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Manual

Fauna Sensitive Transport Infrastructure Delivery
Chapter 15: Species profile – Small mammals

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1 Introduction

Small terrestrial mammals include antechinus, bandicoots, bettongs, dunnarts, echidnas, phascogales, planigales, potoroos, rats, mice, and quolls. Small terrestrial mammals typically weigh less than seven kilograms and most spend almost all of their time on the ground. Some species are scansorial – meaning they are both ground and tree dwelling (e.g. brushtailed phascogale, antechinus, northern quoll) – and are also included in this chapter.

There are more than 70 species of small terrestrial mammal species in Queensland, and 15 are considered threatened under either the *Nature Conservation Act* 1992 (NC Act) and/or the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

Other groups of small mammals are addressed in other chapters, such as flying-foxes in Chapter 10, microbats in Chapter 11, koalas in Chapter 13, arboreal mammals in Chapter 14, and semi-aquatic mammals in Chapter 16. Small mammals unlikely to be encountered by Transport and Main Roads, such as those in arid and tropical rainforest habitats (i.e. in western and far northern Queensland), are not focused on in this chapter.

1.1 Commonly encountered threatened small terrestrial mammals

Table 1.1 – Threatened small terrestrial mammal species in Queensland likely to be encountered on transport infrastructure projects

SCIENTIFIC NAME	COMMON NAME	DISTRIBUTION	HABITAT
Pseudomys novaehollandiae	New Holland mouse	Patchily distributed in small areas of South East Queensland, particularly in the Toowoomba region.	Inhabits open heathlands, woodlands and forests with a heathland understorey, and vegetated sand dunes. Sites where the species has been found are often high in floristic variety, especially leguminous perennials.
Pseudomys oralis	Hastings River mouse	Distributed in small areas of South East Queensland near the border. They are widely distributed in areas over 500 metres above sea level.	Preferred habitat appears to be an open canopy and shrub layer. Ground cover preference is variable from no cover to dense cover of grasses, herbs, and sedges. These habitats occur beside ephemeral and permanent creeks and are found on ridges and grassy plains.
Xeromys myoides	Water mouse	Widespread distribution and mostly found from Coomera River in South East Queensland to coast near Whitsunday Islands, as well as near Cairns.	Occupies in intertidal mangrove and saltmarsh habitats, as well as coastal and subcoastal freshwater and brackish wetlands, swamps and floodplains.
Dasyurus hallucatus	Northern quoll	Fragmented distribution across north-eastern, south-eastern and western areas of Queensland.	Occupies a variety of habitats including rocky areas, eucalypt forest and woodlands, rainforests, shrublands, grasslands, sandy lowlands, and beaches and desert. Also occupies non-rocky lowland habitats such as beach-scrub communities.

SCIENTIFIC NAME	COMMON NAME	DISTRIBUTION	HABITAT
Dasyurus maculatus maculatus	Spotted-tailed quoll (southern subspecies)	Fragmented distribution in South East Queensland, mainly restricted to national parks	Inhabits a variety of habitats including open forest and woodland, rainforest, coastal heath, and inland riparian forest, from the sub-alpine zone to the coastline.
Potorous tridactylus tridactylus	Long-nosed potoroo	Fragmented distribution on the south-eastern coast of Queensland, from Gladstone to the New South Wales border.	Habitat includes coastal heaths and dry and wet sclerophyll forests. Prefers a dense understorey with occasional open areas. Habitat can include areas with grasstrees, sedges, ferns, heath, and low shrubs.
Tachyglossus aculeatus	Short-beaked echidna	Widespread across Queensland.	Occurs in almost every terrestrial habitat from snow covered areas to desert habitat. They are often found amongst rocks, in hollow logs, and holes within tree roots and leaf litter.

Some commonly encountered Queensland species that are not listed as threatened include:

- Brown antechinus (*Antechinus stuartii*)
- Bush rat (*Rattus fuscipes*)
- Common dunnart (*Sminthopsis murina*)
- Delicate mouse (*Pseudomys delicatulus*)
- Grasslands melomys (*Melomys burtoni*)
- Long-nosed bandicoot (*Perameles nasuta*)
- Northern brown bandicoot (*Isoodon macrourus*)
- Rufous bettong (*Aepyprymnus rufescens*)
- Stripe-faced dunnart (*Sminthopsis macroura*)
- Swamp rat (*Rattus lutreolus*), and
- Yellow-footed antechinus (*Antechinus flavipes*).

2 Ecology

Small mammals perform important ecological roles including:

- Dispersal of plants and fungi. Phascogales and antechinus disperse pollen, while mice, rats, bettongs, and potoroos disperse seeds, and bandicoots, bettongs, bush rats, and mice disperse fungi[1].
- Maintaining the health of the ground layer by digging and foraging, aiding nutrient recycling. Bandicoots, bettongs, rats, and echidnas dig into the soil, and antechinus and phascogales dig through leaf litter[2].

[1] (Goldingay et al. 1991, Dundas et al. 2018, Palmer et al. 2021)
[2] (Martin 2003, Fleming et al. 2014)

- Controlling prey populations, particularly of insects[3].
- Acting as a key food source to carnivorous mammals, reptiles, and birds of prey[4].

2.1 Biology

The diet of small mammals varies considerably. Some species are specialised on only a few species of plant or animal (e.g. the echidna), but most are generalists that utilise a wider variety of food sources (e.g. rats and mice). Food types commonly eaten by small mammals include insects, grains and seeds, fruits and berries, grasses, fungi, nectar, and pollen. The diet of carnivorous small mammals such as quolls, phascogales, antechinus, and planigales can also include small reptiles, mammals, birds, and eggs.

Some small mammal species are short-lived, with fast growth and reproductive rates. For example, male yellow-footed antechinus live for a maximum of 12 months, with females typically living two to three years. They allocate most of their energy into reproduction as opposed to long-term survival, producing many young in only one or two breeding seasons before they die. Some species are long-lived, with slow growth and low reproductive rates. For example, the echidna lay one egg per year and live for up to 15–20 years. They allocate more of their energy towards long-term survival as opposed to reproduction, resulting in few young each breeding season, but more breeding seasons throughout their lifetime.

Small terrestrial mammals have undergone significant declines and extinctions across Australia since European settlement[5], with habitat loss, modified fire regimes, and predation by feral predators amongst the key reasons for this. Small terrestrial mammals in the ‘critical weight range’ of 35–5500 grams are particularly vulnerable to extinction. This is primarily because they are the ideal size for cats and foxes to predate, and because they have not evolved alongside these predators, they are not adept at avoiding them[6].

[3] (Gibb 2012)
[4] (Newton et al. 2002, Debus 2019)
[5] (Lawes et al. 2015, Kearney et al. 2019)
[6] (Chisolm and Taylor 2010)

Figure 2.1 – Small terrestrial mammals of Queensland, clockwise from top left, new hollands mouse (Pseudomys novaehollandiae), spotted-tail quoll (Dasyurus maculatus maculatus), pale field rat (Rattus tunneyi), yellow-footed antechinus (Antechinus flavipes)

Source: © Matt Head

2.2 Behaviour

The behaviour of small mammals, including home range movements, activity periods, and avoidance of high-risk areas, varies among species.

The home range size of small mammals varies significantly, with some as large as 4000 hectares (spotted-tailed quoll) and others smaller than 15 hectares (e.g. eastern pebble-mound mouse)[7]. Males generally have larger home ranges compared to females, as they move among several females. The home ranges of males often increase in size during the breeding season as they search for mates. For example, the home range of female spotted-tailed quolls varies between 200–500 hectares, whereas the home range for males varies from 500–4000 hectares, with the higher values occurring during the breeding season[8].

Species with smaller home ranges are likely to encounter transport infrastructure less often compared to those with larger home ranges and therefore are at lower risk of wildlife-vehicle collision (WVC)[9]. However, they may also be more impacted if the small area they inhabit is degraded by transport infrastructure[10].

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[7] (Belcher 2000, Breed and Ford 2007)
[8] (Belcher 2000)
[9] (Rytwinski and Fahrig 2015, Grilo et al. 2018)
[10] (Johnstone et al. 2014)

Most small mammals in Queensland are nocturnal, meaning their peak activity times are at dusk and dawn and/or overnight. Some species, such as the echidna, yellow-footed antechinus, and swamp rat are cathemeral, meaning they are active mostly at night but also during the day. Activity patterns may also be influenced by seasonal breeding and environmental factors. For example, movement may increase during wet weather or foraging periods may lengthen during drought[11]. Species or individuals vary in their behavioural avoidance of high-risk situations such as open areas, and threatening noises and scents[12].

2.3 Habitat

Small mammals occur in all vegetation types and regions across Queensland, including forest, woodland, rainforest, grasslands, plains, deserts, pastures, and gardens. Small mammals should be assumed present unless proven otherwise due to the wide range of environments they can inhabit.

The diversity and abundance of small mammals is closely linked to the structure and complexity of the understorey. This can include the presence of varying densities of ground-layer vegetation (e.g. up to one metre in height), logs, rock crevices, leaf litter, soil cracks, and fungi. Many species rely on this complex ground-layer for denning, provision of food resources, protection from predators, and movement through the landscape. Many scansorial species rely on tree hollows for nesting. Specific habitat requirements of small mammal species vary and should be considered at the species level.

Some small mammal species use transport infrastructure corridors as habitat[13]. It is likely that safety, foraging, and movement advantages provided by corridor habitat outweigh disturbance impacts of the transport infrastructure for many small species. This is especially the case when corridors provide some of the only suitable habitat in an otherwise degraded landscape e.g. agricultural or burnt areas. For many small mammals – particularly habitat generalists – habitat structure (e.g. woody debris, dense vegetation for cover etc.) is more important than plant species composition, so even weedy transport infrastructure corridors can be of high value[14]. Of six native species (brown antechinus, southern brown bandicoots, long-nosed bandicoot, long-nosed potoroo, bush rat and swamp rat) studied in Naringal, western Victoria, all were confirmed to use transport infrastructure corridors[15]. Road verges can provide structurally diverse pathways between patches of habitat essential for gene flow and population persistence of small mammals.

3 Direct impacts

3.1 Wildlife-vehicle collision

Many species of small mammals have been recorded in WVC surveys, however at varying rates. For example, surveys in Tasmania found that a range of species including quolls, bandicoots, bettongs, potoroos, rats, and the echidna made up just 5% of all detected collisions, with arboreal mammals, macropods and birds comprising the majority[16]. However, a survey in south-eastern New South Wales found that small mammals (mostly bandicoots) made up 26% of total WVC detections[17]. In all studies,

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[11] (Ferreguetti et al. 2020)
[12] (Taylor and Goldingay 2010, Ascensao et al. 2015)
[13] (Ascensão et al. 2012, Ruiz-Capillas et al. 2013, Galantinho et al. 2022)
[14] (Garden et al. 2007)
[15] (Bennett 1990b)
[16] (Hobday and Minstrell 2008)
[17] (Taylor and Goldingay 2004)

collisions are likely underestimated because small mammals are harder to detect and quicker to be scavenged compared to larger-bodied animals[18].

Small mammals are generally more likely to encounter and traverse transport infrastructure when:

- They are locally abundant.
- Important resources (e.g. food, water, mates) are on opposite sides of the infrastructure.
- They are more active, such as when males search for females over larger distances during the breeding season, and when individuals forage more at night[19].
- Suitable habitat occurs close to the transport infrastructure. This is especially the case if habitat is present on both sides of the transport infrastructure, and if the species is generalist so is more likely to use such habitat[20].
- They do not avoid open areas and/or disturbance from vehicles[21].

Small mammals are more likely to be struck while crossing the road when:

- The species is slow moving and/or the transport infrastructure is wide, so the animal is on the transport infrastructure for a longer time[22].
- The species is harder for motorists to detect, due to their small size, cryptic nature, and/or the environmental conditions (e.g. night-time, road curvature etc.).
- Traffic volume is high so interactions between vehicles and individuals are more frequent[23]. However, consistently high traffic volume may deter animals from crossing due to consistently high noise and light levels, reducing WVC likelihood[24].
- Vehicle speeds are higher, so motorists are less able to avoid collisions.

Mortalities are more significantly detrimental to population viability when:

- Populations are smaller, so the loss of an individual represents a greater percentage of the total population size.
- A male with several females in its home range dies, so the breeding success of the females is also reduced by the loss, or a female with dependant young dies and thus her young are also lost from the population.
- The species is longer lived with slower breeding rates, so the individual has contributed less offspring to the population before its death[25].

[18] (Ruiz-Capillas et al. 2015)
[19] (Ruiz-Capillas et al. 2015, Chen and Koprowski 2019)
[20] (Ramp et al. 2006, Taylor and Goldingay 2010, Galantinho et al. 2022)
[21] (Ascensao et al. 2015, Ji et al. 2017)
[22] (Goosem 2001, Chen and Koprowski 2019)
[23] (Taylor and Goldingay 2010)
[24] (Ruiz-Capillas et al. 2015)
[25] (Rytwinski and Fahrig 2015, Chen and Koprowski 2019)

Figure 3.1 – Echidna hiding in wheel of car.

Source: © State of Queensland

Mortalities caused by WVC can reduce the abundance of local populations. For threatened species, the loss of even a small number of individuals can drastically reduce population size, genetic diversity, and viability of the population, and potentially lead to local species extinction[26]. For example, a study in Tasmania strongly implicated a road upgrade in the local decline and extinction of the resident eastern quoll (*Dasyurus viverrinus*) population[27]. Mortalities from WVC can also cause the local extinction of small mammal species that occur in Queensland but aren't endangered or threatened due to consistent losses from the population over long time periods. As an example, the common hamster (*Cricetus cricetus*) was once considered a pest in Europe in the mid-20th century, it is now locally extinct in parts of its former range and listed as critically endangered due to long term reduction and isolation of populations by expanding road networks[28].

Numerous studies have shown that rates of WVC and fauna mortality are often positively correlated with the abundance of fauna populations in habitat adjacent to transport infrastructure. Where there are more animals, there is a higher likelihood for WVC. One study undertook a capture-mark recapture study of a population of eastern barred bandicoots (*Perameles gunnii*) in south-eastern Tasmania over four years and completed systematic roadkill surveys on the adjacent highway. They found that the number of dead bandicoots was generally positively correlated with the size of the population, and as the population declined in size, so too did the number of bandicoot mortalities[29].

3.2 Barrier effects

Transport infrastructure can act as barriers to small mammals, potentially subdividing populations, reducing genetic diversity, and increasing the risk of local extinction. The impact of barrier effects differs among species. Some studies have found that barrier effects have major negative impacts on

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[26] (Galantinho et al. 2022)
[27] (Jones 2000)
[28] (Banaszek et al. 2020)
[29] (Mallick et al. 1998)

small mammal populations[30], while others have suggested that impacts may be neutral if species are still able to move through the landscape[31]. Barrier effect impacts should thus be considered at the species level.

The barrier effect may be exacerbated if:

- The transport infrastructure runs through a species' home range or area of habitat use, preventing or impeding access to important resources.
- The species avoids open areas and/or noise so is less likely to attempt to cross the infrastructure barrier[32].
- The road or railway is wider and/or the species is smaller or less mobile, so the individual is less likely to attempt or complete crossings[33].
- Traffic volume is high when the species is active, reducing the likelihood of attempted or completed crossings[34].

3.3 Habitat loss and modification

The loss and modification of habitat and key habitat features (e.g. hollow logs, underground burrows, food resources, rocks etc.), particularly at the ground level, is especially detrimental to small mammal species. Small mammals are more impacted by habitat loss when:

- The larger landscape is also degraded (e.g. agricultural landscapes), and so they have nowhere suitable to move to[35].
- If they are habitat and/or dietary specialists and are less able to adapt and move into alternative habitats as readily as generalists[36].
- Landscape connectivity is reduced by the habitat loss. e.g. riparian or transport infrastructure corridors connecting habitat patches are lost or degraded so animals cannot move among the patches anymore.

The loss or degradation of transport infrastructure corridor habitat could have major impacts on some small mammal populations that reside in or disperse through them[37]. The loss or degradation of habitat along transport infrastructure can also occur during construction (Section 6) and maintenance (Section 7).

3.4 Noise and light pollution

Artificial light at night (ALAN) spilling onto foraging sites can increase the visibility of small mammals to predators[38]. As a result of the perceived predation risk, nocturnal mammals may reduce or discontinue the use of artificially lit habitat for foraging, breeding, and/or commuting[39], resulting in habitat and

[30] (Ascensão et al. 2017)
[31] (da Rosa et al. 2018, Grilo et al. 2018)
[32] (Ascensao et al. 2015, Ji et al. 2017)
[33] (de Freitas et al. 2015, Chen and Koprowski 2019)
[34] (Taylor and Goldingay 2010)
[35] (Ascensão et al. 2012)
[36] (Ascensao et al. 2015)
[37] (Galantinho et al. 2022)
[38] (Clarke 1983)
[39] (Bird et al. 2004)

connectivity loss[40]. Artificial light can also disrupt activity patterns of small mammals – particularly nocturnal species – by confusing their perception of time of day[41].

Vehicle noise can impact animals near transport infrastructure as well as the surrounding areas[42]. One study found that laboratory mice exhibited increased stress levels and reduced reproductive efficiency under high levels of artificial roadside noise[43]. Other artificial noise impacts on small mammals may be similar to other studied animal groups (detailed in Chapter 4), however this has not been well-studied for small mammals specifically.

The impacts of noise and ALAN on small mammals are likely more significant if:

- The species is sensitive to disturbance and/or a habitat specialist so is less able to tolerate disturbed habitat.
- The disturbed area is a large portion of an individual's home range or available habitat, so its unavailability or degradation has a larger impact on the individual and population.
- There is a high volume of traffic, increasing the intensity and distance of noise and light disturbance to the surrounding habitat, and increasing the area of habitat degradation / exclusion.
- Predator abundance is higher in the area, so prey animals under ALAN conditions are more likely to be predated and/or are more cautious of predation and less active in the habitat.

3.5 Environmental pollution

Soil erosion and deposition could impact small mammal activity such as digging and foraging, but no studies have confirmed this. Further research on the ecological impacts of environmental pollution from roads and railways is required.

3.6 Indirect impacts

Indirect impacts of roads and railways on small mammals can include:

- Increased predation pressure after habitat clearing and fragmentation because predators preferentially move along linear clearings and hunt more efficiently in open vegetation and habitat edges[44].
- Increased human occupancy in the area after new access roads are constructed, resulting in impacts such as increased abundance of backyard cats and dogs, noise and light pollution, and risk of WVC.
- Increased impacts of stochastic events such as bushfires and floods, because populations are limited to smaller, less connected habitat areas that may be destroyed[45], and because there is an increased likelihood of fires along roads[46].

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[40] (Rotics et al. 2011)
[41] (Barber-Meyer 2007)
[42] (Swaddle et al. 2015, Shannon et al. 2016)
[43] (Rasmussen et al. 2009)
[44] (Hradsky et al. 2017)
[45] (Bennett 1990a)
[46] (Parente et al. 2018)

4 Avoidance and minimisation

The most effective approach to protect small mammals from the direct and indirect impacts of roads and railways is to avoid their habitat wherever possible. Where it can't be avoided, the road and railway should be planned and designed to minimise potential impacts through the reduction of project width and micrositing. Priority habitat to avoid includes:

- High quality habitat, such as that with complex understorey, logs etc.
- Corridors and linking habitats.
- Any habitat occurring in already highly cleared landscapes.

Detailed knowledge of species occurrence and their habitat requirements are critical to inform planning and design and effectively avoid and minimise to the maximum extent possible.

5 Mitigation

5.1 Wildlife crossing structures

Many species of small mammals have been observed using underpasses, including bridges, culverts, and pipes, across Australia (Table 5.1). Vegetated land bridges are also an effective approach for small mammals because the vegetation and other habitat features can extend from the verge and continue uninterrupted across the road or railway. Brush-tailed phascogales have occasionally been observed on canopy bridges (Chapter 14).

Table 5.1 – Summary of the use of underpasses by small terrestrial mammals in Australia

SPECIES	LOCATION	CROSSING TYPE AND SIZE	REFERENCE
Various rodents (including bush rat, broad-toothed rat, black rat, swamp rat, house mouse, and unidentified rodents)	South East Queensland; north-east Queensland rainforest; north-east New South Wales; east New South Wales; Perth, Western Australia.	• Box culvert road underpasses ranging in size from 1.2 metres x 1.2 metres to 3.4 x 3.7 metres, and in length from 12 metres to 64 metres. • Railway line water drainage culverts 0.15 metres x 0.9 metres. • Boulder filled trenches ranging from 0.2 metres to 2 metres diameter, and 12 metres to 79 metres length. • Road overpasses, ranging in width from 9.4 metres to 35 metres.	(Bond and Jones 2008, Goosem 2005, Harris et al. 2010, Hayes and Goldingay 2009, Hunt et al. 1987, Taylor and Goldingay 2003, Schroder and Sato 2017)
Northern brown bandicoot	South East Queensland; north-east Queensland rainforest; north-east New South Wales.	• Box culvert road underpasses ranging in size from 1.2 metres x 2.4 metres to 3.4 metres x 3.7 metres, and in length from 17 metres to 64 metres. • Road overpasses, ranging in width from 9.4 metres to 35 metres.	(Bond and Jones 2008, Goosem 2005, Hayes and Goldingay 2009, Taylor and Goldingay 2003, Taylor and Goldingay 2014, Schroder and Sato 2017)
Antechinus spp. (incl. dusky antechinus, yellow-footed antechinus, and unidentified antechinus)	South East Queensland, north-east New South Wales, south-east New South Wales.	• Box culvert road underpasses ranging in size from 1.2 metres x 2.4 metres to 3.4 metres x 3.7 metres, and in length from 17 metres to 64 metres. • Boulder filled trenches, ranging from 0.2 metres to 2 metres diameter, and 12 metres to 79 metres length.	(Bond and Jones 2008, Taylor and Goldingay 2003, Schroder and Sato 2017)

SPECIES	LOCATION	CROSSING TYPE AND SIZE	REFERENCE
Long-nosed bandicoot	North-east New South Wales, south-east New South Wales.	• Box culverts ranging from 1.2 metres x 2.4 metres to 2.4 metres x 2.5 metres in size, and 17 metres to 48 metres in length. • Railway line water drainage culverts 0.15 metres x 0.9 metres.	(Hunt et al. 1987, Taylor and Goldingay 2003, Taylor and Goldingay 2014)
Southern brown bandicoot	Perth, Western Australia.	• Box culverts ranging in size from 0.6 metres x 0.6 metres to 1.2 metres x 1.2 metres, and length from 20 metres to 45 metres. • Pipe culverts 0.6 metres to 0.9 metres in diameter.	(Chambers and Bencini 2015, Harris et al. 2010)
Spotted-tailed quoll	North-east New South Wales.	• Box culvert 3 metres x 3 metres, 66 metres long. • Bebo arch 9 metres x 3 metres, 33 metres long.	(Michniewicz and Danvers 2020, Sandpiper 2017)
Echidna	South East Queensland; north-east New South Wales.	• Box culverts ranging from 1.2 metres x 2.4 metres to 2.4 metres x 2.5 metres in size, and 17 metres to 48 metres in length.	(Bond and Jones 2008, Taylor and Goldingay 2003)
Common planigale	South East Queensland; north-east New South Wales.	• Box culverts ranging from 1.2 metres x 2.4 metres to 2.4 metres x 2.5 metres in size, and 17 metres to 48 metres in length.	(Bond and Jones 2008, Taylor and Goldingay 2003)
Common dunnart	South East Queensland; north-east New South Wales.	• Box culverts ranging from 1.2 metres x 2.4 metres to 2.4 metres x 2.5 metres in size, and 17 metres to 48 metres in length.	(Bond and Jones 2008, Taylor and Goldingay 2003)

The optimal size of underpasses for small mammals are provided in Chapter 6, but the following considerations are likely to improve the effectiveness of crossing structures for small mammals:

- Maintaining and/or improving habitat structure and diversity at the approaches and entrances to crossing structures and where possible within the crossings (i.e. under bridges).
- Ensuring dry passage is always available, except during extreme floods. Increasing the width of underpass structures over waterways provides a wider strip of dry habitat, and logs or shelf railings in culverts can work well for small mammals.
- Avoiding use of non-natural substrates such as concrete and extensive areas of large rocks as much as possible.
- Providing furniture (e.g. hollow logs, shelves, pipes, artificial bushes, crevices) in culverts as protection from predators and to encourage use by species that avoid open areas.
- Increasing the number of crossing structures to reduce the risk of predator-prey encounters.
- If connectivity is required for daily use, at least one crossing structure should be installed per home range length for the target species. If the objective is to maintain dispersal and gene flow, crossing structures can be spaced further apart.

A scientific review found that crossing structures only reduced rates of WVC when combined with fencing[47]. When combined, they reduced WVC of small mammals by 25–100%, with an average of 70%. Wildlife crossing structures should always be applied in conjunction with fencing. More details of fencing considerations are discussed in the mitigation chapter (Chapter 6).

The effectiveness of wildlife crossing structures is likely to be improved when land management is integrated. This can include managing the habitat around the structure to suit targeted small mammals and thoughtfully designing and maintaining fauna furniture leading to crossings. Improving small mammal ability to safely occupy the area and easily access the crossing structures will improve population viability and crossing rates.

5.2 Fauna fencing

Fauna fencing is used to reduce rates of WVC and funnel small terrestrial mammals towards crossing structures[48]. Fencing is especially important for small mammals because many often use roadside habitat, putting them at a high risk of crossing roads and WVC. The position of the fence must consider motorist safety, reduction of habitat loss, and maintenance of connectivity. The appropriate implementation of fencing and crossing structures can reduce the rate of WVC while also maintaining connectivity and minimising barrier effects.

Detailed fencing designs are provided in Chapter 6. Considerations for small mammals include:

- Ensuring the size of the mesh is small enough to prevent small mammals passing through. Consider using solid opaque fencing if flooding is not an issue.
- Extending the fence below the ground to prevent species from digging underneath.
- Keeping gates flush to the ground and gaps between gates small so that small mammals cannot pass through.
- Including escape mechanisms appropriate for small terrestrial mammals such as jump-outs and escape poles for those that can climb (Chapter 6). Note, however, that escape mechanisms for small mammals have not been specifically tested and effective designs are unclear.

5.3 Noise and light walls

Noise and light walls can reduce the severity of traffic noise and ALAN for small terrestrial mammals and should be considered where sensitive species occur and at crossings structures. If well designed, the noise and light walls can also be used as fencing to keep small mammals off the road and funnel them to crossing structures.

6 Construction

The clearing and removal of vegetation and habitat may kill or injure small mammals because they are difficult to detect and can hide in dense understorey, hollow logs, crevices, and under rocks. Rates of mortality from clearing may be increased if there is no suitable habitat immediately adjacent to the

[47] Rytwinski et al. (2016)
[48] (Taylor and Goldingay 2010, Rytwinski et al. 2016)

area being cleared for them to escape into. Methods of clearing that flush small mammals into adjacent habitats ahead of machinery should be used (Chapter 7).

The use of temporary fauna exclusion fencing with a fine mesh may be needed to prevent small mammals from entering the construction area during construction.

The provision of specific habitat features, such as hollow logs or artificial shelters, can increase the suitability of revegetated areas more quickly and provide protection from predators. If artificial shelters are designed for use by animals as they are pushed out by clearing processes, they should be installed shortly before clearing. If shelters are designed as part of rehabilitation, they should be installed after clearing and construction is complete.

7 Maintenance

The presence of roadside vegetation can increase the likelihood of WVC due to a higher abundance of fauna nearby and reduced visibility for drivers[49]. Where fencing and crossing structures are both not feasible, managers must decide if vegetation should be cleared to reduce rates of WVC or left intact to reduce habitat loss and the severity of the barrier effect. The ecology of target species and safety of road users will need to be considered in these situations.

For example, in areas with a high population of large-bodied animals (e.g. kangaroos, deer) roadside vegetation should be cleared to improve driver safety. However, this is likely to negatively impact small mammals in the same location due to habitat loss.

In contrast, in areas where roadside vegetation supports mostly small-bodied animals (e.g. antechinus, potoroos), the risk to road users is lower and vegetation can be retained. The risks of retaining vegetation (increasing WVCs), and the risks of clearing the vegetation (reducing habitat availability and connectivity) must be weighed.

In areas of high small mammal importance, roadside slashing should be minimised, for example by clearing only one meter from the road edge instead of the whole verge. The removal of weeds should occur gradually and include replacement with quick-growing native species suitable for target species to provide continuous structure and protection for small mammals.

The context of sites should be considered when maintaining them. For example, species at some sites may benefit from weed removal, whereas others might rely on them to provide habitat (e.g. bandicoots use blackberry bushes to hide from predators). As another example, slashing of road verges at one site might be inconsequential for small mammals because they do not inhabit the verges, whereas it may be detrimental in another area where the density in and use of the roadside vegetation is high.

More details on maintenance considerations can be found in Chapter 8.

[49] (Taylor and Goldingay 2010, Galantinho et al. 2022)

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