FUTURE FORESTS RESEARCH

HARVESTING TECHNICAL NOTE

HTN04-05
2011

Effect of Future Fuel Cost on Harvesting Costs

Summary

Forestry is an intensive user of energy, primarily in the form of diesel, petrol, and oil. Based on current estimates, harvesting crews use anywhere between 1.96 litres/m^3 of wood produced to 3.01 litres/m^3. Given the current price of diesel, fuel cost makes up a substantial proportion of overall logging cost. This study reviewed the implications of estimated future fuel price scenarios for New Zealand's harvesting sector at both the harvest crew scale and at the national level. Results showed firstly, that very few forestry companies surveyed recorded harvesting fuel consumption data as standard practice; and secondly, that maintaining current logging costs under future projected fuel prices will require substantial increases in productivity and/or fuel efficiency. Future fuel prices are likely to cause a significant financial burden and there is financial justification for considerable investment in improving fuel efficiency in the harvesting sector.

Jonathan Dash and Hamish Marshall, Interpine Forestry Limited.

Introduction

Forestry is among the largest sectors in the New Zealand economy, contributing 2.9% of New Zealand's gross domestic product in 2010 (NZFOA, 2010). The national harvest volume is 25.4 million cubic metres per year (MAF 2011) and the forestry sector's importance to the economy will increase further as large timber volumes from forests planted during the planting boom of the mid-1990s approach maturity from 2015 onwards.

Forestry is an intensive user of energy, primarily in the form of diesel, petrol and oil. The most recently compiled figures indicate that logging operations consumed 52 million litres of diesel in 2008 (Statistics NZ, 2009). The costs associated with the consumption of fuels contribute significantly to the total cost of forest harvesting operations. Sandilands *et al.* (2009) noted that fuel consumption rates in harvesting are dependent on harvest crew configuration, terrain, forest type and the degree of mechanisation.

The proportion of energy released by fuel combustion which is converted into useful work is known as fuel efficiency. In this study fuel efficiency is measured as the litres of fuel required to harvest one cubic metre of wood. Fuel efficiency can be improved by either increasing the volume extracted per litre of fuel used, or through decreasing the amount of fuel used to extract each cubic metre of wood.

Fuel price increases experienced by the New Zealand economy are driven by numerous factors including the following:

- The global market price of oil.
- Increased demand for oil in developing countries, intensified by subsidies that insulate consumers from price signals, particularly in India and China.
- Shifts in the balance of demand towards oil products that require more intensive processing, which are placing pressure on oil refining capacity.
- Low production from conventional sources which has led to marginal demand being increasingly met by unconventional and/or synthetic oil sources.
- Increased production costs associated with unconventional and synthetic sources requiring higher prices to justify production (Goldman – Sachs 2008).

Predicting future oil prices using statistical models is the subject of comprehensive research efforts throughout the world. Once the future price of oil has been predicted, statistical modelling techniques can be employed to predict future diesel fuel prices.

The literature from New Zealand sources reviewed for this project documents two separate modelling approaches commonly used to predict oil prices. Firstly, a meta-model approach which considers the major mainstream oil price forecasts from around the world, which are analysed to produce oil price forecasts and error bounds for those forecasts. For a review of this method refer to Donovan *et al.* (2008).

Alternatively a market model may be employed which aims to explicitly model the underlying economic parameters affecting the availability, production, and demand for oil. Both approaches provide useful insight into future oil prices: the meta model approach is superior for short term influences on oil price whereas the market model has value in predicting long term trends.

Following the methodology employed by Donovan *et al.* (2009), the results of a hybrid approach were used in this study to provide estimates of future oil prices, and therefore to derive future diesel prices.

As a major component of harvesting cost, the cost of fuel and the rate of its consumption by harvest crews should be of significant interest to forest managers and harvesting contractors. Several studies have provided recommendations aimed at reducing fuel usage in harvest operations (Amishev 2010, Karalus 2010, Forest Innovation Partnership 2006). Inevitably the cost of fuel in New Zealand will increase further, and will constitute an even higher proportion of the total cost of logging. In addition, any increase in fuel prices will trade off cost savings obtained through increased productivity.

Therefore monitoring fuel consumption and the development of procedures to maximise efficiency in fuel use has been included in the FFR research efforts for New Zealand's forest harvesting sector.

The purpose of this report is to collate information on fuel use in harvesting operations among forestry companies in New Zealand which are FFR harvesting theme members, to discuss fuel consumption with reference to future fuel prices, and to review the implications of the future fuel price scenarios for New Zealand's harvesting sector at both a harvest crew scale and at a national level.

Fuel Efficiency Data Collection

FFR harvesting theme members were contacted and asked to contribute any available data on fuel use in harvesting operations. The response was varied, the majority of members maintaining no records of fuel use by contractors. Many respondents noted that they would have to contact contractors to obtain data which subsequently were not made available. This suggests that either contractors do not collect these data as standard or are not willing to make it readily available to the forestry companies surveyed.

Exceptions to this included one forestry company which employs its own harvesting crews and another company which recorded fuel consumption data to assist in compliance to Forest Stewardship Council (FSC) certification. These data are referred to as Dataset One (Table 1) and Dataset Two respectively in this report.

Table 1. Configuration of the harvest crews in Dataset One.

Crew	Machinery	Extraction Configuration	Log making
1	Edco hauler Volvo 360 loader D85E tail hold Triple Cab Dyna crew bus	95% Scabbing 4% Ground-based logging 1% Skyline	Manual
2	Cat 325 loader Cat D7G dozer Cat 535B skidder Triple Cab Dyna crew bus Volvo 360 (on contract)	100% Ground-based logging	Manual
3	BE78 hauler Volvo 460 loader Volvo 290 loader D85A tail hold Transit van Nissan Navara	98% North Bend cable extraction 2% Shovel logging	Manual

In both cases the data acquired consisted of time series information on litres of fuel used per month and crew productivity, as well as information about harvest crew configuration. The dataset was inclusive of all diesel fuel used by the crews to fell, extract, process, and load out wood, but did not include any fuel used for cartage.

For the three crews in Dataset One there was considerable variability in month-on-month fuel consumption rates in litres/m^3 (Figure 1). Crew 3 displayed the lowest fuel consumption rates, achieving a rate of 0.68 litres/m^3 in September 2010, which was the lowest recorded fuel consumption rate during the study period. The time series (only 10 months) was insufficient to identify temporal trends with any certainty.

Dataset Two contained a time series dataset of productivity and fuel consumption for a hauler crew and a ground-based crew, both using manual log making (Figure 2). The time series data for the hauler crew (almost 4 years) covered a longer period than that for the ground based crew (9 months). The time series data for the ground-based extraction crew were available only from July 2010, and displayed a consistently slightly higher rate of fuel consumption than that for the hauler crew.

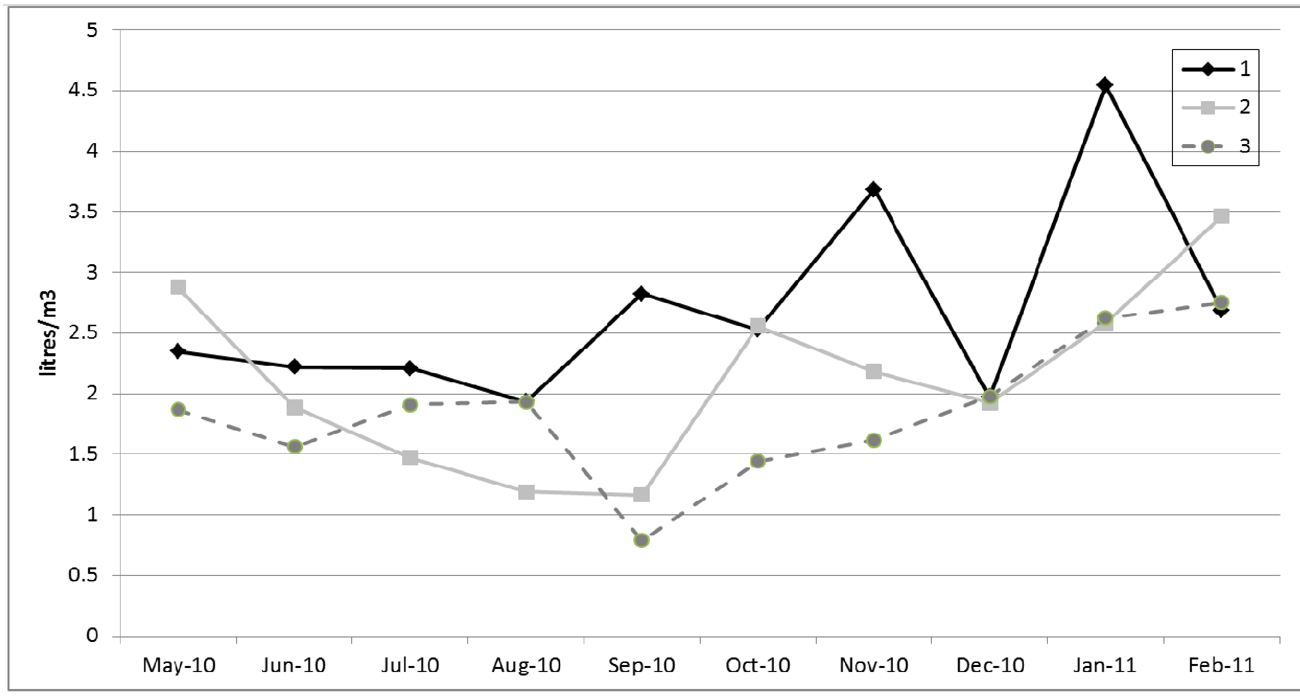

Figure 1. Dataset One: Fuel consumption for three harvesting crews

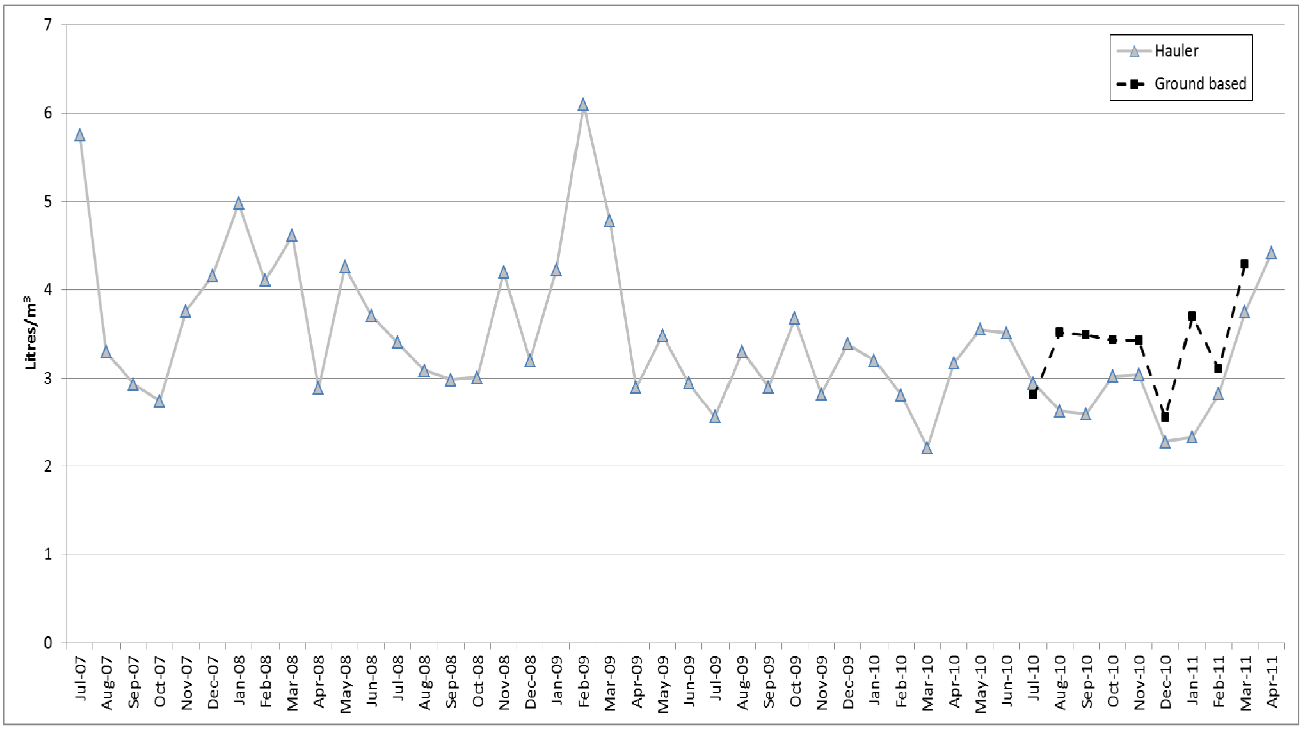

Figure 2. Dataset Two: Time series fuel consumption data for hauler and ground-based crew

Comparison with Published Datasets

A recent review of previous studies of fuel consumption in harvesting in New Zealand (Amishev 2010) collated published fuel consumption rates for the four commonly occurring harvest configurations: Ground-based Manual (GMN); Ground-based Mechanical (GMC); Hauler manual (HMN); and Hauler mechanical (HMC).

Average fuel consumption for various types of harvest crews (collated from two previous studies) has been found to range from 1.96 litres/m^3 to 3.01 litres/m^3, with an average of 2.55 litres/m^3 (Table 2).

Table 2.Summary of fuel consumption for different harvesting systems.

System	Sandilands *et al*. 2009	Karalus 2010	Dash and Marshall 2011
GMN	1.96	1.98	1.98
GMC	2.16	2.76	-
HMN	2.26	2.76	2.66
HMC	2.47	3.01	-

The manual ground-based fuel consumption rate from Dataset One (mean 1.98 litres/m^3, range 1.2–3.5) was very similar to previously published data.

However the manual ground-based fuel consumption rate in Dataset Two was particularly high (mean 3.36 litres/m^3, range 2.5–4.2 litres/m^3). This may indicate that there is a wider range of fuel consumption rates in manual ground-based harvesting systems in New Zealand than was reported by published summarised data. Alternatively, it may just be a feature of the short time series available for both examples of manual ground-based systems in this study. After consultation with the data provider this data was not used in the analysis in Table 2 as it was deemed to be non-representative.

Results for the hauler crew in Dataset One fluctuated between values of 2.21 litres/m^3 and 6.09 litres/m^3, with an average fuel consumption rate of 3.44 litres/m^3. The fluctuations evident in the time series data appear not to be explained by seasonality.

The two published examples of fuel consumption rates for the manual hauler system (2.26 litres/m3 and 2.76 litres/m3) fell between the range of data acquired from manual hauler systems in this study.

No data from mechanical felling and processing systems were available for this study.

Future Fuel Prices and Productivity

Using the fuel consumption data acquired from the forestry companies in this study, published data on productivity and logging costs, and predictions about future fuel prices, the effect on future harvesting costs was investigated. This provided insight into the fuel efficiency improvements required to overcome the effect of increasing fuel costs.

The fuel consumption data for each harvest system in Table 2 and data on the predicted future harvest volumes (MAF 2010) were used to calculate average national fuel consumption rates. These were used in conjunction with the average productivity rates, logging costs and proportion of ground-based versus hauler extraction submitted by FFR members (Table 3) as reported by Visser (2011).

Table 3. The national harvesting data submitted by FFR members and used in scenario modelling (Visser, 2011).

Harvesting system	Logging Rate ($/t)	Productivity (tonnes/hr)	% of total production
All	$26.3	28.9	100%
Ground-based	$19.5	36.3	55%
Cable	$32.1	22.6	45%

Future fuel prices have been predicted for the period 2010–2040 using a combined meta-model and market model approach (Donovan *et al.* 2009). The fuel price estimates with their upper and lower error bounds are shown in Figure 3 below.

The authors noted that forestry contractors typically pay prices significantly below the on-road prices paid by the public, but the relativity should remain the same as the crude oil price remains the key price driver.

This data were then used to model future fuel costs for harvesting and the increased productivity that would be required to overcome the additional costs.

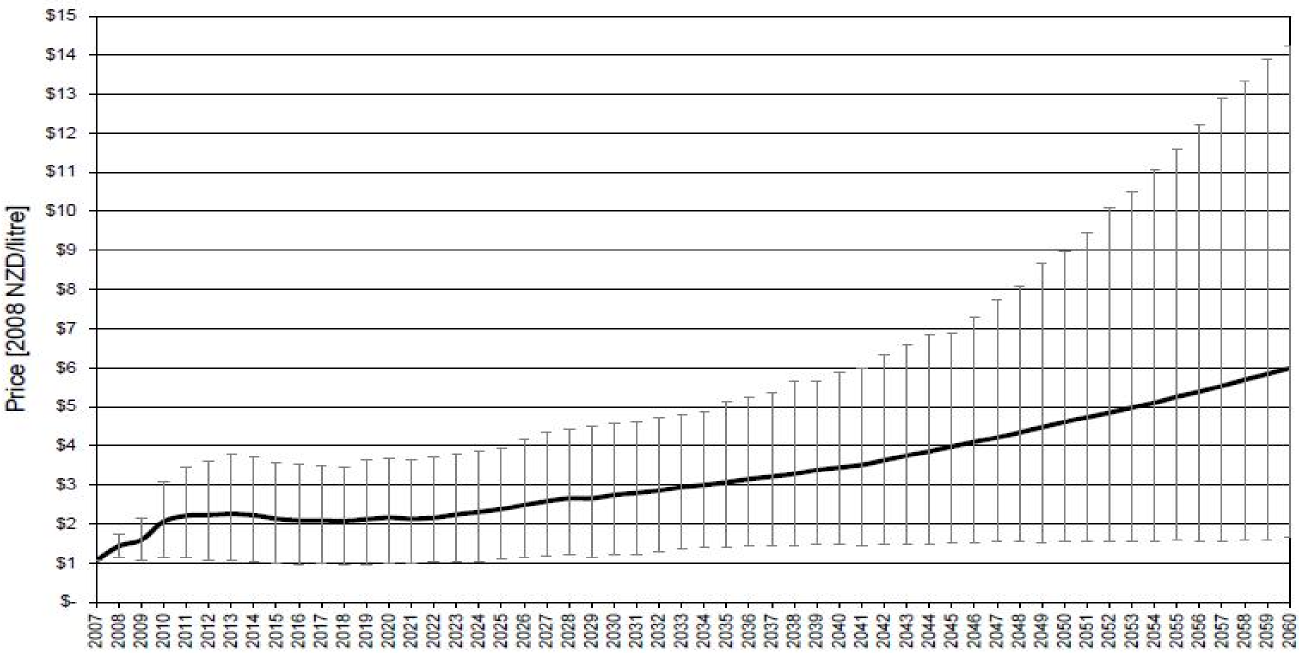

Figure 3. On-road fuel price forecasts 2008 -2060 (Donovan *et al*. 2009)

Results

Using the projected harvest volumes and fuel consumption rates, the future logging costs per m^3 were predicted for the period between 2010 and 2040. The logging costs were increased only as a result of the increasing fuel price; inflation and other cost increases were ignored. Using the projected national wood flow volumes and the future fuel price predictions, the annual total harvesting spend was calculated for the period 2010 to 2040 (Figure 4).

The productivity increase, synonymous with fuel efficiency increase, required to reduce the logging cost back to the cost at the start of the scenario period, and therefore negate the increase in fuel cost, was calculated using the following equation:

$$\frac{Y1}{P1} * Y2 = P2$$

Where:

Y1 = Logging Cost at the start

Y2 = Logging + cost of future fuel price

P1 = Productivity at the start

P2 = Productivity required to compensate for the increased fuel cost

The projected future diesel price forecast (2008 NZ$/litre) from Figure 3 was used to adjust future logging costs, and the resulting productivity increases required were plotted from 2010 to 2040. This indicated a constantly increasing required productivity gain (Figure 5).

As future fuel price prediction is inherently problematic, the effects of the 5th and 95th percentile fuel price prediction were included to provide error bounds. The size of the error bounds shows that there is considerable uncertainty in the scenario model.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

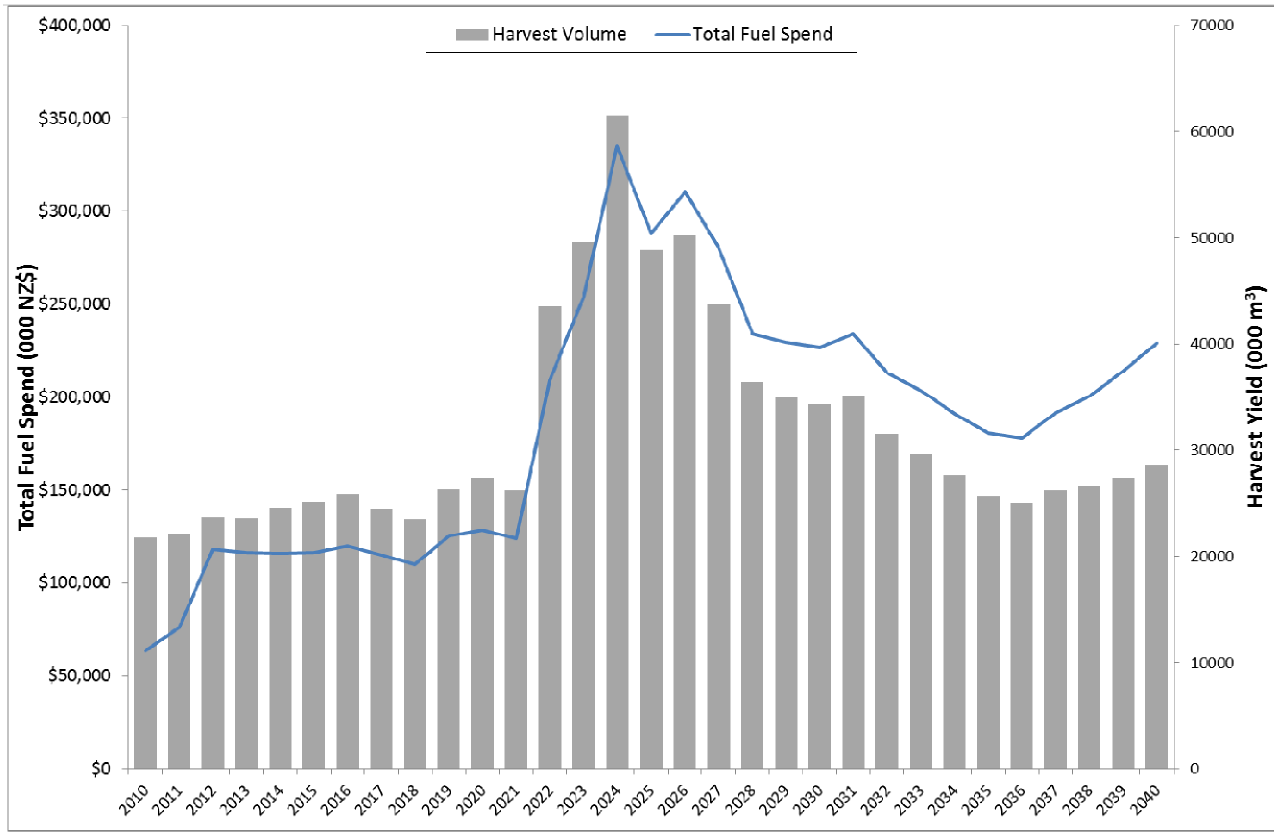

Figure 4. The harvest volume and total annual harvesting fuel cost for the period 2010 - 2040

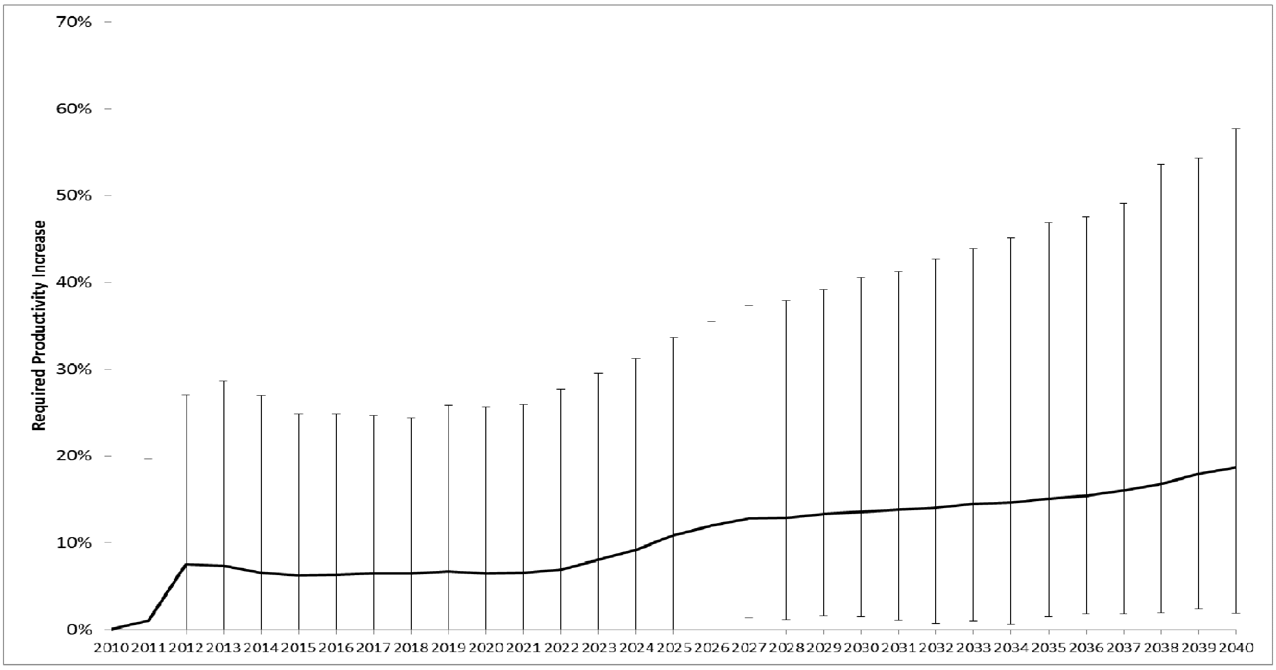

Figure 5. Productivity increase required to compensate for predicted future fuel cost increases (all operation types)

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

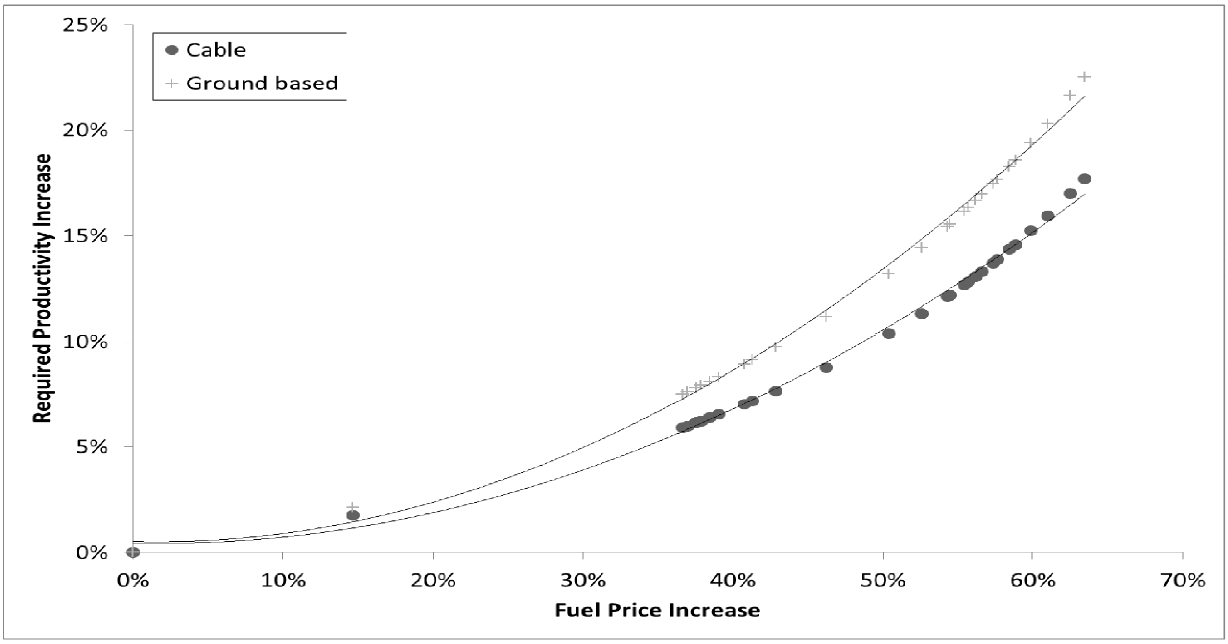

Figure 6. Required productivity increase for cable and ground-based harvesting systems

When the required productivity increase was plotted against the percentage increase in fuel prices, a non-linear relationship was revealed (Figure 6). This indicated that as fuel price escalates the required productivity increased exponentially.

The relationship between required productivity gains and fuel price increases varies depending on the harvesting system due to the different logging costs and productivity levels. Ground-based systems require a greater increase in productivity than cable systems since fuel costs represent a greater proportion of the total logging costs; ground-based systems also have higher productivity.

Fuel Use and Mechanisation

One of the goals of FFR's harvesting theme is to reduce the cost of steep country harvesting. This will be achieved through increasing productivity through mechanisation (FFR 2010). The available data indicate that mechanised cable operations consume 9% more fuel per m^3 of wood extracted, whereas mechanised ground-based systems consume 25% more fuel per m^3 harvested. It is important that the productivity gains made from increased mechanisation are sufficient to outweigh the increased fuel costs resulting from both increased mechanisation and future increasing fuel prices.

Using published data on mechanisation rates (Visser 2011) as a base line, the proportion of mechanisation in the scenario model was varied to investigate the effects on predicted total future fuel cost used by harvesting operations. Increased levels of mechanisation result in large increases in fuel cost per m^3 (Figure 7).

This scenario analysis indicates that by 2040, a 10% increase in mechanisation rates will cost an additional $1.65 million annually in total fuel costs, whereas an increase of 30% in mechanisation will result in a total annual cost increase of $4.96 million.

A key finding of this research is that fuel costs are likely to become an increasingly important component of harvesting costs. Therefore monitoring fuel consumption and the development of procedures to maximise fuel efficiency must be considered in all future technologies aimed at increasing productivity.

The results of this study suggest that there is financial justification for significant research efforts for New Zealand's forest harvesting sector.

HARVESTING TECHNICAL NOTE

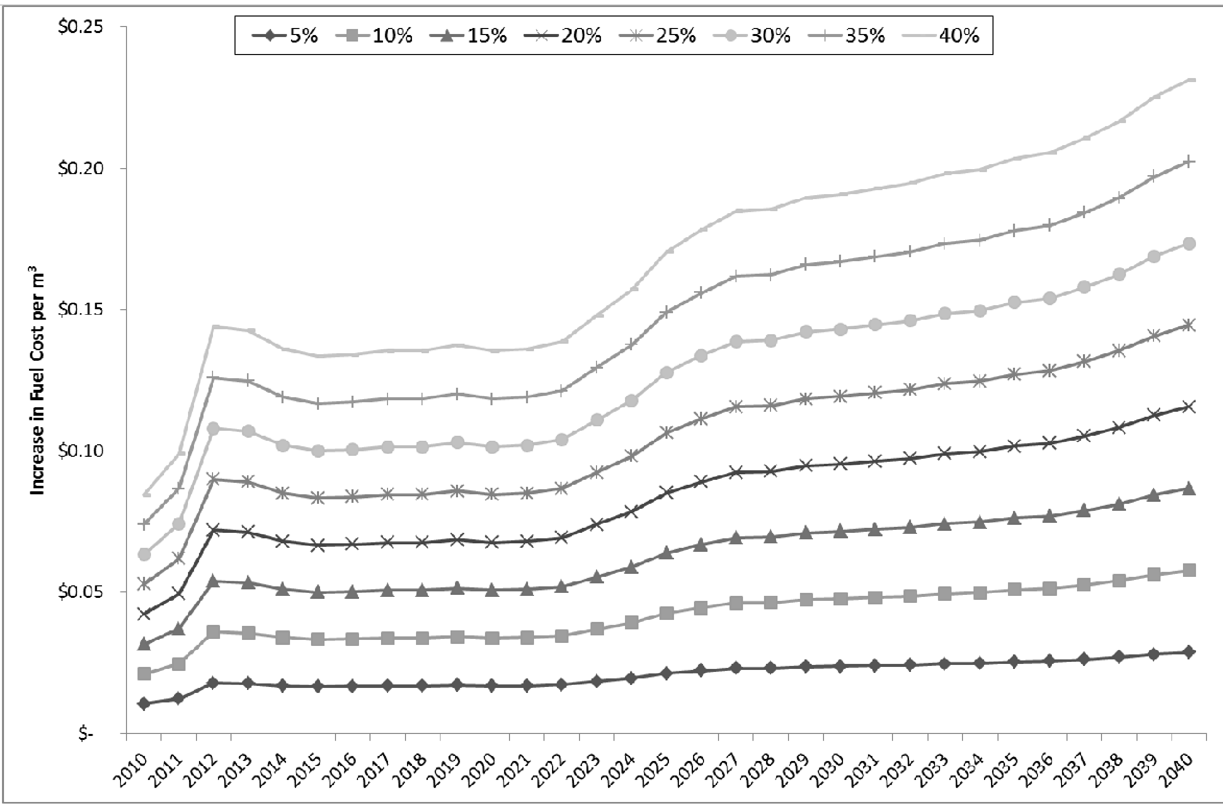

Figure 7. The increase in fuel cost per m3 associated with increase rates of mechanisation

Fuel Efficiency at the Crew Level

There is considerable variation in the fuel consumption rates in the time series data acquired for this study (Figure 1 and Figure 2). It is useful to consider the effects of this at the harvest crew level.

The difference between the maximum and minimum consumption rates for the hauler crew in Dataset Two would result in a daily saving of $696 assuming current on-road diesel fuel cost and a daily productivity of 196m^3.

Variable costs of this magnitude have a significant influence on the profitability of the harvesting operation. With the currently available dataset we cannot isolate the causal factors affecting the fuel consumption rate, but these are likely to include:

- The experience of the operator;
- Operator training and awareness of fuel conservation procedures;
- Terrain gradient;
- Piece size;
- Soil type and water content of soil;
- Surface substrate around processing sites;
- Haul distances;
- Landing layout and harvest plan.

Many of these factors are recorded as part of FFR's harvesting benchmarking data collection. If fuel consumption is better recorded and these data collected, then the causal factors for fuel consumption variation could be analysed, identified and recommendations on fuel efficiency made.

As fuel costs are generally passed on to forest managers by harvesting contractors in New Zealand (through fuel indexation in the logging rates) there are considerable benefits that could be taken by forestry companies through improved efficiency without affecting the profitability of contractors.

Conclusions

This research has shown that very few harvesting fuel consumption data are recorded as standard practice by forestry companies surveyed. This makes studying and quantifying fuel efficiency difficult, and it is a recommendation of this study that fuel use data should be collected by FFR member companies as part of FFR's annual benchmarking of harvesting costs and productivity.

The financial modeling undertaken in this study has shown that future fuel prices are likely to cause a significant financial burden, and that there is financial justification for considerable research funding to be spent on fuel efficiency.

Scenario modeling around increased mechanisation in harvesting indicates that fuel efficiency must be considered carefully when developing and adopting new technologies to avoid productivity gains being reduced by increased fuel costs.

References

Amishev, D. 2010. A Review of Fuel Consumption in New Zealand Harvesting Operations. Harvesting Technical Note.Vol: 3. Number:4. Future Forests Research Limited, Rotorua New Zealand.

Donovan, S., Petrenas, B., Leyland, G., Caldwell, S., Barker, A., Chan, A., and Dempsey, L. 2009. Price Forecasts for Transport Fuels and Other Delivered Energy Forms. Prepared for the Auckland Regional Council.

Donovan, S., Genter, J., Petrenas, B., Mumby, N., Hazledine, T., Litman, T., Hewison, G., Guidera, T., O'Reilly, L., Green, A., Leyland, G. 2008.Managing Transport Challenges When Oil Prices Rise. New Zealand Transport Agency Research Report 04/08. 146pp.

FFR 2010 Future Forests Research Annual Science Report 2010. Future Forests Research Limited, Rotorua New Zealand.

Forest Innovation Partnership 2006. In Forest Operations, Fuel Economy Counts! FERIC Forintek Canada Corporation, and Canadian Forest Service Publication, 15 pp.

Goldman-Sachs 2008. $100 oil reality, part 2: Has the super-spike end game begun? Goldman Sachs Global Investment Research: Global energy equity research team.

Karalus, A. 2010. Managing supply chain emissions to gain competitive advantage. In: Proceedings of Wood Supply Chain Optimisation, pp. 5-16. 24-25 May 2010, Rotorua, New Zealand.

MAF 2010. New Zealand Wood Availability Forecasts 2010 – 2040. Ministry of Agriculture and Forestry 2010. Wellington, New Zealand.

MAF 2011. Statistical Release: Forestry production and Trade for the March 2011 Quarter. SR 02/2011. Release Date: July 2011. Ministry of Agriculture and Forestry, Wellington, New Zealand.

NZFOA.2010. New Zealand Forest Industry Facts and Figures 2009/2010, New Zealand Forest Owners Association, Wellington, New Zealand.

Sandilands, J., Nebel, B., Hodgson, C., and Hall, P. 2009. Greenhouse Gas (GHG) emissions of the forestry sector in New Zealand, MAF Report, Scion, Rotorua 42 pp.

Statistics NZ 2009. Energy Use Survey: Primary Industries 2008. Statistics New Zealand Release, 16 pp.

Visser, R. 2011. 2010 Benchmarking of Harvesting Cost and Productivity. Harvesting Technical Note Vol:3 Number:10. January 2011. Future Forests Research Limited, Rotorua New Zealand.