

8 CONCLUSIONS

The design of fauna sensitive roads encompasses a range of factors related to the impacts of roads on fauna, some of which are largely based on theory. The importance of fauna conservation in the design, construction, operation and maintenance of roads has increased in recent years, providing opportunities for design modifications to be implemented. Examination of numerous measures and their effectiveness at facilitating safe passage of fauna has been undertaken by various scientists, consultants and road authorities in Australia and overseas. Conclusions obtained from examination of this body of research, and recommendations of where further work is required, is included in this chapter.

8.1 INFLUENCE OF ANIMAL BEHAVIOUR ON IMPACTS OF ROADS

The behaviour of animals is known to influence the degree to which animals are impacted upon by roads. Certain behavioural traits make some animals more susceptible to impacts than others. To reduce impacts on fauna from roads, the behaviour of animals needs to be identified and understood so that appropriate measures may be implemented during the design, construction and maintenance of roads.

Certain fauna behaviour will be in response to factors in the environment, instinct and interaction with other species. Therefore, factors such as the topography, vegetation present near the road, natural movement paths of species and influence of predators on individuals and populations all need to be taken into account when determining a route alignment through a natural environment.

Animal behaviour also includes habits of fauna species, such as basking on roads by reptiles and feeding on road verges by birds and macropods. Other such species-specific characteristics include the slow crossing of roads by Koalas or the unpredictability of macropod movement. Characteristics such as these make some species more susceptible to road deaths in certain environments.

Vegetated road reserves are increasingly being identified as essential for the survival of many protected and threatened fauna species in highly fragmented habitats, and in many areas, road reserves are being targeted for protection and conservation.

Increased understanding of animals, their requirements and motorists safety has led to the installation of structures designed specifically to facilitate fauna movement. Many of these modifications or measures have been shown to be successful in facilitating fauna movement. However, only with additional and targeted research will the true effectiveness of these and future modifications be determined and enhanced.

8.2 FAUNA USE OF EXISTING STRUCTURES

The information contained in this report confirms that roads have an impact on fauna. As such, it is essential to identify effective measures to reduce this impact so as not to further endanger Australia's native fauna species.

The key focus of this two volume series is to identify road design measures that will increase the safe movement of animals across roads, either over or under the pavement. The collation of existing information from the literature and the analysis of available field data presented in this volume indicates many areas where further research is required (see Section 8.5). Investigation to further our knowledge in relation to these areas is underway and will be presented in the second volume.

Table 8.1 indicates our knowledge to date with regards to which culvert type fauna have been recorded. The known information is patchy and compiled from a number of sources as no studies have been specifically designed to determine the best culvert design for specific faunal types.

Table 8.1 Confirmed use of culvert or underpass type by fauna (+ indicates known use, - indicates not known or unconfirmed use)

Fauna type	Small pipe <0.5 m dia	Large pipe >0.5 m dia	Small box culvert <1.2 m h	Large box culvert >1.2 m h	Bridge underpass
Small mammal	+	+	+	+	+
Medium mammal	+	+	+	-	+
Large mammal	-	+	-	+	+
Semi-arboreal mammal	-	-	-	+	+
Arboreal mammal	-	-	-	-	-
Microchiropteran bats	-	-	-	+	+
Reptile	-	+	-	+	+
Bird	+	-	-	+	+
Amphibian	+	-	+	+	+
Introduced predator	+	+	+	+	+

* The only semi-arboreal mammals recorded in fauna tunnels are the Koala and Eastern Pygmy Possum. These species are not considered to be exclusively arboreal.

Gaps in known information include the use of underpasses or culverts by arboreal mammals. When identifying impacts on fauna movement by roads, the main concentration has previously focussed on terrestrial species. However, wide road pavements also sever the habitats of arboreal species and movement between habitat areas is restricted.

The present studies have found that only generalist species such as small mammals and introduced predators will use any culvert type. This identifies a need to design culverts to suit larger species of mammal, reptile, amphibian and bird when such fauna types are locally significant.

8.3 RECOMMENDATIONS FOR ACCOMMODATING FAUNA

Practices currently implemented during construction, or retrofitted to previous designs, have increased the likelihood of safe fauna passage. In general, the design and basis for fauna modifications is dynamic and often changes through findings of research and trials. As such, field survey data of the type included in Chapter 7 is important as background information to future studies as it shows that some specific conditions contribute to increased fauna movement.

Available data suggests that some measures have been found to work better than others. However, the practices that fail also provide information on the road related behaviour of fauna species to those planning, designing, constructing and maintaining fauna sensitive roads. From this, designs and management practices may be developed to increase the effectiveness of fauna modifications.

From review of the literature and available field data, the following summarises our knowledge and recommendations with regard to accommodating fauna:

- Underpasses beneath bridges are used for fauna movement overseas, but there has been little research into their use in Australia. It is recognised, however, that provision of dry passage is required to increase their effectiveness. As such, bridge abutments should be set back from the watercourse to allow dry areas for fauna passage.
- Appropriately sized culverts should be used to accommodate numerous faunal types rather than be targeted to only one or a few faunal types (refer Table 8.1). Exceptions may occur when creating a passage necessary to accommodate a single targeted species for conservation reasons (an example being the Mountain Pygmy Possum, refer Section 6.1).
- For terrestrial species, dry passage is preferable. Multiple cell culverts with the outer cells raised or raised ledges within a culvert will assist fauna movement. Soil and debris on the floor of the culverts may also increase the level of use by fauna. It is acknowledged that desilting of culverts is necessary, however, in many cases some natural flooring will persist as a result of continued sedimentation.
- Revegetation using locally indigenous species is suggested for the entrances of culverts. This is to provide extension of habitat areas nearer to culvert entrances and provide shelter for fauna entering and exiting culverts.
- Refuge poles may be effective both at the entrance and exit as well as within the culverts in areas where introduced predators are likely to attack animals, such as Koalas (refer Section 6.1.2 for details). It is important to locate such poles at least 3 m away from exclusion fencing.
- Barrier fences at the entrances of culverts are not recommended as they prohibit the movement of medium and large mammals as well as the predators.

- There is dispute into the effectiveness of skylights in culverts and their ability to increase fauna use. It is likely that culverts that are considered to need skylights are too long to facilitate movement of fauna in any case. Skylights are thought to increase levels of debris into the culvert and therefore increase maintenance requirements. Noise levels may also increase inside the culvert, which may discourage some species. Further investigation is required to establish the effectiveness of skylights.
- Little research into canopy bridges to accommodate arboreal species has been published, although research is currently being undertaken and will be included in Volume 2 of this series.
- Wildlife fencing around culverts has proven to be effective in guiding animals into culverts and reducing road deaths. However, some fence designs require modifications to increase effectiveness and guide an increased number of species into culverts. Fences installed on one side of the road only have not been found to reduce fauna road-kills.
- In many cases, fences should be reflective of species in the surrounding environment. Examples include the two designs of Koala-proof fence described in Section 6.3 of Chapter 6. These designs have been developed in response to the Koala's ability to climb over most fence designs. Other examples would include building fences high enough (e.g. 1.8 m) to discourage macropods jumping over them or providing metal strips at the base of fences to restrict the movement of reptiles and frogs (refer Section 6.3).
- Ongoing maintenance of installed fences is essential to maintain effectiveness. It is important to remember that Koala-proof fences (unlike wildlife fences) require maintenance so that trees do not grow within 3 m of the fence. This ensures that Koalas do not climb the trees and jump the fence.
- The effectiveness of wildlife reflectors is currently being investigated by numerous researchers and may be effective in deterring nocturnal animals from the road when cars approach. Preliminary findings are promising and outcomes of further research will be included in Volume 2 of this series.
- Warning signs may assist in reducing vehicle speeds and collisions with animals in some areas, but the effectiveness of warning signs is dependent on the response of vehicle drivers. Unfortunately these signs are generally not effective in reducing the speed of the motorist and are therefore more likely to be effective in low speed areas where they may be used simply to raise the awareness of drivers.

8.4 OVERVIEW OF PRESENT MANAGEMENT PRACTICES

In recent years, much progress has been made in designing and constructing fauna sensitive roads. The importance of maintaining biodiversity has resulted in government bodies changing past practices and reducing the impacts of development on the environment.

Road authorities throughout Australia are adopting better practices to help accommodate fauna and the findings to date suggest most specifically-designed structures are effective. Maintenance of such structures is important and this area requires further education and adoption of appropriate practices. Continued research into the effectiveness of modifications for fauna movement is essential and continued monitoring is necessary to establish protocols in the design, implementation and maintenance of structures to accommodate fauna movement.

One major success to date is the installation of culverts to re-establish connections between the male and female populations of the Mountain Pygmy Possum, which was suffering a population decline when a road was constructed through its natural dispersal path. The decline of this species was noted by ecologists and measures were implemented to reduce the impact. These measures were found to be successful and have since indicated a turning point in the conservation of this species.

The effectiveness of existing practices is generally measured by the amount of use of culverts or underpasses by fauna and a general reduction in road deaths. At present, these are the only parameters that indicate a change, as indirect impacts such as edge effects, barrier effects and theoretical issues such as genetic isolation cannot be simply measured. However, a relationship between reduced road deaths and increased use of culverts and underpasses indicates that the barriers to movement are dissipating.

8.5 FUTURE DIRECTIONS AND RESEARCH

The design, construction and maintenance of structures aimed at increasing fauna movement has been tending away from what is either expected to work or aesthetically appealing to human eyes toward what is known to work and more suited to animals. In many cases, culverts that both facilitate fauna movement as well as drainage can be installed if properly designed, constructed and maintained. Increasing recognition of the behavioural and ecological characteristics of species when designing culverts and associated modifications has led to more effective safe passage by fauna.

The recognition of vegetated road reserves, as being of importance for the conservation of species, has furthered the installation of appropriate structures and revegetation near culverts and on road verges. Such measures are aimed at facilitating natural fauna migration and dispersal through these environments. Continued recognition of the importance of vegetated road reserves is essential to ensure the retention of a network of viable habitats for a variety of species in otherwise degraded

areas.

The findings of research currently being undertaken will be compiled and presented as the second volume of this series, 'Fauna Sensitive Road Design—Preferred Practices'. Practices currently being investigated and trialed in Queensland, and throughout Australia, will be described and their effectiveness for each relevant fauna type assessed to provide conclusions on successful and unsuccessful designs.

Specific areas of investigation that are targeted for inclusion in the second volume include:

- Confirmation of which fauna types utilise which culverts and underpasses.
- The effectiveness of providing structures (i.e. logs, poles etc.) within culverts and culvert entrances.
- Canopy bridges for arboreal species.
- Appropriate design and location of wildlife fencing.
- Effectiveness of wildlife reflectors.
- Value of raised ledges and skylights within culverts.
- The use of underpasses and culverts by predatory species.

The aim of the second volume is to provide a document that outlines the preferred practices that facilitate fauna movement. Each animal has different requirements, and culverts should be designed, constructed and maintained so as to suit the majority of species found in the surrounding area. As such, a combination of modifications may be necessary to provide the most effective design for fauna passage. Volume 2 of this series will enable practitioners to identify the most suitable design modification to accommodate the passage of fauna species identified in the area. It is, however, noted that the adoption and implementation of structures to accommodate fauna should continue to be assessed in the wider context that enables a balanced assessment of environmental, engineering and economic considerations. To this end, practical solutions to accommodate safe fauna passage shall be the focus of the second volume.