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Processing options to increase the use of post-harvest residues on the East Coast.

Scion contract report for Te Uru Rakau (Ministry of Primary Industries)

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Scion, 2019

Landing residues from an East Coast harvest operation – discarded stem wood sections on edge of a forest harvest landing

Report information sheet

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Executive summary

In the last 2 years there have been a number of storm events that have caused flooding and debris flows on the East Coast as well as other parts of New Zealand. These debris flows have caused property damage and deposited large volumes of wood on beaches and flood plains. The source of some of the wood is post-harvest residues from plantation forests. There are some compounding issues specific to the East Coast; steep terrain, erodible soils and exposure to storm events that make post-harvest residues on the East Coast more vulnerable to movement off-site than other regions. Limited wood processing (especially for low grade logs) and challenging transport contribute to some material that would make a merchantable log specification in other areas not being removed from the cutover or the forest.

One of the mitigation options for managing the issue is to extract the residues and utilise them for manufacture of processed wood products or bioenergy. In order enable this, the scale of the wood resource (pulp logs and residues) it's possible uses, delivered costs and opportunities around expanded wood processing need to be determined.

Without some intervention in terms of regulations, policies and incentives; change to current practices and outcomes may not occur. The opportunity to encourage greater use of potential wood resources, thus alleviating the debris flow issue is also addressed.

This project reviews several studies that contain relevant information, along with gathering other data and presents a summary of the opportunities for greater use of the residual biomass resource.

Issues associated with infrastructure are also addressed along with possible policy and regulation-based interventions.

Key results

The forest resource is sufficient to provide a long-term supply of pulp logs of around 350,000 cubic metres per annum, with some years having much larger volumes available.

The gross supply of post-harvest residues in the long term is around 250,000 cubic metres per annum, with some years (including currently) the supply being much higher. However, with current cost and regulation structures only 150,000 would be considered as economically recoverable.

Processing options identified as having potential for using the pulp logs and residues available on the East Coast are Oriented Strand Board (OSB), Medium Density Fibre-board (MDF), potentially in combination with Combined Heat and Power (CHP) plant fuelled by in-forest post-harvest residues. The opportunity to integrate distributed primary solid wood processing with combined heat and power systems that export electricity to the grid should not be ignored.

Stand-alone heat and power plant may be economically challenged. However, as there is substantial opportunity to process logs from remote forests on the East Coast in primary wood processing (sawmills etc.) there is an opportunity to build heat and power plant along-side these operations that service not only the wood processing but also the local community through local power generation and possibly district heating.

Road transport distances from the forests in the far north-east of the region (Hicks Bay / Te Araroa) are up to 200 km from the port at Gisborne. Upgrading roads to high productivity motor vehicle (HPMV) standard would reduce transport costs and improve the viability of extracting logs and residues from these forests.

Processing closer to the forest would substantially reduce road transport demand; 1 green tonne of logs (~1 cubic metre) becomes 0.5 tonnes of wood products when processing conversion factors and drying are accounted for.

Reinstating the rail link from Napier to Gisborne would make the movement of logs from Gisborne to the pulp mill at Whirinaki a more viable option.

Barging of logs from Hicks Bay to Gisborne or Tauranga would also reduce transport costs compared to road transport.

Energy infrastructure
Electrical infrastructure on the East Coast is able to meet current demands. However, if there are major developments in wood processing, especially north-east of Gisborne then either lines upgrades or distributed generation will be required.

Gas pipelines extend as far as Gisborne City, but do not go along the coast to the North and East. The pipeline infrastructure has some spare capacity

There are no productive coal or gas fields on or near the East Coast. Wood is a viable fuel for the production of process heat or for CHP.

The recently released National environmental standards for plantation forestry (NES-PF) which is aligned with the Resource Management Act (RMA), will have effects on the production and management of forest harvest residues depending on the level of monitoring and enforcement. The NES-PF places restrictions and standards on forest operations, including roading and harvesting operations and management of sites post-harvest.

A carbon price of $50 per tonne would see densified wood fuels such as wood pellets competitive not only with coal, but also with gas.

Utilisation of post-harvest forest residues is well aligned with Government strategies such as Zero Carbon and the Low emissions economy.

Infrastructure priorities are improved roading and the reopening of the Napier to Gisborne rail link, at least as far as Wairoa.

Other transport infrastructure;
Barging of logs and chipped residues from Hicks Bay to Gisborne / Tauranga could be a financially viable option for the next 10 to 15 years whilst log flows are high out of the East Coast. The movement of logs and chipped residues from Gisborne to Gisborne to Napier / OJI Whirinaki by rail appears to be financially attractive (excluding line repair costs).

There are a number of policy and regulation options available to local and central government that would either force or encourage use of forest harvest residues. However, these need to be carefully analysed and implemented to ensure that unintended consequences are avoided.

Variations on wood supply over time presents challenges for full utilisation of peak supplies of in-forest residues and pulp logs. Well planned expansion of forest planting would alleviate this.

The most promising opportunities for the large-scale use of pulp logs and wood residues on the East Coast appear to be;

- OSB and MDF
- Wood pellets possible with terpene extraction prior to pelletisation

Establishment of expanded sawlog processing at locations such as Ruatoria would create an opportunity for use of in-forest residues as fuel for a CHP at the sawmill, along with the mills own residues. The CHP would be required to supply the mills electricity demand and could be sized to export to the grid.

Further work suggested

1. Studies on logging residue volume, piece size, distribution and accumulation points within a harvest setting, catchment and forest. This would include on the ground measurements as well as aerial image capture. Work to include factors which would affect residue production such as felling methods and minimum log specifications.
2. Studies on the production rates and costs of removing material normally considered as residuals with either the primary harvesting operation or with a secondary harvest.

3. More detailed analysis of wood flow on the East Coast to determine routes where existing bridges are limiting the use of HPMVs. This analysis to include the presence / absence of wharf or barging point at Hicks Bay; including data on supply over time to some of the more remote points such as Hicks Bay and Ruatoria.
4. Assessment of costs of barging chipped or hogged residues (lower density and different handling than logs)
5. Feasibility study on converting wood residues to pipeline quality synthetic natural gas via biomass gasification and syn-gas upgrading
6. Stabilisation of future wood supply. Planting of 4,000 to 5,000 hectares per annum for 10 years with planting to start now. However, a more detailed analysis is needed of the potential available land suitable for planting needed to maintain a long-term wood supply to support expansion of regional large-scale wood processing. More detailed analysis of this is recommended, including generating maps of the land designated as suitable for afforestation in order to determine its harvest and transport logistics.

Processing options to increase the use of post-harvest residues on the East Coast

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Introduction

This report covers options to increase the proportion of a tree that is processed into saleable products, with a specific focus on forests on the East Coast (Gisborne / Tairawhiti) region. There are a number of drivers for this study, including issues with debris flows from recently harvested plantation forests triggered by heavy rainfall during storm events. It also aligns with economic development aspirations of the region and some of its infrastructure issues, particularly transport.

This report is divided into sections;

- An overview of the Gisborne region with a focus on its forestry assets.
- A summary of prior studies on the region and other national level studies that are relevant
- Analysis of wood and wood residue supply; current and projected
- Techno-economic analysis of wood processing options
- An assessment of policy adjustments or other Crown interventions that could incentivise increased processing of post-harvest residues; including the impact of NES, RMA and ETS
- Indications of public infrastructure enhancements required to support secondary wood processing options on the East Coast including shipping and the rail link to Whirinaki/Napier including commentary and recommendations concerning heavy transport sector and initiatives to reduce emissions in this sector.

The report aims to inform next steps such as development of public policy, investment in tree/wood processing, local authorities on district development opportunities and infrastructure planning, and where further investment into R&D should be prioritised to fill knowledge and technology gaps.

This study was commissioned by the Ministry of Primary Industries Te Uru Rakau and is intended to be delivered to the Forestry Ministerial Advisory Group (FMAG).

Methods

1. A brief overview of the Gisborne Region with a focus on forestry and wood processing and associated infrastructure was developed from a range of resources and reports.

2. A summary of the work by Scion (Industrial Symbiosis) and others (e.g. MPI regional studies) on utilising in-forest harvest residues as feedstocks for marketable products was written after a search for relevant documents. A brief summary of regional studies and other major reports (Productivity Commission Low Carbon economy) was written.

3. Wood Supply data was gathered from a range of sources (Ministry of Primary Industries National Exotic Forest Description and Wood Availability forecasts) as well as some other studies conducted by Scion using its Biomass Supply Model.

4. The WoodScape model was used to identify a range of wood processing options (energy and other) that could use the in-forest residues as feedstock, including both centralised and distributed processing, with locations centred on Gisborne or distributed to sites closer to the forest resources, such as Tolaga Bay etc.

5. Potential policy options for central and local government were developed through consultation with key stakeholders and assessed using appropriate frameworks. The likely effectiveness of policy and intervention options that would incentivise utilisation of in-forest wood residues were assessed by using a "Policy Arrangements Approach", where the substance and organisation of policy through discourses, coalitions, rules of the game and resources in light of the changing interrelations between the state, market and civil society were examined. Potential policy options were developed through consultation with key stakeholders and assessed using appropriate frameworks.

6. A desk top review identified likely infrastructure constraints for the processing options identified in parts 1 and 2; including consideration of roads, port capacity, power lines, power generation and rail links. The potential benefit of improvement to these were assessed from a value chain perspective.

Glossary

OSB	Oriented strand board – panel product made from flaked pulp grade logs
MDF	Medium density fibre board – panel product made from pulp logs and wood chip
CHP	Combined heat and power - makes electricity and heat in the same unit
m^3	cubic metre (standard unit of measurement for logs)
t/km	tonne kilometre – unit of transport, indicates 1 tonne moved 1 kilometre
GDP	Gross domestic product
GJ	Giga Joule
PJ	Peta Joule
MWh	Mega Watt hour

Results

Gisborne - Regional overview

The Gisborne Region covers 8,265 km^2 (826,500 ha) which is 5% of New Zealand's land area. It also has around 154,000 ha of plantation forest estate (9% of the NZ total). Only 1% of the total NZ population lives in the Gisborne Region, and most of those (75%) live in Gisborne city, therefore the population density in the rural parts of the region density is very low. Unemployment is high (8.8%) in comparison to the national level (4.6%). The East Coast produces 0.7% of NZs total GDP.

The Gisborne Region has some of New Zealand's most remote communities and production of primary products (forestry, beef, sheep etc.). It has steep terrain, highly erodible soils and challenging transport. Average house hold incomes are low in comparison to the rest of New Zealand and population growth is low. The climate supports horticulture on flatter land near rivers and the coast. Productivity in these primary industries is strong and the region has advantages over other regions of New Zealand in this area – including forest growth rates. Horticulture exports are expected to double by 2022.

However, whilst the forestry assets of the Gisborne region are highly productive in terms of growth there are challenges in terms of steep terrain, expensive harvesting, long and challenging transport out of some forests and a lack of local wood processing. Log exports from Gisborne are a high proportion (90%) of the regions total harvest, leaving just 10% being processed locally. The Tairawhiti Economic Action Plan (Activate Tairawhiti, 2017) highlights this opportunity and outlines some goals for getting up to 25% of the log harvest processed locally, along with estimate of impacts on GPD and employment.

The port at Gisborne has been undergoing development and expansion to cope with increasing volumes of log exports. Port capacity is not expected to be a major constraint on log exports. However, the port does not have a major container terminal which may affect movement of some products.

Summary of other studies

East Cape Forestry Transport study

A forestry transport study (Environment BOP, 2000) found that for volumes in excess of 500,000 tonnes per annum, barging from Hicks Bay to Gisborne or Tauranga was economically viable and gave an indicative cost of $15 per tonne to barge logs from Hicks Bay to Gisborne (approximately 190km). Trucking from Hicks Bay to Gisborne would cost in the order of $34 per tonne. Further analysis of wood flows where the transport of chipped or further processed wood residues are included as part of the volume of logs available would be useful. Residues are comparatively low density (tonnes per cubic metre) in comparison to logs or sawn lumber and the impact of this on the barging operation needs to be considered. Further, there is a limited amount of forest adjacent to Hicks Bay and its supply is variable over time. More detailed analysis of the potential supply is recommended

Without the rail link the East Coast is heavily dependent on the port and roads for export of primary produce – which is often needed to be done on demand as the produce comes ready. Recent closures of SH2 through the Waioeka Gorge caused significant disruption and cost to exporters. This issue is exacerbated by the port at Gisborne not having a large-scale container facility.

Having reliable, robust roading infrastructure is critical to the primary industries operating in the Gisborne region.

Over the next few decades climate change may bring about more frequent storm events that could be of sufficient severity to induce floods and debris flows with subsequent impacts to roading infrastructure and maintenance costs, potentially with more road closures and for longer periods of time.

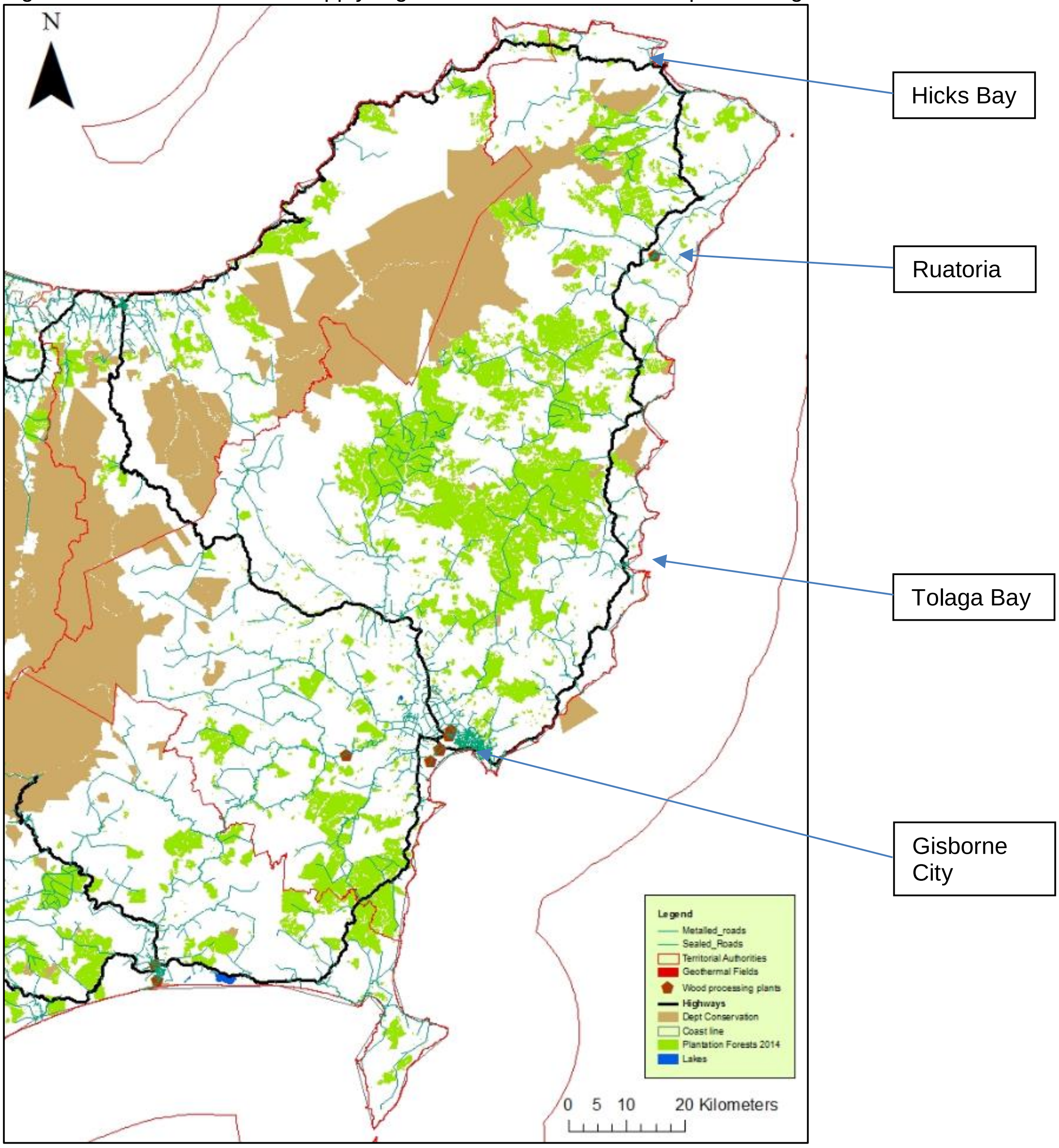
East Coast wood supply region - Wood availability forecasts – summary

The East Coast wood supply region has around 154,000 hectares of forest. Much of this is far from the main population centre, port and wood processing located near Gisborne (Figure 1). There is only one sawmill not located near Gisborne city; Hedley Sawmill, Ruatoria which takes in around 8 to 10,000 m^3 per annum of logs; other wood processors are detailed in Table 2. Long term wood availability is expected to be in the order of no less than 2.25M m^3 per annum, and for much of the next 30 years the volume is much higher. Pulp logs are at least 0.320M m^3 per annum, with an average of 0.640M m^3 per annum

Wood Energy Industrial Symbiosis - Gisborne

The Wood Energy Industrial Symbiosis produced four regional studies, one focussed on the Gisborne region. This report found that there is a significant opportunity around using residues and pulp logs from existing forests for wood processing and possibly for the generation of heat and power supporting processing of higher value logs.

Figure 1 – East Coast wood supply region - forest area and wood processing



The nature of the wood supply on the East Coast is well documented (MPI, 2017, 2014), it is included here as the total wood supply, and therefore the in-forest residue supply, is variable over time – which has an impact on the potential for wood processing and residue use operations that might be developed.

Table 1 shows the age class distribution of the plantation forests (all species) on the East Coast (MPI, 2017). What this shows is a large peak in area that is currently 21 to 25 years old, followed by the 16 to 20-year-old age class.

Table 1 - Gisborne District – forest area by age (MPI 2017)

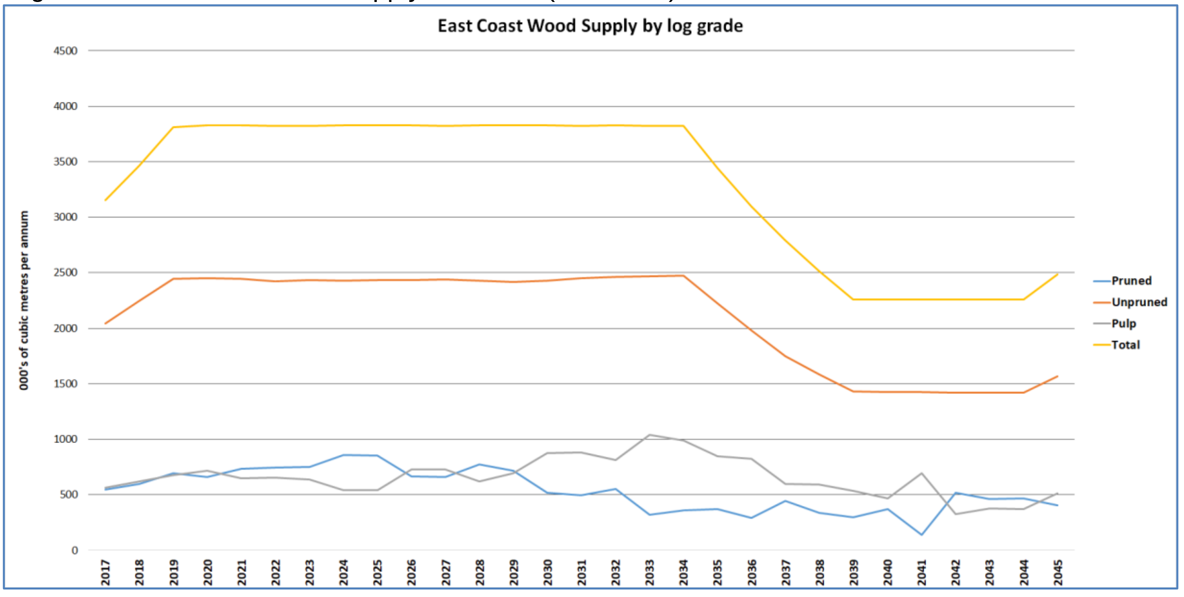
Age class	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-50	51-60
Area, ha	20,099	15,901	13,359	31,071	47,663	12,732	7,978	3,427	1,430	455

The age class data has been converted into wood availability forecasts (MPI, 2014). Figure 2 shows the data from scenario 3 (split non-declining yield) in the East Coast wood availability forecasts (MPI 2014) - which smooths the supply somewhat from the very peaky supply that would be derived directly from the data in Table 1. Even with the smoothing there is a decline in wood availability from around 2035. It is difficult to predict with certainty beyond 25 to 30 years from the present time – up to around 30 years the forecasts are based off what is planted now – beyond 30 years the forecasts have to make assumptions around replanting and / or expanded/new planting – neither of which is certain.

The total log supply needs to be looked at by the different log grades that are generated; pruned, unpruned and pulp/chip. Part of the residue supply on the East Coast may come from expanded wood processing – it would be complimentary to the in-forest residues. This expansion is reliant on long term log supply as the plant would have an expected working life of 25 to 30 years.

Pruned log supply is a modest part of the total, and whilst affected by the area planted, it is also affected by the decisions made around the crop management, that is whether to prune or not.

Figure 2 – East Coast wood supply over time (MPI 2014)



When looking at what is possible in terms of new processing it is important to consider the current demand for logs versus the long-term supply. Figure 3 shows the pruned log supply versus the current demand from processors located on the East Coast.

The flat orange line represents current demand. If we assume that this remains static going forward and deduct it off the predicted supply the result is the amount that is available for other processors in the long term. Figure 3 shows the pruned log supply as variable over time with less than 150,000 m^3 per annum of pruned logs available between 2032 and 2041. This does not preclude the development of pruned log processing but does indicate limits to the possible scale.

One of the opportunities that needs to be considered is wood processing outside of Gisborne City and its environs. For example; a medium sized (100,000 to 300,000 m^3 per annum log in) sawmill has been considered for processing logs at Ruatoria. This mill would need to generate its own electricity as the lines infrastructure, whilst able to cope with the current demand is not capable of suppling the amounts of power that a medium sized sawmill needs (2,500 to 7,500 MWh per annum). The mill could have a combined heat and power plant (CHP) fuelled of its own residues. It is likely that the mill could end up requiring residues above its own bark, sawdust and shavings supply and it could look to its slab chip production as a fuel source, as opposed to trucking it to the nearest chip user (Whakatane or Whirinaki). Further fuel would be available from residues in forests adjacent to Ruatoria.

Figure 3 – Pruned log supply versus current demand (MPI 2014 and Hall et al 2017)

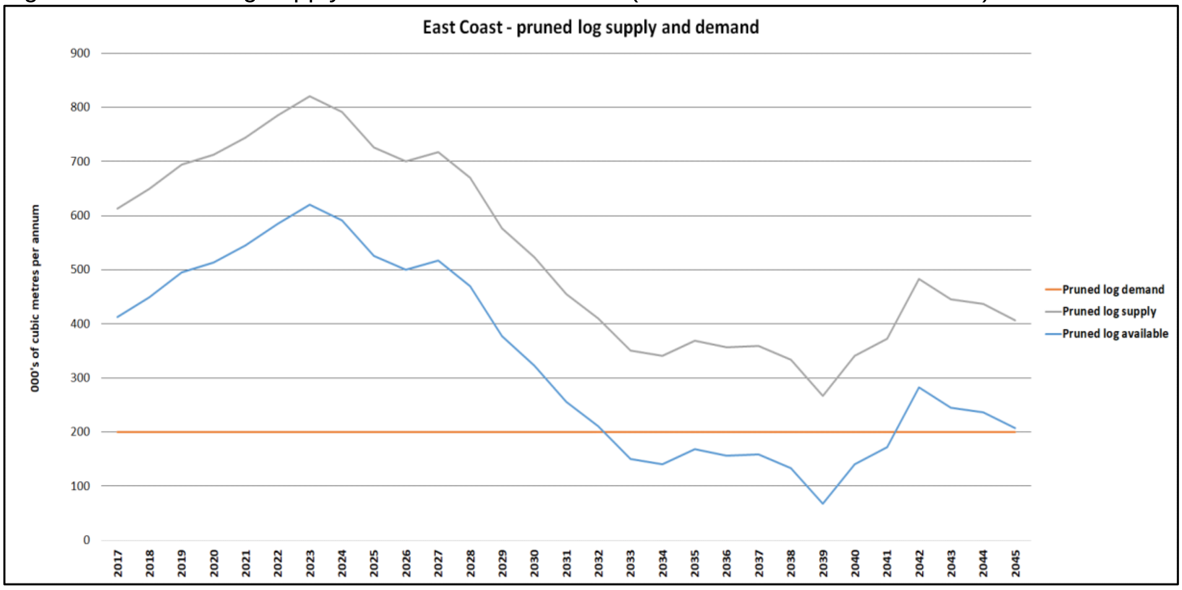
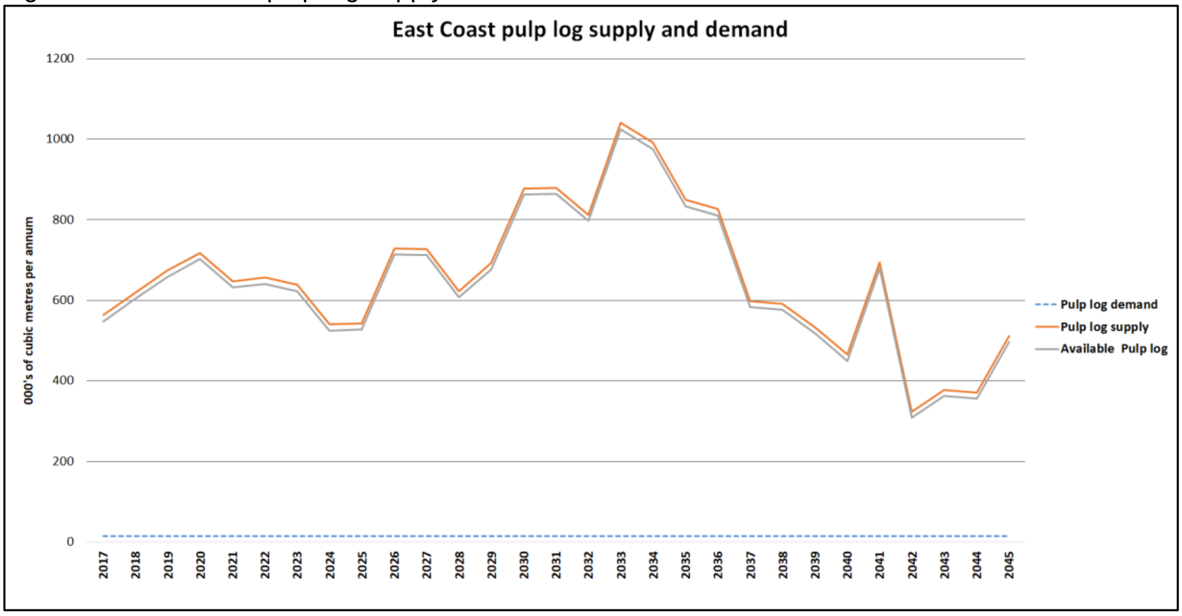


Figure 4 shows the pulp logs supply using the same approach as above. Pulp log demand on the East Coast is minimal, with a small demand for post and poles taking some of the better quality small diameter logs. In the long term there is predicted to be at least 350,000 m^3 per annum of pulp log supply.

This volume figure is important as due to the very low current demand, the low price for pulp logs and the long transport distances, much of this material is not transported out of the forest and the drive to extract broken pieces from steep cutover is low. Therefore, some of this material can end up contributing to debris flows.

However, there are some low-grade logs now being sold as export KIS. These are short, small diameter large knot logs that are straight (no kinks or sweep).

Figure 4 – East Coast pulp log supply and demand



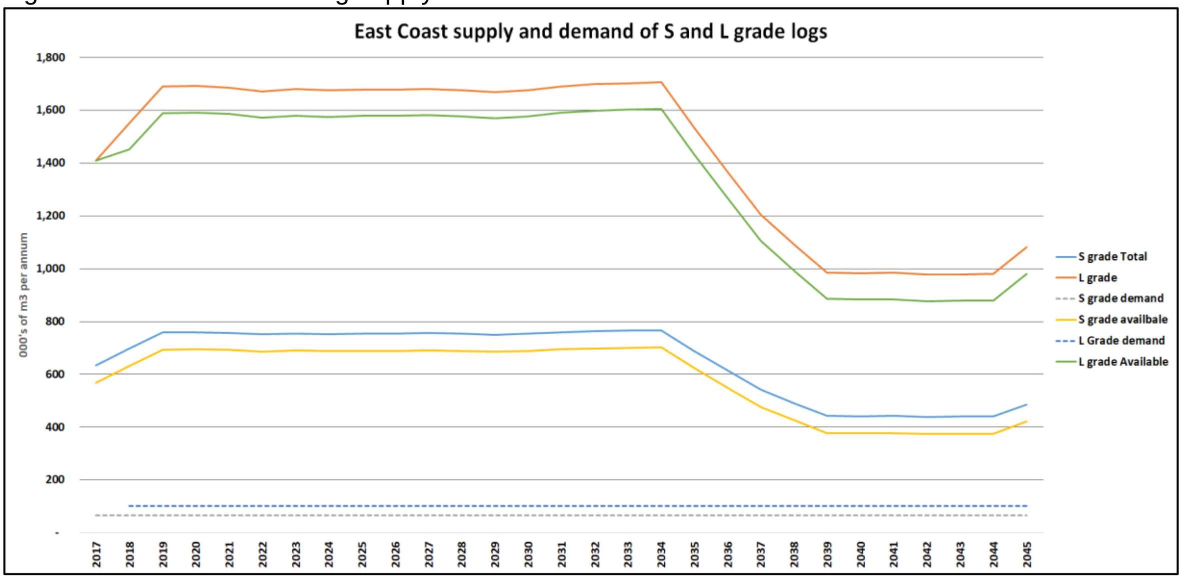
The supply of sawlogs can be split into S and A (small knots, <6 cm and <10cm respectively) and L or K grade (large knot, <15 cm to 25cm depending on grade) and the volumes available estimated based on supply and demand as above.

There is minimal demand (<100,000 m^3 per annum) for unpruned sawlogs on the East Coast in comparison to the long-term supply available (1.3 to 1.4 M m^3 per annum).

The estimation of possible expansion of use of pruned and unpruned sawlogs is included as the expansion of wood processing will have an effect on the production and use of wood residues, which may compliment the production of residues from forest harvesting – this is dependent on the type of processing as some (plywood, particle board) have higher heat demand per unit of product than others (sawmilling).

Figure 5 shows the supply of sawlogs (S/A and L/K) versus current demand. There are substantial volumes of logs available in both categories. Long term there is estimated to be over 800,000 m^3 per annum of L grade logs and 350,000 m^3 per annum of S grade.

Figure 5 – East Coast sawlog supply and demand



Major Wood processors – Gisborne Region

The demand for logs from the wood processors in the Gisborne region (and in Wairoa, which is outside the region, but close enough to supply logs to) is shown in Table 2.

S 9(2)(b)(ii) [redacted]

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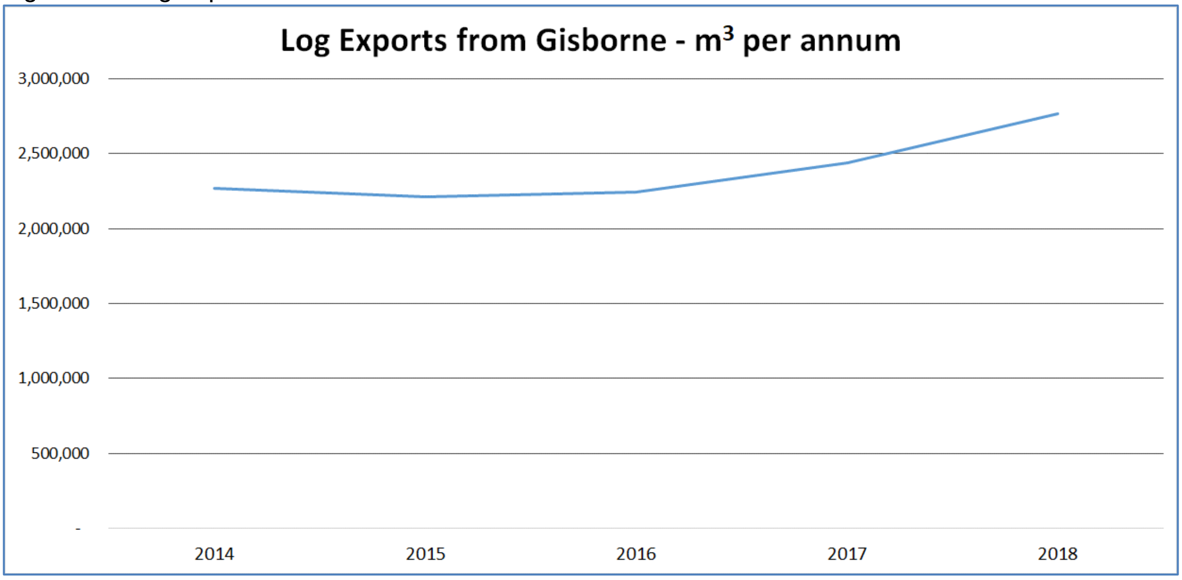
[redacted],000 m^3 per annum. Most of the pruned logs go the Juken NZ ply and LVL plant near Matawhero.

Log exports from Gisborne over the last 5 years (June to July year) are shown in Figure 6. The volume of logs exported via Gisborne has been climbing over the last 2 years, and this volume is expected to continue to grow over the next 5 to 10 years unless there is a major change in local processing.

Figure 6 – Log exports from Gisborne



In summary, the long-term log volume / opportunities are;

- Pruned logs ~100,000 m^3 per annum

- S grade logs ~380,000 m³ per annum
- L grade logs ~800,000 m³ per annum

- **Pulp logs ~350,000 m³ per annum**
  Total* 1,530,000 m³ per annum

*Note – this is the likely minimum export log volume from Gisborne in the long term if there is no change to local processing.

Stabilising long term wood supply

In order to encourage expansion of large scale wood processing, stable wood supply in the long term would be helpful. Otherwise the expansion will be limited by the long-term volumes indicated above.

To stabilise the wood supply at levels similar to that available in the mid-2030s, around 46,000 ha of new forest planting is required, spread over a period of 10 years. Planting of this area needs to start immediately for it to fill the wood supply shortfall in an appropriate time frame. Analysis of the area suitable for forest planting on the East Coast (Harrison et al, 2017) indicates that there at least 64,000 ha that would be potentially profitable, with a further 80,000 ha in Hawkes Bay.

More detailed analysis of this is recommended, including generating maps of the land designated as suitable for afforestation in order to determine its harvest and transport logistics. This analysis will need to factor in potential social and environmental regulatory constraints.

Wood residue supply data

In-forest harvest residues are a potential source of wood fuel, should there be a demand for it at a price sufficient to make its extraction financially viable.

The volumes of in-forest harvest residues available over time based on the harvest levels projected by MPI (scenario three in the East Coast 2014 wood availability forecast) are shown in Figure 7. There is likely to be at least 70,000 green tonnes per annum of long term sustainable supply of comparatively easily accessible material (e.g. landing residues -see cover photo). This is the equivalent of ~450,000 GJ per annum, sufficient to fuel a combined heat and power plant of 2.5MWe and 9MWth.

The cutover residues are more costly to recover, but some from flatter terrain will be recoverable and the total residue supply could be around 100,000 m³ per annum if this material is included.

The harvest residues produced in-forest occur in two places;

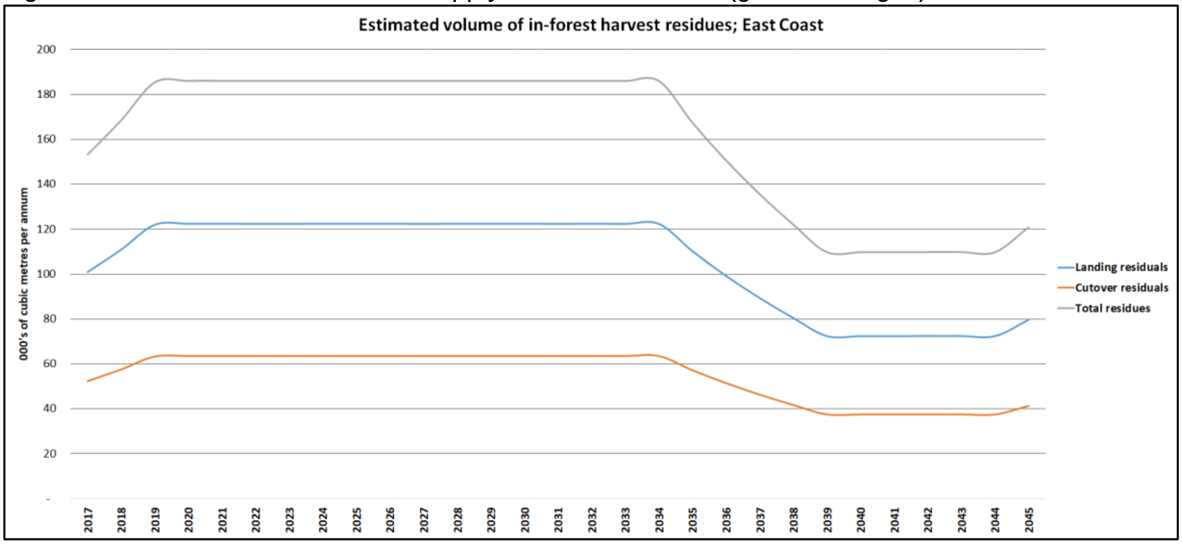
- On landings (effectively at roadside) when extracted tree lengths are cut into logs by grades and defective sections are removed in order to maximise value recovery.

- On cutover (at stump) when the trees are felled, there is frequently breakage in the upper, small diameter stem. These pieces are not generally extracted as most of them are too small to be economically recoverable with existing systems and market values.

The landing and cutover residues are considered separately as they have different composition and recovery costs.

Both sources of harvest residues contribute to the woody material in debris flows, with forest managers holding the view that most of the material that exits forests in storm / flood events comes from cutover residues.

Figure 7 – In-forest harvest residue supply on the East Coast (gross tonnages)



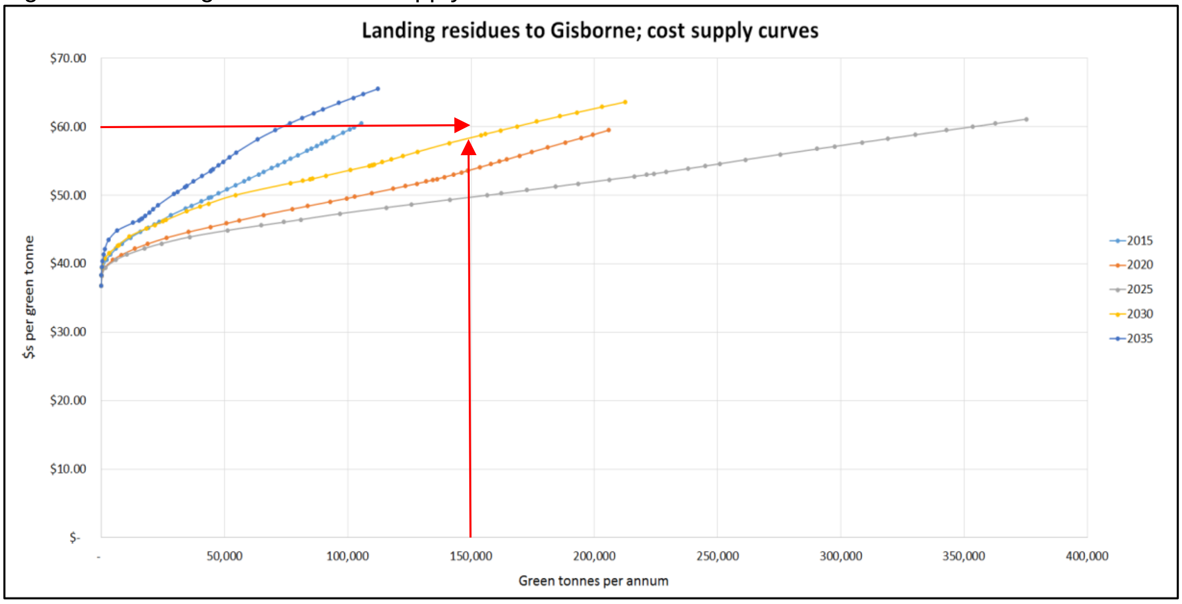
Scion has run its GIS based Biomass Supply Model (BSM) for several sites on the East Coast; Matawhero (Prime Sawmill site, ~10km south-west of Gisborne), Tolaga Bay, Ruatoria and Te Araroa.

The BSM uses several GIS data layers (plantation forest shape file, slope, roads, landcover database along with forest age class, area and yield data to estimate the potential supply of residues to a given site. Data can be presented as volume by distance or volume by cost and segregated into total volume, logs by grade or residues from ground based or hauler operations.

Figure 8 shows the cost supply curves (volume by cost) for in-forest harvest residues to Matawhero. There is considerable variation in supply over time. Smoothing of the harvesting volume will reduce some of this variability. In the long-term supply is likely to be similar to the yellow 2020 line.

This indicates that there is up to 150,000 green tonnes per annum of in-forest residues that could be delivered to Matawhero for a cost of around $60 per green tonne. In energy terms this is $8.70 per GJ.

Figure 8 – landing residues cost supply curves for material delivered to Matawhero over time



In a report for BANZ and EECA Scion estimated the national and regional level supply of wood fuels residues not just from in-forest harvest residues, but also from wood processing, vineyards, orchards and municipal wood waste. These were assessed as the gross supply and then 2 lower levels, assuming that not all of the residues were recoverable. The recoverability varied with the resource type; however, level 1 assumes around 80% recovery and level 2 around 60%. These estimates for Gisborne are shown as tonnages (Figure 9) and energy (gigajoules, Figure 10) per annum.

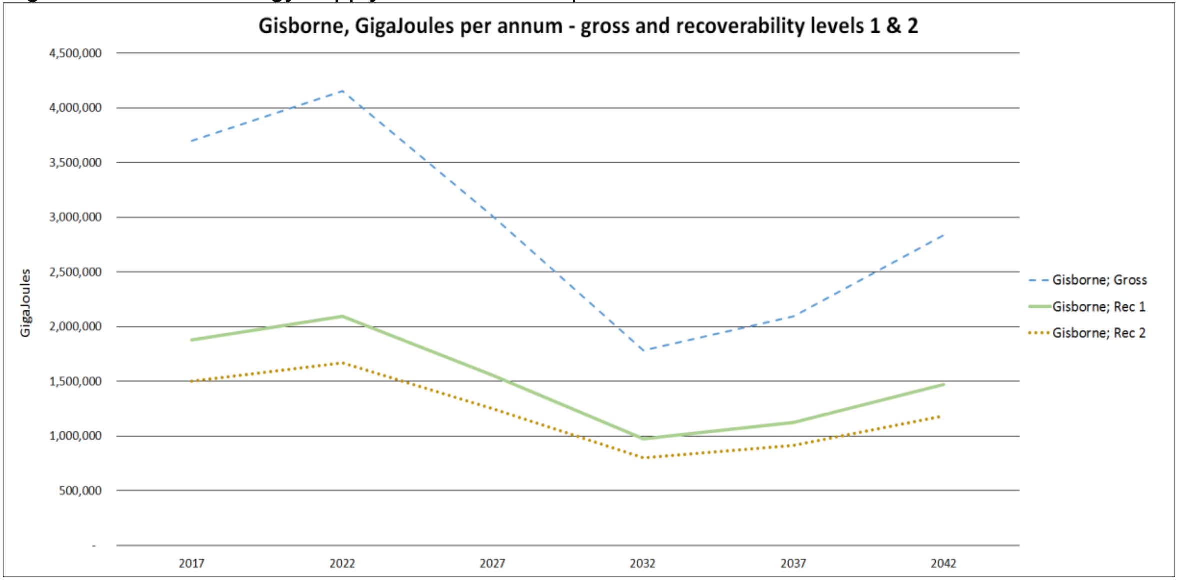
The results for tonnages available over time from the two studies are similar (Figures 7 and 9).

Figure 9 – wood residues for energy supply over time green tonnes per annum

Industry feedback on the published data on available volumes has varied from; we are underestimating, to the lower figures look about right. Anecdotally our cost estimates are aligned with costs in existing commercial operations

The estimated tonnages converted to energy (gigajoules (GJ)) per annum (Figure 10) indicate that there is 0.8 to 1.0 PJ per annum of residues available, after allowing for some being unrecoverable.

Figure 10 – wood energy supply over time – GJ per annum



Other wood residue resources - Gisborne / East Coast

Bark - Port
The Eastland port has around 2.2 to 2.4 M m^3 of log exports per annum in the long term if local wood processing levels stay as they are in 2017. Associated with this log export is the production of bark. Bark comes from both direct and indirect debarking of the logs.

The bark supply could be as high as 72,000 green tonnes per annum (496,000 GJ) but is estimated to be in the order of 44,000 green tonnes (300,000 GJ) per annum as of 2017 (Gifford & Hall, 2014). The bark could be available at modest cost as a raw material but would require hogging and screening to make it suitable as a fuel. Cost is likely to be in the order of $40 to $50 per green tonne ($5.80 to $7.20 per GJ).

Horticulture and viticulture residues
The Gisborne region is estimated to have around 7,000 to 8,000 green tonnes per annum of woody residues produced from the viticulture and horticulture industries. This material has an energy value of 62,000 GJ per annum (Hall 2017). This material would require collection, hogging and cost as a fuel is likely to be in the order of $45 per green tonne ($6.50 per GJ).

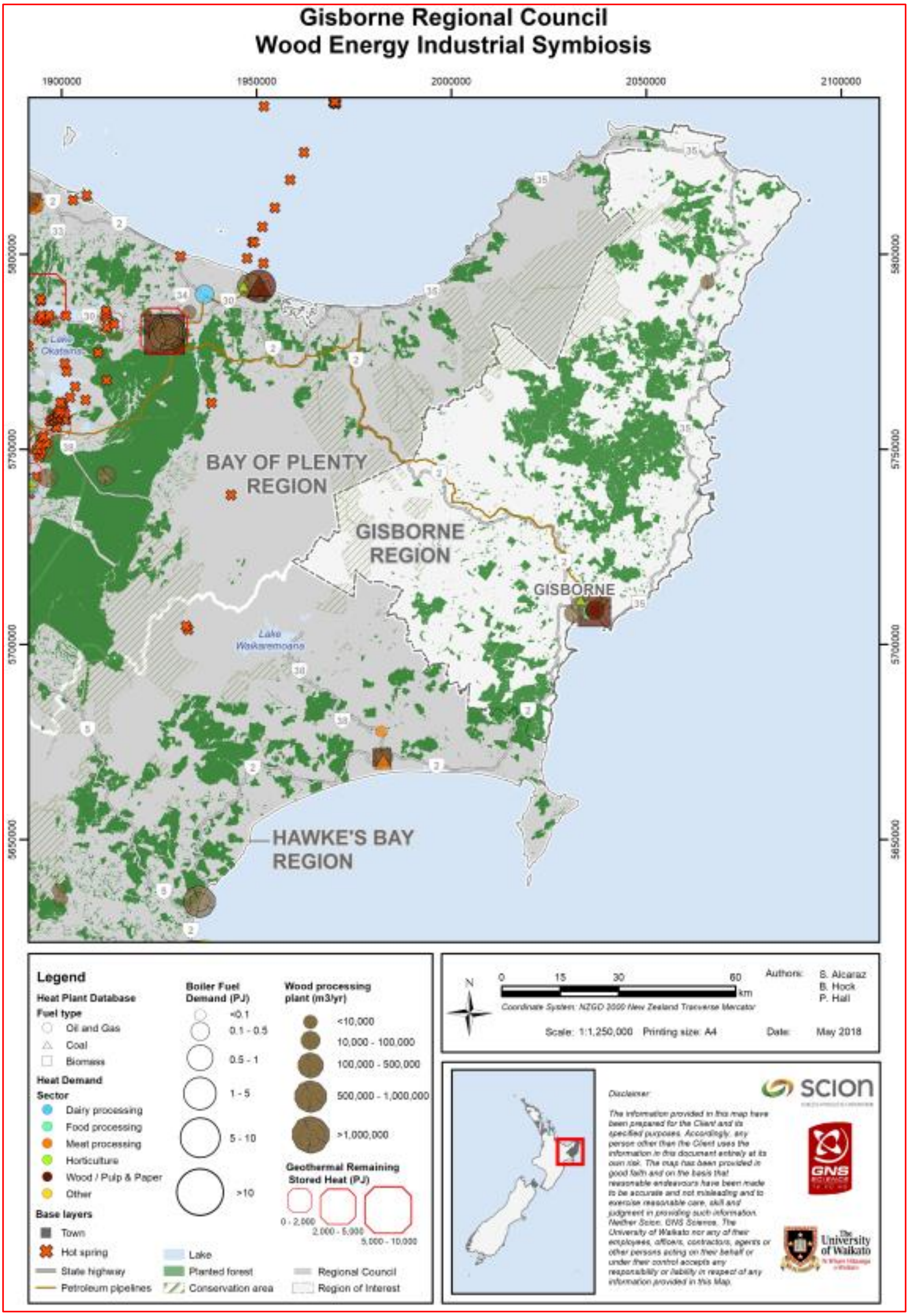
Municipal wood waste
The volume of municipal wood waste produced in the East Coast / Gisborne region is low, with only around 40 tonnes (400 GJ) per annum estimated to recoverable from landfills (Ireland-Blake, 2017). This quantity is trivial and given issues with contamination and the presence of CCA treated wood can be ignored as fuel source.

Therefore, the total supply of wood residues from the port, viticulture and horticulture is in the order of; 51,000 tonnes (351,000 GJ) per annum, with the bulk of it from bark from the port. Likely average weighted costs would be in the order of $45 to $50 per tonne ($6.50 to $7.00 per GJ).

In-forest residues which are the largest source of material is likely to be slightly more expensive and push up the average weighted cost of a large wood fuel demand.

Figure 11 shows the wood processing sites and industrial heat demand sites in the Gisborne region.

Figure 11 – forestry, wood processing and heat demand on the East Coast



Low-emissions economy – New Zealand Productivity Commission

In August 2018 the New Zealand Productivity Commission published its report on a low-emissions economy (LEE). The report is comprehensive and has some key findings relevant to the forestry and wood processing industries and to the issues of wood residues and opportunities to valorise them.

One of the key findings of the LEE report was that for New Zealand to meet its Paris commitments on GHG emissions we need to engage in large scale afforestation (at least 1.3 million hectares of new forest and up to 2.8 million), primarily on hill country much of which is erodible and currently used for sheep and beef. Some of the land targeted for this afforestation would be in the Gisborne region. In order for this to be a viable alternative land use / encourage land use change, some of the issues with current forestry practices (debris flows containing post-harvest wood residues) need to be addressed with urgency.

Further the LEE report suggests that for change to happen around GHG emissions, the emissions (CO2e) price needs to rise to around $75 per tonne or higher, up to $200 per tonne. Emissions pricing is described as a strong tool.

Decarbonising heavy transport (trucks, rail and shipping, along with aviation, potentially through use of drop-in liquid biofuels is seen as potential route to reduce emissions from the transport sector. The use of wood and wood residues is seen as significant in this area as described in the NZ Biofuels Roadmap (Suckling et al 2018).

Distributed electricity generation is also suggested as an option. Where there is an opportunity to co-produce / utilise heat and power wood fuels have a place in distributed generation; fuelling combined heat and power systems aligned with primary processing (meat, dairy, food etc.) that have heat and electricity demands.

The LEE report also highlights the need for New Zealand to switch away from fossil fuels for process heat. This could be to renewable electricity for low temperature heat (hot water) or wood fuels for high temperature heat (steam).

The expansion of forestry, including on the East Coast with its need for debris flow mitigation and the use of low value wood for heat could be aligned.

The LEE report highlights the need for stable laws, regulation (which are science based) and institutions. It also emphasises things that we can do – that are known to make a difference;

- Increasing price of GHG emissions
    - Supported by regulation and policy
- Land use change – especially from ruminant grazing to forests
- Moving away from high emissions activities
- Moving to low emissions energy and manufacturing
    - Note wood processing gives us both of these thing – in 2017/18 we exported 20.33 million m^3 per annum of unprocessed logs – over 2.7 million of these through the port at Gisborne.
        - Wood processing heat demands are largely fuelled by their own residues

New Zealand Biofuels Road Map

Scion has published (Suckling et al, 2018) a study on developing liquid biofuels in New Zealand. Whilst there are a number of feedstocks that could be used, wood residues from forests and wood fibre (including residues and pulp logs) from new forests are reported to be a significant opportunity. Fuels of importance are considered to be marine fuels (low sulphur regulations, comparatively easy to make) and Jet Fuel (difficult to electrify large aircraft)

The study reported that;

- There are credible routes to large scale production of biofuels that New Zealand could adopt
- There would be large and long-term reductions in greenhouse gas emissions

- Forests will be a key resource – planted on land that is not suited to arable crop production and optimal/suitable for forestry.
- Timing is critical, and planting of the expanded forest estate needs to start now in order to get the resource growing
- The existing forest estate and the pulp logs and residues it produces are an opportunity to start now and demonstrate the potential
- There will be substantial benefits in terms of regional economic development
- The East Coast features prominently in the afforestation and production of pyrolysis products from wood
- Target products would be marine fuels and diesel
- Policy support will be required
- Leadership will also be required to build consensus on the future of biofuels in New Zealand; including
    - Which fuels to target
    - Acceptable land types and feedstocks
    - Timeframe and level of biofuels substitution
    - Best use of biomass
    - Co-ordination of implementation
    - Leveraging off overseas developments

Further research and development work on feedstocks for and production of biofuels from these feedstocks to de-risk large-scale development of biofuels is required.

Diagrams showing the increasing importance of the East Coast to a biofuels future for New Zealand are shown in Appendix D.

East Coast Regional Economic potential (2014), Tairawhiti Development partnership: Regional Economic Development Strategy 2009, Tairawhiti Economic Action Plan (2017) & The Regional Growth Programme (2017)

There are several high-level reports on economic development potential on the East Coast. There are common themes across these documents;

- The potential of forestry to be a major contributor to economic growth in the Gisborne region
- The need for improvement in road transport infrastructure
- Uncertainty around the value of the rail link to Gisborne
- Limited comment on the opportunity around barging from Hicks Bay
- Other forms of primary produce, which are also reliant on transport for moving goods out of the region are expected to grow; including horticulture, viticulture and meat.

Costs of delivering wood residues

The costs of the delivered wood residues will have a significant impact on the viability of their use. Scion has undertaken a number of studies, including recent work on types of systems and estimated cost for delivering in-forest post-harvest residues to a point of use outside the forest.

The cost of harvesting residues is made up of several costs items;

- A stumpage fee payable to the forest owner (we assume $10 per green tonne)
- Gathering the material from where it is lying into a pile suitable and accessible for processing into chip or hog fuel.
- Processing the log off-cuts etc. into chip or hog fuel
- Transport (cost being variable by distance).
    - Transport distances on average for the East Coast delivering to Gisborne is estimated at 95 to 100 km.

Some of these costs vary by the origin of the residues which can be either at landings (cover photo) or on the cutover (at stump).

Landings
The likely costs of landing residues over a 100km haul distance would be $60/green tonne ($8.70 per GJ) for material that has been chipped and screened to remove dirt and fines.

Cutover – flat
The costs for recovering cutover residues are higher as the material needs to be brought to roadside, and costs are likely to be in the order of $68 to $70 per green tonne ($9.85 to $10.15 per GJ) for material that has been chipped and screened.

Cutover – steep
Extraction of post-harvest residues from steep terrain is uncommon. It has not been undertaken in New Zealand and there is little evidence of it occurring overseas. Where there is harvesting on steep terrain and residues are collected, it is usually as part of a whole tree harvesting operation and stems are extracted as whole trees with delimbing and log making at the landing or roadside.

New Zealand's Radiata pine forests tend to have large, tall trees, which when felled on steep terrain (often only partially controlled in direction) suffer from breakage when the stem hits the ground. The broken pieces may or may not be of a minimum merchantable piece size (>3.7m long with a minimum diameter of >10cm; with a volume of >0.05m^3), and their extraction will be dictated by the minimum extracted piece size specification set by the forest owner, and how hard this specification is enforced.

Generally these small pieces are not extracted as the cost of bringing them to the landing exceeds their market value.

A study by McMahon et al in 1998 showed the effect of changing the minimum extracted piece size on hauler logging productivity. Larsen (1985) conducted a similar study. Extrapolating from this limited data shows the impact on harvesting production of increasing the removal for stem wood from the cutover with the primary harvesting operation (Appendix A). There is insufficient data to make an assessment of whether moving to a smaller minimum extracted piece size / log specification would have an impact on the volume of residue left on the cutover. However, reducing the minimum pieces size to be extracted is likely to increase the cost of logging by at least $10 per tonne, for all the tonnes extracted.

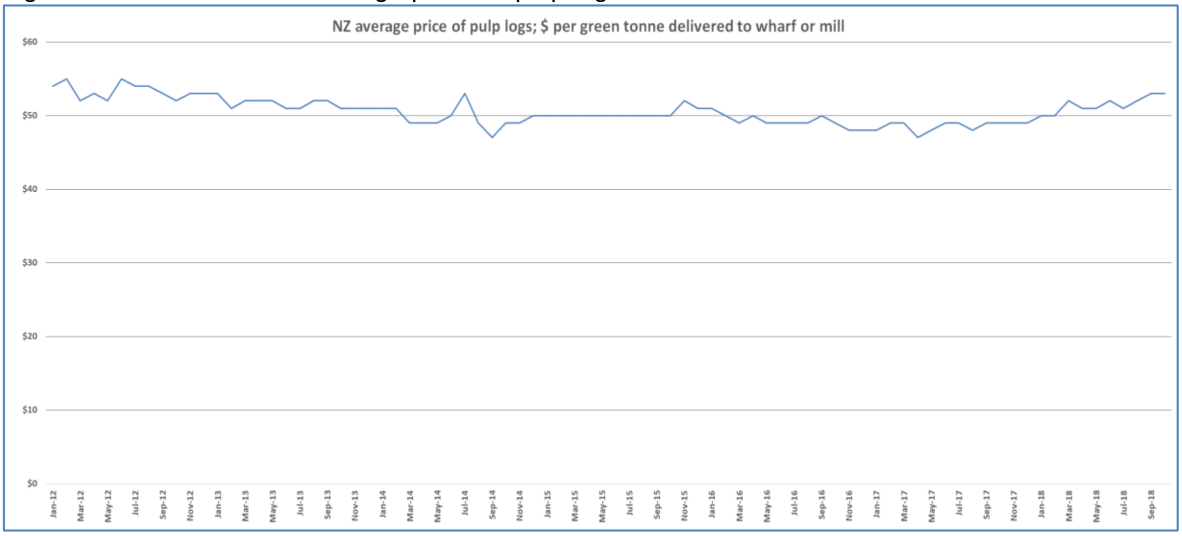
Another option to consider would be a small-scale hauler (Harvestline or smaller) which would come in after the primary harvesting operation and recover residues from the cutover, with a focus on areas within the setting which are identified as vulnerable due to either of, or a combination of, steep slope, high slash loads and adjacency to a waterway.

Typically, these cutover residues would be considered too expensive to extract based on its market value (Figure 11). However, if there are other drivers in place extraction of this material might be necessary or viable. Without more data it is difficult to predict the cost of extracting this material with confidence and more work on this is recommended, including gathering detailed data on residue volume distribution and piece size on cutover sites in East Coast forests and a study of residue extraction operations, both as part of the primary harvest and as a secondary harvest. Post-harvest aerial imagery would be a useful start, with on-ground measurement to calibrate / verify estimates from the aerial imagery.

Cost of pulp logs

Pulp logs in New Zealand on average sell for around $50 to $55 per green tonne (Figure 12) and are considered a bench mark price for in-forest residues. These prices have varied only within a narrow range over the last 6 years.

Figure 12 – New Zealand average price for pulp logs delivered to wharf or mill.



The delivered price of a pulp log does not give the forest grower much of a return after harvest and transport costs are deducted. Logging costs on steep terrain nationally average around $38 per tonne on truck. Typical East Coast forests steep terrain harvest costs are in the order of $44 to 46 per tonne on truck. When the cost ($15 to $17) per green tonne of an average transport distance of 85km is added to this the costs of harvesting and delivering the log are around breakeven ($53 to $55 per tonne) – with no return for growing it. For many East Coast forests, the transport distances are much higher and transport costs at the higher end can be around $40 per tonne (e.g. Te Araroa to Gisborne). This leads to some pulp logs not being taken from the forest to a port or mill, even though they have been extracted to a landing.

Even with current good prices for small low-quality logs s9(2) (b)(ii) there is not a lot of profit in the smaller logs, and none in bent logs or logs with large branches (>25 cm).

The pulp logs from the East Coast have no significant user within the region so they have to go outside the region (OJI Fibre Solutions near Napier, Whakatane Board Mills (Bay of Plenty) or the Oji / NS Norway site at Kawerau. These destinations are considerably further away than Gisborne and so the costs of delivery is much higher. The OJI mill near Napier is nearly 200 km away from Gisborne and the Bay of Plenty mills are 185 (Whakatane) to 220 (Kawerau) km from Gisborne. Taking logs around the coast from for example Ruatoria to Whakatane is 247 km. In the case of sawlogs, maximum financially viable transport distances are considered to be around 160km.

Therefore, in order to encourage the pick-up of pulp grade logs from East Coast forests local use is desirable, or a means of moving these logs from the East Coast to other regions at a cost that makes it economically viable to do so is required.

Impact of the Forestry NES / RMA and ETS

National Environmental Standards for Plantation Forestry

The National Environmental Standards for Plantation Forestry (NES-PF) came into effect on the 1st May 2018 (New Zealand Government, 2017). The objectives of the NES-PF are to simplify and standardise Resource Management Act requirements and provide nationally consistent regulations while adequately protecting national and local environments with the aim to:

- maintain or improve the environmental outcomes associated with plantation forestry activities nationally
- increase certainty and efficiency in the management of plantation forestry activities.

The NES-PF covers 8 core plantation forestry activities (Appendix E), allowing these activities to be carried out as permitted activities, subject to conditions to manage potential effects on the environment. While the majority of forestry activities are permitted, activities identified as posing a risk to the environment can come under increasingly stringent consent requirements and restrictions. The NES-PF takes a risk-based approach and currently identifies three key areas of risk (erosion and sediment, wilding conifer spread, fish and habitat disturbance), where risk assessment tools and accompanying documentation are provided to assist forest managers in identifying, classifying and managing some of the risk areas within their forest estate. In addition, the NES-PF allows Councils to implement more stringent plan rules in some circumstances to protect nationally and locally significant and sensitive environments. A rule in a plan may also be more stringent than the NES-PF regulations to give effect to a freshwater objective developed to give effect to the National Policy Statement for Freshwater Management 2014 (amended 2017) and any of policies 11, 13, 15, and 22 of the New Zealand Coastal Policy Statement 2010.

Erosion and sediment risk

The Erosion Susceptibility Classification tool, used to assess the erosion and sediment risk, indicates that around half the planted forests in the Gisborne region are classified as 'Very High' (red) erosion susceptibility (Table 3). Most forestry activities can't be carried out on red-zoned land without resource consent. Gisborne has the highest planted forested land area in this classification when compared with other regions in New Zealand.

Table 3 - Erosion Susceptibility Classification for the Gisborne regions planted forests (https://www.teururakau.govt.nz/dmsdocument/29804/loggedIn. Downloaded 14th January 2019)

Erosion Susceptibility Class									
Very High (red)		High (orange)		Moderate (yellow)		Low (green)		Other	
Area planted forest (ha)	% total planted forest	Area planted forest (ha)	% total planted forest	Area planted forest (ha)	% total planted forest	Area planted forest (ha)	% total planted forest	Area planted forest (ha)	% total planted forest
104432	55	22475	12	56473	30	5333	3	200	0.1

Wilding conifer spread

The Wilding Tree Risk Calculator must be used by foresters to assess the risk of wilding conifers spreading when planning new forests or replanting with a conifer not previously planted. If the calculator score is less than 12, planting or replanting is permitted; if the score is 12 or higher, then a resource consent required. An assessment of the Gisborne region would identify whether there is a significant risk of wilding pine spread using this process and whether the risk is sufficient to influence planting of new forests and hence future timber supply in the region.

Fish and habitat disturbance

The fish Spawning Indicator Tool identifies fish species that are likely to be impacted by forestry activities and provides fish distribution maps to assist forest managers in identifying fish species likely to be present within their forests. A consent is required for forestry activities that will disturb the spawning habitat of an identified fish species during spawning periods. A number of fish species identified as sensitive to forestry activities are present in the planted forests waterways of the East Coast, i.e. Redfin bully (*Gobiomorphus huttoni*) and Banded Kokopu (*Galaxias fasciatus*). River crossings must provide for the upstream and downstream passage of fish in rivers and there may be restrictions on the types of river crossing infrastructure allowable depending on the sensitivity, habitat requirements and conservation status of fish present.

Key factors likely to impact on forestry operations on the East Coast

- A high proportion of planted forest in the Gisborne District that classified as 'Very High' (red) erosion susceptibility. As mentioned above, most forestry activities can't be carried out on red-zoned land without resource consent. These areas will come under potentially more stringent roading and harvesting requirements and may face restrictions in replanting and afforestation, reducing the area available for afforestation and increasing harvesting costs.
- A combination of high environmental risk and questionable economic viability may see forest owners and managers voluntarily retire land which is no longer considered suitable for production forestry, reducing available land for replanting.
- The steepland forests in the East Coast provide a challenging environment in which to logistically meet the NES-FP requirements to prevent harvesting slash from entering waterways or safely removing slash from any water bodies and land that would be covered by water during a 5% AEP (annual exceedance probability) event (the chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage), to avoid environmental impacts. Improved recovery of these harvesting residues, where safe to do so, will increase existing harvesting costs, but also contribute to available post-harvest residues for potential further processing.
- Fish spawning of some fish species present on the East coast will place restrictions on timing of some forest activities such as harvesting and may impact roading and river crossing design and infrastructure with flow on effects to harvest logistics and costs and timber supply.
- The potential of wilding pine risk to limit the scope of new plantings within the region.
- The ability for Councils to apply more stringent rules and conditions in significant and sensitive areas, or to meet the requirements of the National Policy Statement for Freshwater Management 2017, and the New Zealand Coastal Policy Statement 2010. This will have implications on roading and harvesting logistics and costs and potentially for where production forests can be planted in the future.
- The impact of current pending legal action by the Gisborne District Council under the Resource Management Act, against forest management companies, following recent flooding and debris flows in the region on future forestry activities is unknown.
- Under the NES-PF, there are a range of setback requirements (ranging from 5 to 30m) for replanting and afforestation next to rivers, lakes, wetlands, coastal areas, significant natural areas, adjoining properties and roads. These setbacks will reduce the available plantable area in the East Coast, but may have a more significant impact on harvesting and roading configurations and economic viability.

  Any in-forest processing of harvest residue options that fall outside the definitions of the key 8 forest activities covered under the NES-PF will come under the RMA. If the activity doesn't meet the thresholds for permitted activities, it will need to go through a consenting process.
- Clarity around whether comminution of residues to make a chip or hog fuel product is included under harvesting is required.

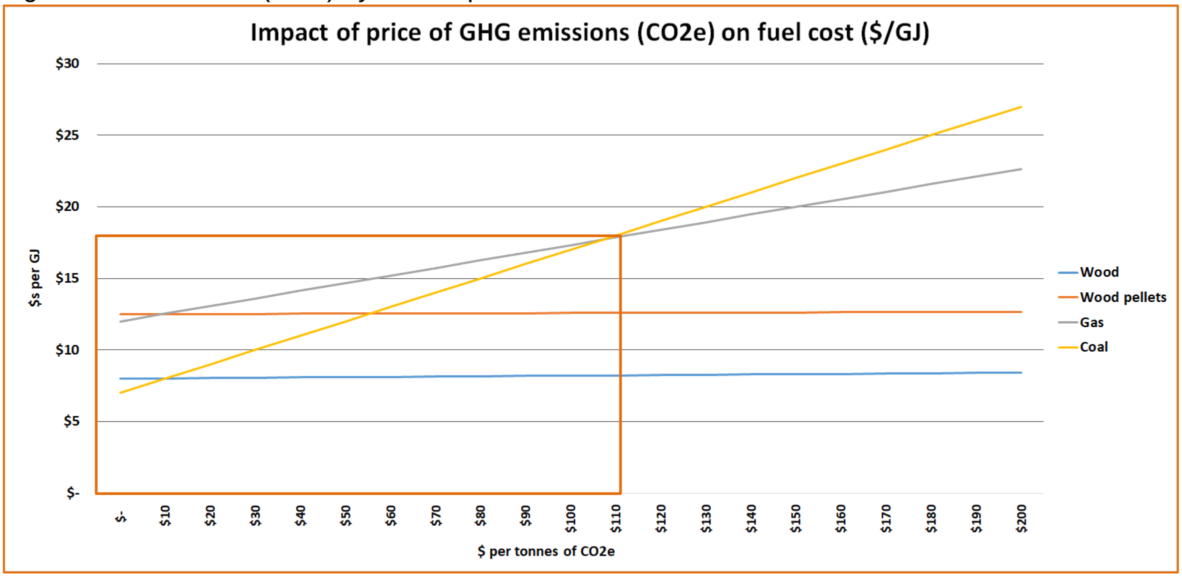
Further modelling and assessment work would be required to ascertain the potential impacts of the above factors on harvesting logistics and costs, forecasted replanting and afforestation options, future wood supply volumes and subsequent feasibility of the potential processing options of post-harvest residues on the East Coast.

Emissions trading scheme (ETS)

Carbon prices are expected to rise – continuing a trend evident over the last 2 years (Appendix C). The current price is $24.90 / tonne and the 2023 futures prices are around $29 / tonne

The impact of the rising cost of CO2e emissions on fuel prices is shown in Figure 13.

Figure 13 – Price fuel ($/GJ) by carbon price



At a $0 cost of carbon, coal is assumed to cost around $7 per GJ and gas around 12/GJ. Both these fuels are affected by the cost of carbon, with coal more so, based on its having twice the GHG emissions of gas. Gas is more expensive without a carbon charge, however with a carbon cost of around $110 / tonne of CO2e the cost of coal per GJ becomes higher than that of gas.

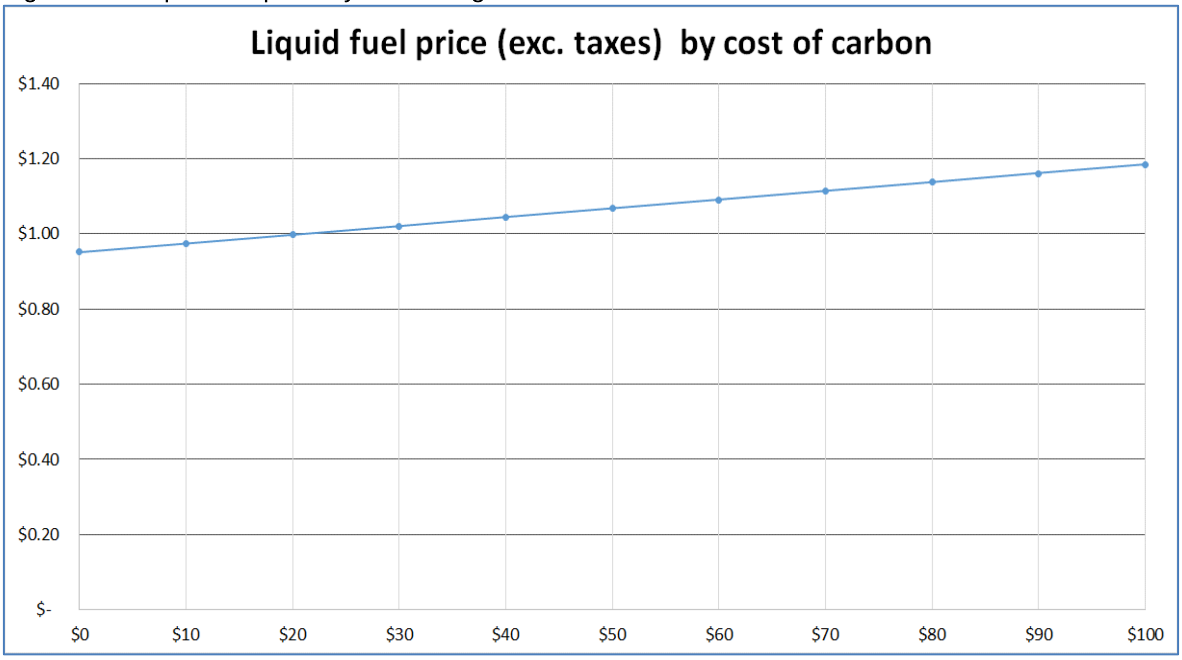
With no carbon charge wood (hog or chip) and wood pellet fuels have prices that are higher than coal, or in the case of pellets higher than natural gas. However, it only takes a modest increase in the cost of carbon, and it being applied fully, to push the cost of the fossil fuels past the cost of the wood fuels. Under the scenario outlined here, at $10 per tonne coal becomes more expensive than wood and gas becomes more expensive than pellets at the same carbon price. Coal becomes more expensive than wood pellets at around $50 per tonne of carbon.

This is not to say that fuel switching will occur at these prices, as a gas boiler cannot burn wood or wood pellets (a coal boiler could co-fire), and the impact of capital costs of changing boilers versus operating costs needs to be considered.

The cost of carbon also has an impact of the price of liquid fuels via the ETS. The impacts of carbon price are shown on the cost of liquid fuels (Petrol and Diesel) excluding taxes and GST in Figure 14. Every $10 increase in the cost of carbon is likely to add around $0.023 to the cost of a litre of fuel. This is a relatively modest amount – and given that the cost of the fuel is made up of many components (oil price, exchange rates, shipping costs and other taxes as well as GST), the impact of this is comparatively minor – but can't be ignored. The data in Figure 14 assumes an oil price of US$67 per barrel and an exchange rate of NZ$1 to US$0.67, with a freight cost of US$4 per bbl.

A carbon price of $100 tonne of CO2e would add around NZ$0.18 per litre to the cost of fuel (excluding GST).

Figure 14 – liquid fuel price by increasing cost of carbon



WoodScape analysis of options for use of in-forest harvest residues and pulp logs

The WoodScape model was developed as part of the WoodScape study conducted by Scion for Woodco (Jack et al, 2013). The model is a tool for comparing the potential financial performance of wood processing options off a common basis. It currently includes 135 wood processing options (65 different technologies, some with scale variants). This number includes scale variations of the same base technology. It covers a wide range of wood processing, from pulp mills (Kraft and thermo-mechanical) to sawmills (with a wide range of sizes) engineered wood products (Plywood, LVL etc.) reconstituted panel products (MDF, particle board, OSB etc.) and several bioenergy products including, wood pellets, bark briquettes, combined heat and power plants and liquid fuels from woody biomass.

The model compares the different processes off a common basis. All the key inputs (labour rates, interest rates, exchange rates, energy prices etc.) are the same across all processing options. There are number of financial metrics calculated; ROCE (Return on capital employed), NPV (Net present value), IRR (internal rate of return), EBITDA (earnings before interest tax depreciation and amortisation) etc. The initial comparison is with ROCE, expressed as a percentage, which is a measure of profitability. For context, the higher the number the better – for a new plant a ROCE of 20% would attract investor interest.

Key drivers of the financial returns of wood processing plants are feedstock cost, yield of product, capital cost and the product sale price, which can be affected by exchange rate.

The ROCE values are not the last point in the financial analysis – but the first – it is a means of identifying opportunities that are worth more detailed analysis.

The model requires that the user filter out inappropriate options, based on knowledge of the type and scale of wood resource available. In this study we do not include primary solid wood processing such as sawmills etc. as the resource we are considering is pulp logs and in-forest residues. We also filter out plants that are too large for the resource available; some pulp and panel plants in the model are much larger than the wood resource we consider to be available in the long term on the East Coast. That is; 350,000 cubic metres per annum of pulp logs (minimum sustainable long term supply, average is 640,000 and there are only 3 years with the low supply; 500,000 m^3 per annum could be a realistic figure), 100,000 m^3 per annum of easily accessible landing residues, 60,000 m^3 of accessible cutover residues and around 200,000 m^3 per annum of cutover residues previously considered not be of interest due to the cost of extraction.

These residues have different costs associated with them, which will affect the viability of any processing option using them. Landing residues should be deliverable (in chipped or hogged form) for ~$60 per m^3 and accessible cutover residues for $68 to $70 per m^3. The cost of the inaccessible steep terrain cutover residues is uncertain but will probably not be less than $70 per m^3 and could be more ($80 to $90 per m^3).

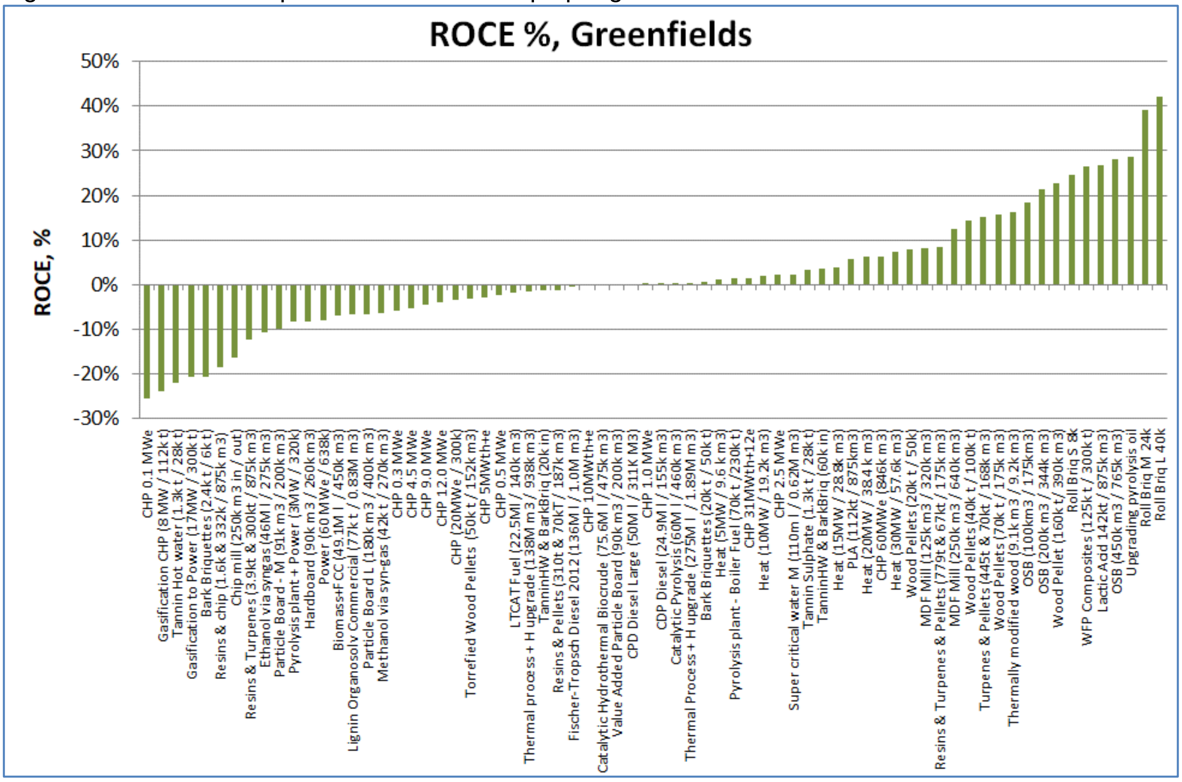
In summary; the analysis here will assume the pulp log volume to be ~500,000m^3 per annum and the harvest residue volume to be another 350,000 to 400,000 m^3 per annum.

The pulp logs are likely to be priced somewhat higher than New Zealand average due to the high transport distance and the high extraction costs associated with most of the East Coast forests. An average delivered pulp log price of $61 per tonne is assumed (NZ average is ~$53/$m^3$) – this should get the forest growers to around breakeven on the delivered log cost – which should be sufficient to see these logs extracted from the cutover and delivered to a point of use.

The model was set-up with current prices and the results for the plants suitable for the wood resource available are shown in the following set of graphs and tables. Figure 15 shows the ROCE of all the possible plants that fit within the limits of the wood resource available in the long term (~850,000 m^3 per annum of log equivalent). This list includes heat, combined heat and power, panel products, chemicals and fuels.

There are a large number of options that fit within the size of the resource. However, many of these have poor financial returns under current conditions and some are niche opportunities (bark briquettes).

Figure 15 – ROCEs for plants the fit with the pulp logs and residue resource on the East coast



In Table 4 the list of opportunities is focussed only on those with a ROCEs of over 10%. There is a wide variety of scales but some fit well within the potential resource and are proven technologies (MDF and OSB). Some technologies are not commercially proven (lactic acid) and pyrolysis + upgrading pyrolysis oil.

Table 4 – List of plants and operation from Figure 15 with ROCEs for above 10%

MDF Mill (250k m3 / 640k m3)*	12.5%
Wood Pellets (40k t / 100k t)	14.4%
Turpenes & Pellets (445t & 70kt / 168k m3)	15.1%
Wood Pellets (70k t / 175k m3)	15.7%
Thermally modified wood (9.1k m3 / 9.2k m3)	16.1%
OSB (100km3 / 175km3)	18.3%
OSB (200k m3 / 344k m3)	21.5%
Wood Pellet (160k t/ 390k m3)	22.8%
Roll Briq. S (8k t / 18k t)**	24.5%
WFP Composites (125k t / 300k t)	26.4%
Lactic Acid 142kt / 875k m3)	26.7%
OSB (450k m3 / 765k m3)	28.2%
Upgrading pyrolysis oil	28.7%
Roll Briq. M (24k t / 53k t)	39.2%
Roll Briq. L (40k t / 88k t)	42.1%

*figures in brackets indicate (product out / volume of wood (m^3 log equivalent in).
**estimated – no fully commercial operations

It is worth noting that based on the current assumed prices for heat and power there are no heat, power or combined heat and power options that would make an attractive investment. For these options to be viable they would have to associated with a large primary wood processing plant or be supported in some other way (carbon price, mandate, feed in tariff).

The assumptions for electricity and heat prices in the base case are $0.08 kWh for electricity and $12 / GJ for heat.

Figure 16 and Table 5 show the ROCE returns for plants focussed on heat and power and fuel products such as pellets and briquettes. Most of the CHP or heat plants have low ROCEs even with increasing electricity prices. The very large CHP unit at 60MWe is likely too large for the Gisborne region, especially in terms of the heat output – with no current demand for process heat at that scale.

Figure 16 - ROCEs for plants making heat and power; or heat and power products (e.g. pellets)

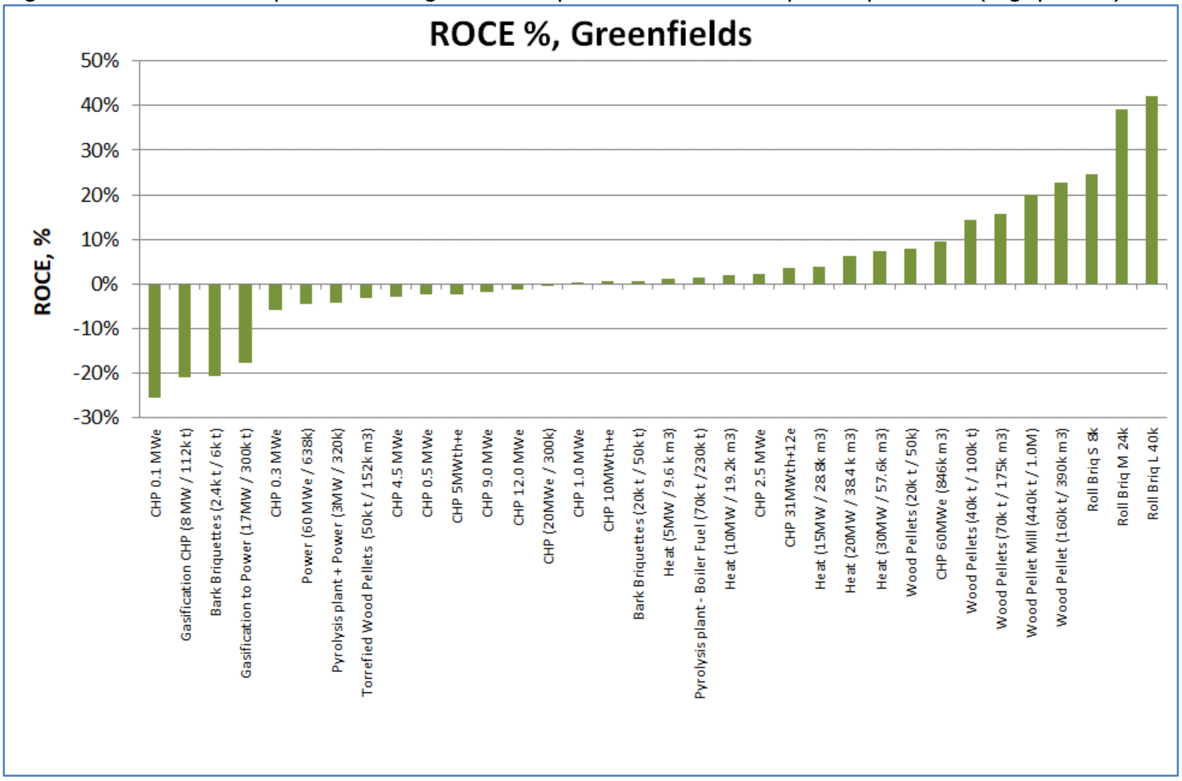


Table 5 – impact on increasing electricity process on power and CHP plants on ROCE

	Electricity sold at $0.08	Electricity sold at $0.14	Electricity sold at $0.20
CHP 0.5 MWe	-7.2%	-2.4%	2.3%
CHP 1.0 MWe	-5.9%	0.0%	5.9%
Power (60 MWe / 638k)	-4.6%	5.3%	15.0%
CHP 2.5 MWe	-4.4%	2.1%	8.6%
CHP 4.5 MWe	-2.8%	4.6%	11.9%
CHP 5MWth+e	-2.4%	-0.7%	0.9%
CHP 9.0 MWe	-1.9%	6.1%	14.0%
CHP 12.0 MWe	-1.3%	6.8%	14.8%
CHP (20MWe / 300k)	-0.6%	8.2%	16.8%
CHP 10MWth+e	0.5%	3.0%	5.4%
Heat (5MW / 9.6 k m3)	1.1%	1.1%	1.1%
Heat (10MW / 19.2k m3)	1.9%	1.9%	1.9%
CHP 31MWth+12e	3.5%	9.5%	15.4%
Heat (15MW / 28.8k m3)	3.7%	3.7%	3.7%
Heat (20MW / 38.4 k m3)	6.2%	6.2%	6.2%
Heat (30MW / 57.6k m3)	7.4%	7.4%	7.4%

The effect of increasing the cost of heat has been included as there is some opportunity for this to have an effect on the East Coast. There is minimal coal demand but modest gas demand with the individual site demands for heat often quite small.

The effect of increasing heat price (via an increase in the cost of carbon) and its flow on effect on the price of heat and power is shown in Table 6. The cost of gas sets the base price for the cost of heat. If the cost of the gas is increased via a carbon tax the base price for the heat is assumed to rise. This increases the price that a wood fuelled CHP or heat plant would be able to charge for its product.

Table 6 – Effect of increase gas price from $12 per GJ to $14.5 per GJ via a carbon price of $50/t on the ROCE of wood fuelled heat and power plants.

	Gas at $12 GJ	Gas at $14.50GJ
CHP 0.1 MWe	-25.5%	-25.2%
CHP 0.3 MWe	-6.0%	-5.7%
Syngas CHP	-2.8%	-2.8%
CHP 0.5 MWe	-2.4%	-2.2%
P syngas medium	0.0%	0.0%
CHP 1.0 MWe	0.0%	0.3%
CHP 5MWth+e	0.9%	2.2%
Heat 5MW	1.1%	8.3%
Heat 10MW	1.9%	9.2%
CHP 2.5 MWe	2.1%	2.4%
Heat 15MW	3.7%	11.0%
CHP 10MWth+e	5.4%	7.3%
Heat 20MW	6.2%	14.8%
Heat 30MW	7.4%	16.2%
CHP 4.5 MWe	11.9%	12.3%
CHP 9.0 MWe	14.0%	14.3%
CHP 12.0 MWe	14.8%	15.2%
Power 60MW	15.0%	15.0%
CHP 31MWth+12e	15.4%	17.6%
CHP 17.8 MW	16.8%	17.2%
CHP L	28.6%	31.0%

Figure 17 and Table 7 focus on reconstituted wood panel products. OSB looks to be a viable opportunity and MDF at large-scale worth more detailed investigation.

These products take low grade materials such as pulp logs (and sawmill slab chip in the case of MDF) and turn them into higher value products through flaking, chipping, grinding, gluing and compression with elevated temperatures.

They are energy intensive in comparison to saw-milling and would demand use of residues in excess of what they produce internally.

Pinus radiata is well suited to MDF with 3 mills well established in the South Island. OSB is not manufactured in New Zealand but is a well-developed technology and the product is widely used in house construction in North America.

The wood fibre composites options is a bolt on addition to an MDF mill, as its feedstock is MDF fibre.

Figure 17 – ROCEs of panel products

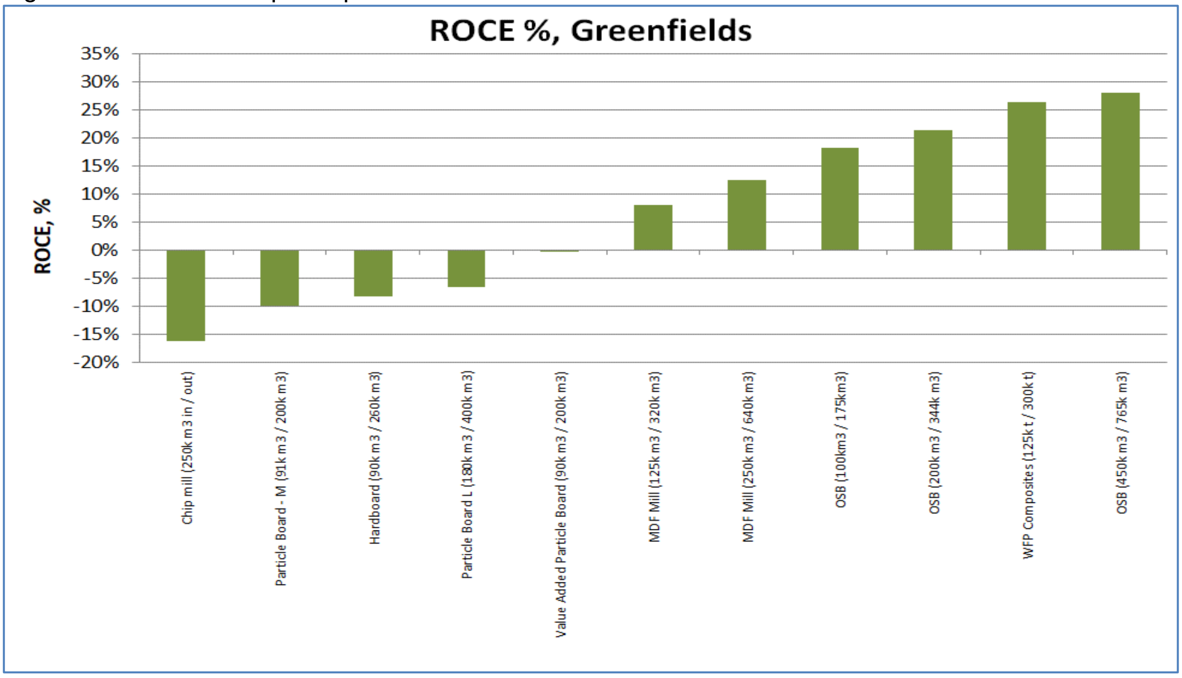


Table 7 - ROCEs of panel products over 10%

MDF Mill (250k m3 / 640k m3)	12.5%
OSB (100km3 / 175km3)	18.3%
OSB (200k m3 / 344k m3)	21.5%
WFP Composites (125k t / 300k t)	26.4%
OSB (450k m3 / 765k m3)	28.2%

There are a number of emerging fuel and chemical processing options to consider (Figure 18 and Table 8). However, given current prices there are few that look attractive and many of these technologies are not commercially proven, including the lactic acid option.

Figure 18 – ROCEs of fuel and chemical products

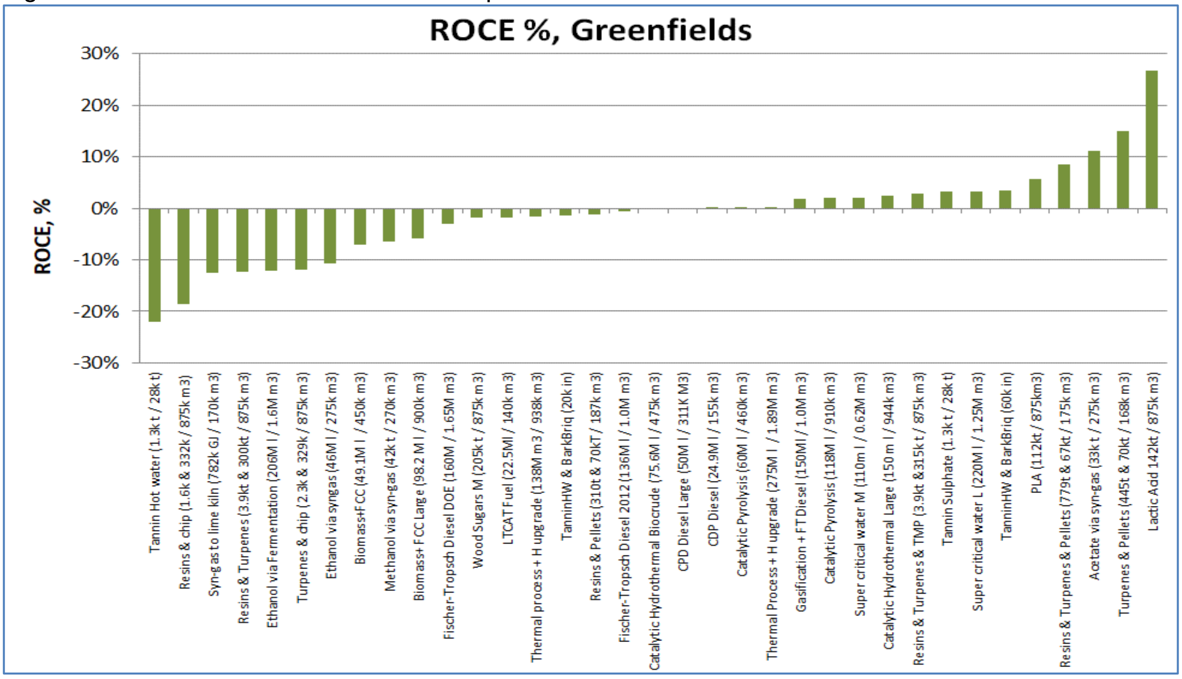


Table 8– Chemical production options with ROCE over 10%

Acetate via syn-gas (33k t / 275k m3)	11%
Turpenes & Pellets (445t & 70kt / 168k m3)	15%
Lactic Acid 142kt / 875k m3)	27%

Wood processing summary

Options not considered as viable;

- Pulp and paper mills; typically too large in terms of their demand to fit with the East Coast wood supply.
- Biochar / activated carbon; the metrics available on these plants is not sufficient to have confidence in the results generated. There are several examples (including in New Zealand) of these operations being established and then failing.

The most promising opportunities for the large-scale use of pulp logs and wood residues on the East Coast appear to be;

- OSB and MDF
- Wood pellets possible with terpene extraction prior to pelletisation

Smaller scale options would be around bark, from the port operations and from local log processors.

One of the ways to get wood energy plant installed in the East Coast region is for primary wood processing such as sawmilling, with associated use of lumber produced for CLT and remanufacture established and operating together. Sawmills typically have wood residue fuelled heat plant as an inherent part of the operation as they have the residues to dispose of (sawdust, bark, off-cuts etc.) and the demand for drying heat. Most sawmills have their own wood fuelled heat plant and some sawmills (Red Stag) have a combined heat and power operation and generate enough of both to meet all their own demands and at times have some electricity for export. Small scale wood fuelled combined heat and power plants are a well-established technology.

For example, if a medium sized sawmill (taking in 360,000 m^3 per annum of S and A grade logs) was established at Ruatoria it could also sit alongside a CLT plant and a remanufacturing plant. The feedstock to the CLT plant and the remanufacturing plant would be dried lumber from the sawmill. The combined residues from all 3 processors is enough to fuel a CHP with enough heat and power output to feed the sawmill and the electricity demand of the CLT and remanufacturing operations. If a larger power output for export to the grid was required, then in-forest residues could be extracted and used in the same facility.

A more detailed investigation of the long-term wood supply at sites such as Hicks Bay, Ruatoria etc. would be required to fully investigate the viability of such an operation. It is worth noting that processing closer to the forest could have a significant effect on road transport demand.

For example, a sawmill takes in a green tonne of log and converts it into ~0.52 tonnes of lumber and chips. If the lumber is processed at the sawmill into other products (CLT and remanufactured materials) then the reduction is even greater. The exact reduction will depend on the nature of the processing cluster and the use of any slab-wood chip but could be in the order of 1 tonne of logs becomes 0.5 tonnes of products.

Potential policy options for central government

Policy considerations

Two general categories of policy interventions have been presented: supply-side interventions to increase the amount of residue collected and demand-side interventions to increase the value of forest residues.

Supply-side interventions may directly target those residues which are at highest risk of mobilisation, providing the greatest likelihood of effectiveness. They effectively turn residue collection into a sunk cost, creating incentive for forest growers to find markets for the residue. However, without complementary demand-side interventions, the market for residues could be oversupplied. Regulatory interventions will increase costs for forest growers and may place unequal burdens on small operations.

Demand-side interventions would be softer and provide co-benefits aligning with other Government priorities, including goals for a low-carbon economy, regional economic development and export value growth. However, these may not guarantee that market needs are met by forest residues rather than substitute sources; or that the residue at greatest risk of mobilisation is taken rather than the residue most convenient for collection.

Forestry industry representatives provide differing assessments of the amount of residue remaining and the difficulty of increasing residue removal. Most forest companies conduct a Wagner Waste Assessment, which assesses the volume of merchantable debris – this is only applicable if there is a market for this material, namely an MDF plant of pulp mill. Where these markets exist, debris can be reduced to $10m^3$ per hectare cutover. In most cases, where these markets do not exist, the debris is left, amounting to $100\text{-}150m^3$ per hectare.

Some operations have explored the use of larger debris to anchor vulnerable soils and trap smaller debris movements. They believe this represents good practice from international experience but may be conflict with accepted practice in New Zealand. Further, there are no engineering standards in New Zealand for anchoring debris, and estimates of cost are high. This would require similar work to the British Columbia Watershed Restoration Program (n.d). Interventions to encourage residue removal should consider the potential implications for positive in-situ uses of residues and should avoid preventing innovation.

Supply-side interventions

Direct regulation

While the NES-PF already requires forestry slash and debris to be managed to reduce the risk of debris movement, amendments to the NES-PF could introduce more stringent or explicit requirements for residue removal. Direct regulation would likely be the most effective option for targeting the removal of residues from high risk areas. As a co-benefit, this would increase the supply of residues available and effectively subsidise the creation of markets for residues.

Regulations could establish, either individually or in combination:

- a minimum ratio of gross tonnes forestry residue harvested to gross tonnes of logs;
- a maximum tonnage per hectare of residues remaining; or
- a maximum size for pieces remaining (length, diameter and volume).

While effective, regulatory changes would have several drawbacks. First, the process of making amendments to national direction could take several years and considerable central government expense to accomplish, particularly if changes to primary legislation were necessary. Once completed, additional time would be required to communicate and implement the changes. Changes to the NES-PF relatively soon after its release would also undermine the intent of providing consistency and predictability to industry.

Regulations would need to be crafted to avoid unintended consequences. In the absence of complementary market interventions and/or considerations for smaller forests, regulations would likely increase harvest costs without necessarily enabling markets for residue where costs could be recovered. This would have greatest impact on smaller operations and could make these financially unviable. Additionally, unless carefully prepared, legislative requirements could also conflict with options to use residue for sediment traps or soil stabilisation and prevent innovative in-situ options. Any amendments to the NES-PF would need to consider potential negative impacts on health and safety. The NES-PF excludes debris recovery requirements in cases where collection would be unsafe. As steep, unstable slopes and gullies are the areas with both the highest risk of debris mobilisation and highest risk to safety, this exclusion could limit the effect of residue removal requirements. However, risks to workers can be avoided or mitigated by use of appropriate technology such as grapple carriages and cameras to give hauler operators good vision of the material being targeted.

To mitigate against placing undue burdens on smaller operators and to encourage best practices, different requirement thresholds or exemptions could be assigned depending on:

- the total harvest area;
- the overlay class;
- the proportion of trees left standing (i.e. through selective harvest rather than clear-felling); or
- the use of alternative means of debris flow mitigation (e.g. debris traps for small harvest areas).

Finally, direct regulation would necessarily require additional compliance, monitoring and enforcement, increasing the burden on regional authorities. As the RMA allows councils to charge for monitoring of permitted activities, much of this cost would be shifted to harvesters. However, depending on the level of monitoring already conducted by the relevant council, the incremental cost of additional requirements may be minimal.

Targeted rates, rates remission and rates rebates

The Local Government (Rating) Act 2002 allows regional councils to create targeted rates, including rates based on land use and/or certain activities under the RMA. The act also allows councils to remit all or part of a rate for any reason provided they follow conditions and criteria which the council has set for itself in a remission policy.[1] A targeted rate on forestry land used in combination with rates remission for properties or harvest areas that meet specific residue removal criteria could provide strong financial disincentive for leaving forestry residues.

Although potentially controversial, there is ample precedent for councils using targeted rates to manage the impacts of land use. Gisborne District Council currently charges forestry five times the standard targeted rate for Roading Flood Damage and Emergency Works and Subsidised Local Roads. There is also precedent for using rates remission to incentivise specific actions undertaken on a property. For example, Wellington City Council offers three years of remission for properties removed from their Earthquake Prone Buildings list through strengthening or demolition of vulnerable buildings (https://wellington.govt.nz/services/rates-and-property/rates/remission). Although rates remission would reduce net revenue for the council infrastructure maintenance, this may be offset by the reduction in damage from debris flows. Such a system would also shift the burden of proof from council to harvester, facilitating compliance, monitoring and enforcement.

Adopting a new or amended targeted rate and remission policy requires following a process of public consultation, which could take multiple years and require significant council resources depending on how the process aligns with council planning programmes and the level of legal challenge faced.

A target rates and remission strategy would also face risks and unintended consequences:

- Because a targeted rate imposes additional annual cost on forestry land, it could affect the profitability of forest lands and create disincentive for new planting. This disincentive would affect growers of slower-growing native timbers more strongly, serving as a barrier to native forestry. Also, unless carefully prepared, such rules could penalise the owners of permanent forests. As a targeted rate already exists in Gisborne, the risk has already been accounted for by growers in that region. Gisborne District Council also already offers rates

[1] See s. 85 of the Local Government (Rating) Act 2002, and s. 102 and s. 108 to 109 of the Local Government Act 2002.

remission to owners of land under covenant for conservation, but this may not cover all permanent forests.

- A targeted rates and remission approach could have greater impact on smaller companies or harvest operations if their scale makes residue collection relatively more expensive and less cost effective.
- The need to monitor compliance with remission conditions would create additional burden for regional authorities; however, as the RMA allows councils to charge for monitoring of permitted activities, much of this cost could be recovered from harvesters through normal monitoring processes. Moreover, the remission approach will shift the burden of proof onto forest growers and create positive incentive for forest growers to document their actions.

Additional economic modelling would be necessary to determine appropriate thresholds, remission levels and remission durations if this strategy were pursued. As with direct regulation, councils could potentially differentiate between forest operations by size, land class, or other metrics to mitigate against the risks noted above.

Increased compliance, monitoring and enforcement under existing regulations

The threat of more coordinated and aggressive enforcement of existing regulations in cases of forest debris movement—whether by regional councils under the current system or through direct central government action following proposed RMA amendments—could provide stronger industry signals to improve practices and remove more residue from high risk areas.

Several recent reviews have noted an apparently low level of compliance, monitoring and enforcement under the RMA (e.g. Brown, 2016). MfE estimates that 3% of all formal council enforcement actions result in prosecution (https://www.mfe.govt.nz/sites/default/files/media/RMA/compliance-monitoring-and-enforcement-report.pdf). In the 2016/2017 financial year, 71 prosecutions were initiated from 3,344 formal enforcement actions and an unknown number of informal actions (http://www.mfe.govt.nz/rma/national-monitoring-system/reporting-data/complaints-monitoring-compliance-and-enforcement-2). Many councils prefer to issue warnings, educate offenders and undertake alternative remedial action in lieu of formal enforcement processes. While arguably more cost-effective, informal approaches mean there is often little public record of non-compliance and council responses (https://www.mfe.govt.nz/sites/default/files/media/RMA/compliance-monitoring-and-enforcement-report.pdf). This, and the reduced threat of tangible penalties, may undermine pressure to comply. In addition, the distributed nature of forestry operations means that a company could theoretically exhibit a pattern of non-compliance across multiple regions without triggering formal enforcement action in any single region.

Stricter compliance, monitoring and enforcement of forest debris management would increase residue removal and supply by sending a message of raised expectations. This could have a relatively rapid effect. Even where softer enforcement approaches are used, coordinated recording and centralised public reporting of non-compliance may help apply stronger social and political and financial pressure for forestry operator compliance within existing regulations and plan rules. It may also help identify patterns of non-compliance, enabling better decisions about when it is necessary to apply stronger penalties.

Enforcement actions would have even stronger influence for foreign-owned companies. Under the Overseas Investment Act 2005, foreign owned forestry companies and individuals in control of those companies are required to pass a good character test to buy, lease or hold forestry rights for land. The test includes offences and “Any other matter that reflects adversely on the person's fitness to have the particular overseas investment.” The Minister of Finance could publicly direct the Overseas Investment Office to consider a broader range of non-compliance under the RMA and related policy instruments in the good character test even if they do not result in formal enforcement action, rise to the level of an offense or result in prosecution. The implications for foreign-owned forestry businesses could include denial of access or forced divestment of existing forest rights. As the legislation allows some Ministerial discretion, the government could elect to issue warnings without necessarily resorting to barring an individual or company from investment. Though drastic, such a threat would create strong incentive for foreign forestry companies to ensure thorough removal of residues from harvest areas. It would have no effect, however, on domestic forest growers.

Attach requirements for residue removal to afforestation funding grants

- Challenges, risks and unintended consequences
  - Requirements placed on current planting would not have effect until those forests are ready for harvest and would require compliance, monitoring, and enforcement over the long term.
  - Such an approach introduces complexity for potential forest growers which may reduce uptake of the schemes and slow progress towards 1BT.

Demand side interventions

Direct investment or cash incentives

Direct investment in businesses to adopt residue use technologies or processes could be made through either outright grants or impact investment loans with expectations of long-term returns. The primary advantage of these approaches is that they have quick impact. Investment in new wood-processing facilities would also further the government's goals for economic development for the region and for increasing the value of exported products. Both options would require significant initial investment from the government and/or other sources, but the latter allows for potential net benefit over the long term.

Two models for direct investment could be considered. The first model is one where direct investment is shared between the government and industry, following the example of the 1973 Swedish Forest Act, where 'state subsidies' for replanting and regeneration of 'less profitable areas' were drawn from government funding and a levy (0.1%) on timber sales (Nylund, 2009). This option may be feasible as the Forest Growers Levy renewal is to be voted on in March/April 2019, with government implementing the Order later in 2019. A proportion of the levy could be matched with government funds to provide direct investment in secondary harvesting and residue processing opportunities.

The second model is direct government funding. An ongoing New Zealand example of this is the Erosion Control Funding Programme (ECFP) (see **https://www.mpi.govt.nz/funding-and-programmes/forestry/erosion-control-funding-programme/**). The land treatment grants, providing funds to plant trees on erosion susceptible land have closed, now coming under the 1 Billion Trees funding mechanisms. Other examples, from Canada demonstrate additional opportunities, for example the Aboriginal Forestry Initiative (AFI), a fund that supports forest-based economic development for Aboriginal peoples. This would likely be of particular interest on the East Coast, with 84% of the population of Māori descent (Stats NZ, 2014). The AFI supports aboriginal communities in integrated natural resource development; forestry is one element of activities and opportunities that exist beyond the traditional forest industry (CCFM, 2015).

Other ways in which the government can directly encourage forest residue use is through assisting the industry in expanding their markets. This could be structured similarly to the Canadian 'Expanding Market Opportunities Program". This program provides federal funding to forest products associations, provinces and Crown corporations to assist them in maintain and growing international forest products markets (CCFM, 2015)

Direct investment in research and innovation to achieve emissions reductions through energy production would also bring about market opportunities to use wood residues. The Canadian government's "ecoEnergy Innovation Initiative" does just this – providing support for energy technology innovation (CCFM, 2015).

Significant initial costs would be borne by government, however, there are potential further benefits through an aboriginal (Māori)-focused initiative and research initiatives.

There is a risk that increasing demand for biomass overall could divert wood residue from panel mills rather than from significantly increasing collection from harvest or pruning sites. For example, subsidies through the USDA Farm Service Agency's Biomass Crop Assistance Program were

found to unintentionally divert biomass from board products to power generation, reducing effectiveness towards the goal of increased residue removal.
Any incentive or assistance programme would have to be linked to conversion from other fuels or expansion of capacity to meet goals.

Overseas examples

- Oregon tax credits to biomass
- E.g. USDA Farm Service Agency's Biomass Crop Assistance Program subsidizing biomass collection

Increase carbon price to incentivise wood-based fuels

Interventions to raise the price of carbon credits would increase the effective relative cost of market alternatives for wood fuels and incentivise residue collection. As noted above, densified wood pellets for CHP are cost competitive against gas when carbon credit prices exceed $10 per tonne and against coal above approximately $50 per tonne. As of 7 January 2018, carbon credit spot prices were approximately $25 per tonne with contracts for credits due in 2023 above $28.

Under current ETS policy settings, the government provides a fixed price offer of $25 as a de facto price ceiling, preventing further price increases. However, the Government has announced its intention to replace the unlimited $25 fixed price offer in 2020 with a cost containment reserve that would be triggered at an as yet unspecified price (MfE, 2018). The trigger price will be determined following consultation in 2019; however, MfE has stated that the new ceiling will likely be higher than $25 and will increase over time.

A large reserve of stockpiled credits serves as an additional damper on price increases. As of June 2016, approximately 130 million NZUs had been stockpiled from previous years when international units were accepted and were available at prices below those for New Zealand units (MfE, 2017).

Evidence suggests carbon prices would rise if the price ceiling were lifted. MfE notes that current carbon credit demand outstrips annual supply, and the deficit is depleting the supply of stockpiled credits (MfE, 2017). Demand for units is forecast to increase 33% from 33.9 million units surrendered in 2018 to 45.0 million units in 2021. In the same period, new allocations are forecast to fall from 31.0 million units to 26.0 million units (MfE, n.d.), resulting in an annual shortfall forecast of 19.0 million units by 2021.

Establishing policies to increase carbon credit prices above $50 per tonne would help provide certainty for industries to invest in densified wood fuel burners. This price is well below the minimum $75 per tonne considered necessary by the Productivity Commission to reach the Government's goal of being carbon-neutral by 2050 (New Zealand Productivity Commission, August 2018). Alongside incentives through the Billion Trees Programme, expected increases in carbon price would also promote increased forestry planting and, therefore, provide certainty of future residue supply.

A full discussion of the various policy options for influencing carbon price is beyond the scope of this report, but options could include:

- a phase-down of free allocation and a reduction or end to agricultural exemption to increase demand for carbon units;
- a cost containment reserve threshold rising to well above $50 per tonne; and
- the introduction of an auction reserve at or above $50 per tonne to provide a price floor.

Challenges, risks and unintended consequences

- There is a risk that other sources would be used to meet market demand without significantly increasing residue harvests. Furthermore, in the absence of complementary regulation or other incentives, harvest operators would be motivated to collect residues from areas which are easiest and most cost effective rather than from areas where the risk of debris movement is highest.
- Without additional incentives, the up-front costs of converting to existing coal or gas burners may serve as a barrier for existing heat plant operators until carbon prices are significantly higher than the prices listed above.

- Given the need to manage socio-economic impacts from the transition to a low-carbon economy and the time required to implement carbon price intervention policies, carbon prices may not rise fast enough to fully achieve the intended effect for several years or decades.

Governmental strategic procurement

Government procurement represents approximately 18% of the national GDP (MBIE, 2015), making it a significant market lever. Strategic government procurement that gives preference to sustainable businesses and products, including those involved in optimisation of forest residues, would help provide markets for forest residue products.

While the government currently lacks a comprehensive sustainable procurement strategy, the New Zealand Timber and Wood Products Procurement Policy directs government agencies to source legally and sustainably sourced timber and wood products (MPI, n.d.). This policy could be amended to specifically include forestry residue management as a sustainability concern to be included in procurement contracts. However, it may be difficult to do so through such a policy unless stricter residue management standards were added to legislation (i.e. the NES-PF) or adopted by third-party certifications (see discussion below).

A more comprehensive governmental sustainable procurement strategy that emphasised consideration of products' and suppliers' carbon footprints, promoted wood construction materials and encouraged the use of clean fuel technologies would help support markets for a broader variety of forest residue products. Such a strategy has become a common and effective tool among other developed nations (UNEP, 2017) and has been recommended by the New Zealand Ecolabelling Trust (https://www.radionz.co.nz/news/national/336585/call-for-govt-to-commit-to-sustainable-procurement), the Sustainable Business Network (https://sustainable.org.nz/wp-content/uploads/2014/09/Call-for-NZ-Government-to-become-global-leader-in-sustainability.pdf) and the sustainable Business Council (https://www.sbc.org.nz/__data/assets/pdf_file/0005/129479/SBC-2017-Pre-Election-Brief-Manifesto.pdf). However, the creation of a comprehensive policy would require considerable time and the involvement of government agencies across policy domains.

With either approach, procurement requirements would likely increase costs to government agencies. Moreover, international treaty obligations bar policies which give explicit or de facto preference to local suppliers, meaning that procurement could not target forest residues in New Zealand specifically.

Encourage/incentivise small secondary harvest operators

In some places, such as British Columbia, the rights to secondary harvest of forestry fibre biomass are sold or granted separately from primary harvest rights.

Objectives of these programmes include; the increase of lower quality wood and wood residue, facilitate integrated harvesting, enhanced business to business (B2B) relationships and enhance the security of fibre supply for secondary and non-lumber users of low quality and residual fibre. Reduction of carbon emissions and improvements in air quality through less open burning-off of residues are additional objectives (British Columbia Government, 2018). While market conditions may not currently support the sale of secondary harvest rights, regulations and other incentives could be used to create such a market. Given sufficient regulatory incentives or risk to social license, companies may even be motivated to give such rights away for free. Encouraging this approach could enable small secondary harvest businesses to access the raw material cheaply and innovate uses.

With private ownership of forests in New Zealand, the primary approach by government would likely be one of promoting B2B relationships between primary harvesters (PHs) and secondary users (Sus). Key ways in which this can be done are through encouraging and facilitating voluntary information sharing between PHs and SUs, facilitating B2B negotiations and assisting PHs and SUs to implement integrated harvesting operations (see FP Innovations, 2017).

To be efficient, there must be coordination between the primary and secondary harvesters to ensure that primary harvesters position waste so that it is more easily recoverable by secondary operators.

Encourage sustainable forestry accreditation organisations to include more stringent standards for residue harvest

Two accredited certification programmes operate in New Zealand, the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification (PEFC). Both of these certification programmes are voluntary for industry and operate outside of direct government control. There is no direct government policy that can change forest certification, however policies to encourage revisions or change to the certification standards can be put in place.

FSC in New Zealand has a dedicated Standards Development Group, comprised of two members of each of the four chambers. This group develops and revises standards as necessary, with final standards being reached through consensus. Standards are then open to public consultation. Government does not sit in any of the chambers, and thus does not have any direct influence or control over the FSC standards. Government can put in place 'internal' policies to ensure that they provide input into standards when they are open for public/stakeholder comment.

In the PEFC standard development process, New Zealand government organisations, the Ministry for Primary Industries and Local Government New Zealand were represented on the committee to develop the standard (Standards New Zealand, 2014). Thus, government policies have the opportunity to influence PEFC standards when reviewed. Further government input can be heard when standard revisions are opened for public/stakeholder comment.

Other general Challenges, Risks and Unintended Consequences

- Horticulture and viticulture are growing in the region, increasing demand on transport infrastructure and raising costs.
- Though industrial processes contribute a minority of air pollutants in the Gisborne area, it is possible that increased wood burning for CHP could be restricted by existing air quality regulations. The annual average for particulate matter (PM_{10}) in Gisborne City is approximately 14 $\mu g/m^3$ and well below the annual guideline level of 20 $\mu g/m^3$, but daily means sometimes approach the 50 $\mu g/m^3$ daily mean threshold set in the National Environmental Standards for Air Quality 2004. On one day in 2018, Gisborne city's monitoring station showed daily average PM_{10} at 49.6 $\mu g/m^3$ –more than 99% of the standard threshold—and seven other days exceeded 30 $\mu g/m^3$ (LAWA). The National Environmental Standards for Air Quality permit one exceedance of the daily mean per year. A relatively small increase in particulate matter could, therefore, push air quality across the threshold.

Review of infrastructure constraints on processing options

Road Transport

The road transport network on the East Coast is widely reported to be challenging, with narrow winding roads. Forests on the East Coast are some of the most remote sites with regular heavy truck traffic. Transport distances are not only long, but travel speeds are also likely to be lower due the nature of the roads.

Figure 19 – HPMV routes on the East coast

The High Productivity Motor Vehicles (HPMV) network is limited on the East Coast (Figure 19).

The only forest areas that are able to access this network are those around Mangatu Forest (North-west of Gisborne) and the forests inland from Tolaga Bay. The extensive areas of forests north of Tolaga Bay and south of Gisborne around Wairoa cannot take advantage of the higher loads permitted to HPMVs.

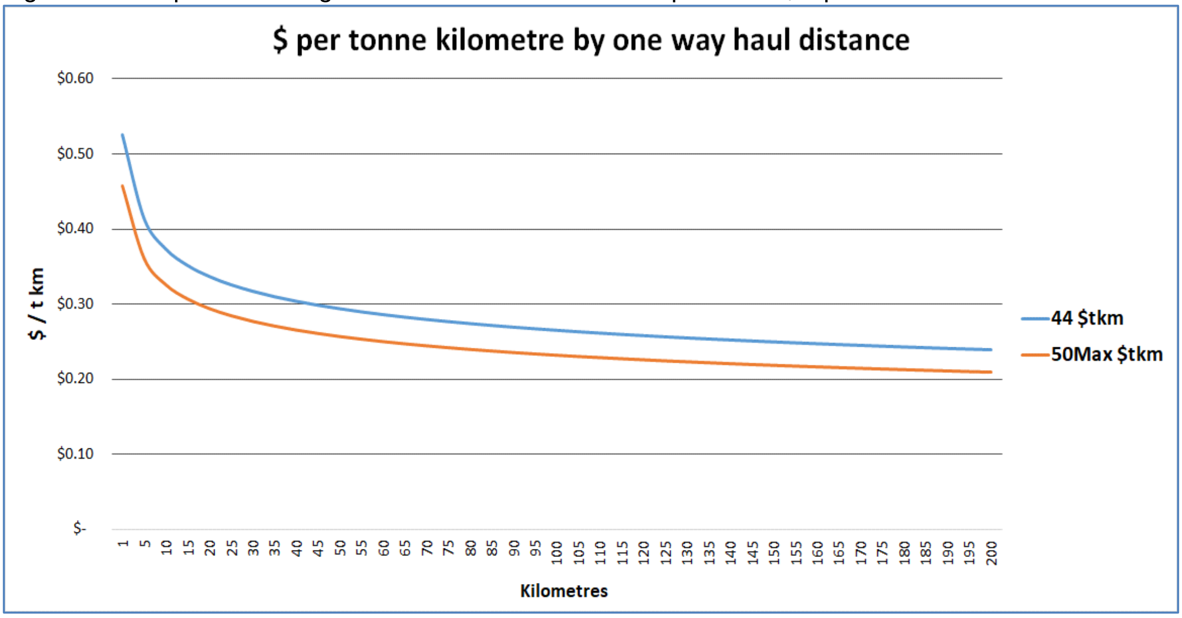
The forests to the south of Gisborne, at Wharerata, that straddle the Hawkes Bay - Gisborne boundary cannot access these routes either north to Gisborne or south to Napier.

Note – plantation forests on this map are marked in pale green, the indigenous forest is in a brighter green.

Source;http://nzta.maps.arcgis.com/apps/webappviewer/index.html?id=e00b3ac6ab524cb19a369fc5c2b4e6fa

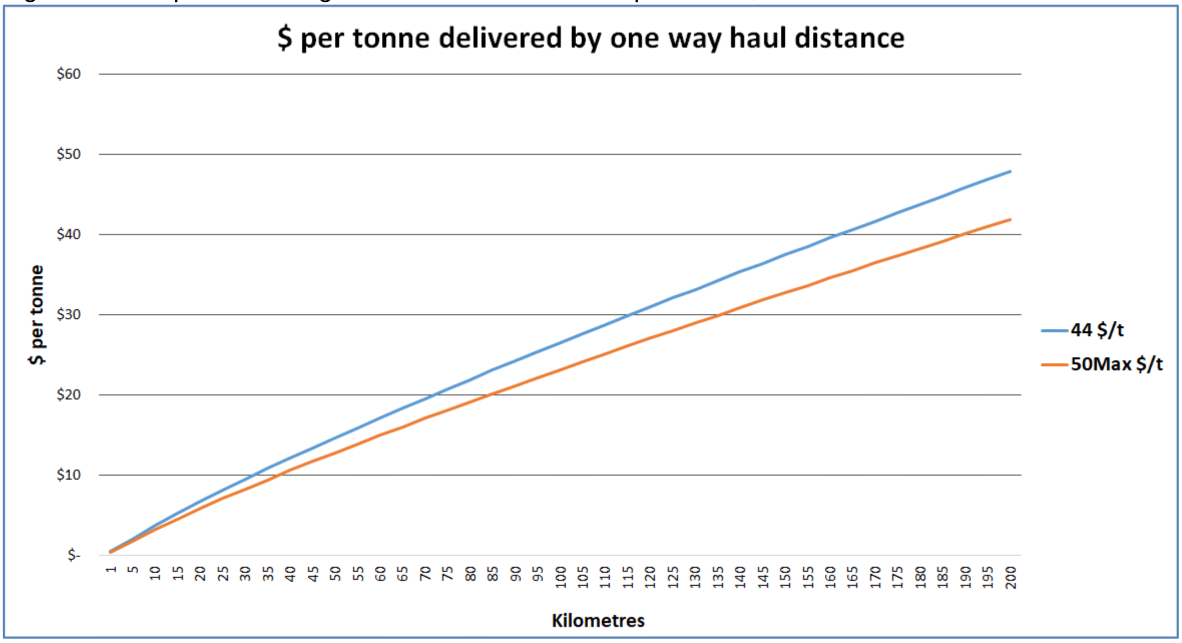
The decrease in transport costs from moving to HPMVs is likely to be in the order of 14% (Figure 20), with the actual costs varying by distance. On longer hauls (~100km) the saving is estimated to be in the order of $0.03 per tonne kilometre or around $3 per tonne Figure 21).

Figure 20 – Impact of change to an HPMV route on transport costs; $ per tonne kilometre



Typical log haul distances on the East Coast are likely to be 100km. The national average is in the order of 86km from forest to mill or port (NZFOA, 2007).

Figure 21 – Impact of change to HPMV route on transport costs; delivered costs



Given the costs of transport and the likely haul distance – the savings from having the logs transported by a 50MAX HPMV as opposed to truck limited to a 44-tonne gross vehicle mass (GVM) are in the order of $3 to $3.50 per tonne.

Rail Links

There is no functioning rail link from Gisborne to other regions. The link from Gisborne to Wairoa and on to Napier was damaged by slips at Kopuawharo (in Northern Hawkes Bay) and has not been repaired. The line has not been functional for several years (mothballed in 2012). The cost of the repairs to the line have been estimated at up to $5 million.

The rail link from Wairoa to Napier was also damaged by slips – and is under repair, with the original time frame for repairs being subject to delay due to further damage since the decision to repair the line. Currently this line is not functional.

The cost difference between road and rail freight is estimated at $0.06 to $0.07 per tonne kilometre on longer hauls (~200 km).

However, this figure does not take into account the cost of mode shifting (handling the logs from truck to rail and possibly back again) that may be necessary in many situations. This cost is often in the order of $3 to $5 per tonne and so the rail freight distance needs to considerable before the benefits is gained (Appendix B).

The value of repairing the rail link would also depend on freight from other industries that might benefit from the reinstatement of the rail link. That analysis is beyond the scope of this study.

For the specific case of the Gisborne to Napier link the distance is sufficient to warrant the costs of mode shifting and using rail to get pulp logs to OFI Fibre Solutions mill at Whirinaki (near Napier) from Gisborne would likely to be around $4 per tonne cheaper than road transport.

<u>Barging</u>

The cost of barging logs is competitive with road transport when the haul distances are around 200km or more – and the barging infrastructure (log yards, access points etc.) is in place.

A cost comparison is shown in Appendix B, this was derived from an Environment Bay of Plenty study conducted in 2000.

The take away from this is that barging of pulp logs and possibly hogged residues would have their delivered costs to Gisborne reduced by several dollars a tonne in comparison to road transport, if barging points were constructed at for example Hicks Bay.

This would not affect the logs and residues sourced closer to Gisborne; for example, Tolaga Bay, which is only 55 to 60km from Gisborne.

Some sites on the Gisborne side of Hicks Bay may be worth considering for barging transport, others it does not make sense;

- For example, logs from near Ruatoria would be required to go about 55km North to Hicks Bay by road and then South to Gisborne (200 km) by barge as opposed to 130 km by road to Gisborne. The cost of road + barge is higher than direct road transport in this instance.

Energy distribution

Gas supply - East Coast

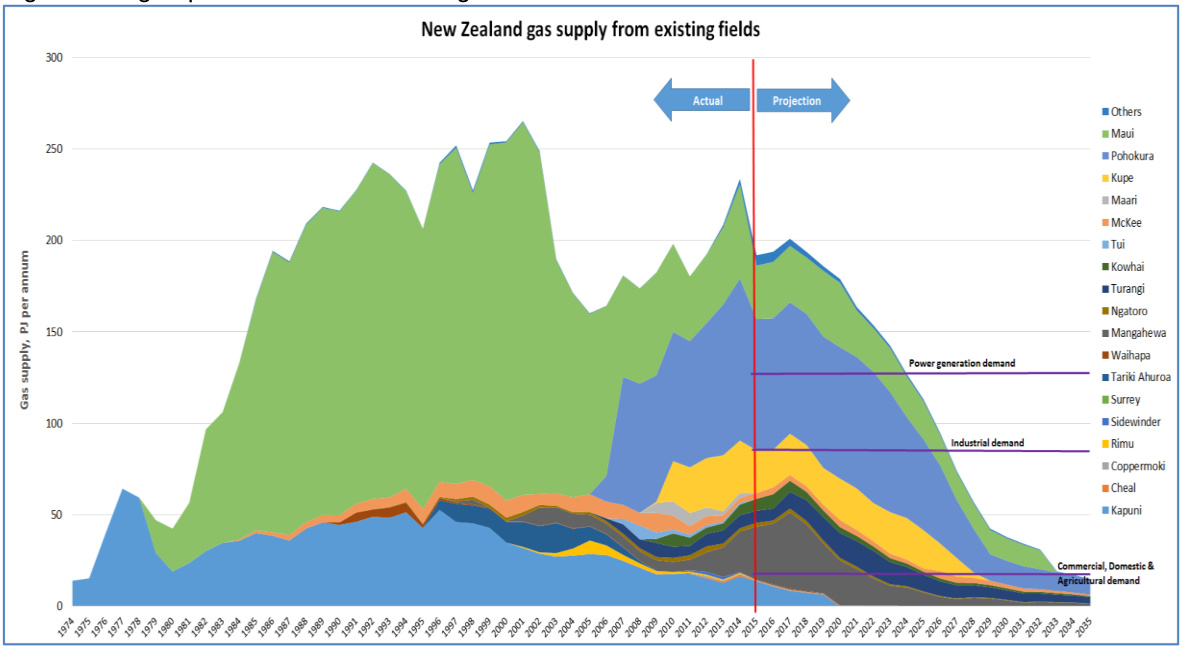
Gisborne is connected to the North Island natural gas pipeline network, and so many of the industrial boilers in Gisborne are natural gas fuelled. Many of these boilers are small.

At a national level natural gas supply is expected to tighten (Figure 22), with increasing prices from 2020. Currently oil and gas exploration is limited with no new fields under development.

The current gas pipeline to Gisborne has some spare capacity - enough to supply a gas generation facility of around 4MWe, so at an efficiency of 60% the gas pipeline has estimated spare capacity of another 6MWth.

Based on the pipeline capacity limits and the potential for future price rises, major expansion of heat plant might do well to consider wood as a fuel. In 2015 gas prices were around \$7/GJ for industrial users and \$14.50 per GJ for commercial users (MBIE, 2016).

Figure 22 - gas production from existing fields



A less technically developed option would be the gasification of biomass, with gas clean-up, making a synthetic natural gas that could be fed into the gas pipeline network and sent direct to existing gas consumers. This technology exists, having been developed to a 20MW scale in Gothenburg during the GoBiGas study, but has not been commercially proven. This approach may warrant further study.

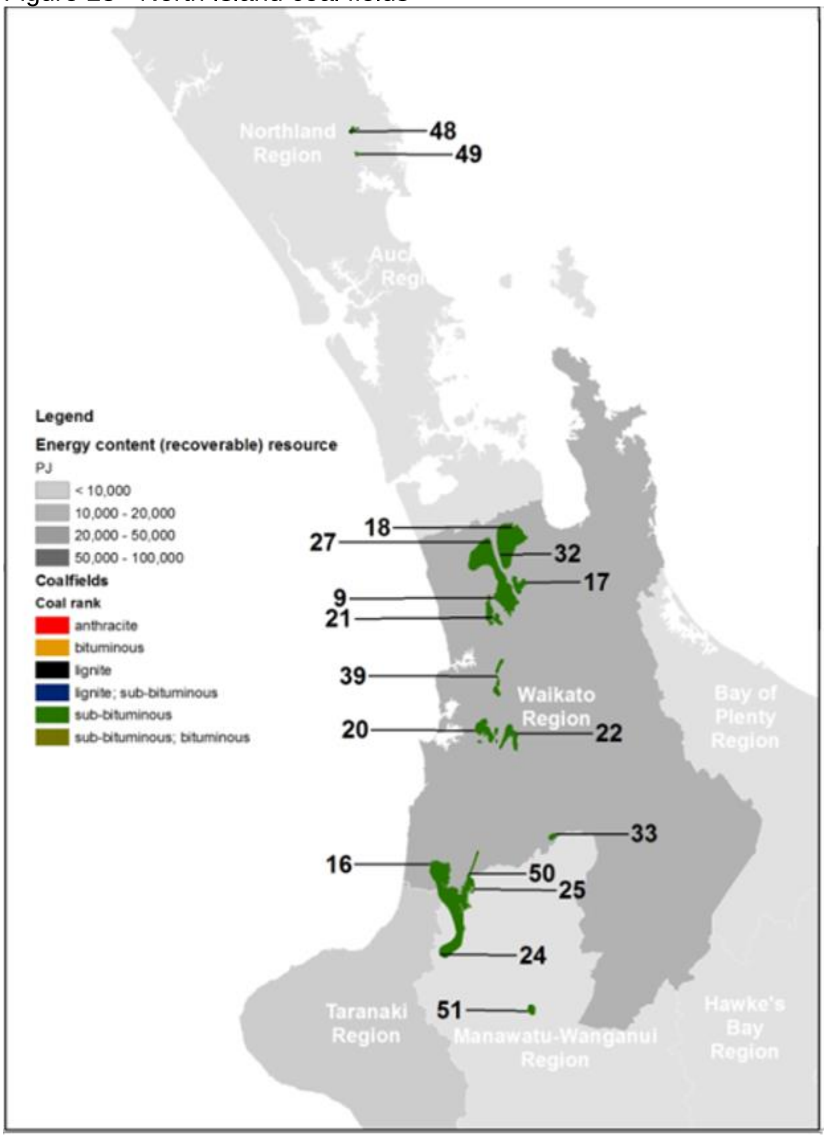
Coal Supply - East Coast

There is no local coal supply on the East Coast, with the nearest coal fields being in the Waikato region (Figure 23).

The transport distance from these fields to Gisborne is in the order of 375 km, which would add around $65 / tonne to the delivered cost of coal. Hence there is very little use of coal in the East Coast region.

There is some coal demand in Northern Hawkes Bay (Wairoa). The delivered cost of coal is likely to be around $8 to $9 per GJ.

Figure 23 - North Island coal fields



Geothermal energy supply - East Coast

High Enthalpy Sources
There are no high enthalpy geothermal resources in the Gisborne region and therefore, there are no geothermal power stations in the Gisborne region, with the closest ones being at Kawerau. There is no direct use of geothermal heat for industrial processes.

Low Enthalpy Sources
In the Gisborne area there are two locations where low enthalpy springs occur, at Morere and Te Puia. These springs discharge warm water at 50 – 70 ºC (Hunt and Glover, 1995; Pohatu et al., 2010).

The heat sources for these springs are considered to be non-magmatic and derived from deep fluid circulation due to tectonic processes.

At Te Puia, the total flow rate from the springs are estimated to be 87 l/s, with a minimal thermal potential of 1.8 MW. With resource temperature below 100 ºC and low flow rates, power generation is not likely to be pursued (Pohatu et al., 2010).

The take at Morere is 77,380 m^3 per annum, with a thermal potential of 0.05MW. The water at Morere is saline, with temperatures of 50 to 70ºC.

The enthalpy of these springs is in the order of 220 to 280 kJ per kg.

Beyond the bathing pools associated with the natural hot springs, there is no commercial use or consented use of geothermal heat on the East Coast.

It is thought that there might be commercially exploitable resources in the vicinity of the Te Puia hot springs, at a depth of around 3000 metres (Hunt and Glover 1995) but until a well is drilled temperatures and potential flows are uncertain. There is currently no imperative to develop this potential resource.

Electricity supply - East Coast

Since, and as a consequence of, Eastland Network Limited (ENL) acquiring Transpower 110k spur assets in 2015 there is now one distribution network supplied from the Transpower GXP at Tuai – previously ENL took supply at 3 GXPs, Tuai, Wairoa and Gisborne. ENL's previous Tuai, Wairoa and Gisborne distribution networks are now one.

Wholesale electricity prices are in the order of $0.06 per kWh.

The Eastland Network Limited distribution network has no stability or performance issues, but in common with other distribution companies more efficient and effective service performance might be delivered to remote parts of the network through the use of small scale localized distributed generation. ENL have investigated distributed generation as part of their long-term management plan (ENL, 2014) as it represents an opportunity to reduce investment in transmission infrastructure as well as providing the power that an expanded wood processing industry might require.

Further investigation of combined heat and power opportunities associated with wood processing for locations between Gisborne and Hicks Bay are underway. This study will not be completed until mid-January 2019, and the availability of the results will be dependent on the client.

Hydroelectricity

Matawai

The Matawai hydro scheme, run by Clearwater Hydro Ltd., was commissioned in 2009[1]. It is located 45 km NW of Gisborne. The scheme intake is a wash over weir (2 m height) on the Waikohu River, with a 2.35 km length and 1.2 m diameter buried penstock pipe (156 m head). There are 2 generators, with Pelton wheel type turbines and a generation capacity of 2 MW.

Waihi

The Waihi hydro scheme is located at Lake Ruapapa on the Waihi River, 78 km SW of Gisborne[2]. The scheme, operated by Eastland Generation Ltd., has been operation since 1986 and generates power for 1,600 homes. The Lake Ruapapa reservoir is 5.2 km in length, with an area of 42 ha and holds almost 2 million m^2 of water. The dam is a 15 m high gated concrete buttress with earth fill flanks. A screened inlet feeds a 2.3 m diameter tunnel which sends water through the twin 1.22m diameter penstocks to the powerhouse below.

The powerhouse is on the left bank of the Waiau River just upstream of the confluence with the Waihi River and about 1.9 km from the dam. The powerhouse contains two 2.5 MW machines with the maximum output discharge of 6 m^3/s and a rated net head of 100 m.

Others

There are other hydro schemes near, but outside of the Gisborne region:

- Matahina
- Aniwhenua
- Kaitawa
- Tuai
- Piripaua

Oil, Gas and Diesel

Diesel

On the Gisborne network Eastland Network Ltd. utilises six 1 MW and one 0.5 MW diesel generators which are owned by Eastland Generation Ltd.[3]. The units are housed in standard shipping containers and weigh about 23 tons each. These can be deployed anywhere in the network that is accessible to a large mobile crane and where up to 1 MW can be injected at 11 kV. The 6 x 1.0MW diesel gensets connected to the ENL distribution network at Te Araroa, Ruatoria, Tolaga Bay, Matawhero and Puha zone substations and the Mahia 11kV network. The 0.5MW unit is not permanently connected at any location and is rarely used.

Electricity demand on the East Coast has been static for several years, with minimal demand or change to demand to the north of Gisborne city. The lines delivering power to the north of Gisborne city do have capacity limits, and major industrial development in that part of the region may need to consider their own power supply. The supply lines into Gisborne have capacity for a further 10 to 12MWe to be delivered before upgrading is required, and with thermal upgrading (via line tightening) a further 10MWe could be added.

At the moment there is little demand for expanded power generation. However, a major wood processing expansion would change the power demand. For example; a single large plywood plant would require additional power capacity in the order of 11MWe. Given the current electricity capacity, developers of major expansion of wood processing might wish to consider combined heat and power (CHP) options.

Conclusions

In the last 2 years there have been a number of storm events that have caused flooding and debris flows on the East Coast as well as other parts of New Zealand. These debris flows have caused property damage and deposited large volumes of wood on beaches and flood plains. The source of some of the wood is post-harvest residues from plantation forests. There are some compounding issues specific to the East Coast; steep terrain, erodible soils and exposure to storm events that make post-harvest residues on the East Coast more vulnerable to movement off-site than other regions. Limited wood processing (especially for low grade logs) and challenging transport contribute to some material that would make a merchantable log specification in other areas not being removed from the cutover or the forest.

One of the mitigation options for managing the issue is to extract the residues and utilise them for manufacture of processed wood products or bioenergy. In order enable this, the scale of the wood resource (pulp logs and residues) it’s possible uses, delivered costs and opportunities around expanded wood processing need to be determined.

Without some intervention in terms of regulations, policies and incentives; change to current practices and outcomes may not occur. The opportunity to encourage greater use of potential wood resources, thus alleviating the debris flow issue is also addressed.

Key results

The forest resource is sufficient to provide a long-term supply of pulp logs of around 350,000 cubic metres per annum, with some years having much larger volumes available.

The gross supply of post-harvest residues in the long term is around 250,000 cubic metres per annum, with some years (including currently) the supply being much higher. However, with current cost and regulation structures only 150,000 would be considered as economically recoverable.

Processing options identified as having potential for using the pulp logs and residues available on the East Coast are Oriented Strand Board (OSB), Medium Density Fibre-board (MDF), potentially in combination with Combined Heat and Power (CHP) plant fuelled by in-forest post-harvest residues. The opportunity to integrate distributed primary solid wood processing with combined heat and power systems that export electricity to the grid should not be ignored.

Stand-alone heat and power plant may be economically challenged. However, as there is substantial opportunity to process logs from remote forests on the East Coast in primary wood processing (sawmills etc.) there is an opportunity to build heat and power plant along-side these operations that service not only the wood processing but also the local community through local power generation and possibly district heating.

Road transport distances from the forests in the far north-east of the region (Hicks Bay / Te Araroa) are up to 200 km from the port at Gisborne. Upgrading roads to high productivity motor vehicle (HPMV) standard would reduce transport costs and improve the viability of extracting logs and residues from these forests.

Processing closer to the forest would substantially reduce road transport demand; 1 green tonne of logs (~1 cubic metre) becomes 0.5 tonnes of wood products when processing conversion factors and drying are accounted for.

Reinstating the rail link from Napier to Gisborne would make the movement of logs from Gisborne to the pulp mill at Whirinaki a more viable option.

Barging of logs from Hicks Bay to Gisborne or Tauranga would also reduce transport costs compared to road transport.

Electrical infrastructure on the East Coast is able to meet current demands. However, if there are major developments in wood processing, especially north-east of Gisborne then either lines upgrades or distributed generation will be required.

Gas pipelines extend as far as Gisborne City, but do not go along the coast to the North and East. The pipeline infrastructure has some spare capacity

There are no productive coal or gas fields on or near the East Coast. Wood is a viable fuel for the production of process heat or for CHP.

The recently released National environmental standards for plantation forestry (NES-PF) which is aligned with the Resource Management Act (RMA), will have effects on the production and management of forest harvest residues depending on the level of monitoring and enforcement. The NES-PF places restrictions and standards on forest operations, including roading and harvesting operations and management of sites post-harvest.

A carbon price of $50 per tonne would see densified wood fuels such as wood pellets competitive not only with coal, but also with gas.

Utilisation of post-harvest forest residues is well aligned with Government strategies such as Zero Carbon and the Low emissions economy.

Infrastructure priorities are improved roading and the reopening of the Napier to Gisborne rail link, at least as far as Wairoa.

Other transport infrastructure;
Barging of logs and chipped residues from Hicks Bay to Gisborne / Tauranga could be a financially viable option for the next 10 to 15 years whilst log flows are high out of the East Coast. The movement of logs and chipped residues from Gisborne to Gisborne to Napier / OJI Whirinaki by rail appears to be financially attractive (excluding line repair costs).

There are a number of policy and regulation options available to local and central government that would either force or encourage use of forest harvest residues. However, these need to be carefully analysed and implemented to ensure that unintended consequences are avoided.

Variations on wood supply over time presents challenges for full utilisation of peak supplies of in-forest residues and pulp logs. Well planned expansion of forest planting would alleviate this.

The most promising opportunities for the large-scale use of pulp logs and wood residues on the East Coast appear to be;

- OSB and MDF
- Wood pellets possible with terpene extraction prior to pelletisation

Establishment of expanded sawlog processing at locations such as Ruatoria would create an opportunity for use of in-forest residues as fuel for a CHP at the sawmill, along with the mills own residues. The CHP would be required to supply the mills electricity demand and could be sized to export to the grid.

Recommendations - further work suggested

1. Studies on logging residue volume, piece size, distribution and accumulation points within a harvest setting, catchment and forest. This would include on the ground measurements as well as aerial image capture. Work to include factors which would affect residue production such as felling methods and minimum log specifications.
2. Studies on the production rates and costs of removing material normally considered as residuals with either the primary harvesting operation or with a secondary harvest.
3. More detailed analysis of wood flow on the East Coast to determine routes where existing bridges are limiting the use of HPMVs. This analysis to include the presence / absence of wharf or barging point at Hicks Bay; including data on supply over time to some of the more remote points such as Hicks Bay and Ruatoria.

4. Assessment of costs of barging chipped or hogged residues (lower density and different handling than logs)

5. Feasibility study on converting wood residues to pipeline quality synthetic natural gas via biomass gasification and syn-gas upgrading

6. Stabilisation of future wood supply. Planting of 4,000 to 5,000 hectares per annum for 10 years with planting to start now. However, a more detailed analysis is needed of the potential available land suitable for planting needed to maintain a long-term wood supply to support expansion of regional large-scale wood processing. More detailed analysis of this is recommended, including generating maps of the land designated as suitable for afforestation in order to determine its harvest and transport logistics.

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- Peter Weir – Ernslaw One Ltd

Data from a range of sources used in this analysis including;
- the Ministry of Primary Industries National Exotic Forest description and Regional Wood Supply forecasts
- the WoodScape study (model and wood processing database) funded by the Woodco and a range of government agencies

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Appendix A

Effect of reducing minimum extracted piece size on hauler productivity and cost

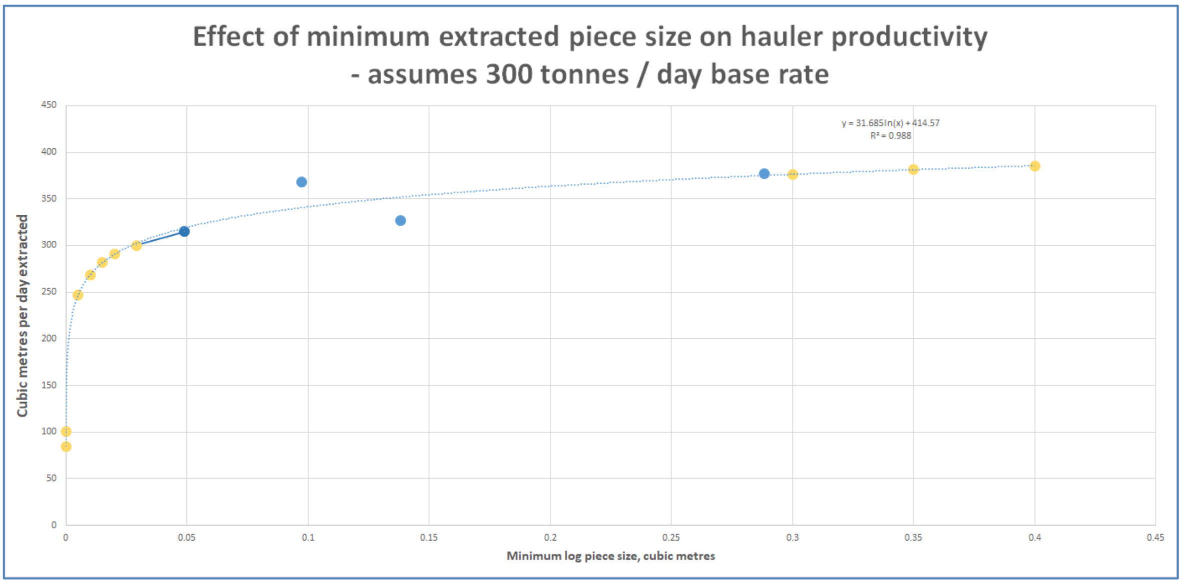
One means of reducing the amount of residue on the cutover is to extract more of the broken head logs with the primary log extraction.

The two studies (McMahon 1998 and Larsen 1985) on New Zealand harvesting looked at the impact of minimum piece size that must be extracted and hauler productivity; the graph below was created by extrapolating from the data in these two studies.

The impact on production is marked, especially if the minimum log specification is lowered to include the extraction of very short (~1m) and small diameter (~8cm) sections of residue.

It is worth noting that both these studies examined the impact of increasing the minimum log specification.

This data on its own is insufficient to support decisions – it should be regarded as a start point for further and more detailed examination of the issue. In particular, more data is need on the distribution of piece size (by length, diameter and volume) of the sections of stem wood left on the cutover.



What the graph does show is that reducing the minimum extracted piece size may have a significant effect on the logging system productivity and hence the cost of the logging operation in terms of $s per tonne for all the material logged.

Note that the blue data point above the 0.05 mark on the log piece size axis is the current common minimum log specification of; 3.7 m long with a small end diameter of greater than 10cm.

Appendix B

Transport costs - variation by transport mode (assuming 200km haul)

Mode	$ per tonne	$ per tonne / kilometre
Road	32	0.16
Rail	18	0.09
Barge	16	0.08
Coastal ship	12	0.06

Mode shift costs;

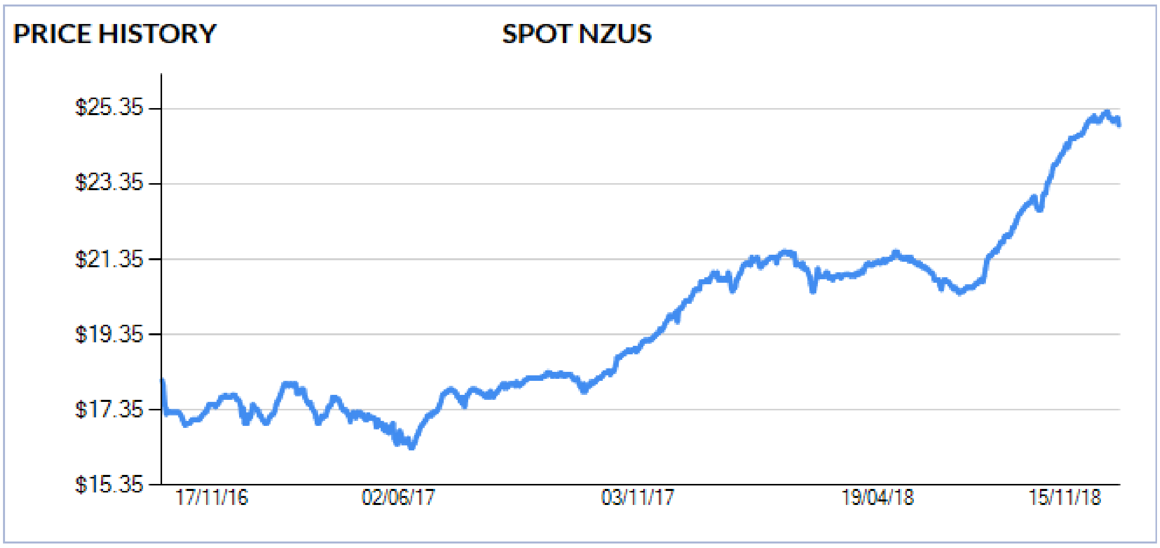
Truck to rail $3 to 5 per tonne (loader only)
Truck to barge $5 to 7 per tonne (loader only)
Truck to ship $16 per tonne (loader, storage, stevedoring, ship loading)

Estimates indicate that for a 200 km haul (e.g. Gisborne to Napier);

- It would be cheaper to rail the logs from Gisborne to Napier than to truck them, even allowing for loader handling at both ends.
- It would be cheaper to barge logs from Hicks Bay to Gisborne or Tauranga, even allowing for loader handling at both ends.
- For coastal shipping to be a viable alternative it would need to be over a longer transport distance to be cost competitive

Appendix C - forestry, carbon and GHG assumptions

Carbon prices (source; https://www.commtrade.co.nz/)



CONTRACT DESCRIPTION (NZ$)	BEST BID	BEST OFFER	LAST/FIX
NZUs - Spot	24.90	24.92	24.90
NZUs - April 2019	25.10	25.50	25.52
NZUs - April 2020	25.70	26.40	26.35
NZUs - April 2021	26.50	27.40	27.35
NZUs - April 2022	27.40	28.40	28.25
NZUs - April 2023	28.20	29.50	29.30

Appendix D – maps showing growing contribution from the East coast / forestry to a biofuels future in New Zealand

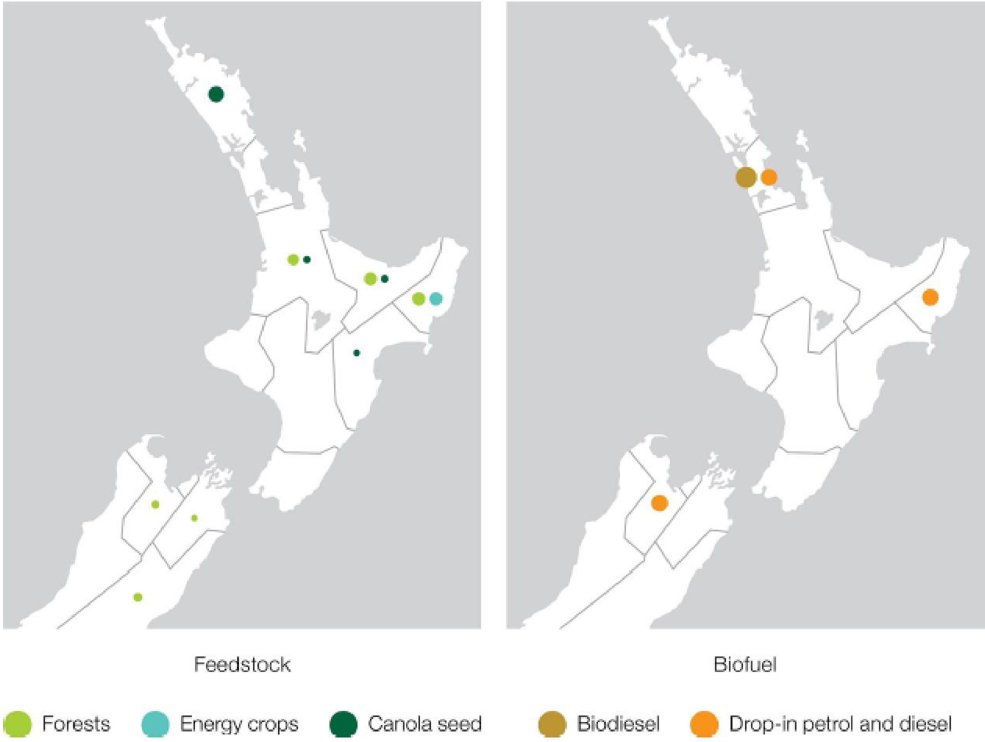


Figure 4.7: Maps showing feedstock consumed and biofuels produced for Scenario 1 (30% substitution, all land classes) in the 2026-30 period.

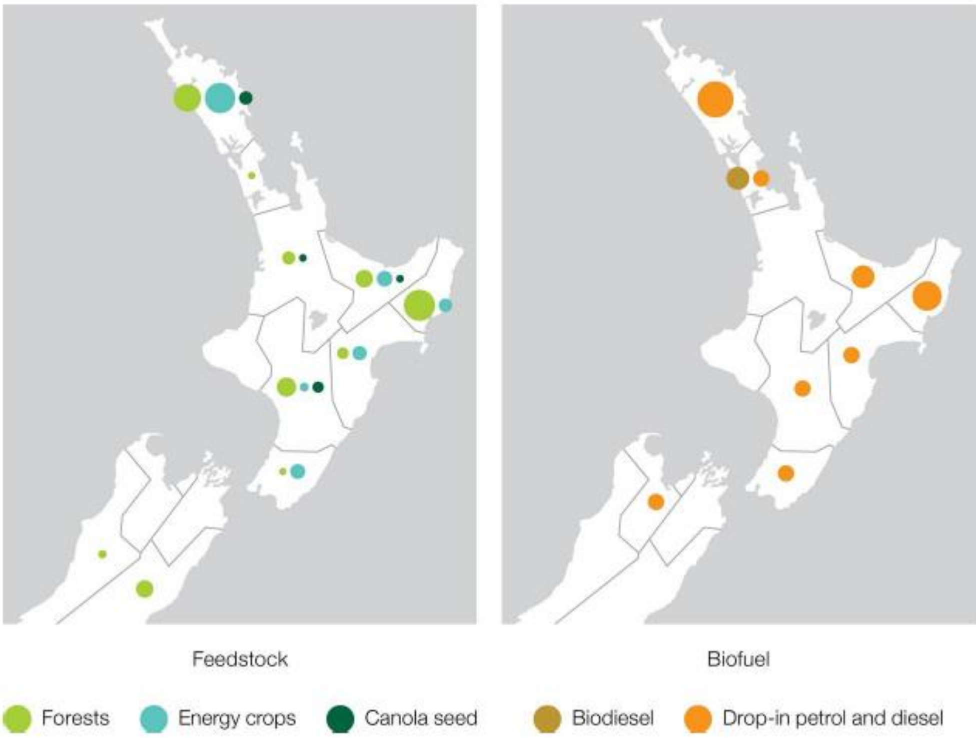


Figure 4.11: Maps showing feedstock consumed and biofuels produced for Scenario 1 (30% substitution, all land classes) in the 2046-50 period.

Appendix E – NES-PF; 8 core activities

The NES-PF regulations cover 8 core plantation forestry activities that have potential environmental effects:

- afforestation (planting new forest)
- pruning and thinning to waste (selective felling of trees where the felled trees remain on site)
- earthworks
- river crossings
- forestry quarrying (extraction of rock, sand, or gravel within a plantation forest or for operation of a forest on adjacent land)
- harvesting
- mechanical land preparation
- replanting.

The NES-PF applies to any forest of at least one hectare that has been planted specifically for commercial purposes and will be harvested.

Source;
https://www.mpi.govt.nz/growing-and-harvesting/forestry/national-environmental-standards-for-plantation-forestry/