REDUCING THE INCIDENCE OF WILDLIFE ROADKILL:

IMPROVING THE VISITOR EXPERIENCE IN TASMANIA

crc Sustainable Tourism
crctourism.com.au

By Zoë Magnus, Lorne K. Kriwoken, Nicholas J. Mooney & Menna E. Jones

Technical Reports

The technical reports present data and its analysis, meta-studies and conceptual studies, and are considered to be of value to industry, government or other researchers. Unlike the STCRC's Monograph series, these reports have not been subjected to an external peer review process.

National Library of Australia Cataloguing in Publication Data

Magnus, Zoë.
Reducing the incidence of wildlife roadkill : improving the visitor experience in Tasmania.

Bibliography.
ISBN 1 920704 79 5.

1. Roadkill - Tasmania - Prevention. 2. Wildlife conservation - Tasmania. I. Kriwoken, Lorne K. II. Mooney, Nicholas J. III. Jones, Menna E. IV. Cooperative Research Centre for Sustainable Tourism.

333.95409946

CONTENTS

Figures

ACKNOWLEDGMENTS

Funding was sought and acquired from the Cooperative Research Centre for Sustainable Tourism (CRCST) by the University of Tasmania, in conjunction with the Tasmanian Wildlife Roadkill Collective (WRC). The WRC is convened by the Tasmanian Environment Centre and was founded in 1999. It has representatives from the Tasmanian Environment Centre, the University of Tasmania, three government departments (DTPHA, DPIWE and DIER), and three local councils.

Members of the Wildlife Roadkill Collective are acknowledged for the many hours they have dedicated to this project. Members are: Margaret Steadman (Tasmanian Environment Centre), Sarah Boyle and Stuart Baird (Department of Infrastructure, Energy and Resources), Sue Bell (Tourism Tasmania), Nick Mooney (Department of Primary Industries, Water and Environment), Jenni Burdon (Parks and Wildlife Service, Department of Tourism, Parks, Heritage and the Arts), Ken Thomason (Kingborough Council), Ron Sanderson (Brighton Council) and Rob Mather (Hobart City Council), Lorne Kriwoken and Zoë Magnus (University of Tasmania).

Jed Gillian was heavily involved in this project as DIER Project Sponsor. DIER provided significant financial support and was also responsible for installing the equipment.

The Nature Conservation Branch (DPIWE) hosted the Research Assistant, providing office space, administrative support and many materials. Warwick Brennan (DPIWE) put many hours into publicity and media events. Colin Reed and Ruiping Gao (DPIWE) assisted with Geographical Information System Services. Many of the Administration, Management and Library staff at DPIWE assisted in numerous ways. Paulene Harrowby (University of Tasmania) also provided indispensable administrative support.

Involvement of Councils other than members of the WRC is also acknowledged: Phil Watson (Clarence City Council), Greg Donald, Don Anderson, Lester Jackson and Michael Stone (Devonport City Council).

Several people provided intellectual assistance: Bill Wilson (Environment Section, DPIWE), Sarah Munks (Forest Practices Board, University of Tasmania), Alistair Hobday (CSIRO), David Croft and Daniel Ramp (University of New South Wales), Norman Scott, Michael Frankcombe and Andrea Yates (Queensland Main Roads), Nigel Weston and Miriam Goosem (James Cook University), Bruce McNamara and John O'Donnell (New South Wales Roads and Traffic Authority), Jackie Coglan (Australian Museum Business Services), Patricia Barwick (Greening Australia), Yvonne Hill (Nature Conservation Branch, DPIWE), Chris Spencer (Interfauna Wildlife Consultancy), Helena Bender (University of Melbourne), Peter Scheifele (University of Connecticut), Richard Shaw (University of Tasmania), Peter Davies (University of Tasmania), Rodney Walker and Jed MacDonald (Tasmanian Inland Fisheries Service), John Whittington (DPIWE), Clive Marks and David Obendorf.

Hugh Bailey (CSR Emoleum), Tonya Cochran, Anna Findlater and Geoff King (along with many other people) helped to identify black spots for trial sites. Several people helped with implementing and trialling the measures: David Ayers, Brian Dennis, Graham Porteous, Brian Moore and Ian Connor (Ayers Transport), Simon Burgess (Aurora Energy), Simon Allen (Kingston Beach Golf Course), Milan Prodanovic (DIER), Taryn Laird (DIER), David James, Alistair Dermer, Shaun Thurstans, Andrew McIntosh, Dan Magnus, Steve Langley (Rexel Lighting), Jane Sargison (School of Engineering, University of Tasmania) and Jen Fry (DPIWE).

EXECUTIVE SUMMARY

One of Australia's premier tourist locations, Tasmania also boasts Australia's highest incidence of wildlife roadkill, a sight that often offends tourists. Tasmanian tourism is highly regarded for its wildlife tourism sector, which attracts many visitors to the state to view and interact with wildlife. Tasmanian newspapers and State government departments commonly receive letters and telephone calls from visitors and residents who demand government action to reduce the amount of roadkill on Tasmanian roads. These protests are often based on ethical and aesthetic grounds. Wildlife roadkill can also directly adversely impact on wildlife tourism businesses themselves. Wildlife tourist operators rely on relatively high density, accessible populations of wildlife, so that viewing of wildlife is reliable. In some situations, these populations are threatened by high levels of road mortality. Roadkill also negatively impacts the tourism industry because it represents a risk to driver safety. Reduction in the availability of hire cars due to associated repairs, especially over the summer months, is also a negative impact on the tourism industry.

The objectives of this project were to address these issues by evaluating techniques to reduce wildlife roadkill and discussing suitability and implementation of these methods in Tasmania. A number of techniques were not evaluated, but are covered briefly. The following techniques were evaluated:

- ultrasonic whistles: attached to vehicles to warn wildlife of oncoming traffic;
- overpasses: consisting of rope tied between trees or other structures to allow ringtail possums to cross over the road without coming down to the ground;
- escape routes: moderating obstacles such as batters (roadside 'cuttings') to allow animals to move off the road quickly, even when panicked;
- table drain management: reduction of roadside grass and water aiming to reduce the number of animals attracted to the roadside to feed and drink;
- platypus crossings: increasing the attractiveness to platypuses to travel through the culvert underneath roads rather than crossing over the road surface;
- signage (with night-time speed limits): advisory speed limits which are 20 kph or more slower than the normal speed limit between dusk and dawn; and
- public education: informing people of the negative and dangerous aspects of wildlife roadkill and aiming for fauna-friendly driving attitudes.

The following techniques were not evaluated but are covered briefly in chapter 7:

- underpasses: a variety of structures passing underneath the road, ranging from small concrete culverts to large bridges spanning gullies, usually used in conjunction with wing fencing to provide an alternative route for wildlife;
- reflectors: plastic prisms attached to guideposts, which reflect headlights to prevent wildlife from moving onto roads and to scare wildlife off roads;
- roadside lighting: produces increased visibility which may discourage wildlife from spending time on the road or roadside and/or improve visibility for drivers;
- light-coloured road surfacing: produces a contrast in colour between dark animals and a light-coloured road, which may discourage wildlife from spending time on the road or roadside and/or improve visibility for drivers; and
- odour repellents: synthetic substance manufactured to mimic canine urine to discourage wildlife from roadsides.

Several measures were identified as being likely to reduce wildlife roadkill and/or decreasing visitor distress on account of roadkill. These are: wildlife signage, escape routes, table drain (ditch) management, platypus crossings, underpasses and potentially odour repellents. Ultrasonic whistles, wildlife reflectors and lighting have doubtful application, at least in Tasmania, although managers should follow up on current research in these areas. Light-coloured road surfacing and use of "driving lights" remain as possibilities for further trials. In terms of further research, priority should be given to research furthering our understanding of roadkill events and sites, and wildlife behaviour in reaction to oncoming traffic. This information will better equip research into wildlife mitigation measures.

These results are useful for road management authorities, environmental management authorities, and consultants who provide advice on mitigation of environmental impacts of road developments. This document will enable better roadkill mitigation, which will result in an improved experience for visitors to Tasmania.

Chapter 1

BACKGROUND

One of Australia's premier tourist locations, Tasmania also boasts Australia's highest incidence of wildlife roadkill, a sight that often offends tourists. Tasmanian tourism is highly regarded for its wildlife tourism sector. Almost 50% of visitors to Tasmania participate in some type of wildlife-based activity while visiting the State (DTPHA statistics 2001/2002). Because these people have a particular interest in wildlife, it is likely that they experience more distress due to animal corpses on the roads than would the general tourist and most Tasmanian residents. Tasmanian newspapers and State government departments (Department of Primary Industries, Water and Environment (DPIWE), Department of Infrastructure, Energy and Resources (DIER) and Department of Tourism, Parks, Heritage and the Arts (DTPHA)) commonly receive letters and telephone calls from visitors and residents who demand that the government takes action in reducing the amount of roadkill on Tasmanian roads. These protests are often based on ethical and aesthetic grounds. The complainants believe that it is unethical to be killing so many animals when there may be measures that can reduce the deaths. They are often disgusted by the visual appearance and smell of the roadkill, which detract from visitor enjoyment of the Tasmanian experience.

Wildlife roadkill can also directly adversely impact on wildlife tourism businesses themselves. Wildlife tourist operators rely on relatively high density, accessible populations of wildlife, so that viewing of wildlife is reliable. Two Tasmanian examples of dramatic losses of populations important to local wildlife tourism operators as a result of roads being widened and sealed have been well documented. The widening and sealing of the Woolnorth Road in far north-west Tasmania resulted in the disruption of a Tasmanian devil (*Sarcophilus harrisii*) viewing/filming business due to dramatically reduced numbers of Tasmanian devils, forcing the operator to find a new site (N. Mooney, pers. obs.). The other case occurred along the access road to Cradle Mountain, perhaps Tasmania's most popular tourist destination, where the Eastern quoll (*Dasyurus viverrinus*) population was eliminated and the Tasmanian devil population halved, following the widening and sealing of the road (Jones 2000).

Roadkill also negatively impacts the tourism industry because it represents a risk to driver safety. About 76% of tourists drive themselves around Tasmania, either in hired vehicles (46%), family/friends vehicles (8%) or their own vehicle (22%) (DTPHA statistics 2001/2002). Fortunately, fatalities attributed to collisions with wildlife are relatively rare (3 in the last 10 years), however, car damage (46.2 incidences per year reported to police) and injuries (7.2 incidences per year reported to police) are fairly common (Data from Road Safety Branch, DIER 2001). Reducing incidents of wildlife roadkill will increase the driver safety of visitors driving in Tasmania.

Reduction in the availability of hire cars, especially over the summer months, is also a consideration. When a collision occurs, the hire car is taken off the road to be fixed, thereby reducing the number of cars available for hire, and the ability of the state to capitalize on tourist demand.

This project addressed these issues by evaluating methods to reduce wildlife roadkill and discussing suitability and implementation of these methods in Tasmania.

Chapter 2

PROJECT BRIEF

The project brief was to assess a range of roadkill mitigation methods for their viability and practicality for reducing wildlife roadkill in Tasmania. The methods evaluated were: signage, ultrasonic whistles, escape routes, underpasses, overpasses, table drain management, platypus crossings, wildlife reflectors, lighting, light-coloured road aggregate, and public education.

A review was conducted to determine what research had already been undertaken in these mitigation methods, and whether they were suitable for Tasmanian conditions. Some methods were deemed impractical due to cost (lighting, light-coloured road aggregate), and some methods had been or were being studied in detail by other groups in Australia (reflectors, underpasses and odour repellents). Therefore, these five methods were not included in the current project, but they will be outlined briefly. Aspects of some methods (ultrasonic whistles, overpasses and platypus crossings) were being studied by other researchers, but different facets were considered in this project. Two methods had not been studied by other researchers as far as could be determined (escape routes and reduction of roadside grass and water), so these were included in the current project. Signage and public education were incorporated into this project also. A list of the techniques included and not included is given in the Introduction (Chapter 3).

Chapter 3

INTRODUCTION

Wildlife roadkill is the death of wildlife resulting from collision with a moving vehicle. It occurs because wildlife and people driving vehicles are on the road simultaneously, and cannot predict the behaviour of one another. Wildlife is present on roads for several reasons and becomes victim to roadkill as a result of several factors. These will be discussed in Chapter 4.

There are three spatial scales of roadkill mitigation: black spots, a length of road and a whole region or state. A black spot is a short section of road where many individual animals are killed or where individuals of a species of special interest are killed.

Regardless of the spatial scale at which the mitigation measure is applied, there are two main types of roadkill mitigation measure: changing driver behaviour and changing wildlife behaviour. There are three potential ways of changing driver behaviour. These are:

- Changing driver attitude (by increasing public awareness and helping people understand that preventing roadkill will benefit their community);
- Making people aware of black spots (signage, rumble-strips and/or lighting);
- Physically or psychologically slowing traffic (traffic-calming devices (chicanes or speed humps), road markings to increase apparent speed).

There are three categories of altering wildlife behaviour:

- Discouraging wildlife from loitering on roadsides (by reducing food and water resources or making the road surfaces lighter in colour which may make wildlife feel more exposed on the road);
- Preventing wildlife from crossing roads, at least when cars are present (ultrasonic whistles, reflectors, fencing);
- Providing safe crossings (overpasses, underpasses and escape routes).

It is important to understand why, where and how roadkill occurs as a basis for developing roadkill mitigation measures. This is discussed in Chapter 5.

It will be beneficial for researchers doing further work in the field to refer to the recently developed *Outline Framework for Fauna Sensitive Road Design and Management* (Jungalwalla 2003). This will ensure that the outcomes of the work undertaken can be placed in some context and can be of use to road management authorities as well as other researchers. This is discussed further in Chapter 5.

The methods evaluated during this project (Chapter 6) were:

- ultrasonic whistles: attached to vehicles to warn wildlife of oncoming traffic;
- overpasses: consisting of rope tied between trees or other structures to allow ringtail possums to cross over the road without coming down to the ground;
- escape routes: moderating obstacles such as batters (roadside ‘cuttings’) to allow animals to move off the road quickly, even when panicked;
- table drain management: reduction of roadside grass and water aiming to reduce the number of animals attracted to the roadside to feed and drink;
- platypus crossings: increasing the attractiveness to platypuses to travel through the culvert underneath roads rather than crossing over the road surface;
- signage (with night-time speed limits): advisory speed limits which are 20 kph or more slower than the normal speed limit between dusk and dawn; and
- public education: informing people of the negative and dangerous aspects of wildlife roadkill and aiming for fauna-friendly driving attitudes.

The following techniques were not evaluated but are covered briefly in Chapter 7:

- underpasses: a variety of structures passing underneath the road, ranging from small concrete culverts to large bridges spanning gullies, usually used in conjunction with wing fencing to provide an alternative route for wildlife;
- reflectors: plastic prisms attached to guideposts, which reflect headlights to prevent wildlife from moving onto roads and to scare wildlife off roads;

- roadside lighting: produces increased visibility which may discourage wildlife from spending time on the road or roadside and/or improve visibility for drivers;
- light-coloured road surfacing: produces a contrast in colour between dark animals and a light-coloured road, which may discourage wildlife from spending time on the road or roadside and/or improve visibility for drivers; and
- odour repellents: synthetic substance manufactured to mimic canine urine to discourage wildlife from roadsides.

Chapter 4

UNDERSTANDING ROADKILL

Although there has been a substantial amount of work undertaken on roadkill mitigation measures and fauna sensitive road design, there have been few published studies into where and why roadkill black spots occur (e.g. Clevenger *et al*. 2003, Shaw *et al.*, in prep. 2003). It is generally recognised that more wildlife is killed on roads where traffic is travelling quickly (Jones 2000, Hobday *et al.* unpublished, 2003; Shaw *et al.*, in prep. 2003), and there are other hypotheses regarding the conditions that make wildlife more susceptible to being killed on roads.

Animals are attracted by grass (e.g. Case 1978) and water (N. Mooney, pers. obs) in roadside ditches, which can often remain well into summer, when little food or water is available elsewhere. Food thrown from vehicles (Drews 1995) and existing animal carcasses resulting from roadkill (Forman & Alexander 1998) also attract wildlife. Roads are also used as open spaces for socialising (Case 1978), and for access to new territories for dispersing young (van der Zande *et al.* 1980). Animals are often present on roads simply through the action of crossing to the other side. They can cross roads to gain access to crops, pasture, water or territories (and in other countries, crossing roads is part of a regular migration route for some animals). Aquatic animals such as platypuses and freshwater crayfish are regularly killed on Tasmanian roads when they cross over the surface of the road to avoid travelling through culverts under the road (Mooney & Spencer 2000).

Almost all Australian mammalian wildlife is nocturnal (active at night). This nocturnal habit leads to most encounters occurring in the dark or semi-dark. In addition, most nocturnal mammal species are dark in colour, resulting in low visibility for drivers. Driving at high speeds and inattentive driving also increases the likelihood of collision. Wildlife can become trapped on the road by steep embankments, cuttings or guard rails, thereby unable to escape from oncoming traffic. When panicked by oncoming traffic or dazzled by headlights, animals often exhibit unpredictable behaviour, making it difficult for drivers to avoid collision. Some roads are used by large numbers of heavy vehicles, which can be difficult to slow down or manoeuvre quickly in response to wildlife. These vehicles are generally not easily damaged by wildlife collisions, and drivers often have rigid schedules, discouraging them from slowing down at wildlife hotspots or slowing to avoid incidents. These factors provide very little incentive to avoid wildlife even in situations where it is possible. Additionally, it is common for drivers to be complacent about hitting wildlife and there are instances of drivers actively attempt to hit animals (*The Mercury* 11 Nov 2000, p.3). The combination of inability to avoid collisions, ambivalence and occasional maliciousness are likely to contribute significantly to Tasmania's high roadkill rate (N. Mooney, pers. obs.).

Hobday *et al*. (unpublished data, 2003) has been recording fine-scale information on the distribution and abundance of roadkill along major Tasmanian roads (2001-present), and the relationship between roadkill and roadside attributes. In 2002-2003, an Honours project was undertaken on this topic (Shaw 2003, Shaw *et al.* (In prep. 2003)). Since 2001, the University of New South Wales has also undertaken study in this field, collecting both broad and small-scale information across New South Wales (Ramp & Croft 2002). These researchers have made valuable contributions, but there is still a great deal to be learned.

Shaw (2003) emphasizes the need for information about why and where and how roadkill occurs so that roadkill mitigation can be addressed at the planning stage of road construction. This should enable mitigation measures to be less expensive, more effective and more appropriate.

Most of the wildlife mortality that occurs on roads is constrained to small, specific sections of road, as has been shown by Hobday *et al.* (unpublished data 2003). For example, unpublished data (N. Mooney) show on a specific route that is regularly driven, 78% of roadkills are on corners and 86% of those kills that occur on corners actually occur on the inside of corners. Nearly 80% of the roadkill occurs on three of the 16 corners on the route. Not all roadkill can be avoided, but it is likely that a large proportion of it can be mitigated through predicting where collision risk is high and utilising mitigation measures in those areas.

Accurate locations of black spots throughout Tasmania, on as many roads as possible, should be determined by running a two-year survey using volunteers who undertake a significant amount of driving. This data can be used to examine the effect of road and roadside attributes on black spots, as demonstrated by Hobday *et al*. (Unpublished data, 2003). The resulting data could also be used to create a prioritised list of black spots for road management authorities. This study could adopt a framework established by the University of New South Wales, where ten volunteers set up with GPS units collect information state-wide (Ramp & Croft 2002).

Conclusions

- In formulating solutions to roadkill problems, managers and researchers should utilise the information developed through researching the reasons and locations for roadkill.
- Understanding why, where and how roadkill occurs should be prioritised over research into effectiveness of mitigation measures until adequate information is available to develop effective mitigation measures.
- Mitigation measures are best applied at the planning stage of road construction.
- Accurate locations of black spots throughout the whole of Tasmania should be determined by running a two-year survey using volunteers.

Chapter 5

EVALUATING WILDLIFE ROADKILL MITIGATION MEASURES

The biological aims of evaluating the effectiveness of wildlife roadkill mitigation measures are to establish whether the animals respond to the mitigation measures and whether the viability of local populations is enhanced (van der Ree, In prep.). However, there may also be a number of other aims (for example determining cost effectiveness), depending on who is doing the evaluating and why.

Much of the work done on evaluating mitigation measures in Australia (and probably elsewhere) has not been carried out to the standards required for publication in refereed journals. There are several reasons for this, including:

- funding restrictions resulting in small scale studies;
- project restrictions resulting from timing of road developments;
- studies being undertaken by people who are untrained in experimental design;
- lack of requirement or motivation for the results to be published in a refereed journal; and
- the inherent difficulty of measuring ecological activities, particularly with the added dimension of human behaviour (i.e. it is difficult to organise “control” treatments, and generally studies need to be undertaken over a number of years).

Many of these studies produce equivocal results, and in some cases, resources could have been used more effectively. In addition, because of the small amount of material published in Australia, it is difficult for researchers to review and build on the work already done, also resulting in inefficient use of resources.

Even published studies have been criticised for lack of detailed information (van der Ree, In prep.). Van der Ree (In prep.) undertook a literature review relating to wildlife road crossing structures and found that many studies did not provide enough information for the research to be repeated, or even for the results to be interpreted in the appropriate context.

Jungalwalla (2003) recognises that road management authorities in Australia are also disadvantaged by the lack of consistency in evaluation and reporting of roadkill mitigation techniques and designs. In May 2002, a workshop on ‘The Evaluation of Fauna Management Devices’ held in Hobart, Tasmania, determined that the greatest difficulty in evaluating success was the lack of defined objectives to relate to, together with the lack of set definition of the success of a project (Jed Gillian, pers. comm. 2003). Austroads (the association of Australian and New Zealand road transport and traffic authorities) funded the production of an Outline Framework (Jungalwalla 2003) and Workshop (Austroads 2003) to address these issues.

The framework provides a step-by-step guide for undertaking fauna sensitive road design, including monitoring and reporting, and should be consulted when undertaking any further work in fauna sensitive road design or other roadkill mitigation.

During the investigation period, an email workgroup was set up for those interested in roadkill research, to allow correspondence and sharing of knowledge Australia-wide and internationally. This was deemed important as little has been published in this area in Australia, yet a significant amount of work is being undertaken, often by people who do not know of each other’s existence. The work group currently has 45 members, mostly from Australia and the USA.

Conclusions

- At the planning stage of new projects, considerable thought should be given to what is required for the results to be useful to other researchers and road managers (particularly focussing on appropriate analysis and experimental design).
- The *Outline Framework for Fauna Sensitive Road Design and Management* (Jungalwalla 2003) should be consulted when undertaking any research or other work

Chapter 6

MEASURES EVALUATED

Wildlife Signage

Introduction

Wildlife signage in Australia has typically taken the form of a black animal silhouette (most often a kangaroo) on a yellow diamond-shaped background. While this is a familiar sign to most Australians, and the implication is that it depicts wildlife on the road, it gives no information about what the risk is, or what the driver is expected to do in response to the sign. Also, anecdotal information suggests that some tourists mistake the signs for tourist information about areas for viewing wildlife. It was decided that if signs are expected to have any impact, more information must be provided.

The second issue to be addressed is the variety of different signs currently used, and whether this is advantageous or disadvantageous. In Tasmania and some other parts of Australia, councils have produced specific signs for particular species that are the focus of the roadkill problem in certain places. These are still in the same style as the original signs, but rather than a kangaroo, they depict one of a number of animals such as bettongs, wombats, penguins, bandicoots and quolls. Presumably these signs have become popular because the belief is that people are more sympathetic to special or rare animals than they are to wildlife in general. However, there are a number of arguments against the use of these specific signs.

While they provide more detailed information to the road users, this type of information does not necessarily reduce the risk of a vehicle colliding with roadkill. It is not particularly relevant what type of animal is at risk, because the recommendations remain the same: be aware and slow down. It could even be argued that these specific signs are confusing to the driver. The average road user does not necessarily know what a quoll or a bettong is, as distinguished from other wildlife, and may not understand the relevance of specifying which type of animal is at risk. In addition to this, an important part of functional signage is that the information portrayed on the sign is reinforced by real life experience. For example, if bettongs are portrayed as being at risk, people will begin to ignore the sign if they do not see bettongs on that stretch of road. It is arguably more beneficial to provide a general wildlife warning, which is more likely to be positively reinforced. Furthermore, it is very unlikely that the specific animal portrayed is the only type of wildlife to be at risk on that stretch of road.

DIER was consulted regarding the possibility of introducing clearer signage. It was decided that a single sign should be developed, to be used in all situations, including local government roads. DIER agreed that the WRC would be responsible for the preliminary design.

Methods

The WRC held a meeting and brainstormed ideas. It was agreed that unambiguous information was required. The following were deemed to be necessary components of any signage. The sign must:

- portray the risk to human safety/car damage;
- portray the risk to wildlife;
- provide a regulatory or advisory speed limit;
- make it clear that the sign is relevant from dusk to dawn, preferably in writing and in the graphics;
- display the word "wildlife" or "wildlife zone"; and
- attempt to make the sign simple but striking.

As a result of this workshop, several ideas were developed, including:

- depicting a car with headlights approaching a wallaby-type animal (because this obviously represents wildlife), on a black background with a legal speed limit and the words "wildlife zone" and "dusk to dawn";
- a copy of the school children sign, replacing the children with a wallaby/kangaroo and the words "dusk to dawn" instead of "shared zone" and a legal speed limit; and
- a sign based on a South Australian sign in three parts – picture at the top, speed limit in the middle and words at the bottom.

It was anticipated that there might be a second sign attached to the same pole that specifies how many kilometres the zone lasts for (e.g. “next 5 km”).

After seeing a conference presentation and attending field trips in Far North Queensland, it was decided that the image on the sign could be based on Queensland Main Roads’ cassowary signs: a car colliding with a cassowary and denting its bonnet and smashing the front window, with the cassowary’s body “dented” also. The cassowary was replaced with the generic wildlife symbol, a kangaroo, and the image was incorporated into the three-part sign (figure 1).

The regulatory speed limit was not supported by DIER, because of difficulty in policing the areas and expected resistance from local people. However, DIER did allow an advisory speed limit (which must be an odd number, such as 65, 75 or 85 km/h).

DIER installed the signs in two locations: the Bruny Island Neck (recommended night-time speed of 45 kilometres per hour cf regulatory speed limit of 100 km/h) and the Coles Bay Road (recommended night-time speed of 65 km/h cf regulatory speed limit of 100 km/h). The two signs at Bruny Island were installed in February 2003 and are at each end of a 2.7 km stretch, one facing northbound traffic and the other southbound traffic. The five signs at Freycinet were installed in April 2003 and are at each end and in the middle of a 25 km stretch, facing both northbound and southbound traffic. Car speeds were monitored at Bruny in January and May and at Freycinet in January and June 2003.

It was not practical to monitor roadkills in these areas because of the length of time required to collect enough data for meaningful analysis. Dique *et al.* (2003) had five years of data collection, whereas the time span for this project was only a few months.

Figure 1: Sign designed by WRC
(top half is white on black and bottom half black on yellow)

Results

Expenditure: The two signs erected at Bruny Island cost $1753 to produce and erect. The five signs at Coles Bay cost $2976 to produce and erect.

Unfortunately, the results from the speed trials were not comparable, as the “before” data were collected in summer (January), and the “after” data collected in winter (May/June). At Bruny Island, there is approximately twice as much traffic in January as in June (Data from DIER, 2003), which is probably mostly due to tourist activity. It is likely that tourists drive more slowly than locals, and also that the increased amount of traffic results in slower speeds, especially as the traffic is mostly from the ferry, so has an uneven distribution throughout the day. Therefore, results from these two months can not be compared. Speeds will be measured again in January 2004.

There is anecdotal evidence that traffic speeds on the Bruny Island Neck have reduced significantly as a result of the signage (Bernard Edwards, Parks and Wildlife Ranger, pers. comm.).

Discussion

It is interesting to note that traffic speeds may have reduced, at least on Bruny Island as Dique *et al.* (2003) found that traffic speed did not decrease as a result of the signage they trialled. If the speed has decreased, it is possible that habituation to the signage could result in the speed reduction being only a short-term effect (or perhaps seasonal as a significant proportion of traffic on these roads is local residents rather than tourists). The signage does not provide new information to local people, as they already know that there is wildlife on the roads, and that collisions occur regularly.

However, it is important to consider that even if the signs do not reduce vehicle speed or collision rate *significantly*, they almost certainly have an effect on some individuals, and are therefore worthwhile. Signs are important in improving public awareness and perceptions of government action on roadkill, particularly those of tourists, and are therefore an important part of the overall roadkill package. Signage can also be regarded as the government’s responsibility with regards to “duty of care”. That is, the government is obliged to inform people of dangers present at particular locations.

One of the main problems with signage to date has been the lack of clear guidelines as to where signs should be installed. Signs are most often installed due to requests from the public. In Tasmania, these requests go to numerous government departments and local councils and there is no one person or process that deals with the requests. In most cases, it is not clear to the person who receives the request whether or not the site in question is a genuine black spot, and if it is, whether it should be prioritised over other black spots. Even if the black spot is a genuine priority, signage is not necessarily the best method of mitigating roadkill at that site. A Draft protocol for determining and prioritising black spots for treatment has been established (see Appendix A), which will assist those who deal with signage requests and other black spot information from the public.

It has been suggested that to make the new signage clearer, the kangaroo could be portrayed as being more obviously injured, which could be achieved by mirroring the kangaroo image and placing jagged cracks through its body.

A suggestion has been made that seasonal signage may be appropriate in some areas where roadkill is only frequent at particular times of year. This is a good idea, but might be unrealistic due to the added work in having to erect and remove the sign at appropriate times. Therefore each individual should decide whether or not it is practical for their organisation.

Conclusions

- "Post-installation" monitoring should be undertaken at the trial sites by DIER to clarify whether vehicle speed has been reduced by the presence of the signs. This should be done at the same time of year as the "pre-installation" monitoring to take into account seasonal variation in traffic speeds.
- Whether or not signage can be shown to reduce roadkill, it should be adopted as a roadkill mitigation measure by State and local government as their "duty of care". DIER might consider slight alteration of the sign design before installing it at other locations.
- Locations for signage should be designated sparingly to avoid habituation, and should be assessed using the "Draft "protocol for determining and prioritising black spots for treatment" (see Appendix A).

Ultrasonic Whistles

This work has been submitted to a refereed journal (Wildlife Research) and is summarised below. Please contact one of the authors if further information is required before the manuscript has been published. Authors: Zoë Magnus, Menna E. Jones, C.W. (Bill) Wilson, Nicholas J. Mooney, Leon A. Barmuta and Lorne K. Kriwoken

Introduction

Ultrasonic animal alerts are often promoted as a cheap, simple way to reduce the chance of wildlife-vehicle collisions. The Hobi "Ultrasonic Animal Alert", a small air-driven whistle used in the current study, was designed to be attached to the outside of a vehicle. It was first developed in Austria in 1979 to deter deer from running out in front of vehicles. The whistle was then produced in the USA and since 1985, in Australia. There have been very few published studies of the effectiveness of the air driven whistles (see Romin & Dalton 1992, Scheifele *et al*. 2003). The one Australian study of ultrasonic whistles (Bender, 2001) examined the electronic device rather than the air-driven whistle considered in the present study.

The three overall aims of this study were to determine:

- what type of sound the whistles actually emit and whether this is likely to provide a warning to wildlife;
- whether the air-driven whistles result in differences in the behavioural responses of animals (mainly wildlife species) on and near the road to an oncoming vehicle, compared with the response to a vehicle without whistles activated; and
- whether use of the whistles results in an increase in safe as opposed to dangerous behaviour by wildlife on the road.

Methods

Acoustic tests were undertaken to determine the characteristics of the sound produced by the whistle, and whether this was able to be distinguished over the noise of the vehicle. The acoustic study included drive-by tests and tests using a wind-tunnel. Field trials were undertaken to assess whether there was any difference in wildlife behaviour when the whistles were activated or not activated. The whistle was activated and deactivated without informing the driver (blind test).

Results

During the acoustic tests, one-third octave and narrow band levels indicated sound from the whistle between 3800 and 4500 Hz, with a peak emission at 4100 Hz. At other frequencies there was no difference between the results with and without the whistle. The sound pressure level of the whistle was 3 dB above the sound pressure level of the test vehicle.

There was no observable difference in behaviour of animals (four categories: moved across the road, moved along the road, moved away from the road, stayed still) when the whistles were activated and not activated. There was no significant difference between the number of animals hit when the whistles were activated (N=18) compared with not activated (N=21).

Regardless of whether whistles were activated or not, most species showed distinct preferences for one or more types of behavioural response ("crossed the road", "moved along the road", "moved off the road", and "froze"). These preferences varied between species.

Of the animals observed during the study, 2.7% were run over by the vehicle. There was a tenfold difference between the most frequently hit species, Tasmanian devils (*Sarcophilus harrisii*, 7.87% of devils observed were hit) and the least frequently hit species, Brushtail possums (*Trichosurus vulpecula*, 0.78% hit).

Discussion

The "Hobi ultrasonic animal alert" appears to have a peak emission at 4 100 Hz, which is within the range of human hearing. Although the whistle emitted a slightly louder sound at this frequency range than the test vehicle, it is expected that the sound of the car across the audio spectrum would completely mask the sound from the whistle.

This study provides no evidence for a representative range of Australian marsupial species (carnivores, macropods, possums, wombats) that ultrasonic animals alerts can be detected or result in behavioural responses that reduce the risk of roadkill. However, sounding the car horn has been observed to have a positive response from wildlife in the cases where there is enough time for the driver to respond in this manner (N. Mooney & Z. Magnus, pers. obs.). Drivers involved in the study also suggested that the 'driving lights' used on their vehicle appear to result in fewer animals being hit. These two methods could be trialled to determine how effective they are.

The data do show that different species respond to oncoming traffic in different ways that may increase or decrease their susceptibility to collision with a vehicle. Knowledge of these behaviours could be usefully incorporated into the design of mitigation measures.

Conclusions

- Ultrasonic whistles should not be considered as a genuine roadkill reduction method.
- The use of "driving lights" and car horns should be trialled as roadkill reduction methods.
- The information on responses of different species to oncoming traffic should be used in developing new mitigation measures and selecting appropriate measure for particular black spots.

Canopy Crossings

Introduction

The removal of trees associated with road construction produces a gap in the forest canopy that forces arboreal (tree-dwelling) species to come to the ground to travel across the gap. This situation is exacerbated because these animals are forced to cross the road, where they are in danger of being hit by passing traffic. Canopy crossings have been constructed for red squirrels (*Sciurus vulgaris*) in Great Britain (Norwood 1999), Colobus monkeys (*Colobus angolensis*) in Kenya (Colobus Trust 2002) and ringtail possums (*Pseudochirops archeri*, *Pseudochirulus herbertensis*, *P. cinereus* and *Hemibelideus lemuroides*) in Far North Queensland, Australia (Weston 2000, 2003). The crossings have two purposes: to ensure that roads do not restrict movement of animals and also to reduce roadkill. These crossings have all been effective to some degree, and so it was decided to trial them in Tasmania, with the Tasmanian species of ringtail possum. In Far North Queensland, the bridges were originally designed as a rope tunnel that the animals could travel through, so as to be protected from predators (Weston 2000, 2003). However, it was found that the possums travelled over the top surface of the tunnel, rather than through the middle, so the next bridge had a simple design of a horizontal rope ladder. The animals that use this bridge walk along one edge of the bridge rather than using the rungs of the "ladder", but it is thought that the ladder design might increase stability. However, use of single strands of rope would be a lot more efficient in cost and time, and it was thought to be likely that ringtail possums would be just as capable of using a single strand of rope as a rope ladder configuration.

Methods

A site was chosen on the Tasman Highway, between the "Tasmania" golf course and the Sorell Causeway because of its reputation as a ringtail possum black spot, and because road works were occurring there, which would provide opportunities for having the crossings erected using machinery available on site, and taking advantages of road closures to do the works. Unfortunately this site had to be abandoned as most of the trees that were selected were felled as part of the road works.

An alternative site was chosen in co-operation with the Kingborough Council, on the basis of regular kills of ringtail possums. This site was on the Channel Highway near the Kingston Beach Golf Club, 100 metres north of Browns River. On one side of the road, some remnant bush (*Eucalyptus obliqua* dry forest) remains on the residential properties. The golf course is on the other side of the road, and there are few trees on the roadside.

A small network of bridges was constructed, in order to increase likelihood that possums would use them. Two bridges crossed the road, about 100 metres apart, and three bridges connected trees between the two road crossings, on the bush side of the road.

One road crossing was constructed between two power poles. Aurora Energy, Tasmania's electricity distributor, volunteered to connect this bridge and two others that led from the poles into the bush, using an elevating work platform truck. DIER contracted a tree-climber to install the other bridges, and purchased the materials.

Twelve millimetre double braid yachting rope was used to construct the bridges. The rope was melted at each end to prevent fraying, and tied on to the tree (with plastic sleeves in between to prevent injury to the tree) or power pole. Aurora Energy screwed eyelets into the power poles for the rope to be tied onto, and attached sheet metal onto the poles above the bridge connection points in order to prevent possums from climbing higher and accessing the power lines.

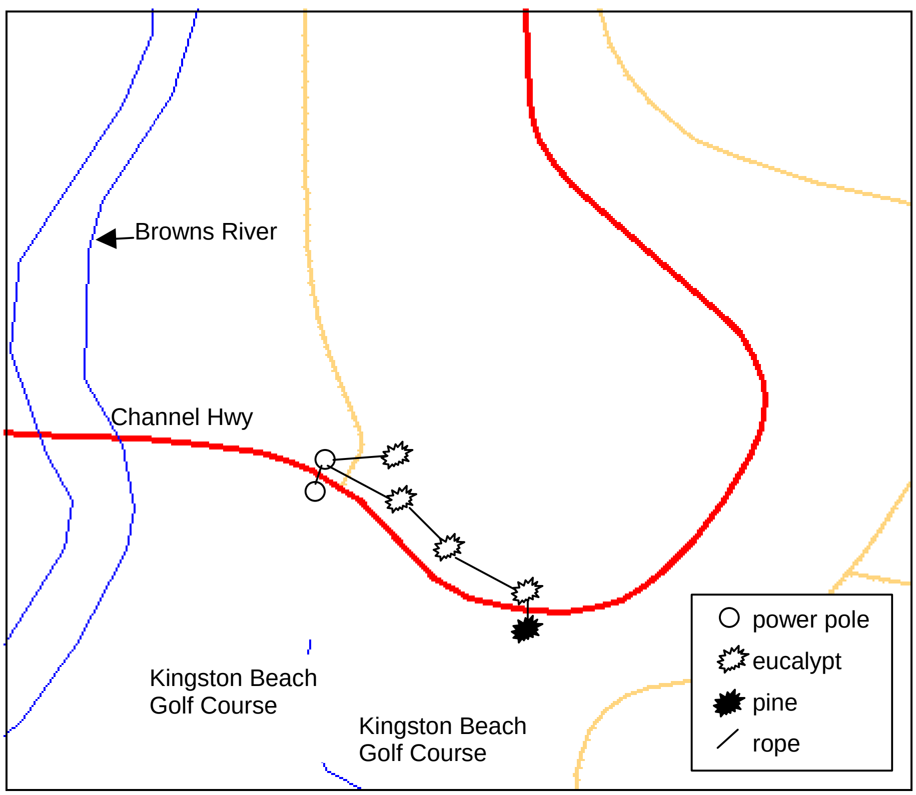


Figure 2: Map of canopy crossing site *(not to scale)*

The two road crossing bridges were monitored by two people watching for three-hour periods from dusk. This occurred on two occasions, and then scat nets were constructed to catch droppings from any animals crossing the bridges. The first scat nets that were constructed ran underneath a 5 m length of a crossing. This was constructed of 900 mm width flywire, 5 mm cord and 1.2 m garden stakes to hold the four corners. Because this net also ran under boughs, it was not certain whether scats caught were from possums on the crossings or on the boughs. Thus, a different type of net was constructed underneath the power poles, where no boughs could interfere. These were constructed by drilling brackets onto the power poles and suspending the flywire between the brackets (see Fig. 3).

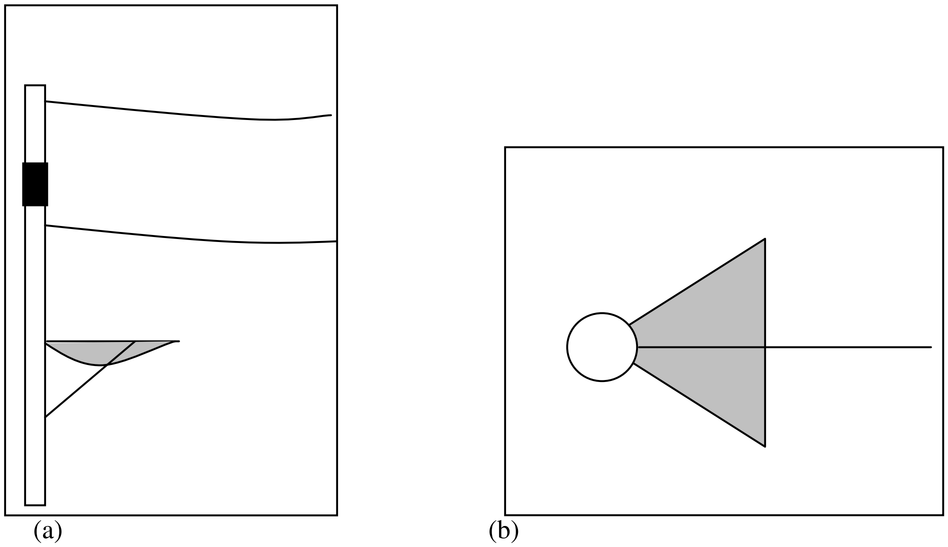


Figure 3: Diagram of canopy crossing: (a) Side view (b) Plan view - scat net attached to power pole

Results

Expenditure: For five crossings, approximately 200 metres of rope was used, which cost $495. The tree-climber was paid $400 (5 hours work) and Aurora contributed $480 in use of the elevating work platform truck and two staff for 3 hours work. The hardware for the scat nets cost $57. In total, $1427 was expended.

Although ringtail and brush tail possums were sighted regularly in the trees where the network of rope bridges were, no possums were sighted using the bridges during the observation period. Numerous ringtail possum and brush tail possum scats were collected in scat nets slung between trees under one of the bridges, but a large bough and some small branches also crossed over the net, and the scats could have come from animals on the bough and branches. No scats were collected in the nets attached to the power poles.

Discussion

Although ringtail possums were not observed using the canopy bridges, it is quite likely that bridges of this design will be used by ringtail possums if they are placed in suitable locations. Ringtail possums are known to balance on fencing wire when pulled reasonably taut (Anna Court, wildlife carer, pers. comm., 2002), and on 8mm wide, 50m long aerial stay wires which are used between power poles across roadways (Simon Burgess, Aurora Energy, Pers. Comm. 2002).

The crossings we put in place were much longer than the ones found to be successful elsewhere, which may increase exposure to predators, however ringtails have been observed crossing exposed power lines on several occasions (M. Jones, pers. obs.). Increased instability from a longer bridge is unlikely to be an issue for this species because of their ability to use long sections of 8 mm power lines.

The site was not conducive to the crossings being successful, as there were very few trees on the Golf Course side of the road, so the power poles and pine tree had to be used, rather than a tree that might be attractive to the possums for feeding.

Ringtail possums are habitual animals and tend to follow the same route for long periods (Sarah Munks, University of Tasmania, pers. comm. 2002). It has been suggested (Yvonne Hill, pers. comm., DPIWE, 2002) that scenting the rope with ringtail possum urine may attract the possums to the crossings, which may then become part of their established route. This was not found to be necessary in Queensland (Nigel Weston, pers. comm.).

Conclusions

- Installation of the canopy crossings was relatively quick and cheap, and it is recommended that they are installed at other locations where ringtail possum roadkill is frequent, particularly if the site is more conducive to such a construction.
- When other canopy crossings are installed, monitoring should take place in order to gain information on favourable conditions for success of these structures.

Escape Routes

Introduction

Shaw *et al.* (In prep. 2003) has recently confirmed the hypothesis that banks, cuttings and fences that trap animals on the road are associated with roadkill. After high traffic speed, wildlife becoming trapped on the road explained most of the roadkill that occurred during their study (Shaw *et al.* In prep. 2003). In order to increase the likelihood of escape from the road, escape routes have been constructed on the access road to Cradle Mountain National Park (Jones 2000). These escape routes span deep, steep drainage ditches on the roadside, which may prevent animals from moving off the road on the approach of a vehicle. The gaps have been spanned by placing a 2 m section of 300 mm culvert pipe in the drain, parallel to the road, and constructing a gravel ramp over the culvert, to create access to the bush. The escape routes were constructed at approximately 25 m intervals. The escape routes were not trialled independently as part of Jones' (2000) study, as several measures were installed simultaneously in an urgent effort to slow the huge increase of roadkill after the road was widened and sealed. However, although it is not known whether the escape routes are being used in emergencies, or whether they are effective in reducing roadkill, it is known that animals are using the escape routes, possibly as part of their daily movement (M. Jones, pers. obs.).

It was hoped that the efficacy of escape routes could be tested as part of this study. However, due to the small budget and lack of time available, this was not possible. It is a simple procedure to determine whether animals are using the routes or not, but more complicated to determine whether they are using them to escape in emergencies, and whether the routes are reducing roadkill.

DIER constructed three escape routes on the Arthur Highway in south-east Tasmania. Although the escape routes could not be monitored, this project was able to provide information on

- Cost of different types of escape routes
- Difficulties encountered in allocating space for escape routes
- Difficulties encountered in construction of escape routes

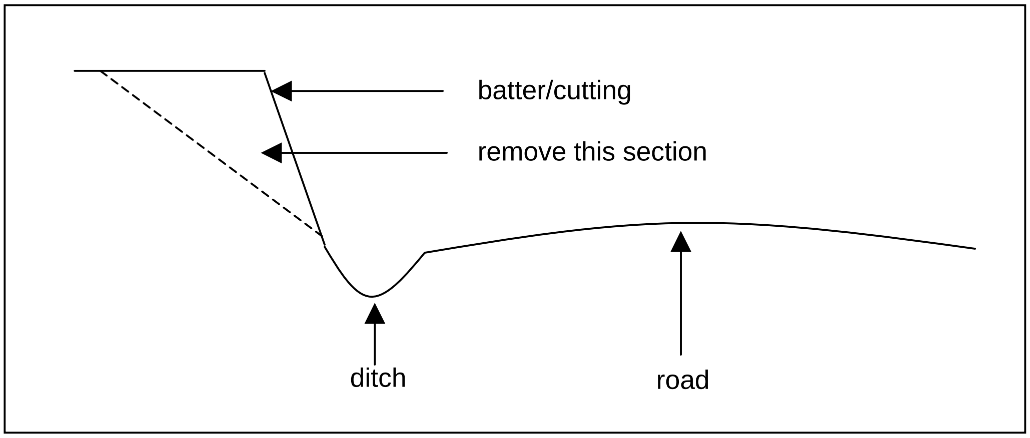
This information can be used in advising state and local government on the suitability of escape routes for particular projects.

Methods

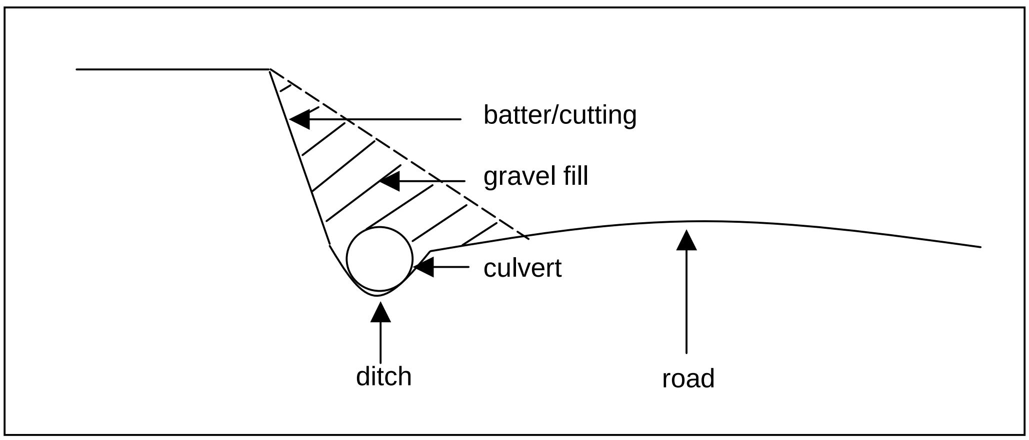
Eight prospective sites were put forward to DIER by the Research Assistant. The sites were visited and assessed for boundaries onto neighbouring properties, threatened species, and cultural heritage. Two of the prospective sites were abandoned because the road reserve was not wide enough and to install an escape ramp would have necessitated acquisition of land from the landowners with adjoining properties. One was discounted due to road works having taken place at the site after the site was proposed. There were no threatened species or sites of cultural significance identified.

The sites that were deemed suitable were evaluated for the cost of installing escape routes. Three sites on the Arthur Highway were selected on the basis of cost and practicalities. Escape routes were installed at these three sites, using two of the three possible methods (concept designs illustrated in Fig. 4.).

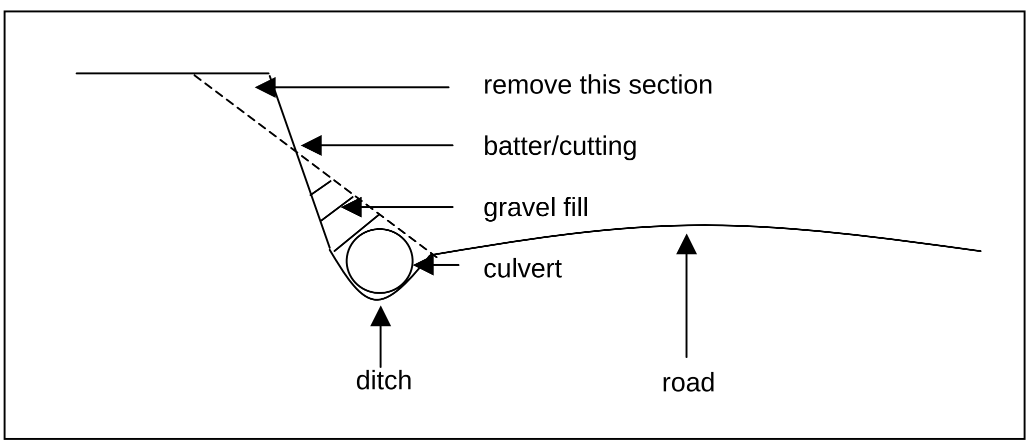
Figure 4: Concept designs of three potential cut batter treatments



(a) removal of material



(b) construction of ramp



(c) removal of material and construction of ramp.

Two of the escape routes were built using method (a) (approximately 75 metres long), and one using method (b) (approximately 3 metres long).

Results

Expenditure: the estimated costs of the escape routes ranged from $750 to $11 246 (average $3985). The three escape routes that were actually constructed cost approximately $21 600 in total. The two longer sections, constructed using method (a) (laying back the batters), cost $7410 and $10296. The 3 m section treated using method (b) (ramp construction) cost $3926.

Monitoring of the success of the escape routes was not practical due to the small number constructed and the time restrictions of the project.

The more expensive escape routes to construct were those involving removal of hard material (method (a)). The escape route constructed by method (b) was cheaper, even though it involved the purchase of culvert, concrete endplates and gravel. However, it was only 3 metres long, whereas the others were 75 metres long.

Escape routes of types 1 and 3 were only practical where there was an adequate amount of space between the top of the batter and the edge of the road reserve. Escape routes of type (b) were only practical where the distance between the road edge and batter was not too small.

Discussion

Given the relative costs of the different types of escape routes, it may be more practical to produce several short type (b) escape routes (which only need to be 50 cm wide) over a 50 metre distance, rather than one long type (a) escape route. However, from a maintenance perspective, it is preferable to have continuous table drains, as they are easier to maintain than culverts which can become blocked and require cleaning out. One solution would be to construct several shorter type (a) escape routes over a larger distance.

It is much more efficient to include escape routes in road designs and construct them at the time of road construction when all equipment is on site.

There are two main methods by which escape routes could be tested. The first is to collect roadkill data for at least three years at a minimum of 10 sites where animals are suspected to become trapped on the road, then install escape routes at all sites and monitor for a further three years. In this regime, there should also be another 10 sites that are monitored throughout, without treatment, to ensure that there are no general changes in roadkill rates attributed to another factor, but coinciding with installation of the escape routes. The second method is to install several escape routes, and monitor them by performing thousands of "drive-by" tests, in order to determine whether animals are using the escape routes in reaction to the approach of the vehicle. A variation of this second method was considered where the escape routes could be filmed with a video camera, to avoid performing the drive-by tests. In this variation, the researcher would be dependent on general traffic to induce use of the escape routes. Both of these methods were excluded by the project budget, and the budget that DIER was able to allocate to the escape routes.

Another potential method for studying the efficacy of escape routes is to examine natural escape routes as opposed to barriers. This would involve driving at night on a road that has many barriers and natural escape routes and noting the behaviour of animals in response to an approaching vehicle when either barriers or natural escape routes were present. Incidental observations of this type at Cradle Mountain formed the basis for the decision to install escape routes on the Cradle Mountain Road (Jones 2000). Hundreds of recordings would be necessary to obtain enough data. Shaw *et al*. (In prep. 2003) were able to gather similar information by collecting roadkill data in relation to roadside features. Although not a direct measure of the efficacy of escape routes, it is considered that their conclusion (that wildlife being trapped on the road is an important cause of roadkill) provides enough evidence that escape routes are an important roadkill mitigation measure.

Using a similar method to that described above, some qualitative data was collected by one of us (ZM), which suggests that escape routes are highly successful. The information was collected while driving on a narrow gravel road cut into a hillside (i.e. steep bank on one side and steep drop-off on the other side), with dense bush on both sides. When an animal was present on the road, rather than stopping to let it past, the car would be driven at an appropriate speed to pursue the animal along the road and observe where it would exit the road. Mostly, animals ran along the middle of the road until a driveway or clear, flat ground was available for its escape. Sometimes the animals used the animal tracks on the roadside, but usually they ran straight past them, perhaps dazzled by the headlights.

Conclusions

- Escape routes should be considered as one of the most useful and imperative measures, especially when new roads are being built or roads are being upgraded, widened or sealed.
- Research should be undertaken into the efficacy of escape routes, probably by observations of animals' response to vehicles in places with natural escape routes and barriers, rather than trialling purpose-built escape routes.

Table Drain Management

Introduction

Wildlife can be attracted to the road by water in roadside drains (ditches) and/or herbaceous vegetation growing by the roadside as a result of run-off from roads. It is thought that reducing these resources could reduce the amount of wildlife attracted to the road. However, threatened flora issues should be considered.

There are several potential means of achieving a reduction in roadside water and green pick. To reduce water, drains could be lined with concrete so that the water would drain away quickly rather than pooling in the drains, or fill the drains with boulders to prevent access to water while allowing water flow. To reduce vegetation growth of herbaceous weeds on the roadside, the affected areas could be regularly sprayed with a biodegradable herbicide. The roadsides could be lined with concrete or bitumen to prevent plant growth, but this would be expensive and would also require cleaning and maintenance. Slashing is not a feasible option, as it encourages the growth of new shoots, which are thought to be particularly attractive to grazing wildlife. This may actually increase the amount of wildlife attracted to the roadside. Given this information, the road maintenance authority is likely to make the best decision on the most appropriate methods, using a site by site analysis.

Clarence City Council and Devonport City Council both assisted the current project by undertaking small-scale trials, using herbicide to reduce roadside herbaceous weeds.

Methods

In both Clarence and Devonport Municipalities, sites were chosen by council staff who had local knowledge. The sites were both areas in which roadkill had been regularly recorded and substantial herbaceous weeds were present. The trials were carried out in the summer of 2001-2002.

The Clarence site, at Flagstaff Gully Road, was 600 m long. The site was divided into 6 x 100 metre sections, 3 of which were treated with herbicide on both sides, and 3 were left as control sites. It was planned that in the following year, the treatments would be swapped. The Devonport site, at Durkins Road, was also 600m long, and treated in the same manner as the Clarence site. Between December 2001 and February 2002 at both sites, the roads were regularly travelled by council staff in order to record roadkill, and in which section it occurred.

Results

Expenditure: To treat one hectare of herbaceous weeds costs approximately $110. One hectare equates to a 2 m strip approximately 5 km long, so to treat a 10 km section of road on both sides (2 m width) would cost approximately $440.

No roadkill occurred at either site.

Discussion

The summer of 2001-2002 was particularly wet, resulting in food and water being freely available to wildlife, which may have resulted in fewer animals being attracted to the road to feed. It is likely that the trial sites were too small, even though roadkill rates would have been higher in a dry summer, and so the project was terminated after the first year. However, the information gathered is still useful as a pilot study, which will provide background for any future trials.

Although roadkill is perceived as being common, it is a fairly rare occurrence on each specific section of road. In order to gain meaningful results from a trial such as this, a much longer section of road must be treated, in the order of tens of kilometres (e.g. 20km), and each section must be at least 1 km in length. Mooney (unpublished data) has recorded up to 40 animals per km per month on Grass Tree Hill Road, Risdon, Tasmania.

Boundary effects occur when a carcass is recorded near the boundary between one treatment and the other treatment. In this situation, it is unclear which section the animal was in when the vehicle first approached. The boundary effect could be removed by discounting any carcasses that occur within a certain distance of the boundary. This distance would depend on the mobility of the species.

Conclusions

- In areas where roadkill of herbivores is an issue, herbaceous roadside vegetation should not be slashed or mown, as this creates new growth which is attractive to herbivores.
- Table drain management should be considered where the roadkill problem is perceived to be related to wildlife being attracted to the road by food and water resources which are present due to the road design (e.g. water in table drains and associated fodder).

- This type of mitigation measure should be dismissed in cases where it influences threatened plants or communities existing in the area. Wildlife behaviour and threatened flora experts should be consulted.

Platypus Crossings

Introduction

Platypuses (*Ornithorhynchus anatinus*) in Tasmania often avoid using culverts to cross underneath roads, preferring to leave the watercourse and cross over the road (Mooney & Spencer 2000). Thus, platypus mortality on Tasmanian roads, while reported less frequently than many other terrestrial mammals, could be quite significant at a local level as the populations of minor water courses may be small with individuals foraging over large areas (Grant & Denny 1991). The platypus home range is at least 4-5 km of stream length, and they are known to forage over several kilometres per day (Grant 1991). Thus, many platypuses may have to negotiate several road crossings each day, perhaps resulting in a significant percentage of particular populations being killed on roads (Grant & Denny 1991). Otley & Le Mar (1998) suggest that in water systems with a large number of culverts, local extinctions of platypuses may occur.

Methods

To undertake primary research on this topic would be a significant task, requiring several years' full-time work. Therefore, it was decided that a literature review, discussion with interested parties, and preliminary analysis of some of the available anecdotal information would be a more practical way of reaching interim conclusions, and documenting future work and research needs. A half-day workshop was held to discuss existing information on platypus avoidance of culverts and to develop interim recommendations and set priorities for further work. The outcomes of this workshop are summarised below (for full report, see Appendix B).

Results and Discussion

It was decided that a substantial amount of data already exists on culvert avoidance by the platypus in the form of published literature, databases and anecdotal evidence.

Four measures were proposed to ameliorate platypus roadkills at new culvert sites:

- Installation of 'bio-baffles' to assist passage through the culvert,
- Provision of suitable access to culverts,
- Provision of an alternative dry passage culvert and
- Installation of funnel fencing to encourage the platypus to use the culvert rather than to go up and over the road.

Priorities for further work included:

- Approaching road development agencies to include the four platypus roadkill mitigation measures in their environmental policies;
- Analysis of existing data (including literature and databases) to improve knowledge of platypus avoidance of culverts.
- Reviewing current literature and databases and interviewing relevant people to identify and prioritise sites to be retro-fitted with mitigation measures,
- Undertake further research into mitigation measures and monitor the effectiveness of proposed measures.

The full report has been circulated to all workshop participants and some other interested parties and has been submitted to the DPIWE library (Culvert avoidance by platypus, and subsequent road deaths: workshop aims and outcomes, Appendix B).

Conclusions

- All road-building agencies should include recommendations of the platypus roadkill report in their road-building policies.
- Existing data should be reviewed and analysed in order to deepen understanding about the reasons for platypus avoidance of culverts and potential solutions.
- The existing information should also be used together with interviews, as part of a state-wide survey of black spots, in order to determine which sites should be retro-fitted with platypus roadkill mitigation measures.
- A decision-tree must be prepared to assist with prioritising existing black spot sites for retro-fitting.
- Further research should be undertaken. This should be directed towards studying the efficacy of mitigation measures such as bio-baffles, funnel fencing, improving access and dry passage.

Chapter 7

OTHER MEASURES

The following measures were considered but not trialled in the current project. Some of these measures have been trialled elsewhere in Australia or overseas.

Underpasses

Introduction

Underpasses for wildlife have been and continue to be studied in Australia and overseas, with some shown to be successful (e.g. Mansergh & Scotts 1989, Goosem *et al*. 2001, Clevenger *et al*. 2001). Underpasses can be of varying types and sizes, from bridges spanning dozens of metres over gullies to 30 mm diameter culverts underneath roads. Generally fencing in conjunction with the underpass is necessary, to guide animals through the underpass, particularly for the smaller underpasses which have narrow entrances. Funnel fencing (constructed at an angle leading away from the road) is preferred because fencing constructed along the roadside can trap animals on the road. A range of one-way gates have been designed to let animals off the road when they become trapped by fencing (e.g. Reed *et al*. 1974), however these have not been widely adopted in Australia. Refuge culverts are being trialled on the outside of such fences at several underpass sites in Tasmania (work in progress, NJM).

Several studies have shown that a wide range of species will travel through underpasses (e.g. Clevenger *et al*. 2001, O'Donnell 2003 in Austroads 2003). Tasmanian devils are known to use underpasses even before fences have been constructed (N. Mooney, pers. obs.). There has not been much research undertaken, however, on how many individuals of each species use each underpass, and whether underpasses have any impact at the population level (van der Ree, In prep.). Underpasses may also be beneficial for maintaining animal movements and gene flow either side of large roads.

The same issue, of increasing predator advantage, has been raised with underpasses as with canopy crossings (see chapter 6).

Potential Use of Underpasses in Tasmania

More research needs to be undertaken into whether wildlife use of underpasses and the associated decrease in road mortality is effective on whole populations or just individuals. However, underpasses do seem to be successful at least at the individual level, and can be relatively cost-effective to install, if the small culvert type is used and if installation occurs at the road-building or upgrading stage, rather than having to be retrofitted.

Underpasses are more likely to be useful for the smaller Tasmanian mammals and those that use burrows (Tasmanian devils, quolls, bandicoots, wombats etc). Larger animals (such as wallabies and kangaroos) are unlikely to use underpasses unless the underpass is very large (e.g. a bridge spanning a gully), as a tunnel may represent a predator trap (Hunt *et al.* 1987).

Conclusions

- Small underpasses (consisting of 300-450 mm diameter culverts and wing fencing) should be installed in areas where roadkill of smaller mammals (e.g. Tasmanian devils and smaller) is a problem. It is probably not practical to use underpasses for larger wildlife in Tasmania due to the expense of constructing large underpasses.
- Installation of underpasses is best done during road upgrade or construction rather than as a retrofitting activity, except in exceptional circumstances.

Reflectors

Introduction

Swareflex wildlife reflectors are small plastic prisms attached to guideposts on the roadside. Because of their triangular cross-section, they reflect vehicles' headlights onto the roadsides, creating an optical barrier to wildlife, which is supposed to scare wildlife away from the lights, or prevent them from crossing the optical barrier created by the reflected light. Swareflex reflectors were developed in Austria for mitigation of deer roadkill, and have since been adopted by an American company, Strieter-Lite, which uses a different design (reflectors face into the middle of the road, and are designed to scare animals off the road surface).

Two US studies on the Swareflex reflector's effects on deer produced conflicting results - one found that the reflectors reduced roadkill dramatically (Schafer & Penland 1985) and the other found no effect (Reeve & Anderson 1993).

The reflectors have been adopted by some Australian road managers in the hope that they will be effective on kangaroos and other Australian wildlife. There have been several studies undertaken in Australia, which have had equivocal results (e.g. Sheridan 1991), probably due to lack of sufficient resources to undertake thorough research.

Reflectors are currently being trialled by the University of New South Wales (Dr Daniel Ramp and Dr David Croft). These researchers have a two-year grant, which has been extended to five years, to study the reflectors and also odour repellents. To date, they have undertaken preliminary trials with conflicting results (Ramp & Croft 2002). Field trials at UNSW have been delayed due to the drought in NSW decreasing kangaroo numbers, resulting in kangaroo populations not dense enough for effective study (Ramp & Croft 2002).

Potential usefulness of reflectors in Tasmania

Swareflex reflectors were designed to work by stopping animals from approaching the roadside. Therefore they can not be effective on animals that are already on the verge or road itself. In Tasmania, it is likely that most wildlife is already on the road or verge when the car approaches (Z. Magnus, pers. obs.). Tasmanian devils and quolls are often on the road scavenging on carcasses, and herbivores are often attracted to the roadsides by the green grass growing there due to run-off from the road (N. Mooney, pers. obs.). The exception may be some forester kangaroos and Bennetts wallabies, which may be traversing the countryside.

In comparison, deer migrate hundreds of kilometres, crossing roads en route, so they may actually be far away enough from the roadside to be halted by the "light fence". The same might apply to the large kangaroo species, and perhaps emus and cattle, on the mainland of Australia.

It is unclear how the Strieter-Lite's inward-facing reflectors might work. If they were found to be effective, this would provide a better solution for the Tasmanian situation. Ramp & Croft (2002) are currently undertaking trials.

Reflectors need to be attached to wooden guideposts rather than the more modern pressed metal or plastic guideposts, as they are attached to the side rather than the face of the post. Depending on the terrain, reflectors need to be placed 20-30 m apart, so installation of extra guideposts is required. This is expensive and guideposts also require maintenance. The reflectors also require maintenance, and are prone to being vandalised and/or stolen (Z. Magnus, pers. obs.).

As Ramp & Croft (2002) have highlighted, the reflectors were designed for large animals (deer), the eyes of which are higher above the ground than the eyes of much Australian wildlife (and most Tasmanian wildlife). If the reflectors are to be successful, it may be necessary to lower the height at which the reflectors are attached to the guide-posts. Ramp & Croft (2002) are currently investigating the effectiveness of this approach.

Conclusions

- At this time, wildlife reflectors should not be considered for use in Tasmania, considering their expense, the high maintenance required and the fact that their efficacy is as yet unknown.
- If wildlife reflectors are shown to be highly effective, their use could be considered in Tasmania, but probably only in areas used by the larger macropods (e.g. Bennetts wallabies and forester kangaroos). Such decisions would best be made in conjunction with a wildlife expert.
- If wildlife reflectors are shown to be highly effective for kangaroos, research into the effectiveness of reflectors for smaller macropods and other mammals could be considered.

Roadside Lighting

Introduction
Roadside lighting as a deterrent to roadkill has been studied in the United States of America (Reed 1981). Lighting the road surface is thought to discourage wildlife from loitering on the road or roadside due to their increased visibility to predators. It is also thought to increase driver awareness, due to the different circumstances, and increase driver visibility.

A quote was obtained for setting up an equivalent system in Tasmania. The quote, for 1.2 km of road to be lit up, using 26 lights was $44251. Because of the expense of installation, it was not possible to test in this study.

It was also considered possible that lighting could have the opposite effect to that required, by attracting insects, which would in turn attract insectivorous vertebrates (e.g. quolls) to the roadsides, possibly creating more roadkill.

Conclusions
- It was not practical to trial lighting in Tasmania due to the high expense of installing the equipment. It is possible that even if successful, lighting would not be a practical mitigation measure in Tasmania because of the cost of installing and maintaining the equipment.
- It may be possible to test the effect of lighting in Tasmania using existing data and survey methods (Alistair Hobday, Pers. Comm., 2003)

Light-coloured Road Surfacing

Introduction
Sealed roads around most of Tasmania are typically surfaced with dark coloured rock such as basalt or dolerite. However, some roads are sealed with locally available material that is of a different colour, for example, quartzite on the Lyell Highway in the west of Tasmania. It is thought that light-coloured road surfaces may decrease roadkill (Jones 2000). Wildlife are likely to feel uncomfortable spending time on the road, due to their increased visibility, and drivers are likely to see an animal sooner against the light surface of the road, as most Tasmanian wildlife is dark in colour. Personal observations (N. Mooney) suggest that this may be one reason why less roadkill occurs on gravel roads in Tasmania, as the gravel used in Tasmania is usually pale in colour.

At the planning stage of the current project, DIER’s position was that the light-coloured road surfacing was being ‘phased out’ in favour of the typical black surfacing. Therefore it was likely to become too expensive in the future to seal a road with a different coloured material. Considering the lack of time and resources available, this project was not carried out.

However, trials would be useful and should be undertaken using existing roads. Captive animal experiments may be effective to gauge reactions to different surfaces. If results were convincing, this method should be financially practical as a roadkill mitigation measure in some circumstances (e.g. national parks, other special projects etc). It should be noted that the selection of stone relates to durability and degree of polishing, which has impact on the friction and skid resistance of the surface. Another consideration is that light-coloured aggregate is more visible and so some people consider that it is not desirable in wilderness areas.

Conclusions
- Light-coloured road surfacing should be trialled as a potential mitigation measure.

Odour Repellents

Introduction
Odour repellents were not considered for study in the current project, as they are a relatively recently developed tool (Ramp & Croft 2002). This mitigation measure is focussed on medium to large herbivores, and aims to repel them from spending time foraging on the roadsides. In this respect, it is a comparable measure to table drain management (see chapter 6). Odour repellents are based on a synthetic substance which has elements of the odour of canine urine.

Ramp & Croft (2002) have begun experiments on the effectiveness of odour repellents, and have had some encouraging results (Daniel Ramp, pers. comm. 2003), but have more trials to complete before confirming efficacy of this mitigation measure. They also intend to investigate the possibility of animals habituating to the odour repellent.

If wildlife did habituate to the odour repellents (thus recognising that the odour repellent presented no danger to them), it is possible that the habituation would extend to genuine dog urine, lowering wildlife wariness to feral and domestic dogs and other exotic predators. This effect would be hard to study, but even if it was a real effect, it would be minimal as odour repellents would in any case used in localised areas for short times.

It is important to recognise that if a strong effect is found, this measure might discourage animals from crossing roads, and could therefore act in a similar way to fencing, preventing animals from moving about the landscape freely. This may inhibit access to new habitat and restrict breeding, which could cause population decline (e.g. Mansergh & Scotts 1989). For multi-lane roads with high traffic volumes, this is not an issue, as the road itself creates a barrier anyway (i.e. if any animal gets onto the road, it is unlikely to survive). However, most Tasmanian roads are small with comparatively low traffic volumes. Therefore any animal on the road has a much greater chance of being successful at crossing. Thus, the advantage of reducing roadkill by using odour repellents would have to be weighed up against possible constraints that might occur at the population level. If odour repellents are found to be effective, they may be useful for short-term mitigation of mortality along specific sections of road.

Conclusions

- It would be advisable to follow-up on the current study (Ramp and Croft, 2002), and make decisions about use of odour repellents based on those results.

CHAPTER CONCLUSIONS

Several measures were identified as being likely to reduce wildlife roadkill and/or decreasing visitor distress on account of roadkill. These are: wildlife signage, escape routes, table drain (ditch) management, platypus crossings, underpasses and potentially odour repellents. Ultrasonic whistles, wildlife reflectors and lighting have doubtful application, at least in Tasmania. Light-coloured road surfacing and use of “driving lights” remain as possibilities for further trials. In terms of further research, priority should be given to research furthering our understanding of roadkill events and sites, and wildlife behaviour in reaction to oncoming traffic. This information will better equip research into wildlife mitigation measures.

APPENDIX I: DRAFT Protocol for determining and prioritising black spots for treatment

Developed in conjunction with Nature Conservation Branch, Department of Primary Industries, Water and Environment (DPIWE) and the Department of Infrastructure, Energy and Resources (DIER).

Background

Tourists in Tasmania and resident Tasmanians frequently protest (verbally or via letters to the local newspapers or wildlife, road and tourism authorities) about the large amount of roadkill on Tasmanian roads and the lack of preventative measures (lack of wildlife warning signs is most often mentioned). The purpose of wildlife warning signs is to inform drivers that there is a danger of their vehicle colliding with an animal, and to encourage them to be particularly alert, and slow down when travelling dangerous sections of road at night time. In many situations, signage is not appropriate. Other roadkill mitigation measures that are recommended are:

- overpasses: consisting of rope tied between tress or other structures an allow ringtail possums to cross over the road without coming down to the ground.
- escape routes: moderating obstacles such as batters (cuttings) to allow animals to move off the road quickly, even when panicked.
- Table drain management: reduction of roadside grass and water aiming to reduce the number of animals attracted to the roadside to feed and drink.
- platypus crossings: increasing the attractiveness to platypuses to travel through the culvert underneath roads rather than crossing over the road surface.
- public education: informing people of the negative and dangerous aspects of wildlife roadkill and aiming for faun-friendly driving attitudes.

To date, government departments such as DIER and DPIWE have been uncertain as to how to decide on which sections of road wildlife signage should be treated. It is undesirable to post an excess of wildlife signs, as they would contribute to general sign "clutter", and will have more of an impact on drivers if used sparingly. Other measures, while potentially being more expensive and more involved could be much more effective. Thus three questions arise: how can we decide which reported black spots are genuine black spots, how can we decide which known black spots to treat, and how can we decide which method (s) is/are appropriate.

This set of guidelines has been formulated to help make these decisions on a case-by-case basis. This document is intended as a working document, to be altered as necessary.

Introduction

There are hundreds of known wildlife roadkill black spots on Tasmanian roads (Lazenby & Jones 1999 and Jungalwalla 2002). Black spots can be defined by the number of animals killed on a certain length of road or by the type of animals that are killed (e.g. threatened species or species of special interest such as Tasmanian Devils). Black spots are also regularly reported to government authorities by members of the public, who usually request that signs are posted. It is difficult to determine whether black spots reported by the public are genuine black spots, and if they are, whether they merit priority. In addition, it must be decided whether signage is in fact the most appropriate measure for the area, or whether an engineering solution is more appropriate.

Signage is thought to have less effect on people living locally, as locals are usually aware of local road conditions, including roadkill black spots, without needing signage. However, non-tourist roads should not be excluded from consideration. Arguably, signage is better used at black spots where a large number of animals are killed, as opposed to a black spot where a smaller number of a threatened species (or species of special interest) are killed. This is for two reasons. The first is that the sign's message needs to be reinforced by people actually seeing wildlife on the roads, so that drivers continue to pay attention to the signs. The second is that signage is less likely to be effective at reducing roadkill than is an engineering solution, such as escape ramps or underpasses, especially where there are very specific locations where animals are being killed. When a threatened species or species of special interest is involved, it is often possible to locate specific points on the road that can be treated to reduce roadkill (however this is not always the case). Also, it is more easily justifiable to go to greater expense to reduce roadkill for these species. Engineering solutions are also generally more appropriate than signage where the black spot is made up of one or several small sites (under 100 metres road length).

Making a decision on which black spots should be prioritised is not simple; many factors must be taken into account. Roadkill rates can change depending on season (e.g. grass establishing, water availability) and stochastic events (e.g. drought, fire), which both produce changes in roadside habitat changes. These factors must be considered when assessing black spot information. Generally, more roadkills occur during summer as there are more animals around due to young leaving pouches and dens and later dispersing. Also in summer less green pick is available for grazing throughout the general landscape so larger distances must be travelled to find food. Water runoff from roads and the consequent green grass alongside roads can also attract herbivores in summer when less food is available elsewhere. For the same reasons, roadkill rates increase in years of drought, and decrease in wet summers. Drastic local habitat changes such as vegetation clearing or wildfire can cause dislocation of animals and increase roadkill events.

Determining black spots

Some initial questions must be answered before the information can be used:

- Is the black spot being recorded in a drought year?
- Have there been roadside habitat changes in the last 12 months?

If the answer to either of these questions is affirmative, information from a period of less extreme conditions must be sought before the significance of the black spot can be properly considered (unless it is possible to use a temporary or cost-effective measure to reduce roadkill in this zone).

It is necessary to collect information on each black spot reported so that the Nature Conservation Branch (DPIWE) can assess priority and determine the most appropriate form of wildlife roadkill mitigation. In most situations, it is appropriate for the person reporting the roadkill black spot to record the information, as most of these reports are made by someone who travels the section of road frequently.

Roadkill should be recorded from the beginning of January to the end of March (or whatever period most roadkill events occur), and the form overleaf must be filled in and returned to the Nature Conservation Branch, with an attached map. It is imperative that he reporter's contact details are included as it is likely that the wildlife officer who assesses the information will need to talk to them directly to ascertain further information. The information will be recorded on GTSPOT (the Department's flora and fauna Geographic Information System).

Prioritising black spots

Several factors will be considered in prioritising black spots to be treated:

- Which species are involved?
- Is there a threatened or unusual species or species of special interest involved (e.g. Tasmanian devils, platypuses)?
- Is/are the species involved endemic?
- Is there a particularly large number of low-priority animals affected?
- Is the black spot on a tourist route?

For the time being, decisions will be made by DPIWE on a case by case basis, and these decisions will be used as case studies to develop more detailed guidelines. Recommendations will be forwarded to DIER, the relevant Council or other road manager.

Wildlife roadkill black spot Assessment: Information required to assess severity of black spot and appropriate mitigation measure(s)

This form has been developed in conjunction with Nature Conservation Branch, Department of Primary Industries, Water and Environment (DPIWE) and the Department of Infrastructure, Energy and Resources (DIER).

Dozens of wildlife roadkill black spots are reported to the Tasmanian government every year. Most people suggest signage as a solution to roadkill, but there are several other roadkill mitigation measures available, some of which may be more appropriate depending each specific situation. To ensure that the worst black spots are prioritised, and that the most appropriate mitigation measure is installed, certain information is required. To qualify for consideration, all questions on this form must be filled out, and you must be prepared to speak with a wildlife expert if necessary.

You must record roadkill events at the relevant black spot for a *minimum of three months from January 1 – March 31*. These records must be provided either as grid references or numbers marked on a map. Please also include dates when no roadkill was seen.

Please return the form to Greg Hocking, Senior Zoologist, Nature Conservation Branch, DPIWE, GPO Box 44a, Hobart 7001. Your application will be assessed by a wildlife biologist and a recommendation will be forwarded to the road manager (DIER, local Council, etc) and a copy supplied to yourself also. Please note that this will be a *recommendation only*, and there is no formal requirement for the road manager to undertake works.

Name of reporter:…………………………………..
Address…………………………………………….
……………………………………………………..
Postcode……………………………………………
Contact numbers: BH………………………………
AH…………………………………………………..
Email………………………………………………..
Name of road………………………………………..
Location of black spot: Please attach a map. If this is not possible, describe in enough detail for location to be found on a map
……
……
……………………………………………………………………………………
Length of black spot…………………………………………………………………………………..
Number of days on which black spot was surveyed:…………………………………………………….
Number of roadkilled animals recorded……………………………………………………………………
Extra information (e.g. has the area recently been under stress through drought, major vegetation clearing, wildfire etc)
……

Date	**Approx time**	**Species/type of animal**	**Grid reference or number on map**
4/1/03	8am	Unidentified mammal	E: 534280 N: 5249460 or #1 on map
6/1/03	8am-8:15am	No roadkills this morning	N/A

Please attach extra sheets as necessary.

APPENDIX II: Culvert avoidance by platypuses and subsequent road deaths: workshop aims and outcomes

An initiative of the Tasmanian Wildlife Roadkill Collective*.
This was part of a CRC Sustainable Tourism research project.

Workshop Participants

Margaret Steadman (Tasmanian Environment Centre – Chair); Sarah Munks (University of Tasmania/Forest Practices Board); David Obendorf (Veterinary Practitioner and Wildlife Pathologist); Peter Davies (University of Tasmania); Jed Gillian and Anahita Jungawalla (Department of Infrastructure, Energy and Resources); John Whittington and Jessamy Long (Conservation of Freshwater Ecosystem Values project, Department of Primary Industries, Water and Environment); Nick Mooney (Nature Conservation Branch, DPIWE); Zoë Tanner (University of Tasmania/Wildlife Roadkill Collective).

Report compiled by Zoë Tanner

Tasmanian Wildlife Roadkill Collective (WRC): Tasmanian Environment Centre; University of Tasmania (Schools of Geography and Environmental Studies and Zoology); Department of Infrastructure, Energy and Resources; Department of Primary Industries, Water and Environment (Nature Conservation Branch); Department of Tourism, Parks, Heritage and the Arts (Tourism Tasmania and Parks and Wildlife Service); Kingborough Council; Brighton Council; Hobart City Council.

Printed by the Tasmanian Environment Centre, 2003.

Cite as: Tanner, Z. (2003). Culvert avoidance by platypuses and subsequent road deaths: workshop aims and outcomes. Tasmanian Environment Centre, Hobart.

Abstract

Platypus roadkill usually occurs as a result of platypuses avoiding passage through culverts, and crossing the road surface instead. A half-day workshop was held on 26th February 2003, to discuss existing information on platypus avoidance of culverts and to develop interim recommendations and set priorities for further work. It was decided that a substantial amount of data already exists on culvert avoidance by the platypus in the form of published literature, databases and anecdotal evidence. Four measures were proposed to ameliorate platypus roadkills at new culvert sites:

- Installation of 'bio-baffles' to assist passage through the culvert;,
- Provision of suitable access to culverts;
- Provision of an alternative dry passage culvert and
- Installation of funnel fencing to encourage the platypus to use the culvert rather than to go up and over the road.

Priorities for further work included:

- Approaching road development agencies to include the four platypus roadkill mitigation measures in their environmental policies;
- Analysis of existing data (including literature and databases) to improve knowledge of platypus avoidance of culverts;
- Reviewing current literature and databases and interviewing relevant people to identify and prioritise sites to be retro-fitted with mitigation measures and
- Undertake further research into mitigation measures and monitoring the effectiveness of proposed measures.

Introduction

Platypuses (*Ornithorhynchus anatinus*) in Tasmania often avoid using culverts to cross underneath roads, preferring to leave the watercourse and cross over the road. Thus, platypus mortality on Tasmanian roads, while reported less frequently than many other terrestrial mammals, could be quite significant at a local level as the populations of minor water courses may be small with individuals foraging over large areas (Grant & Denny 1991). The platypus home range is at least 4-5 km, and they are known to forage over several kilometres per day (Grant 1991). Thus, many platypuses may have to negotiate several road crossings each day, perhaps resulting in a significant percentage of particular populations being killed on roads (Grant & Denny 1991). Otley & Le Mar (1998) suggest that in water systems with a large number of culverts, local extinctions of platypuses may occur. The local extinction of eastern quolls (*Dasyurus vivverinus*) has been known to occur as a result of roadkill (Jones 2000).

In 2000, the Tasmanian WRC succeeded in securing two years partial funding from the Co-operative Research Centre for Sustainable Tourism for a project aimed at trialing several methods to reduce wildlife roadkill. One of the aims of the project was to establish methods to mitigate platypus roadkill. To undertake primary research on this topic would be a significant task, requiring several years' full-time work. Therefore, it was decided that a literature review, discussion with interested parties, and preliminary analysis of some of the available anecdotal information would initially be a more practical way of reaching interim conclusions, and documenting future work and research needs.

Platypus roadkill

Tasmania is the only place where platypuses are regularly recorded as victims of vehicle-wildlife collisions (Grant & Denny 1991). Platypuses are known to use culverts. For example 78% of the 72 culverts studied by the Liffey Landcare Group, were used exclusively used for passage (Mooney & Spencer 2000). However, at many locations throughout Tasmania, platypuses seem to prefer to bypass a culvert by crossing the road surface, rather than going through culverts (Mooney & Spencer 2000, Otley & Le Mar 1998, Taylor & Mooney 1991 and Tyson 1980). This makes the animals at these sites vulnerable to vehicular collisions. Grant and Denny (1991) have speculated that platypuses could be killed on the roads just as frequently in other States, but sighted and recorded less frequently due to the scavenging of carcasses by foxes on the mainland of Australia. However, Tasmanian devils, birds of prey and spotted tail quolls are known to scavenge carcasses in most areas of Tasmania. Another explanation put forth by Grant & Denny (1991) is that platypuses occur in higher densities in Tasmania compared with other States. Another possible reason for the relatively high number of platypus carcasses on roads in Tasmania may, however, be because platypuses appear to be more terrestrial in Tasmania than at other sites where they have been studied on the Australian mainland (Otley *et al*., 2000; S. Munks, unpublished data.). The insignificant number of foxes in Tasmania may make it safer for platypuses to spend time away from water. In New South Wales, platypuses are known to leave drying rivers, possibly looking for habitat (Grant 1991), but generally platypuses are not observed away from water.

Why don't platypuses use culverts?

The carcasses of platypuses killed on the roads have mostly been found where a road crosses a smaller waterway. In most of these cases, a box culvert or pipe underneath the road allows the water to flow underneath the road. In the published literature, there are no records of platypus roadkill near bridges where the passage is larger, water flow less altered and natural substrate occurs (Mooney & Spencer 2000; Otley & Le Mar 1998; Taylor & Mooney 1991 and Tyson 1980). Conversely, platypuses are known to pass through very narrow concrete pipes by choice (Taylor, Mooney & Lange 1991), so ordinary culverts should not necessarily deter them. At some sites, it is obvious that the culvert or pipe is impassable, therefore forcing the platypuses to leave the waterway and cross over the road, re-entering the water on the other side. However, in many cases, there is no obvious reason why a platypus would not travel along the waterway through the culvert. It is likely that a combination of factors deters platypuses from using certain culverts.

Workshop Objectives and Participants

A workshop was held by the WRC on the 26th of February 2003, for experts in the field to discuss whether enough information exists to provide road agencies with instructions for mitigation of platypus roadkill. The workshop also aimed to determine how the existing information (in the form of published literature, database information and anecdotal information) can be analysed and put to use, what research is required in the area, and who should be responsible for funding/undertaking the analysis of existing information and research. This document, the workshop report, is planned to be used as a supporting document for proposals for inclusion of platypus roadkill mitigation measures in road agencies' policies and also for applications for research.

Individuals representing a number of government agencies, non-government organisations and independent naturalists with an interest in platypuses were invited to attend. The following people attended: Margaret Steadman (Tasmanian Environment Centre – Chair); Sarah Munks (University of Tasmania/Forest Practices Board), David Obendorf (Veterinary Practitioner and Wildlife Pathologist), Peter Davies (University of Tasmania), Jed Gillian and Anahita Jungawalla (Department of Infrastructure, Energy and Resources), John Whittington and Jessamy Long (Conservation of Freshwater Ecosystem Values project, Department of Primary Industries, Water and Environment), Nick Mooney (Nature Conservation Branch, DPIWE), Zoë Tanner (University of Tasmania/Wildlife Roadkill Collective).

Apologies: Menna Jones (University of Tasmania), Chris Spencer (Interfauna Wildlife Consultancy), Jed MacDonald (Inland Fisheries Service), Rodney Walker (Inland Fisheries Service), Kevin Lange (Inland Fisheries Service), Suzette Weeding (Forest Practices Board), Niall Doran (Nature Conservation Branch, DPIWE).

Workshop Discussion

Significance of platypus roadkill and justification for mitigation

Roadkill of platypuses was not considered an issue for Tasmania-wide platypus conservation but could be locally significant (i.e. platypuses will not become extinct as a result of roadkill, but local populations could be severely affected). There was doubt expressed that there would be any long-term impact even on local populations. However, the impact may be significant in catchments where populations of platypus are already known to be under stress due to impacts on habitat from land use activities (forestry and agriculture), the introduced fungal disease, *Mucor amphibiorum* and the red fox (*Vulpes vulpes*). It was agreed that further research is required to determine the effect of deaths of platypuses due to collisions with vehicles on the long term viability of platypus populations in such areas.

Since there is currently insufficient information on the impact of roadkills on platypus populations the question was raised as to whether there was any justification for utilising resources on measures to try and reduce the number of road-killed platypuses at culvert sites. However, it was agreed that until the necessary research can be undertaken, a precautionary approach should be encouraged, particularly in areas where platypuses are already vulnerable to other disturbances. It was also agreed that conservation is not the only motivation for reducing roadkills. Human safety, ethical considerations and loss of tourism income through bad presentation also provide valid motivation for mitigation of roadkill. It was strongly felt that as the platypus is an iconic species, use of resources to reduce platypus roadkill is also justified from the point of view of public and tourist perceptions, which include aesthetic, ethical and emotional dimensions.

Factors that might affect platypus passage through culverts

There were numerous possible explanations put forth for platypuses using or avoiding culverts. These explanations were either given credibility through having been backed up by observations or research, or suggested as possibilities that would require further research to be endorsed.

Explanations with evidence

- **Access, including perch height**: A scour pool on the downstream end of the culvert can lead to the culvert outlet being perched in mid-air, preventing access to platypuses travelling upstream, and causing animals travelling downstream to fall out the downstream end. However, platypuses have been observed avoiding culverts that are easily accessed (Otley & Le Mar 1998). Also, captive platypuses have been observed climbing short vertical sections in enclosure at Healesville sanctuary (H. Otley, pers. obs.), so small impediments to access may not be a barrier.
- **Negative/positive experiences with using culverts leading to habitual use or avoidance after the event has passed**: It is widely known that platypuses are “trap-shy”. That is, once they have been trapped, they are extremely difficult to trap again, and have a long memory (S. Munks, pers. comm. 2003). This serves to show that after a bad experience, a platypus will avoid risking that experience a second time.
- **Temporary blockage of normal route**: (e.g. by road works or storm event) forcing platypuses to use alternate route. Chris Spencer (pers. comm. 2002) notes that platypuses follow scents, and will continue to follow a scented route once it has been established.
- **Availability of dry passage**: platypuses have been observed using dry underpasses adjacent to the waterway culvert (Sarah Munks pers. comm. 2003).
- **Availability/attractiveness of alternative terrestrial route and ease of leaving the water**: if it is difficult to leave the water or if there is no terrestrial route available or if it is made less attractive (for example, by floppy-top or alternative appropriate fencing), platypuses are more likely to use the culvert.
- **Surface of culvert base** (e.g. natural (box culvert), concrete, silty): Platypuses are often seen swimming underneath bridges (Tyson 1980), and all of the recorded incidences of platypus roadkills have been at locations where the culverts have a concrete base (Mooney & Spencer 2000, Otley & Le Mar 1998, Taylor & Mooney 1991 and Tyson 1980). Platypuses have been observed using small baffles (placed in culverts to provide resting places for fish) as “handles” in order to push upstream through a culvert (J. MacDonald, pers. comm.). These baffles are referred to in this report as "bio-baffles". At the last 60 cm of the culvert where the baffles had been removed, several sets of scratch marks have been found on the base of the culvert (J. MacDonald, pers. comm.). However, platypuses at the Salmon Ponds near Plenty have been regularly observed using round concrete culverts, even when little debris is present in the bottom of the pipe (Taylor *et al.* 1991).

- **Water flow rate**: Jed MacDonald (Pers. comm. 2002) has observed that platypuses travel along the edge of the water going through the culvert, where they will be less likely to be swept along in the current. Jed MacDonald and also Sarah Munks and colleagues have seen platypus scratch marks on the base and sides of culverts, implying that platypuses have had difficulty in gripping onto the surface when moving upstream. However, a platypus was observed moving in both directions along a culvert, through which the water flow was at least 2.4 m/sec (J. MacDonald, pers. comm. 2002).
- **Terrestrial nature of Tasmanian platypuses**: In Tasmania, platypuses seem just as comfortable on land as in the water. Individual differences or personality may be the reason some platypuses are happy to use culverts and others prefer to travel around a culvert.

Other possibilities

- **Fear of predation**: Some sceptics of the value of culverts as wildlife crossings have suggested that the culvert provides predators with a focus point for hunting, as escape may be difficult. However, there is no evidence that crossing structures such as underpasses and canopy bridges result in increased localised predation.
- **Length of culvert**: Platypuses could be put off by extremely long culverts.
- **Gradient of culvert**: Steeper culverts might be less attractive to platypuses.
- **Aversion to unfamiliar/artificial objects**: However, Rakick *et al.* (2001) reported that a wild platypus they encountered was not at all concerned about the presence of humans, or even a small dog. The platypus actually walked underneath the dog, between the front legs and the back legs. A platypus observed by Jed McDonald also brushed past his leg as it passed him inside a culvert. Platypuses are known to be tolerant of human activity and noise, and have even been seen close to construction sites (Grant 1991). This varies between individuals and juveniles are less wary than adults.
- **Electromagnetic fields**: It has been proposed that platypus electroreception could be interfered with by an electromagnetic field created by the steel reinforcing inside the concrete culverts.
- **Type of habitat (cover)**: It is possible that platypuses are deterred from leaving the stream if there is not sufficient cover over the alternate route.

Other fauna affected by culverts

Culverts also create a barrier to movement of other fauna. The upstream passage of fish such as native galaxiids can be interrupted by culverts, due to the channelisation of the stream through the culvert, making water flow faster and more even. Galaxiids are relatively weak swimmers and require variation in the water flow so that they can rest periodically. Galaxiids swim upstream into the headwaters of rivers to breed, and then travel downstream to estuaries to raise their young, so the barriers caused by culverts can interfere with the normal lifecycle.

There have been numerous anecdotes of giant freshwater crayfish (*Astacopsis* spp.) roadkill being found in the periods following the construction of new forestry roads over streams. Large *Astacopsis* tend to avoid entering fast flowing stream narrows by walking around them, so this may also occur at culvert sites. Smooth surfaces or too steep a gradient may also pose problems. The latter is often identified as needing attention in spillway construction for dams.

It was decided that a universal set of criteria for culvert passage of all fauna would be preferable to separate criteria for each species. However, obviously some measures have specific applications. For example, improving access and installing bio-baffles will probably be of use to all three species, whereas provision of a dry underpass and fencing would be useful for platypuses and crayfish but not fish.

Workshop Outcomes

Involvement of organisations involved in road planning and construction

It was agreed that organisations involved in the planning and construction of road crossings should be approached to promote platypus/fauna-friendly road crossings in their road building and maintenance policies. Organisations directly involved in road building that need to be targeted include: DIER, Hydro Tasmania, local government (Councils), Forestry Tasmania and Gunns Pty Ltd. In addition, platypus-friendly road crossings could be encouraged in priority areas subject to production forestry activities via the Forest Practices System. The Zoology Research and Advisory section of the Forest Practices Board is currently in the process of developing guidelines for the Design and Maintenance of Fauna Friendly Stream Crossings – Culverts (Fauna Technical Note Series, #15). These guidelines could include recommendations to mitigate impacts on platypuses in priority areas.

The advice to be provided to these organisations in the short term will be guidelines for construction of new roads. In the longer term, when further work has been funded, a decision-tree will be provided. This will assist in identifying and prioritising existing sites that need treatment and which sort of treatment is appropriate.

Guidelines for construction of new roads

It was strongly emphasized that sites must be studied from the point of view of complete site management (the road and culvert and surrounds), rather than just the culvert in isolation.

Four initial recommendations that were decided on:

- *Installation of bio-baffles*. Anecdotal evidence has shown that platypuses have difficulty in using the smooth concrete surface of culverts, and that bio-baffles (used in promoting fish passage through culverts) are used by platypuses to move upstream through a current.
- *Provision of suitable access to culverts*. Where there is an elevated perch at the upstream or downstream end of the culvert, it can make platypus entry into the culvert difficult or even impossible. It is necessary to ensure that platypuses are provided with easy access to both ends of the tunnel. This will also be generally more acceptable for native fish and crayfish.
- *Installation of a dry underpass*. Anecdotal evidence shows that in some situations, platypuses prefer to make use of dry underpass adjacent to the stream, which might be a culvert similar to that placed in the stream, but raised up so that water does not pass through it. Provision of dry passage within the main culvert may be a suitable alternative (e.g. by building in a step along one side of the culvert).
- *Installation of funnel-fencing*. Funnel fencing, extending out either side of the culvert, in combination with the above measures, would restrict platypus access to the road. The idea is to make passage through the culvert or dry underpass more attractive to the platypus than travelling across the road. This fencing would need to be designed so that the platypuses do not climb over the top (e.g. use of floppy-top or sheet metal fencing).

Identification of which existing sites need treatment by retro-fitting

It was decided that a state-wide survey of platypus black spots is required. This would take the form of

- Researching published information
- Querying relevant databases (GTSPOT (DPIWE wildlife database) and VETDEX (DPIWE animal health database)) and
- Interviewing technical and community people including Tasmanian Museum and Art Gallery, Queen Victoria Museum, Chris Spencer, Sarah Munks, David Rounsevell, Nick Mooney, Greg Hocking, Michael Driessen, Bob Green, field naturalist groups (particularly Central North), "Land for Wildlife" people, foresters and property owners.

These sites could be recorded on DPIWE's wildlife database GTSPOT. The sites could be used to expand the Liffey Landcare study (Mooney and Spencer 2000) by taking measurements and making observations of these culverts.

It was recommended that a standard form should be produced for use by people who wish to report a platypus "culvert avoidance" event or location (including roadkills) in the future, in order that as much information as possible is available and entered onto GTSPOT.

It was suggested that DIER might be able to fund a three-month project for these purposes in the 2003-2004 financial year. It was suggested that some other agencies could be asked to contribute to enable the project to cover smaller roads not administered by DIER.

Prioritisation of sites to be treated (for existing sites and new sites)

As it will be impractical and probably unnecessary to treat all existing sites, these sites need to be prioritised. A decision-tree is needed in order to prioritise the identified sites. It makes sense to include the development of the decision-tree with the state-wide survey, as many of the interviewees in that process will have critical input into the decision-tree.

Preliminary ideas suggest that the tree would deal with three levels; a decision on whether action is necessary, a decision on which measures should be taken and a costing. A brainstorming session produced the following possible branches

1) Do we need to take action?

- Are there populations in the stream? In Tasmania, the answer always has to be "yes", except on Tasman Peninsula, where there are no platypus records (although there may be fish and/or crayfish issues here). It would be too big a task to survey all creeks for platypuses, and we know that they use all freshwater habitats anyway.
- Is there evidence of platypus roadkill adjacent to a particular waterway? This information will come from "platypus black spot survey" (possibly part funded by DIER).
- Public perception. Is this a significant public/tourist road? (Aesthetic, ethical and emotional dimensions)

- Traffic volume. Is the road subject to high level usage? (e.g. a major cartage route for forestry activities compared with an occasionally used spur road).

2) What sort of action is appropriate?

- Traffic volumes and speed. Appropriate road agency to provide information.
- Is it new road works or an existing site? Are there likely to be road upgrades occurring in the next couple of years? Appropriate road agency to provide info.
- Is there a link to ecosystem values in general – John Whittington's group, Peter Davies & lobster people to provide information.
- Is the road subject to flooding? Appropriate road agency to provide information.
- Is the population impacted by other pressures? Nature Conservation Branch (DPIWE) or other appropriate source to provide information. This will need to include info on catchment disturbance history and planned disturbances (i.e. forestry activities can impact significantly on populations in upper catchment areas), incidence of *Mucor amphibiorum*, frequency of culvert crossings, etc.

Driver behaviour

The issue of signage was discussed. However, there was concern that people don't see platypuses frequently enough for positive reinforcement to take effect, so signs would be ignored after a brief initial period of novelty. It was also pointed out that signage has been shown to have no effect on reduction of roadkill (Dique *et al.* in press) and that perhaps resources would be better placed in terms of undertaking some of the proposed engineering mitigation measures instead.

Chicanes and other traffic-slowing devices were discussed briefly. It was decided that if a black spot falls inside a National Park, this might be the most appropriate measure, as it puts the onus on the driver to change behaviour, thereby emphasising that National Parks are (or should be) dedicated "Wildlife Priority" zones. However, outside national parks, this measure might not be able to be adopted, as there is strong resistance to slowing traffic.

Use of existing data

The existing information that has lead to the decisions being made at this workshop, is based on limited data (published literature, databases and anecdotal evidence). While it is possible to constructively use this information immediately, it is imperative that knowledge and understanding of the issue is improved for longer-term solutions. It would be an extremely productive task to collate, review and analyse the existing data to provide more information on reasons for platypus roadkill and potential mitigation measures. This could perhaps be integrated with the black spot survey, as the sources of information overlap significantly.

Further Research

It was proposed that some research could be undertaken in the form of post-graduate qualification (Doctor of Philosophy) projects within the Freshwater Ecosystems group at the University of Tasmania. This might include researching general culvert usage by aquatic fauna; platypus use of bio-baffles; adequate access into culverts; platypus use of dry underpasses and whether or not deterrence by using fencing is successful.

Summary

A number of tasks were identified as part of a basic strategy to address the issue of platypus roadkill.

Task	**Group responsible**
1. Recommendations for measures for new sites incorporated into environmental policies of road-building agencies.	WRC - lobbying
2. Collate, review and analyse existing data	(combine with #3?)
3. Identify hotspots	DIER - part funding
Check publications & databases, interview relevant people	
Take measurements and record information about each site	
4. Prioritise hotspots to manage (develop decision-tree)	DIER – part funding
Consult with stakeholders	
5. Retro-fit measures into prioritised existing culvert sites	WRC - lobbying
6. Research	U. of Tasmania and FPB would be willing to collaborate.

The Tasmanian Environment Centre, as the convener of the WRC agreed to take on the role of maintaining momentum, and keeping interested bodies active and informed. A list of core bodies/individuals and contact names is provided below. Road-building agencies are considered as a separate group, for the purposes of the type of involvement they are expected to have.

Group	**Contact person**
Wildlife Roadkill Collective	Margaret Steadman restec@southcom.com.au
Nature Conservation Branch, DPIWE	Nick Mooney (Wildlife Officer) Nick.Mooney@dpiwe.tas.gov.au
Nature Conservation Branch, DPIWE	Niall Doran (freshwater crayfish expert) Niall.Doran@dpiwe.tas.gov.au
DIER	Jed Gillian (Senior Environmental Officer) Jed.Gillian@dier.tas.gov.au
University of Tasmania	Sarah Munks (platypuses) sarah.munks@utas.edu.au
UTAS Freshwater ecosystems group	Peter Davies P.E.Davies@utas.edu.au
Water Development Branch, DPIWE	John Whittington John.Whittington@dpiwe.tas.gov.au
FPB fish & lobster group	Sarah Munks sarah.munks@utas.edu.au
FPB	Suzette Weeding (Scientific Officer Zoology) suzette.weeding@fpb.tas.gov.au
Interfauna Consultancy	Chris Spencer Chris.Spencer@bigpond.com
David Obendorf	David Obendorf (veterinarian & naturalist) dobendor@tassie.net.au
Menna Jones	Menna Jones (roadkill expert) menna.jones@anu.edu.au

Conclusions

It remains unclear as to the reasons why platypuses often avoid culverts, but it seems likely that it is a combination of some or all of the factors mentioned in this report. Other species, such as native fish and giant freshwater crayfish, will also be expected to benefit from an alteration in culvert design and other site management techniques.

The outcomes of the workshop are that

- Enough is known in order to advise road-building authorities on measures to reduce platypus roadkill, and consequently a list of actions has been drawn up and work has begun on undertaking them.
- A substantial amount of data already exists in the form of published literature, databases and anecdotal evidence. This data should be reviewed and analysed in order to deepen understanding about the reasons for the platypus avoidance of culverts and potential solutions.
- The existing information can also be used together with interviews, as part of a state-wide survey of black spots, in order to determine which sites should be retro-fitted with platypus roadkill mitigation measures.
- A decision-tree must be prepared to assist with prioritising existing black spot sites for retro-fitting.
- Further research should be undertaken. This should be directed towards studying the efficacy of mitigation measures such as bio-baffles, funnel fencing, improving access and dry passage.

REFERENCES

Austroads (2003). *Fauna Sensitive Road Design & Management Workshop: Workshop Outcomes Report*. Austroads Technology and Environment Programme.

Bender, H. (2001). *Deterrence of Kangaroos From Roadways Using Ultrasonic Frequencies – efficacy of the Shu Roo*. University of Melbourne, Department of Zoology.

Case, R.M. (1978). Interstate highway roadkilled animals: a data source for biologists. *Wildlife Society Bulletin*. 6(1):8-13.

Clevenger, A.P., Chruszcz, B. and Gunson, K. (2001). Drainage culverts as habitat linkages and factors affecting passage by mammals. *Journal of Applied Ecology* **38**: 1340-1349.

Clevenger, A.P., Chruszcz, B. and Gunson, K.E. (2003). Spatial patterns and factors influencing small vertebrate fauna roadkill aggregations. *Biological Conservation* **109(1)**: 15-26.

Colobus Trust (2002) New bridges for Colobus road safety. http://www.bornfree.org.uk/colobus/. Held by Wakuluzu, Friends of the Colobus Trust, PO Box 5380 Diani Kenya.

Dique, D. S, Thompson, J., Preece, H. J., Penfold, G. C., de Villiers, D. L., and Leslie, R. S. (2003). Koala mortality on roads in south-east Queensland: the koala speed zone trial. *Wildlife Research* **30**: 419-426.

Drews, C. (1995). Roadkills of animals by public traffic in Mikumi National Park, Tanzania, with notes on baboon mortality. *African Journal of Ecology*. **33**:89-100.

Forman, R.T.T. & Alexander, L.E. (1998). Roads and their major ecological effects. *Annual Review of Ecological Systems* **29**:207-231.

Goosem, M.W., Izumi, Y. and Turton, S. (2001). Efforts to restore habitat connectivity for an upland tropical rainforest fauna: A trial of underpasses below roads. *Ecological Management and Restoration* **2**:96-202.

Goosem, M.W. and Weston, N. (2002). Under and Over. *Wildlife Australia* Spring 2002: 34-37.

Grant, T.R. (1991). *The biology and management of the platypus (*Ornithorhynchus anatinus*) in NSW*. NSW National Parks and Wildlife Service, Hurstville, NSW.

Grant, T. R. and M.J.S. Denny (1991). *Distribution of the platypus in Australia with guidelines for management*. Mt King Ecological Surveys, Oberon, NSW.

Hobday, A., Minstrell, M. and Ling, S. Distribution and abundance of roadkill on Tasmanian roads. Unpublished manuscript 2003. CSIRO.

Hunt, A., Dickens, H.J. and Whelan, R.J. (1987). Movement of small mammals through tunnels under railway lines. *Australian Zoologist* **24**:89-93.

Jones, M.E. (2000) Road upgrade, road mortality and remedial measures: impacts on a population of eastern quolls and Tasmanian devils. *Wildlife Research* **27**:289-296.

Mansergh, I.M. and Scotts, D.J. (1989). Habitat continuity and social organisation of the mountain pygmy-possum restored by tunnel. *Journal of Wildlife Management* **53(3)**:701-707.

Mooney, N. and Spencer, C. (2000). Why did the platypus cross the road? *Australian Mammalogy* **21(2)**:264-267.

Norwood, C. (1999). Book Review: Linkages in the landscape: The role of corridors and connectivity in wildlife conservation. *Pacific Conservation Biology* **5**: 158.

Otley, H.M. and Le Mar, K. (1998). Observations on the avoidance of culverts by platypus. *The Tasmanian Naturalist* **120**:48-50.

Ramp, D. and Croft, D. (2002). *Saving Wildlife: Saving people on our roads. Annual Report 2002*. University of New South Wales.

Reed, D.F. (1981). Effectiveness of highway lighting in reducing deer-vehicle accidents. *Journal of Wildlife Management* **45(3)**:1981.

Reed, D.F., Pojar, T.M. and Woodard, T.N. (1974). Use of one-way gates by mule deer. *Journal of Wildlife Management* **38(1)**:9-13.

Reeve, A.F. and Anderson, S.H. (1993). Ineffectiveness of Swareflex reflectors at reducing deer-vehicle collisions. *Wildlife Society Bulletin* **21**:127-132.

Romin. L.A. and Dalton, L.B. (1992). Lack of response by mule deer to wildlife warning whistles. *Wildlife Society Bulletin* **20**:382-384.

Schafer, J.A. and Penland, S.T. (1985). Effectiveness of Swareflex reflectors in reducing deer-vehicle accidents. *Journal of Wildlife Management* **49(3)**:774-776.

Shaw, R. A., Jones, M. E. and Richardson, A.M.M. (2003). Predicting the location of wildlife roadkill in Tasmania (In prep).

Scheifele. P.M., Browning, D.G. and Collins-Scheifele, L.M. (2003). Analysis and effectiveness of deer whistles for motor vehicles: frequencies, levels and animal threshold responses. *Acoustical Research Letters Online* **4**, 71.

Sheridan, G.J. (1991). The effectiveness of Swareflex and Wegu brand wildlife reflectors in deterring Perameles gunnii (barred bandicoot) from crossing a section of roadway. Ballarat University, Victoria.

van der Ree (In prep.) Assessing the effectiveness of wildlife crossing structures: a need for a rigorous and standardised approach.

Van der Zande, A.N., Keurs, W.J. & van der Weijden, W.J. (1980). The impact of roads on the densities of four bird species in an open field habitat – evidence of long-distance effect. *Conservation Biology* 18:299-321.

Weston, N. (2000/2001) Bridging the Rainforest Gap. *Wildlife Australia Magazine* summer 2000/2001.

Weston, N.G. 2003. The provision of canopy bridges for arboreal mammals: a technique for reducing the adverse effects of linear barriers, with case studies from the Wet Tropics region of north-eastern Queensland. Unpublished MSc Thesis, JCU, Cairns.

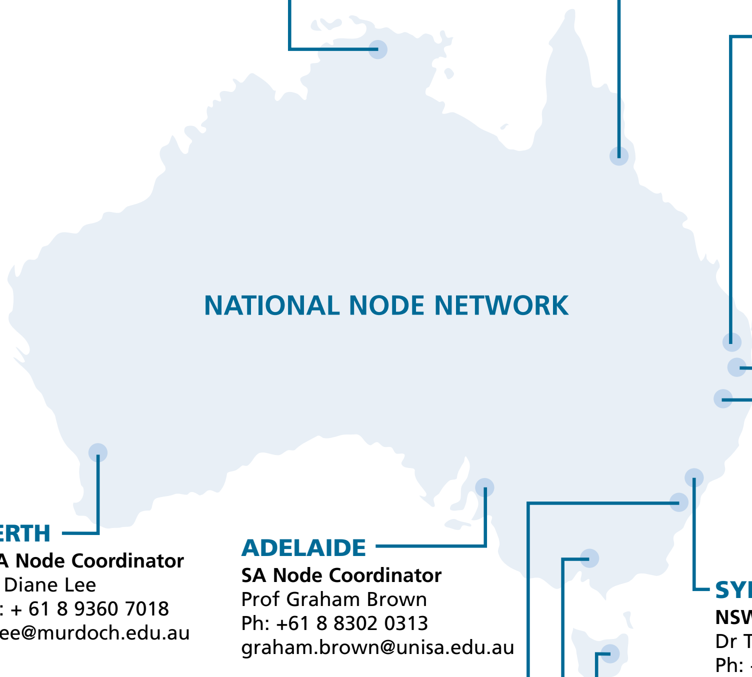
AUTHORS

Zoë Magnus
Working with both flora and fauna, Zoë Magnus (née Tanner) is an ecologist specialising in nature conservation issues. She completed a Bachelor of Science (1998) with Honours in Zoology (2000) at the University of Tasmania. She has spent 18 months working on a variety of nature conservation issues for the Tasmanian government, and two years part-time working on the current CRC project at the University of Tasmania. She has worked as an environmental consultant part-time since 2000. Zoë's main interest is grassroots conservation, or bringing conservation into the day to day life of ordinary people. Email: Zoe.Magnus@keypoint.com.au

Lorne Kriwoken
Dr Kriwoken is Senior Lecturer, Coordinator of the Centre for Environmental Studies and Research Associate at the Institute of Antarctic & Southern Ocean Studies, University of Tasmania, Hobart, Tasmania, Australia. He teaches units on natural environment and wilderness management, environmental impact assessment and environmental technology. He has research interests in ocean policy and law, marine protected areas, World Heritage Areas, sustainable polar tourism and environmental impact assessment. Lorne is on the Editorial Board of *Polar Record* and the Antarctic & Southern Ocean Law and Policy Occasional Papers, University of Tasmania. He currently chairs the Marine, Coast and Estuarine Committee of the Tasmanian State of the Environment Report, is a member of the Tasmanian National Parks and Wildlife Advisory Council, a Member of the World Commission on Protected Areas (IUCN) and a member of the Environment Institute of Australia.

Nick Mooney
Educated at the University of Tasmania concentrating on animal behaviour and raptors, Nick Mooney has worked as a Wildlife Management Officer for the Nature Conservation Branch of the Tasmanian government for 25 years, touching on most wildlife issues. During this time he has worked with birds of prey, penguins, Tasmanian devils, thylacines, injured and orphaned wildlife, developing wildlife emergency responses to disease, whale rescues (beachings), oil spills and incursions of red foxes. Nick has been a strong advocate of high quality wildlife tourism as a means to conservation via value-adding to wildlife and also strongly promotes the 'Living with Wildlife' concept. Email: Nick.Mooney@dpiwe.tas.gov.au

Menna Jones
Dr Menna Jones is a Research Fellow at the Australian National University and an Honorary Research Associate of the University of Tasmania. Her primary research interests are in the evolutionary ecology and conservation biology of terrestrial vertebrates, particularly mammals. She is a foremost authority on Australia's larger marsupial carnivores, the Tasmanian devil and the quolls. Her research encompasses both behavioural and molecular ecological approaches. Dr. Jones is a member of the IUCN/SSC Marsupial and Monotreme Specialist Group, is President of the Australasian Section of the Society for Conservation Biology, and is an Associate Editor of Australian Mammalogy. Email: Menna.Jones@utas.edu.au



DARWIN
NT Node Coordinator
Ms Alicia Boyle
Ph: + 61 8 8946 6084
alicia.boyle@ntu.edu.au

CAIRNS
Node Coordinator
Prof Bruce Prideaux
Ph: +61 7 4042 1111
bruce.prideaux@jcu.edu.au

BRISBANE
Education Coordinator
Prof John Fien
Ph: +61 7 3875 6716
j.fien@griffith.edu.au

GOLD COAST
National Node Coordinator
Mr Brad Cox
Ph: +61 7 5552 8116
brad@crctourism.com.au

LISMORE
Regional Tourism Research
Mr Dean Carson
Ph: +61 2 6620 3785
dcarson@scu.edu.au

PERTH
WA Node Coordinator
Dr Diane Lee
Ph: + 61 8 9360 7018
d.lee@murdoch.edu.au

ADELAIDE
SA Node Coordinator
Prof Graham Brown
Ph: +61 8 8302 0313
graham.brown@unisa.edu.au

SYDNEY
NSW Node Coordinator
Dr Tony Griffin
Ph: +61 2 9514 5103
tony.griffin@uts.edu.au

CANBERRA
ACT Node Coordinator
Prof Trevor Mules
Ph: +61 2 6201 5016
tjm@comedu.canberra.edu.au

MELBOURNE
VIC Node Coordinator
Dr Marg Deery
Ph: +61 3 9688 4626
margaret.deery@vu.edu.au

LAUNCESTON
TAS Node Coordinator
Prof Trevor Sofield
Ph: + 61 3 6324 3578
trevor.sofield@utas.edu.au

International

APEC Centre for Sustainable Tourism (AICST)

A multilateral sustainable tourism research consortium established to facilitate new levels of cooperation between APEC member economies.

International Centre of Excellence for Sustainable Tourism Education (ICE-STE)

Established by the Australian Government to increase Australia's international involvement in travel, tourism, hospitality and related educational services.

International Consulting

CRCST provides teams of researchers and consultants to bid for public and private sector sustainable tourism consulting projects throughout Asia Pacific as well as other regions of the globe.

CRC for Sustainable Tourism Group of Companies and Associated Centres

Decipher Technologies Pty Ltd
Delivering information and knowledge products on demand to travel and tourism enterprises and business information professionals.

Green Globe Asia Pacific Pty Ltd
A joint venture company providing global certification and sustainability services for enterprises and destinations.

Sustainable Tourism Services Pty Ltd
Provides extension and commercial research capabilities for the international and domestic market.

Centre for Tourism & Risk Management
University of Queensland

EarthCheck Pty Ltd
Develops benchmarking and sustainability improvement systems for commercial application.

Sustainable Tourism Holdings Pty Ltd
Dedicated to commercialising innovations developed from CRCST IP.

Centre for Regional Tourism Research
Southern Cross University

Qantas Chair in Tourism Economics
University of New South Wales

*7138 - 06/1003