6 EXISTING PRACTICES

In recent times, the impact of roads on local fauna populations has been given further consideration. As a result of this attention, a number of mitigation measures have been introduced, most targeting specific species. These measures have involved a variety of innovative techniques including tunnels, fences, funnels, bridges, reflectors, overpasses, underpasses, culverts and signage. The effectiveness of these measures varies and in most cases, more research and monitoring is required to determine their relative cost effectiveness. Road modification designs from Australia and overseas are outlined below.

For the purposes of this report, 'underpasses' refer to sections under bridges or raised sections of road over depressions or similar topographical features. 'Culverts' however, refer to structures specifically designed to facilitate fauna movement or water drainage and come in a wide variety of shapes and sizes. Most culverts are either round pipes or box culverts and are generally made of reinforced concrete.

6.1 UNDERPASSES AND CULVERTS

In North America, highway underpasses and culverts are regularly used for the management of large game species such as elk, deer and mountain goats (Reed et al. 1975; Reed and Woodward 1981; Ward 1982; Singer et al. 1985; Harris 1988). More recently, fauna underpasses have become desirable to accommodate native mammal populations in Australia (Hunt et al. 1987; Mansergh and Scotts 1989; Pieters 1993). Some have proved to be effective in facilitating animals crossing roads at migration pathways, or where busy roads bisect fauna habitats.

Underpasses or culverts have also been used to facilitate movement of smaller animals such as the Mountain Pygmy-possum (Mansergh and Scotts 1989). Specifically, a road in the Victorian highlands of south-eastern Australia bisected the possums' alpine habitat. This disrupted social organisation within the population by preventing the dispersal of males and causing direct loss to the population as a result of road kills. When a rock scree corridor and culverts were installed to restore habitat continuity, dispersal of males occurred, and the survival of resident females within the breeding habitat was significantly increased (Mansergh and Scotts 1989). Additional modifications included the culverts being filled with basalt boulders and grills being installed at the entrances to the culverts to prevent predator access. Such modifications require careful consideration, and would not be appropriate for the majority of culverts installed on Australian roads.

6.1.1 Underpasses

The movement corridors provided under bridges are generally referred to as ‘underpasses’. Bridges have been shown to provide successful underpasses that facilitate natural fauna crossings (Evink 1990, Foster and Humphrey 1995). Underpass placement based on knowledge of actual travel routes may be more important in determining underpass use than other factors such as structural dimensions. Underpasses and bridge extensions in locations where movement paths crossed roads were found to significantly reduce road mortalities of the Florida Panther (*Felis concolor*) (Evink 1990). However, Hanna (1982) found that placing underpasses without regard to traditional paths failed to facilitate movement of deer (cited in Foster and Humphrey 1995).

Limited research has been undertaken in Australia into the use of underpasses by terrestrial fauna. Tracks of fauna such as kangaroos and bandicoots are present under many bridge structures, but limited research appears to have been conducted into the effects on population dynamics from constructed underpasses. Such issues will be targeted in the second volume of this series.

Most researchers have concluded that animals using an underpass should have an unobstructed view of the habitat or horizon on the far side of the underpass (Foster and Humphrey 1995). However, some vegetation should be present to suit a variety of species, especially small mammals. Lack of light often limits the amount of vegetation that will grow under a bridge, however Broadbent et al. (1981) feel that vegetation cover should be retained in the areas immediately adjacent to and under the bridge. This provides protection for species using the underpass and may discourage use of the underpass by large predators (Armstrong and Francis 1997).

An example of successful regeneration is found at a bridge over Steggalls Creek on the Yandina Bypass in south-east Queensland. Construction of the bridge was completed in 1997 (Figure 6.1) and substantial regeneration of the site had occurred by 1999 (Figure 6.2). Figure 6.3 shows an underpass which does not provide adequate cover for fauna species, although the dry banks would be suitable for future revegetation.

It is recommended that bridge abutments be moved away from creek banks to increase opportunities for fauna movement. Figure 6.4 demonstrates an underpass unsuitable for fauna movement as it is dark and would not provide dry passage during high flow events.

Figure 6.1 Steggalls Creek bridge on the Yandina Bypass, south-east Queensland, shortly after construction (1997)

Figure 6.2 Steggalls Creek bridge showing advanced revegetation with native species (July 1999)

Figure 6.3 Ideal opportunity to provide native plantings under a bridge that has dry fauna passage (Nambour Bypass, south-east Queensland)

Figure 6.4 Bridges which are dark and have limited dry passage for fauna, consequently providing inadequate cover for native fauna species (Bruce Highway, south-east Queensland)

6.1.2 Culverts

The culverts most suitable for fauna passage allow the free movement of a wide range of native species. Culverts suitable for terrestrial fauna should, in general, provide dry passage during low flow conditions and in some cases, this may require the construction of benches or flow diversions. It has been suggested that box culverts should be placed on an angle to provide dry areas (AMBS Consulting 1997). However, it would be more practically feasible to provide raised ledges (of only 100 mm) on one side of a box culvert (Armstrong and Francis 1997) (see Figure 6.5), or to raise the outer cells where multiple culverts are constructed.

Hunt et al. (1987) established that small native mammals had a preference for established culverts over newer culverts, and that newer culverts were predominantly utilised by predators. This is possibly a consequence of the lack of vegetation around new culvert entrances. The presence of vegetation adjacent to culverts was found to significantly increase activity of fauna near the culvert entrances along the Kwinana Freeway in Western Australia (Ecologia Environmental Consultants 1995). It was also found during this study that the level of activity around the culvert entrance decreased as the distance of the vegetation from the entrance increased. Examples of culverts without appropriate revegetation at entrances are shown in Figures 6.6 and 6.7. The box culvert illustrated in Figure 6.8 has substantial revegetation of the culvert entrance. Although some weed species are present, the majority of the regrowth is native species and provides considerable protection for small animals.

De Santo and Smith (1993) and AMBS Consulting (1997) report that culverts with natural flooring, either dirt or sediments, increased animal usage of culverts. Yanes et al. (1995) noted a high degree of acceptance of culverts by small mammals and concluded that this may be due to the ground surface of the culverts being covered in soil and debris which provides a less hostile environment for these animals than the open roadway. Figure 6.9 illustrates a box culvert where silt has accumulated and provided a base for vegetation. However, in this instance, the species revegetating the site is an introduced grass. Revegetation using native species and installation of appropriate flow diversion structures after construction would have increased the value of this culvert to native fauna.

It is suggested by much research (e.g. AMBS Consulting 1997; Armstrong and Francis 1997; Ishta Consultants 1999) that culverts should be modified to provide protection for native species from predators. These modifications may include revegetating the entrance with local flora, or placing logs, rocks or upright poles inside the culvert to enable protection. In culverts designed specially for fauna use these modifications may be feasible, but many culverts in Australia also have a dual purpose as water conduits and as such, modifications such as these may be unsuitable. Such issues will be discussed at length in the second volume of this series (see also Chapter 8 for preliminary findings).

Figure 6.5 Raised ledges within a culvert (Old Northern Road, south-east Queensland)

Figure 6.6 A small three cell box culvert partially obstructed with sediment and with little revegetation of entrance (Sunshine Coast Motorway, south-east Queensland)

Figure 6.7 Pipe culverts where limited revegetation provides little cover for fauna (south-east Queensland)

Figure 6.8 A culvert entrance where revegetation of native species is well advanced, providing good cover for fauna (Brunswick Heads Bypass, northern NSW)

Figure 6.9 A culvert in which accumulated silt provides a substrate for revegetation but exotic species dominate (Burnett Highway, south-east Queensland)

Modifications to culvert entrances to exclude feral predators have also been recommended by some studies. Ishta Consultants (1999) suggested the installation of fences at the entrances of culverts that Koalas could climb, as these would prevent the movement of large dogs from rural/urban areas into bushland. However, such fences would also negate the movement of other medium and large fauna species (including macropods and bandicoots), and are therefore not recommended. Rather, Koala refuge poles may be strategically placed within the culvert or underpass entrance and exits (see Figure 6.10).

Figure 6.10 A Koala refuge pole located outside a well revegetated culvert entrance (Brunswick Heads Bypass, northern NSW)

Other suggested modifications to culvert design have included roughening the roof and walls of box culverts to encourage the roosting of small bats (Armstrong and Francis 1997). The viability of this suggestion is not known, although the Little Bent-wing Bat (*Miniopterus australis*) and Large Bent-wing Bat (*M. schriebersii*) are both known to roost in overflow culverts associated with Grahamstown Dam, north of Newcastle (H. Parnaby, Australian Museum pers. comm. 1995). However, a debate exists as to whether culverts should provide nesting or roosting habitat for fauna in addition to safe passage. This debate is not addressed in this report.

Culvert skylights (installed in median strips illustrated in Figures 6.11 and 6.12) have also been mentioned as necessary to introduce light into culverts to encourage terrestrial fauna (Armstrong and Francis 1997). The use of skylights or grates in culverts has not been recommended by AMBS Consulting (1997) and Ishta Consultants (1999), as it is felt that these structures will increase levels of detritus and road noise into the underpass. AMBS Consulting (1997) noted that reptiles used the underpasses during the day only on a opportunistic basis. As most Australian mammals are nocturnal, it is considered that the addition of skylights would only encourage the use of culverts by domestic and feral predators during daylight hours.

Figure 6.11 Surface view of a culvert skylight

Figure 6.12 View of skylight in roof of culvert

6.2 OVERPASSES

The consideration of overpasses in road projects is particularly relevant where tree-dwelling (i.e. arboreal) species are common. Arboreal mammals are rarely recorded using underpasses. Koalas, although considered arboreal, traverse the ground to move from one area to another, but other exclusively arboreal animals, especially gliders, often have difficulty crossing wide roads. The use of vegetated overpasses has had relatively little investigation in Australia due to the high costs of building and maintaining bridge like structures or tunnelling roads. Generally, for an overpass to allow successful movement of arboreal species, an upper canopy is considered necessary to provide gliding ability. This would require a substantial amount of ground surface above a tunnelled road to allow tree growth.

AMBS Consulting (1997) outlined some of the studies that have been undertaken into overpasses but did not provide recommendations. The NSW Roads and Traffic Authority is presently trialing structures, such as rope or canopy bridges, to assess the viability of accommodating movement of arboreal mammals. Research into the effectiveness of canopy bridges in the rainforests of north Queensland is also being undertaken by the Rainforest Co-operative Research Centre (CRC). This research will include examination of a purpose-built canopy bridge built around five years ago (Radio National 2000). Outcomes of both investigations will be included in the second volume of this series.

6.3 EXCLUSION OR GUIDE FENCING

Wildlife-exclusion or guide fencing has been used widely throughout the world, though most investigations of its effectiveness have been conducted in America. This fencing is generally 1.8 m high chain-wire mesh fencing. Such fences have been constructed to reduce collisions between vehicles and large game animals, such as deer and elk. Research by Ratcliffe (1974) demonstrated that small mammals, such as badgers, also benefit from guide fences.

In Australia, fencing has most commonly been used for the conservation of Koalas (see Prevett et al. 1992; Gardyne 1995) and to exclude macropods from roads. The guide fencing is mainly associated with underpasses and culverts (see Figure 6.13), leaving large sections of highways unfenced. This is necessary and appropriate in areas where culverts are impractical, but it also prevents animal deaths from fire where the ability of an animal to escape is impeded by extensive lengths of fence without sufficiently spaced and suitably sized underpasses. Fencing of areas where regular movement paths cross over roads may be of significant benefit to some fauna populations. However, many animals in Australia have random movement paths and will not benefit significantly from extensive wildlife fence networks.

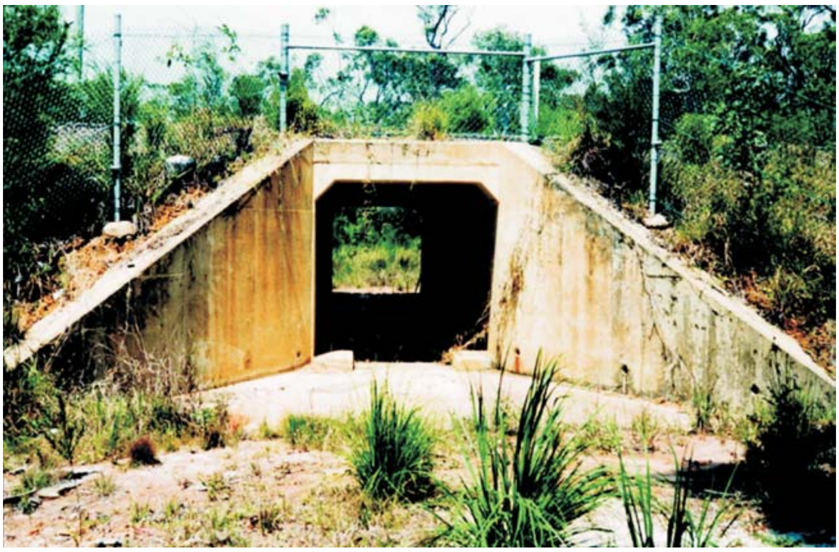

Figure 6.13 A culvert with wildlife guide fencing and raised ledges (Sunshine Coast Motorway, south-east Queensland)

Many animals are hit by cars where unfenced sections of road join a fenced culvert, particularly at high risk areas such as woodland/grassland interfaces or areas that support remnant corridor vegetation. The design of many guide fences around culverts cause the fence to narrow close to the road, shown on Figure 6.14. Guide fence designs have recently included breaks in the fence to allow animals to escape off the roadway. Kinhill Pty Ltd has designed an alternative culvert fence for two road projects in north-eastern NSW, the proposed Pacific Highway realignments at Halfway Creek (Kinhill Pty Ltd 1997a) and Tandys Lane (Kinhill Pty Ltd 1997b) (see Figure 6.15). This innovative fence design requires monitoring to document its effectiveness.

Guide fencing may be constructed to suit a range of animals or may be species specific. In North America, specifically designed deer fencing is required in some areas, as deer can jump over the standard wildlife fencing (Foster and Humphrey 1995). In Australia, the majority of wildlife fencing used is designed to discourage macropods, but will also discourage many other medium to large sized mammals. Small mammals, reptiles or amphibians are rarely restricted from road surfaces by the commonly used wire mesh fencing. However, installing strips of sheet metal at the bottom of the guide fence has proved effective in controlling some species (M. Ryan, Technology and Environment Division, Department of Main Roads, pers. comm.).

In areas containing a Koala population, specifically designed Koala fencing is required, as Koalas will climb standard wildlife fences (Prevett et al. 1992). There are two designs for Koala-proof fencing: one is a metal sheet retrofitted to the top of an existing fence (see Figure 6.16), and the other is a fence with a floppy-top (see Figure 6.17), which cannot be climbed. The former fence design appears more aesthetically pleasing and the metal sheet may be retrofitted to standard wire mesh. In addition, the floppy-top fencing is more susceptible to invasion by introduced vines and other weed species, and therefore requires more ongoing maintenance.

It is necessary to ensure that all Koala-proof fencing is located or maintained so that trees do not grow within approximately 3 m of the fence. Should trees grow within this zone, Koalas may readily climb the tree and jump over or on top of the fence.

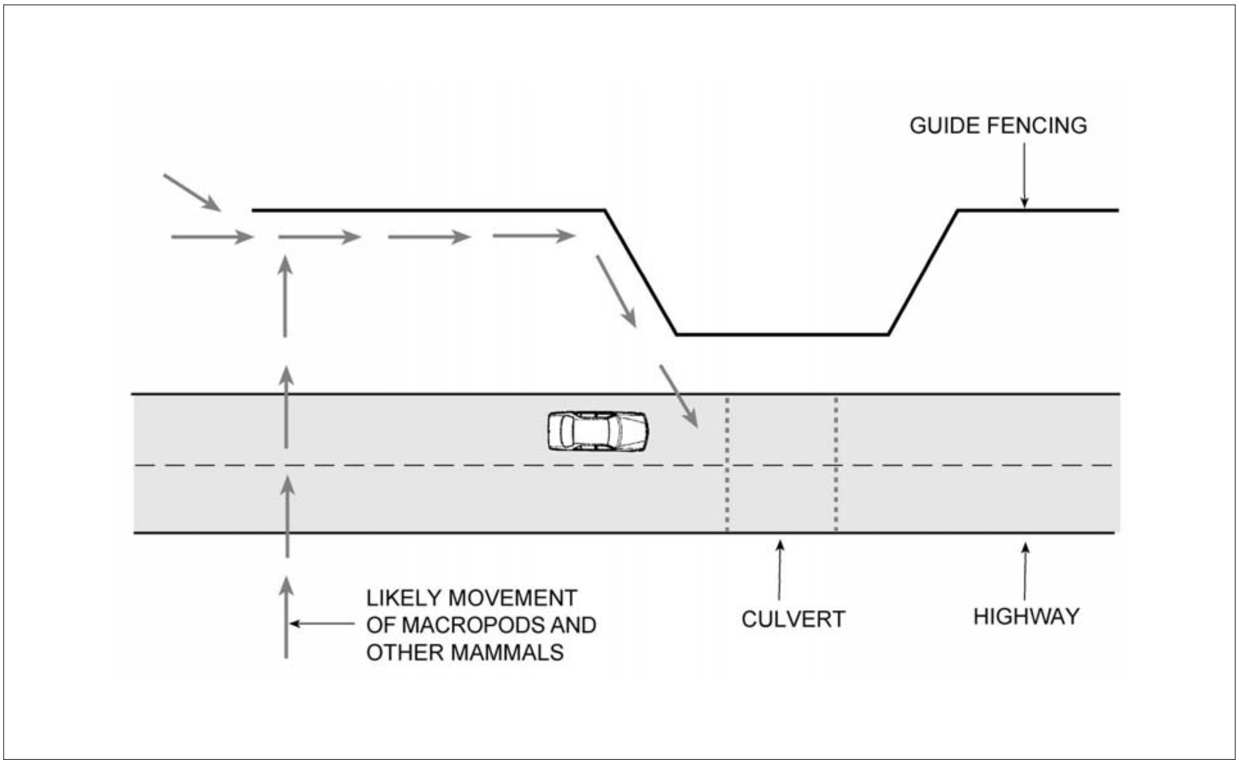

Figure 6.14 Illustration showing how guide fencing on only one side of a road may increase road-kills

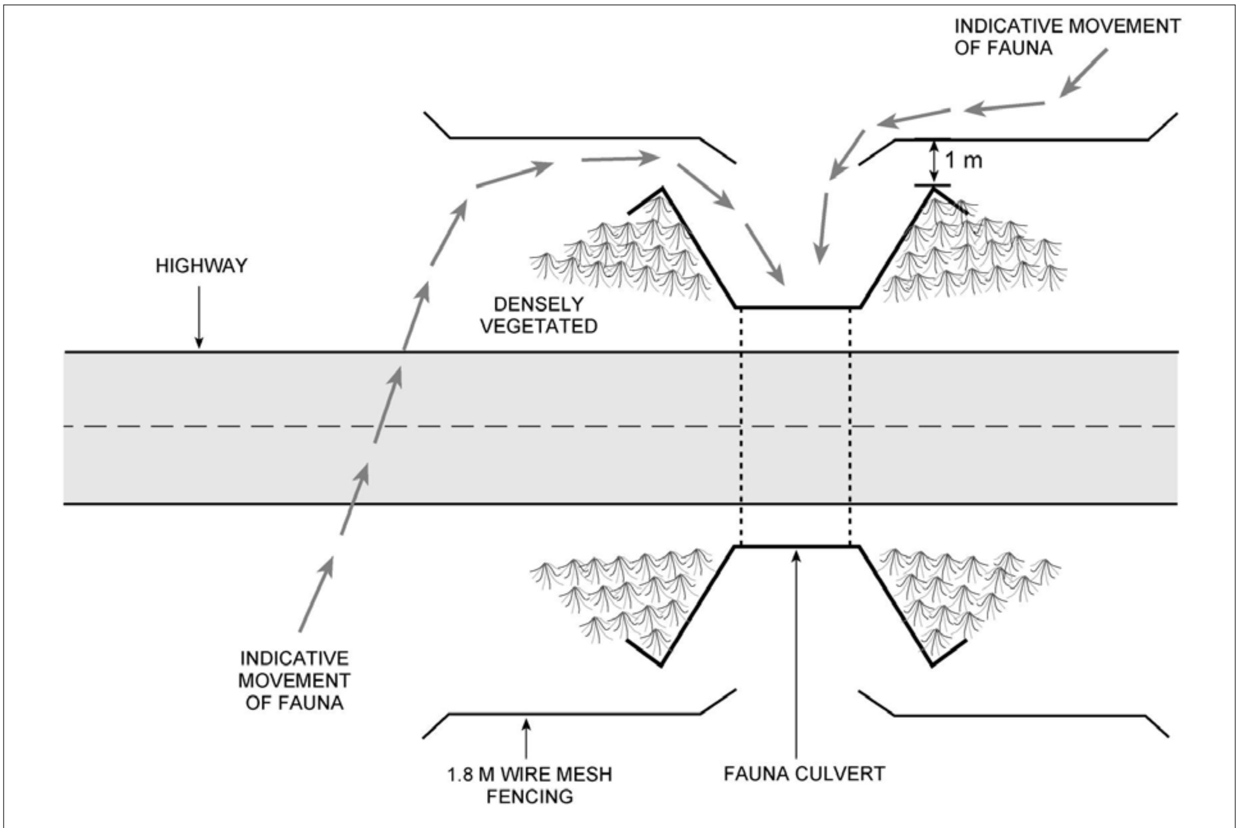

Figure 6.15 Modified fence design to allow trapped animals to escape from road reserve

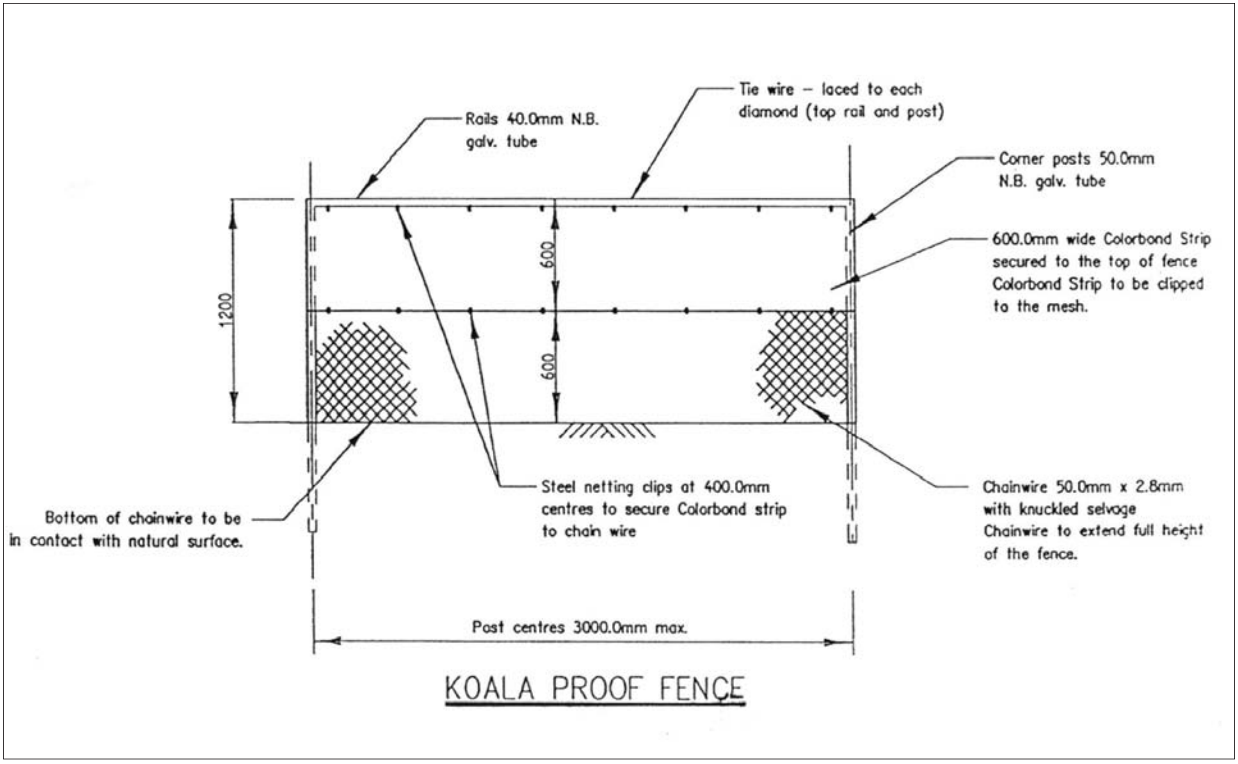

Figure 6.16 Design drawing for a 'sheet metal' type Koala-proof fence

Figure 6.17 'Floppy-top' fencing designed to prevent Koalas entering the road reserve (Brunswick Heads Bypass, northern NSW)

It is generally recognised that ongoing maintenance of fences is essential for the effective restriction of animals from roads. Wildlife quickly exploit breaks in fences and one problem often associated with guide fencing associated with culverts is a lack of maintenance and that holes caused by vandalism or general wear are often not repaired (AMBS Consulting 1997).

6.4 WILDLIFE REFLECTORS

An Austrian company, Swareflex, manufacture wildlife reflectors that were demonstrated to be effective in reducing the number of traffic collisions with deer in Austria (Schafer et al. 1985). The Swareflex wildlife reflectors consist of a series of 16 cm x 5 cm red reflectors mounted along the roadside on posts at a height of about 1 m. Light from the headlights of an approaching vehicle is reflected as red light at right angles to the road by the reflectors. The purpose of this is to cause approaching animals to 'freeze' and remain motionless until the car passes and the headlight reflection ceases (see Figure 6.18).

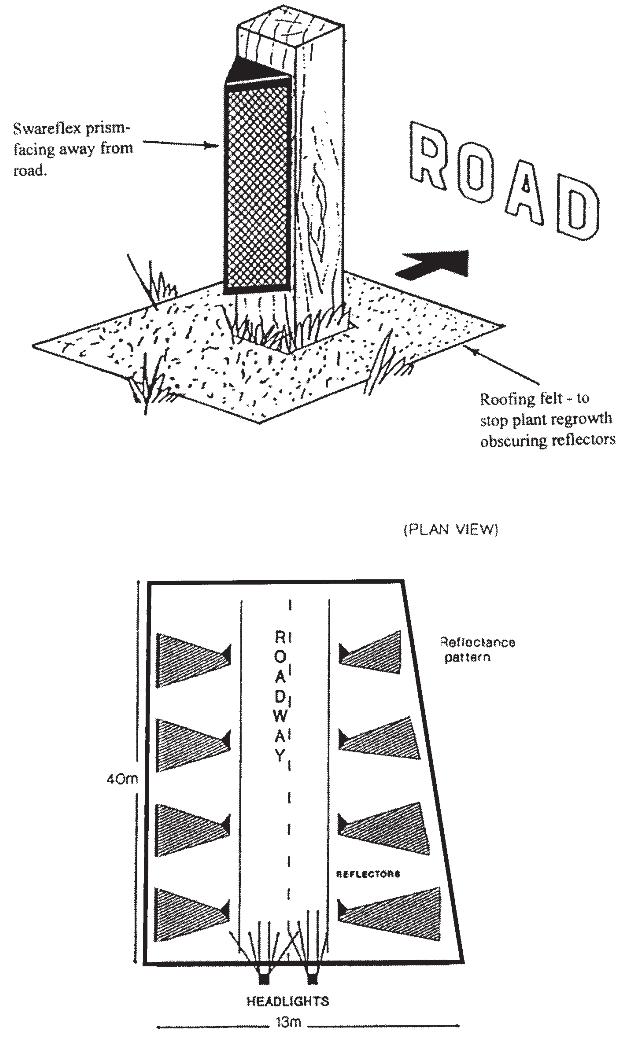

Figure 6.18 An illustration of a 'Swareflex' wildlife reflector and a description of its use
Figure redrawn from Sheridan, 1991

A study conducted in Ballarat, Victoria, to assess the usefulness of such reflectors in an attempt to reduce road kills of the Eastern Barred Bandicoot (*Perameles gunnii*) met with little success (Sheridan 1991). The apparent failure of these reflectors may be the result of poor experimental design with respect to the target animal rather than the ineffectiveness of the reflectors. In particular, subsequent studies of the Eastern Barred Bandicoots have shown that these animals are less perturbed by red light than they are by white light (Sheridan 1991). As such, more specifically-designed experiments are required before the use of these reflectors is rejected.

The NSW Roads and Traffic Authority have trialed red and white reflectors in northern NSW with early results indicating that this combination of colours may be effective (M. Ryan, Technology and Environment Division, Department of Main Roads pers. comm.). The Queensland Department of Main Roads is undertaking studies on wildlife reflectors and the finding of this work will be included in the second volume of this series.

6.5 WARNING SIGNS

In Australia, Coulson (1982) and Gardyne (1995) reported that warning signs were not an effective method of reducing the number of animals killed. They found no significant difference in the number of kangaroos and Koalas respectively, killed before and after the installation of warning signs in central Victoria and the Redland Shire of Queensland (see Figure 6.19 for a typical kangaroo warning sign).

Warning signs that reveal the number of animals killed on a particular stretch of road have also not contributed to a reduction in road mortalities. Such signs are generally used for Koalas throughout Australia, including along the roads of Phillip Island in Victoria.

However, a reduction in the speed limit from 100 km/h to 80 km/h was found to reduce the number of Koalas killed on the roads in the Redland Shire of Queensland (Gardyne 1995). Signs that suggest a lower speed during the Koala breeding season have been used near Koala populations with high densities in south-east Queensland (see Figure 6.20).

Figure 6.19 ***A kangaroo warning sign intended to increase motorists awareness of these animals***

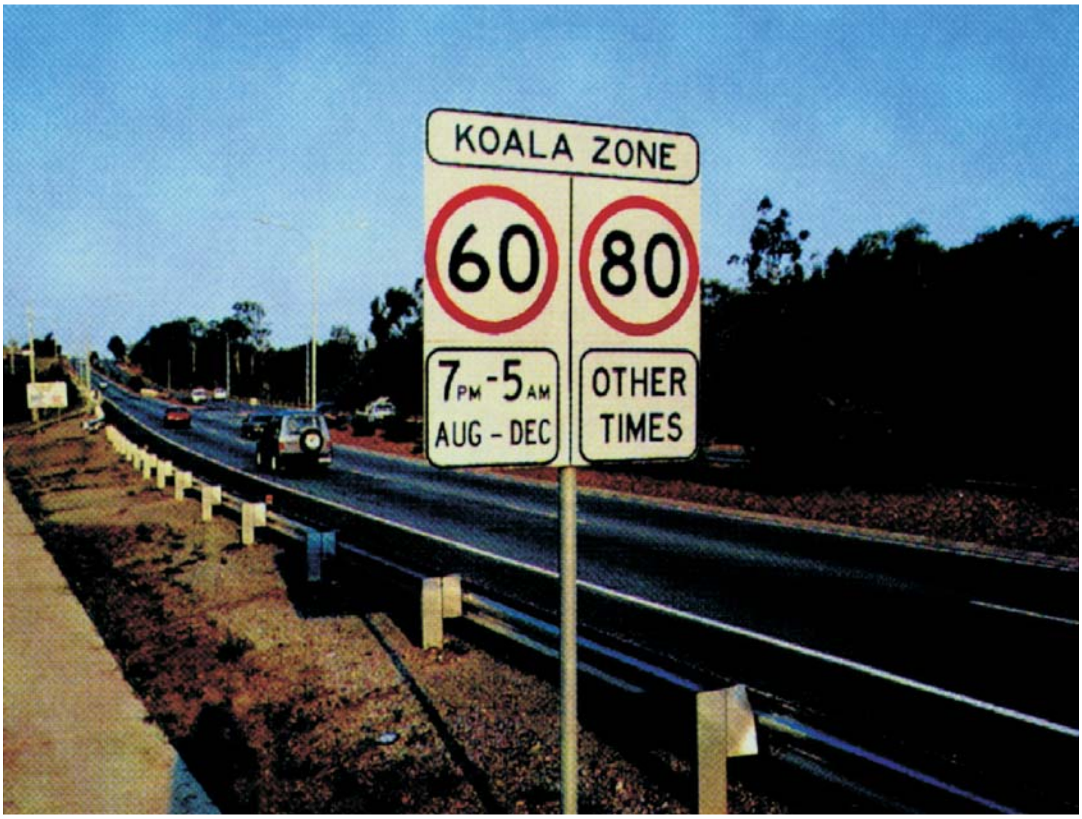

Figure 6.20 ***A sign used in south-east Queensland to increase driver awareness during the Koala breeding season***

These signs are aimed at increasing driver awareness in areas where fauna are known to cross roads. It is not known whether the number of road accidents between motorists and fauna has decreased as a result of signage and raised awareness. Other Local Government Authorities are also installing signs to increase the publics awareness of fauna (see Figure 6.21).

It is considered preferable to use Koala awareness signs that more accurately represent a Koala in the walking stance (see Figure 6.22a), rather than those which show a Koala in a tree (see Figure 6.22b).

Figure 6.21 A fauna awareness sign used by local government (Pine Rivers Shire)

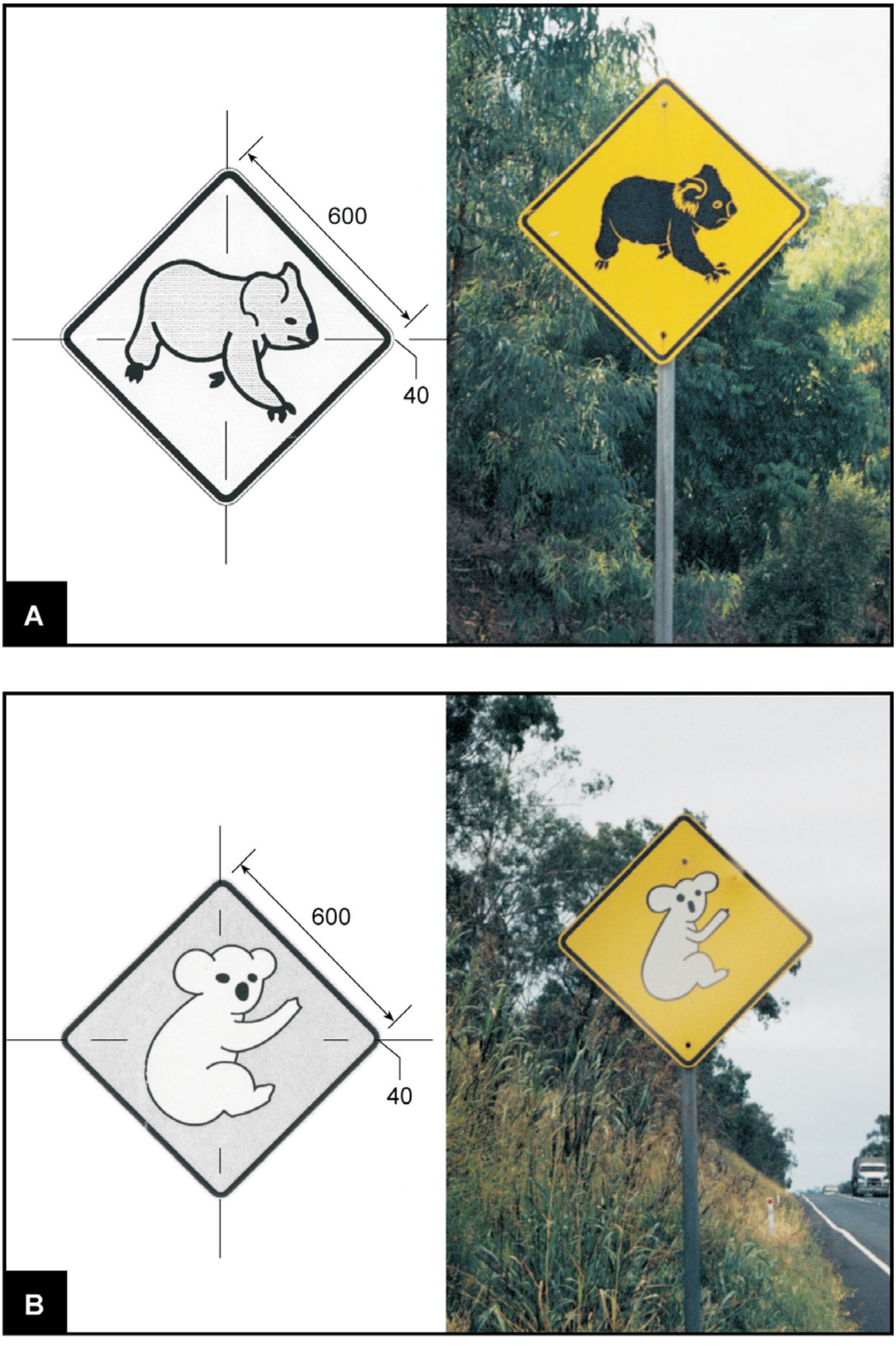

Figure 6.22 Design drawings and erected signs of (A) a walking Koala and (B) a sitting Koala

Source: (A) NSW Roads and Traffic Authority (B) Department of Main Roads