1. LAND USE AND TRANSPORT DEMAND COMPARISON

1.1 Background

The New Zealand Business Growth Agenda includes six policy areas that the Government considers will make a significant impact on national business performance: export markets, innovation, skilled and safe workplaces, resources, infrastructure and capital markets.

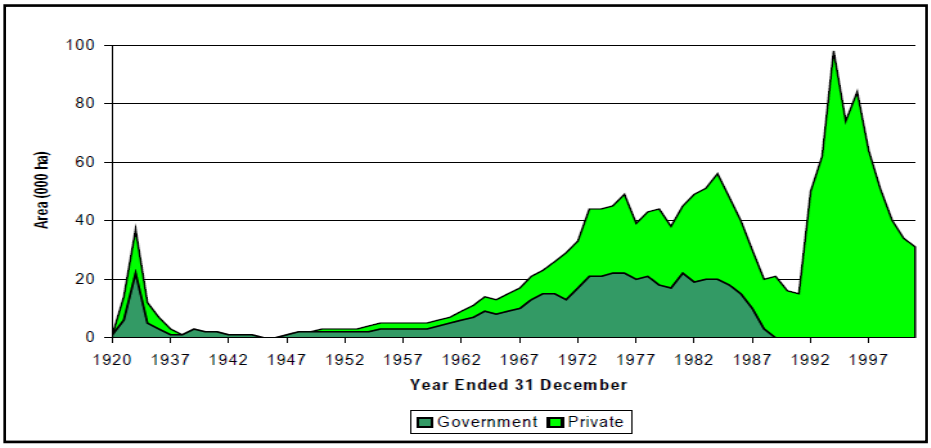
Government policy seeks to increase the ratio of exports to GDP to 40 per cent by 2025. The primary industries currently earn 71 cents in every dollar of merchandise export earnings. The goal is to double primary industry exports in real terms from $32 billion in June 2012 to $64 billion by 2025. To achieve this, New Zealand's primary industries must sustain an average growth rate of 5.5% a year through to 2025. As the value of primary industry exports is determined by the international markets, and there is no reason to foresee a doubling of value for these in real terms by 2025, it is reasonable to expect that the freight task supporting this growth in exports must grow proportionately.

1.2 Primary Sector trends

An example of the changing freight task is the onset of significant forest harvest of the North Island woodlot. These plantations coming to harvest in the next decade were planted in response to Government economic policies and financial assistance regimes in the 1990's

Figure 1 shows annual new planting of exotic forest by government and private landowners over the period from 1920 to 1997 and clearly shows the spike in planting between 1992 and 1997. These trees will be due for harvest over the next decade.

Figure 1 Annual Government and Private New Planting of Exotic Forest (1920-1997)[1]

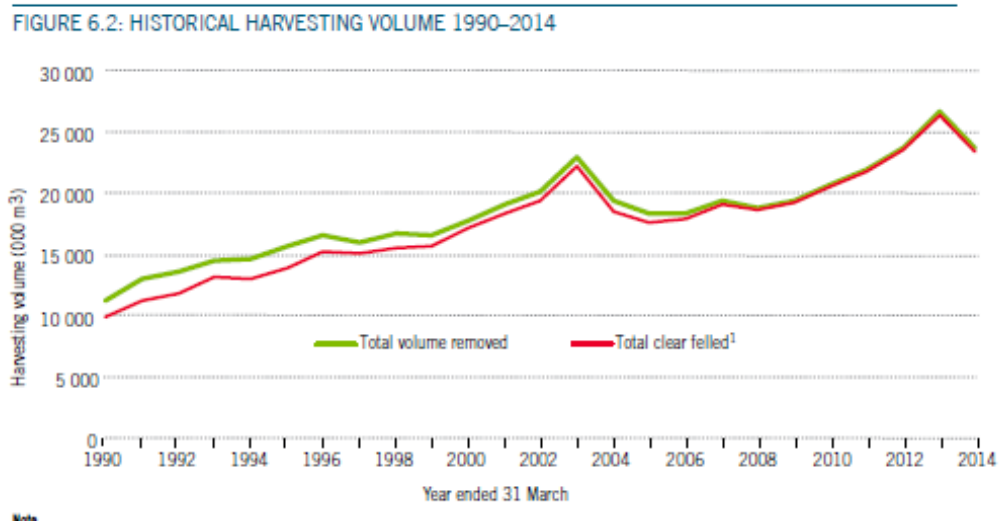


[1] After MAF 2002, Discussion Paper No. 45, Development of Plantation Forest Resources in New Zealand

The majority of new planting through the 1990s was undertaken by a variety of small-scale investors, rather than the government or major forestry companies. Today, 91 percent of the plantation forest resource is in private ownership and the plantation forest estate contributes 99.7 percent of New Zealand's total wood harvest.[2]

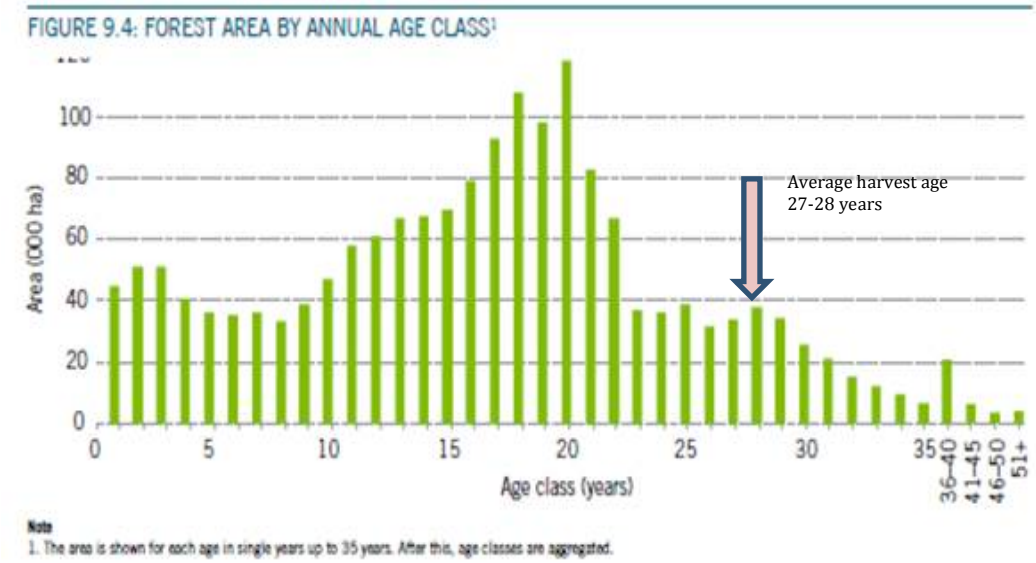
The National Exotic Forest Description[2] shows that there has already been a 145% increase in forestry harvesting over the quarter century since 1990. This can be seen in Figure 2.

Figure 2 Forest Harvest Volumes (1990-2014)



Very little of the forest planted since 1991 will have yet been harvested. The average age at harvest is 27 or 28 years. The published age class data for New Zealand forestry indicates that the volume of wood available for harvest will increase almost exponentially from less than 40,000 Ha in 2020 to almost 120,000 Ha in 2023, before declining steadily to return to current levels by 2035. This is shown in Figure 3.

Figure 3 Exotic Forest Area by Annual Age Class (2014)



2 National Exotic Forest Description as at 1 April 2014, MPI

Timber companies will harvest at different ages and vary their plans according to the state of the market and their capacity to harvest, process or export the rapidly increasing supply of product. Wood availability forecasts explore a number of scenarios for harvesting.

Some forests have been planted with harvesting transport needs in mind, close to state highways or in ways that limit the impact on local roads. Other blocks are located in relatively isolated areas and in steep hill country with road access suitable only for light vehicles. Upgrading of these roads will be needed to cater for the weight and size of logging trucks.

The other significant change in the primary sector over the same period that has had implications for rural road controlling authorities has been the conversion of pastoral farms to dairying. Between 1985 and 2015 some 737,964 Ha of pastoral farm land was converted to dairying and the national dairy herd increased 116% from 2,321,012 cows to 5,018,333 cows. Figure 4 shows the increase in milk production from 5,868 million litres in 1980/81 to 21,253 million litres in 2014/15.[3]

Figure 4 New Zealand Milk Production (1980-2015)

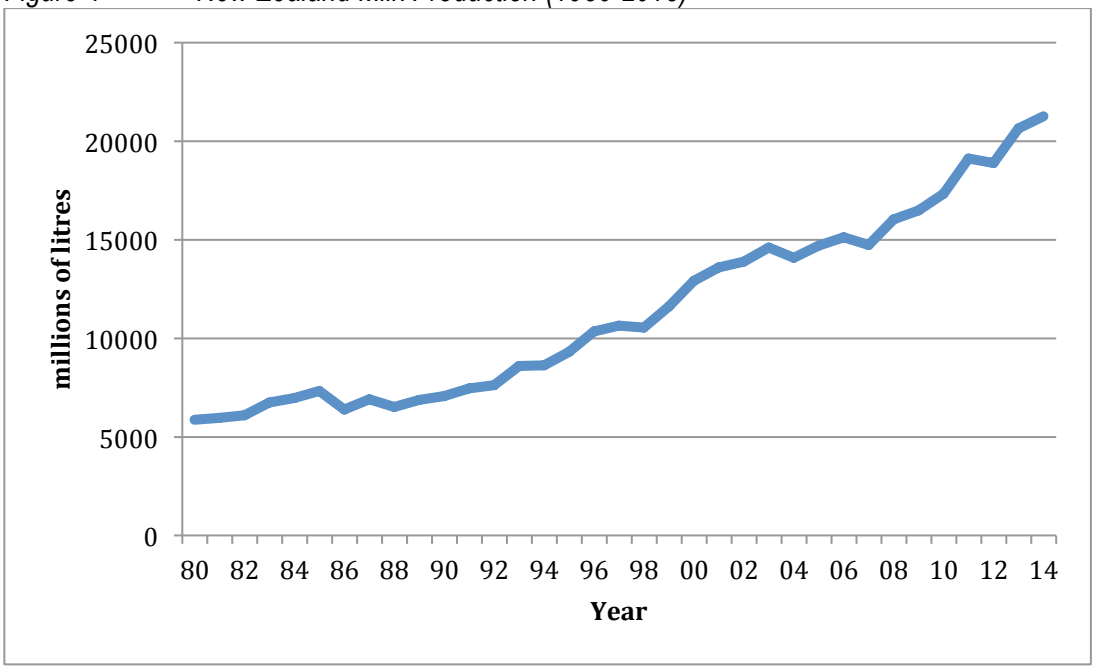


Figure 5 shows the dramatic increase in the price paid for milk solids in the 2007 year and the sustained historically high prices paid over the next six years.

[3] New Zealand Dairy Statistics 2014-15 Table 2.1 and Table 2.2

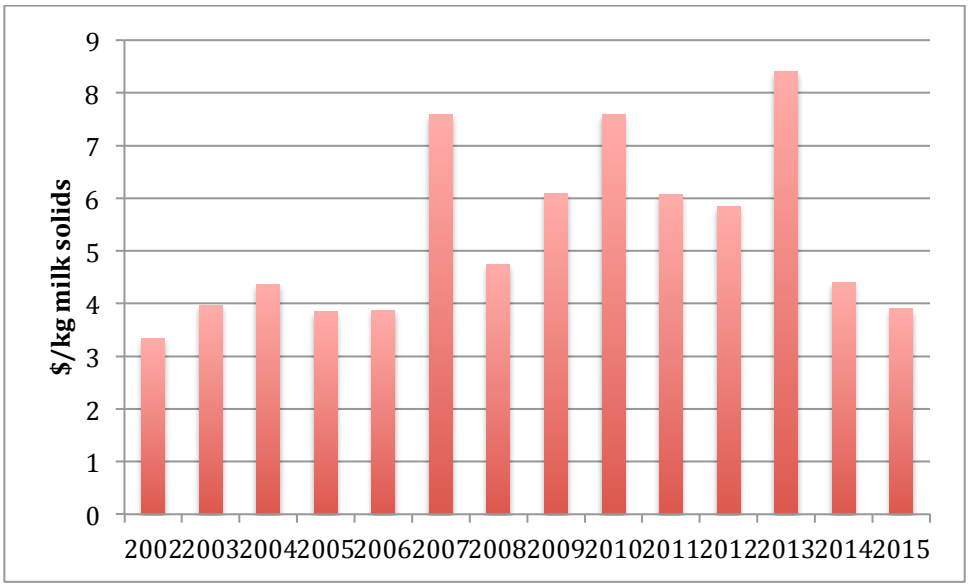


Figure 5 Fonterra Milk Price (2002-16)

1.3 Land use correlation with heavy commercial vehicle traffic

The productivity per hectare from rural land uses and the associated pavement loading from heavy vehicles varies significantly between sectors, and varies between regions. The productivity per hectare can be determined for different farming sectors. For example, New Zealand Dairy Statistics suggest a national average number of dairy cows per hectare is 3.2 and the average milk production is 3930 litres per cow per year.[4] Some regions will have lower carrying rates and lower productivity; others will have higher rates.[5] For this national average, production of approximately 12.576 tonnes per hectare per year is expected. Each tanker can carry a maximum of 26,300 litres of milk, or 26.3 tonnes. Based on these numbers, for a 30 year period, 14.35 outward tanker trips are generated per hectare by dairy production:

$$3.2 \times 3930 \times 30 \div 26300 = 14.345.$$

Variations in stocking rates and milk production between regions and districts will affect the number of outward tanker trips on local roads, with a likely range between 10.7 and 16.3 outward tanker trips per hectare over a 30 year period.

Pastoral farming can involve a wide range of activities: sheep, mixed sheep and beef, beef for finishing and for store livestock, deer and other exotics. A means of expressing the carrying capacity of a farm in a unit with a standard value across all of these potential activities was developed between 1965 and 1994. Most countries now use live-stock units per hectare (or acre) to express pastoral productivity. These units vary in basis and equivalent weight between countries. In New Zealand the live-stock unit is the ewe equivalent system. It expresses the annual feed requirements required for one ewe rearing a single lamb. The base assumption is that a ewe weighing 55 kg at mating and raising a single lamb to weaning at 25 kg will require approximately 520 kg of good quality pasture dry matter per year. This is 1.0 LSU.

If a district has a stocking rate on average of 9 LSU per hectare, it produces in an average year sufficient good quality pasture dry matter for nine 55 kg ewes to each rear a single lamb to

[4] DairyNZ 2014: average for all North Island is 3.05; for upper South Island, 3.48; and lower South Island, 3.28.
[5] Central North Island average is 2.53 cows per Ha and average production of 3710L per cow p.a.

weaning. Over a period of 30 years a hectare with an average stocking rate of 9 LSU would produce about 140.4 tonnes of pasture dry matter, which may be expressed as equivalent to 270 LSU.

Complex tables of equivalency have been developed for differing breeds, types, ages and weights. A weaner beef heifer is 3.5 LSU and a weaner steer is 4.5 LSU.

Assuming one beef cow requires nine live-stock units to raise a calf to weaning, a hectare with an average productivity of 9 LSU would carry 1.0 cow with calf. Over 30 years 270 LSU could support 30 cows raising 30 calves to weaning weight (135 - 270 kg) within that period. If 15 percent of the weaners were retained as replacements[6] and the rest were sold at an average weight of 200 kg, that hectare would generate about 5 tonnes of produce over 30 years:

$$30 - (0.15 \times 30) \times 200 = 5100$$

If those weaners were placed on pasture with a similar stocking rate for finishing, a hectare with an average productivity of 9 LSU would carry 1.636 cattle to finishing weight. Assuming a two year finishing period and sale weights of 450 kg, over a 30 year period about 11 tonnes of finished beef would be sent to the freezing works per hectare: $1.636 \times (30 \div 2) \times 450 = 11045$

Assuming a full stock truck and trailer carries 28.8 tonnes, the hectare in the first example generates 0.18 outward truck movements over 30 years. The hectare in the second example generates 0.38 outward truck movements over 30 years.

Stocking rates vary for sheep farming, but average rates between 150 kg and 260 kg of liveweight per hectare per year and 28 kg to 36 kg of wool clip per hectare per year can be adopted. Assuming an average live weight of 38.5 kg for each lamb and 4.9 kg for each fleece implies that one hectare with an average stocking-rate of 6.6 live-stock units per hectare produces 254.1 kg of live weight lamb per year as well as 32.3 kg of wool.

Over 30 years one hectare with a relatively high stocking-rate for sheep farming would produce 7.6 tonnes of lamb live weight and 970 kg of wool, and generate 0.3 outward truck movements: $6.6 \times (38.5 + 4.9) \times 30 \div 28800 = 0.298$.

In addition to their outward production, however, farms have inwards movements of fuel, fertiliser, and replacement or finishing stock. This traffic can equal or exceed the outwards freight weight in some instances.

The carrying rate of the land, mix of stock carried and individual farming practices can cause significant variations in the freight load generated by farms even within the same sector. This can include variables such as the rates at which fertiliser is applied.

Nationally, mixed sheep and beef farming applies fertiliser and lime at an average rate of 0.26 T/Ha, while specialised sheep or beef farms apply fertiliser at rates of 0.33 T/Ha and 0.36 T/Ha respectively.[7] Even within the same farming activities, however, the rates of application can vary dramatically. In the small sample shown in Table 2 the rates of application range between 0.06 T/Ha and 0.233 T/Ha within the same district.

[6] Replacements in beef herds average 14 to 16 percent; in dairy herds 24 to 26 percent. Waikato Regional Council.

[7] Statistics NZ, *Fertiliser and lime applied by farm type; Agricultural areas in hectares by farm type; Year to 31.03.2012*

A random sample of farm production data from mixed sheep and beef farms implies these inwards freight movements contribute significantly to the total movement of mass per hectare per year for such farms.[8]

An analysis of the reported productivity of the six mixed sheep and beef farms in one district used in the sample is reproduced in Table 1.

Table 1 Reported farm productivity values for six combined sheep and beef farms

Farm	1	2	3	4	5	6
Land area (Ha)	1800	650	400	1470	1500	1200
Outwards (tonnes)						
Wool	43.00	21.00	18.00	51.75	51.00	22.32
Cattle	52.50		2.20	1.45	122.00	111.40
Sheep	221.00	103.25	127.92	342.00	270.00	133.60
Total outwards (T)	*316.50*	*124.25*	*148.12*	*395.20*	*443.00*	*267.32*
Total outwards /Ha (T)	*0.176*	*0.191*	*0.370*	*0.269*	*0.295*	*0.223*
Total out /Ha in 30 yrs (T)	*5.28*	*5.73*	*11.10*	*8.07*	*8.85*	*6.69*
Inwards (tonnes)						
Live-stock	85.00	108.00	36.04	64.80	69.00	2.08
Fertiliser	380.00	40.00	58.00	342.00	220.00	120.00
Fuel	6.00	3.60	6.00			10.10
Total inwards (T)	*471.00*	*151.60*	*100.04*	*406.80*	*289.00*	*132.18*
Total inwards /Ha (T)	*0.262*	*0.233*	*0.251*	*0.277*	*0.193*	*0.110*
Total in /Ha in 30 yrs (T)	*7.86*	*6.99*	*7.53*	*8.31*	*5.79*	*3.30*
Total in and out (T)	787.50	275.85	248.16	802.00	732.00	399.50
Inwards as % of Total	59.81	54.96	40.31	50.72	39.48	33.09
Total /Ha (T)	0.438	0.424	0.620	0.546	0.488	0.333
Total /Ha in 30 years (T)	13.14	12.72	18.60	16.38	14.64	9.99

Adopting a figure of 0.254 tonnes per hectare per annum for outwards freight and 0.221 tonnes per hectare for inwards freight, traditional sheep and beef pastoral farming would yield a total inwards and outwards freight productivity over a 30 year period of 14.25 tonnes per hectare, which equates to 0.5 truck movements: $(0.254 + 0.221) \times 30 \div 28.8 = 0.49$.

By comparison with sheep and beef farming, dairying is a significantly more intensive land use. Stocking rates are higher and other inputs tend to be proportionately higher as a result. The national average application rate for lime and fertiliser on dairy farms, for example, is 0.76 T/Ha.[9] Dairy farms also tend to buy in supplementary feed, such as silage or palm kernels. Bought feed averages 1.36 T/Ha nationally, ranging between 0.82 T/Ha in the lower North Island and 1.86 T/Ha in the upper South Island.[10] Over a 30 year period the average input for fertiliser, lime and supplementary feed on a dairy farm amounts to 63.6 tonnes:

$(0.76 + 1.36) \times 30 = 63.6$.

A significant difference between dairying and other pastoral farming is that roughly 20% of dairy farm expenditure is on replacement or winter grazing and feed.[11] Providing replacement and winter grazing can represent more than 80% of this expense.[12] In several regions dairy

[8] After Gribble, M. *Logging trucks on local roads – is forestry really having an unreasonable impact? (2011)*
[9] Statistics NZ, *Fertiliser and lime applied by farm type; Agricultural areas in hectares by farm type; Year to 31.03.2012*
[10] DairyNZ 2014: averages: upper North Is, 1.66; lower North Is, 0.82; upper South Is, 1.86; lower South Is, 1.10.
[11] DairyNZ 2015: *Farm expenditure price index 2009-2012*
[12] South Island Dairy Development Centre, Lincoln University, *Financials to year end March 2015*

herds are moved to alternative, often distant, pastures for a period of approximately 16 weeks over winter and return in-calf.

Using the average dairy stocking rate of 3.2 cows per hectare and assuming the average cow going onto winter grazing weighs about 450 kg, the outward movement to winter grazing represents 1.44 T/Ha. Assuming the average cow returning from winter grazing weighs about 475 kg, the return movement from winter grazing represents 1.52 T/Ha. The annual movement to and from winter grazing adds 2.96 T/Ha to the impact of dairying on local roads. Over a 30 year period this amounts to 88.8 tonnes: *3.2 × (0.450 + 0.475) × 30 = 88.8*.

So a dairy farm with milk production of approximately 12.576 tonnes per hectare per year, and generating 14.35 outward tanker trips per hectare over a 30 year period, will also generate another 3.64 tonnes per hectare per year of inward freight movements and 1.44 tonnes of outward freight movements. Over a 30 year period this amounts to 152.4 tonnes per hectare or 5.3 truck movements: *(0.76 + 1.36 + 1.44 + 1.52) × 30 ÷ 28.8 = 5.29*.

Sheep, beef and dairy farms also harvest significant volumes of exotic forestry. In the year ending 31 March 2007, 1,380,565 m^3 was harvested from farmland and this rose to 1,671,566 m^3 in the year ending 31 March 2012.[13] Details of this production are shown in Table 2.

Table 2 Forestry production by farm type[14]

	Year to 31 March 2007			Year to 31 March 2012		
Land use	*Ha*	*Harvest m^3*	*m^3/Ha*	*Ha*	*Harvest m^3*	*m^3/Ha*
Sheep	629	275200	437.52	1126	536392	476.37
Beef	706	310551	439.87	628	275887	439.31
Sheep/beef	866	361356	417.27	932	475998	510.73
Dairy	1079	433458	401.72	822	383289	466.29
Forestry	37239	16798052	451.09	44376	23369522	526.63
See Note 1	40519	18178617	448.84	47884	25041088	523.36

Note 1: For *Ha* and *Harvest (m^3)* the total is the sum of the individual land use figures; for *m^3/Ha* the weighted average is based on the percentile contribution of each land use to the total harvest.

Forestry analysts adopted a representative figure of 660 tonnes per hectare as an average for forestry production in 2003.[15] This appears to adopt a weight of 1.46' tonnes per cubic metre of harvested exotic timber, based on an average harvest of 450 m^3/Ha, which is in keeping with internationally accepted conversion factors for green softwood logs. Assuming a 30 year harvest period and that each truck carries 28.8 tonnes, one hectare of exotic forestry over 30 years would therefore generate 22.9 truck movements: *660 ÷ 28.8 = 22.92*.

As Table 2 indicates, however, the average harvest per hectare has increased substantially. The forestry production statistics indicate a significant improvement in the harvest per hectare for all land uses, except from specialist beef farms. The weighted average harvest has increased by 74.52 m^3/Ha. This suggests that the harvest in tonnes has increased by 109.29 tonnes between 2007 and 2012: *74.52 × 1.4666 = 109.291*.

On the basis of the updated national data, a representative figure for average forestry production in 2012 was 769 tonnes per hectare. Assuming a 30 year harvest period and that

[13] Statistics NZ, *Forestry production and planting by farm type, Year to 31.03.2007 and Year to 31.03.2012*
[14] Statistics NZ, *Forestry production and planting by farm type, Year to 31.03.2007 and Year to 31.03.2012*
[15] Frame Group, 2003, 22 T/Ha for averaged annual production

each truck carries 28.8 tonnes, one hectare of exotic forest harvested now should generate 26.7 outward truck movements: *(660 + 109.29) ÷ 28.8 = 26.71*.

In Table 3 the forestry production for the land uses listed in Table 2 has been extended to give the estimated tonnage per hectare and number of trucks required.

Table 3 Forestry production by farm type[16]

	Year to 31 March 2012				
Land use	*Ha*	*Harvest m³*	*m³/Ha*	*T/Ha*	*Trucks*
Sheep	1126	536392	476.37	698.64	24.26
Beef	628	275887	439.31	644.29	22.37
Sheep/beef	932	475998	510.73	749.04	26.01
Dairy	822	383289	466.29	683.86	23.75
Forestry	44376	23369522	526.63	772.36	26.82
See Note 1	47884	25041088	523.36	767.56	26.65

Note 1: For *Ha* and *Harvest (m³)* the total is the sum of the individual land use figures; for *m³/Ha* the weighted average is based on the percentile contribution of each land use to the total harvest; for *T/Ha* the total is the weighted average *m³/Ha* multiplied by the conversion factor of 1.46'.

1.4 Comparing HCV Traffic Generation

It is possible to compare the land use traffic loading associated with pastoral farming activities over a 30 year cycle with the traffic loading from dairying or forestry. Sheep and beef farms generate 0.5 truck movements per hectare. Assuming a full truck weighs 44 tonnes and an empty stock truck weighs 17.5 tonnes, the total traffic loading over a 30 year period would be 29.2 tonnes per hectare:[17] *0.254 × (44 + 17.5) + 0.221 × (44 + 17.5) = 29.21*.

For dairying, a dairy tanker will fill progressively as it travels out from, and returns to, the milk factory, so the applied load will vary between 17.7 tonnes for an empty tanker and potentially 40 tonnes for one almost full. If a dairy farm sends out 14.35 full tankers per hectare, the outward traffic loading over a 30 year period would be 631.4 tonnes per hectare. Adopting an average weight of 28 tonnes for an incoming tanker, the inward traffic loading over a 30 year period would be 401.8 tonnes per hectare.

Assuming an empty weight of 17.5 tonnes for stock trucks and 15.5 tonnes for empty stock feed and fertiliser trucks, rotating stock to and from winter grazing and bringing in feed and fertiliser generates additional traffic loading of 338 tonnes per hectare over 30 years:

(0.76 + 1.36) × 30 ÷ 28.8 = 2.21 — *2.21 × (44 + 15.5) = 131.50*
1.73 × 30 ÷ 28.8 = 1.80 — *1.80 × (44 + 17.5) = 110.70*
1.50 × 30 ÷ 28.8 = 1.56 — *1.56 × (44 + 17.5) = 95.94*
338.14

For forestry, if an inwards traffic loading of 17.5 tonnes for an empty logging truck carrying jinkers is adopted, the total traffic loading over a 30 year harvest cycle would be 1642 tonnes per hectare, based on 26.7 outward loads of 44 tonnes and 26.7 inward loads of 17.5 tonnes.

[16] Statistics NZ, *Forestry production and planting by farm type, Year to 31.03.2007 and Year to 31.03.2012*
[17] Normal pavement design is based on the heaviest loading in one direction only; taking the total traffic loading is for the comparison of land use demand on the road network between different activities.

The different traffic loadings from these different uses of rural land over 30 years (equivalent to one forest harvest cycle) are summarised in Table 4.

Table 4 Traffic loading generated by various rural land uses over 30 years (T per Ha)

Land use	Outwards	Inwards	Totals
Pastoral	15.6	13.6	29.2
Dairy	876.4	494.9	1371.3
Forestry	1174.8	467.25	1642.1

The actual district production values need to be used to calculate the contribution of each industry to the vehicle loading on the road. It cannot be simply assumed that forestry yield is twenty percent greater than that of dairy, therefore the damage generated is only twenty percent greater. It is clear, however, that traditional pastoral farming will generate something like only 1/50th of the total vehicle loading generated by modern dairy farming.

1.5 Determining HCV Traffic Generation from Land Use

The following steps outline the process described in the previous sections for identifying the HCV traffic generated by a particular land use:

1. Identify the Land Use or Activity ie forestry, quarrying, dairying, dry-stock beef farming, stock finishing, sheep, etc.

2. Determine the average productivity per hectare for that land use.
   - Regional or local stocking rates
   - Local milk production statistics
   - Local beef, sheep, wool production statistics
   - Local forest harvest statistics or quarry statistics

3. Determine the average farm input values per hectare.
   - Regional or local fertiliser or lime application rates
   - Regional or local statistics for restocking rates
   - Regional or local statistics for feed supplement use
   - Regional or local statistics for fuel, fencing, etc

4. Determine the HCV traffic generated by the established land uses.
   - List the types and number of HCV traffic generated by land uses.

5. Determine the comparison period to be used to compare the HCV traffic generated by differing land uses.
   - One forest harvest cycle is recommended.

For most districts the figures adopted for HCV capacities and weights in the preceding sections will be appropriate. The variation from national average figures will be sufficiently minor in some districts to allow the national average figure to be adopted without modification, but this should be done only after establishing the deviation from the average.