Mining and biodiversity

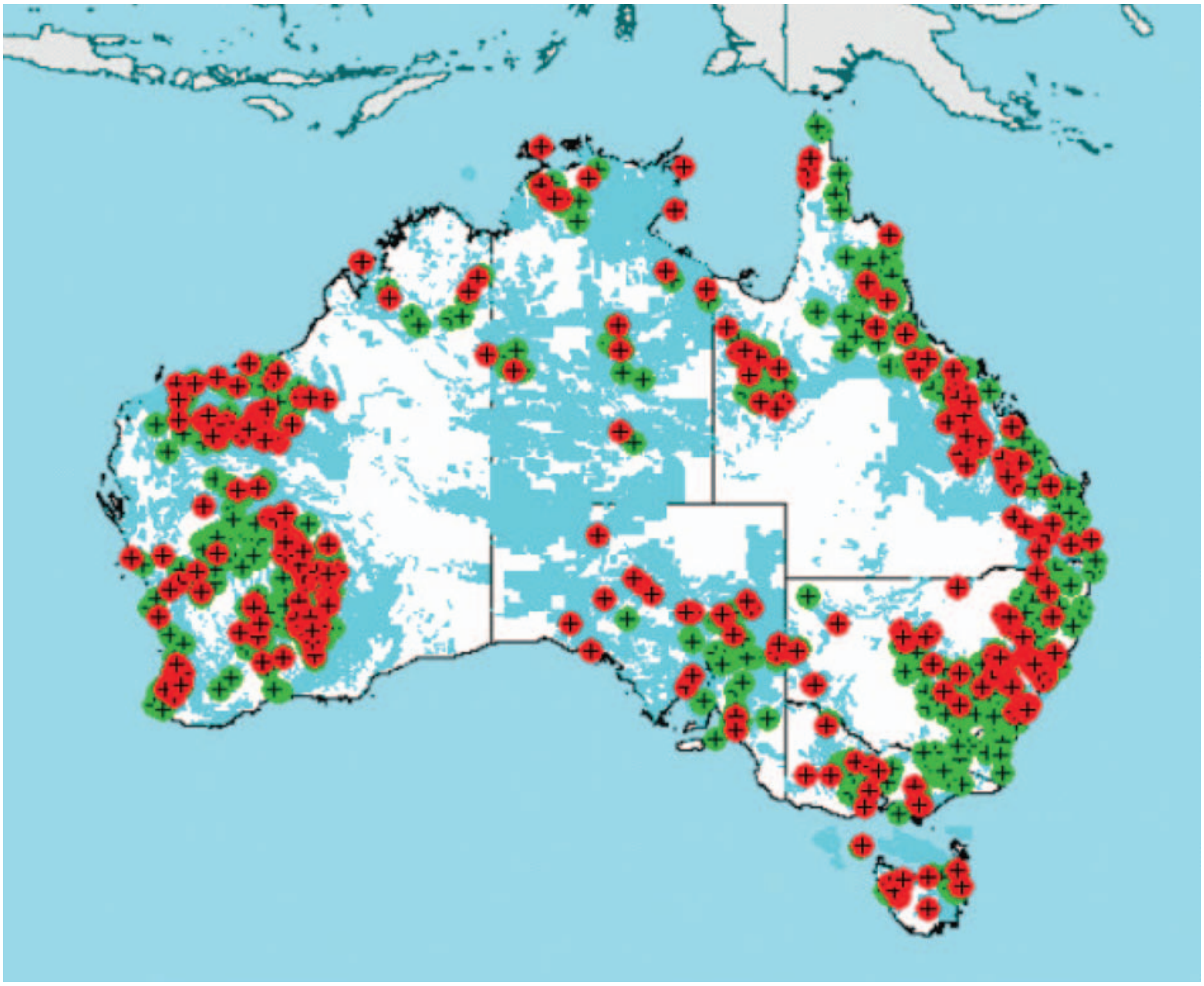
Alan Andersen, Garry Cook and Nicholas Bax

Key messages

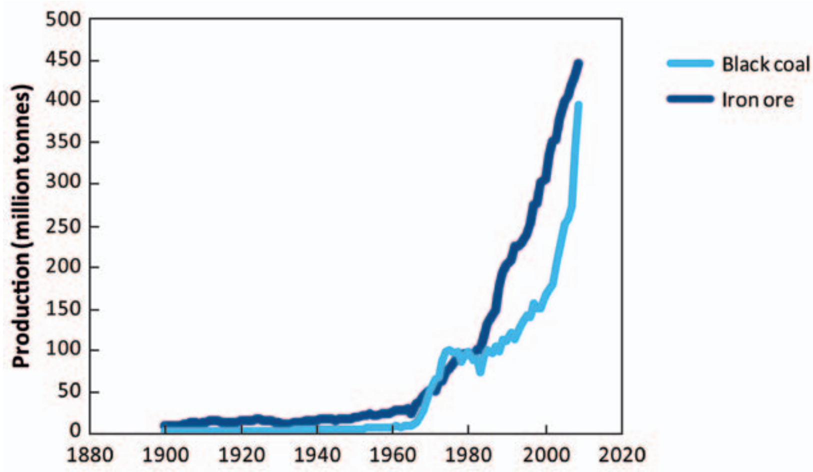
- Mining occurs throughout most regions of Australia, but its direct impacts on biodiversity are relatively limited compared with other major land uses because the areas affected are generally small.
- The greatest potential for biodiversity impacts occurs through cumulative effects of multiple projects in prospective regions, including indirect impacts from regional development; these are best managed by strategic assessments that consider whole-of-region development in the long term.
- In the past, rehabilitation projects following mining simply aimed to establish vegetation cover. Now, projects increasingly seek to develop self-sustaining ecosystems that interact sustainably with the surrounding landscape.
- Unavoidable impacts on biodiversity can be partially compensated for (or ‘offset’) through activities that provide conservation benefits elsewhere. Given the wealth created, there are opportunities for mining to leave a positive legacy for biodiversity conservation in the broader region.

MINING AND ITS BIODIVERSITY FOOTPRINT

Mineral prospecting and exploration are allowed throughout most of Australia (Figure 11.1), and so mining has the potential for extensive impacts on biodiversity. Many people worry about the environmental impacts of mining, but society has a growing need for its products and it is a valuable industry to Australia. Australia is a globally significant supplier of minerals and energy, holding a substantial proportion of the world's known reserves of many important minerals. Mining is vital to the Australian economy, delivering more than half of the total value of the nation's exports. Mining exports have increased rapidly over recent decades on the back of unprecedented demand from China and other developing economies, with annual production of black coal and iron ore increasing exponentially (Figure 11.2).[1]



▲ ***Figure 11.1***: *Operating (red) and historic (green) mines, and mineral tenements in which mining, exploration and prospecting is allowed (blue). Source: Copyright Commonwealth of Australia – Geoscience Australia, 2010.*



▸ ***Figure 11.2**: Australian black coal and iron ore production over the past 130 years.*[1]

Nevertheless, individual mine sites are typically small, and collectively they cover less than 1% of the Australian land area (Table 11.1).[2,3] As a result, the direct impacts of mining on biodiversity are limited compared with other major land uses.

The localised effects of mining can be important, however, and there are many examples of serious environmental impacts from old mines that operated under lax environmental regulation. In particular, the planned release or accidental leakage of contaminated water can have a major impact on local wetlands and waterways. For example, 100 years of release of wastes from the Mt Lyell Mine has had devastating impacts on the ecology of the King and Queen Rivers in Tasmania.[4] Localised impacts can have broader significance, such as when the mining of rare but particularly prospective geological formations competes with the conservation of species or ecosystems that are endemic to that area. Mining can also have significant indirect impacts, such as through extraction of water from aquifers or the Great Artesian Basin, or accidental oil spills from ships transporting minerals for export. Volumes of oil spills are predicted to increase in Australian waters by nearly a third between 2010 and 2020, due to a dramatic increase in sea traffic.[5]

Table 11.1: Land use in Australia in 2006 as a proportion of the total area of land.[3]

Land use	**Percentage of total land area**
Agriculture	62
Grazing natural vegetation (rangelands)	56
Dryland grazing (improved pastures)	2.5
Cropping	2.8
Horticulture	< 1
Irrigation	< 1
Minimal use	15
Traditional Indigenous uses	12
Biodiversity conservation	6
Forestry	2
Water	1.7
Managed resource protection	1.4
Urban uses	< 1
Mining	< 1
Total	**100**

The greatest potential for negative impacts on biodiversity is not from individual mines, therefore, but from the cumulative impacts of extensive development in highly prospective regions, or where diffuse exploration and development take place over large regions. Iron-ore mining in Western Australia's Pilbara and coal mining in central Queensland are examples of the former, and examples of the latter are coal seam gas development in eastern Australia and exploration for gas, oil and minerals across outback Australia. In these situations mining can dominate regional development, and potentially affect biodiversity regionally through a combination of the scale of exploration activity, the mine sites themselves and, importantly, the roads, towns, pipelines, water supplies and ports required to service them.

At a regional scale, biodiversity is likely to be affected more by infrastructure development relating to processing and transport than by mines themselves. Photo: Woodside.

This chapter focuses on three issues of particular importance for managing the impacts of mining on biodiversity:

1. Cumulative impacts in highly prospective regions, which are best managed by planning that addresses whole-of-region development over the longer term, based on a comprehensive assessment of regional biodiversity assets.
2. Mine site rehabilitation, which is increasingly aiming beyond simple establishment of vegetation cover towards re-creation of biodiverse ecosystems that interact sustainably with the surrounding landscape.
3. Biodiversity offsets, which can help compensate for unavoidable on-site losses of biodiversity by activities that provide conservation benefits elsewhere in the region.

REGIONAL ASSESSMENTS

Regional assessments can limit the impacts of large-scale development by identifying the biodiversity assets of a region and establishing a planning framework by which these assets can be protected. Such assessments can also be beneficial to the industry itself by providing clear 'goal posts' for development, reducing duplication with impact assessment, and streamlining administrative processes. The Australian Government has a formal process for strategic regional assessments under the *Environment Protection and Biodiversity Conservation Act 1999*.[6] The first priority is to avoid any impacts on nationally significant biodiversity assets. If such assets are threatened, then appropriate mitigation measures are required, and if significant biodiversity impacts are unavoidable, then these need to be compensated for by appropriate offsets. There is a requirement for ongoing adaptive management to ensure that regional biodiversity objectives are ultimately achieved.

A regional strategic assessment process has recently been implemented for the Great Barrier Reef (see Chapter 5 for more detail). Most of the threats to the Great Barrier Reef have their origins outside it, and include catchment run-off, coastal development and climate change.[7] No mining, oil or gas development is allowed in the Great Barrier Reef Marine Park. However, the booming mining industry in central Queensland means that coastal development pressures, including ports, are increasing rapidly, with shipping traffic to Queensland ports predicted to increase four-fold by 2020. Managing such development pressures is a challenge, particularly while trying to protect a globally significant natural wonder that is becoming more vulnerable due to climate change. These pressures are threatening the World Heritage status of the Great Barrier Reef Marine Park, with UNESCO concluding that development of new ports or other major infrastructure would have a significantly negative, and largely irreversible, impact on its biodiversity.[8]

Although mining, oil and gas developments are not allowed inside the Great Barrier Reef Marine Park, there is international concern about the negative impacts that increased coastal development, resulting from the central Queensland mining boom, could have on the Reef's biodiversity values. Photo: Marie Davies.

Projects under the aforementioned strategic assessment are defining the biodiversity values of the Reef, examining cumulative impacts, and designing an integrated monitoring program. There are existing monitoring programs being undertaken by government, industry and non-government organisations, but these could be better integrated. The new regional assessment will provide this integration, identify major information gaps, and form the basis of strategic adaptive management (Box 11.1).

Box 11.1: Marine indicators

A cornerstone of adaptive management is the monitoring of indicators that signal management success. Marine indicators are well established for single-species fisheries, but are less well developed for the broader and more complex issues of biodiversity and ecosystem health. There is often, therefore, a gap between high-level management objectives as articulated in marine bioregional plans and the capacity to measure them. The linking of management needs to monitoring requires close collaboration to specify environmental objectives that are not only scientifically measurable but also meaningful to managers.

An Australian breakthrough came when the Commonwealth identified the most significant areas for marine productivity or diversity as 'key ecological features', including seamounts, canyons and areas of upwelling or regular current eddies. CSIRO scientists then worked with regional experts to develop conceptual models for 31 key ecological features around the country. The use of simple, qualitative models to link pressures (such as climate change, fishing and mining) to these features has led to reliable indicators of ecological change that will support future State of the Environment reporting. Such simple models that capture local understanding and link operational management to monitoring are now being applied to the Great Barrier Reef World Heritage Area, as part of the assessment of cumulative impacts of rapid coastal development associated with land-based mining.

MINE SITE REHABILITATION

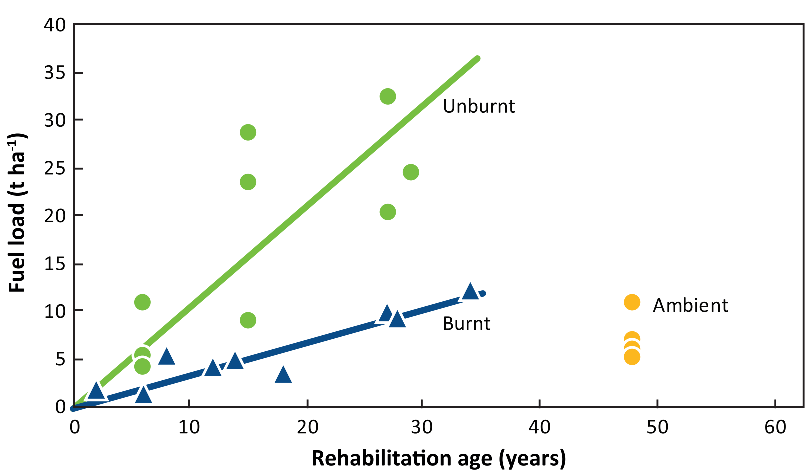
Mine site rehabilitation has historically focused on site stabilisation and the establishment of vegetation cover, but this is often now just the start of a rehabilitation process that is increasingly aimed at ecosystem restoration. Successful ecosystem restoration requires the re-establishment of animal as well as plant communities, and also the effective functioning of ecological processes such as nutrient cycling. Restored ecosystems also need to be resilient to natural disturbance, especially fire, and to invasion by weeds. In this way, the rehabilitated mine site becomes sustainably integrated with the surrounding landscape.

Fire management and ecosystem restoration

Fires are the major agent of natural ecological disturbance throughout much of Australia. Average intervals between burns range from 1 to 2 years in tropical savannas to many decades in the tall forests of temperate Australia. In highly fire-prone regions, the capacity to recover after fire ('fire resilience') is a key attribute of ecosystems, and is taken into account in effective mine site rehabilitation. There has been a major research effort into the role of fire in ecosystem restoration in bauxite mines of south-western Australia.[9] There, rehabilitated landscapes aged 12–15 years are resilient to fire, with low- to moderate-intensity spring-time burns being recommended as best practice in fire management.

For much of Australia, however, the responses of plant and animals to fire are not so well known and therefore difficult to incorporate into rehabilitation plans.[10] Even in northern Australian savannas, which are the most fire-prone of all ecosystems and have the advantage of scientific understanding through a strong history of fire research, incorporation of fire into mine site rehabilitation has been problematic. Despite fires occurring every 1–3 years in the surrounding landscape, fire is often mistakenly excluded from rehabilitated mine sites in order, it is believed, to maximise vegetation growth. It is typically assumed that when local native plants are used in rehabilitation, the system will therefore be resilient to fire. In many cases, however, this is unlikely to be the case.

From the perspective of those who actively wish to exclude fire, the build-up of leaf litter on the soil surface of rehabilitated landscapes is viewed as a positive development. It is true that leaf litter protects the soil from extremes of temperature, from rain impact and from soil erosion, and can support the invertebrate diversity that leads to increases in soil organic matter. However, build-up of leaf litter is an increasing fire hazard. The rate of energy released by fire – fire intensity – increases with the fuel load, and higher intensity fires are more likely to kill the above-ground parts of trees. In the long-term absence of fire, leaf litter in rehabilitated sites can increase to many times the levels found in frequently burnt natural savanna (Figure 11.3).[11] Fire exclusion can thereby create a more serious fire management problem – when fires inevitably occur they can be very intense, killing most trees. Incorporation of fire from an early stage of the rehabilitation process is a more sustainable approach to managing fire hazard and conferring resilience to the ecosystem through management of the fuel load.



▸ ***Figure 11.3**: Changes in total fuel load with age of rehabilitation after bauxite mining at Gove, Northern Territory, on burnt sites and unburnt sites compared with unmined sites (ambient). The graph demonstrates that active burning programs are necessary to manage fuel loads.[11]*

Many mine site management plans view fires as emergencies to be managed. In rehabilitation, however, the key concern should be how quickly fires can be introduced into the rehabilitation process, and what the subsequent fire regime should be. These approaches require deeper consideration of the intensity, frequency and timing of fires.

*The exclusion of fire from minesites undergoing restoration can lead to unusually high litter loads **(a)**, which can then fuel destructive fires **(b)**. Photos: (a) Garry Cook, CSIRO; (b) Barbara McKaige, CSIRO.*

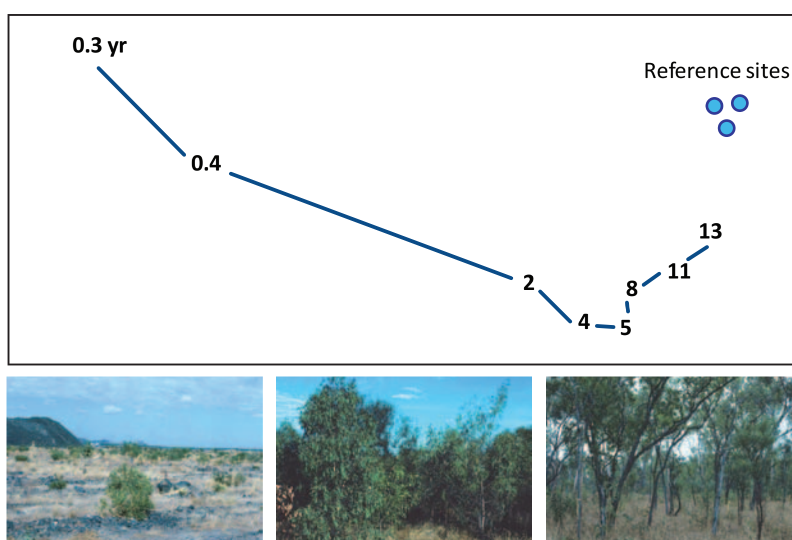
Assessing rehabilitation success

Another major challenge in mine site rehabilitation is the monitoring and assessment of success, which requires the development of reliable indicators of biodiversity and ecosystem health. One approach is landscape function analysis, which was originally developed as a tool for understanding and managing degradation in Australian rangelands.[12] Landscape function analysis supplements traditional approaches to vegetation monitoring by adding an interpretation that links vegetation structure closely with soil processes, such as water infiltration and run-off and nutrient cycling. The analysis uses rapid field techniques, the results of which are correlated with those of more detailed soil assessments.

Landscape function analysis has been expanded to ecosystem function analysis through the inclusion of vegetation composition and dynamics and habitat complexity, which are used as surrogates of biodiversity.[13] However, any measurement of soil or vegetation has a limitation as an indicator of biodiversity – at best it can indicate that the habitat is *potentially* suitable for fauna, but not that appropriate animal assemblages actually occur. An additional approach to monitoring and assessment is to use the occurrence of particular animal species as an indicator of rehabilitation success.

Invertebrate animals make excellent indicators of restoration because they are extremely abundant, play important roles in ecological processes that are crucial to restoration (such as soil formation and nutrient cycling), and are sensitive to environmental change. They may make good surrogates – if invertebrate communities are in good shape, then it may be safe to assume that the broader ecosystem is likewise. As the dominant faunal group throughout most of Australia, ants are commonly used as indicators of mine site rehabilitation.[14] Ant species change in a systematic way with increasing time since rehabilitation (Figure 11.4), and these patterns reflect those of other invertebrate groups and of important processes such as nutrient cycling.[15,16]

Anyone home? Ants are an ecologically dominant group throughout Australia, and are used in the mining industry as bio-indicators of mine site restoration. Photo: Alan Andersen, CSIRO.



▸ ***Figure 11.4***: *Ant recolonisation at rehabilitated mine sites of different ages at Ranger Uranium Mine in the Northern Territory. Numbers represent sites of different rehabilitation ages, with distances between them reflecting the similarity of ant species occurring at them (the closer together, the more similar). Ant species composition at sites of increasing age from a few months (left photograph) to four years (middle photograph) is increasingly similar to that at undisturbed reference sites (right photograph).[15] Photos: Alan Andersen, CSIRO.*

BIODIVERSITY OFFSETS

Mining will often have unavoidable negative impacts on biodiversity. In these cases, it is possible to offset impacts by creating benefits elsewhere so as to produce an overall conservation outcome that maintains the biodiversity assets of a region. Such offsets can be direct, through acquiring comparable land and managing it for biodiversity conservation, a process sometimes referred to as 'biobanking'. If mining has unavoidable impacts on habitat of particularly high quality, then the offset might require many times the area directly impacted.[17] Another form of a direct offset is through funding the implementation of regional conservation plans. Biodiversity offsets may also be indirect, such as by conducting relevant research for improved conservation management, or through education and training that increases regional capacity for biodiversity management.

Under the Environmental Offsets Policy of the *Environment Protection and Biodiversity Conservation Act 1999*, a minimum of 90% of offsets must be direct, except where greater benefits can be shown from indirect offsets, or where scientific uncertainty is high (such as in marine environments, as outlined below).[18] A stringent offset policy acts as a powerful incentive for limiting biodiversity loss in the first place. The *Arid Recovery* project is a partnership at Roxby Downs in South Australia between BHP Billiton, the local community, the South Australian Government and the University of Adelaide. Although not formally a mining offset project, *Arid Recovery* demonstrates many of the environmental and community benefits of such investment (Box 11.2).[19]

Offsets in the marine environment

The use of offsets in the marine environment offers challenges not encountered on land. In the first place, less is known about how resource development affects biodiversity and ecological function in marine ecosystems, given that impacts are frequently not visible to humans. The scope and scale of any offset requirement may therefore be uncertain. Second, there is often limited capacity for rehabilitating degraded marine sites because of the logistical difficulties of working under water, especially at depth. Third, ecological communities such as those occurring in the cold, low-energy deep sea typically have far slower rates of growth than those on land, and are unlikely to be able to be rehabilitated within a reasonable time-frame. Finally, even if an offset option could be identified, it is not legally possible in the marine environment for a company to purchase a site for habitat rehabilitation or to prevent others from subsequently re-damaging it. An alternative option for achieving marine offsets is to reduce or remove extractive pressures elsewhere, such as through the purchase of licences. These complex issues are formally recognised in the Environmental Offsets Policy of the *Environment Protection and Biodiversity Conservation Act 1999*, where the requirement for 90% direct offsets is not so rigidly applied in marine environments.[18]

Marine offsets requirements, therefore, have often not been so tightly coupled with the actual mining activity as they are on land. An example is provided by the Ichthys Project in north-

Box 11.2: The Arid Recovery project

BHP Billiton is the operator of Olympic Dam near Roxby Downs, one of Australia's largest mines. The *Arid Recovery* project aims to ensure that mining activity has a net positive impact on regional biodiversity assets. It has combined scientific research and monitoring with on-ground management to produce significant conservation benefits for threatened species.

Arid Australia has experienced severe loss of native mammals since European settlement, due to overgrazing by rabbits and domestic stock, and predation by cats and foxes. These forces have led to extinctions of most small- and medium-sized mammal species. *Arid Recovery* features a reserve of 123 km^2 with predator-exclusion fencing, supplemented by broader scale control of feral animals and ecosystem regeneration. Between 1998 and 2001, several regionally extinct mammal species – including the greater bilby, *Macrotis lagotis*; burrowing bettong, *Bettongia lesueur*; western barred bandicoot, *Perameles bougainville*; and greater stick-nest rat, *Leporillus conditor* – have been reintroduced into the reserve following feral animal control. Trial reintroductions are currently underway for other species such as the numbat, *Myrmecobius fasciatus*. The species have shown strong population growth, with, for example, the 30 burrowing bettongs initially released into the main exclosure growing to approximately 1000 by 2010.

Ongoing research and monitoring has shown that control of feral animals and species reintroductions have had a broader effect on biodiversity beyond threatened mammals. Burrowing by reintroduced bilbies and bettongs has promoted germination of seedlings and increased levels of soil carbon, and provided important shelter for other native mammals and reptiles. Freed from the impacts of introduced predators, many ground-nesting and ground-active birds have increased in abundance inside the reserve. The abundance of native nocturnal predatory birds has also increased, presumably in response to an increased food supply.

The Arid Recovery *project at Roxby Downs in arid South Australia has had benefits for threatened species, such as this burrowing bettong. Photo: Sam Secker,* Arid Recovery.

As well as providing a model for broad-scale restoration, *Arid Recovery* has made important contributions to our understanding of the ecology of arid Australia. The reserve includes different combinations of grazing, introduced predators and reintroductions, providing an opportunity for studying the effects of each of these factors. The project has demonstrated the role of introduced predators in causing extinctions of small mammals, while also uncovering some fascinating interactions that affect animal populations.[20] For example, reintroduction has been trialled for the woma, *Aspidites ramsayi*, a desert python that has declined in abundance throughout its range, but all nine reintroduced individuals were eaten by the native mulga snake, *Pseudechis australis*, within a few months. Similarly, trial reintroductions of numbats showed that these animals are highly susceptible to predation by native predatory birds.

western Australia, where the Inpex Corporation plans to pipe natural gas from the western edge of the Timor Sea nearly 900 km to Darwin Harbour for processing. Hence, the proponents have negotiated a coastal offsets program with the Northern Territory Government that includes habitat mapping for the Darwin Harbour region, conservation co-management of dugong, dolphins and marine turtles with Aboriginal communities, and an integrated marine monitoring and research program for Darwin Harbour.[21]

Dolphin conservation management is a feature of a marine offset project that compensates for potential environmental impacts of infrastructure development in Darwin Harbour. Photo: Carol Palmer.

CONCLUSION

Mining stands out from other major land uses in terms of the wealth it creates from the limited areas that it directly affects and the relatively short duration of the effect. This provides an opportunity for achieving high standards of environmental management, encompassing mitigation, ecosystem rehabilitation, and environmental offsets. In this chapter we have highlighted the importance of taking a regional approach to managing the cumulative impacts of multiple projects. In particular, infrastructure development in highly prospective regions can have reduced impacts if it is carefully planned on the basis of regional assessment, is conducted in advance of substantial capital investment, and is compensated for by offset activities where effects cannot be avoided or mitigated. Moreover, biodiversity offsetting can be used to promote conservation efforts in remote regions that would otherwise attract little conservation attention. Given the wealth created, it seems reasonable to expect and require mining to leave a legacy of enhanced biodiversity conservation at the national scale, despite any local losses.

FURTHER READING

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