What are the Factors that Affect Log Port Capacity in New Zealand Ports? (A Case Study at the Port of Tauranga)

A dissertation submitted in partial fulfilment of the requirements for the degree of Bachelors in Forestry Science with Honours by:

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Abstract

61% of New Zealand's total harvest was exported as logs in 2018, highlighting the economic importance of ports to the New Zealand forestry sector. This proportion has doubled since 2008, and at the same time harvest has increased by 13 million m^3 (MPI, 2019). As a result, log ports in New Zealand have been experiencing problems with port congestion and port capacity. Identifying the factors that influence capacity and congestion is the purpose of this dissertation, as a first step in solving the problem.

Port operations experts at New Zealand's main log export ports were surveyed to identify factors that affect port capacity. The potential additional volume of future log exports was estimated for each port, using wood availability forecasts.

The survey identified that log storage area and vessel frequency were the two most important internal factors limiting port capacity, through their impact on log throughput at ports. The survey also identified that log price and forest harvest were the main external factors that affected log supply to ports. Finding solutions to the internal factors will overall increase the profitability of a port, while increasing the efficiency of port operations will increase the profitability of log exports.

The Port of Tauranga (PoT), which may experience an additional 1.85 million m^3 through the port in the future, is estimated to already be at capacity by Pacific Forest Products (PFP). Discussion with PFP staff yielded three options to increase capacity at PoT:

1. moving vessels to another berth for lashing,
2. re-location of methyl bromide fumigation operations from loading berths, and
3. the use of mobile harbour cranes

Analysis indicated that Options 1 and 2 together would increase port capacity by just under 1 million m^3. Option 3 is expected to be able to provide all the potential capacity required.

Keywords*: port capacity, factors, wood availability, PoT, regions, exports, domestic, New Zealand*

Contents

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1. Introduction

The forestry industry in New Zealand is significant to the economy as the third largest merchandise export earner, with over $6 billion earned in 2017 (NZIER, 2017). Forestry also contributes around 3% of New Zealand's GDP (MPI, 2019b). The forestry sector directly employs 9,500 people (NZIER, 2017) and in 2018, 35 million m^3 of forest resource was harvested, with 61% of all logs being exported (MPI, 2019b).

This study is supported by Pacific Forest Products Ltd (PFP), who are a log export and logistics company. PFP predominantly exports out of the New Zealand ports of Marsden Point (North Port), Tauranga (Tauranga Port), Gisborne (Eastland Port), Napier (Napier Port), Timaru (Prime Port) and Dunedin (Port Chalmers). They also export out of Australia at ports such as Hobart and Burnie. In 2018 PFP exported 6.3 million m^3 of wood which is 31% of the total log volume exported from New Zealand.

The purpose of this dissertation project is to identify the factors that affect log port capacity and throughput in New Zealand. The study also studies the options that the Port of Tauranga (PoT) can implement in order to help increase its capacity to cope with future wood supply increases. An analysis will also be carried out to identify the ports in New Zealand where log supply for export could increase due to increasing regional harvest.

1.1. Problem statement

With increasing mature forest being available to be harvested in the next 10 years, it is important to assess the capacity of the log export ports in New Zealand. Port congestion is already occurring in logs ports around New Zealand, especially in the larger ports such as the PoT and Eastland Port. With the increase in backlog of vessels due to port congestion this has led to increased demurrage fines as vessels are not following their schedule. In 2018 there was an estimated $14 million USD in demurrage charges (Rays, 2019). PFP has identified that these trends are also present at the PoT where there are issues with log throughput as vessels have not been able to be berthed on schedule (Gardner, 2019). Due to this the 45 ha log yard as shown in Appendix 1 and 2 has experiened flow on effects such as congestion. This congestion at the port's log yards has caused consequent effects such as the stopping of logging trucks and harvesting crews. This then has resulted in demurrage fines for exporters such as PFP as vessels have not followed the schedules that have been allocated. As log exports are a low value commodity product, unexpected costs result in lower profits that can affect a company's profitability. It is critical now to understand and identify the factors that limit port capacity and log throughput in order to implement appropriate actions to increase capacity where appropriate.

The forests of the planting boom of the 1990s are now reaching age of harvest. This has resulted in increase in log exports which has contributed to increased congestion at New Zealand ports. The Port of Tauranga is uncertain of the volume of wood to plan for in the future and is therefore unsure if their current systems have enough capacity to accommodate future export log volumes in the CNI region. This reinforces the importance of identifying factors that affect port capacity as solving these limiting factors will be critical to coping with any increase in wood flow.

1.2. Research Questions

1) What are the factors that affect port capacity?
2) What are the factors that affect the maximum supply of logs to a port?
3) What are the estimates of these number for the Port of Tauranga?
4) What are the options for increasing capacity at the Port of Tauranga?

2. Literature review

A literature review is carried out to gather a greater understanding of the topic and identify the gaps in literature that are related to this study topic. This will review previous literature regarding methodology, factors that affect port capacity and to identify the potential gaps in literature.

2.1. Previous literature on port capacity

Although port operation efficiencies are obviously important in regards to trade flows and revenue to a country, the measurement of these efficiencies are often a difficult task as mentioned by Blonigen & Wilson (2008). The study stated that there is a myriad of factors that affect port efficiencies and capacities, which make identification of single factors difficult. This suggests that looking at the factors that affect port capacity would be a difficult task as there are many factors that influence each other and that all variables are linked. However, there are obvious factors that are generally known globally that affect port efficiencies such as dock facilities, time to clear customs, customer relation and, harbour characteristics such as channel depth and ocean/tide movements (Blonigen & Wilson, 2008). Kasypi, Shah and Mohammad (2013) identified in their study that the factors that limited port capacity were container yard area, operating hours and berth length and draft. A consultant study by Ernst & Young (2016) also discussed that a key finding was that the capacity of a port is largely dependent on two main factors which are infrastructure to accommodate trade volumes and the size and number of vessels. The third main factor was port productivity which means that the faster the vessel turnover, the greater the capacity (Ernst & Young, 2016). From previous studies, this suggest that these findings may also be the case for ports around New Zealand.

Munisamy (2010) described that ports are viewed as a system that is made up of a number of subsystems. The study investigated timber terminal capacity planning for Port Klang located in Malaysia using a queuing theory model. Relevance of this study is that the model used the interactions between cargo handling sub-systems, considering cargo handling elements of a timber terminal. This included equipment such as tractors, forklifts, trailers and quay cranes to investigate congestion points. This study identifies that a group of subsystems is what ultimately affects the capacity of a port, which suggests that ports in New Zealand will also consists of subsystems that ultimately affect the capacity of timber terminals.

There is only a small amount of literature on factors that affect port capacity for a bulk product such as logs. Studies are often researched about container stock vessels with literature discussing the factors that affect container stock such as by Maloni & Jackson (2005) where it attempts to establish the urgency of container network capacity problems in America. Many port studies used what are called analytical approaches which discuss about queuing theory and mathematical programming which are used to for container vessel port modelling (Bobrovitch, 1982; Chen, 1999; Maloni & Jackson, 2005; Munisamy, 2010; Shneerson, 1983). The studies provide an idea on how to model vessel frequency in order to increase efficiency at ports. For this study these results are not relevant as the purpose of this study is not to model log vessel frequency but to identify the factors that affect the log port capacity. Although there are similarities between port modelling of container vessels and log vessels, ultimately the studies are not based on log operations and only provide an indication of what may be expected in the results from this study.

2.2. Survey methodology

Previous literature suggests that survey methods are the most efficient way of identifying factors that affect port efficiency. A survey method was used in the Global Competitive Report (Porter et al., 2000) which used surveys to ask firms to rank countries port efficiencies using a ranking system of 1-7 (Blonigen & Wilson, 2008). However, one major flaw that has been mentioned in previous literature is that surveys only represent the responses in that point of time. This means that if a survey method was used to identify the factors that affect port capacity, those factors are only relevant to that point in time. Surveys are not an accurate indicator of what factors affect port capacity in the future as variables may change over time and as mentioned above, they only represent the responses at that point in time. For this research investigation, the topic is a current issue as major ports in New Zealand are experiencing congestion at present. The result of this is that the problem is time sensitive and identification of the current limiting factors is the most efficient way of solving these problems. For this reason, it is assumed that to identify the factors that affect port capacity, a survey would be the most suited method for this study as it investigates the current issues.

2.3. Wood Forecast Availability

Previously studies on wood availability have been carried out in New Zealand. The Wood Availability Forecast that is provided by MPI provides a detailed forecast supply for all major regions in New Zealand (Indufor Asia Pacific, 2016). However, the forecast does not display the amount of volume that is forecasted to be domestically processed and exported in the future. As a result of this, the study aims to fill in the gaps and provide a wood supply forecast displaying the domestic processing and export volumes for the future. This will then in turn also identify the ports that will face a surplus in supply of volume.

2.4. Gap in literature

Currently there is a gap in literature that discusses the factors that affect port capacity in New Zealand regarding log operations. Globally there are many studies that investigate container vessel operations and what factors affect productivity. A summary of these determinants can be shown in Table 1 below where Kasypi, Shah and Mohammad (2013) displayed the main elements that affect productivity are crane utilisation, crane productivity, berth utilisation and service time, yard utilisation and storage productivity, gate throughput and truck turnaround time, and labour productivity. For log operations there are no studies investigating the common factors that affect log port capacity.

Table 1 summary of the measures of productivity and the elements that affect container vessel port productivity

Element of Terminal	Measure of productivity	Measure
Crane	Crane Ultilisation	TEUs/Year per Crane
	Crane Productivity	Moves per Crane-Hour
Berth	Berth Ultilisation	Vessel/Year per Berth
	Service Time	Vessel Service Time (hrs)
Yard/Storage	Land Ultilisation	TEUs/Year per Gross Acre
	Storage Productivity	TEUs/Storage Acre
Gate	Gate Throughput	Containers/hour/lane
	Truck Turnaround Time	Truck Time in Terminal
Gang/Stevedore	Labour Productivity	Number of Moves/Man-Hour

3. Method

3.1. Wood Volume Forecasts

To forecast volumes for the Central North Island and New Zealand, data was obtained from the Ministry for Primary Industries (Indufor Asia Pacific, 2016). To forecast the estimated volumes for the Central North Island the total removals of roundwood by region from 2002 to 2017 was obtained from MPI (MPI, 2019a). To forecast the future processing volumes an average was taken from the last 5 years from the MPI processing removals data set (MPI, 2019b). It was then assumed this average was constant throughout the next 30 years. Forecasting of future export volume was calculated using the log exports by ports data set from MPI (MPI, 2019c). Again, an average was taken from the last 5 years to provide an average export volume that was used as a constant for the next 30 years. This same method was carried out for other regions in New Zealand's such as:

- Northland
- East Coast
- Hawkes Bay
- Southern North Island
- Nelson and Marlborough
- Canterbury
- Otago and Southland

The 5-year averages give a better representation of future forecasts for domestic processing as the numbers have relatively stayed the same over the last 5 years. However, export volumes show to fluctuate which is a limitation in using the 5-year average for these numbers. Although it can be argued that the 5-year average takes into the latest trends from log export sector which can be identified as an appropriate predictor for future volumes. An example can be shown in Table 2 for the Canterbury region.

Table 2 Comparison of the 5 year averages with the actual domestic processing and export numbers for the Canterbury region

Canterbury				
Year	**Domestic processing**	**Export**	**5 year domestic processing average**	**5 year export average**
2014	660	988	-	-
2015	660	900	-	-
2016	665	947	-	-
2017	641	680	-	-
2018	652	1133	655.404	929.5124964

For regions such as Canterbury and Northland it was assumed that if there was a shortage of supply, the volume was assumed to go towards domestic processing mills rather than exports. A summary table displaying the regions that will have an increase and decrease in log supply can be shown in Appendix 3, 4 and 5.

Wood forecast availability data was also obtained from MPI. The forecasts were carried out based on different forest owner objectives. To find the estimated incremental wood for the CNI region, the average domestic processing and export volumes were subtracted from the estimated wood availability forecasts.

Three of the wood availability forecast scenarios from MPI (2015) were used in this study. Scenario 1 assumes that large scale owners harvest at their stated intentions and small-scale owners harvest at age 28 for radiata pine.

Scenario 2 assumes that large scale owners harvest their forest will be at their stated intentions for the period 2015 to 2023. The wood availability from the large scale owners is assumed not to decrease. The total wood availability for the region is then modelled to be a non-declining yield to perpetuity with target rotation age of 28 years. As the average rotation age is 28 for large scale owners, this will result in some small-scale owners forests being harvested at rotation ages significantly higher.

Scenario 3 wood forecast estimates are based on a non-declining split yield with a rotation age of 28. The main difference is that there is more flexibility in the harvest constraints which means that some of the small scale owner estates can be harvested earlier. With the constraints small scale owners will still harvest at ages of around 35 years through the 2030's. For this study is was assumed that scenario 3 was the most likely scenario and estimates of future harvest were based on this projection.

3.2. Factors affecting port capacity survey

To identify the factors that affect port capacity a survey was sent to the main log exporting ports in New Zealand. From the 11 Major ports surveyed, 7 ports responded (a 63% response rate). A ranking system of 1 to 6 was used to rank the limiting factors where a ranking of 1 was the most limiting factor. There was also the option for the respondents to comment on the improvements that could be implemented to improve capacity and log throughput at their ports.

3.3. Tauranga berthing capacity

Berth occupancy data was provided by the PoT. It is defined as the time a berth is occupied by a vessel. Berth occupancy percentage was calculated by the time (days) berths were occupied by vessels divided by the total days in the month. Variables such as maintenance and repairs were also recorded. This is reflected in some months having lower berth occupancies which will be explained later on in the results. The data that was provided by the Port of Tauranga however does not account for what is defined is "dead berth time". This is time referenced as time lost due to factors such as:

- Piloting vessels
- Lashing

These factors are likely to increase the average berth occupancy of the port. This study will identify a "true" berth occupancy which includes these factors.

3.4. Estimates for the PoT

An excel model produced by PFP was edited to produce the estimates of volumes for the PoT. The equation used is shown below:

$$\text{Total Amount of Vessels that can be loaded annually} = \frac{TPBD}{TTL+Lt+St}$$

Where:

- TPBD = the total productive berth days for a calendar year
- TTL = the time taken to load an average vessel for the port
- Lt = lashing time
- St = Shifting time

Variables that were used to calculate the time taken to load an average vessel for the PoT was the average uplift for log vessels, and the average 24 hour load rate for all vessels. Lashing time (Lt) is defined as the time taken to secure log cargo on the top deck with chains. Shifting time (St) is defined as the total time to move vessels in and out of the port, and takes into account variables such as tidal windows, vessel survey delays, and priority movements. The priority movements are defined as the delay in time to move log vessels due to the PoT priority to pilot container vessels. The total productive berth days (TPBD) for a calendar year is defined as the amount of days where the berths can be worked. This factor takes into variables such as berth maintenance, weather delays, vessel breakdowns and Marine Safety Administration (MSA) impositions. For ports where there is fumigation on the berths, the TPBD calculations also take into account the number of days lost due to fumigation.

To find the total number of vessels that could be loaded at the PoT annually, the following equation was used:

$$\text{Total Amount of Volume Loaded Annually} = TVLA \times AVU$$

Where:

- TVLA = Total amount of vessels loaded annually
- AU = Average vessel uplift

4. Results

4.1 Factors that affect port capacity

To understand how to increase port capacity and efficiencies in New Zealand ports, it is necessary to identify the factors which affect port capacity and throughput. The volumes that are exported per berth are shown for the ports studied shown in Figure 1, indicating those ports that, for a variety of reasons, are the most efficient in the use of their berths for loading logs.

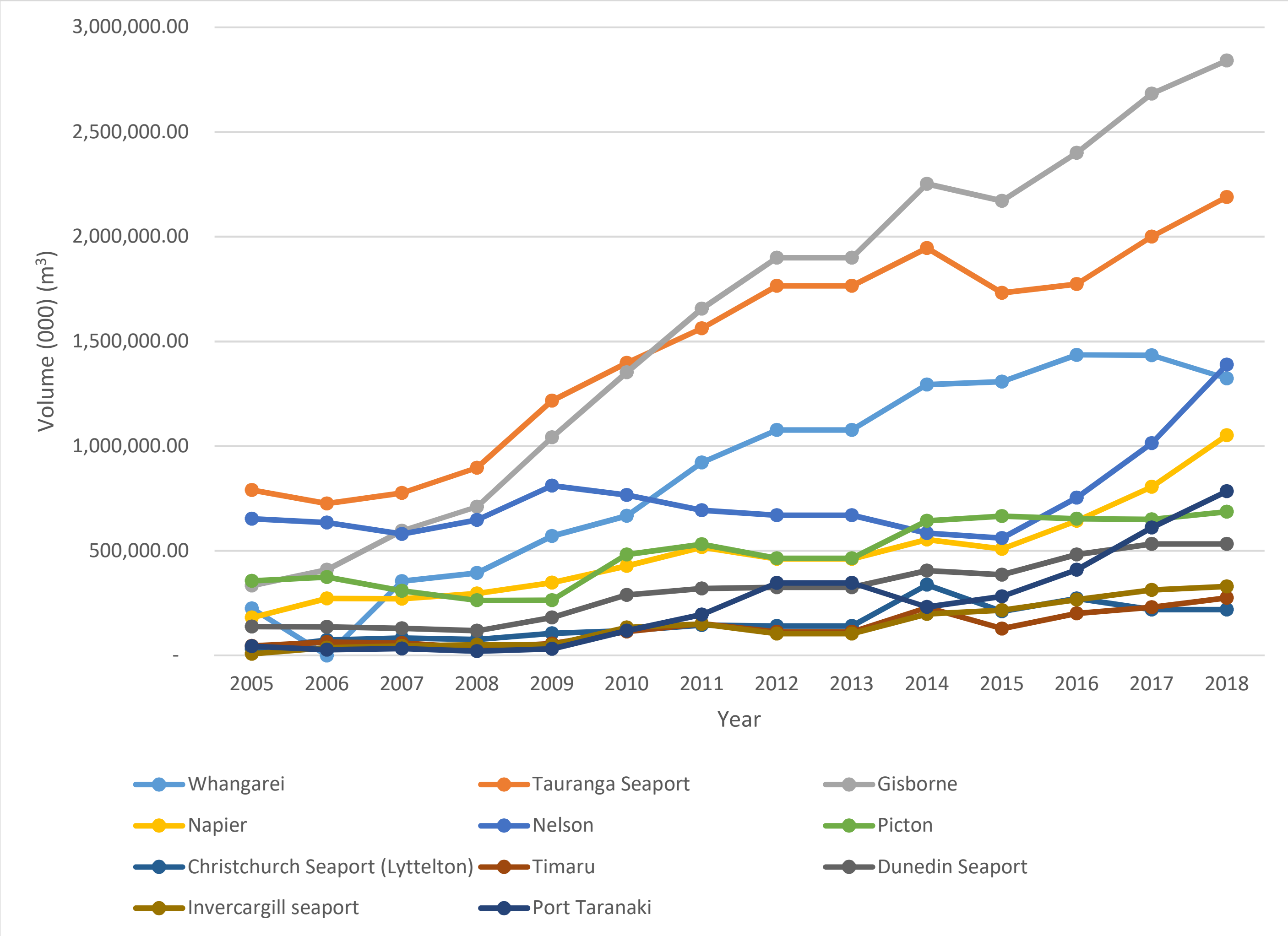

Figure 1 Volume of log throughput for a single berths for ports around New Zealand.

As shown in Figure 1, ports in New Zealand have widely varying volumes exported per berth. In 2018 Gisborne port had the highest efficiency of berth usage with 2.7 million m^3 of wood exported through one berth. The Port of Tauranga is the largest export port, however in 2018 they only exported 2.3 million m^3 of logs across its wharf. This poses the question why certain ports are able to export higher volumes per berth. The factors that affect port throughput and capacity determine the differences in volume.

4.1.1. Port operation factors that affect port capacity

Port operations experts at New Zealand's main log export ports were surveyed to identify factors that affect port capacity. These individuals were deemed to be experts based on their occupation position at the ports. This was carried out to find commonalities between the ports to determine a general understanding of the factors that affect log throughput and capacity. Shown below are the factors that were deemed the most significant from the survey.

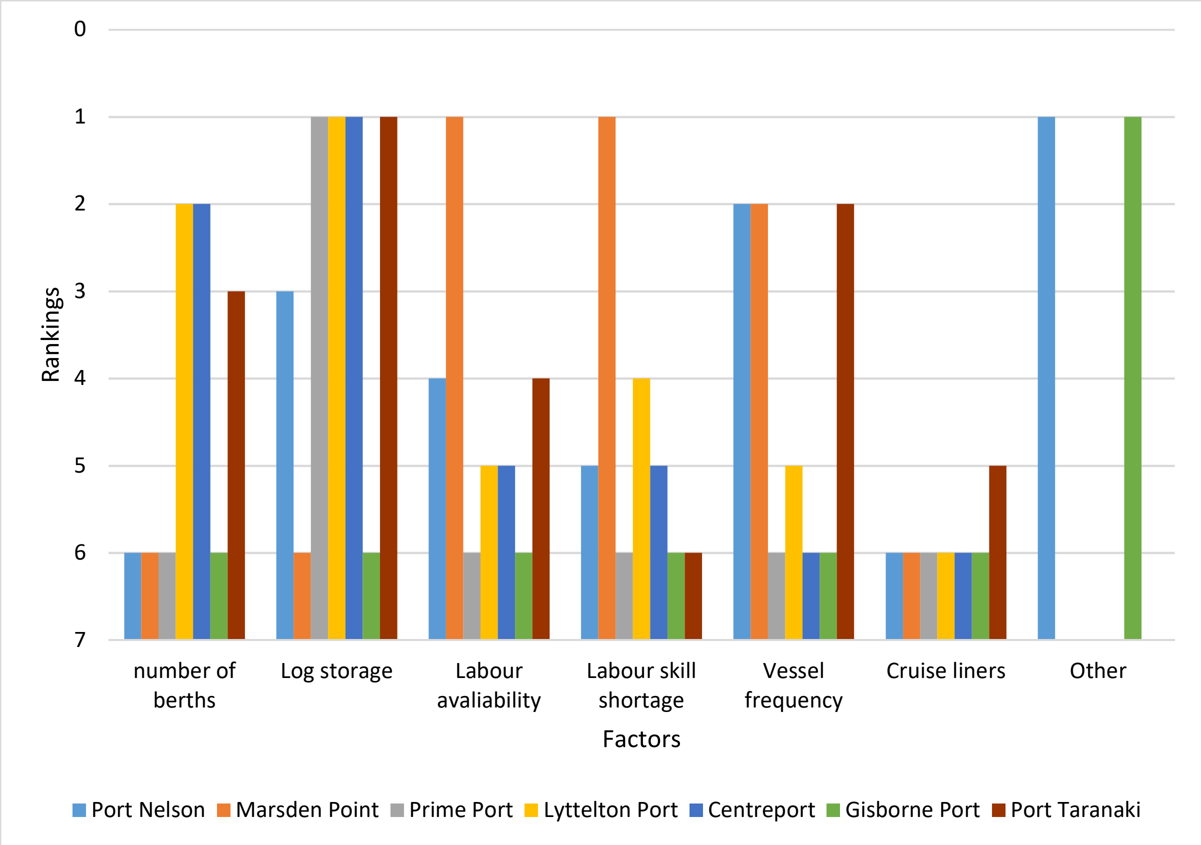

Figure 2 Port operational factors that affect port capacity

Overall the responses from the survey showed that there are a variety of factors that limit the ports. The most limiting operational factors shown from the survey were log storage and vessel frequency. The number of berths also showed to be a limiting factor but did not hold as much of an importance when compared to the other top factors. It's important to highlight that there were two ports that stated "other factors" as the most limiting factor. These were specific to the region where Gisborne Port's major limitation was the gravitational swells that close the berths and prevented vessels coming into the port. The second "other factor" mentioned was "irregular truck flow" where log throughput was limited by peak periods of truck arrival causing a bottleneck in operations.

4.1.2. External factors that affect port capacity

The survey also asked respondents to identify the external factors that affected port capacity. External factors are defined as variables that are not part of port operations and are outside of the port operation area. The results are shown in Figure 3.

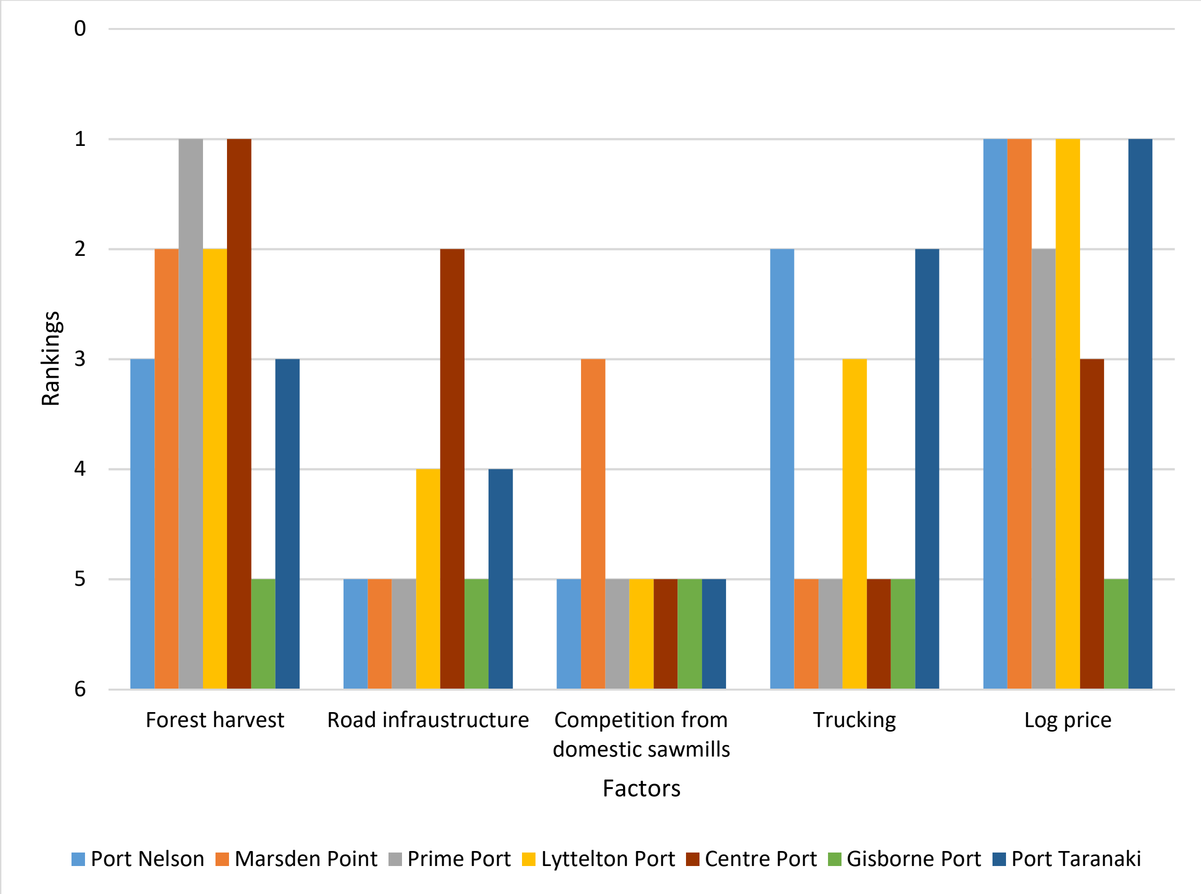

Figure 3 External factors that affect port capacity

Log price and forest harvest were ranked as the most important factors that limited log capacity. A few ports also stated that trucking and road infrastructure also limited log capacity but were not the major limiting factors. 6 out of the 7 ports that answered stated that competition from domestic sawmills were not a problem.

4.1.3. Survey information

Survey participants were also asked respondents what improvements could occur in New Zealand ports to help increase throughput. Their responses are summarised below.

4.1.3.1 Log storage

Log storage improvements was one of the common improvements that respondents identified, stating that it could be used to increase wood throughput and minimise congestion. This included suggestions such as increasing the current storage area or improving the current storage area by sealing the yard. One survey stated that centralising log storage to one storage area would improve log throughput. Expansion of storage areas to hold more volume was also another improvement that could be made to ports.

4.1.3.2. Resource supply

The survey also identified that for some ports, a lack of resource supply was limiting throughput. These ports are currently not at capacity and state that they can increase their throughput if the wood was available. This is one of the most important limiting factors, especially for Northport where there have been improvements in building infrastructure in the last 10 years to accommodate future woodflows. Improvements suggested by the respondents were to have improved ship scheduling and planning from exporters.

4.1.3.3. Efficient port operations

One major limitation that affects the log throughput rate is the efficiency of port operations. One major factor that affects the efficiency rate is the rate of scaling of logs. Respondents stated that one of the bottlenecks was the scaling and ticketing of logs. This included issues such as scaling areas in locations that are not efficient. Scaling area also interfered with storage space where respondents identified that offsite scaling areas may help increase the rate of log throughput.

4.1.3.4. Berths allocated for logs

Berth allocations are defined as the number of berth space available that are allocated for log vessels. They are important for the export of logs as an increased number of berths will increase vessel scheduling. Two respondents stated that the development of a second berth would help increase throughput and reduce congestion at ports. The development of an additional berth would increase the number of ships that could be loaded annually. However, the decision to construct or allocate additional berths to log vessels are based on cost benefits. For example, there is a trade-off between the allocation of berth space for log vessels, and other bulk cargo and container vessels.

4.2. Wood volume forecasts for New Zealand

An estimation of New Zealand's wood forecast was carried out to identify the trends in wood availability for the whole country. There is an increase in incremental log supply throughout the nation from the period 2019 to 2035. This represents the log supply volume that will be potentially going through the ports. Incremental volume peaks 2024 where the resource available will be 4.15 million m^3. It is important to highlight that there will be a downturn in resource supply from 2036 to 2044. This can be shown in Figure 4.

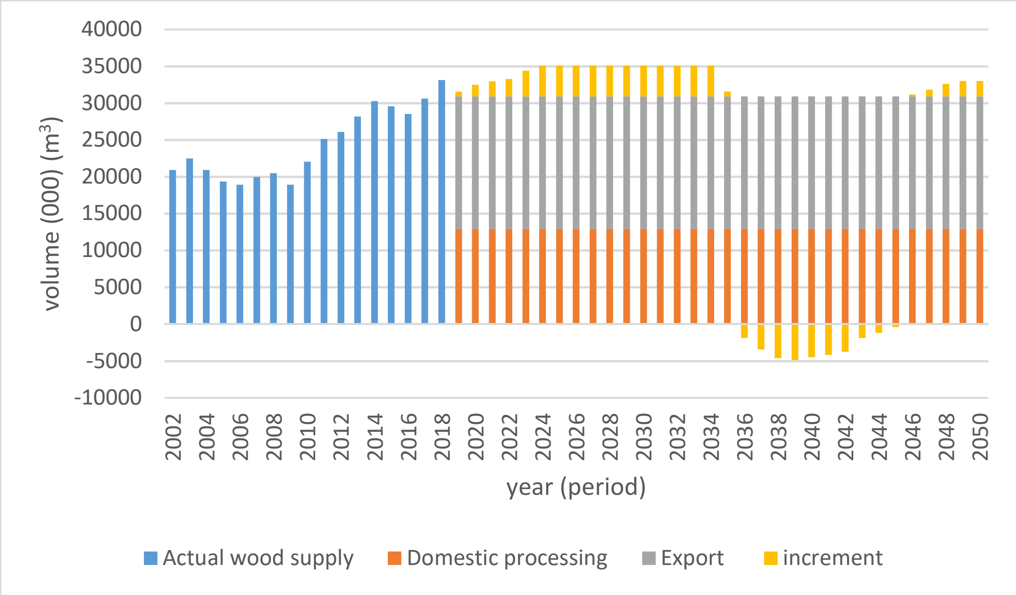

Figure 4 New Zealand log supply forecast, 2019 – 2050 (non-declining yield)

4.2.1 Wood volume forecasts for the Central North Island region

To estimate the wood supply that will potentially go through the PoT, wood volume forecasts were carried out for the CNI. It was assumed that the wood in the CNI region as defined by MPI will go through the Port of Tauranga. Shown in Figure 5 is the estimated wood forecast for the region under an unconstrained yield.

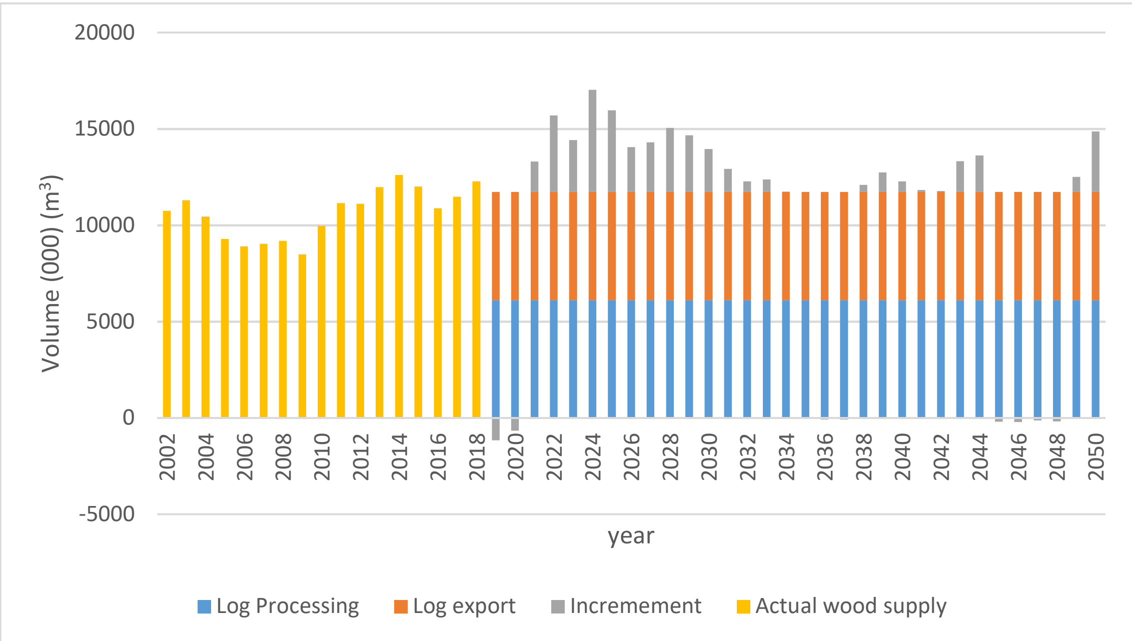

Figure 5 Log supply forecast for CNI region, 2019 - 2050 (unconstrained yield)

Wood forecasts for the region show that there are large fluctuations in volume. At the peak of wood supply there is an estimated 5.3 million m^3 of volume that could be going through the PoT. The peak of wood supply ranges from 2021 to 2032 and indicates the time period that the port will have prepare for. There is a decrease in supply where the current roundwood removals will exceed the resource that is available from 2035 to 2037. The fluctuations in volume are due to small scale owner estates. This graph displays the worst case scenario and the maximum amount of volume that the PoT will have to prepare for. A non-declining yield model will be carried out to estimate the minimum amount of wood flow that the PoT should prepare for.

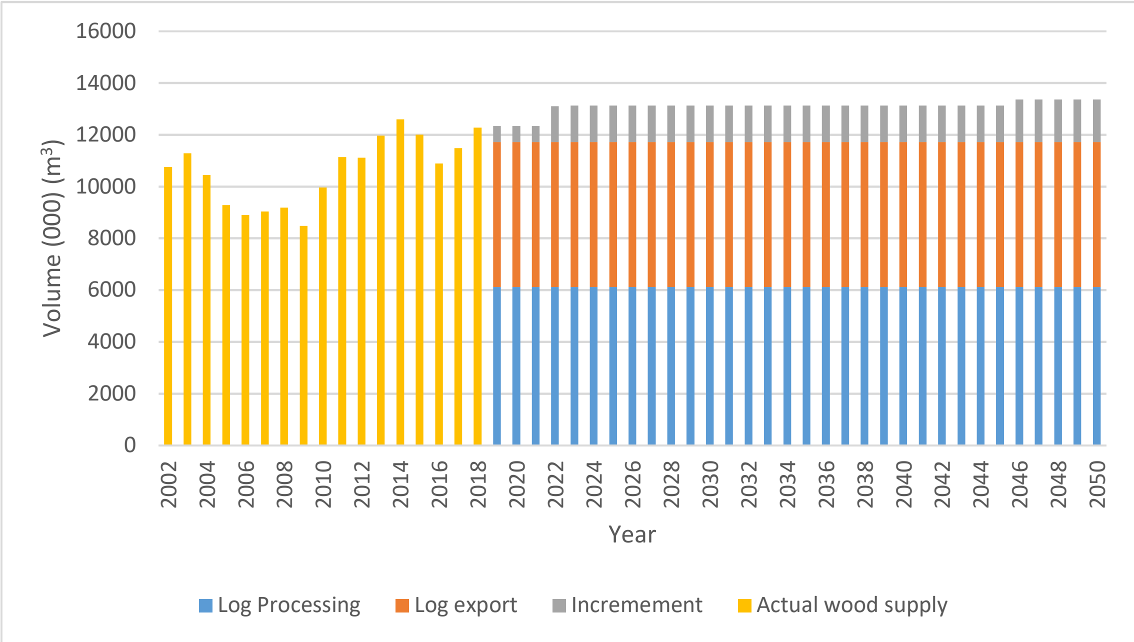

Figure 6 Log supply forecast for CNI region, 2019 – 2050 (Non-declining yield)

Shown in Figure 6 is the estimated wood forecast availability for the CNI region under a non-declining yield. Figure 6 shows that under the current assumptions there will be an increase of 607,000 m^3 from 2019 to 2021 and then a further increase of 1.39 million m^3 of increment. Figure 6 represents the minimum volume that the PoT should prepare for. It is important to note however, that this scenario is unlikely to occur as the assumptions under this wood forecast assumes that small scale owners have their harvest prolonged to a rotation age of 35. This is unrealistic as small scale owners will harvest when the log prices are high and are not focused on smoothing of yields.

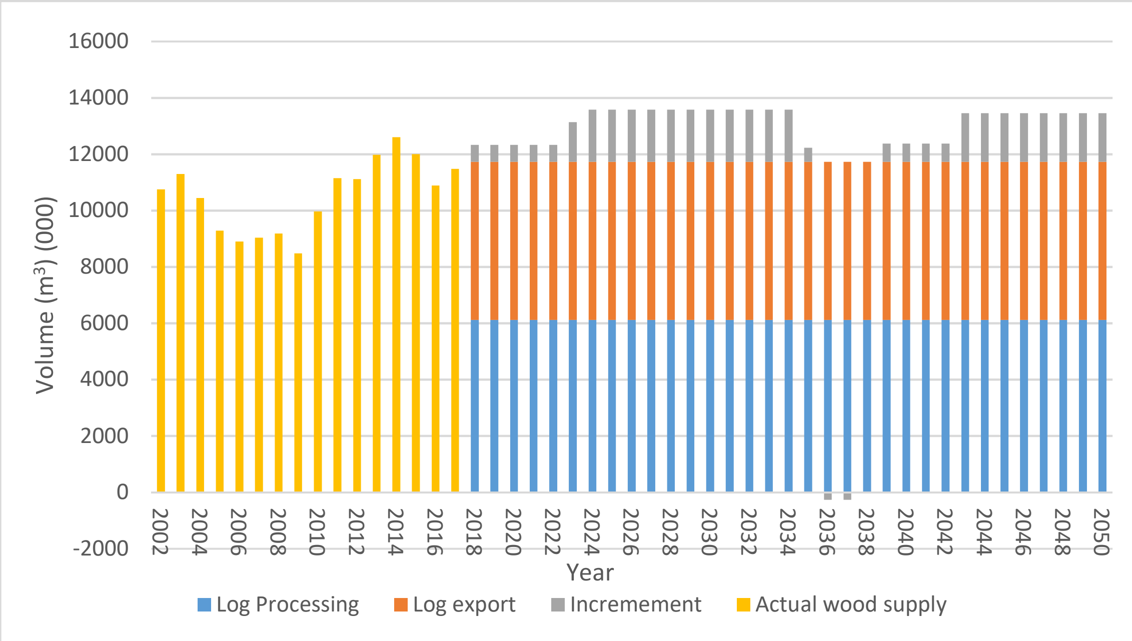

Figure 7: Log supply forecast for CNI region, 2019 – 2050 (Non-declining split yield)

A forecast of wood availability was carried out for a non-declining split yield scenario. This scenario shows that there will be an increase of 1.85 million m^3 at the peak of supply. This is the volume that the PoT will have to prepare for under this scenario. The analysis also shows that there will be a downturn in estimated wood volume in the periods 2036 and 2037 as the current demand of domestic processing and exports will be higher than the supply. This scenario is the most realistic scenario and is the volume that the PoT should prepare for.

4.2.2. Wood forecast for other regions in New Zealand

Wood forecast estimates were also carried out for other regions in New Zealand to identify the ports that will have an increase in volume supply. The findings from this analysis show that although overall there is an increase in wood resource forecasted for New Zealand, it is only a few regions that will have increased wood supply. The analysis was performed for the regions:

- Northland
- East Coast
- Hawkes Bay
- Southern North Island
- Nelson and Marlborough
- Otago and Southland

4.2.3. Northland

The Northland region is located at the northern end of the North Island. The region includes all four territorial authorities such as the far North District, Kaipara District, Whangarei District, and Auckland Council. The export port for this region is Northport. An analysis of the projected future log supply is shown Figure 8 below.

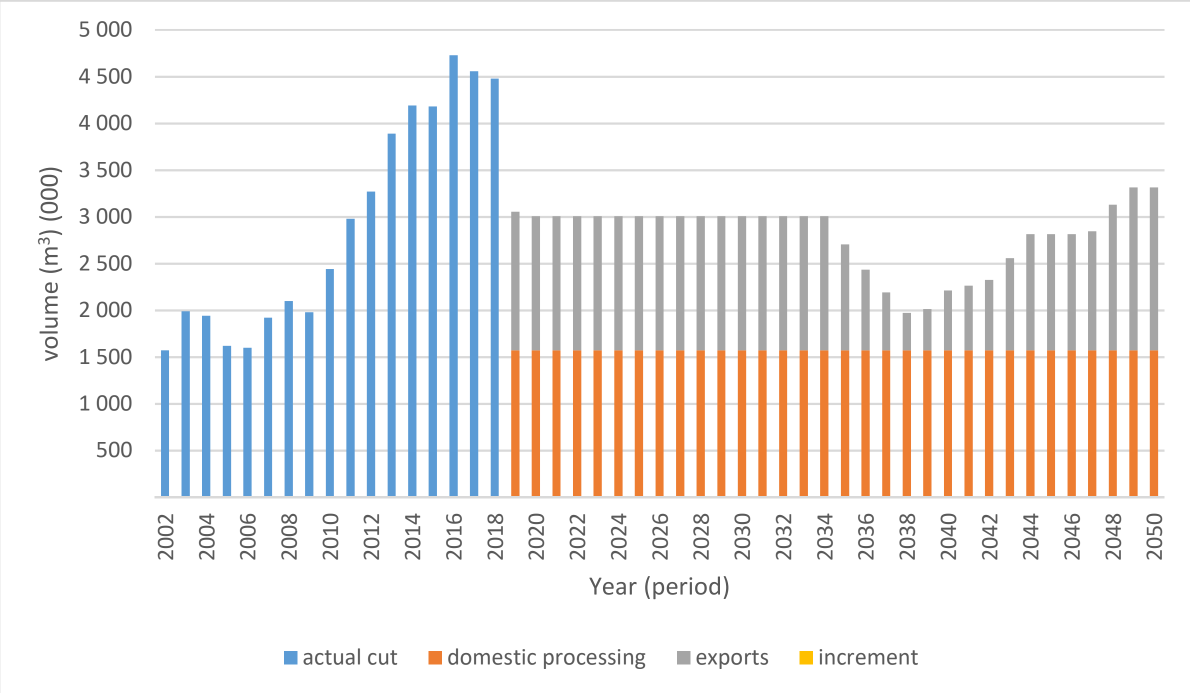

Figure 8 Log supply forecast for Northland region, 2019 - 2050 (Non-declining split yield)

The wood forecast availability for Northland can be shown in Figure 8 displaying that the future wood resource will not be able to support the current harvest demands for the region. The 5 year average for domestic processing volumes from 2014-2018 is 1.5 million m^3 and in 2018 Northport exported 2.6 million m^3. Figure 8 shows that there is an estimated reduction in wood resource for the region. The region's current harvest of export and domestic volumes cannot be supplied by the forecasted resource availability. Assuming that the domestic mills will take priority in procurement of the resource, this will mean that there will be a reduction in resource going to exports. As a result of this, it is unlikely that the port will face problems with port congestion and capacity as there will not be incremental wood available in the region.

4.2.4. East Coast

Historical domestic processing and roundwood removals published by MPI group both the Hawkes Bay and East Coast into one region. The volume for East Coast alone was estimated by combining the volume exported out of Gisborne Port and the domestic processing volumes from mills in the East Coast region. The estimated resource forecasted is shown in Figure 9 below.

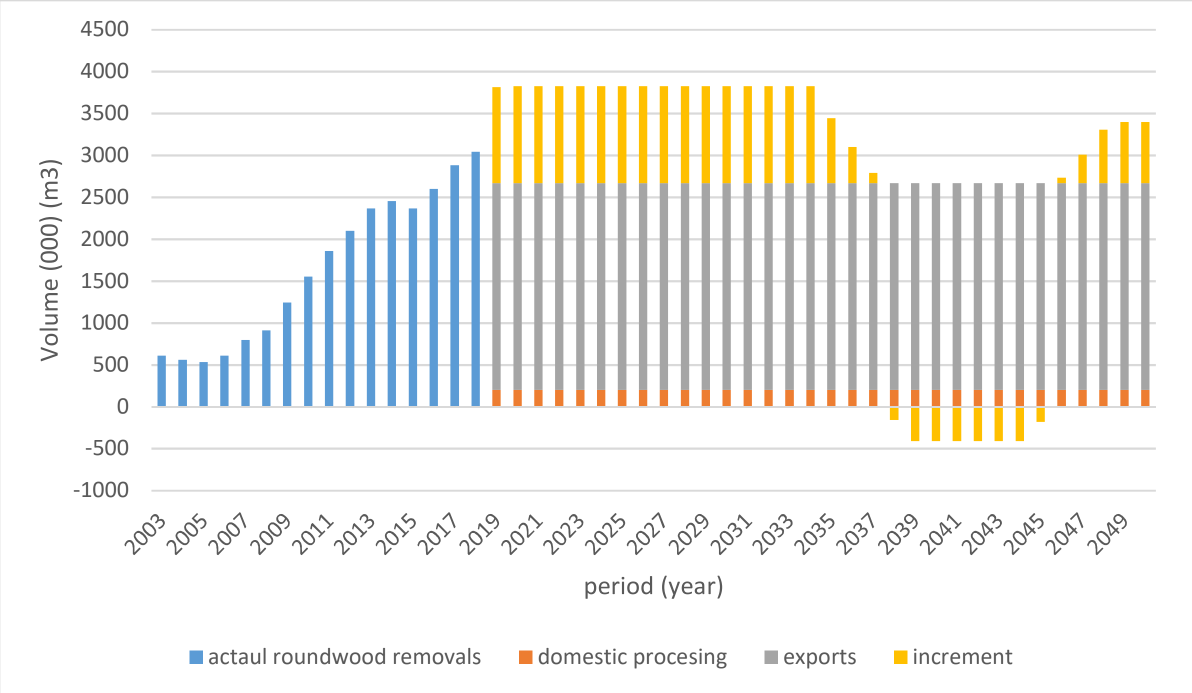

Figure 9 Log supply forecast for East Coast region, 2019 to 2050 (non-declining split yield)

The wood resource in the East Coast region will increase in the next 10 years under a non-declining split yield. There is estimated to be an increase in 1.1 million m^3 from 2020 to 2034 before the volume drops. During the drop in volume resource to supply will not meet the assumed demand. The increase in volume during the years 2020 to 2034 indicate that there will be an increase in supply of resource to exporting ports. This is assuming that the domestic processing mills are already currently at capacity and that they will not be able to take on much more resource unless there are changes.

4.2.5. Hawkes Bay

As mentioned above, data provided by MPI combine the East Coast and Hawkes Bay regions together. To estimate the current domestic and export volumes, the East Coast numbers were removed from the combined region (East coast and Hawkes Bay) to give the Hawkes Bay region estimates. The estimated log supply forecast is shown in Figure 10.

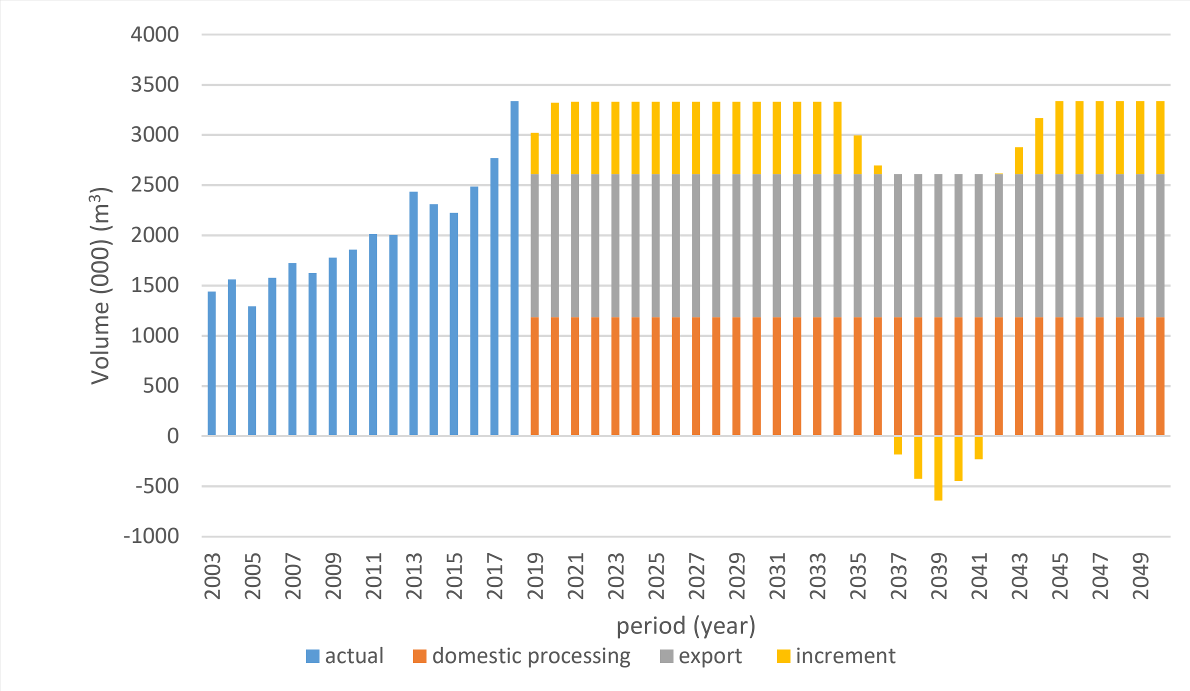

Figure 10 Log supply forecast for Hawkes Bay region, 2019 – 2050 (Non-decline split yield)

The Hawkes Bay region is forecasted to have an increase incremental wood volume. From the periods 2020 to 2034 there will be an increase of 720,000 m^3. With the majority of this volume going through the export market, ports such as Napier Port will likely experience increased volumes. Highlighted in Figure 10 is also a drop in supply from 2035 where the current domestic and export volumes will not have enough supply, representing a negative wood availability volume.

4.2.6. Southern North Island

The Southern North Island region is spread across thirteen territorial authorities. It comprises of two sub regions which are Eastern Southern North Island and Western Southern North Island. The region has a developed forestry sector where larger forests are located in Wairarapa and inland Wanganui. Shown in Figure 11 are the estimated wood volume forecasts for the periods 2020 to 2050.

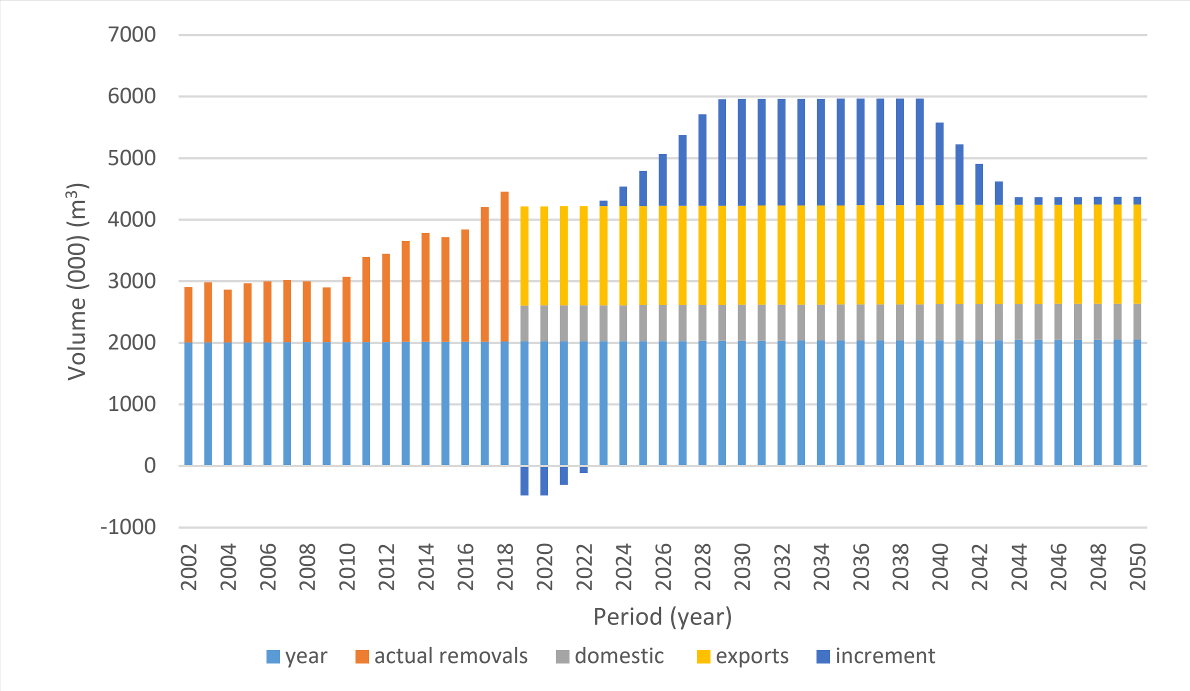

Figure 11 Log supply forecast for Southern North Island, 2020 – 2050 (Non-declining split yield)

Estimates for the Southern North Island show that there will be increasing incremental wood forecasted for the region. The peak in incremental wood is shown to gradually increase from 2022 to 2028 where it then peaks to 1.7 million m^3. This volume stays constant until 2038 before it decreases again. The increase incremental wood will mean that ports in the region will have an increase in wood supply which may result in problems with congestion and log capacity.

4.2.7. Nelson and Marlborough

The Nelson and Marlborough region is spread across two districts. The wood availability forecasts can be shown in Figure 12 for the periods 2020-2050. Major export ports in this region are Nelson Port and Picton Port.

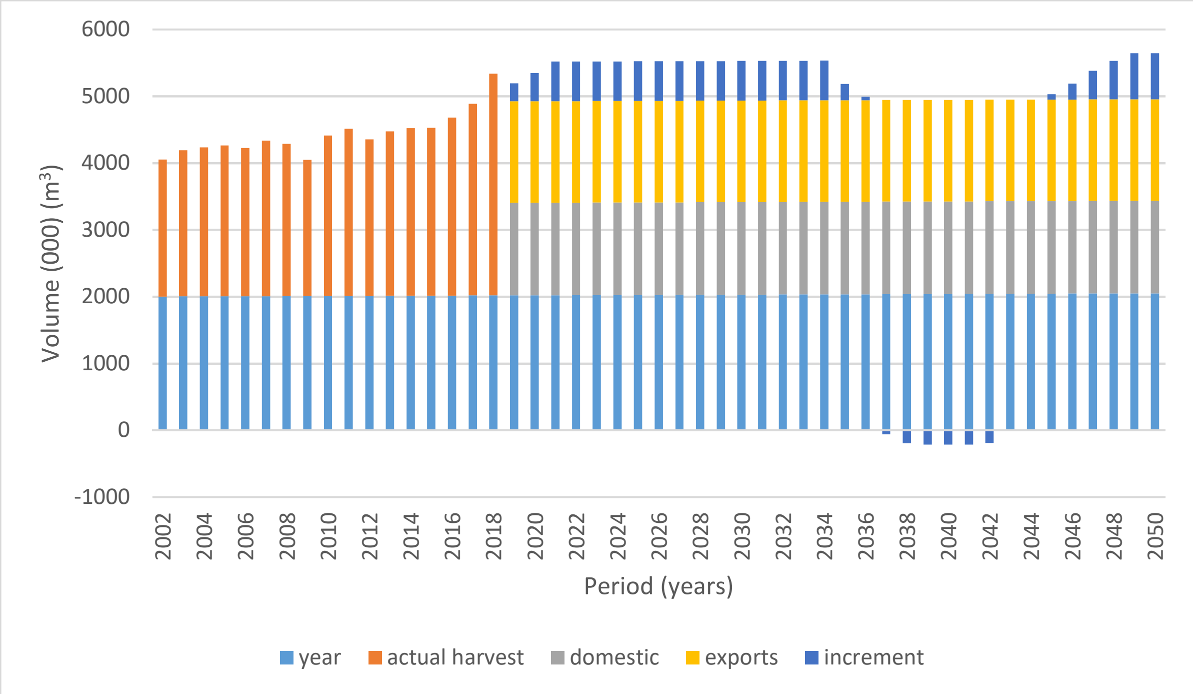

Figure 12 Log supply forecast for the Nelson and Marlborough region, 2019 -2050 (Non-declining split yield)

The Nelson and Marlborough region will have an increase in wood volume. In 2021 there will be an increase of 592,000 m^3. There will also be a decrease in volume in 2037 where the supply will not be able to meet the current demand for domestic processing and exports. Volume then increases in 2044 again, and peaks at 2049 at 690,291 m^3. The increase in increment wood will mean that ports such as Nelson Port and Picton port may have to deal with issues such as port congestion due to the increase in supply.

4.2.8. Canterbury

The Canterbury region is spread across 8 territorial authorities. Major export ports from this region include Timaru Port and Lyttelton Port. Shown in Figure 13 are the estimated wood availability volumes for the region.

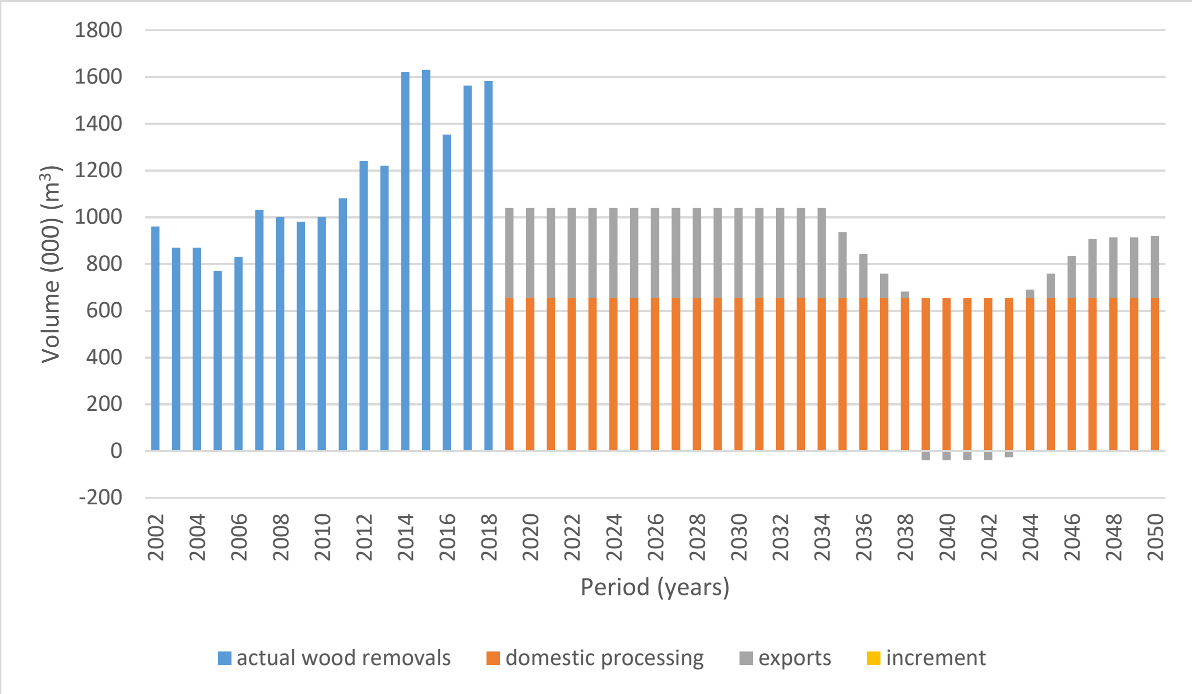

Figure 13 Log supply forecast for the Canterbury region, 2019-2050 (Non-declining split yield)

The estimates for the Canterbury region were estimated by assuming wood volume would be prioritised for domestic processing. Overall the region will have a decline in wood resource available where the supply will not meet the demand for current domestic processing and export volumes. Under the assumption that wood resource availability will be prioritised to domestic mills, this will result in a decline in export volumes. This means that ports such as Prime Port and Lyttelton Port will not have issues with increasing volume and is unlikely to have issues with congestion and capacity. Major problems for these ports will instead be procurement of wood resource.

4.2.9. Otago and Southland

The Otago region is spread across five territorial authorities which are Central Otago, Clutha, Dunedin City, Queenstown-Lakes and Waitaki. For the Southland Region, it is spread across three territorial authorities - Gore, Invercargill City and Southland District. Shown in Figure 14 are the estimated forecast volumes for the Otago and Southland region.

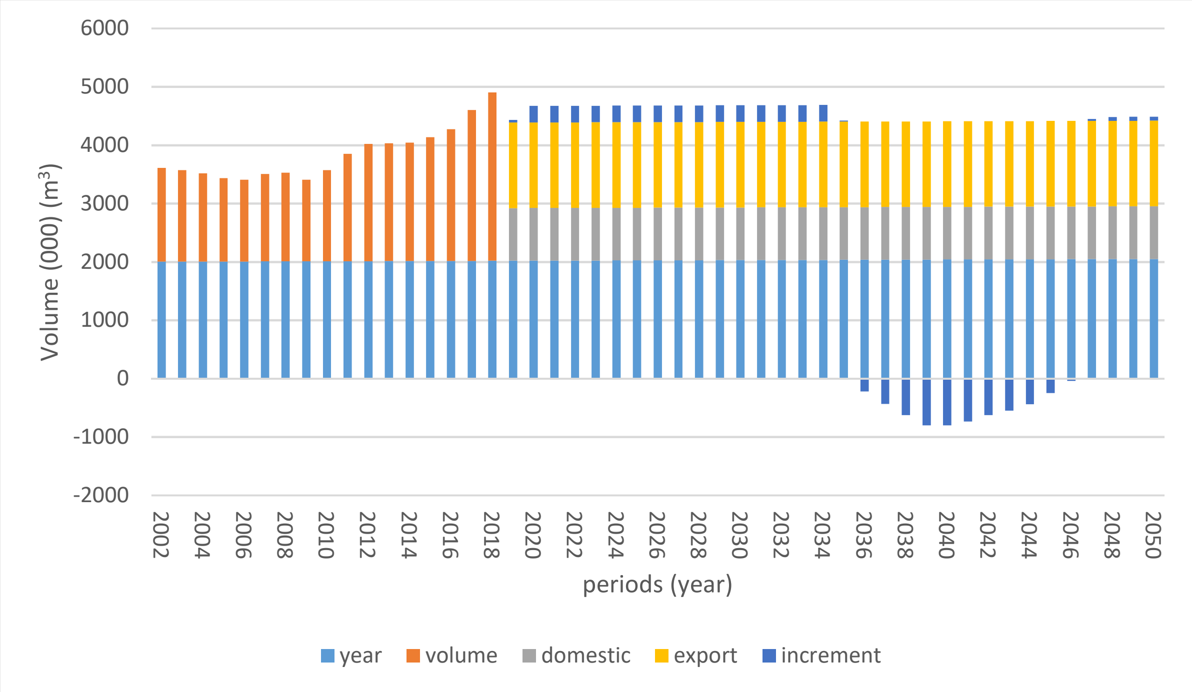

Figure 14 Log supply forecast for the Otago and Southland region, 2019 – 2050 (Non-declining yield)

The Otago and Southland regions are shown to have an increase in projected wood supply from 2020 to 2034. The incremental volume peaks at 284,491 m^3 where it is constant from 2020 to 2034, before the volume decreases again. Assuming that the domestic mills are already at capacity, and there is no increase in capacity, this is the volume that the ports will have to "gear up" for which may cause capacity issues.

4.3. What are the estimates if these numbers for the Port of Tauranga?

Part of this study project was to estimate these numbers for the PoT. This included estimates such as:

- % of berth occupancy from 2018 calendar year
- Total number of logs vessels and number of log vessels that finished at POT
- Average volumes loaded (uplift)
- Average volumes loaded per 24 hours
- Number of vessels that fumigated on the berths
- Vessel timings from pilot to berths

This was conducted so the PoT can view to understand their performance. One major factor that influences log throughput is berth occupancy which is defined as the amount of time a berth is occupied by a vessel. Shown in Figure 15 is the berth occupancy percentages for the Port of Tauranga 2018 calendar year.

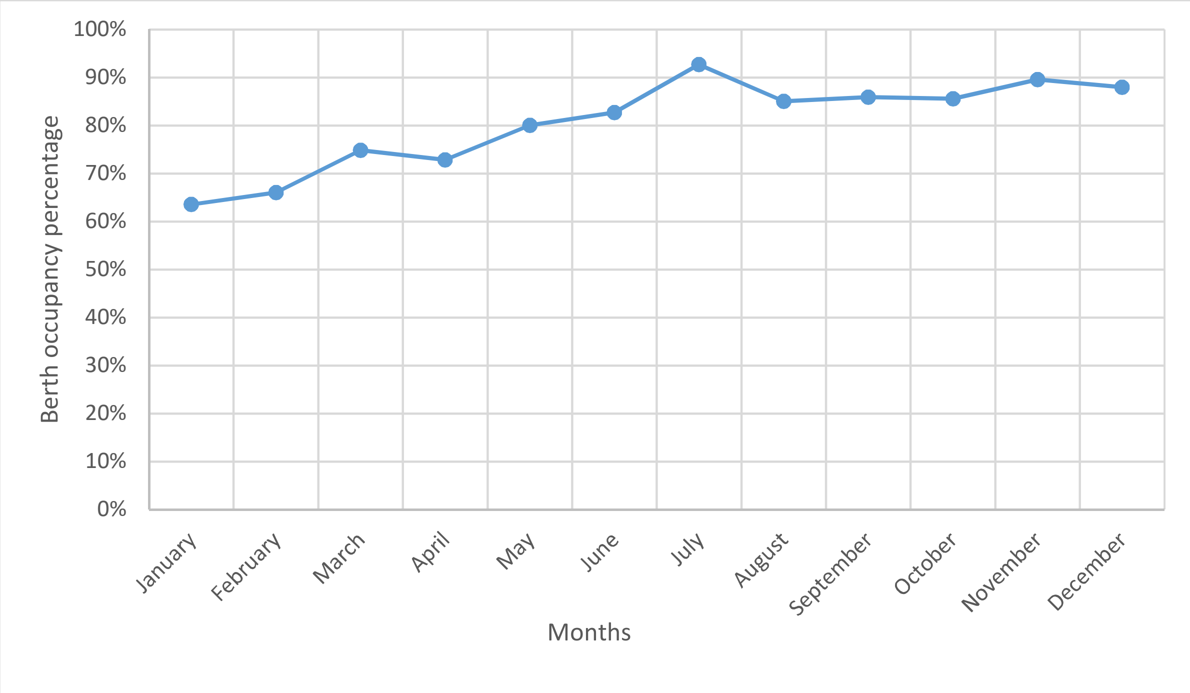

Figure 15 berth occupancy percentage for the Port of Tauranga for the 2018 calendar year

Figure 15 displays the berth occupancy averages for three berths over each month for the 2018 calendar year. The average berth occupancy for the Port of Tauranga is 83%. However, it is likely that the berth occupancy will be higher as the PoT does not include the time the berth is empty due to vessel movements. The "real" berth occupancy for the PoT when taken into account vessel movements, is likely to be around 90 %. This indicates that the PoT is already at capacity and the berths are already fully occupied.

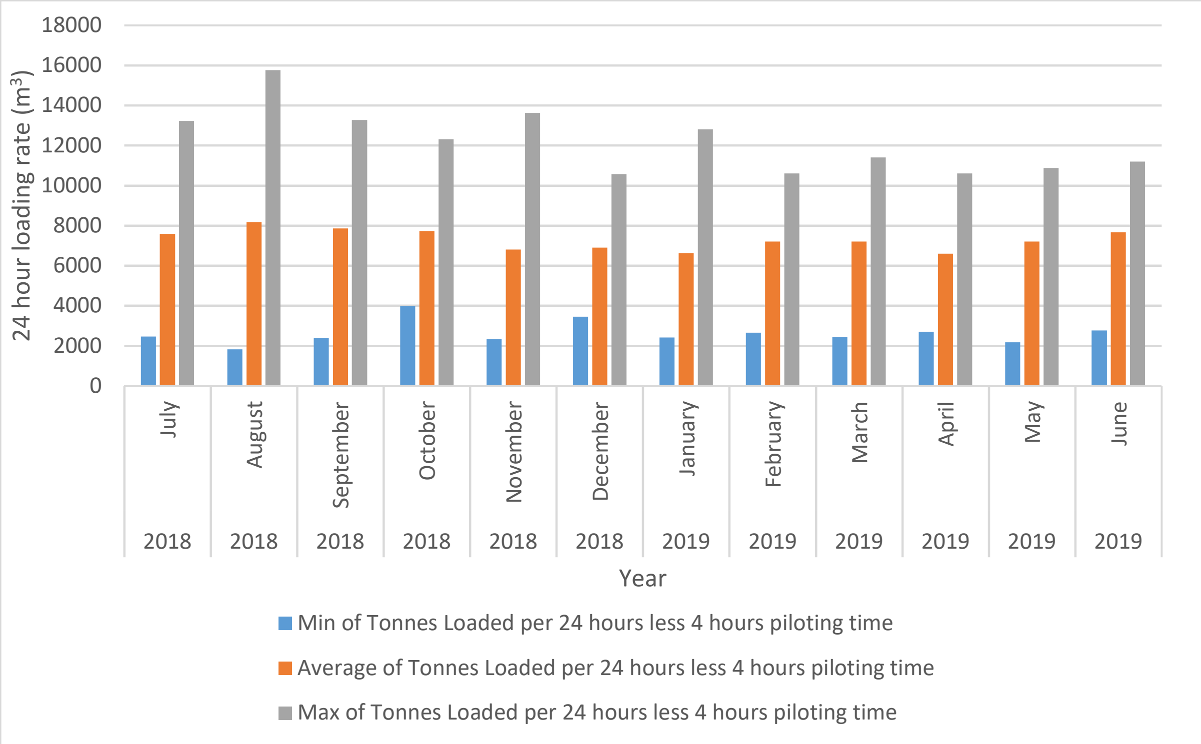

Figure 16 loading rates for the Port of Tauranga

Loading rates are also a crucial factor when determining the factors that affect port log capacity. Shown in Figure 16 are the loading rates for the PoT, displaying the minimum, average and maximum loading rates for a 24-hour period. The average loading rate for the PoT from July 2018 to June 2019 is 7,295 m^3 per 24 hours. This loading rate will affect the time taken to load a vessel which will be discussed later. There is a range in loading rates for the PoT meaning there is potential to have higher loading rates. For example, in August the largest volume was loaded was 15,767 m^3 in 24 hours. This indicates the potential that the PoT could achieve.

Table 3 estimates for the Port of Tauranga

Total log volume (m^3)	6,660,385
Total number of log vessels	257
Average uplift (m^3)	25,915
Ships that advised next port off shore	211
Ships advised next to port Marsden point	33
Ships that advised next port TBA	12

The numbers for the PoT can be shown in Table 3. Log volume exported through the PoT in 2018 is 6.6 million m^3 with a total number of 257 vessels. There were 211 ships that finished at the PoT with an average uplift of 25,915 m^3 per vessel. From the 257 vessels that were loaded at the PoT, 33 went to Marsden Point and 12 were advised to be shipped to another port but were to be advised (TBA) meaning that their schedule after leaving the PoT is unknown.

4.3.1 Berth fumigation numbers

Fumigation with methyl bromide is a critical phyto-sanitary operation that is carried out at the Port of Tauranga. Top deck cargo are logs that are stored above the holds of a vessel and are required to be treated using phyto-sanitary treatments. For vessels with top deck cargo going to China, logs will only be accepted if they are either debarked or treated with methyl bromide. Customers such as India will only accept logs that have been treated with methyl bromide. For some cases in the PoT, fumigation operations occur on the berth, which restricts the ability for logs to be loaded. Data obtained from PFP show that in 2018 there were 4 fumigations on the berths each month. In total for the 2018 calendar year there was a total of 48 berth fumigations. The total time taken to load logs onto a berth, fumigate and recapture takes approximately 48 hours. With 48 berth fumigations occurring in 2018 and a total time of 48 hours, there was a total of 96 days that were lost to fumigation.

4.3.2. Workable berth days

At the PoT there are three berths that are allocated for the purpose of log vessels. The total amount of days that the berths are deemed "workable" is 345 days a year. Workable is defined as the amount of days where operations on the berth can occur. This takes into variables such as berth maintenance, weather delays and vessel breakdowns. With three operating berths at the Port of Tauranga there are a total of 1035 workable days a year. However, with operations such as fumigations on the berths taking up 96 days a year, the total productive berth days available is 939.

4.3.3. Vessels that can be loaded at the Port of Tauranga

The total amount of vessels that can be loaded at the Port of Tauranga was calculated using the formula:

$$\text{Total Amount of Vessels that can be loaded annually} = \frac{TPBD}{TTL + Lt + St}$$

The total amount of vessels that can be loaded at the Port of Tauranga shows that using the average load rates, the PoT can load 244 vessels a year. When multiplied by the average volume uplift for vessels the total volume that can be exported is 6.3 million m^3. Last year the PoT loaded 257 vessels and exported 6.6 million m^3 showing that the PoT loaded and exported more than the average displaying that the PoT was loading faster than the mean loading rate in 2018.

4.3.4. Options for increasing throughput at the Port of Tauranga

With increased supply forecasted for the CNI, the PoT will need to implement appropriate actions in order to accommodate the increase in supply. Currently the Port of Tauranga is facing problems with port congestion and backlogs of vessels that have resulted in demurrage fines. Two operation practices that have been identified as factors that can be modified to help decrease log congestion and increase throughput, is the lashing of logs and the fumigation of vessels on the berth. Using an excel model, an analysis was carried out to identify the number of vessels and volume the PoT could increase if different scenarios were changed.

Currently lashing operations for vessels in the PoT takes 7.2 hours on average. One scenario that was proposed was to shift vessels from log berths to another empty berth to lash. If a 5 cent per JAS levy was charged to exporters the port would be able to afford to move 103 vessels a year. This would result in 52 days saved a year from moving vessels to lash and an increase of 13 vessels per year. A total increase of 336, 895 m^3 a year, bringing the volume up to 7 million m^3.

Scenario 2 looked at the option of moving fumigations off the log berths and onto a different fumigation area. If fumigation on the berths were to be removed there would be an increase in 25 vessels a year that could be loaded. This would result in an increase of 647,875 m^3 of volume annually which would bring the total volume exported annually to 7.3 million m^3.

Scenario 3 was an analysis into the Port of Tauranga looking at bringing in new loading technology. This new technology is mobile harbour cranes that are proposed to increase loading rates. If mobile harbour cranes were to be placed at the PoT, there will be an increase in 166 vessels a year which would increase the volume annually by 4.3 million m^3. This would bring the total volume annually to increase to 10.9 million m^3.

5. Discussion

In general, there are a wide range of factors that affect port capacity in New Zealand. These ‘factors” can be group into what is called subsystems. These subsystems are what directly influence the overall ‘system’ which is viewed as a port (Munisamy, 2010)..

5.1. Factors affecting port log capacity in New Zealand ports

Results provided from the survey indicated that the two most limiting sub-systems of a port are storage space and vessel frequency. Storage space represents the total area that can be loaded with log volume. As vessels come into ports, they are on strict schedules and due to this, there is the need to have sufficient volume to load the vessels. By having a sufficient size storage space this means that there is adequate volume on site that can be carted to load vessels.

Larger storage areas increase the log throughput of a port as it can take up more volume for a longer period of time before being at capacity. As this is the main limiting factor that was indicated by respondents, this means that many of the ports in New Zealand are currently being limited by small or inadequate storage areas. An implication of this is that, unless there is change and investment into expanding the storage areas, ports that have been forecasted to have increased log supply will experience problems in congestion. However, as mentioned earlier, factors that affect port capacity are linked and although log storage is an important factor, volumes cannot be loaded onto vessels if the vessel scheduling is not there.

Vessel frequency was also one of the most limiting factors from the survey. Vessel frequency is referred to the number of vessels being chartered into a port at a given period. It is logical that this is one of the most limiting factors as this determines the rate that logs will be exported out of the port. Higher frequency of vessels will result in a higher turnover of volume which then results in reduce congestion due to logs being carted from storage yards. In contrast lower vessel frequency will result in less vessels coming to a port to be loaded, therefore reducing the total amount of logs that could be exported. This then causes issues with the storage yard as the log supply coming into the port is higher than the amount being exported. An implication of this again is that the storage areas will be at capacity which will reduce log throughput, ultimately decreasing the profitability for both the port and exporters.

5.2. External factors affecting log port capacity in New Zealand ports

When identifying the external factors that limit port capacity, respondents from the survey stated that log price and forest harvest were the two most limiting factors. Log prices are the major driver in regard to the volume of logs offered for export by forest owners, therefore an increase in export log prices will drive increase volume into ports. Forest harvest supply is also one of the most limiting factors as increased harvest will result in more volume going to the ports therefore resulting in increased supply in the storage yards. It is important to mention that this factor is also directly linked with forest harvest. Increased export log prices would also mean that there will be an increased in forest harvest supply to exporting ports which is why these factors have been indicated as the most limiting factors.

Ports such as Eastland Port are not limited by port operation factors but instead external factors where vessels are unable to be berthed due to tides. This introduces a domino effect where the supply chain gets backlogged resulting in operations such as harvesting and trucking coming to a stop. One option for a port that faces problems such as Eastland Port is to increase the number of berths that are allocated to log vessels. An increase in the number of berths will result in more vessels being loaded when vessels can come into the channels, therefore taking advantage of when the tides are favourable. However, as mentioned previously many of the factors are linked and by changing one limitation, this will have flow on effects. Having more berths will also mean that there is a need for more volume available on the port to ensure the loading of vessels are efficient. Installing extra berths will also result in more volume needed which means that for some ports, there may need to be an increase in storage area which is an improvement that Eastland Port is considering. All of the facilities need to be in balance to have port operations performing at minimum cost.

5.3. Estimates for the PoT

As mentioned previously, berth occupancy is one of the major factors that affects the capacity of log ports. On average the PoT berth occupancy is at 83%, however it is likely to be higher and around 90% as data provided by the PoT did not account for piloting time. This means that the PoT is already at capacity. The implication of this it that the PoT will instead have to increase their efficiencies in order to have faster vessel turnover.

The total amount of vessels that were loaded in 2018 at the PoT was 257, however based on the average loading times for the PoT, the port on average can only load 244 vessels. This means that in 2018 the PoT total amount of vessels loaded annually, was higher than the average, and currently the PoT are loading faster than the average load rates. However, although the port is loading more efficiently than the average, last year there were still issues with congestion and log capacity which limited log throughput. This means that although the port is loading faster than the average, its loading rates are still not high enough and the PoT still needs to improve its efficiencies in order to reduce the vessel back logs.

5.4. Options for increasing throughput at the PoT

As mentioned previously, the PoT is already at berth capacity and increases in efficiency are the key to reducing congestion. Three solutions have been identified to help facilitate the increase in efficiencies. It is important to highlight that moving vessels to lash and the relocation of the fumigation pad on the berths, would help increase capacity for the PoT, but cannot accommodate the potential forecasted 1.85 million m^3 of log supply that is estimated to go through the port. Mobile harbour cranes will be able to deal with the forecasted log supply on the basis that the new technology is able to load two vessels at the same time, which will increase the load rates for the PoT. However, it is important to highlight that the load rates estimated for the harbour cranes are optimistic and that the port will not know its true ability until it is implemented into the port operations.

5.5. Wood volume forecasts for other regions

The future increase in wood availability in New Zealand is driven by CNI, East Coast, Hawkes Bay and Southern North Island. Provided there is no increase in demand from domestic processing in these regions, the ports in these regions are forecasted to have large amounts of increase volume going to log exports. It is therefore likely, that the ports will experience issues with congestion and capacity as log exports increase. For ports that have vessels finishing top deck cargo and are experiencing problems with congestion, an option may be to have vessels moved to empty berths to increase loading rates. This may be an option for ports such as Napier Port and Marsden Point where there is the opportunity to take advantage of empty berths. In this case, both the exporter and port would benefit. Another option for these ports is to implement new equipment in the same way as the PoT. Mobile harbour cranes could also be a viable solution for these ports that are going to have issues with port capacity. This however involves high capital investment where there is a trade off as log supply is expected to increase for on average 10 years, but then drop. Due to this, these ports will have the issue of deciding if the high capital investment is worth it for the 10 years where there is increased supply, or if there will be other uses for these cranes at that time.

Northland and Canterbury are unlikely to face problems with port capacity due to the regions decrease in future log supply availability. With a lack of resource going to these ports, this means the ports log throughput are not constrained by capacity but by log supply.

6. Limitations

The results carried out in this dissertation project requires a range of assumptions that are made which can lead to potential limitations of this study. This study aims to predict the future wood flows for regions in New Zealand and with any prediction of the future, there is no guarantee that the numbers will be accurate.

6.1. Survey Methodology

The methodology included a survey that was sent to individuals that were deemed experienced in their field and were experts at their designated port. This is a limitation to the study as the answers given by these experts may be biased or not representative of the port.

A larger pool of experts to survey may help give a better representation of factors that affect port capacity.

Another limitation with using a survey as a way to identify the factors that affect port capacity is that a survey is only representative for that point in time. The identification of factors that affect port capacity may not be the same in the future as the survey method does not account for any trends.

6.2. Wood Availability Forecasts

Estimates of wood availability were sourced from MPI where the documents were produced in 2014. This is a limitation as the wood forecast availability took into variables that were present during the time of publish which may not represent the same variables today. The wood forecast availability was also based on the assumptions from large scale and small scale forest owners such as harvest age intentions which could be subject to change.

Forecasts of future domestic processing and export volumes were carried out by taken an average of the last 5 years (2018-2014) as this took into consideration of the most recent trends. It was assumed that these trends reflected future consumption of wood resource for these regions. This is a limitation as predictions of future consumption is not possible to measure and there will always be a level of error.

For regions where the current domestic processing and export consumption were higher than the forecasted volumes, it was assumed that wood supply would take priority to domestic mills. However, this is a limitation as this may not be the case, and volume may be prioritised for exports instead of domestic processing.

Identification of ports that would have issues with capacity was based on the assumption that incremental volumes would be exported as the domestic mills were assumed to be at capacity. However, domestic mills may not be at capacity and may have the potential to accommodate an increase supply. It was also assumed that the incremental wood from one region would go through one main port. For example, it was assumed that all incremental wood volume from the CNI region would go through to PoT, however wood resource located at the bottom half of the region will go to ports such as Port Napier and Port Taranaki. This is a limitation as this will mean that this will change the estimated forecast wood supply going through the PoT.

6.3. Estimating numbers for the PoT

The total amount of vessels that can be loaded at the PoT are derived from factors such as the average time taken to load and sail a vessel. These factors include variables such as lashing and piloting times. The time taken to carry out these operations are based on the assumption that it takes 9.6 hours on average to lash a vessel, and 7.2 hours on average to pilot a vessel in and out of the channel. This is a limitation as the actual time to carry out these operations will vary, which would influence the estimates for the total number of vessels loaded annually.

6.4. Options for increasing log throughput at PoT

One of the options identified in this study was to move the lashing process to another empty berth so that another vessel could be piloted into that berth to be loaded. A limitation is that there was the assumption that the PoT would have empty berths available at the times when they would be needed for this operation. This is a limitation, as there is the possibility that other vessels could be occupying the berths which mean that the movement of log vessels to other berths for lashing cannot occur.

7. Conclusion

Overall there will be an estimated increase wood volume in New Zealand over the next 10 years. This will result in an increase of supply to log exporting ports which will increase the issues already occurring of port congestion and increasing demurrage fines. However, it is important to highlight that not all ports in New Zealand are going to face these issues as the increased in volume is only driven by a few regions namely CNI, East Coast, Hawkes Bay and Southern North Island.

The survey conducted as part of this study showed that the major factors that affect port capacity at an operational scale are log storage space and vessel frequency. These main factors limit log throughput as log storage space determines the amount of volume that can stored at the log yard, where larger storage area allows for larger accommodation of wood supply. Vessel frequency determines the rate the wood supply from the storage area is shipped which allows more volume to be supplied to the port. The frequency of vessels and storage area determines the rate that log volume can go through the port hence why it is the most limiting factors.

Log price and forest harvest were the two most limiting external factors that affected port capacity. As log price drives the supply of wood volume to a port, it is logical that this is one of the most limiting external factors. Forest harvest was identified as a limiting factor as if there is no harvest of forest resource this will result in no supply. It is also important to highlight that these factors are directly related to each other as log price drives the harvest of forests.

The PoT is currently at capacity as the berth occupancy percentages are in the high 90s which mean that their only option is to increase their efficiencies. Efficiencies show that the PoT is currently loading more volume and vessels than their average, however in 2018 the port still faced issues with port congestion and vessel delays which mean that although the port is operating higher than the average, there is still a need to improve their efficiencies.

Options that the PoT can implement to help increase its efficiencies and log throughput include:

1. moving vessels to another berth for lashing operations
2. relocation of fumigation of logs on the berth
3. the installation of mobile harbour cranes

With 1.85 million m^3 of log supply coming through the PoT, options 1 and 2 will increase port capacity just shy of 1 million m^3. These two options will help accommodate some of the volume coming through the port but not all. However, the implementation of mobile harbour crane equipment is estimated to process 4.3 million m^3 of volume which to provide all the potential capacity required. It is important to highlight however, that the numbers for mobile harbour cranes are optimistic and until they are implemented, there will be no information on the real log throughput.

As all regions in New Zealand have estimated forecasts of increase in wood availability apart from Northland and Canterbury, the majority of ports in New Zealand will have an increase in log supply. However, the majority of the volume is located in regions in the North Island namely the CNI, East Coast, Hawkes Bay and Southern North Island. It is the ports in these regions that are will experience problems with capacity and congestion. The solutions to help increase log throughput in PoT are examples that could potentially be applied to other ports that are facing problems with congestion. Regions such as Northland and Canterbury show a downturn in wood availability where ports will potentially have a lack of supply. The main issues for these port will not be with congestion and capacity but the lack of supply in wood resource.

This research has highlighted the sub-systems that affect the port system as whole, identifying the major factors affecting port capacity. Opportunities to reduce port congestion and port capacity have shown to be log storage space and vessel frequency, with external factors being log price and forest harvest. Solutions in solving these limiting factors are the key to decreasing vessel delays and increasing profitability of a port.

8. References

Blonigen, B.A., & Wilson, W. W. (2008). Port efficiency and trade flows. Review of Bobrovitch, D. (1982). Decentralised planning and competition in a national multi-port system. Journal of Transport Economics and Policy, 31-42.

Chen, T. (1999). Yard operations in the container terminal-a study in the 'unproductive moves'. Maritime Policy & Management, 26(1), 27-38.

Ernst, & Young. (2016). Consultants Report to Port Future Study. Retrieved from http://www.portfuturestudy.co.nz

Gardner, J. (2019) What are the Factors that Affect Port Capacity/Interviewer: A. Chen.

Indufor Asia Pacific. (2016). Wood Availability Forecasts. Retrieved from https://www.mpi.govt.nz

Kasypi, M., Shah, M., & Muhammad, I. (2013). A Productivity Study of Medium Container Terminal. IUP Journal of Supply Chain Management, 10(1).

Maloni, M., & Jackson, E. C. (2005). North American container port capacity: a literature review. Transportation journal, 16-36.

MPI. (2019a). Estimated roundwood removals from New Zealand by wood supply region, 2002-2018. Retrieved from https://www.mpi.govt.nz

MPI. (2019b). Forestry production and trade statistics detail the production, trade, and other forestry activities in New Zealand. Retrieved from https://www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry/

MPI. (2019c). Log Exports by New Zealand Port by Quantity and Value. Retrieved from

Munisamy, S. (2010). Timber terminal capacity planning through queuing theory. Maritime Economics & Logistics, 12(2), 147-161.

NZIER. (2017). Plantation Forestry Statistics. Retrieved from https://nzier.org.nz

Porter, M. E., Schwab, K., Sachs, J. D., Warner, A. M., Cornelius, P. K., Levinson, M., . . . Development, H. U. C. f. I. (2000). The global competitiveness report 2000: Oxford University Press New York.

Rays, C. (2019) Factors that Affect Port Capacity/Interviewer: A. Chen.

Shneerson, D. (1983). Short term planning for a ports system. Maritime Policy & Management, 10(4), 217-250. International Economics

9. Appendix

9.1 Image of Port of Tauranga's log yard

Appendix 1 image of Port of Tauranga's log yard

9.2. Image of Port of Tauranga's off site log yard (Hewletts log yard)

Appendix 2 image of Port of Tauranga's off site log yard (Hewletts log yard)

9.3 Nationwide increment log supply

Log supply forecasts for New Zealand	
Year	**New Zealand**
2019	657
2020	1568
2021	2021
2022	2325
2023	3467
2024	4155
2025	4155
2026	4155
2027	4155
2028	4155
2029	4155
2030	4155
2031	4155
2032	4155
2033	4155
2034	4155
2035	669
2036	-1888
2037	-3439
2038	-4620
2039	-4906
2040	-4509
2041	-4176
2042	-3741
2043	-1896
2044	-1185
2045	-429
2046	263
2047	898
2048	1675
2049	2061
2050	2067

Appendix 3 Nationwide incremental log supply forecast

9.4. Log supply forecasts for North Island regions

Log supply forecasts for North Island regions (m^3) (000)					
year	Northland	East Coast	Hawkes Bay	Central North Island	Southern North Island
2019	- 1,232	1,145	410	607	- 478
2020	- 1,281	1,156	712	607	- 479
2021	- 1,281	1,156	720	607	- 307
2022	- 1,281	1,156	720	607	- 118
2023	- 1,281	1,156	720	607	89
2024	- 1,281	1,156	720	1,414	318
2025	- 1,281	1,156	720	1,855	569
2026	- 1,281	1,156	720	1,855	846
2027	- 1,281	1,156	720	1,855	1,150
2028	- 1,281	1,156	720	1,855	1,485
2029	- 1,281	1,156	720	1,855	1,732
2030	- 1,281	1,156	720	1,855	1,732
2031	- 1,281	1,156	720	1,855	1,732
2032	- 1,281	1,156	720	1,855	1,732
2033	- 1,281	1,156	720	1,855	1,732
2034	- 1,281	1,156	720	1,855	1,732
2035	- 1,582	774	387	1,855	1,732
2036	- 1,852	430	87	497	1,732
2037	- 2,096	120	- 182	- 267	1,732
2038	- 2,315	- 159	- 425	- 267	1,732
2039	- 2,275	- 410	- 643	- 17	1,732
2040	- 2,074	- 410	- 447	643	1,339
2041	- 2,025	- 410	- 231	643	986
2042	- 1,961	- 410	7	643	667
2043	- 1,728	- 410	269	643	381
2044	- 1,472	- 410	557	1,728	123
2045	- 1,472	- 184	728	1,728	123
2046	- 1,472	64	728	1,728	123
2047	- 1,441	338	728	1,728	123
2048	- 1,157	638	728	1,728	123
2049	- 973	727	728	1,728	123
2050	- 973	727	728	1,728	123

Appendix 4 Log supply forecasts for North Island regions, displaying which regions will have an increase and decrease in log supply

9.5. Log supply forecasts for South Island regions

Log supply forcasts for South Island regions (m^3) (000)		
Nelson and Marlborough	**Canterbury**	**Southland and Otago**
269	- 512	43
423	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
592	- 512	284
242	- 616	19
49	- 709	- 220
- 62	- 793	- 435
- 197	- 869	- 628
- 214	- 937	- 802
- 214	- 937	- 802
- 214	- 937	- 735
- 191	- 937	- 625
- 16	- 924	- 547
- 16	- 861	- 442
81	- 792	- 250
239	- 717	- 41
426	- 644	30
576	- 638	67
690	- 638	67
690	- 632	67

Appendix 5 Log supply forecasts for South Island regions, displaying which regions will havean increase and decrease in log supply