6

Developing the desert – potential effects on wildlife

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Introduction

> The dogger and prospector follow the explorer; the survey party follows both and makes record of their findings; and hard upon their heels has been the stockman with his cattle, horses, donkeys, and camels, his sheep and goats and dogs; and the great hosts of the uninvited also – the rabbits, the foxes and the feral cats.
>
> The results of all this are hailed by the statistician and economist as progress, and a net increase in the wealth of the country, but if the devastation which is worked to the flora and fauna could be assessed in terms of the value which future generations will put upon them, it might be found that our wool-clips, and beef and timber trades have been dearly bought. (Finlayson 1935)

Arid regions of Australia cover ~5.5 million km^2 – three-quarters of the continent. This immense area supports a population of ~600 000 people, just under 3% of the overall Australian population (Stafford Smith and Cribb 2009). Pastoralism is the major form of land use and occupies most of the arid land area, but other significant desert enterprises include mining, tourism and conservation, as well as recreation and service industries near major watercourses and centres such as Uluru, Alice Springs and Mt Isa (Dickman *et al.* 2014). Around 300 000 km^2 are designated as Indigenous Protected Areas, occupied by many of the 93 000 people of Aboriginal descent for whom the desert is home (Brown *et al.* 2008).

The vast plains of the interior are often viewed as under-populated and ripe for increased exploitation of their aesthetic, biotic and other natural resources. This has led policy-makers to offer assistance programs (e.g. drought and mining subsidies) to ensure that desert residents remain where they are, and incentives such as start-up packages and tax breaks to attract entrepreneurs to begin new enterprises (Callender *et al.* 2011). This emphasis on financial capital has often overlooked other capital, such as human, social, physical, cultural and natural, essential for maintaining sustainable livelihoods in desert regions (Stafford Smith and Cribb 2009). In the Australian deserts, two further factors are usually also overlooked in discussions about 'progress' and economic development: the 'boom and bust' nature of the climate, and the vulnerability of some plants, animals and other organisms to environmental change (Finlayson 1935; Dickman and Wardle 2012; Dickman *et al.* 2014; Seddon *et al.* 2016). Native mammals declined dramatically with wide-ranging changes to the environment that accompanied the arrival of European settlers; ~19 species of small and medium-sized rodents and marsupials disappeared from arid Australia, within 150 years of settlement (Morton 1990).

Recent proposals and legislative changes by Australian and Queensland state governments could effect great changes to the environment (see Chapters 20 and 22). For example, the Australian Government has proposed that by 2030 much of northern Australia (areas north of the Tropic of Capricorn) would be transformed into a 'food bowl' that would double the nation's agricultural output (Australian Government 2014). Achieving such a great increase in agricultural productivity, assuming this is even possible, would drastically alter current drainage patterns and floodplain dynamics, and require the development of areas for irrigation. Because the extraction of water from rivers, lakes or groundwater changes an ecosystem well beyond the extraction or irrigation zones, the proposed developments would predictably have serious deleterious impacts on the environment and its organisms (Northern Australia Land and Water Taskforce 2009). Mining, similarly, has more extensive impacts on the environment than is evident at mine sites, owing to the expansive regional development and infrastructure that is needed to support mining activity (Andersen *et al.* 2014).

In Queensland, the *Wild Rivers Act 2005* was repealed in 2014, with river (and land) protection placed under the new *Regional Planning Interests Act 2014* (see Chapters 17, 20 and 21). Although claiming to 'identify areas of Queensland that are of regional interest because they contribute, or are likely to contribute, to Queensland's economic, social and environmental prosperity', there is much concern that the new Act will lead to increased mining, irrigation and other developments that compromise environmental values (see Chapters 19 and 22). Concern is particularly acute in the desert channels environment of south-western Queensland where rivers are currently unregulated; their flood waters cover extensive areas that connect waterholes, lakes and wetlands after heavy rainfall (Kerezsy *et al.* 2013), and the ephemeral pulses of productivity that they generate support livestock grazing (see chapters 10 and 11) and highly diverse native plants, animals and other organisms (Robin *et al.* 2010; see Chapter 1). A coalition of groups fought successfully against plans to introduce irrigated cotton farming to the region in the mid-1990s because of the probable impacts on production and biodiversity values (Kingsford *et al.* 1998). Proposals to increase water extraction for mining and irrigation have continued (see Chapters 19 and 20), with the region potentially less able to resist powerful corporate interests that are well served by the *Regional Planning Interests Act 2014*. The Queensland Government changed in early 2015 but does not have a majority government, making changes to environmental or natural resource legislation difficult.

We consider the potential effects of broad-scale irrigation and mining activity on ecological function in the desert channels environment (Fig. 6.1). We focus particularly on how native mammals and other vertebrates might respond to such developments, as their role as consumers also depends on plants in the food chain. We begin with a description of the boom and bust nature of the desert channels environment as this drives the ebbs and flows of many of our native mammals. We then draw upon a long-term dataset on small native mammals to show how species respond to large rainfall events and to the intervening dry periods, before finally considering how these species might respond to irrigation and mining. Because the magnitude of future development activities is not known, we consider different scenarios.

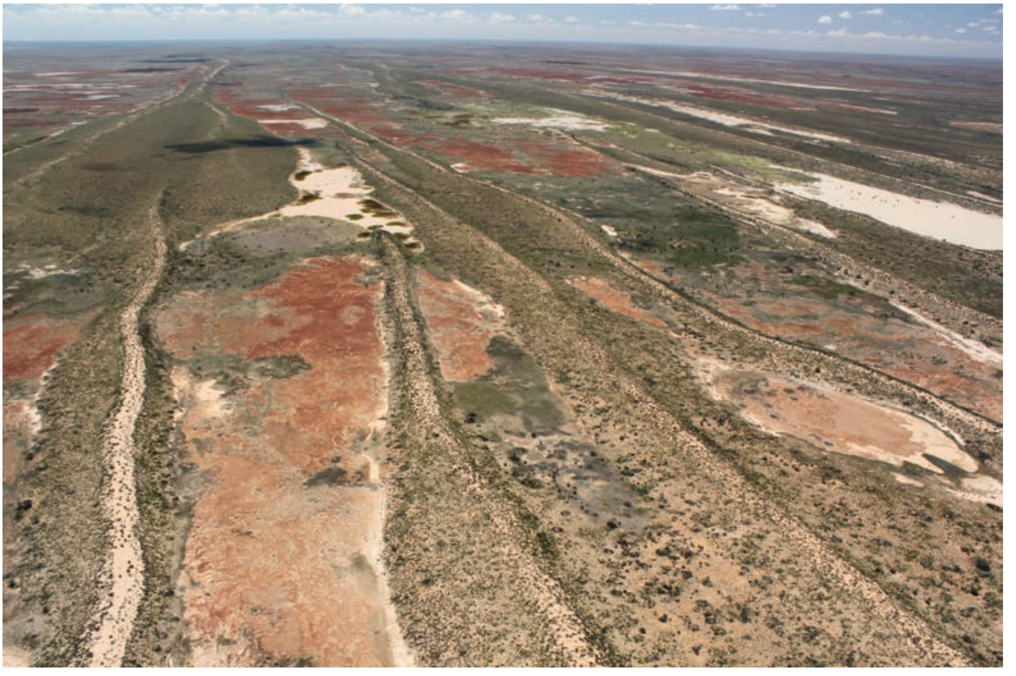

Fig. 6.1. These dunes and channels across the Simpson Desert are part of the desert channels environment, including the Channel Country of Cooper Creek and Georgina–Diamantina Rivers, Mitchell grass downs, desert uplands and Simpson–Strezlecki dunefields. This vast area is biologically highly productive, driven by boom and bust cycles of rainfall and flooding, and it provides habitats for many terrestrial mammals (photo, R. T. Kingsford).

The desert channels environment

This region occupies the north-eastern part of the Lake Eyre Basin in central and western Queensland, and covers over 500 000 km^2 (Dickman 2010). It incorporates parts of seven bioregions, including large tracts of the Channel Country and the Mitchell grass downs, as well as the desert uplands and Simpson–Strzelecki dunefields on the eastern and western boundaries, respectively (Desert Channels Queensland Inc. 2004). The desert channels environment stretches across the catchments of Cooper Creek and the Diamantina and Georgina Rivers (Fig. 6.1), which rise in the north and flow in a southerly direction towards Kati Thanda-Lake Eyre. Rainfall is higher in the north of the region (e.g. annual average for Camooweal = 398.7 mm) than in the south (e.g. 166.9 mm/year at Birdsville and 291.5 mm/year at Windorah), but very heavy rainfalls sometimes punctuate the usually arid conditions (Bureau of Meteorology 2014). Annual rainfalls of ~1000 mm have occurred at both Camooweal and Windorah and more than 540 mm at Birdsville (Bureau of Meteorology 2014); these types of events result in both local filling of river channels and downstream surges that can produce floods covering many thousands of square kilometres (Desert Channels Queensland Inc. 2004). The frequency and magnitude of these extreme rainfall events have increased over the last 100 years, a trend that may continue with climate change (Greenville *et al.* 2012).

Heavy local rains or floods arising from deluges in the northern Desert Channels recharge wetlands and swamps, and sustain the extensive networks of riparian vegetation that line the major watercourses and their braided networks of minor channels (Fig. 6.1). These events provide windows of opportunity for mass flowering and seeding of grasses and herbs, recruitment of perennial shrubs and trees, and surges of vegetative growth (Brock *et al.* 2006; Wardle 2010; Wardle *et al.* 2015). In turn, these pulses of primary productivity drive booms in populations of consumer organisms such as herbivorous insects, many birds (Kingsford *et al.* 1999; Kingsford *et al.* 2004; Kingsford *et al.* 2010) and mammals (Letnic and Dickman 2010). Population booms usually subside within a year unless further rains fall, and give way to bust or dry periods that can last for several years. Organisms can survive these periods by dispersing to wet areas outside the desert, by retreating to refuges within the arid landscape, or by weathering conditions as drought-resistant seeds or eggs (Boulton *et al.* 2006; Brock *et al.* 2006; Robin *et al.* 2010).

Mammals of the desert channels environment

We have monitored vegetation, invertebrates, small vertebrates and weather in the far western part of the desert channels environment since 1990 (Dickman *et al.* 2014). This area in the north-eastern part of the Simpson Desert has long red sand dunes that run in a north-north-westerly to south-south-easterly direction, ~0.5–1.0 km apart. The valleys and sides of the dunes are dominated by hard spinifex (*Triodia basedowii*) with small areas of gidgee (*Acacia georginae*) woodland in patches of heavy clay soil (Wardle *et al.* 2015).

We began catching small animals at Ethabuka Station (now Ethabuka Reserve) in the drought of 1990, using lines of pitfall traps (PVC pipes sunk into the ground). Mammals (and small reptiles) were trapped three to six times a year, usually for three days and nights each time, with captured animals identified, measured, marked and then released (Dickman *et al.* 2014). We have caught more than 40 species of lizard and 14 species of small mammal, with perhaps 30 more species of mammals and reptiles occurring in habitats just outside the sand dune system (Dickman and Wardle 2012). We show how populations of the two most abundant species of native rodent – the spinifex hopping-mouse (*Notomys alexis*, 30 g; Fig. 6.2) and the sandy inland mouse (*Pseudomys hermannsburgensis*, 12 g) – and a common marsupial, the brush-tailed mulgara (*Dasycercus blythi*,100 g; Fig. 6.3), have changed between 1990 and 2012 (Fig. 6.4). The rodents are omnivores, although a large part of their diet comprises seed, whereas the brush-tailed mulgara hunts invertebrates, rodents and other small vertebrates (Chen *et al.* 1998; Murray *et al.* 1999). Their dynamics are represented as catch-per-unit-effort (i.e. a trap-night is one pitfall trap open for one night), standardised as numbers of captures/100 trap-nights.

After a period of prolonged drought in 1990, large rainfall events occurred in the summers of early 1991, 1992, 2000, 2007 and 2010, with other reasonable summer rainfall events in 1995, 1997, 2009 and 2011 (Fig. 6.4a). Spinifex, the dominant vegetation, fluctuated with rainfall, ranging in ground coverage from under 20% during dry periods to over 50% in the months following exceptionally heavy summer rain (Dickman *et al.* 2014; Nguyen *et al.* 2015). Populations of the three mammal species rose and fell with rainfall (Fig. 6.4a–d). Spinifex hopping-mouse populations were often undetectable during periods of

Fig. 6.2. Small mammals such as this spinifex hopping-mouse (*Notomys alexis*) live in the sand dune habitats of the Simpson Desert, feeding on seeds, and go through boom and bust phases that coincide with productive rainfall and dry periods, respectively (photo, A. C. Greenville).

Fig. 6.3. Brush-tailed mulgaras (*Dasycercus blythi*) are predators, feeding on invertebrates, rodents and other small vertebrates, living in the sand dune habitats of the Simpson Desert. Similar to native rodents, mulgara populations go through boom and bust phases that coincide with productive rainfall and dry periods, respectively (photo, A. C. Greenville).

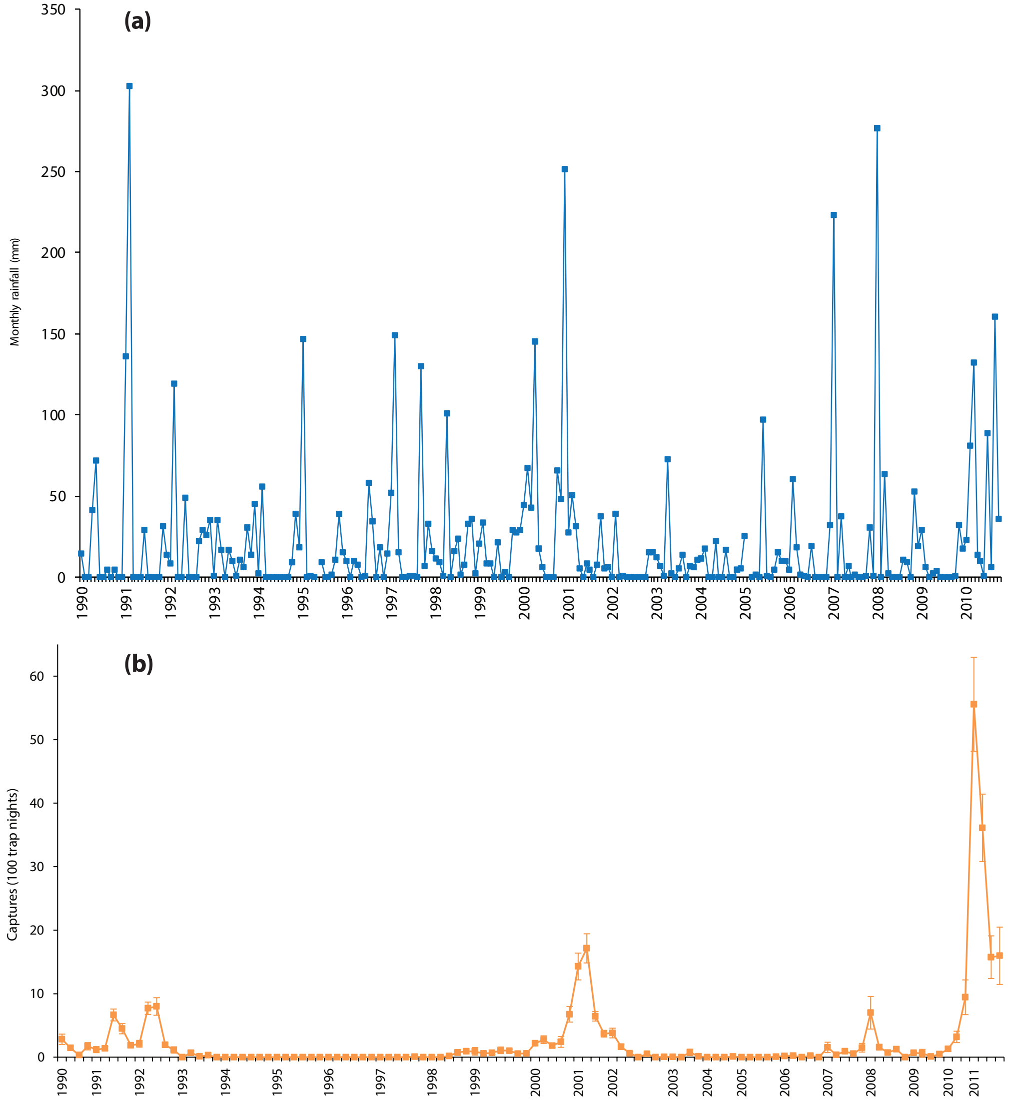

Fig. 6.4. (a) Monthly rainfall (mm) at Ethabuka Reserve, Simpson Desert, western Queensland from 1990 to 2012 (mean annual rainfall for this site is less than 200 mm), and mean capture rates (± s.e.) expressed as captures/100 trap-nights for (b) spinifex hopping-mouse (*Notomys alexis*).

drought, but irrupted within a few months of each of the major rainfall events (Fig. 6.4b). Sandy inland mouse populations were similar but were always detectable, even in dry periods (Fig. 6.4c). This species also showed a small response to moderate rainfall in the summer of 1997, contrasting with the lack of effect on spinifex hopping-mouse populations at that time. These two rodent species had different-sized responses to summer rainfalls, although the highest capture rates were in the most recent irruptions (Fig. 6.4b and c). These population booms were triggered by increases in primary productivity due to rainfall, providing food for breeding (Dickman *et al.* 1999; Breed and Leigh 2011).

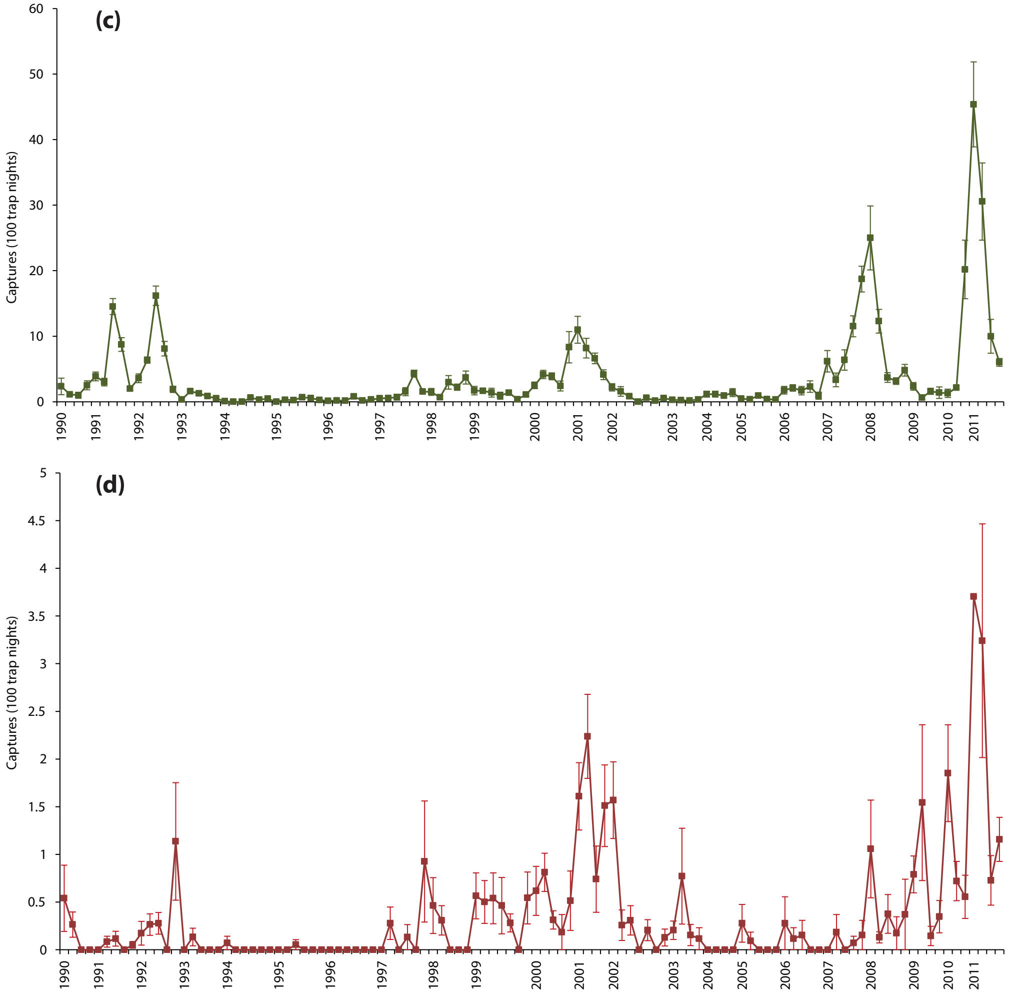

Fig. 6.4. (cont.) (c) sandy inland mouse (*Pseudomys hermannsburgensis*), and (d) brush-tailed mulgara (*Dasycercus blythi*). (Redrawn from Dickman *et al.* 2014).

Brush-tailed mulgara (Fig. 6.3) populations also fluctuated with rainfall, although peaks in the capture rate were usually 9–12 months after heavy summer rain (Fig. 6.4d). Unlike the rodents, this carnivorous marsupial has a fixed breeding time in winter and produces only a single litter. Its delayed response to summer rainfall arises from breeding adults taking advantage of the flush of rodent prey in winter, which improves survival of adults and their young, increasing the population in the following spring (Dickman *et al.* 2001). As dry periods increase, populations of all species fall to low levels (Fig. 6.4), with many retreating to refuges in the landscape where food, shelter and other resources are more consistently and reliably available (Dickman *et al.* 2011; Greenville *et al.* 2013). After 1995, we extended our study to eight other sites in the sand dune environment, using the same methods of trapping, and found very similar changes in populations (Greenville *et al.* 2016). Other, short-term studies from sites in the nearby region describe very similar patterns (Letnic *et al.* 2011; D'Souza *et al.* 2013; Wardle *et al.* 2013).

Populations of waterbirds, flock bronzewings (*Phaps histrionica*), frogs, butterflies, dragonflies and brightly coloured insect pollinators also increased with the rains, often irrupting spectacularly. Increasing populations of plague locusts (*Chortoicetes terminifera*), introduced house mice (*Mus musculus*) and native long-haired rats (*Rattus villosissimus*) exhibited similar patterns, damaging agricultural infrastructure and livestock pastures. This proliferation of prey brings increases in several species of elapid snakes (e.g. western brown snake (*Pseudonaja nuchalis*), ringed brown snake (*P. modesta*) and king brown or mulga snake (*Pseudechis australis*)) that feed on the many mammals and frogs. Feral cats (*Felis catus*), red foxes (*Vulpes vulpes*) and dingoes (*Canis dingo*) also increase in numbers during boom periods (Dickman *et al.* 2014). Heavy rainfall also increases weeds (e.g. buffel grass (*Cenchrus ciliaris*), athel pine (*Tamarix aphylla*)) and other vertebrate pests (e.g. cane toads (*Rhinella marina*), feral pigs (*Sus scrofa*)). With more vegetation growth and spread, fire risk also increases. Fires in the study region are estimated to return to the same patch about every 26 years (Greenville *et al.* 2009), but this may reduce with future climate changes (Low 2011).

Potential consequences of irrigation and mining developments

The boom and bust dynamic that prevails in the desert channels environment and the Lake Eyre Basin more broadly will be affected by developments that destroy habitats and these cycles. For example, coal seam gas contaminates groundwater (Osborne 2012), damaging aquatic animals and potentially polluting surface artesian waters (GABCC 2009). Animals can fall into uncapped drill holes where exploration is unregulated (Pedler 2010), while surface mining activities and their associated infrastructure can remove large tracts of habitat (Andersen *et al.* 2014). More generally, irrigation and mining developments increase human habitation, requiring water and waste disposal operations which can affect populations of plants, animals and other organisms. For example, development of mine sites can artificially inflate predator numbers, change home-range sizes and indirectly affect co-occurring species through changes in levels of predation or competition (Newsome *et al.* 2013; Newsome *et al.* 2015). In addition, increased roads, even if unsealed, and other transport infrastructure increase weeds and feral animals, especially foxes and feral cats that preferably use vehicle tracks (Mahon *et al.* 1998).

We focus on two potential scenarios, assuming current development recommendations (Northern Australia Land and Water Taskforce 2009), which are irrigation developments, mining modification of landscapes with removal of native vegetation for roads and mine infrastructure, and depletion of ground waters and surface water flows. We acknowledge that global environmental change will very likely further alter these scenarios and increase uncertainty in outcomes, both for development options and environmental degradation. This uncertainty emphasises the need to critically evaluate evidence for the success of any proposed scheme before it goes ahead.

Scenario 1: Fixation of boom-period conditions

Increased irrigation will affect natural boom and bust cycles, emulating heavy onsite rainfall or flooding events. Persistent water in the landscape in the form of increased low flows and channels could increase the persistence of introduced house mice, native rodents such as long-haired rats, brown snakes, and many species of mosquitoes and other biting insects. For example, dense populations of the highly venomous eastern brown snake (*Pseudonaja textilis*) use burrows in the banks of irrigation canals in the Murrumbidgee Irrigation Area (Whitaker and Shine 2003), where the snakes feed on house mice, and move over much of the agricultural landscape during warm months of the year. Dense populations of native and introduced species of rodents have also established in irrigated regions of south-east Asia (Aplin *et al.* 2003), damaging crops and livelihoods. Increased reliability of water and concentration of food in cropping areas can also be invasion hubs for feral pigs, cane toads (Letnic *et al.* 2014) and other invasive species (Letnic *et al.* 2015). Irrigation areas could also promote establishment of tropical disease organisms.

Scenario 2: Fixation of bust-period conditions

Depletion of ground and surface waters will prolong dry conditions, reducing opportunities for aquatic organisms to breed (see Chapters 3–5). Vegetation will be stressed; woody plants reliant on deep water will die and the lack of shade and refuge they provide will have flow-on effects for the remaining flora and fauna (Wardle *et al.* 2015). Loss or fragmentation of refuge habitats from surface mining activities will reduce the utility of these habitats as refuges. Over time, reduced numbers of refuge-dependent organisms will lead to losses of their local populations.

Managing the effects of irrigation and mining

Monitoring how irrigation and mining affect animals, plants and other organisms at local and regional scales is essential, if these activities proceed across the Lake Eyre Basin, with clear trigger points identified if any indicators fall outside previously agreed norms. There is, at present, very little indication that regional policy and planning documents understand the importance of such evaluation (e.g. Northern Australia Land and Water Taskforce 2009; Australian Government 2014). Changes in land use would also need to be coordinated across industries. For example, water remoteness is a well-established concept in managing rangeland pastoralism, as it provides relief from grazing pressure (Fensham and Fairfax 2008). Therefore, any new water points or larger irrigated areas arising from development would need to be considered in the landscape context.

We are still discovering the full extent of the dynamics of arid Australia, as witnessed by the extreme years in 2010–11. The intense 'greening' in these years led to unprecedented irruptions of small mammals, invertebrates and frog populations, migrations of species outside their known ranges, novel interactions among species, and greatly increased risks of predation and wildfire (Wardle *et al.* 2013). The greening also formed a major carbon sink, with an extraordinary 60% of global carbon being taken up by the growth of vegetation in Australia's arid interior (Poulter *et al.* 2014). Managing broad-scale developments under such dynamic conditions will not be easy. What we can expect is for the already erratic dynamics of the Lake Eyre Basin to increase due to global climate change (Greenville *et al.* 2012; Greenville *et al.* 2013).

Conclusion

Natural boom and bust cycles driving animal populations in the Lake Eyre Basin potentially will be seriously affected by developments in irrigation and mining. New mining and irrigation developments could have their most serious effects along the rivers and the floodplains of the Lake Eyre Basin (see Chapter 22). There are potentially two broad and contrasting scenarios, affecting the two ends of the cycles. If current environmental conditions (booms or busts) become fixed, or de-coupled from natural boom–bust cycles, we can expect great changes for the organisms and communities that have evolved to survive in a fluctuating environment. It is critical that decisions about the economic development of the rivers of the Lake Eyre Basin account for these potential effects on their natural values and adequately recognise current uses that are often providing economic values or global environmental services. We argue for a precautionary approach. As the visionary naturalist HH Finlayson warned in 1935, we should not bequeath to future generations the knowledge that our decisions have come at costs they cannot bear.

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