MANAGING TREES IN ROAD RESERVES FOR ROAD SAFETY

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ABSTRACT

Trees are planted or allowed to grow in road reserves for reasons such as aesthetics, glare screens, control of marginal access or median crossings and shade for rest areas. International research on the role of trees in road safety confirms that trees do pose a risk and positive policies to manage trees must be formulated and executed. South African provincial road authorities do not have comprehensive policies on trees. Some have policies with respect to the landscaping of road reserves, including planting of trees, at developments along the road. The road reserve must be managed to provide reasonable safety where vehicles run-off the road or hit objects on the roadway. This is in line with the philosophy of a forgiving highway. Some aspects of the management of highway trees are presented from international research. Trees must be classified with respect to factors including the distance from the road edge and possibility of falling on the road. A methodology to assess risk and manage trees is proposed. It is advised that road authorities adopt policies with respect to trees and develop strategies and procedures to manage trees to insure road safety, by maintaining clear zones (recovery areas) free of trees.

1 INTRODUCTION

The paper is based on a final year project by Reinhardt Pienaar, a final year student in 2011, and his contribution is acknowledged.

Trees are planted or allowed to grow in road reserves for reasons such as aesthetics, glare screens, control of marginal access or median crossings and shade for rest areas. International research on the role of trees in road safety indicates trees pose risks and positive policies to manage trees in road reserves must be formulated and executed. South African road authorities do not have explicit policies on trees with respect to safety. Some have policies with respect to the landscaping of road reserves, including planting of trees at developments along the road. An example is the Gauteng Department of Public Transport and Roads' *Application Guidelines for Planting of Trees and Landscaping, (*Gauteng Provincial Government, 2010*).*

The responsibility for road safety with respect to infrastructure and physical features in the road reserve, including trees, lies with the road authority. This was confirmed in South African case law in Kruger v King Williams Town Municipality [1959] 4 All SA 361 (E):

- "*Trees belong to the owner of the property where they are planted.*
- *It is the landowner's duty to prevent these trees from becoming a source of danger and the owner is responsible for any damage occasioned by its failure to fulfil this duty*".

The road reserve must be managed to provide reasonable safety of the roadside in the case of run-off the road incidents. This is in line with the philosophy of a forgiving highway.

2 EXTENT OF THE PROBLEM

The lack of accuracy and completeness of South African road accident statistics undermines research into the nature and extent of trees as a problem in local context. The opportunity to record such accidents occurs under the heading "ACCIDENT TYPE" in the SAPS Accident Report Section 15 "Accident with fixed/ other object (specify)". This is rarely filled out and further capturing of data leads to aggregation. The extent of crashes into trees can only be estimated from research in other countries.

At the 22nd ARRB Conference 2006, Tziotis, Roper, Edmonson and Sheehan (2006) quoted research dated 1997*: "In a case-control study of single-vehicle crashes within a 200 km radius of Melbourne in 1995-1996, Haworth et al. (1997c) found that 78% involved running off the road and hitting a pole or tree*". This sample is probably too specific to be transferable to South Africa.

According to the National Cooperative Highway Research Program (NCHRP) Report 500 Volume 3 (2003, page I-2), run-off-road crashes (ROR) into fixed objects are one the major types of fatal crashes. Of these ROR crashes, the fixed objects most commonly struck are trees. According to the Fatal Accident Reporting System (FARS), 10 967 fatal crashes into fixed objects were reported for the year 1999 in the USA. Of these 3 010 were into trees (27% of fatal crashes into fixed objects). Fatal crashes into trees are approximately 8 per cent of all fatal crashes.

The number of fatal crashes in South Africa in which trees were hit can thus be estimated (assuming the same ratio as USA data of 1999) as 0.08*13709 = 1 097 fatal crashes in 2009. At the ratio of 1,296 fatalities per fatal crash, this could translate to 1420 persons losing their lives. This is considered an overestimation, as the South Africa climate is much drier than the USA and most of the rural roads have no significant trees in the road reserve. None the less, crashes into fixed objects, including trees, do occur.

Table 1: Percentage of Fatal Crashes in South Africa (RTMC, 2009)

Crash Type	Crashes (%)
Pedestrian	34,1
Overturned	23,61
Head On	10,79
Hit and Run (Mainly pedestrian)	8,16
Head-Rear end	4,77
Collision – Fixed object	4,5
Other	14.1

Table 2: Number of Crashes for Cape Town (2005)

Crash Type	Fatal	Serious	Slight	Damage	Total	Percent
Unknown	5	530	2 169	28 856	31 560	37%
Head/Rear end	28	184	2 590	18 638	21 440	25.1%
Sideswipe – opposite direction	8	103	676	5 609	6 396	7.5%
Hit fixed object	25	123	661	5 117	5 926	6.9%

The total number of crashes in 2005 involving fixed objects in the City of Cape Town was 5 926. If the ratio (8% for fatal crashes) found in the NCHRP Report 500 Vol 3 is applied, 474 of all crashes into fixed object are into trees in the Cape Town Metropolitan area.

The problem is much wider than just vehicles crashing into trees. Trees that are not maintained properly can grow branches in unwanted places such as in front of information signs or hanging over the road in a dangerous way. Some tree species grow roots that lift the road surface and the kerbs. This can prove damaging to a vehicle.

Some of the variables for tree crashes are traffic volume, road geometry and the condition of the road. Although the main reason for vehicles running off the road and into trees is as a direct result of the human factor, the human errors can be reduced if the road geometry is designed to reduce risk. If the road side is maintained properly, the probability of crashes will decrease.

The effect of traffic volume on crashes per mile is shown in Figure 1 (Exhibit III-5B: NCHRP Report 500 Volume 3). On roads which have a tree coverage of 15 to 30 percent, there are 0,25 accidents/mile/year at 4 000 vpd with trees 0 – 3 m from the road. This ratio decreases as the distance from the travel lane increases to approximately 1,4 with trees 6 - 10 m from the road. The effect of trees on crash rates where traffic volumes are below 1000 vehicles per day is not clear, but the crash rate appears low. Remedial efforts should thus focus on high volume roads.

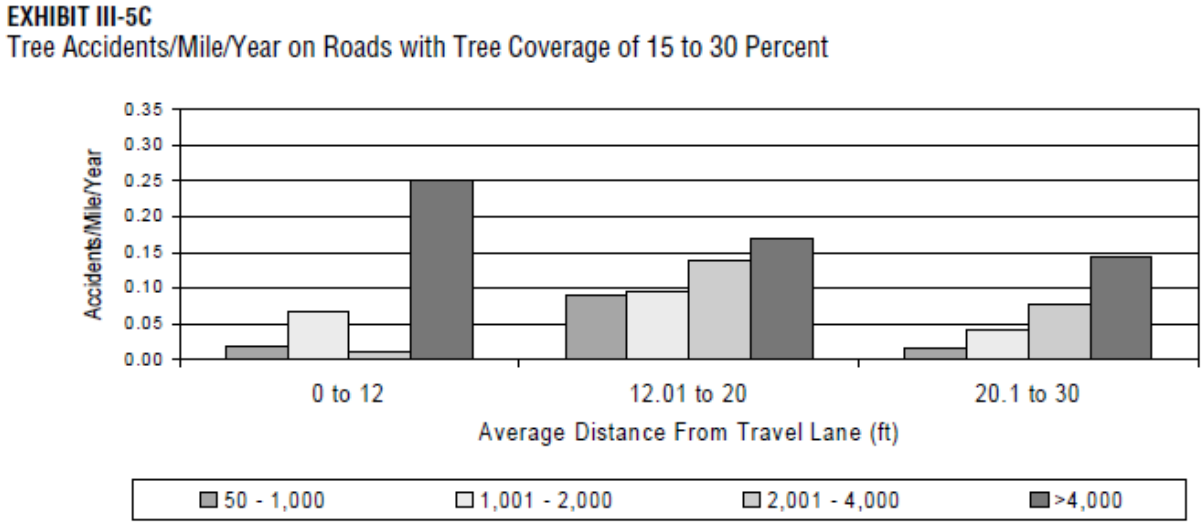

Figure 1: Tree Accidents/Mile/Year as a function of shoulder width and traffic volume. (Source: NCHRP 500 Vol 3, 2003)

The research (NCHRP, 2003) shows that 56% of all fatal tree crashes occurred at night. Possible reasons may include poor vision at night, speeding in low volume conditions and

drinking and driving. Nearly half of all fatal tree crashes occur on curved roads. This could be due to inadequate sight distance around the curves and over-speeding on the curve.

3 SOLUTION STRATEGIES

The reduction in risk of road crashes with trees can be done by limiting exposure or mitigating the consequences of such crashes. The presence of trees should be justified in each case and context. Removal of trees can be implemented where the trees are invasive or intrude the clear zones along roads. The process should start on high volume, high speed roads in areas where trees grow abundantly.

A survey of trees was conducted along four sections of provincial roads in the vicinity of Stellenbosch. The survey was not based on a statistical sample and it is not claimed to be representative of the tree population along the Western Cape roads, but serves as illustration. The road sections form a circle route to the north and west of Stellenbosch: the R44 (Stellenbosch – Klapmuts), R101 (Klapmuts – Paarl), R45 (Paarl - Boschendal), R310 (Boschendal – Stellenbosch). All the trees growing in these road reserves are invasive species. The trees occurred as single trees, in fence lines, on verges and in plantations on adjacent land.

3.1 Eliminating invasive tree species

Trees found in South Africa can be classified according to the National Environmental Management Biodiversity Act, Act 10 of 2004. Three categories of weeds and alien invader species are indicated. These categories indicate how a specific tree should be managed. Table 3 indicates what each category entails.

Table 3: Invasive Tree Categories (RSA, 2004)

Category	Description
1a	Invasive species requiring compulsory control. Remove and destroy. Any specimens of Category 1a listed species need, by law, to be eradicated from the environment. No permits will be issued.
1b	Invasive species requiring compulsory control as part of an invasive species control programme. Remove and destroy. These plants are deemed to have such a high invasive potential that infestations can qualify to be placed under a government sponsored invasive species management programme. No permits will be issued.
2	Invasive species regulated by area. A demarcation permit is required to import, possess, grow, breed, move, sell, buy or accept as a gift any plants listed as Category 2 plants. No permits will be issued for Category 2 plants to exist in riparian zones.
3	Invasive species regulated by activity. An individual plant permit is required to undertake any of the following restricted activities (import, possess, grow, breed, move, sell, buy or accept as a gift) involving a Category 3 species. No permits will be issued for Category 3 plants to exist in riparian zones.

There were a few occurrences of Category 1 invasive trees namely Wattle and Port Jackson trees. These should be removed immediately and if not, road authorities should be prosecuted to the same extent as private land owners should such trees be found in road reserves.

Trees that are very typical on road in the Western Cape are Oak, Blue Gum (*Eucalyptus*) and Pine (*Pinus*) trees. They are alien trees that need to be controlled. According to the invasive tree list, Eucalyptus and Pine trees are both Category 2 trees that cannot be allowed to be planted or grown without a permit. It could not be determined if the road authorities have permits to allow Category 2 trees in road reserves. These trees should be removed immediately, starting with those growing in dangerous areas.

In some areas along the road, the Australian *Hakea Salicifolia* was observed. This is a shrub-like tree and is regarded as safe, because of its ability to absorb energy from vehicles crashing into them. However, it is also invasive, poses a threat to the fynbos of the Cape and is regarded as a weed. Road authorities wishing to retain or grow these trees for glare screen on the medians of dual carriageway road, should apply for permits and ensure that the plants do not propagate beyond the approved areas.

3.2 Containment and Mitigating Strategies

According to NCHRP 500 Volume 3, there are two main strategies to reduce tree crash fatalities.

3.2.1 Prevent Trees from Growing in Hazardous Locations

Trees are eco-friendly, but on the side of the road they could be hazardous.

- Ensure that no trees are planted in danger zones during new construction. Clear zones should be established by following design guidelines such as the TRH17 to ensure safe sight distances and recovery area.
- Road authorities must keep these recognised danger zones mowed and free from natural growing trees. This needs to be checked at constant intervals throughout the year.

3.2.2 Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash.

On existing roads, the complete removal of the hazard or reducing the severity of the risk is required.

- Remove the trees in the hazardous locations. When a certain tree (or trees) has a history of being struck frequently, they are obvious candidates to be removed. Trees stumps must be removed or must be cut down as low as possible.
- Providing guardrails to ensure drivers do not hit the trees is an effective method that decreases the severity of the crashes, but can increases the number of crashes.
- Modifying the roadside clear zone in such a manner that the vehicle can recover.
- Warn of hazardous conditions. This can be done by putting up W401 hazard markers or a strip of reflective tape around the trees.

4 RISK ASSESSMENT

4.1 Identifying Hazardous Trees

Identifying hazardous trees should be done in conjunction with specialists in tree maintenance. There are many factors to take in account when trying to identify a hazardous tree. According to the United States Department of Agriculture, there are a number of conditions to look out for (United States Department of Agriculture, 2006). These conditions may include:

- Deadwood
- Cracks
- Weak branch unions (and overhanging branches)
- Decay
- Cankers
- Root problems
- Poor tree architecture
- Trees growing skew (and towards the road).

4.2 Determining the Risk

The South African Road Safety Manual (Road Traffic Management Corporation, 2011) uses four steps in order to complete a risk assessment:

- Estimate the possible crash Frequency
- Estimate the possible crash Severity
- Determine the level of Risk
- Determine a Course of Action

The crash frequency shows how often crashes occur, whereas the severity refers to how dangerous the crash is in the event of it happening. Table 4 shows a typical assessment matrix. The following tables explain the definitions of all the terms that will be used in the risk assessment matrix (Road Traffic Management Corporation, 2011). Risk is defined as the product of Frequency and Severity of an incident and numerical values are given. This example uses a simple ranking, but the values can be weighted.

Table 4: Risk Assessment Matrix

RISK		**Frequency**			
		Frequent 4	**Probable 3**	**Occasional 2**	**Remote 1**
Severity	**Catastrophic 4**	Intolerable 16	High 12	High 8	Medium 4
	Serious 3	High 12	High 9	Medium 6	Medium 3
	Minor 2	High 8	Medium 6	Medium 4	Low 2
	Negligible 1	Medium 4	Medium 3	Low 2	Low 1

Table 5: Frequency: Definitions and values

Frequency	Definition
Frequent = 4	One or more events per month
Probable = 3	One or more event per year
Occasional = 2	Once every one to three years
Remote = 1	Less frequent than once in three years

Table 6: Severity of Outcome: Definitions and values

Severity of Outcome	Equivalent Crash Outcomes	Examples
Catastrophic 4	Likely Multiple Deaths	Bus or taxi hits a large tree. Tree falls on public transport vehicle. High speed car with passengers hits tree.
Serious 3	Likely death or serious injury requiring hospitalization	High or medium speed vehicle hits tree. Vehicle hits branch that fell on road. Vehicle swerves to avoid tree on road.
Minor 2	Likely minor injury	Low speed vehicle hits tree.
Negligible 1	Likely trivial injury or property damage only	Car reverses into tree.

When the risk is known, the road authority can set out a course of action to reduce the risk in a structured manner. The actions can be related to the calculated risk, linked to the budget constraints. The following is an example of how actions can be linked to risk.

Table 7: Course of Action

RISK	**SUGGESTED TREATMENT ACTION**
Intolerable (16)	The safety concern MUST be corrected, even if the cost is high.
High (12 to 8)	The safety concern SHOULD be corrected or the risk significantly reduced, even if the cost is high.
Medium (7 to 3)	The safety concern SHOULD be corrected or the risk significantly reduced if the cost is moderate, not high.
Low (2 to1)	The safety concern SHOULD be corrected or the risk reduced if the cost is low.

Table 8 gives examples of the probable frequency of modes in which failures can occur for types of hazards, as well as reasons why it can be assessed as such. Table 9 gives examples of severity of failures for types of hazards, as well as reasons for these assessments. These examples are not comprehensive, but serves to show how road authorities can adapt the methods to their specific circumstances.

Table 8: Probable Frequencies of Failure of Hazardous Trees

Type of Hazard	Probable Frequency	Reason
Plantation or tree lined road	Probable	There are many trees, thus the probability to hit at least one is great.
Trees in isolation	Occasional	The probability to hit a single tree is very low.
Trees growing at an angle	Occasional	Trees growing at angles are still fairly stable.
Tree stumps	Occasional	Tree stumps are difficult to see.
Trees near edge of road	Frequent	Tree in clearance zone.
Trees interfering with other objects	Probable	These trees grow fairly quick if not maintained.
Overhanging branches	Occasional	They are generally weak and break easily.
Damaged trees	Occasional	Not many damaged trees, but if they are damaged they break easily.
Sick and weak trees	Probable	Once a tree is sick, it spreads quickly and the trees then become weak.
Dead trees	Frequent	Dead trees break very easily.
Trees on curves	Probable	Interference with line of sight.
Unkempt trees outside of road reserve	Occasional	They may grow awkward branches that could fall onto the road.

Table 9: Severity of Hazardous Trees

Type of Hazard	Severity	Reason
Plantation or tree lined road	Serious	If a tree gets hit at high or medium speed the deceleration will almost certainly kill a person.
Trees in isolation	Serious	If a tree gets hit at high or medium speed the deceleration will almost certainly kill a person.
Trees growing at an angle	Serious	Hitting a tree or branch on the road will cause damage.
Tree stumps	Serious	If a tree stump gets hit at high or medium speed the deceleration can be lethal.
Trees near the edge of road	Serious	If a tree gets hit at high or medium speed the deceleration will almost certainly kill a person.
Overhanging branches	Minor	Branches are not fixed objects, thus they will not cause such a sudden deceleration.
Damaged trees	Serious	They are still fixed objects and the deceleration will kill a person.
Sick and weak trees	Serious	They are still fixed objects and the deceleration will kill a person.
Dead trees	Serious	They are very brittle and will break easily.
Trees on outer/inner edge of curves	Serious	If a tree gets hit at high or medium speed the deceleration will almost certainly kill a person.
Unkempt trees outside of road reserve	Serious	If a tree gets hit at high or medium speed the deceleration will almost certainly kill a person.

5 ACTION PLANS

5.1 Planning

Road reserves on high speed rural road should be free of trees. Where trees are justified, the clear zones should be in accordance with appropriate design guidelines.

Geometric design standards are given in guidelines such as TRH17 or the SANRAL Geometric Design Guidelines, 2003. Once the design speed, traffic volume and road class are known, the shoulder and clearance zones widths can be determined.

Where lanes of trees are planted for aesthetics, careful consideration should be given to using barriers or delineators, or reducing speed limits.

5.2 Maintenance

Maintenance is probably the most important aspect of road safety. If trees are not maintained to a high standard they will start to grow out of proportion and affect the road. A proper maintenance schedule must be followed by all road authorities. Listed alien species such as wattles and Port Jacksons must be removed. A tree maintenance team must be deployed on a biannual basis looking for hazardous trees. Overhanging branches must be sawn off, dead trees/branches immediately removed. When trees are cut down the stumps must be removed or not be higher than 0,15 m. Sick trees must be observed, as they tend to infect other trees which will lead to the trees dying and falling onto the road.

6 CONCLUSION

Trees in road reserves pose a road safety risk. Road authorities, under legal duty to ensure road safety, should have comprehensive policies for design or maintenance of trees. It is advised that road authorities adopt risk based policies with respect to trees and develop strategies and procedures to manage trees to insure road safety.

High speed rural road reserves should be kept clear of trees. Invasive trees should not be tolerated in road reserves.

References

City of Cape Town, Department of Transport, Roads and Stormwater, 2005. *Traffic Accident Report*. Cape Town.

Gauteng Provincial Government, Department of Public Transport and Roads. 2010. *Application Guidelines for Planting of Trees and Landscaping*, Directorate: Transport Engineering, Totiusdal, Pretoria.

Kruger v King Williams Town Municipality [1959] 4 All SA 361 (E).

National Cooperative Highway Research Program, 2003. *Volume 3: A Guide for Addressing Trees in Hazardous Locations*. Washington: Transportation Research Board.

National Cooperative Highway Research Program, 2003. *Volume 6: A Guide for Addressing Run-Off-Road Accidents*. Washington: Transportation Research Board.

National Environmental Management Biodiversity Act, 2004. *Invasive Alien Plants: NEMBA List*. [Online] Available at: HYPERLINK "http://www.sana.co.za/Alien-Invasive-Plants/" http://www.sana.co.za/Alien-Invasive-Plants/ [Accessed 3 October 2011].

Road Traffic Management Corporation, 2009. *Road Traffic Report for the Calander Year 2009*. Pretoria: Department of Transport.

Road Traffic Management Corporation, 2011. *South African Road Safety Audit Manual*. Pretoria: Department of Transport.

RSA, 2004. National Environmental Management: Biodiversity Act, 2004 (Act 10 OF 2004).

SANRAL, 2003. Geometric Design Guidelines. Pretoria.

Technical Recommendations for Highways, 1988. *TRH 17: Geometric Design of Rural Roads*. Technical. Pretoria: Department of Transport Committee of State Road Authorities.

United States Dapartment of Agriculture, 2006. *How to Recognize Hazardous Defects in Trees*. [Online] Available at: HYPERLINK http://www.na.fs.fed.us/spfo/pubs/howtos/ht_haz/ht_haz.htm [Accessed 19 August 2011].

United States Department of Agriculture, 2011. *United States Forest Service Handbook*. Washington, DC: Department of Agriculture.

Tziotis, M., Roper, P, Edmonston, C. and Sheehan, 2006, Road Safety in Rural And Remote Areas of Australia. 22nd ARRB Conference, Canberra Australia, *2006*