A MODEL TO PREDICT LOGGING TRAFFIC & ASSOCIATED PAVEMENT LOADINGS FROM NEW ZEALAND FORESTS

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AN IMPORTANT NOTE FOR THE READER

The material contained in this report is the output of research and should not be construed in any way as policy adopted by Transit New Zealand, but may form the basis of future policy.

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EXECUTIVE SUMMARY

1. Introduction

The amount of timber a forest generates during its production cycle is predictable. The number of trips, i.e. the logging traffic, required to remove that timber from the forest is determined by the types of vehicles used to carry the timber as well as the productivity of the forest. Therefore the amount of logging traffic and the loads required to remove the timber are also predictable.

2. Prediction of Forest Productivity

A computer model was devised in 1993 to predict the productivity of a forest in New Zealand. The model can also be used to predict the heavy vehicle traffic flows, including the type of vehicle used and the size of loads that are carried. This prediction is based largely on the regulations and economic instruments in place in New Zealand during the harvesting stage of the forestry production cycle (e.g. The Heavy Motor Vehicle Regulations 1974 and Road User Charges Act 1977).

3. Prediction of Forestry Traffic Loads

Combining these predictions allows a transport planner to assess the vehicle loads, arising from the forestry operations of the production cycle, that will be carried on associated road networks. Because the growth-to-harvest cycle of forests is of the same order as the long-term planning period for highways, i.e. about 30 years, the data are relevant for both forestry and road planning cycles.

The research highlights the sensitivity of the harvest stage of the forest cycle to market conditions and to the changes that can occur in the market. Because the market can change the harvest pattern, for example by reducing the length of the production cycle or by encouraging a change of tree species, the effects of such changes are also accounted for in the model.

4. Prediction of Economic Strategies

The model is used to examine the economic strategies available for the maintenance of roads carrying forestry logging traffic. This model shows that the imposition of logging traffic on an appropriately designed road does not overwhelm the effects of other traffic. An economic strategy is suggested that would lessen further the effect of the logging traffic.

On local authority rural roads that are not designed to take the loadings imposed by logging traffic, the practical necessities of reinforcing or reconstructing the road for reasons of safety and trafficability are the key factors affecting economic considerations.

5. Conclusions

- The pavement loading on roads used by logging traffic from forest harvesting is predictable.

- The timing and extent of pavement loading are determined by harvesting requirements which can change markedly in response to market conditions.

- The vehicles used to transport logs from the forest source to their first destination generate predictable loadings. Based on 1993 data the loading is about 3.3 EDA (Equivalent Design Axles) per vehicle.

- These loadings are most affected by economic instruments, regulations, and technology, and can be expected to cluster around legal limits.

- On roads designed to take strategic rural traffic flows, the addition of logging vehicles to the traffic flows does not overwhelm the effects on the pavement of other traffic using the roads. It does accelerate the use-of-pavement life by a factor in the order of 10%.

- Some additional expenditure, that can be planned for and will control the physical effects of logging traffic on rural strategic roads, can be predicted. This planned expenditure can reduce the costs of logging traffic on other users of the road.

- The imposition of logging traffic on a lightly constructed rural local road causes rapid deterioration of the road. Generally the road will require major reconstruction or strengthening to maintain a safe trafficable surface. This is an unavoidable cost of forest harvesting. The economics of a rural local road reconstructed to an appropriate standard are similar to those of a rural strategic road.

- Where the road structure is capable of carrying the logging traffic, suggested additional expenditures are:

  1 cent/ km/ EDA/ NAASRA* count/ year for sealed roads (including shape correction, and 200+ vpd (vehicles per day)),
  0.25 cents/ km/ EDA/ NAASRA count/ year for unsealed roads (<300 vpd).

- Regular expenditure on maintenance can hold the NAASRA roughness measure to 100 counts. If no expenditure is allowed, a predicted deterioration to 160 counts (i.e. 60 counts above normal) is likely.

- The recommended expenditure on a road requiring increased maintenance or reconstruction in response to forestry traffic is:

  60 cents/ km / EDA/ year for sealed roads; and
  15 cents/ km/ EDA/ year for unsealed roads.

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*NAASRA National Association of Australian State Road Authorities, now operating as AUSTROADS.

ABSTRACT

A computer model was devised in 1993 to predict heavy traffic flows generated by the operations arising from the 30-year planning period of a production forest (from planting to harvest) in New Zealand, for an area served by a road network. Economic strategies are suggested.

The results show that both heavy traffic loadings on the road and future road expenditures can be predicted, based on figures recorded by the forestry industry in New Zealand. These predictions can be applied to long-term road planning for the area.

1. INTRODUCTION

A research study carried out by Gabites Porter in 1991 *(Traffic Generation of Forests)*, investigated the amount of traffic generated by forestry operations. It shows that the data relating to traffic generation and the vehicle loads carried by the road pavements during the production cycle of a forest (generally 30 years) could be developed further. Thus this present study was undertaken in 1993.

The purpose of this 1993 study was to determine any relationship between the area of standing forest in a particular part of New Zealand, and the traffic (expressed as Equivalent Design Axles (EDA)) that would be generated by the forestry operations, specifically those associated with harvesting. A model for predicting this traffic is devised.

The model is not intended to establish the loads that could be carried on a particular section of a road, but rather to establish, as accurately as possible for transport planners, estimates of the roading needs of the forestry industry. The model is also intended to estimate the likely future impacts on the road network of both standing forest and forest planting.

The model that has been developed allows a transport planner to take forest inventory data that are readily available, and from that data generate an estimate of the traffic (in EDAs) that will be imposed on the road network by forestry operations. For small forest areas, the results provides reasonably accurate data.

The New Zealand *National Exotic Forest Description* (Edition 7, April 1992) was used as the source of forestry data. This inventory is published about every two years by the Ministry of Forestry (MOF), Wellington, and records information on the areas, species and age class, of planted forest within the boundaries of each territorial authority in New

Zealand. It is updated regularly, is nationally available, and records information about most private and public forests. In conjunction with local authorities, MOF is improving this information with the use of satellite imagery.

Traffic data on roads used by forestry traffic were extrapolated from one year's records of heavy vehicle weights collected by Ministry of Transport (MOT) for major roads in the South Island.

To illustrate the effect of forestry operations on a road network, particularly the effect of logging traffic, and to examine the economics of the range of planning options possible for road maintenance and reconstruction, a notional section of a road servicing a typical forest area was analysed, based on the procedures set out in Transit New Zealand (TNZ) Project Evaluation Manual (PEM 1991).

The analysis has been considered with and guided by assessments from experienced road engineers, because the available data had limited details of maintenance costs. As a more rigorous scientific approach was not possible, a "rule of thumb" approach to determine appropriate levels of expenditure on roads subject to logging traffic was applied.

2. FOREST GROWTH AND HARVESTING CYCLE

Modern forestry operations are essentially a long-cycle farming operation designed to generate the optimum return from trees grown on the land resources that are available. The technology of modern forestry is relatively well established, and forestry operations follow a relatively well defined cycle of clearing, planting, pruning, thinning, and harvesting. The time for the entire cycle from planting to re-planting is called the rotation length, and is generally unique to the species of tree being grown. Rotation length is generally about 30 years.

While each stage of the forest cycle generates its own traffic, and estimates of this are given in Gabites Porter (1991), most loading on the road pavement is generated during the harvest period.

Pavement loading generated during thinning operations is of the order of 10% of the total loading generated during harvesting. This pavement loading is accounted for in the model, although it is taken to occur during the harvest period. The effect of this inclusion on the economic analysis is minor.

The pavement loading is entirely dependent on the timing of harvesting, which is in turn highly dependent on the market demands for wood at the time. Thus, while the loading on the road pavements expected from a particular forest can be closely predicted in terms of traffic EDAs generated per hectare at any particular stage in the cycle, the actual time that harvesting will be carried out, and therefore the time that these loads will be imposed on the associated roads, is determined by the market.

As an example, if market demand for chipping logs (which accepts logs of any size) increased substantially while the market for saw logs (accepting only larger trees) decreased, the rotation length could be reduced from 25 years to 15 years. Because logs for chipping are generally smaller and lighter, the total number of loads on pavements could be less. For each trip, however, a vehicle would still carry its maximum load.

The length of logs extracted from the forest can also vary considerably, although this does not affect the EDAs generated per hectare.

The traffic trip considered in this study is the first trip only, that of logs from the forest to their first destination. In many cases this trip is from the forest to the nearest port area, and in other cases, this trip may be on local roads to a local sawmill.

When evaluating the pavement loading, the first need is to establish if forest areas are serviced by private roads, e.g. to major processing plants within the forest. This is the case in central North Island, where private forestry roads carry the most logging traffic that is moving to the major processing plants in the area. On these private roads, records of axle weights were significantly in excess of the legal limits for public roads in New Zealand.

3. CHARACTERISTICS OF LOGGING TRAFFIC

3.1 Introduction

To investigate the characteristics of logging traffic, the hard data on logging traffic axle weights were gathered from two main sources:

- MOT weigh-bridges on state highways,
- Private weigh-bridges at processing sites.

In addition a driver survey was carried out to determine current practice and use of technology for checking the weight of loads before departure from processing sites. The survey also determined driver attitudes to loading regulations, how often a driver was stopped to be weighed, and how often he was caught infringing loading regulations.

TNZ weigh-in-motion data were reviewed to determine any pattern in overloading on general traffic that matched overloading on logging traffic.

3.2 Survey of MOT Weigh-bridge Data

Data relating to log-carrying vehicles only were extracted from records of heavy vehicle weights for a complete year, collected by MOT for major roads in the South Island. The data were checked for consistency against TNZ weigh-in-motion data, private weigh-bridge operations, and responses from a driver survey. The clear pattern of vehicle loading was found to be governed by regulation, and this pattern allows quite accurate prediction of the EDAs generated by the logging traffic from a forest.

These weight records include the commodity being carried on the vehicle at the time, the number of axles and their spacings, the weight of each axle, and the combined train weight. This information provided the necessary data to calculate the EDAs of only those vehicles that were carrying logs.

Although no statistical means are available to establish if the results are truly representative, the large number of entries and their distribution satisfied the requirements for a large statistical population and are representative. Also these data are weights of only loaded logging vehicles, whereas other data gathered from the entire population of heavy vehicles include both loaded and unloaded vehicles.

Logging vehicles are involved in one-way line haul operations and are fully loaded for only one way. Therefore they have less effect on the road than vehicles that travel fully loaded both ways. The contribution of unloaded logging vehicles to pavement wear is generally small.

MOT weigh-bridge data from state highways were expected to record higher than average operating loads as only vehicles that are likely to be overloaded are weighed. To determine if there was this bias the data obtained from MOT records were compared with gross vehicle weight data from records obtained by the forestry and wood processing companies from their own weigh bridges.

The comparison indicates that the state highway weigh-bridge data are not over-high, and that most vehicle weights tend to cluster closely around the legal weight limits for the different vehicle configurations. For example, the average weight from MOT weigh-bridge data is 40.98 tonnes while that from private weigh-bridge data is 41.87 tonnes.

Although means and standard deviations have been calculated on the assumption that the distribution of axle weights conforms to a normal distribution, the distribution of axle weights is likely to be skewed and to have a tendency to be bi-modal because of physical and technological reasons.

The expected distribution for heavy vehicles of different configurations is shown in Figure 1. The distribution consists of two distinct peaks, the first around the average tare weight of vehicles of that particular vehicle class, and the second around the legal loaded weight for the vehicle class. This peak is about the legal gross vehicle mass (GVM) limit for the class, and the distribution drops steeply beyond the compliance limit (i.e. the legal GVM limit plus 10%). The combined distributions start at the same point of minimum tare weight. This point is definite because a particular vehicle class cannot weigh less than a finite amount. The upper end of the distribution has an extremely long tail created by the few really high overloads that had been recorded.

Tables 1, 2 and 3 show data gathered from MOT weigh bridges, private weigh bridges, and from TNZ weigh-in-motion stations respectively. Tables 4 and 5 compare data gathered from TNZ weigh-in-motion stations with those from this forestry road study (using MOT and private weigh bridge records).

The comparisons between logging traffic and general traffic show that, generally, logging vehicles are closer to their legal maximum weights than are the average weights for the overall heavy vehicle population. Also generally, logging vehicle weights are somewhat more tightly clustered as indicated by the lower standard deviation. This clustering is more significant than the figures suggest because the TNZ weigh-in-motion data do not have the very high overloads that are included in the data from inwards private weigh bridges at processing plants.

Figure 1. Theoretical distribution of load weights of all classes of heavy vehicles, based on records obtained from MOT weigh bridges on state highways in the South Island, New Zealand.

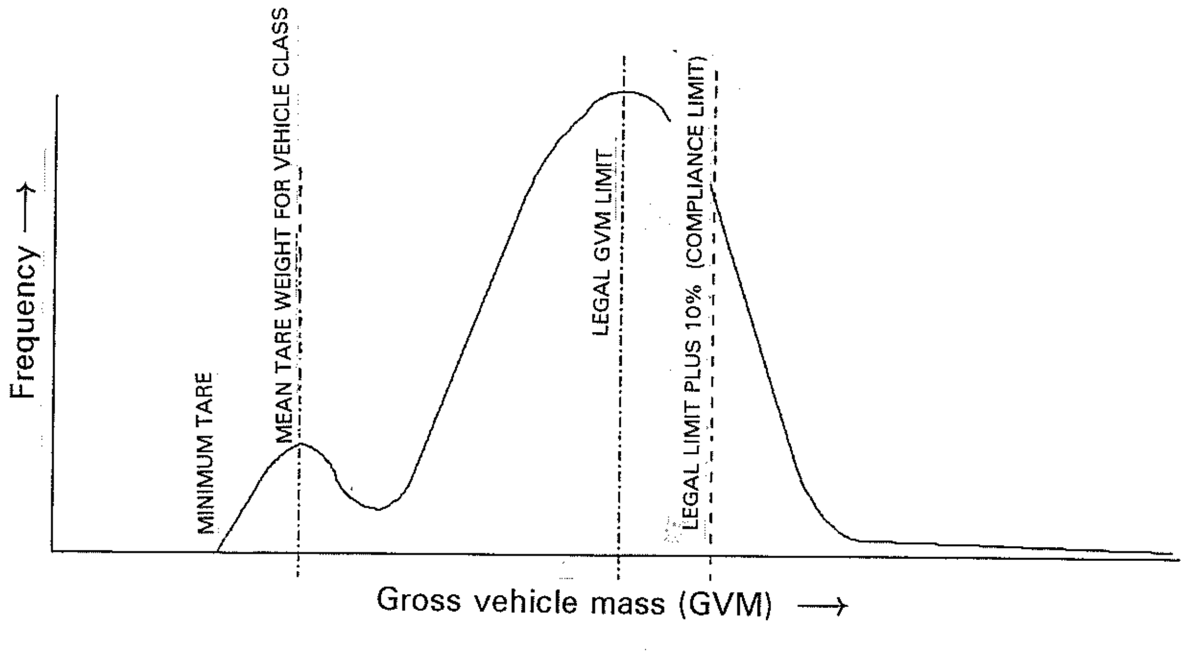

Table 1. Weights (tonnes) of axle groups of laden logging trucks obtained from MOT weigh bridges.

Heavy vehicle axle group	No. in sample	Mean weight (t)	Standard deviation	Maximum weight (t)	Minimum weight (t)
Single tyre	194	5.24	0 .71	9.58	3.11
Two single tyre (twin steer)	78	10.97	3.15	19.99	7.10
Dual tyre single axle	260	7.23	1.49	17.29	3.07
Dual tyre tandem axle	520	13.76	1.97	22.42	6.54
Dual tyre tri-axle	18	20.31	2.09	24.64	17.30

Table 2. Gross weights (tonnes) of classes* of logging vehicles from inwards private weigh bridges at processing plants.

Vehicle Class	No. in sample	Mean weight (t)	Standard deviation	Maximum weight (t)	Minimum weight (t)	Legal Limit (t)
C4	6	15.14	3.65	19.42	11.06	14.20
C9	408	41.55	4.92	72.00	28.00	36.00
C10 6-axle	30	38.62	4.73	50.10	29.86	39.00
C10 & C12 7-axle	419	44.08	4.14	-	-	44.00
All types	863	42.49	5.29	72.00	4.56	NA

Table 3. EDAs of classes* of logging vehicles with known weight and axle configurations, from MOT and private weigh bridges.

Vehicle Class	No. in sample	Mean EDA	Standard deviation	Maximum EDA	Minimum EDA
C4	6	1.38	1.96	5.30	0.20
C9	131	3.44	2.82	25.64	1.36
C10 & C12 6-axle	30	3.59	1.67	9.05	1.31
C10 7-axle	101	3.15	1.61	10.17	1.32
All types	268	3.30	2.31	25.6	0.20

* TNZ vehicle classes (i.e. DKW System used in National Traffic Database):
C4 2-axle, 2 axle group truck;
C9 5 axle, 3 axle group truck & trailer;
C10 6-axle, 3 axle group transporter;
C10 7-axle, 4 axle group transporter;
C12 7-axle, 4 axle group B-train;
NA not applicable

Table 4. Comparison of axle weights (tonnes) obtained from TNZ weigh-in-motion data and forestry study data (from MOT and private weigh bridge records).

Axle type	**TNZ weigh-in-motion data***			**Forestry road study data****			**Legal limit**
	No. of observations	**Mean value (t)**	**Standard deviation**	**No. of observations**	**Mean value (t)**	**Standard deviation**	**Value (t)**
Single steer	729	4.588	1.453	194	5.240	0.710	6.000
Twin steer	60	9.440	2.237	78	10.970	3.150	10.800
Tandem	718	12.255	3.773	520	13.760	1.970	18.000
Tri-axle	71	12.371	3.346	18	20.310	2.090	17.500
Single dual tyre	570	5.709	2.074	260	7.230	1.490	8.200

* PAT weigh-in-motion systems monthly data reports, November 1991 (TNZ internal report).

** MOT enforcement records and private weigh bridge records gathered for this study in 1991.

Table 5. Comparison of values for EDAs and weights (tonnes) obtained from TNZ weigh-in-motion data and forestry road study data (from MOT and private weigh bridge records).

	TNZ data from weigh-in motion sites					Forestry road study data				
Vehicle Class	Mean EDA	Std dev. EDA	Mean wt (t)	Std dev. weight	No. obs.	Mean EDA	Std dev. EDA	Mean wt (t)	Std dev. weight	No. obs.
C4 [b]	0.282 0.254 0.305	0.365 0.403 0.543	8.286 8.084 8.248	1.504 1.404 1.637	142 431 520	1.381	1.959	15.14	3.65	6
C9[b]	1.922 2.682 2.187	0.713 3.864 0.899	30.618 30.858 31.913	4.565 6.793 6.541	5 31 23	3.445	2.822	41.55	4.92	131
C10 6-axle[b]	2.301 2.582 1.815	1.267 1.186 0.834	36.308 37.817 34.134	6.574 6.005 6.695	64 383 184	3.589	1.665	38.62	4.73	30
C10 & C12 7-axle[c]	1.214 3.004 2.872 2.720	0.551 1.594 1.134 0.975	35.434 40.141 40.939 41.037	5.763 10.101 9.293 5.237	5 89 63 110	3.148	1.606	44.08	4.14	101
5- & 6-axle[a]	2.329* 2.895 3.057	1.247 1.546 1.618			2650 6971 1704					
7+ axles[a]	2.746** 3.008 3.224	1.109 1.390 1.188			1392 4950 1212					
Notes	* Mean = 2.63 ** Mean = 2.75 [a] Source: Estimated EDA for heavy vehicles, DK Wanty, January 1992, TNZ internal report. [b] Source: PAT weigh-in-motion monthly reports, November 1991, TNZ internal report. [c] Axle loads on New Zealand roads, J Ihaka, DK Wanty, TNZ internal report.					Legal limit for train weight for Class 9, 10 and 12 vehicles: 39.00 (t) without permit. 44.00 (t) with permit. Legal limit for typical Class 4 vehicle: 14.20 (t).				

3.3 Survey of Weigh-in-motion Data

For comparison, vehicle weight data for November 1991 obtained from three TNZ weigh-in-motion stations (Drury, Pukerua Bay, Waipara on SH1) were analysed. They provide continuous 100% sampling of axle weight, axle spacing, and traffic counts. Although Waipara was the only weigh-in-motion station operational in the South Island at the time of the research, and all the logging traffic data had been gathered from the South Island, comparing the heavy vehicle populations from these stations with those from the survey is still considered valid.

3.4 Survey of Logging Vehicle Drivers

A survey of drivers of logging vehicles was carried out to investigate vehicle loading behaviour. The survey was a mail-out to fleet operators and log processors, asking them to distribute question forms to their logging drivers. The number of responses was neither large enough nor random enough to analyse statistically, and the most useful information came from the comments section on the survey form.

The responses show that more drivers are making use of scales on-board their own vehicles or weighing scales on the loading equipment at the forest skid site. This weighing technology is now available and affordable, and will be used more by heavy transport drivers. As a result, loads are increasing, becoming closer to the maximum legal limit. The survey respondents also indicated a clear knowledge of weight limits and a strong desire to avoid infringements, but at the same time loading to the allowed maximum.

3.5 Logging Vehicle Configurations

The average EDA of a heavy vehicle used in forestry operations is between 3.15 and 3.59, with a mean EDA of 3.3. Vehicles using the most efficient haulage equipment can be expected to have lower EDAs at the bottom end of this range, i.e. about 3.15. The configurations and axle loadings, and therefore the EDAs, generated by forestry operations tend to be close to the maximum legal limits.

The configurations are affected also if economic instruments, such as Road User Charges (RUC), are used to manipulate road use. For example, in the author's experience as a heavy vehicle designer, significant changes in logging truck configurations have occurred since the introduction of RUC.

3.6 Effects of Road User Charges

The main changes that can be readily identified from the introduction of RUC (Road User Charges Act 1977) relate to the number of axles used in a typical logging truck. Before RUC was introduced, the typical logging jinker (i.e. the back pole trailer) had two axles.

By 1993 three-axle and often four-axle jinkers were common. The increased use of twin-steer trucks and of four-axle full trailers is also a consequence of RUC, and many existing rigs were retrofitted with additional axles.

These changes in vehicle configuration were driven by the view of operators that the cost of fitting the extra axle was economically justified to reduce the cash outgoings on RUCs. It is not clear if the decision has been fully justifiable economically.

3.7 Effects of Improved Heavy Vehicle Technology

The main technological advance in heavy vehicle design that has affected pavement design is the improvement of traction through the use of anti-lock braking systems. These control skidding during heavy braking, and also limit wheel slip during acceleration, thus ensuring that maximum effort is obtained from road–tyre friction. This improved traction does not increase weight loading but it does affect pavements on inclines and at intersections.

Fully controlled load-sharing suspensions and variable rate suspension systems are other improvements likely to occur in the future. These are in use in Europe and are contributing significantly to the safety of lightly loaded trucks, but are still undergoing development as the systems have been unreliable and require high maintenance.

The efficiency of fully controlled load-sharing suspensions is affected by the level of maintenance and the skill with which the suspension system has been installed. Although they do reduce pavement loadings, the variance in load between axles within an axle set, and the sensitivity of the suspension to load position with respect to load sharing between axle sets, are still problems.

3.8 Summary

Significant shifts in the characteristics of logging vehicles could occur if the above technology is developed and used in New Zealand. They could occur if changes are made in the allowable total train weights or axle loads, or to taxation or other legislation that would make utilisation of this technology economically desirable from an operator's viewpoint.

The overloading patterns noted in the records and the general experience of haulage operators indicate that penalties alone will not discourage overloading the heavy vehicles used in logging operations, especially where drivers are paid on contract by weight delivered.

4. PAVEMENT LOADING CALCULATIONS

4.1 Parameters for the Model

To establish the pavement loading and EDAs that will be generated by forestry operations, basic production parameters for the forest area must be established and used to calculate its likely output. The parameters include: species; rotation length and age of trees; and geographic region.

Because of the extended time frame of forestry operations, both the species and the age of timber in the forest area need to be known. The species can be relatively easily established by examination or enquiry, or from data available from the Ministry of Forestry's *National Exotic Forest Description* (NEFD 1992, or latest edition).

A combination of these parameters can give the output of the forest as total recoverable volume (in cubic metres per hectare). The volume when multiplied by the Green Density factor, which is species-dependent, gives the weight of the output (in tonnes per hectare).

Forest managers and planners are continually refining these parameters, but a sensitivity analysis (based on TNZ PEM 1991) carried out as part of this present study showed that generally the variations in the parameters that could be expected in New Zealand did not make a great difference in the calculated EDAs.

Therefore a standard model with default values was developed that could be used by planners who did not have access to detailed forestry information, but did know the area (ha), species, and age class distribution of the planted forest.

This model can be easily refined if more detailed knowledge or better information is available. Appropriate local factors are simply substituted into the overall model. The model is produced using the spreadsheet that is set out in Table A1 in Appendix 1. (For further information or assistance in applying the model, the authors can be contacted.)

4.2 Sensitivity of the Model

The model is sensitive to the timing of the harvesting stage. The time when this stage will take place can only be established by information in current management plans obtained from the forest owners. However, to construct the overall model, and for its general application, a default for an accepted optimum time of harvest for each of the species is used within the structure of the model.

Once the harvest time has been established, based on the age class distribution, the productivity of the forest is calculated. The model is then used to establish the number of trips and therefore the number of EDAs that will result from harvesting the forest.

5. ECONOMIC ANALYSIS

5.1 Economic Impacts of Logging Traffic on Roads

The economic analysis of the impacts of logging traffic on the road network was most easily developed by considering specific cases and then drawing generalisations from these.

Although logging traffic commands attention so that it may appear to have a relatively high frequency on a particular route, it generally only forms a small part (mostly less than 5%) of the overall traffic stream on a road. Logging traffic has this apparent impact because it travels constant routes, and to the far ends of a road network. It uses major strategic roads* (e.g. state highways) and rural strategic roads, as well as rural local authority roads, and private roads.

Economic impacts of logging traffic on the pavements of major strategic roads are relatively low as these roads are designed to carry significant flows of heavy vehicles with loads and configurations similar to those of logging trucks.

Economic impacts of logging traffic become more significant on rural strategic roads. On a rural strategic road, logging traffic may be up to 10% of the overall traffic flow, and may, over a relatively short period of time, account for 20 to 25% of the design EDAs of the pavement.

While this increased flow is economically significant, it is relatively temporary and cannot be classified as a major influence on roading economics. Also a rural strategic road will not be used continuously as a logging route, but only for a 5- to 10-year period in a 20- to 25-year forestry cycle. This cycle corresponds to the normal planning cycle for roads, and interacting effects between forestry operations and road planning need to be accounted for in an economic analysis. For example, if both forestry traffic demands and the normal re-construction cycle are planned, the logging traffic can use remaining pavement life of the existing road rather than consume the new capacity of a recently re-constructed road.

Economic impacts are most significant on rural local roads. The pavements of these rural local roads may not be designed to carry the high weights of loaded logging vehicles. The impacts are greatest on the pavements at the far ends of roads that usually carry low volume farm traffic.

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* Major strategic road: traffic volume greater than 10,000 vehicles per day
Rural strategic road: traffic volume less than 10,000 vpd, greater than 2,500 vpd
Rural local road: traffic volume less than 2,500 vpd (based on TNZ PEM 1991)

5.2 Economic Analysis for Rural Local Roads

Logging traffic using a rural local road can cause significant rapid deterioration of the pavement. Major rehabilitation or reconstruction to rural strategic standards is required almost immediately when logging traffic begins using a rural local road.

When major road work on a rural local road is required to support a logging operation, the cost of that work is essentially part of the economic cost of converting the standing trees to the value-added product of the trees delivered as logs to a potential user. Once the road has been upgraded, the economic analysis is relatively straightforward and follows the procedure of a rural strategic road.

5.3 Economic Analysis for Rural Strategic Roads

To investigate the likely consequences of forestry traffic on a rural strategic road a specific section of road was modelled, assuming that a notional forest existed at the end of the road. The traffic flow mix for roads of this rural strategic classification was taken from TNZ PEM (1991)

The pavement loading model was then run for the notional forest, and the traffic volumes predicted by the model were added to the rural strategic traffic flows.

Using EDA figures for each of the vehicle classes obtained from the traffic flows recorded at TNZ weigh-in-motion stations, the logging traffic flows were determined. They represented about 10% of the trips and 20% of the EDAs imposed on the road. This suggests that, rather than analysing the traffic flows arising from forestry only, the flows should be treated as additions to the existing traffic flows.

5.4 Economics of Road Maintenance and Reconstruction

On a rural strategic road the additional traffic flows arising from a typical forestry operation are not significant enough to alter the economics of road maintenance and reconstruction, but do alter the timing of large remedial works such as shape corrections. The economic effect is to increase the present value of such works by about $30,000 (present value in NZ$) per kilometre over the life of the road.

The imposition of the extra logging traffic is, however, significant enough to have a small effect on operating costs, and therefore imposes an additional economic marginal cost on all road users, including forestry operators.

Table 6. Worked example of an economic analysis of forest roading strategies.
(See Appendix 1 glossary for explanations of abbreviations.)

OPTION: Maintain at a set dollar amount per forest EDA per km
GOAL: To maintain NAASRA Count to a set value less than level road will deteriorate to as a result of extra forest traffic
PHILOSOPHY: Determine what expenditure additional to the standard "spend anyway" maintenance is economically justified
ASSUMPTION: That forest vehicles are added to the basic typical traffic flow

Year	SPPWF	Activity Description	Forest EDA's	Roading Expenditure	Present Worth Road Exp	$/km	Km/yr trucks	Extra op cost forest trucks	P.V. extra cost forest trucks	Extra op costs non forest	P.V. extra costs non forest vehicles
1	0.91	Maintain	3,739	67,302	61,244.82	2,243.40	124,920	19,539.99	17,781.39	93,105.94	84,726.40
2	0.83	Maintain	3,739	67,302	55,860.66	2,243.40	124,920	19,539.99	16,218.19	93,105.94	77,277.93
3	0.75	Maintain	3,739	67,302	50,476.50	2,243.40	124,920	19,539.99	14,654.99	93,105.94	69,829.45
4	0.68	Maintain	3,739	67,302	45,765.36	2,243.40	124,920	19,539.99	13,287.19	93,105.94	63,312.04
5	0.62	Maintain	3,739	67,302	41,727.24	2,243.40	124,920	19,539.99	12,114.79	93,105.94	57,725.68
6	0.56	Maintain	6,328	113,904	63,786.24	3,796.80	208,140	32,557.26	18,232.06	93,105.94	52,139.32
7	0.51	Maintain	6,328	113,904	58,091.04	3,796.80	208,140	32,557.26	16,604.20	93,105.94	47,484.03
8	0.47	Maintain	6,328	113,904	53,534.88	3,796.80	208,140	32,557.26	15,301.91	93,105.94	43,759.79
9	0.42	Maintain	6,328	113,904	47,839.68	3,796.80	208,140	32,557.26	13,674.05	93,105.94	39,104.49
10	0.39	Maintain	6,328	113,904	44,422.56	3,796.80	208,140	32,557.26	12,697.33	93,105.94	36,311.32
11	0.35	Maintain	9,492	170,856	59,799.60	5,695.20	301,440	47,151.24	16,502.94	93,105.94	32,587.08
12	0.032	Maintain	9,492	170,856	54,673.92	5,695.20	301,440	47,151.24	15,088.40	93,105.94	29,793.90
13	0.29	Maintain	9,492	170,856	49,548.24	5,695.20	301,440	47,151.24	13,673.86	93,105.94	27,000.72
14	0.26	Maintain	9,492	170,856	44,422.56	5,695.20	301,440	47,151.24	12,259.32	93,105.94	24,207.54
15	0.24	Maintain	9,492	170,856	41,005.44	5,695.20	301,440	47,151.24	11,316.30	93,105.94	22,345.42
16	0.22	Maintain	18,983	341,694	75,172.68	11,389.80	624,480	97,681.16	21,489.86	93,105.94	20,483.31
17	0.2	Maintain	18,983	341,694	68,338.80	11,389.80	624,480	97,681.16	19,536.23	93,105.94	18,621.19
18	0.18	Maintain	18,983	341,694	61,504.92	11,389.80	624,480	97,681.16	17,582.61	93,105.94	16,759.07
19	0.16	Maintain	18,983	341,694	54,671.04	11,389.80	624,480	97,681.16	15,628.99	93,105.94	14,896.95
20	0.15	Maintain	18,983	341,694	51,254.10	11,389.80	624,480	97,681.16	14,652.17	93,105.94	13,965.89
21	0.14	Maintain			0.00	0.00		0.00	0.00		0.00
22	0.12	Maintain			0.00	0.00		0.00	0.00		0.00
23	0.11	Maintain			0.00	0.00		0.00	0.00		0.00
24	0.1	Maintain			0.00	0.00		0.00	0.00		0.00
25	0.09	Maintain			0.00	0.00		0.00	0.00		0.00
Net Present Value Totals					1,083,140.28				308,296.78		792,331.52

Total P V of option 17488 Benefit/Cost Ratio for extra expenditure 1.016

Table 7. Worked example of nominal design traffic flows obtained for a rural strategic road (based on TNZ PEM, Volume II, 1991). (See Appendix 1 glossary for explanations of abbreviations.)

Base condition vehicles	**per day**	**200**	**Extra cost $/km from roughness**	**EDA/unit**	**Annual trips**	**Annual EDA**	**Annual KM**	**Extra Operating Costs/year**
Traffic Mix	Car	0.71	0.024	0.00	51,120		1,533,600	$37,266.48
	LCV	0.12	0.025	0.10	8,640	864	259,200	$ 6,485.18
	MCV	0.05	0.075	0.70	3,600	2,520	108,000	$ 8,100.00
	HCV1	0.04	0.165	3.00	2,880	8,640	86,400	$14,224.90
	HCVII	0.08	0.156	3.20	5,760	18,432	172,800	$27,029.38
	TOTALS				72,000	30456		$93,105.94

Road length (km)	30	
Road life planned (years)	25	
Design EDA	761,400	(This is the EDA generated by the typical traffic pattern over design life)
Forest EDA	192,710	(This is the Forest EDA generated by the model)
Ratio of Forest EDA/Design EDA	0.25	(This is the proportion of forest traffic pavement load to average traffic)
Ratio of Forest Traffic/Design Traffic	0.12	(This is the proportion of trips from the forest relative to design trips on the road)
Maintenance $/EDA/km/year	0.6	($0.01 x 60 NAASRA counts)
Target roughness reduction	60	(This figure is a matter of judgment from experience)
$/km/year/NAASRA Unit	$0.01	(From experience)

Data are inadequate to allow the consequences of extra logging traffic to be assessed in terms of travel times. However general experience in road maintenance, and of the process of road failure when logging traffic is imposed, does allow an assessment to be made of the additional user costs. This assessment is calculated from the increase in NAASRA[**] road roughness counts.

5.5 Applying the Model

5.5.1 Principle of the Economic Analysis

The underlying principle of the economic analysis is that maintenance expenditure must reach some level at which the damaging effect of logging traffic on the road is reduced or in equilibrium.

If the existing maintenance regime continues unaltered following the sudden imposition of logging traffic, the road roughness will increase.

If the maintenance regime is modified to take account of the additional logging traffic then some increased level of expenditure must be allowed, which will reduce or remedy the damaging, or roughening, effect of the logging traffic.

As neither specific data nor correlation between maintenance expenditure and roughness reduction exist, this assessment has been made on the basis of experienced opinion of road engineers. For example, where such roads have had roughness monitored, an increase of 60 NAASRA counts is not unusual after the logging traffic commences.

5.5.2 Initial Roughness

An initial target roughness has been assumed to be a NAASRA count of 100, a typical figure for rural strategic roads. The economic analysis has been carried out on the basis that an appropriate expenditure is that which will reduce (or prevent the increase of) the NAASRA counts by 60.

Assessment of the expenditure that will produce this result is again based on experienced engineering opinion.

The complete economic analysis is set out in Tables 6 and 7, which are printouts from the spreadsheet incorporating the forestry model. It reflects the economic consequences of logging traffic on the road.

[**] NAASRA count - measure of road roughness used by NAASRA (National Association of Australian State Road Authorities, now operating as AUSTROADS).

5.5.3 Marginal Expenditure Approach

The methodology implicit in this model is that a likely cost per kilometre to reduce roughness by 60 NAASRA counts (based on experience) is assessed against the additional running costs arising from the increased roughness. That means the costs extra to existing maintenance expenditure are compared to the extra running costs that accrue to users if the road is not upgraded or maintained and is allowed to deteriorate under the extra loadings arising from the logging traffic.

The analysis was then run on the basis of a marginal maintenance cost per year sufficient to deal with observed pavement failure on roads subject to a sudden increase in heavy traffic. The results indicated that a marginal expenditure approach would be the most effective economically.

Economic analysis using the marginal expenditure approach was an issue of timing, i.e. more loadings justified earlier reconstruction to overcome the likely deterioration. However the user costs were not high enough to justify reconstruction in advance of impending deterioration before the road is used for logging traffic.

The marginal expenditure approach was then tested on a trial and error basis using an arbitrary optimum. This optimum was the yearly expenditure that just balanced the user costs. While this optimum could be disputed, the analysis does not consider user costs other than those arising from roughness. Extra travel time and safety are two obvious factors that have been ignored in the model, but which improve the Benefit/Cost Ratio which would otherwise stand at 1.0 (Table 6).

5.5.4 Rule of Thumb Approach

A good engineering "rule of thumb" that emerged from the calculations is an additional expenditure of 1 cent/ EDA/ kilometre/ year/ NAASRA count reduction on sealed roads. Thus for an increased roughness of 60 counts, additional expenditure on sealed roads is 60 cents /EDA /km /year. On unsealed roads this translates to 15 cents/ EDA/ km/ year.

This rule of thumb does not have any statistical basis, but it nevertheless ties together all the data gathered for this study.

The model produces figures for expenditure planning that appear to be high enough to be beneficial but low enough to be achievable.

6. CONCLUSIONS

- The pavement loading on roads used by logging traffic from forest harvesting is predictable.

- The timing and extent of pavement loading are determined by harvesting requirements which can change markedly in response to market conditions.

- The vehicles used to transport logs from the forest source to their first destination generate predictable loadings. Based on 1993 data the loading is about 3.3 EDA per vehicle and is likely to reduce with time if the current regime continues.

- These loadings are most affected by economic instruments (e.g. Road User Charges Act 1977), regulations (e.g. The Heavy Motor Vehicle Regulations 1974), and technology (e.g. weigh-on-truck systems, improved suspensions), and can be expected to cluster around legal limits.

- On roads designed to take rural strategic traffic flows, the addition of logging vehicles to the traffic flows does not overwhelm the effects on the pavement of other traffic using the roads. It does accelerate the use-of-pavement life by a factor in the order of 10%.

- Some additional expenditure, that can be planned for and will control the physical effects of logging traffic on rural strategic roads, can be predicted. This planned expenditure can reduce the costs of logging traffic on other users of the road.

- The imposition of logging traffic on a lightly constructed rural local road causes rapid deterioration of the road. Generally the road will require major reconstruction or strengthening to maintain a safe trafficable surface. This is an unavoidable cost of forest harvesting. The economics of a rural local road reconstructed to an appropriate standard are similar to those of a rural strategic road.

- Where the road structure is capable of carrying the logging traffic, suggested additional expenditures are:
  1 cent /km /EDA /NAASRA count /year for sealed roads (including shape correction, and 200+ vpd (vehicles per day)),
  0.25 cents / km/ EDA/ NAASRA count/ year for unsealed roads (<300 vpd).

- Regular expenditure on maintenance can hold the roughness to 100 NAASRA counts. If no expenditure is allowed, a predicted deterioration to 160 counts (i.e. 60 counts above normal) is likely.

- The recommended maintenance expenditure on a road requiring increased maintenance or reconstruction in response to logging traffic is:
  60 cents /km /EDA /year for sealed roads, and
  15 cents /km /EDA /year for unsealed roads.

7. REFERENCES

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APPENDIX 1

MODEL FOR GENERATING ESTIMATES OF EDAs FOR A FORESTRY OPERATION

MODEL FOR GENERATING ESTIMATES OF EDAs* FOR A FORESTRY OPERATION

Use of the Model

- To estimate the equivalent design axles (EDAs) that will be generated by standing forest in any particular region of New Zealand.
- To estimate traffic flows along a particular road from a particular forest plantation if routing is predictable.

Principle of Model

- Default Values
  Standard factors have been incorporated to generate a reasonably reliable answer to the question posed to the model.
  The factors are: TRV or Volume per hectare (m^3/ha), Green density (t/m^3).
- Substitution of Default Values
  If more detailed information relating to the region or plantation is available, then use this in lieu of the default values.
  These values relate primarily to the characteristics of only that forest.
  They can generally be obtained from the forest managers.

Sensitivity of Model

- As the factors for particular tree species are relatively consistent, the overall sensitivity of the model to normal variations in the performance figures for the forests on the EDAs generated by the model is small.

Procedure

1. Establish the area (hectares) of forest that is planted in the district
   by species and
   by age class.
   Obtain this information from local knowledge, from the forestry owners, or on a regional basis from the National Exotic Forest Description (NEFD), published and updated every two years by the Ministry of Forestry.

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* See Glossary for explanations of abbreviations.

2. Gather 5-year age class data. This is reported in the NEFD in five year bands. The model has been constructed to match this.
   If individual year by year data are available, and vary significantly, modify the model.

   Note: a five year age class is the normal planning band in forestry;
   a harvesting operation, once started, is unlikely to stop even if the trees are one or two years younger than their optimum age.

3. Calculate the log tonnages generated by the area of forest.
   Log tonnages are a function of forest age at harvest,
   based on the volume of timber generated per hectare and
   the Green Density, which is the
   ratio of green wood volume (m^3) to green wood weight (t).
   Therefore Volume/ha x Green density x hectares = Log Tonnage.

   See model for these figures, which can be varied if required.
   Sensitivity of the volume per hectare is greatest to age at harvest.

   Note: Most forest owners planning an early harvest will have an accurate idea of the volume per hectare they are expecting, and these figures can be adjusted easily within the model.

4. Calculate the harvests in each year for the planning period being used, e.g. 10 years.

   Note: Because volumes in the model are based on the 30-year planning horizon, volumes for shorter cycle harvests should be based on the average forest age and harvest.

5. Generate EDAs from the characteristics of the vehicles hauling the logs from the forest. Average figures determined from the survey and heavy vehicle specifications are included in the model.

   If for some reason an alternative logging vehicle was proposed, the vehicle characteristics can be varied within the model to allow for that vehicle.

6. Print out a copy of the model for a known forest at the end of a single road. This will show numerically the results which can be expected from a typical forestry operation.

The model and its formulae are given in the printouts of the spreadsheets (Table A1) and a worked example is given in Table A2.

Table A1. Model and formulae used to generate estimates of EDAs from a known forest.

	A	B	C	D	E	F	G	H	I	J	K
1					TRANSIT NEW ZEALAND						
2											
3											
4											
5	AGE CLASS		P.RAD	D.FIR	HARDWOODS						
6											
7	0-5 YEARS										
8	5-10 YEARS										
9	10-15 YEARS										
10	15-20 YEARS		1500								
11	20-25 YEARS		750								
12	25-30 YEARS		500								
13	30-35 YEARS		300								
14	35-40 YEARS										
15											
16											
17	FOREST AGE		30	45	40	30	(Age at harvest)				
18											
19	VOLUME PER HA		460	640	510	460	(This is variable with age at harvest)				
20											
21	GREEN DENSITY		1.04	0.88	1.11	1.18	(Varies slightly with location)				
22											
23	TONNES/HA		=C19*C21	=D19*D21	=E19*E21	=F19*F21	(Varies with volume/ha and slightly by region)				
24											
25							PERIOD TOTAL	ANNUAL TOTAL	ANNUAL EDA	PERIOD EDA	ANNUAL TRIPS
26											
27	0-5 YEARS		=(C14+C13)*C23	=D14*D23	=E14*E23	=(F14+F13)*F23	=SUM(C27:F27)	=G27/5	=((H27*F42)/(F3	=I27*5	=(H27/(F38-F40)
28	5-10 YEARS		=C12*C23	=D13*D23	=E13*E23	=F12*F23	=SUM(C28:F28)	=G28/5	=((H28*F42)/(F3	=I28*5	=(H28/(F38-F40)
29	10-15 YEARS		=C11*C23	=D12*D23	=E12*E23	=F11*F23	=SUM(C29:F29)	=G29/5	=((H29*F42)/(F3	=I29*5	=(H29/(F38-F40)
30	15-20 YEARS		=C10*C23	=D11*D23	=E11*E23	=F10*F23	=SUM(C30:F30)	=G30/5	=((H30*F42)/(F3	=I30*5	=(H30/(F38-F40)
31	20-25 YEARS		=C9*C23	=D10*D23	=E10*E23	=F9*F23	=SUM(C31:F31)	=G31/5	=((H31*F42)/(F3	=I31*5	=(H31/(F38-F40)
32	25-30 YEARS		=C8*C23	=D9*D23	=E9*E23	=F8*F23	=SUM(C32:F32)	=G32/5	=((H32*F42)/(F3	=I32*5	=(H32/(F38-F40)
33	30-35 YEARS		=C7*C23	=D8*D23	=E8*E23	=F7*F23	=SUM(C33:F33)	=G33/5	=((H33*F42)/(F3	=I33*5	=(H33/(F38-F40)
34	35-40 YEARS		=C13*C23	=(D6+D7)*D23	=E7*E23	=F13*F23	=SUM(C34:F34)	=G34/5	=((H34*F42)/(F3	=I34*5	=(H34/(F38-F40)
35											
36	TOTALS		=SUM(C27:C34)	=SUM(D27:D34)	=SUM(E27:E34)	=SUM(F27:F34)	=SUM(C36:F36)	=G36/5			
37											
38	AVERAGE GROSS WEIGH					44.08					
39											
40	AVERAGE TARE PER VEHI					16.5					
41											
42	AVERAGE EDA PER LOAD					3.148					
43											
44	AVERAGE EDA PER UNLO					0.5					
45											
46	PREDICTED TOTAL NUMBE					=G36/(F38-F40)					
47											
48	PREDICTED TOTAL EDA F					=F46*F42+F46*F44					

Table A2. Worked example of the model in which estimates of EDAs from a known forest have been generated.

HECTARES BY SPECIES - TEST FOREST

AGE CLASS	P.RAD	D.FIR	HARDWOODS	
0-5 YEARS				
5-10 YEARS				
10-15 YEARS				
15-20 YEARS	1500			
20-25 YEARS	750			
25-30 YEARS	500			
30-35 YEARS	300			
35-40 YEARS				

YIELD ESTIMATES FROM NEFD					
FOREST AGE	30	45	40	30	(Age at harvest)
VOLUME PER HA	460	640	510	460	(This is variable with age at harvest)
GREEN DENSITY	1.04	0.88	1.11	1.18	(Varies slightly with location)
TONNES/HA	478.4	563.2	566.1	542.8	(Varies with volume/Ha and slightly by region)

TOTAL LOG TONNAGES GENERATED					PERIOD TOTAL	ANNUAL TOTAL	ANNUAL EDA	PERIOD EDA	ANNUAL TRIPS
0-5 YEARS	143520	0	0	0	143520	28704	3797	18983	2082
5-10 YEARS	239200	0	0	0	239200	47840	6328	31639	3469
10-15 YEARS	358800	0	0	0	358800	71760	9492	47458	5204
15-20 YEARS	717600	0	0	0	717600	143520	18983	94917	10408
20-25 YEARS	0	0	0	0	0	0	0	0	0
25-30 YEARS	0	0	0	0	0	0	0	0	0
30-35 YEARS	0	0	0	0	0	0	0	0	0
35-40 YEARS	143520	0	0	0	143520	28704	3797	18983	2082
TOTALS	1602640	0	0	0	1602640	320528			

AVERAGE GROSS WEIGHT PER VEHICLE	44.08
AVERAGE TARE PER VEHICLE	16.5
AVERAGE EDA PER LOADED VEHICLE	3.148
AVERAGE EDA PER UNLOADED VEHICLE	0.5
PREDICTED TOTAL NUMBER OF LOADED TRIPS	58109
PREDICTED TOTAL EDA FOR PERIOD ANALYSED	211981

GLOSSARY

Abbreviations used in Tables 6, 7, A1, A2

NEFD	National Exotic Forest Description (NZ MOF)
P.RAD	Pinus radiata
D.FIR	Douglas fir
OTHER	Other softwood pines excluding Radiata and Douglas fir
HDWDS	All hardwood species, e.g. Eucalyptus species
TRV(m^3/ha)	Total Recoverable Volume (in cubic metres per hectare)
CF m^3/t	Conversion Factor: used to determine cubic metres volume per tonne weight
GD t/m^3	Green Density Factor: the ratio of green wood weight (tonnes) to green wood volume (cubic metres). It is the reciprocal of the Conversion Factor.
Tonnes(t)/ha	Total recovered weight per hectare determined by use of either the Conversion Factor or the Green Density Factor from the Total Recoverable Volume per hectare (TRV).
Ha	Hectares
Longs	All cut and transported log lengths greater than or equal to 8 metres in length
Shorts	All cut and transported log lengths less than 8 metres in length
SPPWF	Single Payment Present Worth Factor
EDA	Equivalent design axle
PV	Present value
km	kilometre
vpd	vehicles per day
yr	year

DEFAULT VALUES

used in Model

Default Species Grouping

As with NEFD species grouping of P.RAD, D.FIR, HDWDS (all hardwoods).

Default Harvesting Age (Rotation Length)

P.RAD	- 30 years; range 25-40 years - 16 years cash crop, i.e. merchantable material
D.FIR	- 45 years; range 45-60 years
OTHER	- 40 years; range 35-50+ years
HDWDS	- 30 years; range 25-35 years approximately - 15 years cash crop

Many factors contribute to variation in harvesting age within species groupings. They are principally: site potential (soil, climate, aspect), management regime, marketing constraints. Many of these factors (e.g. site, markets) can be beyond the control of management.

Production Thinning (PT) Default

- PT may account for some of the total harvested volume. Gabites Porter (1991) has used an estimate of 10% and Briggs (1992) gives an estimates of 15% of total harvested volume.

- Timing and intensity of PT will vary considerably from region to region, if PT is practised at all. Timing of PT usually occurs between ½ and ⅔ of the rotation length.

- Net Productive Forest Plantation Area by Age Class and Silvicultural Tending Regime, as at 1 April 1990 (NEFD 1992, Edition 7, p. 13, Histogram 5), shows a definite national trend away from PT regimes in younger area–younger age classes, as a proportion of total planted area.

- Recommended regional default estimate of production thinning volume is 10% of total harvest volume.

Example

Total tonnage (over 5 years), for 1990-91 period, is estimated at 707,790 tonnes.
To account for PT volume, add 10% to this total (70,779 tonnes) to total tonnage.
Total tonnage estimate is now 778,569 tonnes.

Default Values for Conversion Factor (CF) & Green Density Factor (GD)

Species	CF (m^3/t)	GD (t/m^3)	Source
P.RAD	0.96	1.04	NEFD(App.5)
D.FIR	1.13	0.88	NEFD (Table 1)
OTHER	0.90	1.11	LIRA (1984)
HDWDS	0.85	1.18	Estimated from local information

Default Log Type – Length Class Matrix

Default log types are based on three broad market classifications (NEFD 1992 Appendix 4). Classifications influence in turn the log length. Log length is a major factor influencing logging truck configuration, and consequently axle layout and EDA loadings.

Log Type

Export sawlog	pruned unpruned
Domestic sawlog	pruned posts and poles peelers unpruned
Chip/pulp	low grade cash crop, i.e. merchantable material

Log Length Class

Long	lengths greater than or equal to 8 metres
Short	lengths less than 8 metres

Note: Some truck and trailer configurations allow logs of 8-m maximum lengths to be transported on the trailer unit. The 8-m log length is the minimum transportable log length on a jinker trailer configuration.

Logs with lengths between long and short length classes has been identified (by TH Jenkins & Associates) to have a critical influence on logging truck configuration.

Differences in truck configuration and therefore on axle layout directly influence EDAs. Consequently a basic matrix incorporating the influence of each of the above variables appears to be an important connection between forest production (tonnes) and the EDAs generated by that production. However data from the field indicate that this is not the case.

Log Type – Length Class Matrix

Log Type	%	Length Class	
		% Longs	% Shorts
Export	24	70	30
Domestic	31	10	90
Chip/Pulp	45	5	95

Source: National Log Type Breakdown (NZFOA 1992)
Note: Ratio of Longs to Shorts is a national estimate

The log type classes within the matrix are expressed as a percentage of total production. Length class is expressed as a percentage of each log type.

Log type default values are based on 1992 data produced by NZFOA (Appendix 4), These values can be reviewed annually or adjusted for regional or district wood-flow trends.

The default ratio of long length logs to short length logs within each log type is based on professional knowledge of the forestry industry and on known trends within the different market outlets. Variance within these estimates is likely to be within 5-10% of the default ratio.

A recent survey by Briggs (1992) shows the following ratio of length class at a national level for New Zealand:

15%	random length	0-12m
38%	long length	10-12m
19%	medium length	6-10m
28%	short length	4- 6m

Using the defaults in the matrix, the overall weighted ratio between long length and short length is 22% long to 78% short compared to Briggs' (1992) direct survey result of 57% long to 43% short. The effect of log lengths on EDAs based on field data is small and has been excluded from the final model. It could be re-introduced if local conditions required it by a simple addition to the EDA calculation.