotation age was greater at a poor site and at a higher carbon price. Under a clearwood regime, carbon trading (with a carbon price of $30/t CO_2) increases the LEV by $5424/ha compared to traditional forestry which gives an LEV of $1223/ha at age 24 (Manley & Maclaren in press).

More recently, West *et al*. 2011 presented research results and knowledge to assist Environment Waikato with the advance of a regional carbon strategy. This report summarised results of previous studies, and reported that carbon forestry substantially improves the profitability of forestry with expected positive cash returns over $500/ha/year (after negative cashflows in the first 5 to 7 years). The report compared this with other agricultural land uses and concluded that the competiveness of carbon forestry is dependent on the agricultural revenues foregone and the objectives of the land owner. However it is strongly noted that carbon forestry offers a significant improvement in financial returns for marginal land such as eroding or reverting hill country.

Regardless of many analyses finding an increase in profitability through carbon cashflows, many forest owners are still reluctant in entering the ETS due to potential risks - such as uncertainties of future carbon prices and policies, and liability through an unexpected event that will require early surrender of units (e.g. wind, fire, pest and disease).

Evison (2008a) used a simple discounted cashflow analysis (single hectare, single rotation) to investigate the effect of ETS on profitability of radiata pine forestry and the implication of a change in carbon price during the investment cycle. The analysis generated a positive NPV of $6422/ha under a series of assumptions; a fixed rotation age of 30 years, 7% discount rate and under a modelled carbon sequestration profile under a direct sawlog regime (using the Radiata Pine Calculator).

CHAPTER 3 METHODOLOGY

There are five parts to the analysis:

- Estimation of potential small-scale forest resources
- Estimating the delivered wood cost of small-scale forest wood resources
- Profitability of harvesting small-scale forests
- Valuation of the existing small-scale forests
- The profitability of new land planting

3.1. Estimation of potential small-scale forest resources

This section presents the approach used to estimate the potential resource from the small-scale forests. The forest area was estimated, and categorised by owner type, stand age, size class, and ETS eligibility.

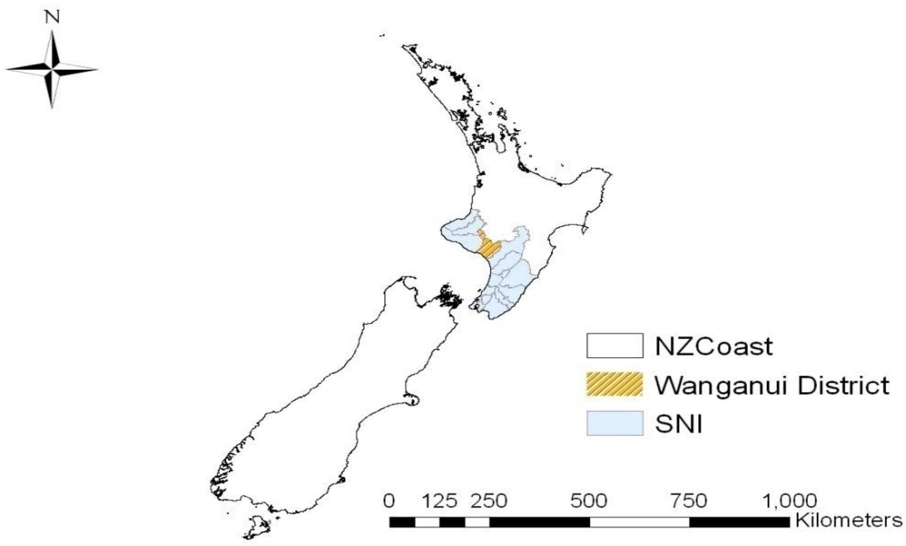

Figure 3.1.1 Map of New Zealand and the location of Southern North Island

3.1.1. Forest Area Estimation

ArcGIS shape files data were provided by a forestry consultant, Russell Flavell (Forestry Maps) on the exotic plantation forest blocks within Wanganui District. The data consisted of geographical information of the 1034 exotic forest stands (area and location) as well as other information on species, ownership, and planting years for some forests. This set of data was last updated in October 2009 and was originally produced for forestry roading plan development in the region for future harvesting.

For this study, small-scale forest data was extracted from the given set of data. The small-scale forests were defined to be radiata pine forest stands that are bigger than 1 ha in size and do not belong to the large-scale forest owners (those with 1000 hectares of forest or more). Therefore only 522 out of 1034 forests were selected for the study. Using the MAF large owners map (2008) and further assistance from Russell Flavell, forest blocks owned by the following large-scale forests were identified and removed from the data to give a separate GIS layer of the small-scale forests:

- Arbor Forestry Ltd
- Ernslaw One Ltd
- Forest Management Ltd
- Global Forest Partners LP
- Kaitoke Prison farm
- Matariki
- NZ Forestry Group
- Utaraya Finance Inc
- Wanganui District Council

In order to estimate the nature of the potential resource, the small-scale forest data was then sorted and mapped by planting year, stand size class, and ETS eligibility. Planting year and size class information was included in the given data. External data was used for ETS eligibility; Land Use Mapping (LUM) on 1998-2008 Manawatu-Wanganui regions from Land Use and Carbon Analysis System (LUCAS) was downloaded from the Ministry for the Environment to enable identification of carbon eligible post-1989 forests. As there were some concerns over the accuracy of the LUCAS data, the LUM was compared with the planting year map of the forest data received.

3.1.2 Small-scale Forests Sampling

A sample of 58 small-scale forest stands were randomly selected out of 522 small-scale forest stands by using probability proportional to size (pps) sampling method. PPS sampling technique is often used for surveys or mini-surveys in which the probability of selecting a sampling unit is proportional to the size of its population. It gives a probability sample that is both random and representative. This technique was considered to be the most appropriate sampling technique as the sampling units (small-scale forest estates) vary considerably in size. The technique assures that any single hectare in those forests of larger size has the same probability of getting into the sample as those of smaller blocks. The future harvest volume and the carbon stock of the sample forests were calculated for further cost and economic analyses. As age information is essential for the analyses, forest data without planting year were excluded from the population pool before sampling.

3.1.3. Harvest Volume Estimation

It was assumed that all sample forests are equally productive, sharing the same total recoverable volume per hectare. For the NEFD wood availability forecast (MAF), there are four different yield tables for Western SNI region's radiata pine forest, which are categorised by age –young (post-1989 planting) and old stand (pre-1990 planting), and silviculture regime- intensive (pruned) and minimal. These provide total recoverable volume and volume by pruned, unpruned, and pulplogs.

The NEFD shows that 81% of radiata pine forests in Wanganui region is pruned (MAF, 2009). For this project, it was assumed that all small forests are pruned (i.e. clearwood regime) as small forest owners are more likely to make maximum investment in their woodlots (Alan Bell pers. comm.). As this study required volume by log grades as well as the total recoverable volume (TRV), a yield table for rotation ages between 20 and 50 was generated by using the Radiata Pine Calculator. For simplicity, a single yield table was generated and used for all stands regardless of the planting year. By doing this, an assumption is made that all forests produce the same type, proportions, and volume of log grades at a given rotation age. The developed yield table used the western SNI yield table for younger stands with intensively pruned regime (RIY) as a benchmark, matching the generated TRV at age 30 to the value in RIY (521 m^3/ha).
For Calculator inputs, a 300-index value of 27.5 m^3/ha/year and a site index of 29.5 m were assumed. These were set by trial and error to produce TRV to match the benchmark TRV in the yield tables; i.e. 521 m^3/ha at age 30. An altitude of 169.5m was obtained through a surface analysis on GIS by averaging the average altitude values of each sample forest area. The average latitude of Wanganui city, 39.5°, was used. The silviculture regime inputs were entered:

- Plant 1000 stems/ha
- Prune to achieve 5m green crown
    - 1st prune to 2.4m (450 stems/ha)
    - 2nd prune to 4.6m (350 stems/ha)
    - 3rd prune to 6m (320 stems/ha)
- Waste thin at
    - Age 5 to 500 stems per hectare
    - Age 8 to 350 stems per hectare

The volumes by log grade from the Calculator were similar to those of aggregate grades used in the NEFD RIY yield table.

3.1.4. Carbon Stock Estimation

Under the ETS, there are two approaches to estimate the future carbon stocks of post-1989 forests; measurement and look-up table. The measurement approach is mandatory for forest owners with more than 100 hectares while the look up table approach is required for participants who own less than 100 ha. Because most blocks are less than 100ha, it was decided to use the look up tables for all blocks in this study. The look-up table reflects growth rates for typical forests in regionally averaged environments, under average forest thinning and pruning regimes. For this project, the H/SNI regional radiata pine look-up table was used (MAF 2009, as shown in Figure 3.1.2).

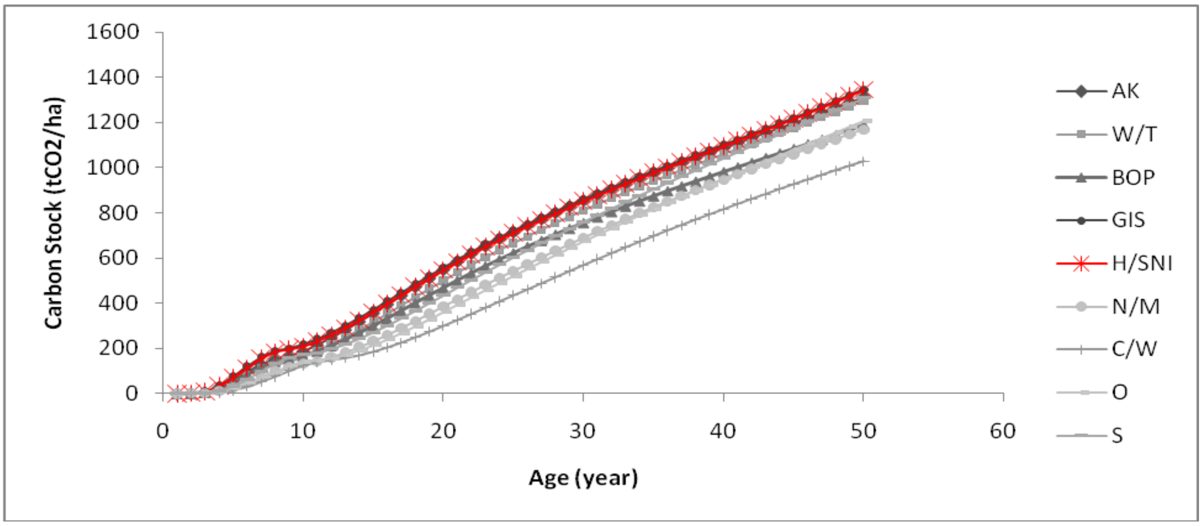

Figure .3.1.2. Carbon Stock per Hectare for Post-1989 radiata pine Forest Land by region Source: MAF (2009)

3.2. Estimating the delivered wood cost of small-scale forest wood resources

This section presents the modelling approaches used to estimate the delivery cost for each forest at harvest and the associated inputs for the cost model. The Visser Cost Model (VCM) was used to estimate the delivery cost for each sample forest stand at each rotation age from 20 to 50. The VCM provides indicative costs ($/tonne) for three main components that make up the total delivered cost; harvesting, infrastructure establishment (roading) and log transportation to market. Each cost component value is a product of a regression using some physical factors of the site as dependent variables. The VCM was considered appropriate for the project as it was readily available and the input variables were obtainable remotely through spatial data analyses.

Figure 3.2.1 provides an overview diagram and Figure 3.2.2 shows the screenshot of the VCM excel model. For this project, the confidential regression models were released and an additional spreadsheet was set up to calculate the total costs for the sample forests.

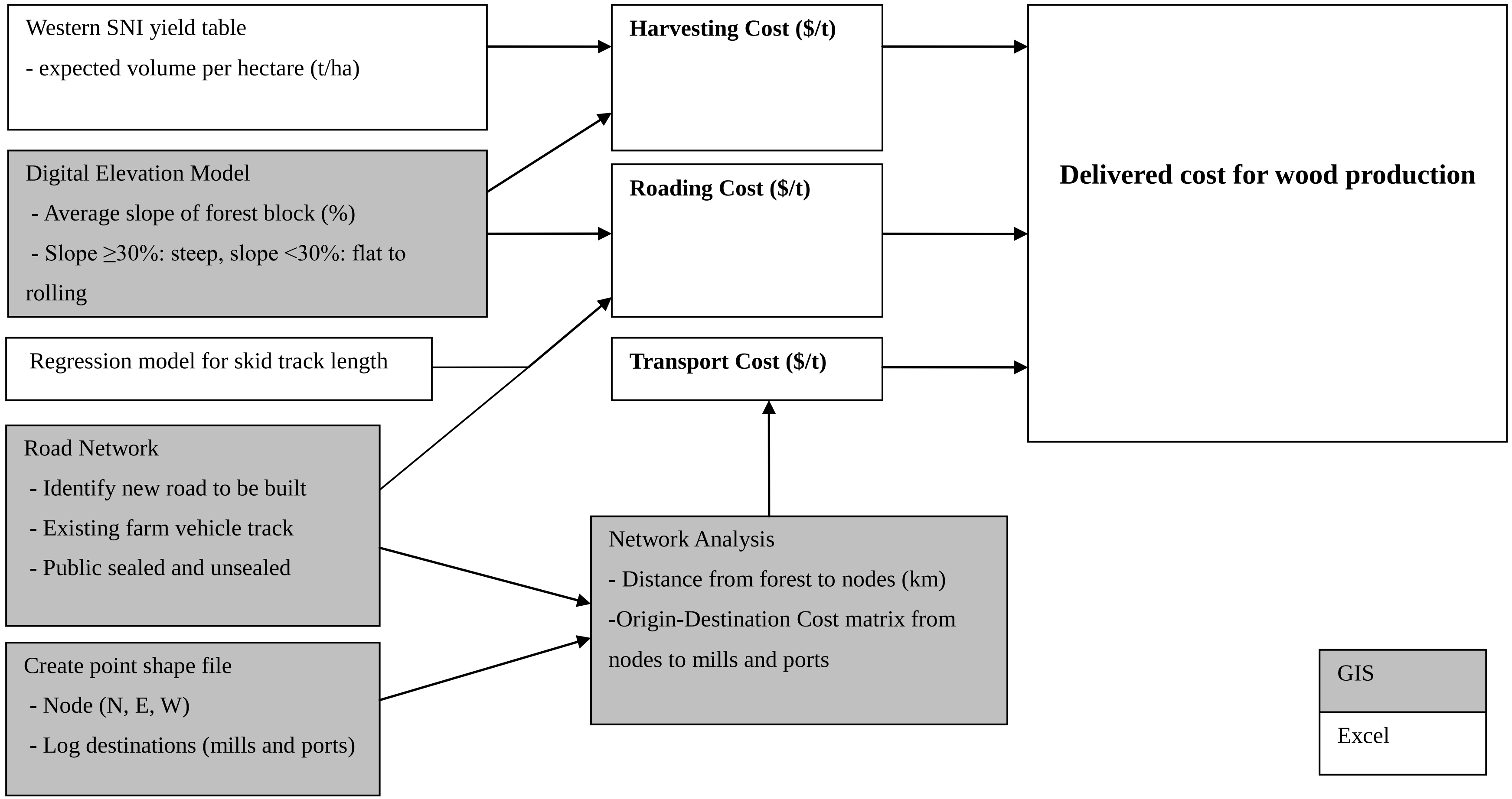

Figure 3.2.1 Overview of Visser Harvest Cost Model

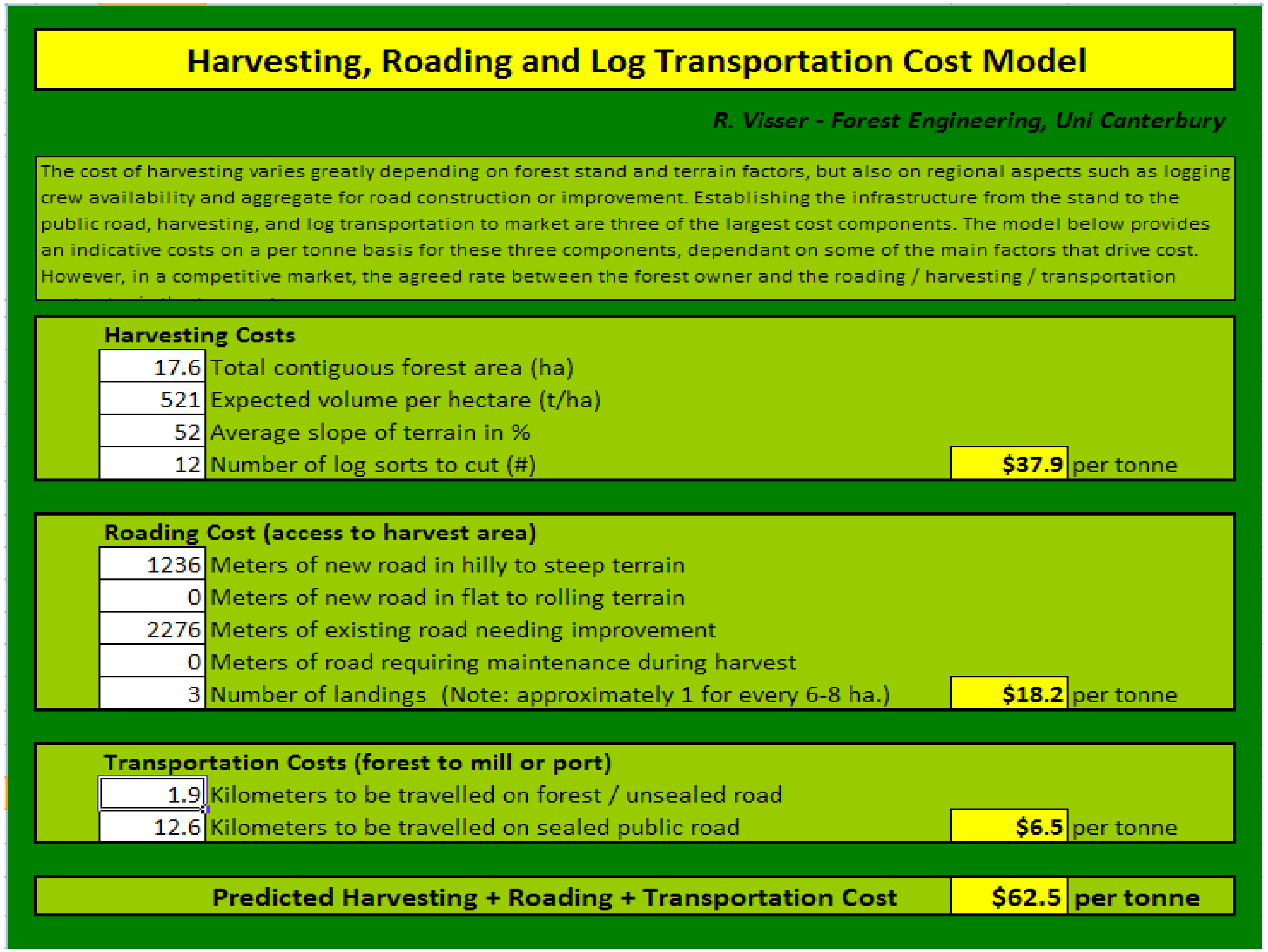

Figure 3.2.2. Outlook of the Visser Cost Model, the equations for the model were embedded for confidentiality

3.2.1. Estimation of Harvesting Costs

Forest location and attributes of terrain and proximity to infrastructure are crucial in harvesting operations. These factors are taken into account in the cost modelling. The input variables used in VCM for harvesting costs are:

- Total contiguous forest area (ha)
- Expected volume per hectare (t/ha)
- Average slope of terrain in %
- Number of log sorts to cut

Total contiguous forest area is also known as net stocked area (NSA). An unstocked percentage of 10% was assumed for all forest areas i.e. an adjustment factor of 0.9 was used to reduce the forest land area to NSA.

Expected volume, also known as total recoverable volume (TRV) at the time of harvest for each forest was obtained from the Calculator-generated yield table.

To obtain the average slope of terrain for each forest, a surface analysis on GIS was carried out. Firstly, an analysis for North Island digital elevation model (nidem) 25m raster was carried out to give slope values across the North Island. The Zonal Statistics tool was then used to give an average slope value for individual sample forest blocks. Nidem is a high resolution digital elevation model of NZ developed by Landcare Research from the national TOPOBASE data by LINA.

Number of log sorts to cut was assumed to be 12 for all forests. This is an average value for New Zealand radiata pine plantation forests (Rien Visser pers. comm.).

The model takes into account the influence of slope and size of the forest on the cost. The harvest cost increases with slope and number of log sorts while expected volume of the forests reduces overall harvest cost, i.e. given that the other variables are identical for all forests, a forest with a greater expected volume would have a lower harvest cost.

3.2.2. Estimation of Roading Costs

To estimate roading costs the data for the existing road network and a new road construction plan were required, input variables for roading cost model are:

- length of existing road needing improvement,
- length of road requiring maintenance during harvest
- length of new road to be constructed
- number of landings,

Road network data:

Two road network shape files were downloaded and merged together to form a road network dataset for this study. Input variables for the roading cost model were extracted from this road network dataset via network analysis. Both data sets were last updated in March 2010.

1) Roading Road centreline layer from the LINZ 1:50,000 NZTopo database[6]:
The data is defined to be any formed all weather route suitable for the passage of any vehicle. The attributes of the data include road name, length and road surface.[7]

2) NZ Walking and Vehicle Tracks from LINZ, updated in March 2010[8][9]:
The data is defined to be deliberately formed route of a lesser quality than a road. Vehicle tracks are defined as all weather routes suitable for four-wheeled vehicles. From this shapefile, vehicle tracks were extracted and merged to the other road network above. The vehicle tracks were assumed to be un-metalled and appropriate for forestry vehicles to travel on once improved.

Length of existing road needing improvement:

There were three road surface types in the existing road network data; sealed, metalled (gravel or shingle), and un-metalled (dirt or clay). While sealed and metalled roads were assumed as public infrastructure, it was assumed that the improvement on un-metalled access tracks would occur at the forest owner's cost. Therefore the length of existing un-metalled roads that would be used at harvest- either within the forest or outside the forest to connect to the public road - was identified and measured for each stand on GIS.

[6] http://koordinates.com/maps/linz/#/layer/40-nz-roads-centrelines/
[7] http://www.linz.govt.nz/topography/technical-specs/data-dictionary/index.aspx?page=class-road_cl
[8] http://koordinates.com/maps/linz/#/layer/614-nz-walking-and-vehicle-tracks/
[9] http://www.linz.govt.nz/topography/technical-specs/data-dictionary/index.aspx?page=class-track_cl

Length of road requiring maintenance during harvest:

It was assumed that only metalled or sealed road would require maintenance. As this project also assumes that these roads are public, the private forest owners are free from the responsibility of the road maintenance. Therefore, the road length to be maintained was assumed to be zero for all forests.

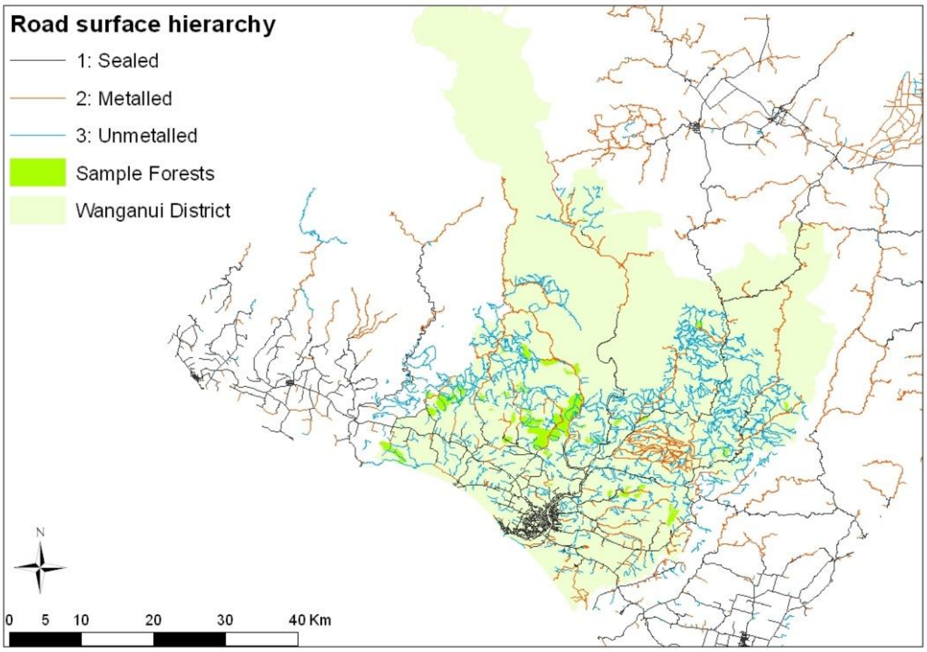

Figure 3.2.3 Road network with Road surface classes

New road construction:

There are two types of new roads to be built; (a) access tracks from the forest stand to the nearest existing track/road, and (b) harvesting skid tracks inside the forest for access to the loading area. The required access track outside the forest was simulated on GIS so that all forests would be connected to the existing road network. For the in-forest roading, the required in-forest track length was estimated using a relationship developed from 19 recently harvested sites. The visible in-forest tracks inside the harvested sites were measured on aerial photos using a GIS measurement tool. Based on this sample, a regression model was developed to calculate the skid track length of forest as a function of the stand area. This was then implemented to the 58 sample forests for this project.

The roading cost model takes the different slope classes into account. For this project, forests with an average slope greater than 30 % were considered hilly to steep terrain whereas the stands with average slope less than 30% were considered flat to rolling terrain.

Number of landing:

Number of landings was assumed to be one landing per every 6 hectare of forest, average value for New Zealand woodlots (Rien Visser pers. Comm.).

3.2.3. Estimation of Transportation Costs

This section presents the modelling approach used to estimate the average transportation cost of logs delivered to potential mills and ports. The input variables for the transportation cost model are distance travelled from forest to mill or port on unsealed roads (metalled or un-metalled), and on sealed roads. Information used for transport cost estimation were:

- Road network file;
- Location of forest/stand or point from which wood product from each stand will be transported;
- Location of sawmills and ports (Log destinations);

Road network data:

The road network shapefile from 3.2.2 was converted to "Network Database" on Arc Catalogue to enable network analysis on GIS. There were 3 classes of road surface; sealed, metalled (unsealed, gravel or shingle), or unmetalled (unsealed, clay or dirt). A hierarchy function was set up for the road surface classes so that sealed road type is preferred to be travelled on over unsealed roads. With the hierarchy setting, most travel routes from the sample stands were identical on highways. Therefore, an assumption was made that all travelling routes towards destinations are identical from a given point on highways in each direction (nodes), and the network analysis was done in two parts; (a) from forests to nodes located on highways and (b) from nodes to mills and ports. This was done to increase efficiency of the analysis instead of running the Origin-Destination matrix with all 58 origin points (forests) and 9 destinations (mills/ports).

Location of forest/stand or point from which wood product from each stand will be transported:

As the polygon shapefiles of the forests were not recognised as travelling origins, an analysis was done to allocate a point as the starting point of the transport route (road) for each stand. Three nodes were allocated on highways in direction towards the mills (North, East, and West) to which logs from all 58 sample forests were initially destined on GIS network analysis (Figure 3.7).

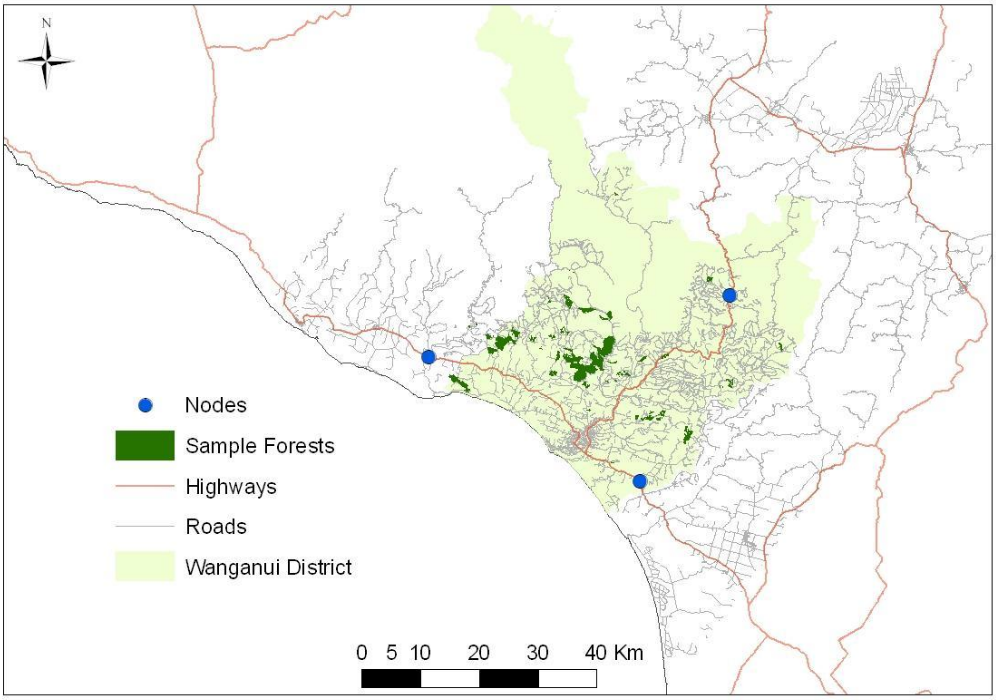

Figure 3.2.4 Road network and Nodes

Location of sawmills and ports:

MAF provided an ESRI shape file displaying locations and size class of major sawmills and export ports. The names of the mills were identified and added to the shape file based on their physical address information. New Plymouth port and Taranaki sawmill were proximate to one another, therefore combined to one destination as New Plymouth (Figure 3.2.5). Table 3.2.1 shows the proportions of the total recoverable volume that is sent to each destination. It was calculated using information from local forestry companies. It was assumed that these proportions apply to all forests for all harvest ages.

In terms of road network, it was assumed that all travel routes from nodes to the mill/port destinations are only on sealed roads and are identical for all sample estates. This is a realistic assumption as it is likely that all travel routes from forest estates would take the same highways to the destinations. As the VCM transport cost model allows only one distance value, the average distance was calculated by summing the weighted value of each route distance from node to log destinations by the proportion of the timber product to the destination (Table 3.2.1).

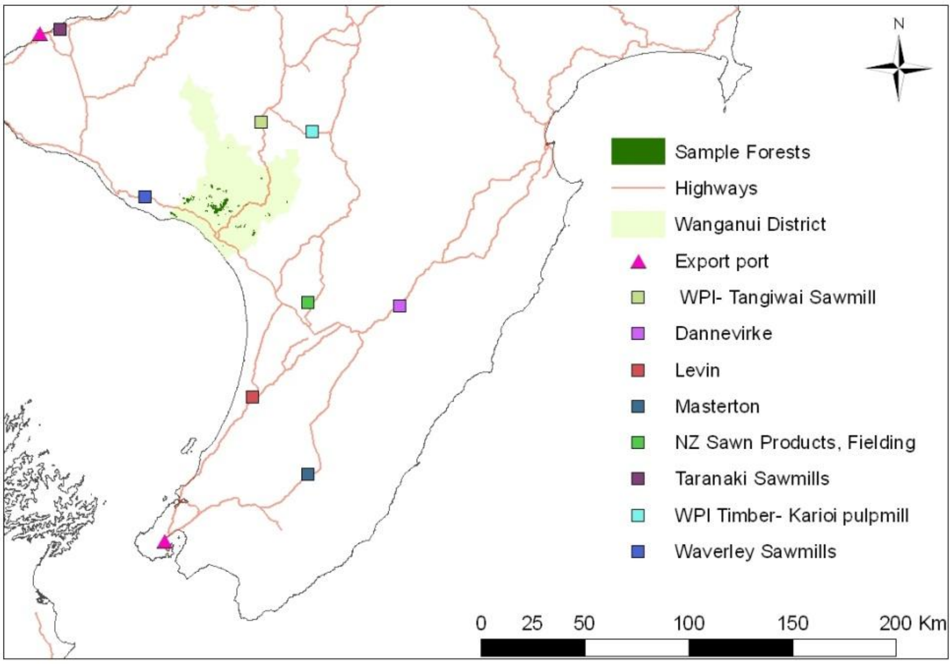

Figure .3.2.5. Location of WDC Log destinations (mills and ports)

Table 3.2.1 Proportion of the TRV to the Log destinations

29% Wellington Port	6% Fielding	15% Karioi
8% Dannevirke	5.25% Levin	8.25% Waverley
7.5% Masterton	17% Tangiwai	4% New Plymouth

3.2.4. Estimation of the small scale log production supply functions

A supply function gives the amount supplied at different prices. The stand data was sorted in ascending order of the delivered cost and was plotted against accumulated number of forests, thus obtaining an accumulated quantity of log production as a function of harvest costs. Assuming profit maximising forest owners, this supply function gave the amount of log production that is profitable to “harvest” given the average price of logs.

3.3. Profitability of harvesting small-scale forests

The purpose of the economic analysis was to estimate the portion of the small-scale that would be economically feasible to supply logs at different log price levels. The economic feasibility was considered as positive revenue firstly to an extent that the costs at harvest can be covered i.e. positive stumpage value, and secondly to an extent that a given rate of return can be achieved on historic growing costs prior to the harvest. The analysis assumed a rotation age of 30 years for each forest.

3.3.1. Stumpage Calculation

The stumpage value is an estimate of forest growers' returns for standing timber ready for harvest. It equals the product value at mills or ports minus total cost at harvest per unit production volume ($/m^3). For this study, the stumpage value for each sample forest at age 30 years was calculated by subtracting the costs at harvest ($/t) from the average log prices. The 1:1 ratio was assumed for tonne:m^3. The New Zealand Ministry of Agriculture and Forestry website provides information on log prices by log type[10]. Log grades produced from local Wanganui region were matched to the log type by specification and log price for each grade was multiplied by the assumed proportion of the log grade produced from each cubic metre of logs. The sum of these weighted prices gave the average log price per cubic metre log production of the region (Table 3.3.1).

Table 3.3.1 Estimation of average stumpage at age 30 years. Twelve quarter average log prices as at September 2010 and average prices weighted by grade. The grade weights are the proportion of TRV made up by each log grade at age 30 years.

Log type	Export Log price ($/JAS m^3)	**Log Grade**	Length (m)	SED minimum (mm)	Branch max (mm)	Grade weight	**Price ($)**
Pruned	159.50						
A Grade	[11]88.71	**A30**	4 - 6	350	10	**0.1529**	**13.57**
K Grade	[12]76.50	**K**	4	200	10	**0.1611**	**12.33**
Pulp	79.96						
Domestic Log prices ($/t delivered at mill)							
P1	130.08	**Pruned**	4.9 – 6.1	350	0	**0.2556**	**29.93***
P2	104.13						
S1	89.08						
S2	83.29	**S30**	4.9 – 6.1	350	6	**0.1388**	**11.56**
L1&L2	73.08						
S3&L3	69.13	**S20**	4.9 – 6.1	200	6	**0.1230**	**8.50**
Pulp	49.21	**Pulp**	3.7 - 6	100	15	**0.1685**	**8.29**
		Average log price ($/m^3)					**84.18**

*the product of grade weight and the average price of P1 and P2 ($117.10/t)

[10] Ministry of Agriculture and Forestry website, 2010. www.maf.govt.nz/news-resources/statistics-forecasting/forestry/indicative-new-zealand-radiata-pine-log-prices.aspx

[11] $108.71/m^3 free on board minus wharf cost of $20/m3

[12] $96.50/m^3 f.o.b. minus wharf cost of $20/m3

The cost at harvest for each forest was divided by the average price ($84.2). The stand data was sorted in ascending order of these cost/price ratio values then was plotted against cumulative % of forest number. This was to show how much the log price level has to change (as % the log prices as at September 2010) for the forests to be harvested at a breakeven stumpage value (where log price equals cost at harvest).

3.3.2. Return on growing costs

The calculation in 3.3.1 does not include any return on forest growing costs. Therefore a subsequent analysis was carried out to look at the number of forests that would be harvested if the owner required some return on growing costs. The growing costs include all costs that occur before harvest, hence the costs of growing the crop. Three single-rotation economic analyses were carried out for each forest with three levels of growing costs as followings:

- **Silviculture:** The typical silviculture regime and the costs associated were provided by a local forestry consultant. Planting costs $960 with stocking of 1000 stems per hectare. At year 4, low pruning and thinning costs $900, while medium pruning costs $540 in year 5, and high pruning costs $500 at year 7. The Second thinning cost of $350 occurs at year 8. Each of these costs was compounded to a future value at year 30.
- **Overhead:** An annual overhead cost of $40 per hectare per year was assumed. This was added to the silviculture costs, giving the second growing cost scenario for the analysis.
- **Rental:** The annual rental cost for the land was assumed to be $80 per hectare per year. This was added to the silviculture and overhead costs, giving the third growing cost scenario.

As the growing costs occur in different time periods to harvest, they were converted to future value at year 30, taking an account of the time value of money up to the harvesting time in future.

$$Vn = \sum[Vt * (1+i)^{n-t}] \qquad \textit{Eauation 3.2}$$

Where Vt is present value of the costs at time t years. n-t is the length of time in years between when Vt occurs and time of harvest (i.e. n = 30), and i is the interest rate or average annual rate of return on an investment. The three interest rates used for this study are 2, 5, and 8 %. The compounded value of the costs Vn is what the investor would expect to receive at least n years after the initial investment Vt is made at a given interest rate. If the stumpage value (log price minus cost at harvest) is less than Vn, the investment on the growing cost is not worth making.

Table 3.3.2 Growing costs and compounded values as future value in year 30, using 8% discount rate

Time (t)	Vt ($/ha)			∑V30 ($/ha)	Time	Vt ($/ha)			∑V30 ($/ha)
	Silv Cost	O/h Cost	Rental Cost			Silv Cost	O/h Cost	Rental Cost	
0	-960	-40	-80	**-10868**	**16**		-40	-80	**-352**
1		-40	-80	**-1118**	**17**		-40	-80	**-326**
2		-40	-80	**-1035**	**18**		-40	-80	**-302**
3		-40	-80	**-959**	**19**		-40	-80	**-280**
4	-900	-40	-80	**-7544**	**20**		-40	-80	**-259**
5	-540	-40	-80	**-4520**	**21**		-40	-80	**-240**
6		-40	-80	**-761**	**22**		-40	-80	**-222**
7	-500	-40	-80	**-3640**	**23**		-40	-80	**-206**
8	-350	-40	-80	**-2555**	**24**		-40	-80	**-190**
9		-40	-80	**-604**	**25**		-40	-80	**-176**
10		-40	-80	**-559**	**26**		-40	-80	**-163**
11		-40	-80	**-518**	**27**		-40	-80	**-151**
12		-40	-80	**-480**	**28**		-40	-80	**-140**
13		-40	-80	**-444**	**29**		-40	-80	**-130**
14		-40	-80	**-411**	**30**		-40	-80	**-120**
15		-40	-80	**-381**				**Total ($/ha)**	**-39655**

The cumulative sums of the growing costs were then divided by total recoverable volume at age 30 (521m^3/ha) to give three growing costs ($/m^3) of the wood produced (namely +Silviculture, +Overhead, + Rental) (Table 3.3.3). The cost/price ratio was calculated for each growing cost scenario at each discount rate to see how much the log prices have to change for forests to achieve the given rate of return on different levels of growing costs.

Table 3.3.3. Growing cost scenario at three discount rates

Growing cost scenario	+ Silviculture			+ Overhead			+ Rental		
Discount rate	2%	5%	8%	2%	5%	8%	2%	5%	8%
($/m^3)	10.48	22.53	47.70	13.73	27.96	57.17	20.24	38.83	76.11

The proportion of forest blocks with positive net value was calculated at each discount rate. The historical rate of return was found for each forest under each growing cost scenario (+silviculture, +overhead, + rental) by using a goal-seek function on Microsoft Excel. This is the rate that gives zero value for the net future revenue (stumpage value – growing costs) and provides a simple method to observe and compare the historical return of the forests under different growing cost scenarios.

3.4. Valuation of the existing small-scale forests

The net present value (NPV) of each sample forest at each rotation age was calculated to give an investor's value of the forest. The analysis for each forest was carried out by using a financial model spreadsheet[13]. The spreadsheet displays the NPVs for traditional (i.e. revenue from logs only) forestry and ETS forestry (including carbon) at varying rotation ages from 20 to 50, taking account of the respective stumpage volume, growing costs, and carbon stock for each rotation age. The NPV analysis assumed a perpetual forestry land use with the same harvesting age throughout subsequent rotations.

For the financial model a discount rate of 8% was assumed while all previously assumed growing costs remained the same. The carbon overhead cost was assumed to be $20 per hectare per year, and carbon price to be $20 per tonne CO_2. The harvesting and roading costs for each rotation age were calculated taking into account the changing volume produced with age. In the financial model spreadsheet, the log sale revenues are the sum of the revenues for each log grade. Therefore the volume by log grades, as well as TRV for each rotation age between 20 and 50 were obtained by using the Radiata Pine Calculator so that the total log sale revenue would vary with different rotation ages (see 3.1.3). The log prices used are those in Table 3.3.1. The maximum NPV of each forest was recorded and plotted against the optimum rotation age, planting year, and forest size to observe how NPV varies with each variable. This was then compared to the maximum NPVs of the post-89 forests with additional carbon cashflows.

3.5. The profitability of new land planting

Profitability of future forestry investment was analysed by another NPV analysis where all forests were assumed to be new planting on bare forestland. As with the NPV of existing forests in 3.4, a perpetual forestry land use was assumed with the same harvesting age throughout subsequent rotations. The new land planting NPV represents the value of the investment. The NPV is calculated with an annual land rental of $80/ha/year. The Land Expectation value (LEV) (i.e. the maximum that can afforded for bare land and still achieve a 8% rate of return) could be estimated by adding the capitalised land rental cost in perpetuity to the NPV; i.e. converting the $80/ha/year rental cost into a capital value of $1000/ha and adding this to the NPV.

[13] developed by Dr Bruce Manley at the NZ School of Forestry to illustrate concepts at the UC/MAF 2010 Carbon Forestry Financial Modelling Workshops

The new planting NPV at each rotation age between 20 and 50 was calculated using 8% discount rate and all costs of growing and harvesting. For each forest, the maximum NPV and the rotation age which the max NPV occurs (i.e. optimum rotation age) were recorded for both traditional forestry and carbon forestry. The internal rate of return (IRR) at rotation age 30, and the IRR at optimum rotation age were found and compared between traditional forestry and carbon forestry.

CHAPTER 4 : RESULTS

4.1. Estimation of Potential Small-scale Forest Resources

4.1.1. Forest Area Estimation

Forest area by ownership

The dataset provided for this study has a total area of 26 524 ha in radiata pine plantation forests in Wanganui district. This is a little less than the NEFD estimate of 29 352 ha (MAF NEFD for 2009). The small scale owners' estates contribute 10819 ha, about 40 % of the total radiata pine plantation area in the region. Although smaller than the total area of the large-scale forests, the small-scale forests belong to a far greater number of owners than the large-scale forests. There are 155 small-scale forest stands that belong to 32 known owners. The ownership information of the other 367 forest stands was unknown in the data (Table 4.1.1). The small-scale forest estate is a significant yet complex forest resource in the region.

Table 4.1.1. Estate comparison between Large and Small owners

	Large Owners	Small Owners
Number of owners	9	>>32
Total Area (ha)	15 706	10819
Number of forest blocks	483	522

Figure 4.1.1 shows that while the large-owner estate is concentrated in the south-eastern part, the small owner estate is more widely scattered throughout the district. Forests are located mainly in the southern part of the district.

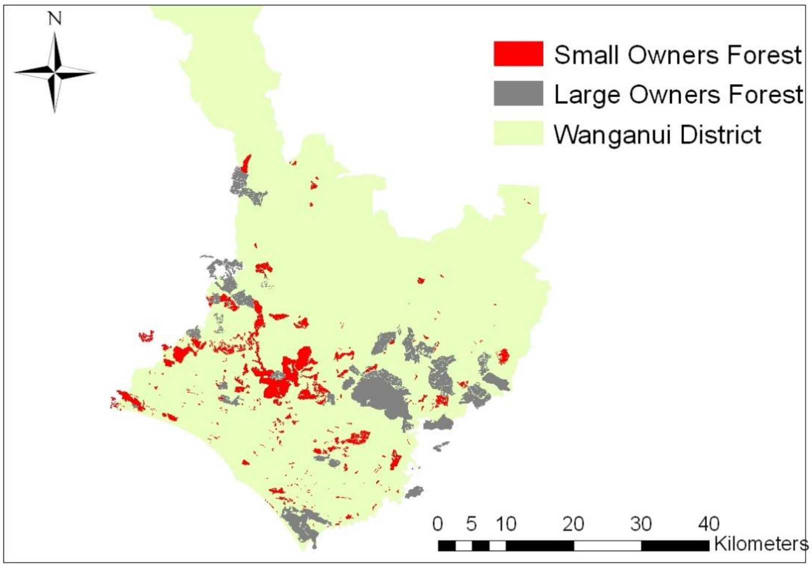

Figure 4.1.1.Ownership Map of Radiata pine Forests

Age distribution of the small-scale forest resources

A significant amount of resource is available from forests that were planted in the 1990s, from both large and small scale owners. While the wood supply in the immediate future is likely to come from the large scale owners' forests, the extent of increase in wood availability in the future relies on the small scale forest resources, especially those that were planted in the 1990s (Figure 4.1.2). Figure 4.1.3 shows some clustering of small-scale forests from the 1990s planting boom. The planting year was not available for 270 of the blocks that total 1803 ha.

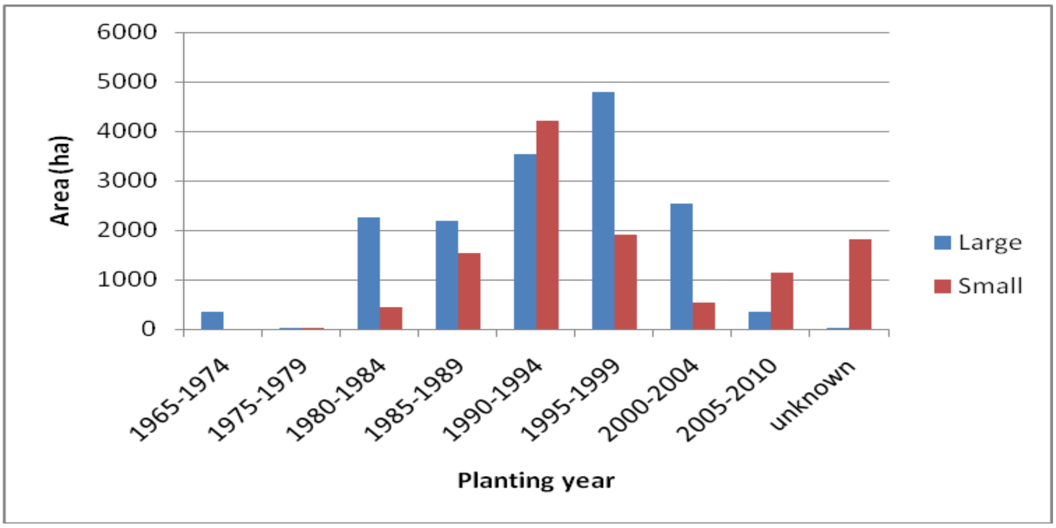

Figure.4.1.2. Forest Area distribution across Age groups

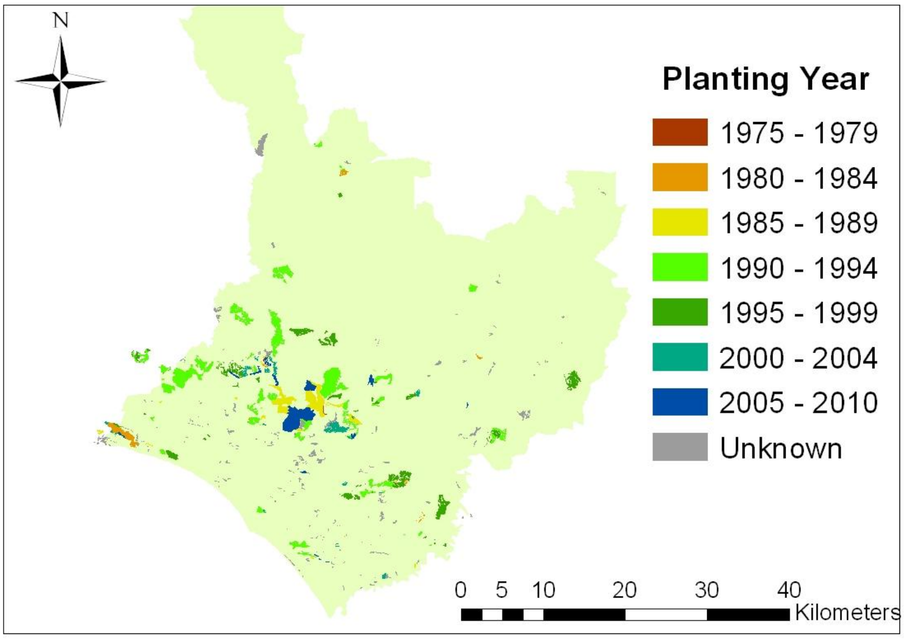

Figure 4.1.3. Spatial Map of Age distribution of Small-scale Forests

Size distribution of the forest resource

The size distribution of the small-scale forests is skewed with the majority of blocks being smaller than 50 ha. The size distribution varies across different age classes (Table 4.1.2). The resources planted in the 1990s, especially those planted in the early 1990s, are distributed more evenly across size classes. The older stocks planted in the 1980s are also distributed across all size classes. (Figure 4.1.4 & 4.1.5).

Table 4.1.2 Size distribution of Small-scale forests by age class

Size class (ha) / Age class	1 - 9.9	10 - 24.9	25 - 49.9	50 - 99.9	100 - 299.9	300 - 499.9	>500	Total no. of forests
1975-1979	4	1	0	0	0	0	0	**5**
1980-1984	6	4	1	0	0	1	0	**12**
1985-1989	12	3	1	1	2	1	1	**21**
1990-1994	24	18	20	15	6	1	1	**85**
1995-1999	34	21	11	9	2	0	0	**77**
2000-2004	9	18	6	0	0	0	0	**33**
2005-2010	6	4	5	1	2	0	1	**19**
unknown	231	31	5	2	1	0	0	**270**
Total no. of forest	**326**	**100**	**49**	**28**	**13**	**3**	**3**	**522**

Most small scale forests that have an unknown planting year belong to the 1-9.9 ha size class (Table 4.1.2 & Figure 4.1.4). The largest sized forest blocks (>500 ha) are geographically close to each other while other blocks appear to be scattered all across the region regardless of size class (Figure 4.1.5).

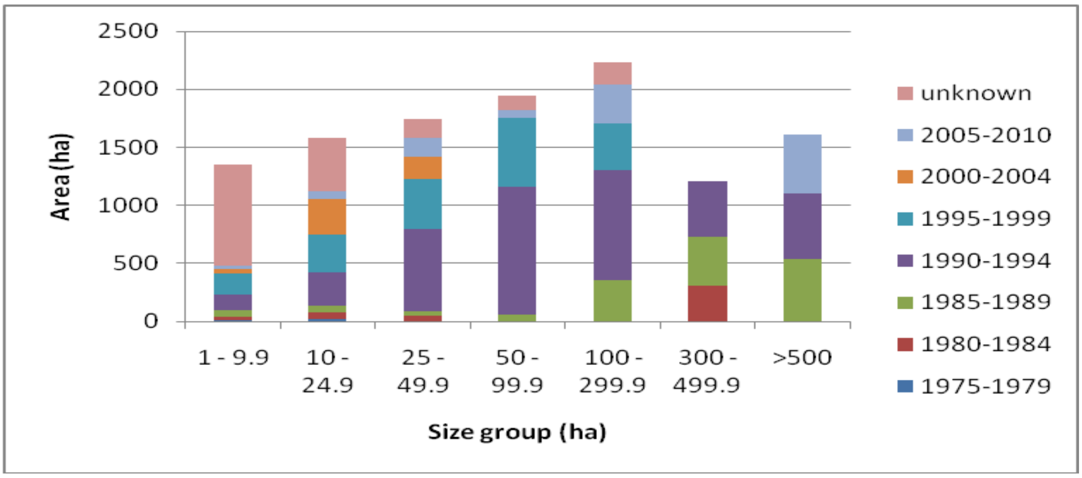

Figure 4.1.4. Size distribution of Small scale forest blocks (area)

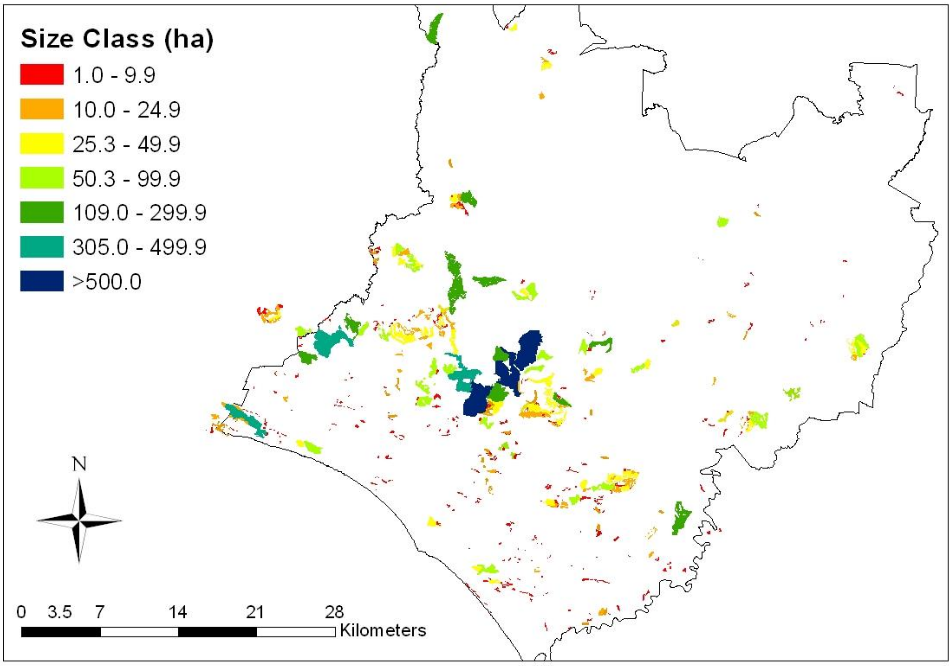

Figure.4.1.5. Spatial Map of Small-scale Forests by Size class showing scattered distribution of small size estates

Carbon eligibility distribution of the forest resources

The LUCAS_LUM data defines the ETS eligibility not only by the planting year but also on previous land-use;i.e. post-1989 forest land is primarily forest land that was established in forest after 31 December 1989 on land that was not forest land on 31 December 1989. Although there is a large proportion of forests that are planted after 1989 (7851 ha), the area of LUCAS-defined post-89 forests is only 4012 ha out of 11660 ha (Figure 4.1.6 & 4.1.7). This indicates a significant amount of forest is on its second or greater rotation period.

There are many forests with missing information on planting year and/or carbon-eligibility (i.e. LUCAS definition). On the other hand, there are 7 existing forest blocks that are shown as "post-89" in LUCAS, but have the planting year earlier than 1990; and 36 forests with unknown carbon-eligibility status in LUCAS data regardless of available planting year information. An assumption is made on the ETS eligibility of the stands with unknown LUCAS definition based on the planting year; i.e. 12 stands planted before 1990 are categorised as Pre-90 regardless of the LUCAS definition (which says either post-89 or unknown). It is also assumed that those 31 forests planted after 1989 with no LUCAS record to be post-89 forest. Overall, the LUCAS data along with the assumptions made for the study define that 171 blocks with 4399 ha area are post-1989 in the study area (Table 4.1.3).

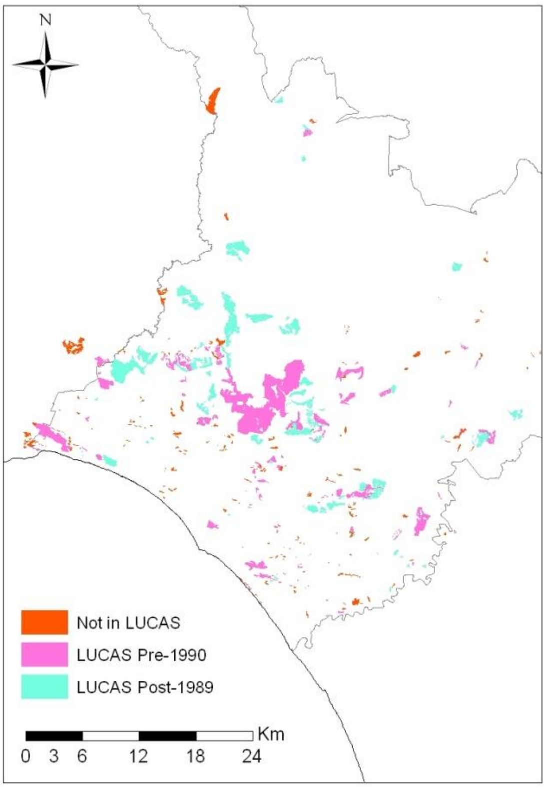

Figure 4.1.6. Small-scale forests overlapped by LUCAS_LUM data for Carbon eligibility

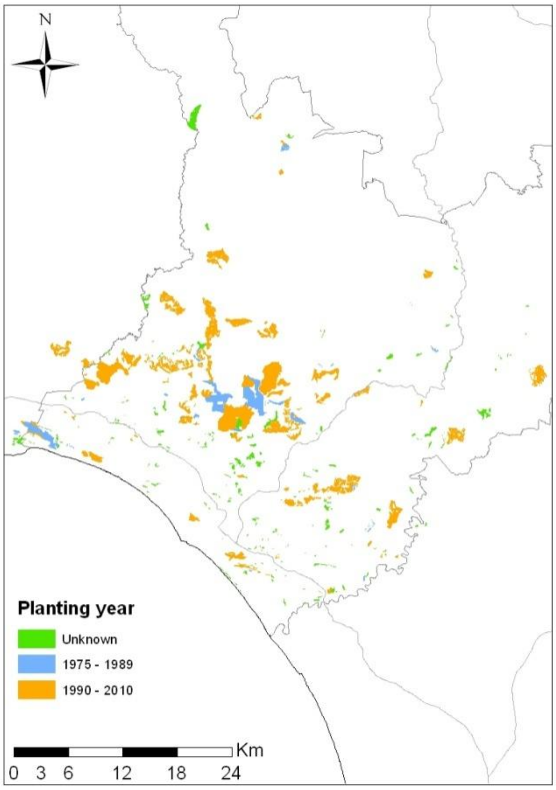

Figure 4.1.7. Small-scale forests grouped by planting periods (pre 90, post 89)

Table 4.1.3. Comparison of extent of pre-90 and post-89 forests according to the planting year and LUCAS-definition, producing adjusted LUCAS definition of the forests

	Pre 90		**Post 89**		**Unknown**		**Total**	
	Area (ha)	Number	Area (ha)	Number	Area (ha)	Number	**Area (ha)**	**Number**
LUCAS	6014	145	4191	147	1455	230	**11660**	**522**
Planting year definition	2006	38	7851	214	1803	270	**11660**	**522**
Adjust LUCAS	**6137**	**157**	**4399**	**171**	**1124**	**194**	**11660**	**522**

4.1.2. Sample Forests

A sample of 58 small scale forest blocks out of 252 forest blocks with a known planting year were randomly selected by using probability proportional to size (pps) sampling method. As a result, the age, owner, and ETS eligibility distribution of the sample forest resemble the distributions of the total population. However, the size distribution of the sample forests is not as skewed towards small size classes as the total population, but more evenly distributed across all size classes (Figure 4.1.8 & 4.1.9)

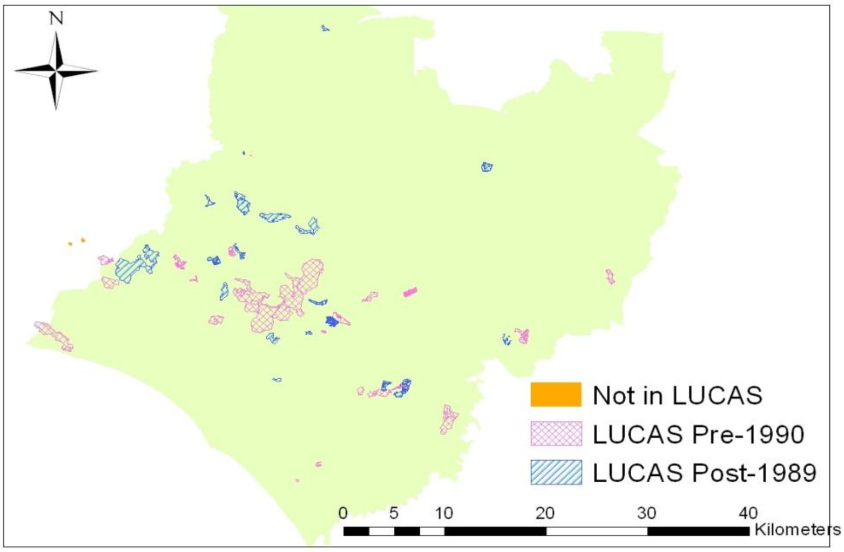

Figure 4.1.8. Distribution of 58 Sample forests

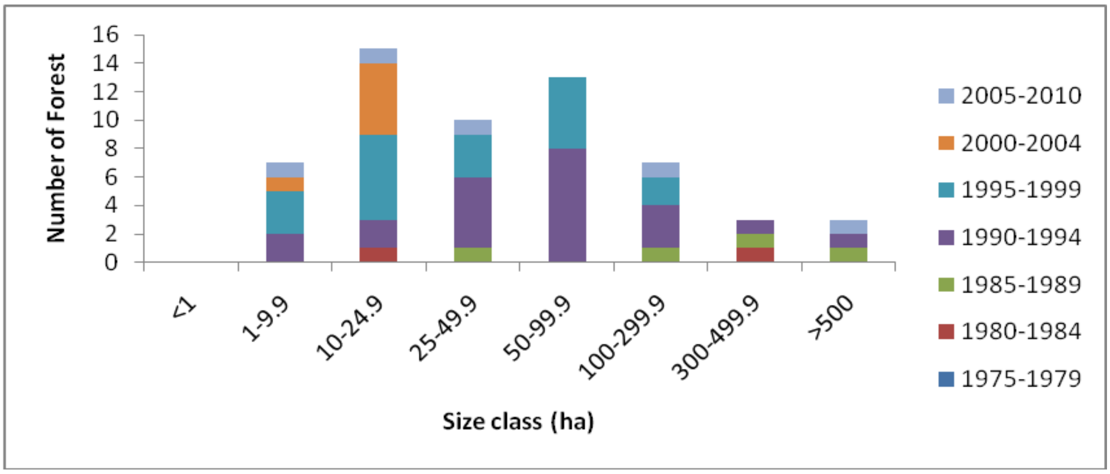

Figure 4.1.9. Size and Age distribution of the Sample Forests

Table 4.1.4. Sample forest ETS eligibility distribution

ETS eligibility	Number of Forest blocks	Area (ha)
Pre-90	31	3930.9
Post-89	27	1643.6

4.1.3. Harvest volume estimation

Table 4.1.5 shows the yield table by log grade generated by the Radiata Pine Calculator. The recoverable total volume (TRV) at age 30 from this table matches the NEFD yield table for intensively managed young stands (i.e. RIY). For rotation ages less than 30, the Calculator-generated TRVs are slightly less than the values from the RIY, while the generated TRVs are greater than the RIY yield table from age 40 where the TRV is kept constant in the NEFD yield table.

Table 4.1.5. Log volume by grades (m^3/ha)- Yield table generated by Radiata Pine Calculator.The TRV is compared to the TRV from the NEFD RIY yield table

Log grade	**Calculator-generated Volume (m^3/ha)**							**NEFD Yield Table (m^3/ha)**
Rot. age	**Pruned**	**S30**	**A**	**S20**	**K**	**Pulp**	**Total**	**RIY**
20	56	48	4	56	61	68	293	309
21	66	51	8	57	71	66	319	332
22	74	56	16	56	73	71	346	354
23	96	51	21	48	81	72	369	377
24	102	52	32	53	77	77	393	399
25	109	61	38	51	80	78	417	419
26	114	62	45	52	90	76	439	441
27	119	64	53	57	90	77	460	462
28	124	68	62	61	85	81	481	481
29	129	68	72	61	86	86	502	502
30	133	72	80	64	84	88	521	521
31	137	75	88	61	86	93	540	540
32	141	81	91	64	93	90	560	557
33	145	86	99	69	88	90	577	574
34	149	86	110	70	89	90	594	589
35	152	85	117	72	91	93	610	605
36	155	98	119	76	83	97	628	622
37	158	97	129	77	83	98	642	639
38	161	98	137	76	86	100	658	656
39	164	113	139	78	76	103	673	672
40	167	113	147	78	80	103	688	688
41	170	112	156	78	83	103	702	688
42	173	119	161	85	76	103	717	688
43	175	127	164	86	75	103	730	688
44	178	128	172	86	77	103	744	688
45	181	128	180	87	78	105	759	688
46	183	136	184	94	69	105	771	688
47	186	146	188	89	69	107	785	688
48	189	147	196	87	70	111	800	688
49	192	157	199	91	63	113	815	688
50	191	152	199	93	64	114	813	688

4.2. Delivered Cost of Small Scale Forestry Production

Using the physical factors of the stand as input, the cost of harvesting, roading, and transportation are calculated and together give the delivered cost of wood produced at each stand at each rotation age from 20 to 50. The initial analysis calculated the estimated delivered costs for stands at age 30 to indicate how much small-scale wood resources would be available at a given log price at this age.

4.2.1. Harvesting Cost

The average harvesting cost value for the sample forests is $35.4 per tonne of expected (recoverable) volume at the harvest age of 30 years. Harvesting cost ranges from $21 to $56/t, but most values are concentrated between $30 and $40/t (Figure 4.2.1). This, to some extent, reflects the distribution of average slope values of stands which are mainly between 30 and 50%. As the increasing trend in Figure 4.2.2 indicates, the model captures the variability of terrain characteristics in the cost calculation.

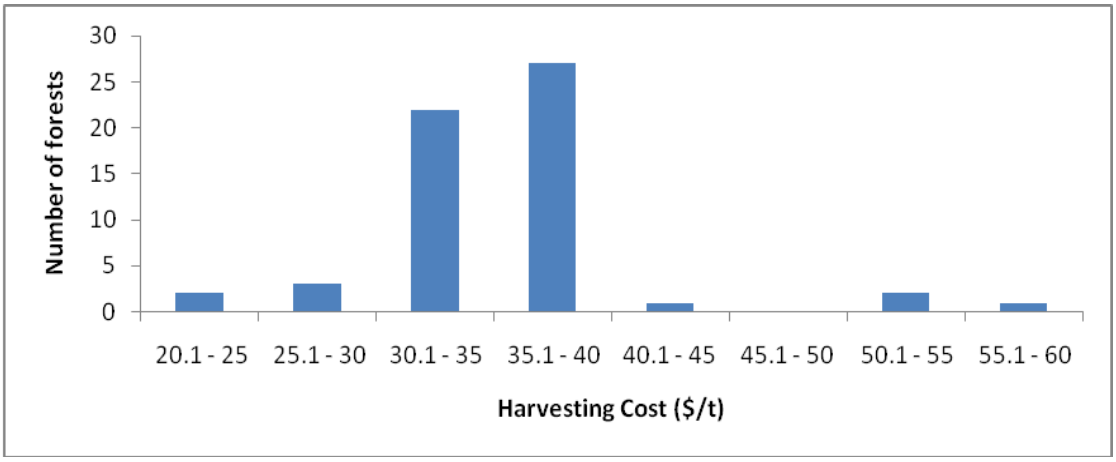

Figure 4.2.1. Histogram showing distribution of Harvesting cost of sample forests

The cost distribution also shows how the cost is determined by combined effects from the two main independent variables of the regression model - slope and NSA. For example, the three stands with the highest harvesting costs are located on medium slope but have much higher costs than other forests in similar terrain condition due to the small size of the stands. Both variables are statistically significant as indicated by small p-values of 0.0003 and 0.008 respectively for slope and NSA. The trend between slope and the cost becomes more significant i.e. much smaller p-value, when outlier forests with a cost greater than $50 are removed. For the cost-NSA relationship, the p-value decreases slightly to 0.006 with a removal of outliers.

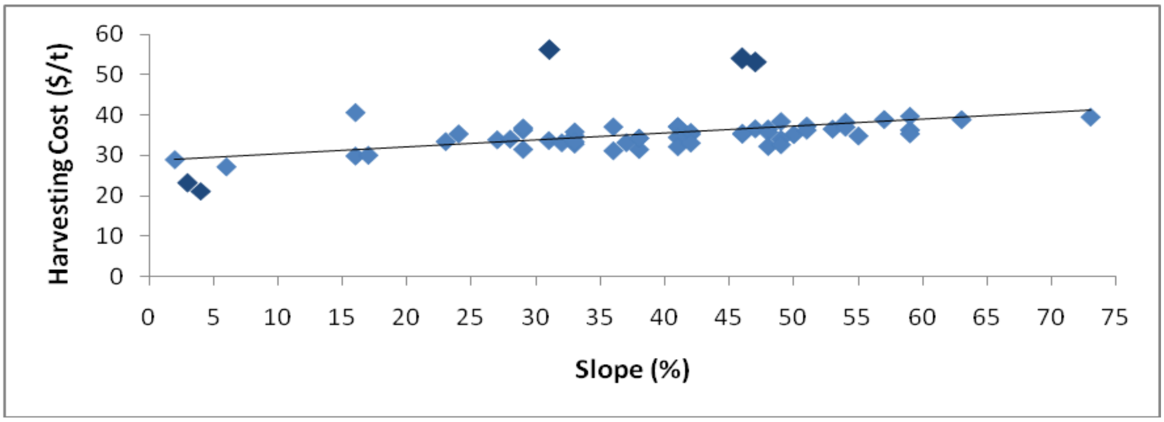

Figure 4.2.2. Harvesting Cost vs. Average slope of sample forest

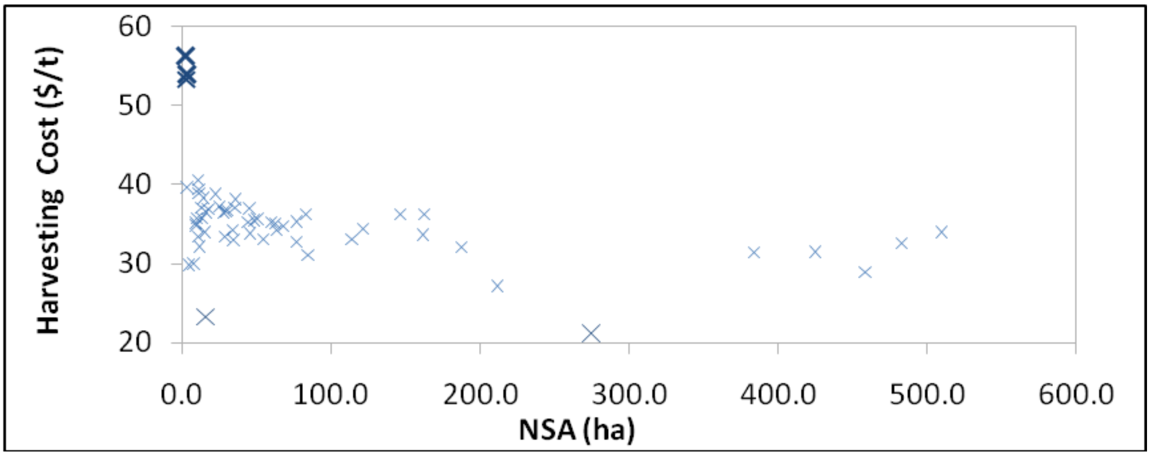

Figure 4.2.3. Harvesting Costs of sample forests with varying NSA

4.2.2. Roading cost

The roading cost model used for this study takes into account of a length of existing road needing improvement and the length of new road to be constructed for each stand. Two types of roads are identified for the cost calculation: skid tracks inside the forest, and access tracks from a loading point of the forest to public road. The road improvement is assumed to be made on un-metalled (dirt/clay surface) access tracks only, while new road construction considered roads both inside and outside the forest. It was assumed that all sealed and metalled (shingle/gravel) roads are public. The roading cost model takes into account variability of slope, location, and size of the stands.

Existing un-metalled road requiring improvement

Overall, there are 36 (62%) stands with already existing un-metalled vehicle tracks outside the forest that give access to the public road. These tracks are assumed to need improvement at harvest. On average 1428 m of existing access track needs improvement for these 36 stands, ranging from 2 to 7385 m

New road construction- (a) Skid track

Skid tracks are defined as tracks built inside forest blocks between points of felling and the skid site. Figure 4.2.4 show a developed linear regression model based on spatially measured area and track length of 19 recently harvested sites (an example site is shown in Figure 4.2.5). The model estimates the minimum skid track length of 353 m which would increase by 18.5 m with every 1 ha increase in size. This correlation is statistically significant as indicated by the low p-value (less than 0.001) and the high r^2 (0.957) of the relationship.

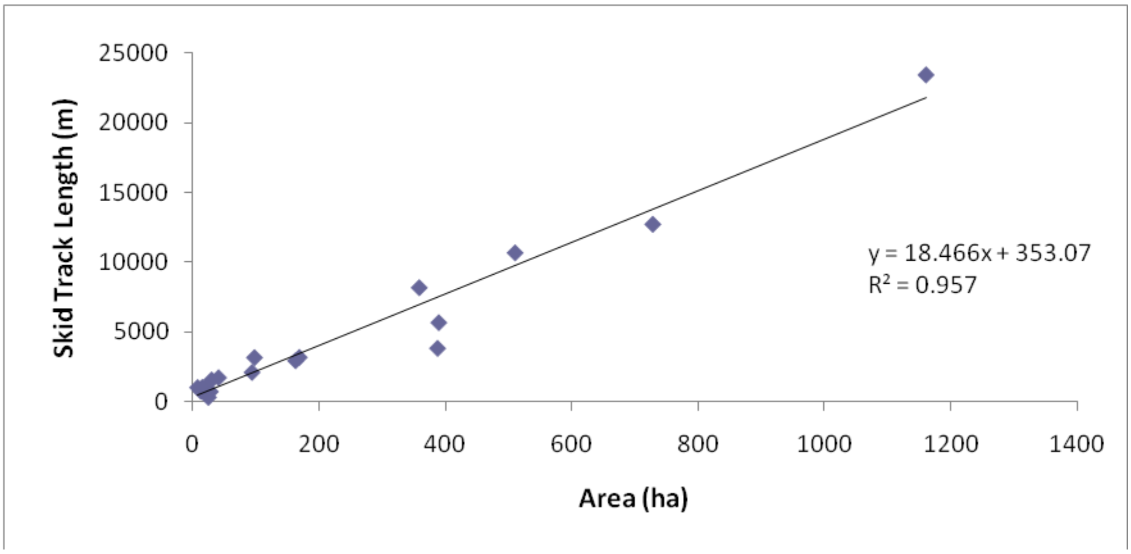

Figure 4.2.4. Regression model of Skid tracks on 19 recently harvested area

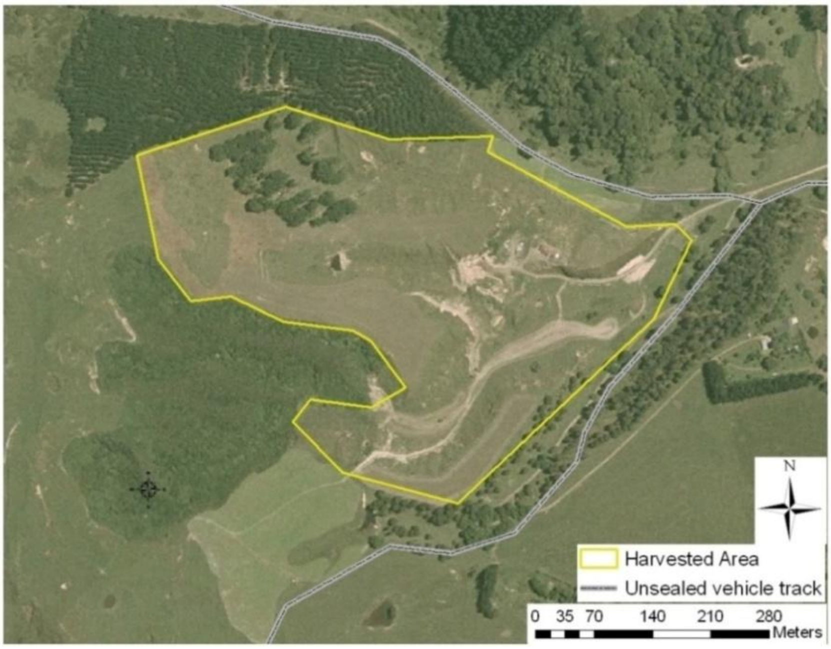

Figure 4.2.5. An example of manual identification of a recently harvested area with traces of skid tracks inside the harvested area

Some 12 sample forests already have some existing skid tracks. The new skid track length estimation takes account of existing skid tracks previously built through these 12 forests by subtracting the existing length from the modelled skid track length. For example, a forest in Figure 4.2.7 (a stand in centre, 179 ha in area) already has 1800 m existing track going through the forest. This existing track length is subtracted from the modelled length (3670 m) and the stand would only require construction of 1870 m of new skid track. It is estimated overall, that the forests requires 1568 m of new skid track construction inside the forest on average, ranging from 0 to 10258 m depending on the size of the forest (Figure 4.2.6).

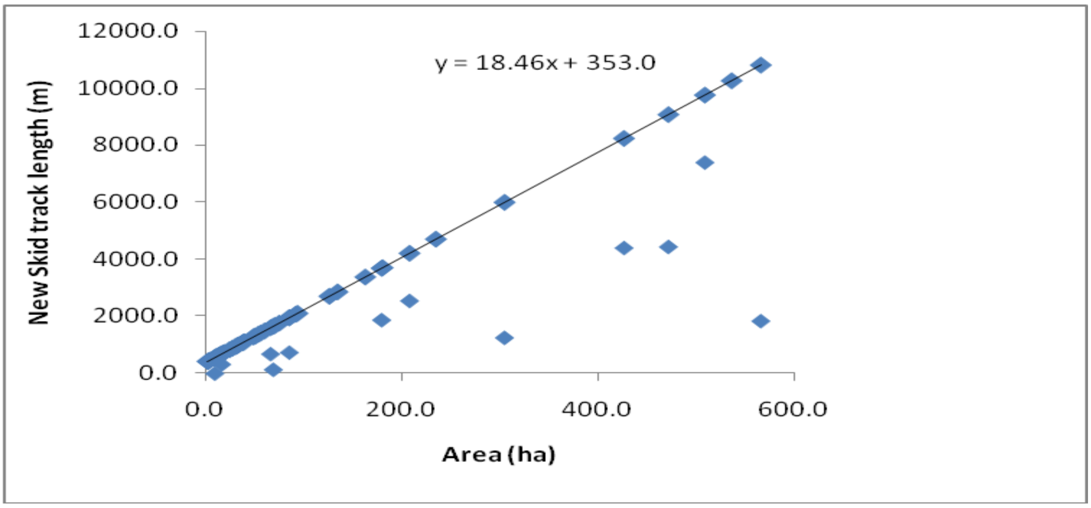

Figure 4.2.6 The new length of skid tracks to be built – the line shows the total track length established by the model. Points not on the model line represent blocks with some existing skid tracks.

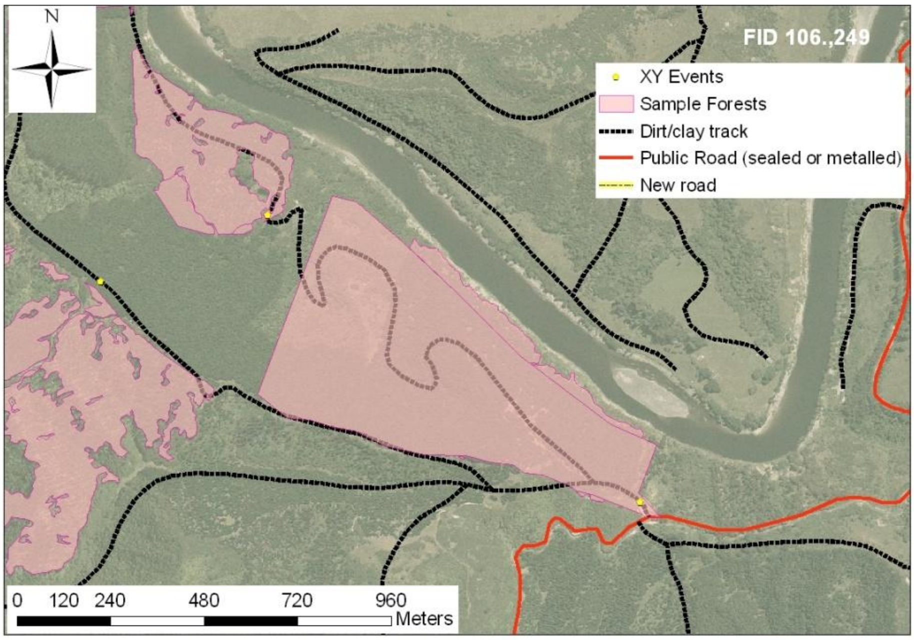

Figure 4.2.7. Two forest blocks (top left and middle) owned by River Ridge Ltd

New road construction- (b) Access track

Out of 58 sample stands, 10 stands require new access tracks to be built outside the forest- 2 of these stands require new tracks for direct access from the forest to existing public sealed roads, 1 to an existing metalled road (an example in Figure 4.2.9), and 7 to existing un-metalled dirt roads (an example in Figure 4.2.8). The average new access track length for these 10 stands is 405 m, ranging from 90m to 1014m.

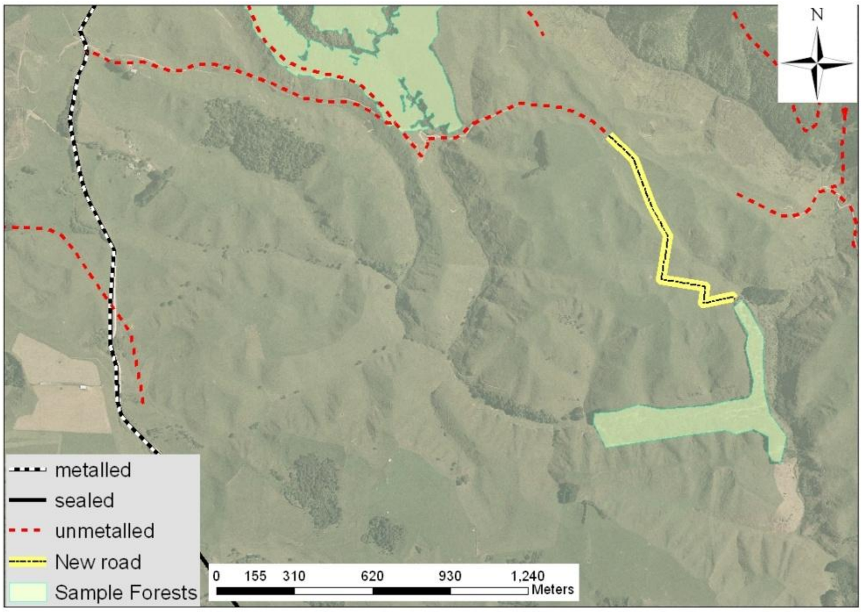

Figure 4.2.8. 1014 metres new access track required to be built (yellow) between a sample forest and an existing un-metalled track (red)

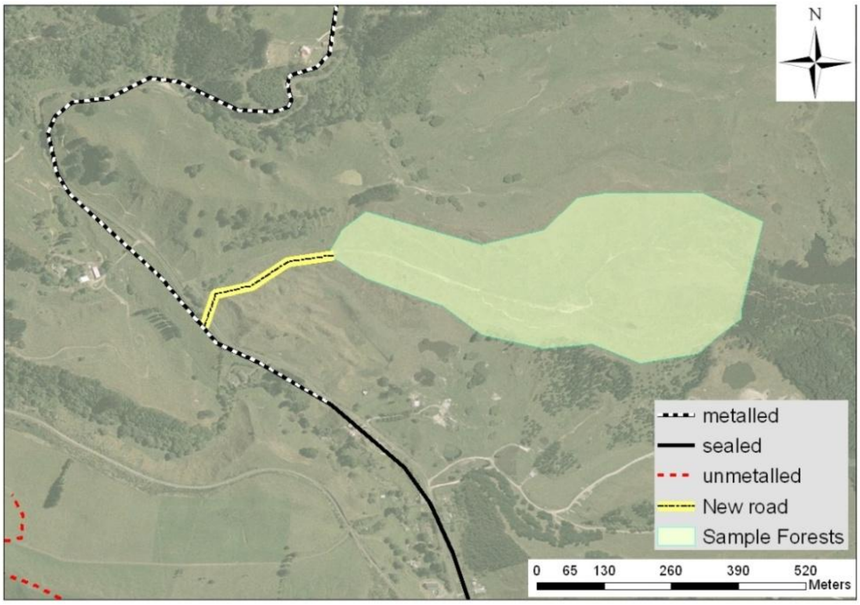

Figure 4.2.9 A simulated 316 metres access track to be built between a sample forest and metalled road (dotted)

The total length of access tracks can indicate proximity of the forest to the public road. Out of 58 samples, 26 forests (45%) are located with direct access to a public road (19 to metalled and 7 to sealed roads). For the other 32 sample forests, the mean length to be travelled on the new and existing access track before reaching a public road (metalled or sealed) is 1300 metres, ranging from 90m to 3300 m (Figure 4.2.10).

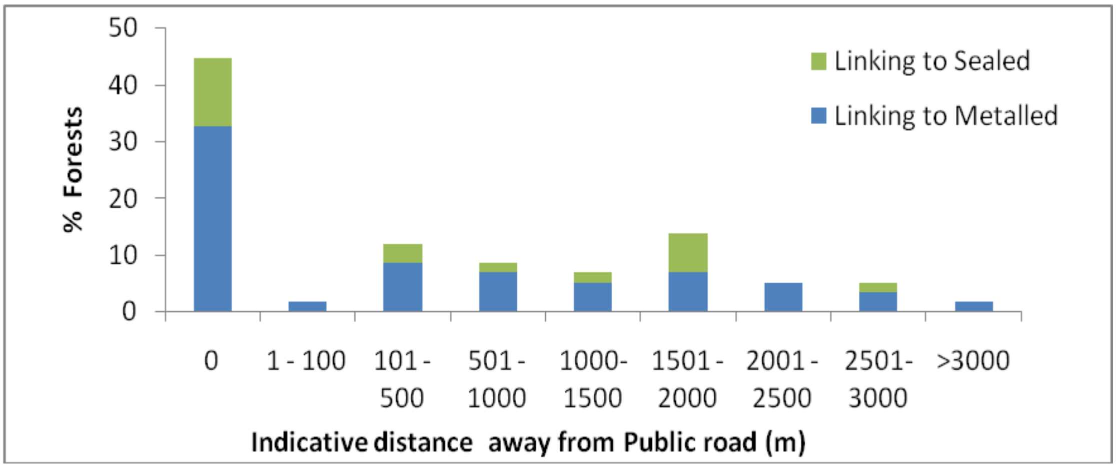

Figure 4.2.10. Histogram of the Sum of lengths of new access track and existing access track

Roading costs are shared between the adjacent forests if forests with the same owner share the road. For example, two forests in Figure 4.2.7 are owned by the same owner, and share the same existing tracks for access to a public road. The cost of improving the 2400 m long track that goes through the two forests is therefore shared between the two forests. Out of 58 forests, 25 forests (43%) are adjacent to another forest(s) that is (are) under the same ownership. For these estates, the total lengths of the roads were divided by the number of adjacent stands so the cost of roading is shared across the estate. It is assumed that each owner has their own access to public roads so that the cost is not shared when adjacent forests have separate owners.

Total Roading Cost

Overall, the roading costs of most forests are distributed between $5 and $15 per tonne of timber production, with a mean value of $9.3/t and median of $6.5/t (Figure 4.2.11). The forests with high roading costs are forests with the smallest area (Figure 4.2.12).

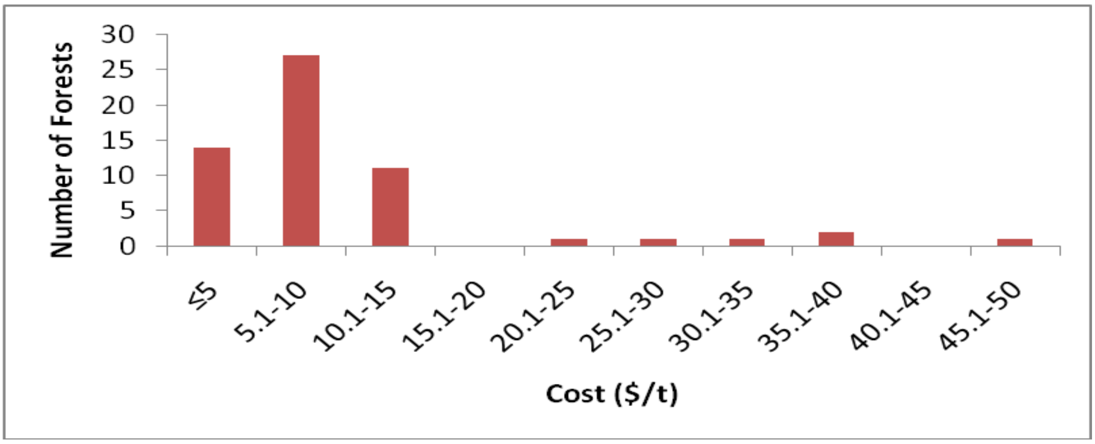

Figure 4.2.11. Histogram showing distribution of Roading cost of the sample forests

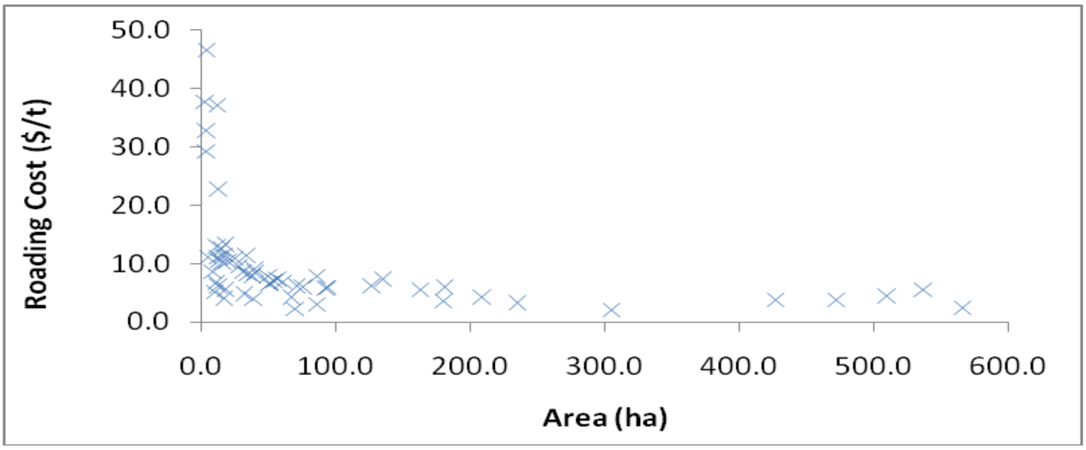

Figure 4.2.12. Roading Costs of sample forests with varying NSA

4.2.3. Transportation cost

Distance from the forests to each node on highways, and the distance from each node to each log destination (mills and ports) were measured by using the origin-destination cost matrix function on ArcGIS network analysis (Table 4.2.1 & Table 4.2.2). The distribution of the cost is so narrow that all forests' costs are within a range between \$25 and \$34/t with an average value of \$29.1/t at age 30. This is because the cost difference among the forests solely depends on the distance from each forest to the nodes. The VCM takes account of the variability of forest locations in transportation cost given a single average distance for each forest. This project considers an average of all potential markets in the region for all forests. This general approach results in small variability in transportation distances across all forests. In reality, the cost variability between forests may be much bigger.

Table 4.2.1. Average Travelling Distance from forests to Nodes

	East			**West**			**North**		
	Unsealed (km)	Sealed (km)	**Total (km)**	Unsealed (km)	Sealed (km)	**Total (km)**	Unsealed (km)	Sealed (km)	**Total (km)**
Mean	5.7	30.5	**36.2**	7.5	34.9	**42.4**	6.6	52.7	**59.2**
Median	3.8	30.5	**35.3**	2.7	30.0	**46.0**	3.0	58.0	**60.5**

Table 4.2.2. Distance from Nodes to Log destinations

Node	**Destination**	**Travel Distance (km)**	**Node**	**Destination**	**Travel Distance (km)**
East	Fielding	75.1	West	New Plymouth	135.7
	Levin	94.1		Taranaki sawmill	138.5
	Dannevirke	117.1		Waverley	9.8
	Masterton	175.8	North	Karioi Pulpmill	80.2
	Wellington	183.7		Tangiwai sawmill	36.9

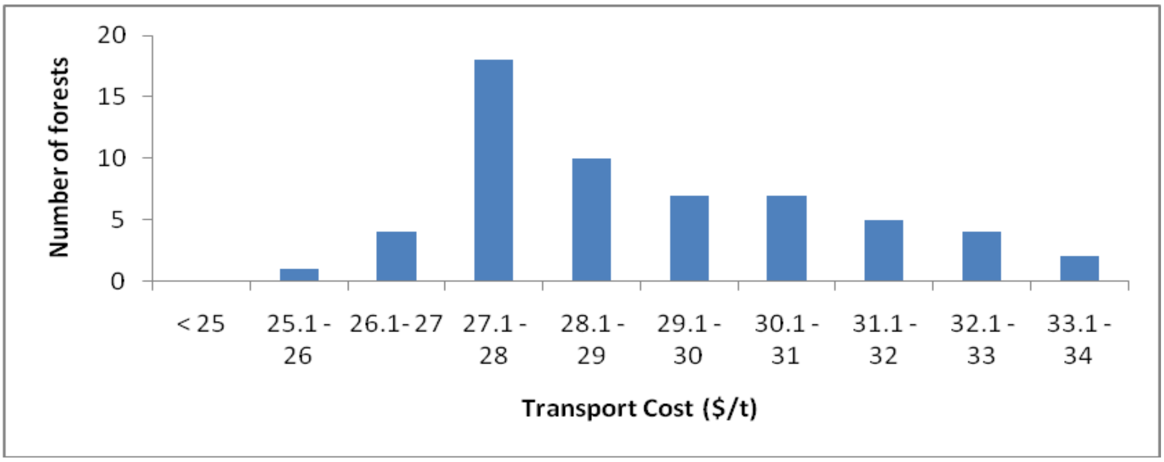

Figure 4.2.13. Histogram of Transport cost of sample forests

4.2.4. Total Costs at Harvest

The average total cost at harvest (assuming harvest at age 30 years) for the sample forests is $74 (median $71) per tonne of log production (Figure 4.2.14). The cost of most forests is within a range of $65 and $75/t, as a result of most common harvesting ($30-$40/t), roading (5-$10/t) and transport costs ($25-$30t). The two forests with the lowest total costs are those with minimum harvesting cost on flat terrain. On the other hand, the smallest sized estates that are located on remote steep terrain have the highest total costs at harvest due to both high roading and harvesting costs (Figure 4.2.15).

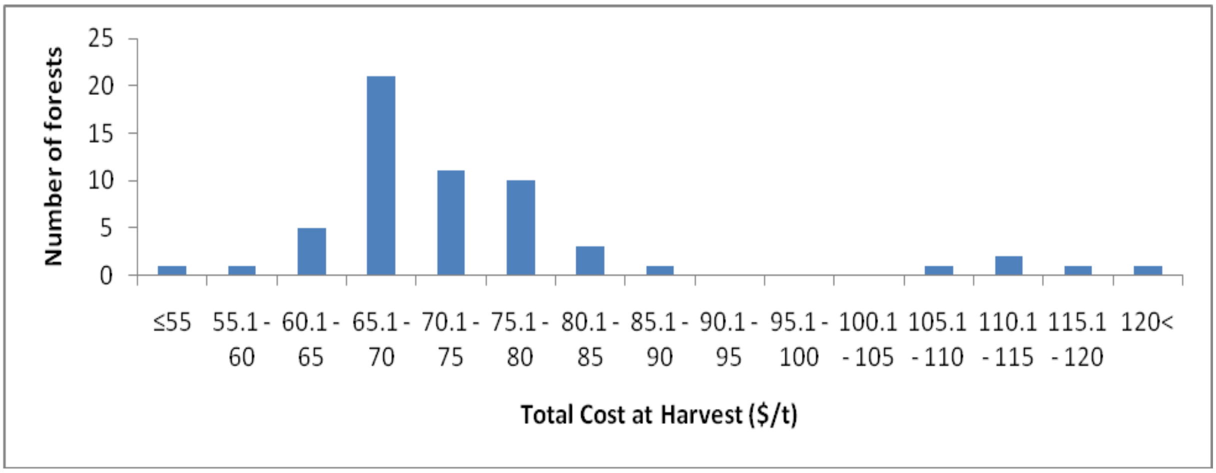

Figure 4.2.14. Histogram showing distribution of Total Costs at Harvest

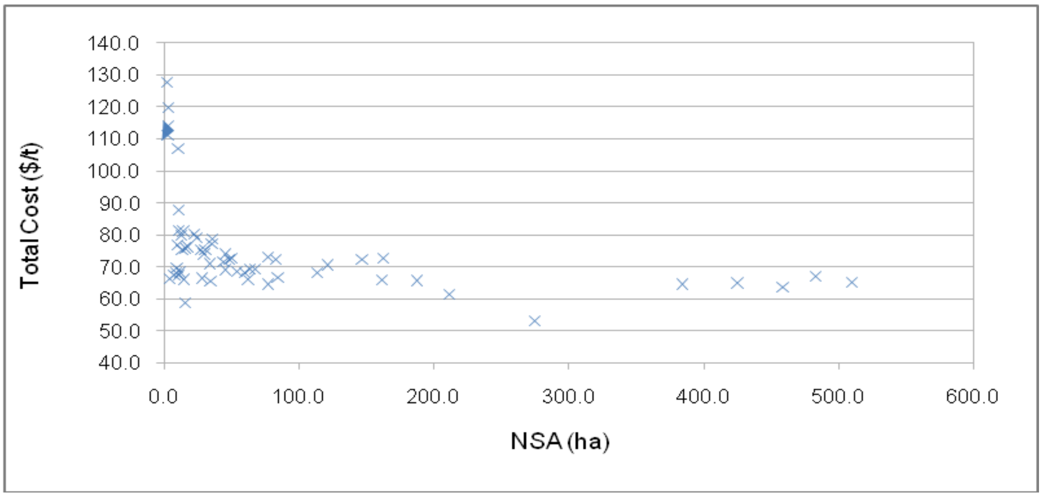

Figure 4.2.15. Total Cost at Harvest vs. NSA

Figure 4.2.16 shows the delivered cost-supply functions of small scale forests' wood production. The harvesting costs contribute the most to the total costs at harvest. The delivered cost curve indicates the percentage of small scale forest stands that would be profitable to harvest at a given average log price at the end of a 30 year rotation. For example, no forest would be profitable to harvest at an average log price under $50/t because of the delivered costs surpassing the price. Meanwhile, 90 % of the small scale forests would be profitable to harvest at an average log price of $80/t (Figure 4.2.16).

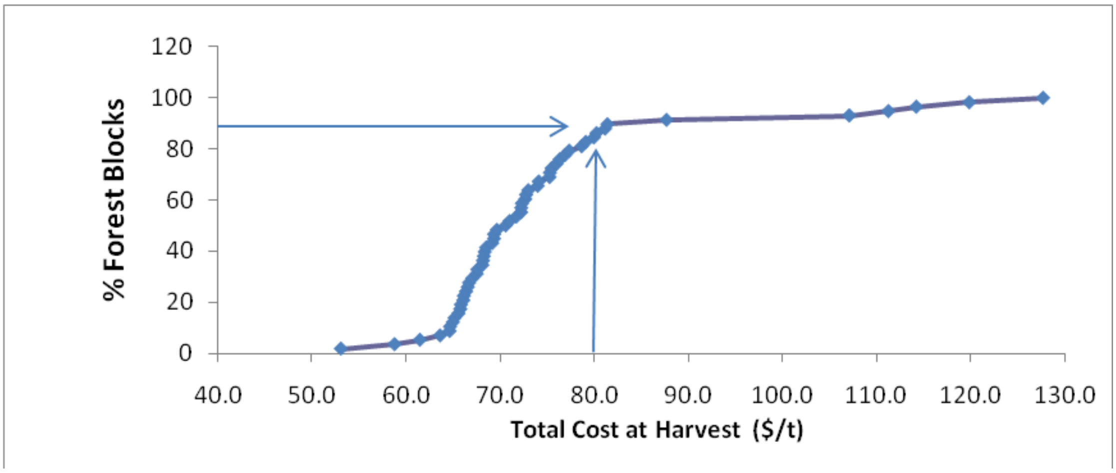

Figure 4.2.16. Total Delivered Wood Costs at Harvest of the 58 Sample forests at age 30 years

The total delivered cost curve shown in Figure 4.2.16 considers all 58 blocks together regardless of age and assumes a fixed rotation of 30 years. Although the stands may in practice be harvested in different years and at different ages it is indicative of cost distribution for the small-scale estate in the Wanganui District.

4.3. Economic Profitability of Harvesting Small Scale Forests

The proportion of the small-scale forests for which it is economically feasible to supply logs at the end of single 30-year rotation is observed. The economic feasibility is estimated through 1) stumpage calculation and 2) the historical rate of return on growing costs that a forest can achieve. The units used in this section are $\$/m^3$. The 1;1 factor is assumed between m^3 and tonnes – consequently the costs calculated in the previous section as $/t are assumed to be $\$/m^3$.

4.3.1. Stumpage Calculation

The stumpage value is an estimate of forest growers' return for standing timber ready for harvest. It is calculated for each sample forest by subtracting the delivered cost at harvest from the current average log price of $\$84.2/m^3$ at a rotation age of 30. Overall 52 sample forests (90% in number) out of the 58 sample forests' have positive stumpage values. The other 6 forests with negative stumpage values are very small in size or located on the most marginal sites. The average stumpage value of the sample forests is $\$10.3/m^3$ (median $\$13.7/m^3$) with a range between $-43.5 and $\$31.3/m^3$ (Figure 4.3.1).

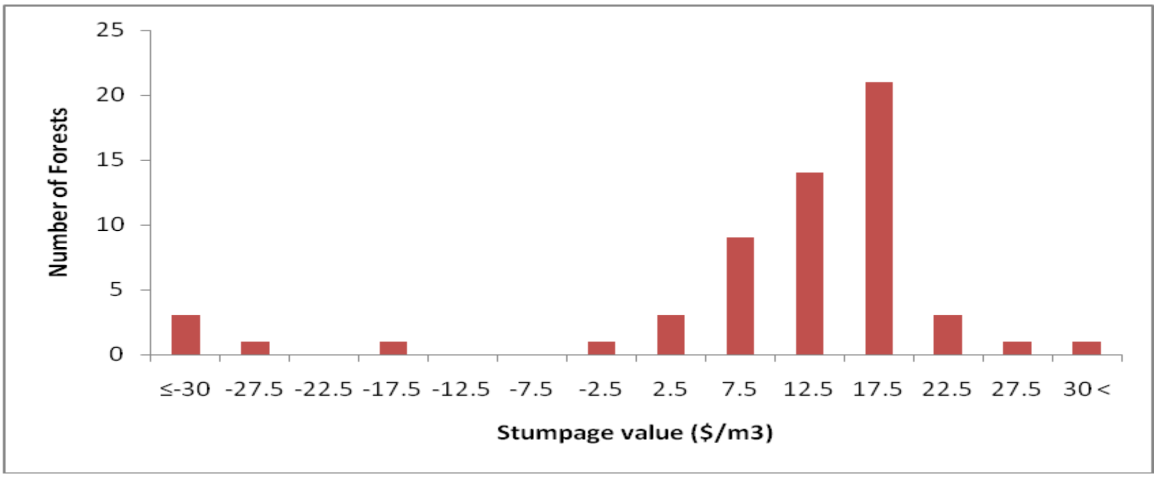

Figure 4.3.1.Histogram of stumpage values of the 58 sample forests

Figure 4.3.2 shows how much the current log price level has to change for the forests to be harvested with a breakeven stumpage value where the price of logs cancels out the cost at harvest. This curve directly reflects the cost curve in Figure 4.2.16 as an identical log value was applied for all forests. In developing the curve the total delivered wood cost for each of the 58 stands was expressed as a percentage of the average price of $84.2/m^3$.

At the September 2010 log prices, 90 % of the forests can generate positive stumpage values. If the average log price decreases by 15% ($71/m^3$), only 50% of the sample forests would have positive stumpage while a 52% increase ($128/m^3$) in the price would enable all sample forests to have positive stumpage at harvest including the most marginal forests.

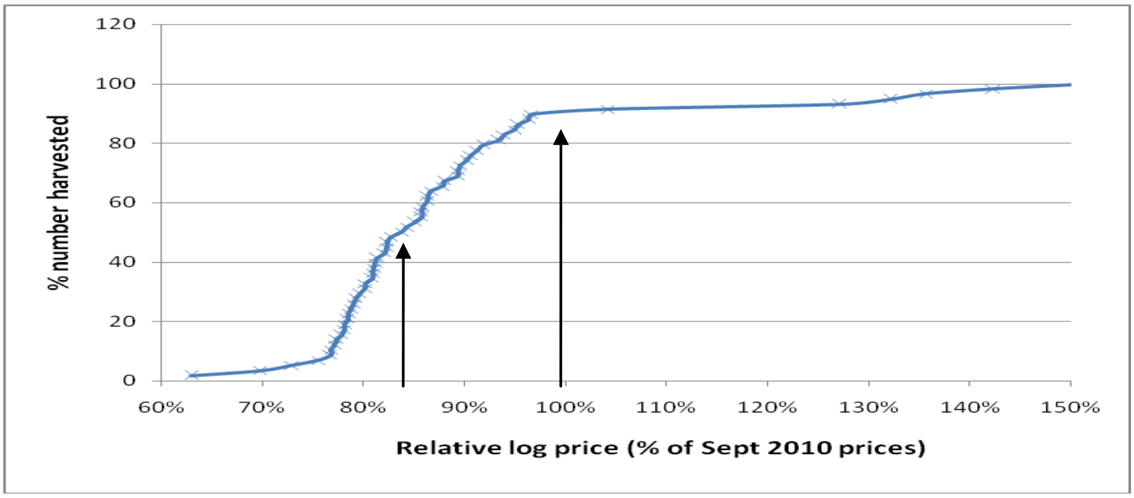

Figure 4.3.2. % Number of Forest that would be harvested at different % of current log price

4.3.2. Return on Growing Costs

Growing costs include all historical costs that have occurred before harvesting. The compounded value of silviculture, annual overhead, and rental costs (expressed on a $/m^3 basis) are cumulatively added to the delivered wood cost for each forest. This shows what the stumpage would need to be to give the grower a return on the historical costs incurred in the single rotation.

As Figure 4.3.3 suggests, none of the forests would achieve an 8% rate of return at the end of single rotation on any of the growing costs. This is with a harvest age of 30 and the average log price as at September 2010 ($84.2/m^3). The average log price has to cover the costs at harvest plus $48 per m^3 to achieve an 8% rate of return to the forest owners on the additional silviculture cost. This has to increase further by $9 (i.e. costs at harvest plus $57/m^3) for the net cost including additional overhead cost, and further $19 (i.e. costs at harvest plus $76/m^3) for the net cost including additional rental cost. With the current log prices and costs at harvest, the 8% return is not achievable for any small scale forest on any growing cost scenario.

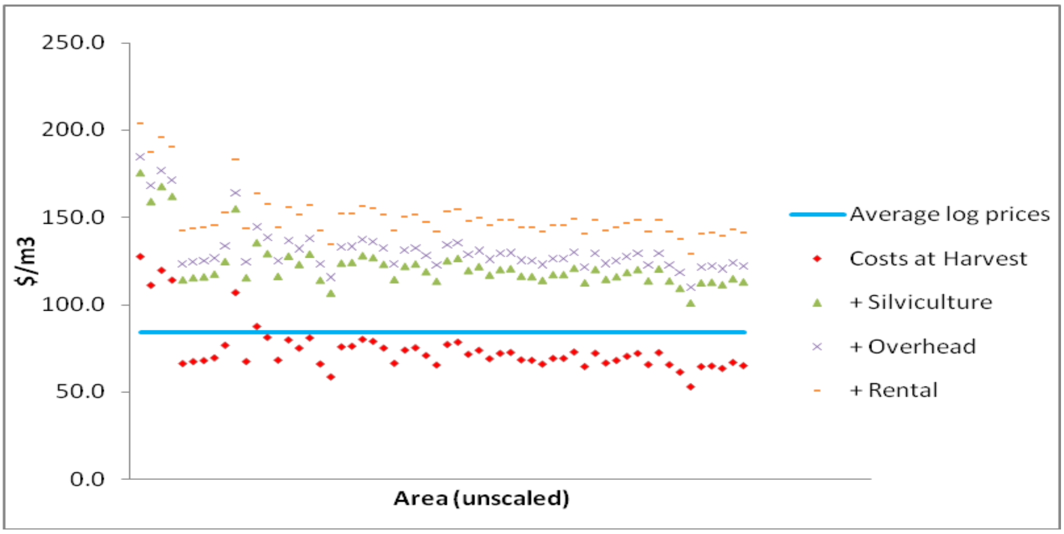

Figure 4.3.3. Comparison of the average Log prices and Costs (at 8% discount rate for growing costs)

Figure 4.3.4 and 4.3.5 show that lower rates of return cannot be achieved either on the full set of growing cost at current stumpage value. Table 4.3.1 shows the number of forests that would earn the given rates of return on each growing cost scenario. For example, 38 out of 58 forests would achieve a 2% rate of return on silviculture costs, and 29 forests would achieve 2% on both silviculture and overhead costs.

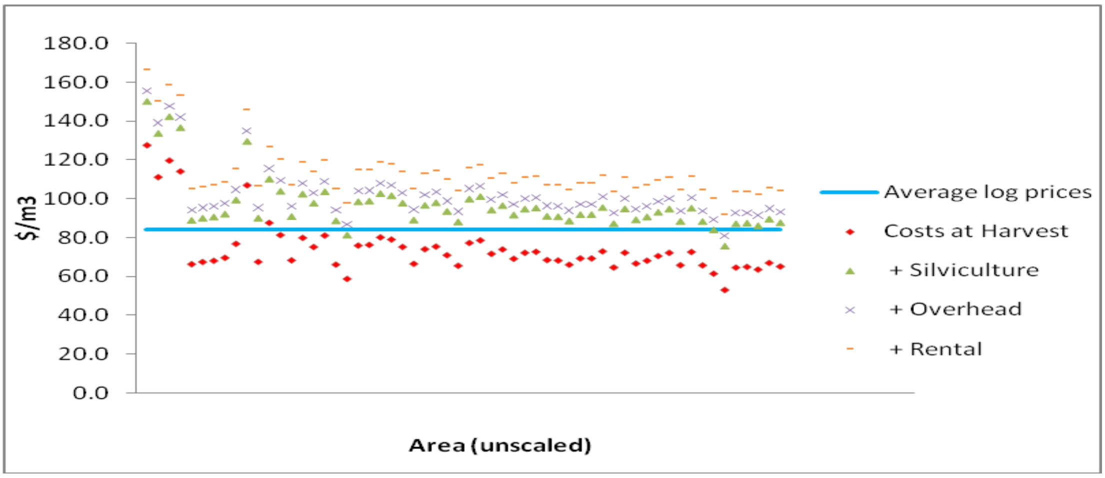

Figure 4.3.4 Comparison of the average Log prices and Costs (at 5% discount rate for growing costs)

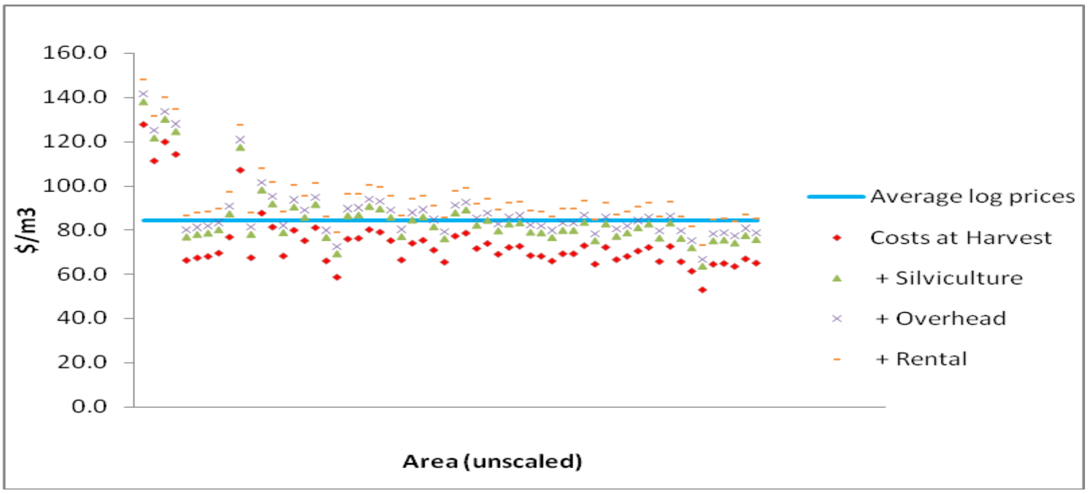

Figure 4.3.5 Comparison of the average Log prices and Costs (at 2% discount rate for growing costs)

Table 4.3.1. % of Forests economic to harvest at age 30

	Harv+Transport	+ Silviculture			+ Overhead			+ Rental		
Discount rate		2%	5%	8%	2%	5%	8%	2%	5%	8%
No. of forests	52	38	3	0	29	1	0	5	0	0
% Forest number	**89.7**	**65.5**	**3.4**	**0.0**	**3.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
% Forest area	**99.3**	**92.6**	**10.0**	**0.0**	**78.0**	**5.5**	**0.0**	**19.3**	**0.0**	**0.0**

An increase in log prices would further enable the forest owners to gain greater rates of return on the growing costs. At current log prices, only 5 forests can achieve a 2% rate of return on the full set of growing costs (Table 4.3.1). With a 22% and 44% increase in the average log price, 90% of the forests would achieve the rate of return of 2% and 5% respectively (Figure 4.3.6 & Figure 4.3.7). The average log price has to increase 90% to achieve an 8% rate of return on 90% of the forests.(Figure 4.3.8).

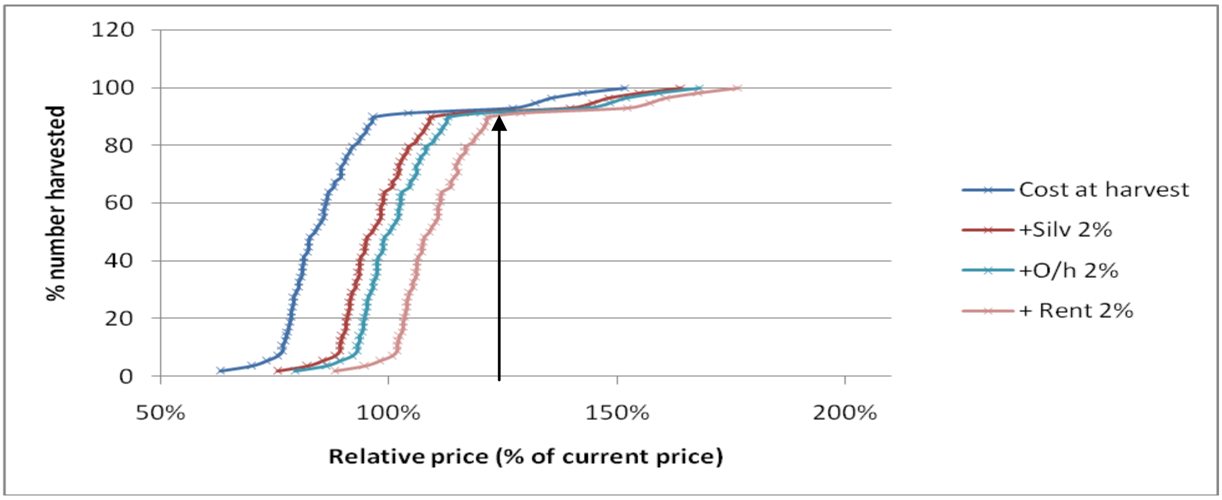

Figure 4.3.6.% Forest number harvested along Log prices levels at varying Cost Scenarios with 2% discount rate

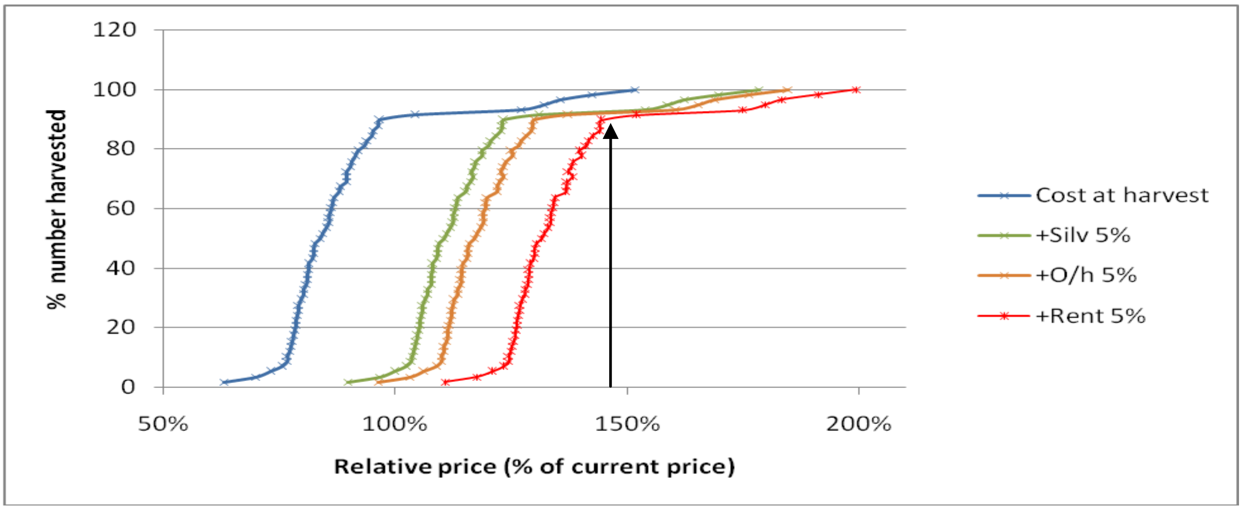

Figure 4.3.7 % Forest number harvested along Log prices levels at varying Cost Scenarios with 5% discount rate

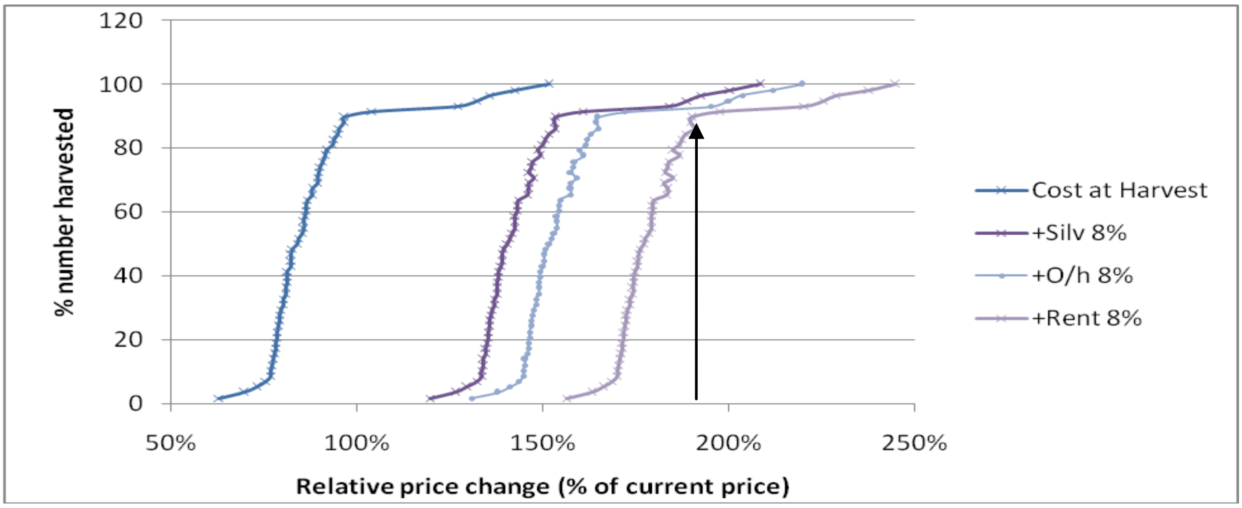

Figure 4.3.8 % Forest number harvested along Log prices levels at varying Cost Scenarios with 8% discount rate

4.3.3. Historical Rate of Return on Forestry

The historical rate of return (HRR) of each forest with three levels of growing costs on top of stumpage value are calculated to represent the historical profitability of the forestry at the end of single rotation. With silviculture cost only, there are 10 forests with negative HRRs. The other 48 forests generate a 3.3% rate of return on average. With the addition of overhead costs and land rental, the HRR of each forest decreases and more sample forests have negative profitability. With inclusion of overhead costs, 14 forests (24%) have a negative rate of return while the other 44 forests generate a 2.5% rate of return on average. With the additional rental cost, 27 (47%) forests have a negative rate of return and those forests with a positive rate of return (the other 53%) generally have rates less than 2% with an average of 1.4% (Figure 4.3.9 – 4.3.11).

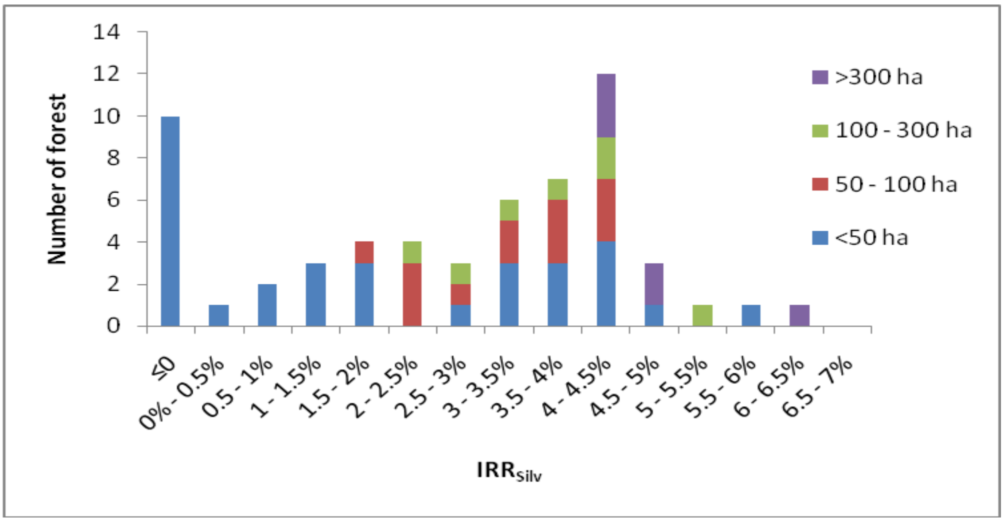

Figure 4.3.9.Histogram of HRR at age 30 when cost of silviculture was included

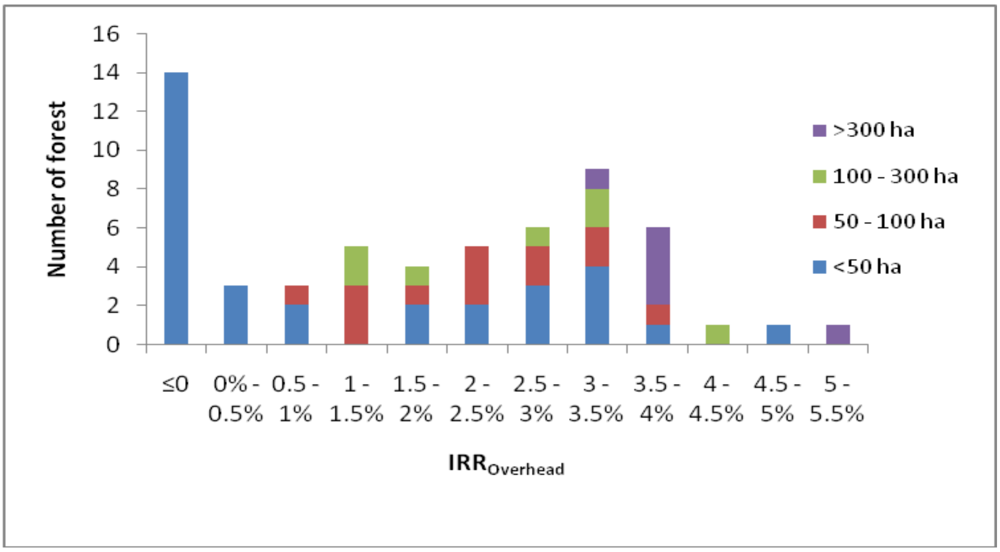

Figure 4.3.10 Histogram of HRR at age 30 when cost of silviculture and overhead were included

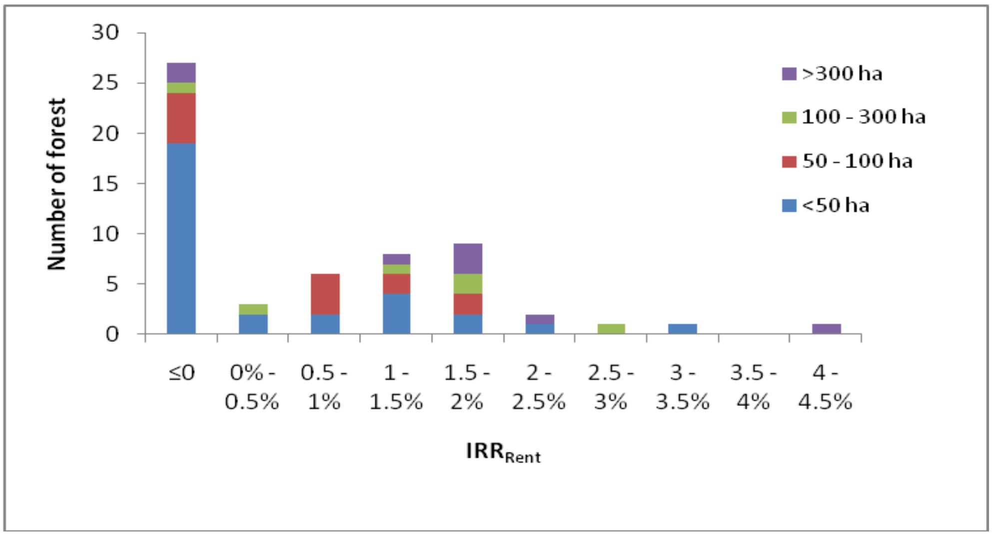

Figure 4.3.11 Histogram of HRR at age 30 when costs of silviculture, overhead, and rent were included

4.4. Valuation of the Existing Small Scale Forests

The valuation of small-scale forests is carried out by calculating a net present value (NPV) of each forest. The NPVs of all existing forests' timber production are estimated at optimum rotation age for each forest. This was then compared with the NPV and rotation age of the forests when carbon trading under the ETS is included.

4.4.1. Valuation of Existing Small-scale Forests- Traditional timber-production forestry only

The average NPV of existing forests is $575 per hectare with traditional production forestry land use with a range between $-2804/ha and $6852/ha at optimum harvesting age. The average optimum rotation age is 35. All except 3 forests have optimum rotation ages greater than 30. Some 15 forests (26%) have a negative NPV i.e. present value of costs exceeds the present value of revenue (Figure 4.4.1). One forest with an exceptionally high NPV compared to others is a large old stand (planted in 1983) with minimal cost at harvest. Figure 4.4.2 indicates how a longer rotation period is required for stands with high costs at harvest.

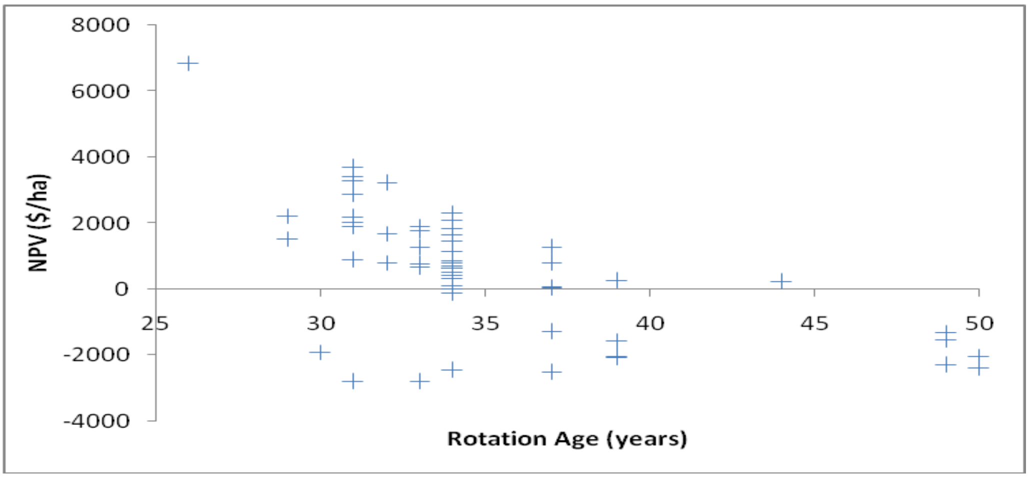

Figure 4.4.1 Net present value of 58 small-scale forests with optimum rotation age

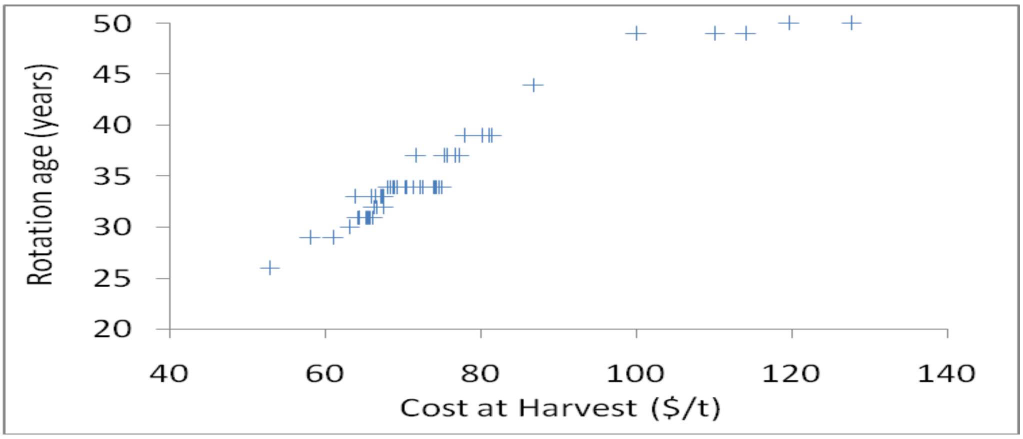

Figure 4.4.2 Optimum rotation age of forests vs. Cost at harvest

The value of the existing stands displays a negative relationship against optimal rotation age (Figure 4.4.1). As expected, younger stands i.e. stands of latest planting year have a lower value (Figure 4.4.4).

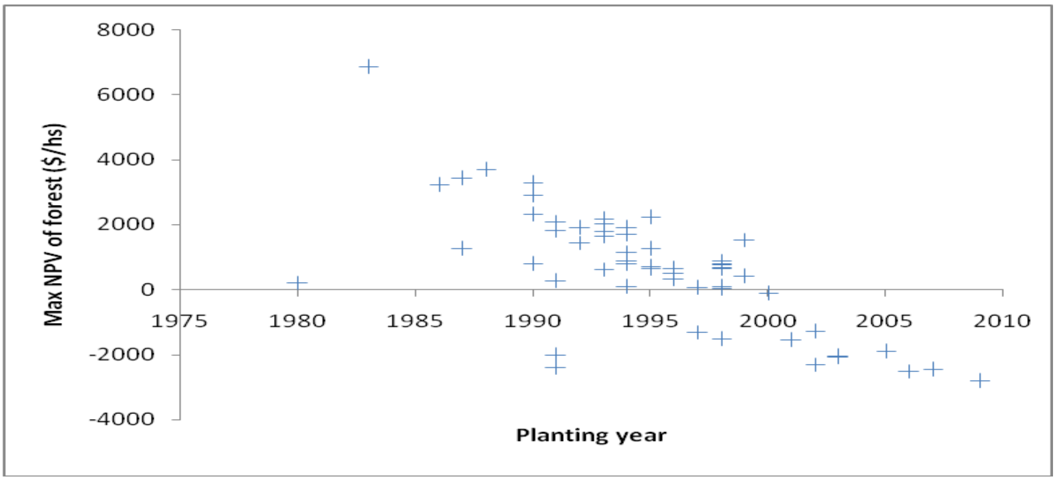

Figure 4.4.3. Maximum NPV of small-scale forests of varying planting years

4.4.2. Valuation of Existing Small scale Forests- with the ETS

Out of 58 sample forests, there are 27 forests (45%) that are currently eligible to enter the ETS. The implementation of the ETS results in an increase in both rotation age and profitability of the existing forests by a large amount. The average optimum rotation age shifts to 49, and all forests have positive NPV with an average value of $5609 per ha (Figure 4.4.5). The prolonged rotation age implies a delay in the peak period of future wood supply. However this also depends on the forest owner's intention to harvest and the risk in prolonging the rotation and decision making based on those risks.

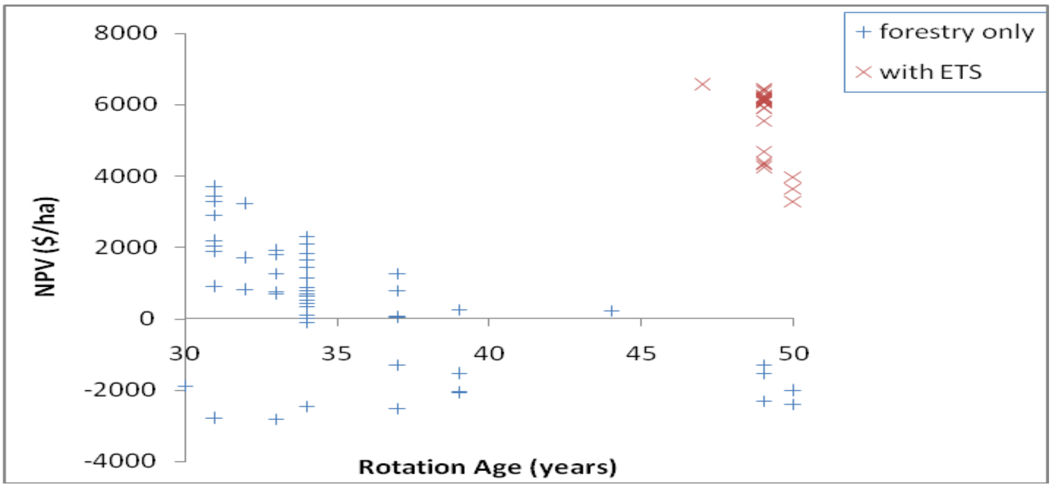

Figure 4.4.4. Comparison of Existing Post-89 stands' NPVs and Rotation age (traditional forestry vs. with ETS)

The benefit of ETS is greater on younger stands than on the stands planted in early 1990s. This is because much of the carbon sequestration (i.e. before 2008) has already taken place without monetary payment for older post-89 forests (Figure 4.4.6).

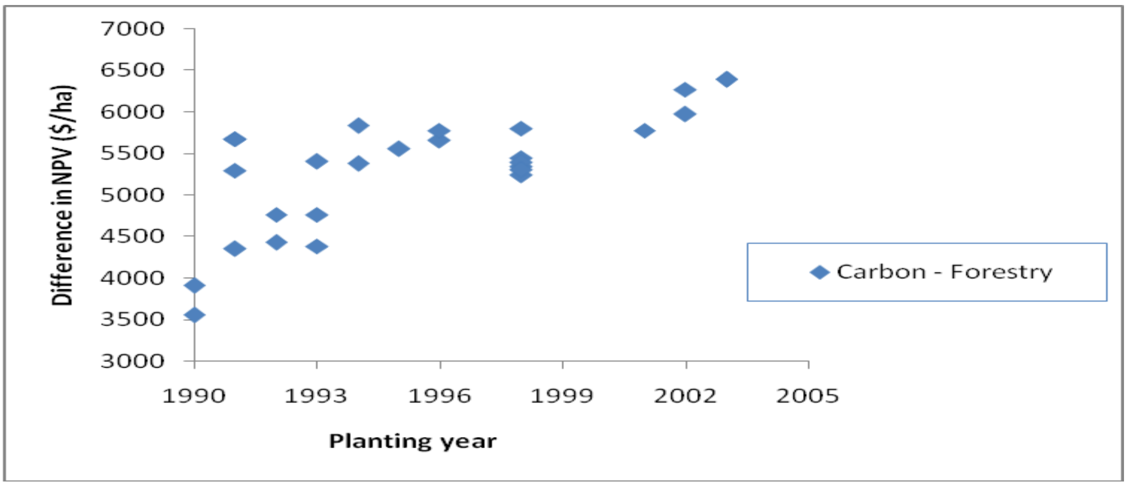

Figure 4.4.5. The benefit of ETS on existing post-89 forests of varying planting years

4.5. The profitability of New Planting

4.5.1. The Effect of the ETS on New planting NPV

NPV analysis was carried out for all 58 stands, assuming that all forests are new stands to be planted on a land which has a value of $1000/ha- the land rental of $80/ha/year that the forest growers would theoretically pay in perpetuity is capitalised to this land value. With traditional forestry, the maximum NPV of all forests is below zero with an average value of $-3092 at an optimum rotation age occurring between 30 and 40 years for most forests (Figure 4.5.1). The negative NPVs indicate that forestry production alone cannot achieve an 8% rate of return on the investment in the forest land.

With ETS implementation, the value and rotation age of the forests increases by $5063 per hectare and 13 years on average. The forests are now valued $1972 per hectare on average (in addition to the capitalised land rental value of $1000/ha) at an 8% discount rate with a rotation age of 48 years. The implication of this is that investors can pay up to $2972 per ha on average for the land and still achieve 8% rate of return. In both traditional and carbon forestry, forests with low cost at harvest have a shorter rotation age, with an older rotation age and lower NPV for the most marginal forests with high cost. However the effect of harvest cost on the NPV is lower in carbon forestry as indicated by little variation among the NPVs of different forests (Figure 4.5.1 & 4.5.2).

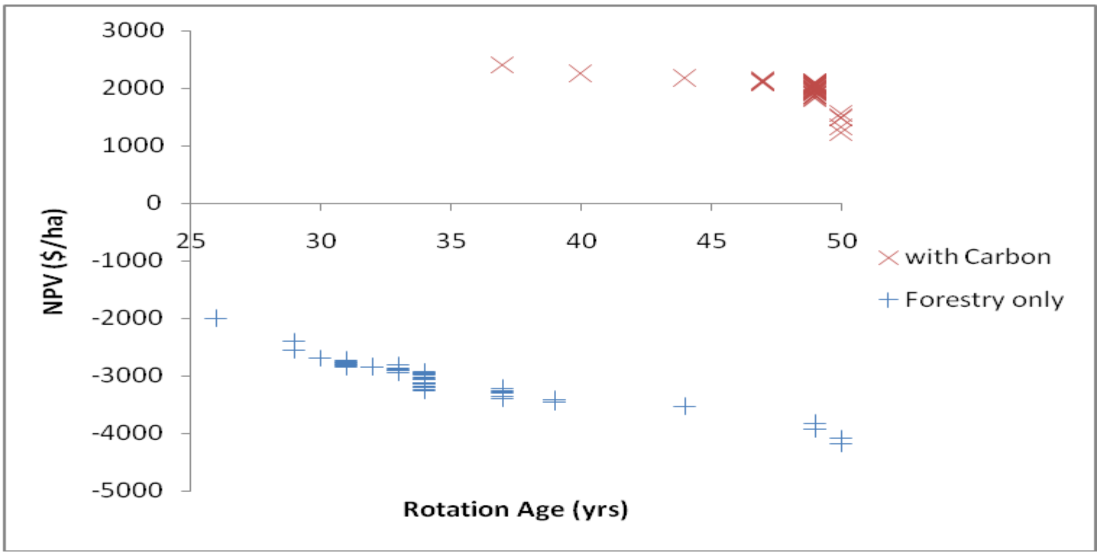

Figure 4.5.1. Optimum Rotation age vs. maximum Net Present Value of 58 sample forests

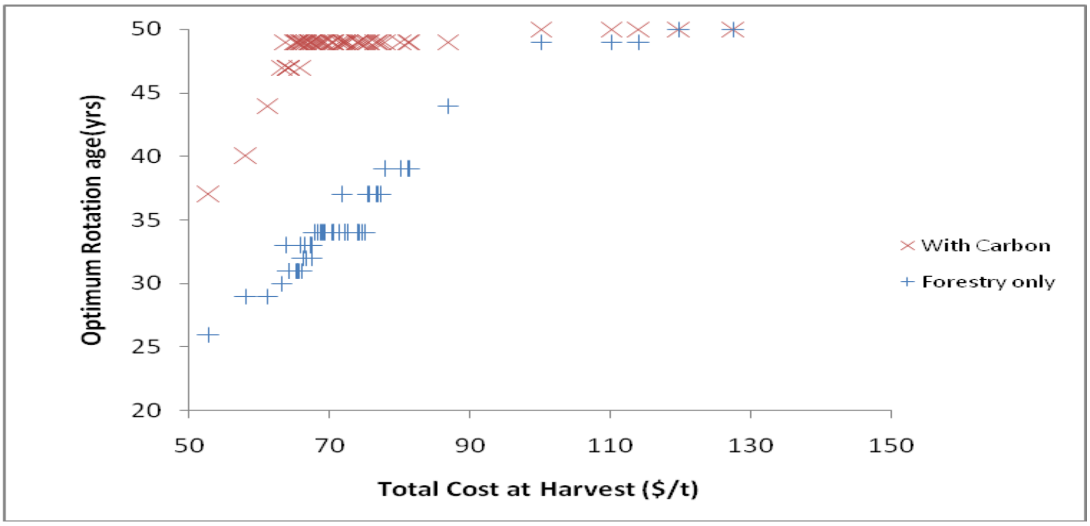

Figure 4.5.2. Total Costs at harvest vs. Optimum Rotation age of the sample forests

4.5.2. Effect of ETS on Forestry Rate of Return

The internal rate of return (IRR) of each forest is calculated to represent the profitability of forestry with and without the ETS. If the IRR of the forest is smaller than what investors desire i.e. minimum acceptable rate of return (MAR), the investors would not opt into the forestry investment and would invest in an alternative investment. Assuming that all stands are new planting, the IRR on forestry investment is calculated, firstly at a fixed rotation age of 30 year (IRR30) and secondly at the optimum rotation age (optimal IRR).

Under traditional forestry at a fixed rotation age of 30, all forests' IRRs are less than 8% including 13 forests with negative IRRs i.e. negative return on investment. The other 45 forests have an average IRR of 2.8%, ranging from 0.2% to 5.0%. With the inclusion of the ETS, all except 5 forests are able to achieve a positive rate of return with an average IRR30 of 13.3%.

The 5 forests with negative IRR have the highest costs at harvest and are of small area (Figure 4.5.3 & 4.5.4). The traditional forestry IRR30 of each forest in this analysis is higher than the historical rate of return calculated in section 4.3.3 which was also calculated at fixed rotation age of 30. This is mainly due to the difference in calculation procedures. While the section 4.3 estimates are the rate of return at the end of current rotation, here the IRR is the return of the forestry land-use in perpetuity.

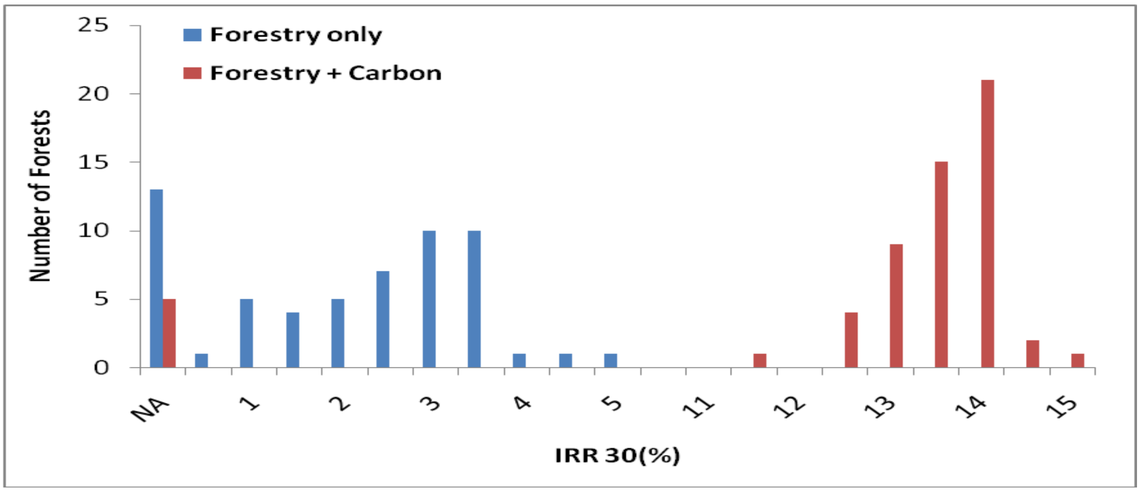

Figure 4.5.3. Internal Rate of Return at age 30 years in NPV analysis

Figure 4.5.4 shows that the IRR has a negative correlation with the cost at harvest, i.e. forests with high costs at harvest have a lower rate of return. For the forests with a harvest cost of less than \$90/t, the gradient of this correlation flattens slightly with an addition of carbon cashflows. This indicates that the ETS revenue offsets the effect of the harvest cost in profitability of the forests. However, 5 forests with the highest cost values remain unprofitable even with the ETS.

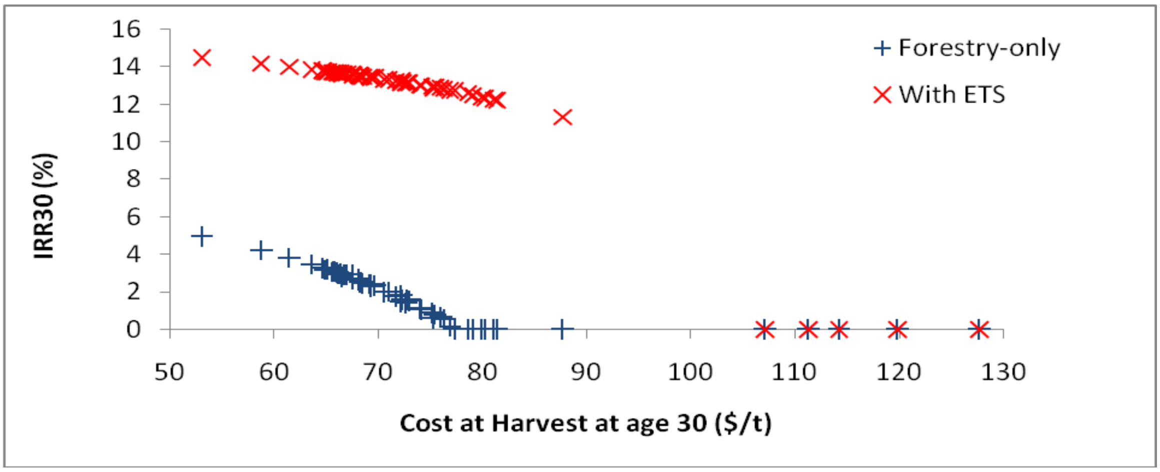

Figure 4.5.4. Correlation between IRR30 and Cost at Harvest at age 30

With varying optimum rotation ages, the average traditional forestry IRR remains at 2.8%. However, the median value is higher than for a fixed age 30 year rotation with more forests concentrated around 3- 3.5%. Although the traditional forestry cashflows still cannot achieve desired rate of return of 8% in any of the sample forests, harvesting at an optimum rotation age enables more forests to earn a positive rate of return (Figure 4.5.5). The optimum rotation age of many sample forests is greater than 30, with an average rotation age of 35.

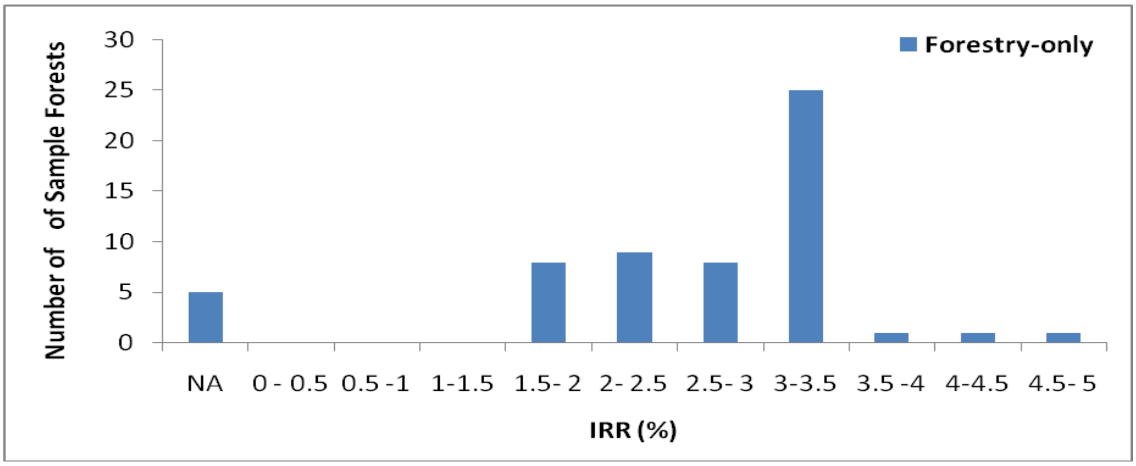

Figure 4.5.5. Histogram of IRR at optimum rotation age for sample forests, considering traditional forestry cashflows only

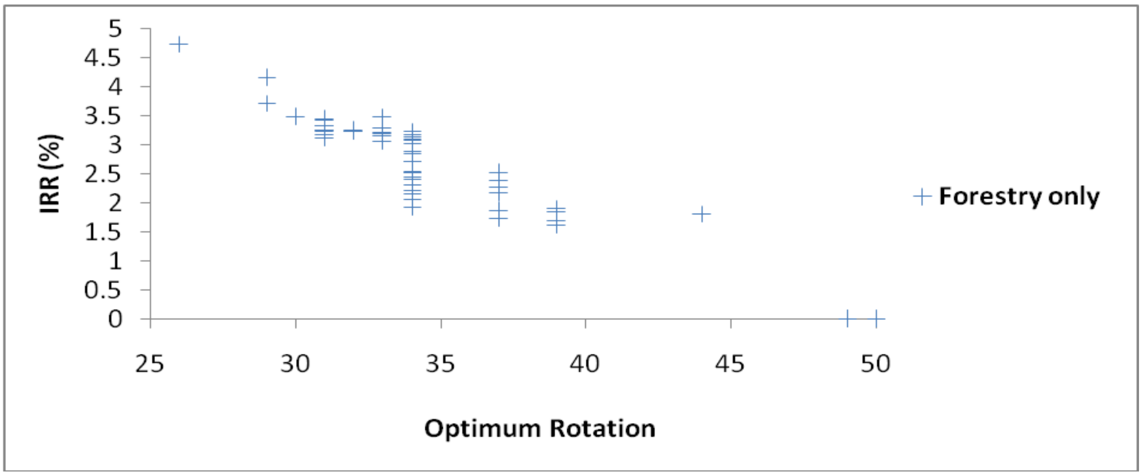

Figure 4.5.6. Correlation between the sample forests' IRR on traditional forest investment and Optimum rotation

The ETS results in a large increase in IRRs for all forests in such a way that all forests earn a similar rate of return within a range between 13.7% and 14.4%, with an average value of 14% (Figure 4.5.7 & 4.5.8). Note that no forest has a negative rate of return with carbon cashflows. This shows how the ETS adds a significant revenue stream to the forest growers, offsetting the negative effects of challenging topography and low stumpage value on the profitability of the forests. The optimum rotation of the carbon forests differ little between forests around the average age of 48 compared to traditional forestry with varying rotation ages (Figure 4.5.9). While the optimum rotation age of traditional forestry is determined by log sale revenues and costs, carbon cashflows add value to the growth of forests to an extent that the harvest time is delayed substantially for all forests regardless of the different profitability status of log production.

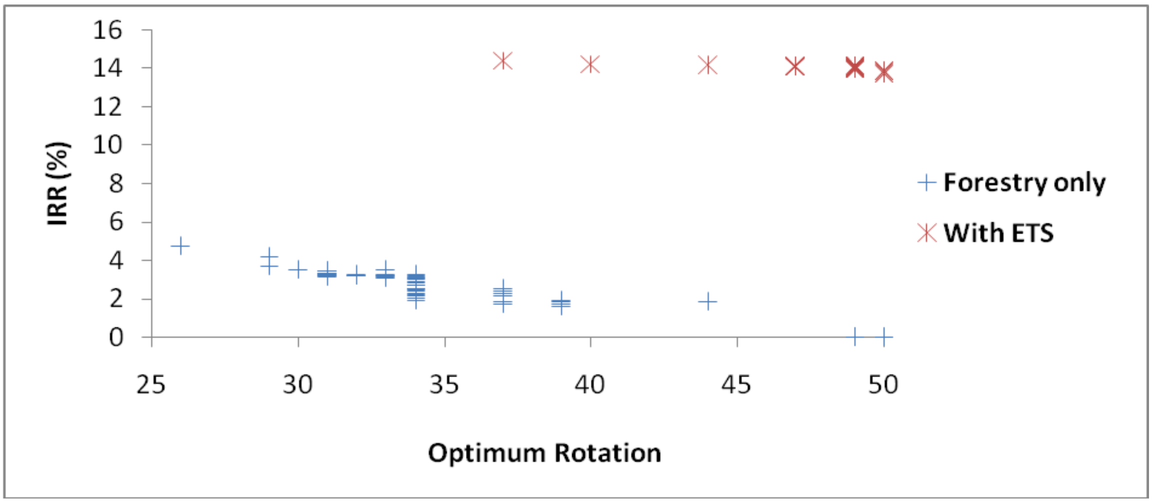

Figure 4.5.7. The effect of ETS on IRR of forests

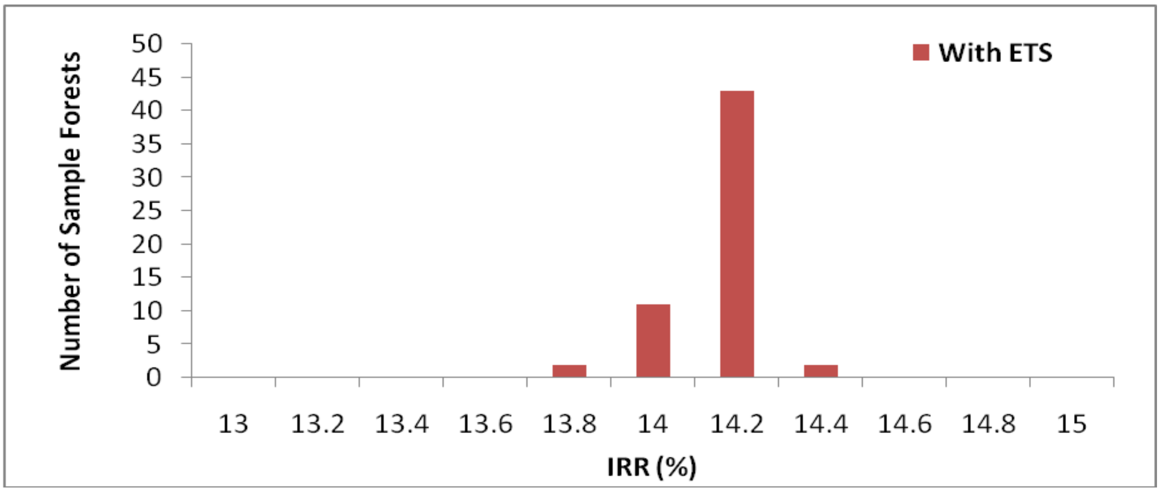

Figure 4.5.8. Histogram of IRR for sample forests, considering timber production and Carbon credit NPV

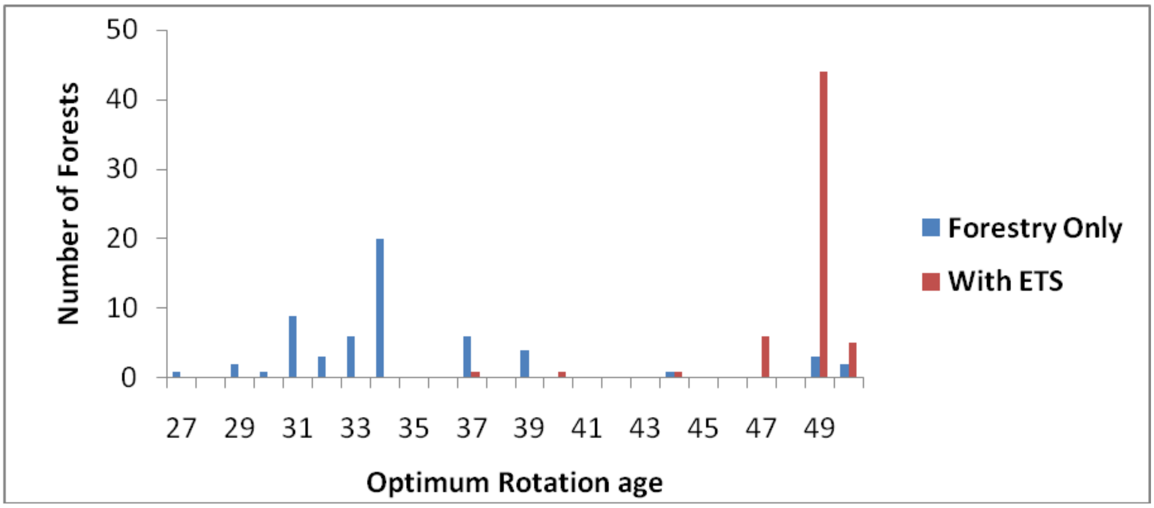

Figure 4.5.9 Histogram of Optimum Rotation age of Sample forests

CHAPTER 5 : CONCLUSIONS and DISCUSSION

5.1. Conclusions

5.1.1. Economic Availability of the Forests at age 30

At a fixed rotation age of 30 years, 90% of the small-scale forest area in the Wanganui District is economically available for harvest given the average log prices for the 3 years to September 2010. These forests have a positive stumpage value. Overall stumpage values are low with an average value of $\$10.3/m^3$. The cost of harvesting is the biggest driving factor behind the stumpage value of the forest and it determines the shape of the delivered cost curve.

Increasing stumpage prices, either from increasing log prices or decreasing transportation costs would increase the percentage of small-scale forests that are economically available for harvest. However it would take a 52% increase in at-market log prices for 100% of forests to be economically available. Most of the forests with negative stumpage values have values of -$15/m3 or worse. They are generally very small forests on difficult steep terrain with high harvesting and roading costs. In reality these forests may never be harvested.

5.1.2. Rate of return on historical investment at harvest age of 30

If only silvicultural costs are considered, 17% of the small-scale forests will make a negative rate of return if harvested at age 30 years. The other 83% of forests will have achieved a historical rate of return of 3.3% on average.

If allowance is also made for overhead costs and land rental, 47% of the small-scale forests will make a negative rate of return if harvested at age 30 years. The other 53% of forests will have achieved a historical rate of return of 1.4% on average. The main reasons for the relatively low rates of return are the impact of slope on harvesting cost and the impact of transport distance on transport cost.

5.1.3. Valuation of existing forests and profitability of new forests

The majority of the small-scale forests have a positive value with the optimum rotation age. The NPV of most existing forests is maximised at a harvest age exceeding 30 years with an average of 35 years. The optimum rotation age increases, and NPV decreases, with increasing harvesting cost. Harvesting at the optimal harvest age enables 74% of the existing forests to have a positive NPV with an average value of $575/ha at a discount rate of 8%. Those with a negative value include the forests with a negative stumpage value and other forests for which the positive stumpage value will not cover ongoing costs until harvest. As expected, the estimated value increases with forest age.

The use of 8% discount rate in this study is considered to be reasonable as a series of surveys of the discount rates by practitioners in New Zealand show – the average discount rate applied to pre-tax cashflows was 9.0 % in the 2007 survey, and 8.6% in the 2009 survey (Manley, 2007 & Manley, 2010).

The sample of 58 stands can be used as an indicator of the profitability of traditional forestry in the Wanganui District. The sample forests indicate that new land planting would be profitable for 91% of the small-scale forests in the Wanganui District. The unprofitable 9% are those blocks with negative stumpage at all rotation ages in the range of 20 to 50 years.
The small-scale forests that can generate a positive rate of return on investment have an average rate of 2.8% and an average optimum rotation age of 35 years.

5.1.4. Effect of the ETS

The ETS has a major impact on the NPV of the existing forests. With entry into the ETS by owners, all eligible post-1989 forests can achieve an 8% rate of return or higher with much greater NPVs compared to NPVs for traditional forestry cashflows. The ETS encourages forests to be harvested at older ages by adding monetary value to the forests during the growth period. The impact of the ETS on NPV is greater on younger forests because carbon sequestered prior to 2008 is not recognised.

Rotation age and NPV vary relatively little across the forests in the region as the greater NPV of carbon cashflows for younger stands offset the lower forestry NPV for these stands. The results from this study indicate an average NPV of $5609/ha at an 8% discount rate. Average optimum rotation increases to 49 years.

The ETS also has a major impact on the IRR of new planting. With carbon cashflows included, the average IRR is 14%. With the ETS, investors can afford to pay up to $2972/ha for the land on average with a required rate of return of 8%. This would make forestry a competitive land-use on marginal land.

The average optimum rotation age for carbon forests is 48 years. This implies a significant delay in the peak wood supply period compared to the SNI Wood Availability Forecasts where the maximum rotation age of small scale forests is approximately 40 years. It should also noted that the spreadsheet model used for this study only goes up to age 50 Which is the optimum rotation age calculated for some forests. This implies that some forests will be harvested at even longer rotations or may not even be harvested with the ETS, causing a significant gap between potentially available wood resource and the actual wood supply.

However, the actual wood supply from carbon forests will depend on the forest owners' harvest intention and perception towards the risks of ETS and other factors associated with prolonged rotation. For example, a forest owner may decide to harvest at an earlier age than the optimum rotation age to avoid the risk of carbon market failure or unpredictable natural hazards.

5.1.5. Comparison of model results with other studies

Delivered cost at harvest

The estimates of the costs at harvest in this analysis include the cost of harvesting, roading, and transporting. Harvesting cost contributes the most to the total cost at harvest. The harvesting cost of forests ranges from \$21 to \$56 per tonne, but is mostly between \$30 and \$40 per tonne, giving an average value of \$35.4 per tonne. The roading cost of the forests ranges from \$5 to \$47 per tonne but mostly concentrated below \$15, giving an average value of \$9.3 per tonne. A few extreme outliers of the harvesting and roading costs belong to the small size forests that are often on steep terrain. The average transport cost from the forests to all potential markets (mills and ports) is \$29 per tonne and the cost of all forests ranges from \$25 to \$34 per tonne.

Neilson (2010) presented the typical cost range to be \$22 to \$32 per m^3 for harvesting, \$4 to \$6 per m^3 for roading, and \$15 to \$23 per m^3 for transporting. These values were estimated for an intensively managed pruned log regime in 2009. Evison (2008b) collected forestry costs from industry sources and noted the logging/loading (i.e. harvesting plus roading) costs to be \$36 per m^3 and transport cost to be \$21 per m^3.

The modelled costs in this analysis are generally higher than those presented by Neilson (2010) and Evison (2008b). The main reason for the difference is because this study focuses on the costs of the small-scale forests while the others obtained the cost values of the forestry industry in general. The small-scale forests are often located on more marginal land than the typical production forests and are less efficient at harvest due to size of the blocks.

Profitability of forestry

Neilson (2010) summarised typical rates of return (IRR) for radiata pine since the mid-1990s. The IRR was estimated to be 4% and 4.4% for structural sawlog and pruned sawlog regimes respectively in 2009. There was a consistent decreasing trend in IRR returns over the last 17 years. Meanwhile, Liley (2010) analysed the IRR for a large number of forestry investments in New Zealand and estimated an average of 5.8%, with a range from 3.2 to 8.2%. The estimates of IRR collected in the survey carried out by Manley (2010) ranged from 1 to 7% pre tax. This survey noted that the estimated IRR is typically less than the discount rate used for the forest valuation. Manley and Maclaren (in press) estimated a land expectation value (LEV) of $1223/ha for the profitability of a traditional forestry with a clearwood regime.

In this study, the NPV of small-scale production forestry is estimated to be -$3092 per hectare on average, with an 8% discount rate. The profitability of forestry investment is low as indicated by negative NPVs for all sample forests when considered as new plantings. The profitability as represented by IRR of production forestry based on the estimated costs ranges from 1.6 to 4.7% (2.8% on average) along with 5 forests with negative profitability due to extremely high production costs. This is very close to the estimate of Evison (2008b) that compared the profitability of rural land uses using IRR as a measure and calculated the IRR for forestry to be 2.7% for a typical pruned regime. This implies that the profitability of small scale forest production is between high-return land uses such as dairy farming and low-return land uses such as sheep and beef farming.

Impact of the ETS

With the ETS, the value of existing forests increases significantly, giving increases in NPV ranging from $3281 to $6552 per hectare and adding $5325 to the traditional forestry NPV on average. The optimum rotation age of traditional production forests ranges from 26 to 50, with an average harvest age of 35. With the ETS, the average rotation age increases to 49 years, with a narrow range of 47 and 50.

The new-planting carbon forestry investor would be able to afford to pay $2972 per hectare on average for the land while still achieving 8% return or more. This is $6064 per hectare higher than the traditional forestry LEV of -$3092 per hectare. .

Evison (2008a) has estimated that an additional NPV of $6442 per hectare would be generated by the ETS. The LEV of forestry increases by $5424/ha with the addition of carbon cashflows according to Manley and Maclaren (in press). The estimates of the NPV of carbon forestry in both studies are similar to the estimated values in this study regardless of different assumptions made on carbon price and discount rate. While this study assumed $20per t CO_2 for the carbon price, Evison (2008a), Manley and Maclaren (in press), and Maclaren et al. (2008) assumed the carbon price to be $30 per t CO_2. Evison (2008a) made assumptions of 7% discount rate and a fixed rotation age of 30 years for the NPV while other two studies estimated the maximum LEV with the same discount rate as this study (8%).

On the other hand, the estimated change in rotation length is greater in this study. Manley and Maclaren (in press) estimated that the rotation would increase by 6 years from 24 to 30 years by addition of carbon cashflows to forestry, while Maclaren et al. (2008) estimated an increase of 11 years from 25 to 36 years for a framing regime. The results from this study indicate a greater increase in rotation age with a 13 year increase from 35 to 48 years on average. It should be noted that the maximum rotation age in the model was 50, indicating that some forest growers may prefer to leave the stands unharvested.

5.1.6. Modelling Approach

The delivered cost modelling approach used in this study follows similar methodology to some bioenergy studies that produced a cost-supply curve of the biofuel resources from forests over time. However this study differs in using forests of different ages to indicate the supply of the small-scale forest resources as a portion of the total available amount regardless of the time of availability; i.e. it does not look at the likely supply in any specific year but uses a sample of stands to indicate the overall proportion of the small-scale resource that is likely to be economic to harvest. In addition this study analyses the profitability of each forest by measuring the NPV of current and future forests, and internal rate of return.

Microsoft Excel is used for the most parts of the cost model analysis. Other software systems such as forest growth models (e.g. Radiata Pine Calculator) and GIS are used to give inputs. The previously developed MAF (2009) look-up table provide the input for regional forest carbon stocks. These enable the analysis to be specific to a particular region or area of interest. GIS combined with the forest modelling improves the estimation of the costs by taking account of spatial aspects such as slope and transport distance to the mills. Outputs from the analyses provide information that can be useful for decision makers regarding whether the forests should be harvested, when the rotation age for the traditional and carbon forestry should be, and whether the forest owner should enter the ETS. It also provides indicative results about costs and profitability of the wood production from the forests, and overall the economic wood availability from the small scale forests in a region.

5.2. Implications of the Conclusions

The results of the economic analysis at a fixed rotation of 30 years correspond to scenarios 1 and 2 in the SNI wood availability forecast. As stated in MAF (2009) these scenarios are not practical because arising "Fluctuations of this magnitude …would be impractical because of marketing and logistics realities (immediate availability of logging crews, transport capacity, and wood processing capacity)." The fluctuations would arise from harvesting the large area planted in the a990s at a fixed age. This study has indicated that the SNI wood availability forecast based on scenario 1 and 2 is not likely to occur because the economically optimum harvest age is older than 30 years for small scale forests at least in the Wanganui District.

Results from this study support the feasibility of scenario 4 in the forecast where the rotation age of the small scale forests is often older than 30 years. However they indicate that only 90% of small-scale stands in the Wanganui District will be economic to harvest. The data for SNI wood availability forecast had the area of the small-scale estate reduced by 15% as part of the process. However this reduction was done because "the area in this ownership category is often reported on the basis of gross area rather than net stocked area." The reduction of 10% suggested by this study would be in addition to this 15% area reduction.

The introduction of the ETS has the potential to significantly improve profitability and competitiveness of forestry as a land use. However the prolonged rotation age indicates that the increase in wood availability anticipated from the small-scale estate will be delayed. The risks associated with political uncertainties, the carbon market, and significant natural disasters may mean that forest owners do not extend rotations to the extent indicated by this study. Nevertheless the study indicates that scenario 3 in the SNI wood availability forecasts may be relevant. This scenario was based on non-declining yield of the total estate. It was qualified as 'it results in the small-scale owners' estate being harvested at rotation ages that differ markedly from 30 years, approaching 40 by 2035." This study indicates that it could in fact be a realistic scenario.

5.3. Implications of the Assumptions

Forest Productivity

It was assumed that all forests are equally productive and produce the same types and proportion of log grades under the same silviculture regime. Log sale revenues, growing costs and optimum rotation age all depend on this assumption. Although the site productivity and production would vary in reality, it is considered to be an appropriate assumption for such a broad-level analysis on the small scale forests.

Overhead costs and land rentals

An annual overhead cost of $40 per ha per year and a land rental of $80 per ha per year have been applied to all forests. Actual costs will vary between blocks. On freehold land there will be no land rental. In this case the land rental represents a notional payment and reflects the opportunity cost of the land. Removal of these costs would mean, for example, that some of the forests for which a negative NPV was calculated would have a positive value.

Transport costs

The high transport costs calculated in this analysis have a major impact on the calculation of stumpage, NPV and IRR. The average transport distance of 140km is high by New Zealand standards and reflects the long distance to export log ports as well as the limited processing capacity in the region. With an increase in harvest volumes it might be expected that there will be additional processing capacity developed in the region and that transport costs would decrease.

5.4. Areas for further research

A number of areas where further research is necessary were identified. Key areas for further research are detailed in this section

5.4.1. Time of Supply

This study estimated the proportion of the total amount of potential small forest resources in the region that is economically available. Based on the delivered costs of each forest at harvest, the cost-supply function is produced but without consideration of the time of such supply. Therefore, further analyses should be done to create the cost-supply function across time so that the results would be parallel to the existing SNI wood availability forecast.

5.4.2. Harvesting costs

The Visser harvest cost model is based largely on data from harvesting operations in large-scale owners' forests. The model does have area as an input but may not accurately estimate harvesting costs for small blocks, particularly non-contiguous blocks. Further work is being undertaken (Berkett et al.; pers comm.) to validate the model using date from harvesting operations in the small-scale estate.

5.4.3. Roading cost

There is lack of data defining public and private road. For this study, all sealed and metalled roads were assumed to be public roads that would be maintained by the government body rather than by the forest owners. However, this assumption may not be realistic and therefore further information is required on the ownership of the road and how much the forest owners are responsible for.

5.4.4. Transport cost

This study used the average distance from each forest to all log destinations (mills or ports) in calculating the transport cost. The transport cost in real life may be significantly different if the logs get transported to specific destinations based on the distance from the forest. Therefore, the information on actual log destinations from each forest needs to be updated. The transport route also needs to take into account the urban roads that forestry trucks are prohibited to go through.

5.4.5 Small forest owners' objectives

This study assumes that the objective of small-scale forest owners' is profit maximisation and that the wood resources would be available for wood supply at the estimated optimum rotation age. A more accurate estimate of the extent and timing of wood supply would depend on the owners' intentions for their forests. For example, the owners may have non-monetary objectives behind the forest planting. For carbon forestry, the forest owners' decision on harvesting would depend on their perception towards the risks of the ETS and other factors such as natural hazards. Therefore further studies are required on the objectives of small-scale forest owners.

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