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PROVINCIAL ROAD CONDITION AND ROUND WOOD TIMBER TRANSPORT IN SOUTH AFRICA

The context of the study is concern over declining provincial road condition due to insufficient government funding for road maintenance. These roads are by their public nature used by a wide variety of commercial and private interests contributing a broad range of axle loads. There was no information available on the use of these roads by forest companies, nor on their condition. Consequently a survey was conducted to determine condition and length of each segment of provincial road in use by forest companies and the volume of wood transported over them. In addition, an attempt was made to gather data on other road users and their contribution to the volume transported over each section.

The questionnaire indicated that the provincial roads are in a poor to very poor state. References reviewed suggests maintaining or rebuilding these roads can achieve a significant reduction in total cost of transport. South African forest companies provide the majority of the heaviest axle loading to these roads and must therefore take responsibility for damage caused to them. Also a variety of forest companies use the same roads and consequently collaborative studies between companies are needed.

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Провінційні дороги і лісотransпорт в Південній Африці

Зосереджено увагу на погіршенні стану провінційних доріг через недостатнє державне фінансування їх експлуатації. Ці дороги за своїм призначенням широко використовуються для перевезення вантажів в комерційних та приватних цілях. Однак відсутні дані про використання таких доріг лісовими компаніями. Дослідження проводилося з метою визначення технічних та експлуатаційних параметрів кожної ділянки провінційної дороги, що використовувалася для транспортування деревини. Крім того, зроблено спробу зібрати інформацію про використання цих доріг іншими користувачами.

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Виконане опитування показало, що провінційні дороги перебувають в дуже поганому стані. Південноафриканські компанії, як найбільший користувач цих доріг, повинні взяти на себе зобов'язання стосовно зменшення їх пошкоджень. Також потрібна співпраця лісових компаній з іншими організаціями-користувачами для вирішення виявлених проблем.

Introduction

A decision taken by the National Transport Commission during the 1990's, to withdraw funding from provincial road maintenance programmes, including the removal of certain provincial roads from the national database has had dire consequences for secondary timber transport from plantations to processing plants in South Africa. This decision has resulted in increased vehicle transport costs due to poor road surfaces, limited access to timber sources by secondary timber transport vehicles, unreliable transport of roundwood from plantations and reduced productivity by vehicles due to reduced travel speeds.

The government has made its intentions clear in this regard; it will concentrate scarce resources on critical transport corridors and reduce spending on feeder roads. In addition it is expected that road costs (maintenance and upgrading), including externalities, are to be redistributed to the actual users of the road. Externalities include costs that, although accrued by society, are not factored into the financial determination of costs.

The importance of secondary timber transport in the forest industry is widely understood. The management of this transport has formed the basis of many studies in South Africa. Ackerman (2001) reported on several of these studies, which concludes that secondary transport of forest products contributes 50-60 % of the cost of round wood delivered to the mill.

Secondary timber transport has been the focus of cost reduction efforts during the last decade, during which vehicle tare masses were significantly reduced through the importation of foreign technology in the form of altered configurations, lighter materials and the resultant rejuvenation of the existing transport vehicles in the country.

Vehicle robustness has thus been reduced, while road management has been neglected, resulting in increased impacts, of poor roads, on these vehicles. Lightweight vehicles require well-constructed and maintained roads in order for them to perform at optimum speeds (Douglas, 1988; Marshall, 1989). However, provincial road conditions continue to decline, as government funding is channelled into more socially orientated infrastructure.

Secondary timber transport cannot be effectively considered or managed in isolation of roads. There is a definite interface between the vehicle and the road, in that a good quality road will facilitate optimum (cost-wise) timber transport. Furthermore it is strongly suggested by Morkel (1995) and Jones & Paige-Green (2000), that road condition can affect travel speeds and therefore productivity.

The very nature of public roads is such that these roads are not owned by any specific interest, now that the government has basically surrendered these roads. In addition, because public roads have never fallen within the Forest Enterprise management policies, the available information on provincial road conditions is

vague and incomplete. As a basis for the analysis of current and future policy formulation, and to facilitate the determination of the cost impact of this situation on the delivered cost of roundwood, it is imperative that more is known about the current state of the provincial road network.

The objective of this study was to conduct and analyse an industry-wide survey using a questionnaire in which the following were addressed:

- Identify provincial roads used by forest companies for timber transport.
- Total volume of forest products carried by these roads?
- What other enterprises use these roads?
- To what extent do different forest companies use the same roads and what is the potential for collaboration?
- What is the current condition of the roads?
- What is the change of condition of the roads when wet?

Forest road and transport interaction

The influence of the forest road on the vehicle can be grouped according to direct and indirect resistances. Indirect resistance refers to the characteristics of the road that impede the efficient passage of the vehicle, often as a result of the driver's perception of safety and comfort (Morkel, 1994). Direct resistances are those that retard the motion of the vehicle and include rolling resistance (road stiffness and roughness) and grade resistance.

Roads, regardless of the quality of their construction, are flexible structures and deflect under the weight imposed on them by the vehicle. Consequently the tyre is always in a deflection bowl (Douglas, 1986) that moves continually with the vehicle. The force required to perpetually drive out of this deflection is a major component of rolling resistance and the magnitude of this force is dependent on the stiffness of the road structure. The stiffness is in turn dependent on the compaction of the material and the depth to which it is compacted (Morkel, 1994).

Roughness, a measure of irregularities in the surface (Ljubic, 1982), causes unnecessary flexing in the tyres (Douglas, 1986). The flexing of the tyre absorbs energy and gives rise to higher rolling resistance. Road roughness has been shown to be a significant contributor to all aspects of transport costs (Jones & Paige-Green, 2000; DOT, 1990). Roughness of a road is a controllable factor connected to the design specification of the road and affects operating cost (DOT, 1990). Road roughness decreases vehicle speed (affecting productivity) and increases the cost of maintaining the vehicle (Iwakawa, 1981) and its tyres (DOT, 1990).

An additional aspect of road roughness is surface condition, which refers to the frequency of defects on a road section (Morkel, 1994). Examples of defects would be potholes, washboard and erosion gullies. Defects have both a psychological effect on the driver, causing slower driving owing to a perceived lack of safety, as well as increased gearing as a result of slowing down for potholes and eroded areas. This increased gearing causes higher fuel consumption and greater wear and tear on the engine parts, while the slower driving speeds will affect productivity.

There is thus considerable evidence that an improvement in road surfacing will reduce operating costs of transport enterprises. Specific cost reductions noted are: 5 % reduction in vehicle maintenance spending (Nader & Williams, 1993) and

10-20 % reduction in fuel consumption (Williams & Nader, 1993; Ljubic, 1983). In South Africa, Jones and Paige-Green (2000) predicted a 20 % reduction in total operating costs resulting from improved road maintenance.

In many cases the reductions in operational costs will offset the costs of road improvement (Paterson, 1971). These observations were confirmed, under South African conditions by Jones and Paige-Green (2000), who found that the major proportion of the total cost of unsealed forest roads is the vehicle operating cost, which is normally several times the cost of initial road construction and maintenance. It is emphasised in the available References that in many cases improving road condition will reduce transport operation costs. It is, however, unclear to what extent the provincial roads in question should be improved and who should pay for this improvement.

Methodology

The survey of the current state of provincial roads in South Africa was conducted by means of a questionnaire. As mentioned previously the goal of the questionnaire was to gather information concerning the condition and use of provincial roads. The questionnaire was sent to a company representative of seven forest enterprises. The following six forest companies comprising 25 individual responses returned the completed questionnaires: Sappi; SAFCOL; Mondi; NCT; Masonite; Northern Timbers (HM).

The only group not included in the survey was the Department of Water Affairs and Forestry (DWAf), which manage 11 % of afforested land in South Africa (FOA, 2001).

Each respondent (forest enterprise) was asked to identify provincial roads in their management sphere which are used for the transport of their roundwood timber and to locate these on a 1:50 000 topographical map. Each road was then analysed according to three criteria:

- Other road users that might impact on road condition or that would be significantly affected by the road's condition. This provided some of the qualitative information that plays a role in land management within rural development and tourism areas. In addition it gave an indication of the stakeholders involved for distributing the costs of road maintenance or upgrading.
- The average annual volume transported over the roads and the lengths of each road segment.
- Estimation of road condition in both dry and wet states according to the following five categories (Table 1).

Table 1. Road condition assessment classes and criteria *Category Explanation*

1	20 % of the road is passable; the other 80 % is not in a condition conducive to safe and economical transport of timber for the time of year during which it is being used to haul timber.
2	40 % of the road is passable and the balance as above for the time of year during which it is being used to haul timber
3	60 % of the road is passable and the balance as above for the time of year during which it is being used to haul timber
4	80 % of the road is passable and the balance as above for the time of year during which it is being used to haul timber

The total length is trafficable and in good condition for the time of year during which it is being used to haul timber. The respondents were required to make a visual estimate of the section of road and classify the percentage considered to be passable, i.e. the percentage of the road that can sustain the quality of service it was originally designed for.

When the questionnaires, with accompanying maps, were returned, the information was entered into a database (Microsoft Access®). The distances were confirmed by manually measuring the marked roads on each map. In cases where maps were not included or were of a scale different to the requested 1:50000-map set, the roads were located on appropriately scaled maps and re-measured. From Microsoft Access® the information was analysed and where necessary exported to Microsoft Excel® for further analysis and graphical representation.

The data was grouped and analysed by direct comparison or visual means (graphs and tables). The fact that the data is non-parametric and discrete, ruled out simple statistical tests. The quality of information that would be gathered by these nonparametric tests would not warrant the time and effort required to conduct them. Furthermore, due to the large number of roads it was not possible to compare them individually. Therefore roads were grouped in 5 km categories starting at 0-5 and extending to 65 km to accommodate the longest road.

Results and discussion

A total of 224 roads were identified in the survey. This represents a significant and representative sample for a cross section of South African provincial roads that serve forestry interests. Seven spoilt responses were returned but not included in the database. This reduced the total response from 224 to a final sample population (n) of 217. Company responses (FIGURE 1) are proportional to the sizes of the individual companies and as expected, the larger Sappi, SAFCOL and Mondi provided the majority of the data. Twenty of these roads were used by more than one company. However the length portions for which they were in use differed and consequently the volume could not be aggregated. They have therefore been maintained as separate responses.

Of the seven companies that were approached, six returned information on at least part of their areas. The total volume transported over the roads contained in the survey was 8.7 million m³, transported over approximately 1,821 km of road. In the same year (1998/1999) 15.6 million m³ were harvested from South African plantations (FOA, 2001). The sample represents 56.2 % of the total volume harvested. It is concluded that the discussion and conclusions derived from this data about distances, road quality and payloads are therefore representative.

However, some caution should be exercised, as the responses to the questionnaire are subject to human interpretation and error. For example, in one of the regions surveyed only one company listed other users of the roads. This could either suggest that most forestry plantations are completely isolated from other industries, or, more likely, that the remaining companies did not fill in the questionnaires properly. In another case it appeared that respondents did not understand the question regarding road length and condition, for example many provincial road

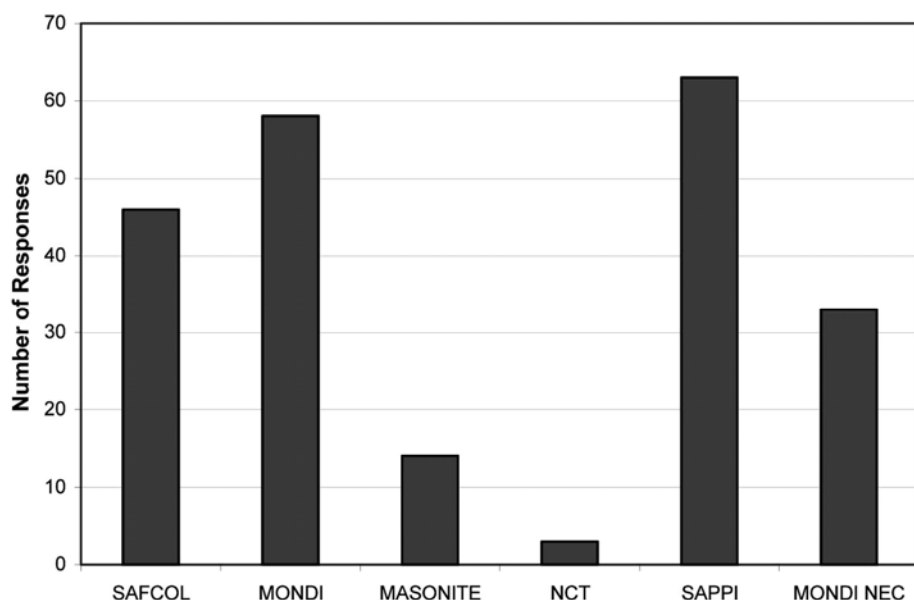


Figure 1. Responses divided according to company

lengths are listed in the original questionnaire responses as 500 m. It is doubtful that the roads are of this length, and although it is possible that the road is only used for a short section, it is more likely that the respondents have only supplied information for the section of the road in its poorest state.

Road length and timber volume

Both the lengths of roads and volumes transported over these road segments have a large range and variation (Figure 2). The left hand vertical axis shows the range in volume with the majority of the volume being transported over short roads. The right hand axis shows the total distance of roads for each 5-km road length interval. In other words the sum of the road lengths that fall between 5 and 10 km is 495 km. The average length of roads was 8.4 km and carried an average of 40 297 m³ annually. One road was reported at 60 km carrying a volume of 100 000 m³. This was, however, a distinct exception as the remainder of the roads were less than 25 km long with most roads being between 5 and 15 km. The corresponding median values are 6.0 km and 15,000 m³ carried annually.

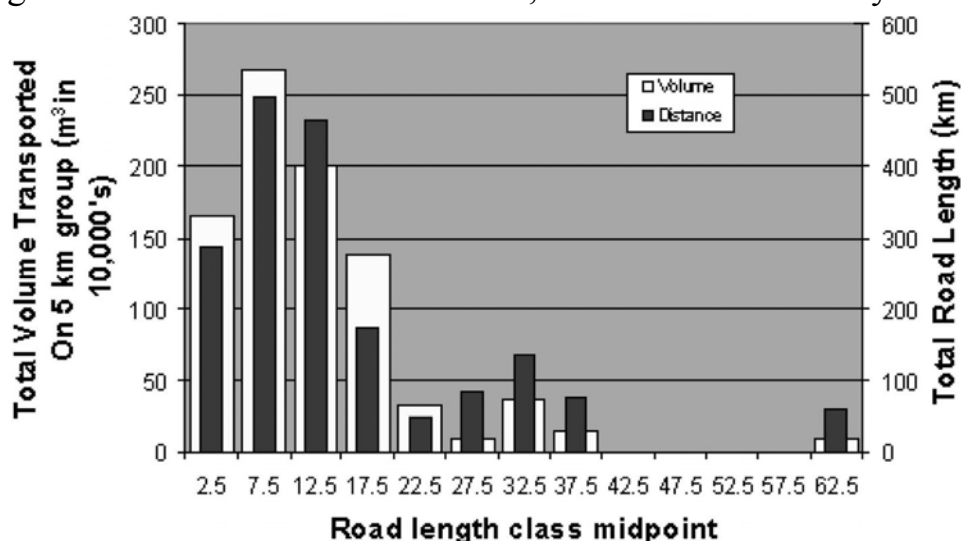


Figure 2. Volume and road length distribution in 5 km classes

The descriptive statistics for road lengths and volumes are given in table 2.

Table 2. Descriptive statistics on road distance and volume

Statistic	Distance (km)	Volume (m ³)
Minimum	0.5	100
Maximum	60.2	100,000
Average	8.4	40,121
Median	6.0	15,000
Total	1823.7	8 746 360

The distribution across companies for provincial road length and volume transported are shown in Figures 3 and 4, respectively.

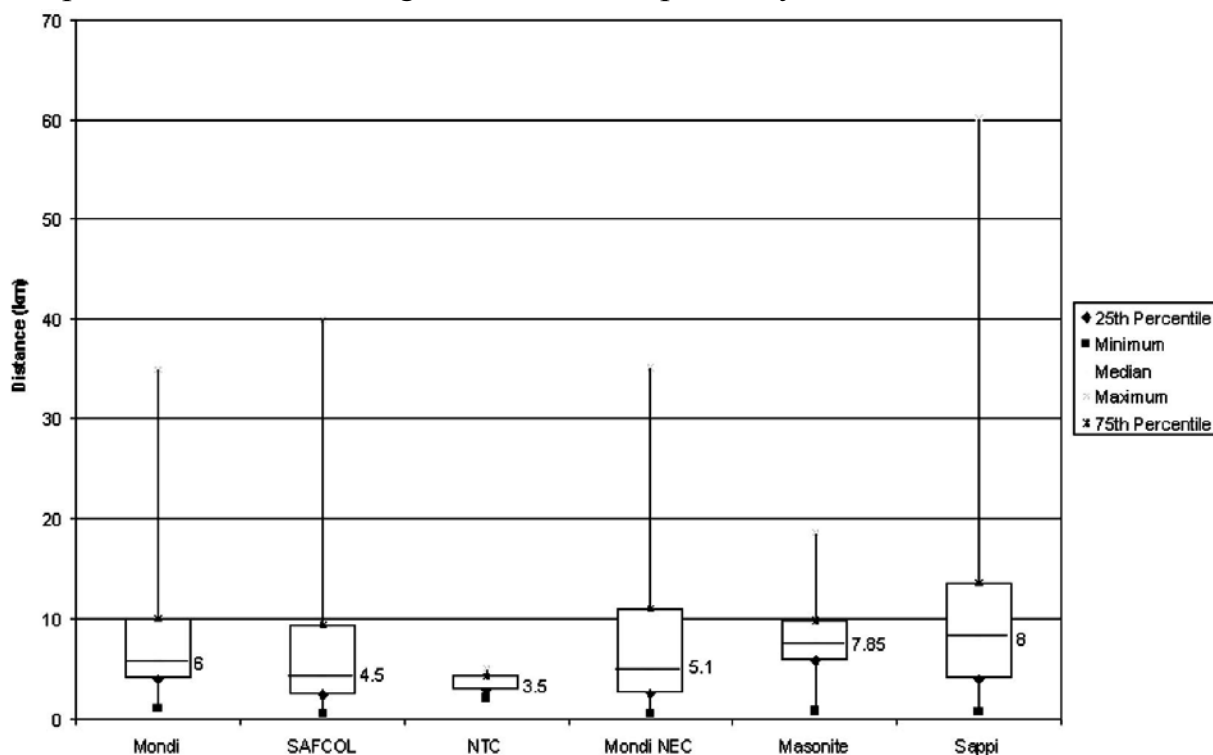


Figure 3. Box and whisker distribution of provincial road section length by company

It is clear that the maximum values, i.e. the top quartile, for each company are much higher than the majority. These are individual roads, which may have a large potential for reducing costs if correctly managed, especially in cases where the roads carry high individual volumes. The majority of the data however occur at much lower values and can be best described by their median values.

The median provincial road lengths do not show large variation and most of the road lengths fall around the forest industry median of 6 km. Sappi (8 km) and Masonite (7.85 km) have the longest median distances while NCT (3.5 km) has the lowest. Most of the company volume medians are aggregated around the median volume for the forest industry of 15 000 m³ per reported road segment. The obvious exception is that of NCT, which represents a special case. NCT's median volume of roughly 150 000 m³ is transported over three short roads. The implication for NCT is that there is a significant potential to reduce transport costs by concentrating maintenance on the three roads that represent this sample. While NCT certainly has the greatest potential for cost reduction, there is no company that

stands out as not using provincial roads. Consequently the results of this study are relevant to all the forest companies in South Africa.

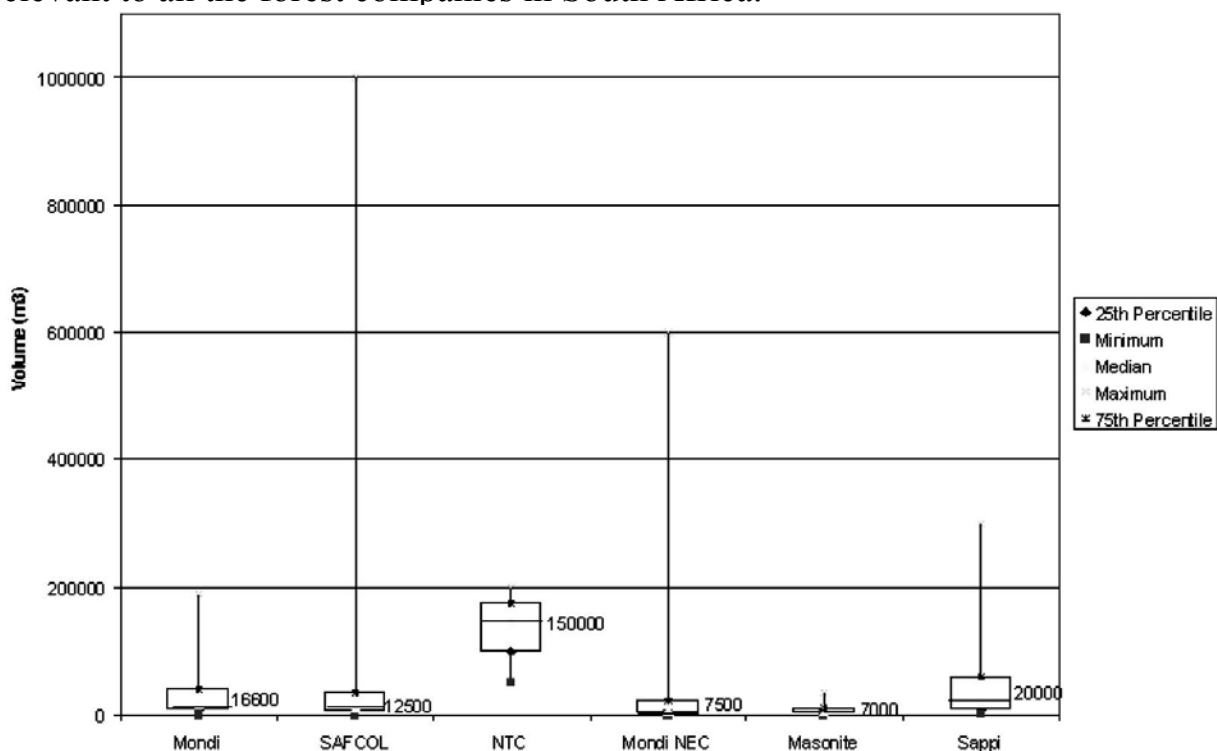


Figure 4. Box and whisker distribution of volume/road segment by company

For the remaining companies it would appear that provincial roads are used for short distances but carry relatively high volumes (the industry median of 15 000 m³ would justify about 395 truck trips using a payload of 38 tonnes). However there is significant variation and each road should be investigated on its own merits, a conclusion which is repeatedly emphasised in the References. It is clear that there is great potential to generate large cost reductions from rebuilding short portions of road.

Road condition: dry and wet

The distribution of dry road condition is fairly uniform, with a peak at class three (Figures 5 and 6). The median dry condition is 3, indicating that 50 % of the road is not conducive to transport. Only 36 roads (12 %) are listed as class five and are considered to be trafficable all year round. At the other end of the scale, 39 roads (18 %) are considered to be in very poor condition (class one) for transport.

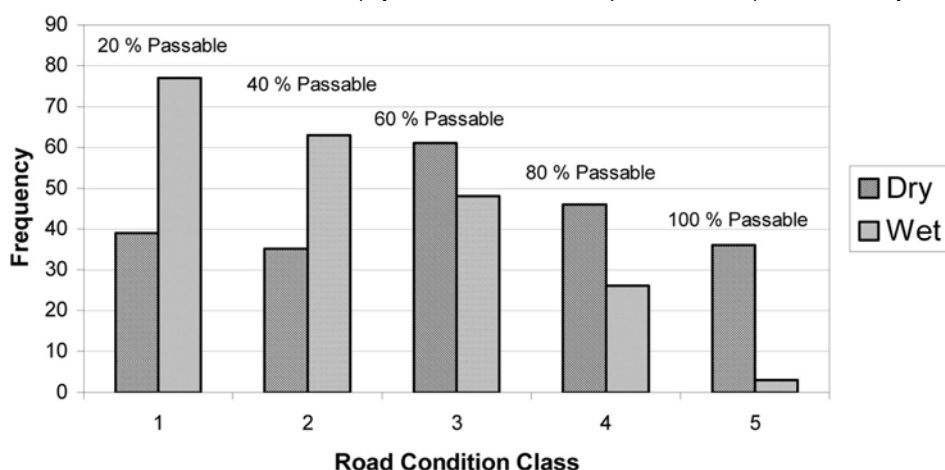


Figure 5. Frequency of road condition classes for wet and dry conditions

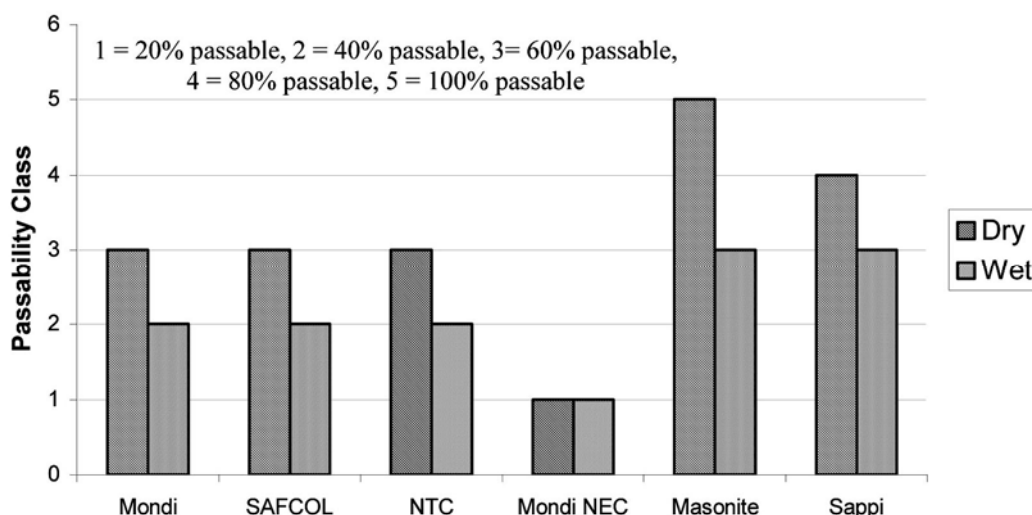


Figure 6. Median road condition in both wet and dry states by company

The change in the distribution in wet conditions is marked. The median decrease in road condition is one condition level, resulting in a median condition of two. Of all roads, 158 changed by one condition level while 13 changed by two levels, and two changed by three levels. Only three roads maintained the best criterion of class five; the roads were not negatively impacted by wet weather.

It is apparent that Mondi, NEC uses very poor roads, with their median road condition being class one even in a dry state. Hence it would not be possible for them to decrease further due to wet conditions. Although there is some decrease in passability due to moisture on and in the road, for most companies road passability decreases by one road condition class (20 %) in wet weather. The fact that some roads in the sample do not change by one class (i.e., no change or a change of two classes) suggests that this is a controllable factor. Masonite is most affected by poor drainage as provincial roads in their use deteriorate by two classes from class five to three (40 % passability). Sappi moved from a lower class condition four to class condition three and others from class condition three to class condition two.

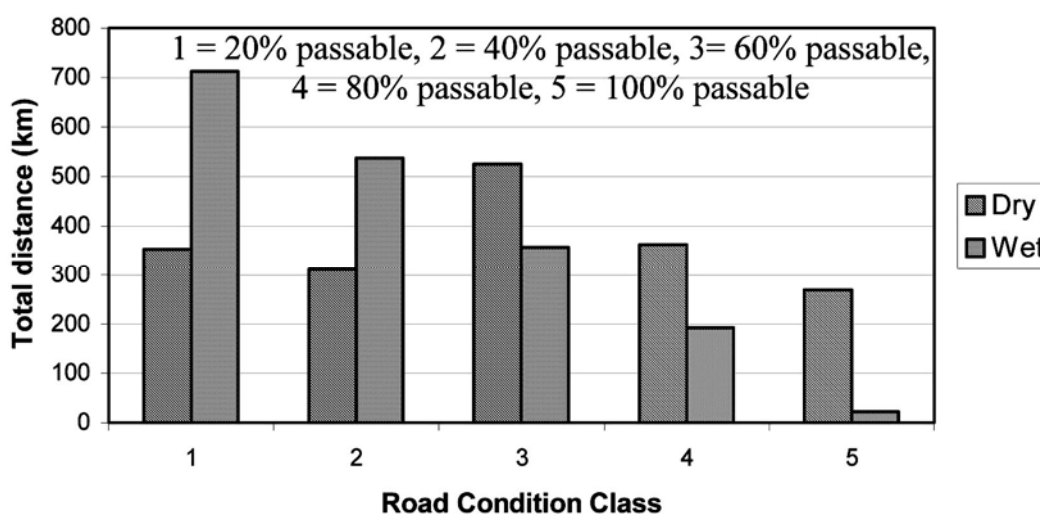


Figure 7. Road class grouped according to distance

If the same information is presented in terms of distance of each condition class (Figure 7), a similar scenario is apparent. The majority of the road distance

slips into a poorer road class with very little road distance remaining in class condition category five.

If the volume transported over each road class is considered (Figure 8), it is seen that the conditions are more favourable in the dry state. Most of the volume is carried over class three and four roads. In the wet state, however, the situation worsens considerably, with more than half (roughly 70 %) of the volume being transported over poor (class condition two) and very poor roads (class condition one).

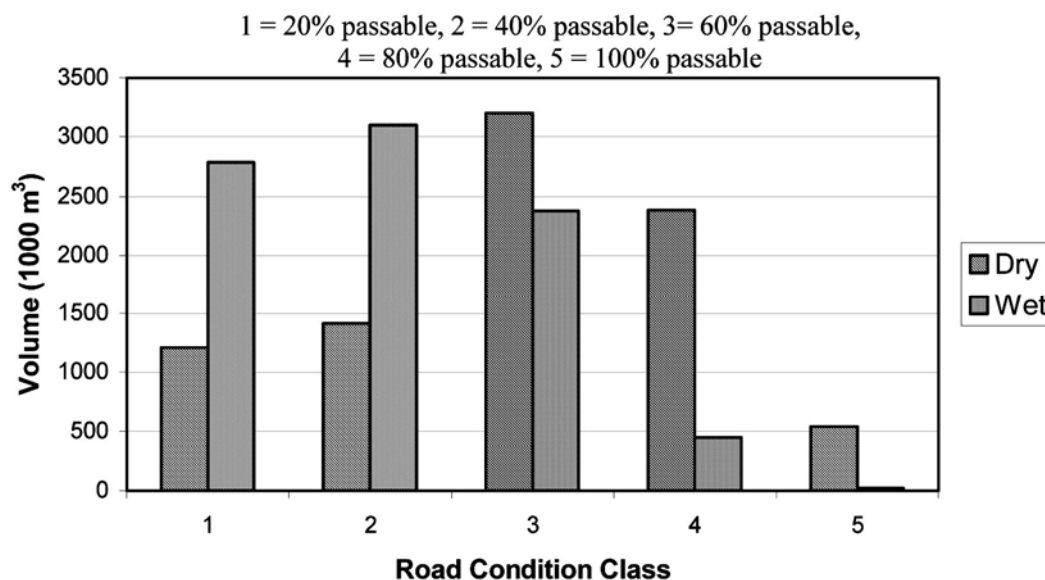


Figure 8. Volume transported over the varying classes of road in wet and dry states

It can be concluded that inadequate road surfacing and poor road drainage due to reduced provincial road management is an issue requiring serious attention from the South African forest industry. Typically a road will deteriorate by one condition class or about 20 % passability, which would be acceptable for small forest roads but not for provincial roads.

Other users

Two groups of other users were identified in the study. The first group consists of users who transport non-timber goods and add traffic at high axle loads. The second group includes lower axle load traffic that will not have a significant impact on the road, but may have a high priority for qualitative reasons. Included in this second case are tourists and local communities who may use these roads for access to maintain quality of life, but which cannot be ignored. Users in this second category range from other farmers to visitors of small nature reserves. The most common users of the roads surveyed are: farmers (agricultural) (49 %), rural communities (31 %), general public (18 %) and tourism (12 %). Often more than one type of industry uses a road segment and consequently there is some overlap between the previous four categories of user. Only 5 % or less of roads indicated in the survey were used by groups falling outside the previous four categories.

In terms of the total survey, the contribution of other road users to heavy traffic is insignificant. The four greatest contributors were sugarcane, maize, flour and citrus. Only 11.9 % of the total length of roads surveyed had other users, and they contributed only 6 % of the total volume of heavy traffic.

Looking at the data in terms of distance travelled by other users further emphasised the unimportant role that other users play. Only 126 km of road are shared with the transport of sugarcane, 107 km with maize, 62 km with bark, 18 km with citrus and 16 km with flour. This only represents 7 % of the total distance for sugarcane and 6 % for maize, with each of the remaining other users representing less than one percent of the total distance. Only five roads, totalling 50 km, had more than one non-timber product being transported on them.

If the roads carrying other products are examined separately, a different picture is evident. In this case timber still contributes the greatest volume (62 % of tonnes transported), followed by sugarcane (33 %). The remaining users contribute 4 % of the volume. By considering single roads it was revealed that certain roads are less dominated by timber. In these specific cases a far more collaborative effort in determining road maintenance funding will be needed.

Sharing

A further complication in determining budgets for road maintenance, rebuilding or upgrading is that timber companies share some roads; 20 % of the roads were used by more than one company. The average length of these roads was 9 km, carrying an average annual volume of 59 732 m³. The median serviceability in dry weather was three and when wet this degraded to a two. This is contrasted to industry averages of 8 km and annually 40 297 m³. The roads' serviceability stays constant with medians of three-dry and two-wet.

Discussion

It is quite evident from the results of the questionnaire that the state of provincial roads is poor to very poor. The majority of the roads are considered unserviceable for the greater portion of the length. This implies that they have been poorly managed and that they are in serious need of repair.

Most roads are seriously affected by rainfall, with most roads moving down one road condition class in the wet season. In other words, after rain an additional 20 % of the road length is not conducive to efficient transport. Clearly, effective drainage and surfacing are lacking in these roads. The unfortunate implication for the forest industry is that many of these roads will not merely require improved maintenance but in many cases also reconstruction.

An analysis of road condition with respect to wet and dry states within companies (Figure 8) reveals that SAFCOL, Mondi, Sappi and NCT have a similar distribution around the industry median. They have changes in condition of approximately one unit. Mondi NEC, has considerably worse roads in both dry and wet states. The fact that there is no change in condition for Mondi NEC is most likely due to there being no lower road class available.

It appears that most of the traffic on the surveyed roads, in terms of axle loads, is contributed by Forest Enterprises. It can therefore be assumed that most of the damage to these roads is caused by forest companies which implies that Forest Enterprises should consider taking on the responsibility of maintaining these roads partly for the benefit of their own transport operations and partly because they have

a social responsibility to do so. The decrease in government spending on, and the decommissioning of, South African provincial roads, has introduced a complex policy issue for these enterprises. The nature of public roads is such that they are used by a number of commercial and private vehicles with varying axle loads.

There is an inequality between the transport companies (who garner the benefits) and the road owners (who incur the costs). It is logical that users contributing high axle-load traffic would cause the most wear and damage and should provide for most of the budget.

An additional dimension to the problem facing the industry as a whole is that, although private enterprises are expected to maintain public roads, they are still expected to pay taxes and levies that are meant for the maintenance of public roads in use by forest companies. Consequently there should be an appropriate reduction of these fees in order to compensate for the forest industry's efforts. Forest companies, who may share some of these public roads, are faced with the problem of how they should manage these roads and whether it is worth managing them at all.

While the forest companies should take responsibility for some aspect of the maintenance of all the roads that they use, the level to which they maintain these roads will be dependent on a number of factors. The most striking omission in the questionnaire is the portion of the total transport route that the provincial road represents. If the provincial road covers a very short section of the total route, it may not be necessary to maintain it to a very high level. In addition, because the roads are considered as part of a network, there is no way of predicting changes in routes based on rebuilt links. That is, by upgrading a certain road one could attract traffic volume from other routes intent on taking advantage of the improved road. As a result, the development of a model that considers the road network as a whole is essential. This will also provide input into calculating the division of costs amongst stakeholders.

The results of the questionnaire, combined with the conclusions made in the References review, emphasise the need for a model that allows managers to combine their significant personal experience and intuition with an understanding of a larger network. The ability to vary user inputs allows the analysis of the effect of changing road condition and drainage quality.

Conclusion

The objective of this study was to determine the current state of the provincial road network and its management, or lack thereof. The questionnaire confirmed a number of expectations built up from the References review and personal experience. It was clear that provincial roads are in a poor state with more than 50 % of them having only 50 % of their length serviceable. It is an unfortunate fact that government will no longer be supplying adequate funds for the maintenance of these roads. In addition it is by no means clear who will become responsible for the future maintenance of these roads.

In most cases it appears that the forest companies account for the greatest axle load traffic and should provide the largest portion of funds for road maintenance. Forest companies need to contribute to the funding of provincial road main-

tenance, partly due to the necessity to improve operating costs and partly as a result of their social responsibility to pay for the damage they cause to public roads.

Different companies using the same roads to transport varying volumes further complicate the management environment. Fortunately, these volumes should be easy to quantify and hence a contribution ratio would be relatively easy to establish. The problem will arise with deciding between the levels to which these roads should be maintained to and therefore the total amount of money that should be invested. Different companies have different philosophies on road management. For some it is a priority and for some it is not.

Furthermore there is justification for some future benefit in the form of tax reductions where industry carries out public road maintenance. However there can be no hope of lobbying government to institute such reductions unless forest companies can form a united front backed up by accurate industry wide data and analysis models.

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